ACCURACY AND VARIATION IN TRANSCRIPTION OF ANTEMORTEM DENTAL DATA

Catherine Alexandra Storer

Faculty of Health and Medical Sciences, Forensic Odontology Unit,

Adelaide Dental School, University of Adelaide

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In loving memory

Elizabeth Rosemary Sims
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Abstract

Comparison of dental features has been used successfully for human identification throughout history. The data from an individual's dental records and identifying dental findings are compared to an unknown postmortem dataset to determine if both datasets belong to the same individual.

Currently, a major focus of the forensic science community is on the standardisation and validation of processes. Despite extensive research on the postmortem and reconciliation phases of dental identification, no studies have evaluated antemortem dental data collection, presentation, analysis, and collation. Antemortem information is of paramount importance for definitive identification since without it, comparisons cannot be made. Poor quality data and inaccuracies or errors in transcription could delay identification, or more seriously, lead to a false exclusion or identification.

This thesis aims to assess the current antemortem phase process and devise standardised procedures to improve archiving and transmission of antemortem records and increase accuracy and repeatability of dental data transcription. Information contained within dental records, their complexity, and the potential impact this content and its presentation had on antemortem transcription was investigated. Following this, a study requiring transcription of dental data was conducted to identify variation in coding and evaluate the types and causes of errors. Using this information, a standard operating procedure and a computer-aided method to implement it were developed to enhance antemortem transcription quality. This research highlights the large variation in both antemortem data complexity and interpretation and the impact that this can have on transcription. The computer-aided method developed from the knowledge gained showed that analysis and transcription can be further standardised to improve accuracy. Additionally, standardisation will improve calibration between examiners and will enable proficiency testing, which will enhance the scientific basis of dental identification.

Declaration

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Signed: Date: 20 December 2022

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CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

"The humane and social importance of identification cannot be doubted by anyone" – Oscar Amoedo, 1897

Human Identification

In a forensic context, human identification establishes the identity of all parties involved in legal affairs (Gowland & Thompson 2013), including both civil and criminal matters. Civil matters, such as the provision of a death certificate for a funeral to proceed, a will to be enacted, or life insurance claims, require the deceased to be identified (Sopher 1976; Nuzzolese & Di Vella 2007; Gowland & Thompson 2013). In criminal matters identification is important as without the name of a victim, there is doubt and justice cannot be sought (Charangowda 2010; Knott 2016). In addition to its legal implications, human identification is also a humanitarian act, the primary aim of which is to give the unidentified deceased back their name (Knott 2016). Bodies of the deceased have an important symbolic value for families and communities of every culture and creed (PAHO 2004; Knott 2016). Not knowing what has happened to a loved one is painful as those left behind are in a state of uncertainty and despair, which delays the grieving process. When the deceased are returned to their families, knowing that they are resting peacefully, is crucial in helping the living accept and deal with the death, enabling them to work through their grief (Sopher 1976; PAHO 2004; Nuzzolese & Di Vella 2007; Knott 2016; Cook 2020).

Disaster Victim Identification and Identification Methods

Disaster Victim Identification (DVI) is the method used to identify victims of mass casualty incidents, either man-made or natural. The first identification committee was established in Norway in 1945 (Taylor 2009) which stated that when several victims are found in the same location an identification committee should be appointed. This committee would consist of a police officer, a dentist, and a pathologist. The key principles of this committee's orders still underlie DVI today (Taylor 2009). Several disaster events over the following three decades refined the DVI process and in 1982 the International Criminal

Police Organization (INTERPOL) established a working party on Disaster Victim Identification to improve international coordination and consistency (Taylor 2009). The committee became a standing committee that still meets today to analyse DVI cases which allows learning from previous incident responses to inform future action and protocol. The first published Guide to DVI became available in 1984, is updated every 5 years, and is accepted as the international standard for DVI protocols (Taylor 2009; INTERPOL 2021). The largest single-incident DVI response was conducted by INTERPOL for the 2004 Asian tsunami. The international operation involved specialists from 31 countries in Thailand alone and successfully identified approximately 5,000 victims (INTERPOL 2021).

Methods of human identification used in both individual cases and disasters can be separated into two categories (Sopher 1976; Hill, AJ, Hewson & Lain 2011; Knott 2016; INTERPOL 2018a; Loomis 2018):

- Primary (scientific)
  - DNA
  - Dental data
  - Fingerprints
- Secondary (non-scientific)
  - Visual
  - Medical findings
  - Tattoos
  - Blood group
  - Personal effects

All these identification methods have one thing in common. They are a comparison of postmortem (PM) information of an unknown deceased to antemortem (AM) information of a known individual (Sopher 1976). They compare a pattern of features — facial features, jewellery, scars, teeth, fingerprints etc. — to determine discrepancies for reconciliation and identify individualising features to ascertain whether the unknown information could have originated from the known individual.

In many countries, including Australia, in cases where visual identification is not appropriate, an individual must be scientifically identified (Blau 2020). Techniques utilised for scientific identification are synonymous with the primary identifiers above.
Primary identifiers are often accepted as stand-alone, while secondary identifiers are used in combination with each other or with primary identifiers (Sopher 1976; Knott 2016). The level and number of identifiers required for positive identification in disaster situations largely depend on the justice system of the country running the DVI response.

Dental Identification

Comparison of dental features has been used successfully throughout history to aid in the identification of deceased people who cannot be visually identified. The first known incidence of this dates as far back as the 15th century when people known to the deceased recognised them by their teeth (Hill, IR 1984). While there are numerous documented cases of identification by dental comparison, it wasn't until the 1800s that the process was performed in a more formal manner with scientific papers describing its use and reporting on cases being produced (Taylor 2009; de Valck 2021). In 1869 M'Grath published a paper explaining the identification of two Ohio River disaster victims. This paper describes the AM condition of both victims in question, the state of the dentition of the deceased and then reconciles the two. Modern forensic odontology is said to have begun with the dental identification of victims of the Bazar de la Charite fire in Paris in 1897 where some of the victims were identified by their dentists (Amoëdo 1897; Taylor 2009; de Valck 2021). Amoëdo (1897) writes that the dentists were able to perform examinations and compare the dentition of the deceased to the detailed charts they possessed. In the same journal, in the same year, another paper by Thompson (1897) was published advocating for identification by dental comparison to be more widely considered. It also provided a classification system for recording dental ‘peculiarities’ and noted the need to make ‘reasonable allowance’ for features that can change. The process these papers describe, while less refined, is the basis for the process of dental identification used today. Namely the AM data collection, PM data collection and reconciliation of the two, with an expert deciding on the reconcilability of any discrepancies.

Australian Experiences

It is unknown when forensic odontology was first applied in Australia. However, in Melbourne, Victoria, some cases report using dental evidence in 1923 and 1924 (Taylor 2009; Kieser, J et al. 2016). In terms of DVI, an air crash in Botany Bay in 1961 was the first cited use of dental identification. This disaster led to the development of a disaster victim identification form for use by the police in New South Wales and likely influenced the current INTERPOL forms (Taylor 2009). Australian forensic odontologists have been involved in many multiple fatality incidents in the past six decades which has increased the importance and use of dental comparison. More recent examples where dental identification has played a major role include the 2002 Bali bombings, 2004 Boxing Day tsunami, 2009 Black Saturday Victorian bushfires and air crash MH17 in 2014. With the improvements seen in participating in the international efforts for identification in the Bali bombings and Thailand tsunami, Australian DVI practices are now regarded as representing international best practice (Taylor 2009).

Scientific Basis

To be used for identification, a biological feature must be resistant to damage, unchanging and recognisably unique (Forrest 2019; Xavier & Alves da Silva 2021). Teeth are the most durable tissue in the body and can survive longer after death than other body tissues due to their highly mineralised structure and protected position within the oral cavity (Thompson 1897; Pretty & Sweet 2001; Nuzzolese & Di Vella 2007; Madi, Swaid & Al-Amad 2013; Knott 2016; Middleton 2016; Loomis 2018), thus the dental state can survive for centuries after death (Sopher 1976; Xavier & Alves da Silva 2021).

As with all identification methods the more features available for comparison, the more individualising the pattern. Human dentition provides two categories of individualising characteristics that are used in identification (Knott 2016):

1) Biological features – anatomy and morphology of both hard and soft tissues
2) Dental treatment – irreversible interventions that remove or change the appearance of the teeth

It is generally accepted that identification by dental comparison relies on three underlying assumptions (Sopher 1976; Clement 1998; Forrest 2019; Xavier & Alves da Silva 2021):

1) The dentition and surrounding structures are stable through time
2) Teeth are resistant to decomposition and relatively extreme environmental conditions
3) When examined in detail every person has a dentition that is fundamentally and recognisably unique

Dentition Stability

Once teeth have formed, the outer mineral layer (enamel) is relatively stable, however, environmental factors contribute to irreversible damage and changes are dependent on diet, oral hygiene, and lifestyle (Clement 1998). Such factors include but are not limited to decay (dental caries), loss of alveolar bone attachment (periodontal disease), tooth wear (attrition, abrasion, and erosion), and trauma from accidents or habits (Vodanovic, Richter & Pavicin 2021). An individual's dentition represents personal characteristics and a history of dental treatment. Loss of natural tooth structure is not reversible; therefore, any changes and treatments assist in the identification process (Knott 2016). While changes during life are inevitable, the permanence of teeth comes into effect after death, as taphonomic changes in mineralised structures are very slow (Xavier & Alves da Silva 2021).

Dentition Survivability

Teeth are very resistant to the effects of decomposition that occur after death as they are the most mineralised tissues, and therefore hardest, in the human body (Knott 2016; Vincenti, Biancalana & Pires-de-Souza 2021). The dentition is resistant to many conditions that may occur PM, including prolonged immersion, decomposition, desiccation, extensive trauma, and direct heat (Clement 1998; Loomis 2018). Dental materials used to restore teeth in life are also resistant to these conditions (Sopher 1976; Vincenti, Biancalana & Pires-de-Souza 2021) and may persist even when the teeth themselves do not. While teeth themselves are resilient, their position within the oral cavity, the soft tissues of the cheek and tongue and the hard tissues of the jaw afford them extra protection, particularly in cases of incineration (Sopher 1976; Loomis 2018).

Dentition Uniqueness

'In the human dentition, the concept of uniqueness is described as the combination of morphological and positional information obtained from each tooth in respect of comparison to every other dentition' (Perez 2015).

Studies have set out to prove the uniqueness of the dentition with a focus on bitemark analysis as summarised by Franco et al. (2015), who concluded that the uniqueness of the human dentition has not been scientifically proven. Importantly, Page, Mark, Taylor and Blenkin (2011) assert that proving 'uniqueness' is neither possible nor a requirement in the forming of forensic conclusions. They suggest that conclusions are instead based on the relevant agreement between two data sets, the more closely they resemble each other, the 'more likely' one is the source of the other. Therefore, rather than searching for uniqueness, it is more appropriate to evaluate the diversity of dental patterns. Multiple studies examining the diversity of the whole dentition have been conducted worldwide including the United States of America (Adams 2003), India (Kumar, Ghosh & Logani 2014; Bhateja, Arora & Katote 2015; Metgud et al. 2016), Brazil (Biazevic et al. 2011; Deitos et al. 2015), Turkey (Yılancı, Akkaya & Göksülük 2017), Peru (Perez 2015), Spain (Martin-de-Las-Heras et al. 2010), and multi-nationally (Madi, Swaid & Al-Amad 2013). These studies conclude that dental characteristics, recorded in their simplest forms show a diversity that is useful for human identification, and additional characteristics would increase the number of theoretically possible combinations. Diversity was also shown to increase with dental intervention, a change to only one tooth drastically reduced the percentage of similar dental patterns. This diversity also increases when age and sex are taken into consideration. Biazevic et al. (2011) and Perez (2015) highlight the limitation of dental patterns, in that any database created from dental patterns would only be applicable to the population it was based on, as this is closely related to dental health status.

While these studies draw their conclusions from using written records and radiographs to record teeth in their simplest forms, there are many more features used to describe and compare teeth as outlined in Figure 1 (Sopher 1976; Clement 1998; Yılancı, Akkaya & Göksülük 2017; Xavier & Alves da Silva 2021).

Hereditary

Congenital

- Positioning of teeth within jaws and their relation to each other
  - Ectopic eruption
  - Crowding
  - Rotation
  - Root angulation
- Occlusal anatomy and crown morphology
- Pulp morphology
- Pulp stones
- Palatal rugae
- Agenesis
- Retained deciduous teeth
- Anomalies
  - Dental fusion
  - Micro or macrodontia
- Sinus pattern
- Bone trabeculae

Pathology

Trauma

- Dental caries
- Missing teeth
- Periodontal bone loss

Restorative Procedures
- Materials, construction and shape
  - Fillings
  - Crown and Bridgework
  - Root canal treatment
  - Implants
  - Dentures
- Retaining wires
- Plates and screws

Figure 1: Features Used for Comparison in Dental Identification

Permanence, survivability, and dental diversity contribute to the long-term use and success of identification by dental comparison. However, history and anecdotal evidence are insufficient to prove a technique as scientifically reliable and valid.

Dental Identification Process

Dental identification is achieved through the comparison of an unknown, PM, dataset to known, AM, data from an individual's dental records. Discrepancies between the two datasets are reconciled as to whether they can be explained scientifically or biologically, or unexplained, resulting in an identity exclusion (Pretty & Sweet 2001).

Arguably, AM information is the most important aspect of identification (Prajapati et al. 2018), and has often been described as the most demanding task of forensic odontologists, particularly in disaster situations (Griffiths, Parker & Middleton 1988; Nuzzolese & Di Vella 2007). Without this information, data comparison cannot be made, and with poor-quality data identification may be delayed, or worse, a false exclusion or identification may be made (Griffiths, Parker & Middleton 1988; Kieser, JA, Laing & Herbison 2006; Delattre 2007; Charangowda 2010; Dawidson 2011; Hill, AJ, Hewson & Lain 2011; Forrest 2019).

The objective of AM dental data transcription is to recreate a representation of the last known status of an individual's dentition and oral structures (Griffiths, Parker & Middleton 1988). This task is made more difficult with the vast number of different types of notations used worldwide (Fischman 1987; Griffiths, Parker & Middleton 1988) as well as individual dentists using their own form of shorthand or uncommon abbreviations. Antemortem dental data can be derived from any records that document the teeth or oral structures, including written notes and images produced by dentists and dental specialists, dental appliances (Fischman 1987; Nuzzolese & Di Vella 2007; Hill, AJ, Hewson & Lain 2011; Knott 2016; Forrest 2019), medical images showing the teeth, and personal photographs that are often found on social media.

Obtaining these records begins with identifying a deceased's dentist and requesting their dental records. While forensic odontologists can aid in this (Nuzzolese & Di Vella 2007), the process differs depending on the country and jurisdiction. Privacy policies can also interfere with the collection of dental records as the patient in question is not considered deceased before identification, but identification cannot take place without the records (Knott 2016). Some dental practices are hesitant to release records, particularly originals (Loomis et al. 2018). Once one set of records is obtained, the forensic odontologist can examine it for quality and quantity. More records may be identified (Hill, AJ, Hewson & Lain 2011) through referrals for imaging or to specialists. These new sources of records can be contacted directly, or through the correct legal channels, depending on the legislation of the area (Knott 2016). If records from multiple sources are delivered to the forensic odontologist, they must be thoroughly examined to determine whether they all represent the same person. Patient details, including names, date of birth, and correct labelling of images are essential elements of records, particularly as hard copies can be accidentally combined.

After determining that all records available are from the same individual, the forensic odontologist's task is to analyse and collate all dental data (Hill, AJ, Hewson & Lain 2011) into a standardised format (Fischman 1987; Nuzzolese & Di Vella 2007) and evaluate each piece of evidence for its probative value. This reconstruction is one of the most demanding aspects of dental identification (Griffiths, Parker & Middleton 1988; Nuzzolese & Di Vella 2007). It requires knowledge of dental treatment codes and dental materials, as well as the ability to read and interpret radiographs, determine overriding treatments completed more recently, distinguish which tooth is which, and problem solve conflicting records. It is not as simple as exchanging one code for another, experience and knowledge of disease processes are essential for deciphering AM dental records and this task should always be completed by a specialist in the field (Hill, AJ, Hewson & Lain 2011).

Postmortem dental data collection consists of an examination, photographs, and radiographs (including computed tomography) of a deceased's dentition (Rosário Junior et al. 2012). Missing teeth, treatment, and unusual morphology and anatomy are all recorded on a PM dental form. The dental forms and nomenclature used should be standardised across both AM and PM record creation. To extract meaningful PM data an odontologist must be able to detect dental interventions and individualising features. It is also essential to be able to classify individual teeth based on their morphology, particularly in cases of incineration or fragmentation where teeth may no longer be in situ.

In the reconciliation phase, all PM information is compared to the AM information. The use of standardised codes allows for automated computer searching to help narrow down potential matches between datasets. Codes recorded on the standardised forms and any images available are compared. Each tooth, and associated dental structures, are carefully examined and any discrepancies are noted. These discrepancies must then be carefully considered (Whittaker & MacDonald 1989). 'Judgement is required by odontologists to determine the significance of these differences and their bearing on the reconciliation process' (Hill, AJ, Hewson & Lain 2011). To be reconciled differences must be explained logically and adhere to biological laws, for example, a tooth that has been extracted in the AM records, cannot have grown back, therefore that tooth should not be present in the PM records. Discrepancies can be due to; errors in recording by either the creator of the dental record or during transcription, other dental treatment not recorded in the available data, the continuation of dental disease, a lack of detail in available data, PM damage, or a combination of these factors. When irreconcilable differences exist then identity must be excluded. If all discrepancies are reconciled, the information is then examined for concordant individualising features. Antemortem and PM images are evaluated with the size and shape of dental interventions as well as tooth morphology compared or superimposed to show similarities. Once all data has been compared a conclusion is reached based on the weight of the available evidence.

Table 1 displays the different dental identification conclusions and their definitions from the Australian Society of Forensic Odontology (AuSFO) (AuSFO 2012), the American Board of Forensic Odontology (ABFO) (ABFO 2017), The International Organization for Forensic Odonto-Stomatology (IOFOS) (IOFOS 2017), and INTERPOL (INTERPOL 2018b).

While identification conclusions and input forms differ across the world, their aims are the same. Standardisation across AM and PM forms, while required for computer search algorithms, also allows for time-efficient and more accurate human evaluation, comparison, and reconciliation of information. It is evident immediately as to whether a discrepancy between teeth exists and removes the need for another level of code or shorthand interpretation.

Table 1: Forensic Odontology Identification Conclusions

AuSFO	**Identification Established**	**Identification Probable**	**Identification Possible**	**Identity Excluded**	**Insufficient Evidence**
	There is absolute certainty the PM and AM data are from the same person	Specific characteristics correspond between PM and AM data but PM, AM, or both are limited.	There is nothing that excludes the identity but PM or AM data--or both--are minimal.	PM and AM records are from different persons.	Insufficient data exists to allow comparison.
ABFO	**Positive Identification**		**Possible Identification**	**Exclusion**	**Insufficient Evidence**
	The AM and PM data match in sufficient detail to establish that they are from the same individual. In addition, there are no irreconcilable discrepancies.		The AM and PM data have consistent features, but, due to the quality of either the PM remains or the AM evidence, it is not possible to positively establish dental identification.	The AM and PM data are clearly inconsistent. However, it should be understood that identification by exclusion is a valid technique in certain circumstances.	The available information is insufficient to form the basis for a conclusion.
IOFOS	**Identity Established**	**Identity Probable**	**Identity Possible**	**Identity Excluded**	
	There is enough PM and AM dental comparison information with several specific characteristics that are identical. Any discrepancies are compatible with time difference between the AM dental records and the PM dental investigation. Nothing refutes identity.	There is limited PM and AM dental comparison information with at least one specific characteristic that is identical between AM and PM. Any discrepancies are compatible with time difference between the AM dental records and the PM dental investigation. Nothing refutes identity.	There is limited PM and AM dental comparison information with no specific characteristic that is identical between AM and PM. Any discrepancies are compatible with time difference between the AM dental records and the PM dental investigation. Nothing refutes identity. In this case identity cannot be excluded.	At least one special characteristic refutes identity.	
INTERPOL	**Identification**	**Identification Probable**	**Identification Possible**	**Identity Excluded**	**Insufficient Evidence**
	Absolute certainty the PM and AM records are from the same person.	Specific characteristics correspond between PM and AM but either PM or AM data or both are minimal.	There is nothing that excludes the identity but either PM or AM data or both are minimal.	PM and AM records are from different persons.	Neither PM nor AM comparison can be made.

Dental Identification Computer Software

Programs have been developed to aid the forensic odontologist in matching AM and PM dental information to expediate identification for both single cases and multiple casualty events. The output of any program depends on the quality of information entered and can lead to successful outcomes promptly when good quality data are available. When matching AM and PM profiles, the computer will rank possible matches that are then manually compared by a forensic odontologist (Loomis et al. 2018; Forrest 2019). While the computer can quickly select possible matches, manual reconciliation is still required to form an opinion (Al-Amad et al. 2007). Odontology is not alone in this, AFIS – Automated Fingerprint Identification System also requires a fingerprint examiner to verify the result and make their conclusion (Australian Police 2012). ‘Qualitative judgement will always be at the centre of forensic science evidence evaluation’ (Evett et al. 2017).

Forensic Science Validation Questioned

The importance of documenting the fundamental scientific method in forensic science has been highlighted over the last decade with two reports from the United States of America (USA) in particular, examining the validity of forensic science pattern matching or ‘feature-comparison’ methods. The President’s Council of Advisors on Science and Technology (PCAST) report ‘Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods’ (President's Council of Advisors on Science and Technology 2016) and the National Academy of Sciences (NAS) advisory report ‘Strengthening Forensic Science in the United States: A Path Forward’ (National Research Council 2009). Both question the processes and future of forensic science disciplines such as DNA, fingerprints, forensic odontology, tool marks, firearms, and hair analysis. All areas that employ these methods are under pressure to demonstrate through empirical validation studies that they are scientifically based (President's Council of Advisors on Science and Technology 2016). While published for the USA forensic science community and relevant funding bodies, the conclusions reached have had a global impact, with responses to the report published from authors in the United Kingdom (UK), Europe, Australia, New Zealand, Canada and the USA (Evett et al. 2017; Morrison et al. 2017; ANZFSS Council 2018). While forensic odontology was mentioned in these reports in terms of controversies in bitemark analysis and comparison, dental identification of unidentified human remains was not discussed. As a feature comparison method and the case type most often undertaken, it is necessary to address the concerns raised in relation to dental identification techniques and processes. In conjunction, it is also important to consider the aspects of the responses to PCAST that apply to forensic dental identification. Through this evaluation, steps can be made to undertake the important task of establishing this methodology as valid and reliable. This is a difficult task considering both objective and subjective methods are employed and subconsciously intertwined throughout the process.

In my opinion, to achieve this aim, it is prudent to take a step back and evaluate the components of the dental identification process and determine the most appropriate way to conduct validation studies. This will also allow the profession to review past studies and determine their value in the context of validation. Scientific approach and quality assurance have become prominent issues (de Valck 2021) in the forensic sciences. However, while traditional scientific identification techniques are supported by anecdotal evidence rather than formal validation studies, this does not imply that they are unreliable (Budowle et al. 2009).

Validation of Dental Identification

When determining the next steps in the context of dental identification it is important to consider the concerns raised in and as a result of the PCAST and NAS reports, as well as the replies to PCAST. The PCAST report defines validity and types of empirical studies, however, they are focused on validating the tests used in analysis and do not consider the importance of judgement (Evett et al. 2017). Some areas and processes of dental identification are a statement of opinion that cannot be automated, they rely on expert judgement, knowledge, and reasoning. While a computer may be able to find matches and distinguish non-matches in some forms of data, it cannot currently readily apply knowledge and experience to reconcile potential discrepancies.

Differences between datasets are inevitable due to the quality of records, data collection methodology, and changes in the dentition due to time, disease, and intervention. This is not unique to dentistry, other disciplines, such as fingerprint analysis, also come across discrepancies due to surface composition, distortion, background, and processing (Ulery et al. 2012; Ulery et al. 2013). Additionally, Evett et al. (2017) note that while the issue of bias surrounding too much knowledge of an incident is very real, for some forensic techniques relevant additional knowledge is vital. For example, in forensic odontology, whether a radiograph was taken a month ago or ten years ago is important to the decision-making process. Hence it is important to distinguish between task and non-task relevant contextual information.

Both PCAST and NAS also discuss the need to evaluate and report error rates and accuracy. The National Research Council (2009) defines error rate as the proportion of cases in which analysis leads to a false conclusion. Both reports discuss this in the context of a binary outcome: is it a match or a non-match. Dental identification, however, is not binary but has a series of potential conclusions (INTERPOL use: 'Established', 'Probable', 'Possible', 'Insufficient Information', and 'Excluded') that do not lend themselves to an 'is it right or wrong' analysis. The definitive terms on either end of the scale, for example, 'Excluded' and 'Established' can be compared for accuracy against the known ground truth. This however cannot be said for the intermediate terms, for example, 'Possible' which can never objectively be shown to be either correct or incorrect.

It is agreed that validation studies must be performed to establish the validity of a method or process (National Research Council 2009) and dental identification is no exception. However, due to the feature-comparison and examiner judgement aspects of this technique, it may not be as simple as following the PCAST recipe. Hahn, Mourges and Simpson (2018) state that forensic odontology identification cannot be tested by performing the same experiments over and over for a ground truth, like DNA, but is an observational science where skill and judgement of the expert inform the conclusion. Dental identification is not alone in this, fingerprint analysis is another example of 'experience and judgment-based analytical process' (Melissa et al. 2012).

Validation and Standardisation

Extensive research has been conducted in all areas of forensic odontology and dental identification is no exception. However, in searching the literature, no published studies addressing the validation of the entire dental identification process could be found. Studies that do exist focus on the validation of specific techniques used in reconciliation, including the comparison of radiographs (Borrman & Grondahl 1990, 1992; Ekstrom, Johnsson & Borrman 1993; MacLean, Kogon & Stitt 1994; Kogon, McKay & MacLean 1995; Korkchi et al. 1995; Kogon 1996; Kogon & MacLean 1996; Sholl & Moody 2001; Pretty et al. 2003; Soomer et al. 2003; Fridell & Ahlqvist 2006; Richmond & Pretty 2010; Wenzel, Richards &

Heidmann 2010; Pinchi et al. 2012; Balla & Forgie 2017; Page, M. et al. 2018; Chiam et al. 2019), cone-beam computed tomography and virtual autopsy (Murphy et al. 2012; Rosário Junior et al. 2012; Franco et al. 2013; Trochesset, Serchuk & Colosi 2014; Ruder et al. 2016; Jensen et al. 2019), palatal rugae (Shukla et al. 2011; De Angelis et al. 2012; Shamim 2013; Adisa, Kolude & Ogunrinde 2014), and video superimposition (Austin-Smith & Maples 1994). Research on other aspects of the process have been published (Phillips & Stuhlinger 2009a, 2009b; Miranda et al. 2016); however, they are not true validation studies. The process of radiographic comparison has received the most attention, however, studies examining this process do not reflect real casework scenarios. They present radiographs as isolated data and offer a simple binary (match/non-match) option for the conclusion. Whereas, in casework, there are usually multiple types of data to aid in the comparison and there are a series of conclusions that cover a range of 'certainty' of the identification. Of the studies evaluating radiographs, only four allowed participants a non-binary option (Pretty et al. 2003; Richmond & Pretty 2010; Wenzel, Richards & Heidmann 2010; Page, M. et al. 2018; Chiam et al. 2019).

Postmortem studies focus on methods for detecting and increasing available data (Benthaus, DuChesne & Brinkmann 1998; Pretty et al. 2002; Bush et al. 2007; Berketa et al. 2010; Berketa 2014), replicating the position and angulation of AM radiographs (Goldstein, Sweet & Wood 1998; Newcomb et al. 2017) and environmental effects on dental materials (Bush, Bush & Miller 2006; Bush et al. 2007; Bagdey et al. 2014; Biancalana et al. 2017; Vincenti, Biancalana & Pires-de-Souza 2021). While raising interesting points, further investigation is required as these are generally not true validation studies.

Research regarding the AM phase has mostly been focused on the completeness and accuracy of dental records, adherence to record guidelines and dentist's awareness of forensic odontology (Fischman 1987; Hill, IR 1988; Borrman et al. 1995; Delattre & Stimson 1999; Kieser, JA, Laing & Herbison 2006; Forrest 2012; Stow, James & Richards 2016; Brown & Jephcote 2017; Stow & Higgins 2019) with a few studies evaluating the accuracy and effectiveness of AM records available in mass disaster situations (Kieser, JA, Laing & Herbison 2006; Petju et al. 2007). Very little has been concerned with the process undertaken by the forensic odontologist once dental records have been received. No studies could be found assessing the accuracy and variation in AM dental data evaluation, analysis, and collation.

Guidelines from professional organisations such as INTERPOL and IOFOS also exist providing a step-by-step process for the three phases. However, they do not specifically address details within each step and do not comment on decision-making processes or the evidentiary value of data. This is left to the opinion of the odontologist. During the development of the IOFOS guidelines, it became clear that on an international level, forensic odontologists were not going to agree on exact procedures, which is why these guidelines do not detail how to perform each procedure (Solheim 2021).

Most research into dental identification, is focused on two of the three phases: Postmortem – maximising and improving data collection, and Reconciliation – validating or improving methods of comparison, in particular image evaluation. The lack of research into the AM phase is an obvious gap in the literature, which lead to the direction of my research.

Arguably, the AM phase is the most important phase of dental identification, as, without reliable data of known individuals, there cannot be a comparison to the unknown deceased (Borrman et al. 1995; Delattre & Stimson 1999; Kieser, JA, Laing & Herbison 2006). This is supported by a recent, as yet unpublished, study by Maley and Higgins (2022) which demonstrates that the quality of AM data directly impacts the level of confidence that a practitioner has in forming an opinion. The need for reliable AM data is highlighted in disaster situations when it is necessary to compare multiple AM data sets to multiple PM data sets via a computerised search. Errors in the AM transcription may result in the computer program finding exclusionary data and not placing the correct match high in the list of possibilities. This in turn leads to prolonging the identification process and potentially the need to rely on additional identification methods.

Determining Antemortem Error

In my experience, there is variation between practitioners when transcribing dental data in routine casework. Figure 2 displays the AM process and areas of potential error and variation.

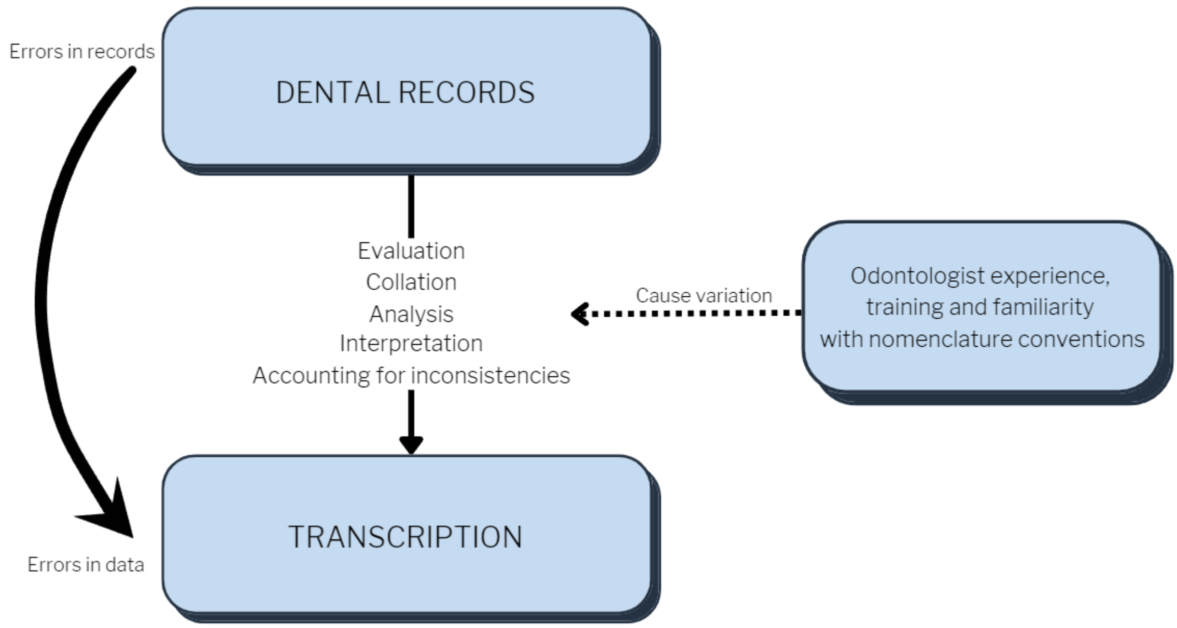

Figure 2: The Antemortem Process and Areas of Potential Error and Variation

Forensic odontologists evaluate the quality of dental records while they are working through the AM process. However, this evaluation or giving the records a 'score' is not part of the standard operating procedure. In the science of fingerprint comparison, before the analysis stage, the latent print is given a value determination based on the quality of features, the number of features and the specificity of features and their relationships (Ulery et al. 2013). Value determination is made by examiners based on knowledge and experience and is, therefore, a subjective determination, rather than an objective one, based on quantitative standards.

Consideration should be given to the quality and value of AM records used in a comparison. Although it does not change the information available or whether the record will be used, it provides the examiner performing reconciliation with an idea of the likely causes of variation between the two data sets. When two or more dental clinics or data sources contribute to a dental record, collation is required. It is essential to determine if all images are in the correct orientation and that all records provided are indeed of the same person. The odontologist analyses and interprets the records while transcribing from each data source onto the standardised form using standardised codes. An odontologist can determine errors in the dental record at this point and reflect this in the final collation.

Odontology Error/Variation Research

Although AM data transcription has not been researched, studies have shown variation between participants when transcribing PM data (Leow & Higgins 2020) while others have measured the accuracy of PM recording (Rasmusson & Borrman 1992; Sand, Rasmusson & Borrman 1994; Murphy et al. 2012) including the use of CT compared to traditional PM examination (Kirchhoff et al. 2008; Jensen et al. 2020). Other error related research includes studies that test the accuracy of dental identification on radiographic comparison alone measuring the accuracy of conclusion rather than the accuracy or discrepancies of recording the features present (Borrman & Grondahl 1990, 1992; Ekstrom, Johnsson & Borrman 1993; MacLean, Kogon & Stitt 1994; Kogon, McKay & MacLean 1995; Korkchi et al. 1995; Kogon & MacLean 1996; Wood, Kirk & Sweet 1999; Sholl & Moody 2001; Pretty et al. 2003; Soomer et al. 2003; Fridell & Ahlqvist 2006; Richmond & Pretty 2010; Wenzel, Richards & Heidmann 2010; Gorza & Mânica 2018; Page, M. et al. 2018; Lundberg et al. 2019).

Kirchhoff et al. (2008) discuss the types of discrepancies and where they occurred between practitioners rather than how accurate they were compared to a gold standard, while Leow and Higgins (2020) discuss the kinds of errors made but do not detail the inter-examiner variation. Murphy et al. (2012) describe what was classed as true and false positives and negatives when compared to a gold standard, however, do not detail the specific errors made or how often. A limitation of all these studies is the small sample size.

Types of transcription variation noted in these studies and sample size are presented in Table 2. With the exception of incorrect recording of teeth missing AM or PM and the transcription variations noted in PM data transcription, studies can be extrapolated to AM transcription. These studies suggest that missing or missed restorations, restoration surfaces and incorrect naming of teeth within a class are the most common errors. In my own casework experience these are also the most common errors in AM transcription.

Table 2: Transcription Errors Discussed in the Literature

Variation in:	Rasmusson and Borrman (1992) N=12	Sand, Rasmusson and Borrman (1994) N=16	Kirchhoff et al. (2008) N=3	Murphy et al. (2012) N=2	Leow and Higgins (2020) N=19	Jensen et al. (2020) N=2
Naming teeth within a class or quadrant (transposition)	✓	✓			✓	✓
Restorative materials recorded					✓	✓
Missing or mis-recording of restorations	✓	✓	✓	✓	✓	✓
Surfaces involved in restorations	✓	✓	✓	✓	✓	✓
Treatment type (e.g.: restoration or crown, crown or pontic etc)			✓	✓	✓	✓
Missed tooth/root fragments				✓		
Missed or mis-diagnosed caries	✓			✓		
AM or PM tooth loss	✓	✓	✓			

Budowle et al. (2009) suggest that evaluating the error, rather than just reporting it, is more meaningful. What was the error, why did it happen, how did/could it affect the outcome, and what is being done to reduce it in the future? In addition to making mistakes, dentists will, in general, have their own version of diagnostic criteria and ways of recording features and treatments (Do et al. 2020). The primary purpose of record creation, for the dentist, is to provide care for the patient, not identification. Different operating procedures and non-standardised terminology are issues when using this data for forensic purposes (Wright et al. 2015). Standardisation of both terminology and procedure should be the ultimate goal for forensic odontology.

While not conducted for forensic purposes, research has been published on the accuracy and types of errors found in dental records. These errors can affect the accuracy of the AM transcription. Figure 3 displays the potential cause of errors in the dental clinic, AM transcription process, and those that are common to both.

The most frequently reported errors were an incomplete dental chart including previous existing treatment that has since been replaced or removed (Hill, IR 1988; Whittaker & MacDonald 1989; Borrman et al. 1995; Petju et al. 2007; Waleed et al. 2015; Stow, James & Richards 2016; Brown & Jephcote 2017) and recording the wrong tooth number (Hill, IR 1988; Whittaker & MacDonald 1989; Borrman et al. 1995; Zahrani 2005; Manica 2014; Brown & Jephcote 2017). Transposition, incorrect tooth of the same class, and inversion, for example, left as right, upper as lower, mesial as distal, are frequent errors when labelling teeth or restoration surfaces. Transposition most commonly occurs in the molar and premolar teeth (Hill, IR 1988). Another challenge is interpreting illegible, and ambiguous treatment records with numerous non-standard abbreviations (Manica 2014).

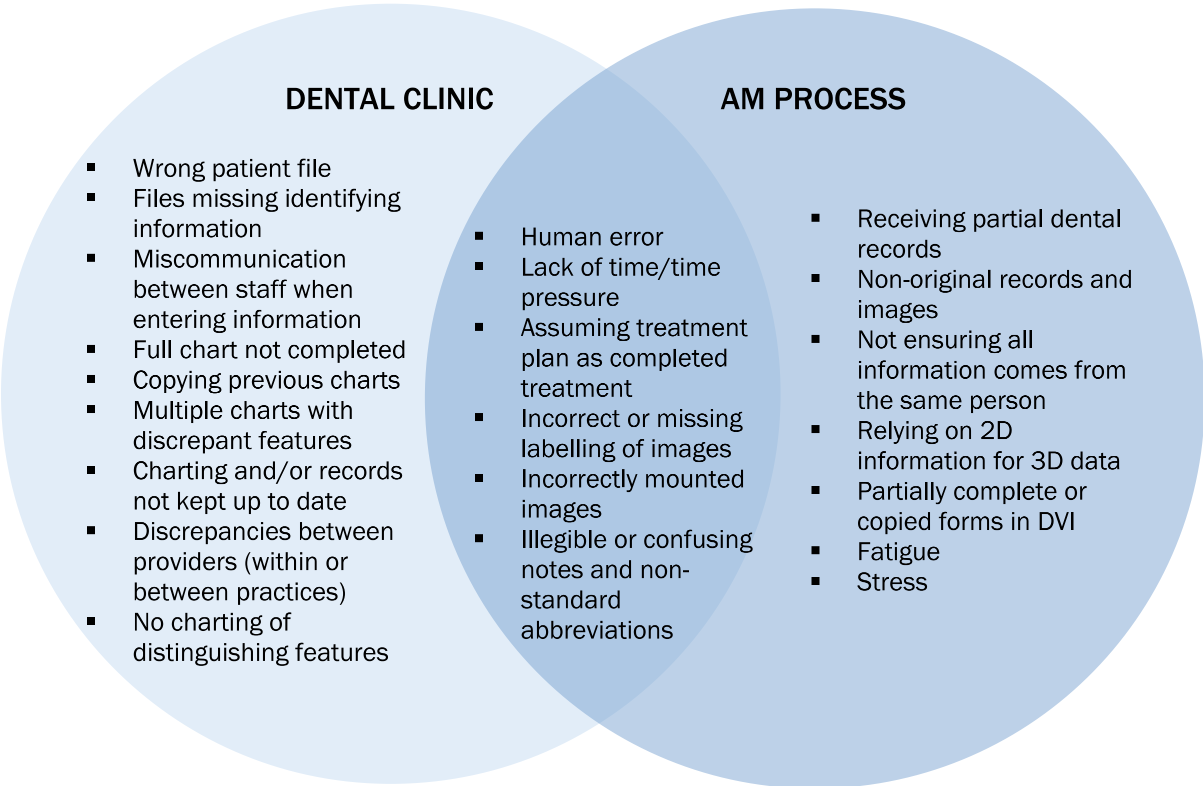

Figure 3: Potential Causes of Error in the Dental Clinic and During the Antemortem Process

Potential causes of error in the creation and use of dental records in the dental clinic and when records are used for in dental identification, including causes that are common to both[1].

Similar errors can occur during the transcription of dental data. However, even with the most accurate AM transcription, errors in the dental records will translate to inaccuracies in the transcription, Table 3 displays potential erroneous information transferred to the AM odontogram due to the dental record errors described in Figure 3.

[1] Figure 3 references: (Griffiths, Parker & Middleton 1988; Hill, IR 1988; Whittaker & MacDonald 1989; Alexander 1991; Prinz 1993; Borrman et al. 1995; Brannon & Kessler 1999; Zahrani 2005; Petju et al. 2007; INTERPOL Tsunami Evaluation Working Group 2010; Manica 2014; Waleed et al. 2015; Wright et al. 2015; Stow, James & Richards 2016; Trengrove 2016; Brown & Jephcote 2017)

Table 3: Errors Made in, and Transferred to Antemortem Transcription[2]

Incorrect number of missing teeth recorded
Incorrect teeth recorded (transposition, inversion)
Treatment charted but not present
Treatment present but not charted
Incorrect recording of restorations (simple and complex, including root canal treatment)
Incorrect or missing restoration material
Incorrect or missing surfaces
Inaccurate or missing information on bridges or prostheses
Treatment carried out and not recorded
Treatment recorded on a previously extracted tooth
Coding simple procedures as more complex

It is possible to detect some of these errors while interpreting the AM information. Where multiple different record types exist, it may be possible to identify where an error has occurred and record the correct code on the correct tooth on the transcription form. For example, when there is charting for both a 17 and a 16 but it is obvious from a radiograph that these are one and the same tooth or where a restoration has been charted on the left but radiographic evidence puts it on the right.

Unfortunately, not all errors are identifiable and when records are incomplete or no images exist, the forensic odontologist only has the written records or an incomplete chart to rely on. These errors may then have an impact on the reconciliation of identification when compared to the PM data.

While studies have found that in most cases a lack of dental record quality and quantity does not preclude an identification outcome, it does prolong the identification process as more time is required to decipher the records and a greater number of issues need to be

[2] Table 3 references: (Hill, IR 1988; Alexander 1991; Prinz 1993; Borrman et al. 1995; Petju et al. 2007; Manica 2014; Stow, James & Richards 2016; Brown & Jephcote 2017)

reconciled before a conclusion is reached (Hill, IR 1988; Prinz 1993; Brannon & Kessler 1999; Delattre & Stimson 1999; Brown & Jephcote 2017; Stow & Higgins 2019). This may also reduce the confidence that the odontologist has in the outcome leading to the choice of less decisive identity categories (Chiam et al. 2021). In the worst-case scenario, the forensic odontologist must advise that there is insufficient AM evidence to perform a dental comparison (Brown & Jephcote 2017; Stow & Higgins 2019). In a mass disaster situation, where there is reliance on a computer system to find matches, inaccurate, or minimal AM data can greatly reduce the efficiency of automated searches.

While forensic odontologists cannot always detect errors made at the level of the dental clinic, standardised guidelines can ensure the least amount of error possible during the AM transcription phase. It is important that any code selection guidelines followed during the AM transcription should also be followed during the PM data transcription to reduce discrepancies in the reconciliation phase.

Error is inevitable. This should not, however, discourage efforts to minimise it. This can be achieved by limiting the number of human choices and when they are necessary, having specific guidelines on how to approach the choices. According to Feng et al. (2020) computerised records result in far fewer errors than handwritten notes. Budowle et al. (2009) place a strong emphasis on quality assurance through peer review, adherence to documented protocols and minimising the risk for error as well as methods for detecting errors.

The World Health Organization states that there are two main reasons for variation in charting (World Health Organization 2013):

1) Inconsistency in scoring levels of disease
2) Physical or psychological factors related to the examiner (fatigue, visual acuity etc)

Therefore, standardisation is required to create uniform interpretation, understanding, and application by all examiners. This requires distinct definitions that leave no room for interpretation in coding convention and guidelines to aid the examiner if ambiguity arises. As reliance on technology increases standardisation will most likely be found in computer programs made specifically for the forensic odontologist and the types of data, information and display required. Several studies have commented on the usefulness of software in cases of mass disaster, the need for pre-determined terminology with a glossary, and the effectiveness of limiting code possibilities to reduce ambiguity and maintain discrimination (Torpet 2005; Clement et al. 2006; INTERPOL Tsunami Evaluation Working Group 2010; James et al. 2016).

Conclusion

The basic techniques used in dental identification have been employed for centuries and are accepted and considered reliable by forensic science and the law. As dental comparison is one of three primary scientific methods used in disaster victim identification, the methods employed in the process must be scientifically valid. In the context of forensic science, The President's Council of Advisors on Science and Technology (2016) advocates two levels of validity, foundational validity (repeatable, reproducible, and accurate) and validity as applied (practically applied).

Dental identification consists of multiple phases, utilising variable techniques, all of which must demonstrate validity for the overall process to be deemed scientifically valid.
While PCAST has been widely read and is accepted within USA courts, not all forensic science practitioners agree that these standards apply to all forensic processes (Evett et al. 2017; Morrison et al. 2017). The PCAST report focuses on the binary conclusion “match or non-match” allowing for the calculation of false positive and false negative rates.

However, as highlighted by responses to PCAST, these rates cannot be derived for feature comparison methods such as dental identification, which have within-source variability and use a categorical scale to form a conclusion, rather than a binary approach (Evett et al. 2017; Morrison et al. 2017). Due to the categorical nature of the conclusion scales adopted, that is, the opinion of the likelihood of identity (IOFOS 2018) and the subjective nature of the process even if two examiners follow the same steps, they may still not reach the same conclusion. This does not necessarily imply that one is incorrect. If, for example, the opinion reached is 'possible identification', whether the outcome of the identification process discovered by the coroner is a match or not, the odontology opinion is not necessarily incorrect. Finding a mechanism to assess the overall reliability, accuracy and error rates of dental identification will be difficult because the process involves multiple types of data of varying quality and a non-binary conclusion that is dependent on opinion. This is reflected in fingerprint evaluation, where experienced based determinations are made at two levels. First examiners must determine the value of fingerprints for analysis. Ulery et al. (2013) concluded that value determination is a continuum rather than a binary 'value' or 'no-value'. The second is the conclusion made when comparing two prints. Three options are available, identification, exclusion and inconclusive (Daluz 2018). What we can take from reports such as PCAST and NAS is the need for objectivity, standardisation and reproducibility of techniques employed in identification by dental comparison.

I elaborate further on this thought in a commentary article that I published during my candidature, which can be found in Appendix 1:

Sims, CA, Berketa, J & Higgins, D 2020, 'Is human identification by dental comparison a scientifically valid process?', *Science & Justice*, vol. 60, no. 5, pp. 403-405

General guidelines are available to forensic odontologists for each phase of a dental identification. However, a specific step by step procedure has not been agreed upon, indicating that while the overall process is similar across the world, variation does exist. To improve standardisation of the process it is important to understand where this variation occurs and whether the validity of the scientific method is affected. An investigation into practices of forensic odontologists with a specific focus on dental identification can shed some light on this issue.

Errors arise at various stages of the creation of a dental record and AM transcription. While some aspects are out of the control of the forensic odontologist, it is imperative that when AM transcription occurs, guidelines and procedures are followed to ensure standardised and consistent recording. To reduce the errors made in AM transcription, standardised terminology, specific guidelines, and computer software is ideal.

Research Purpose

The purpose of this research began with assessing the current validation of dental identification and the creation of studies to improve upon this validation. However, as more information was gathered, surveys conducted, and gaps in the literature uncovered, it transformed to focus specifically on variation in AM dental data transcription and improving the standardisation and objectivity of the process.

Research Aims

1) Assess Australian forensic odontologist's current identification practices and opinions on American reports (PCAST and NAS) on pattern matching techniques and how they think it affects forensic odontology in Australia
2) Evaluate the contents of dental records from a forensic identification perspective, assessing the information available, complexity and the potential effect on AM transcription
3) Assess the AM phase transcription of dental information for accuracy and variation
4) Produce a standard operating procedure and a computer aided method to improve AM data transcription reliability. This will also increase the objectivity of the process, improving calibration between examiners, and will allow proficiency testing, thus enhancing the scientific basis of the AM dental identification procedure

Significance

Recently many sources in the forensic sciences, and more specifically the discipline of forensic odontology, have highlighted the need for research in many areas. Bitemarks were identified as 'the area in most need of modern research' in the ABFO manual of forensic odontology 5th ED (Bush & Delattre 2013). The area ranked second was identification, specifically the 'degree of certainty of identification in test cases.' According to the National Research Council (2009) report the technique used for dental identification is well established but makes no reference to the literature. The President's Council of Advisors on Science and Technology (2016) report states that studies must show a technique to be accurate (with error rates), reproducible, and consistent for each step. Furthermore, there are few population studies reporting the percentage of the population that exhibit particular dental characteristics, both developmental and through dental treatment, making it impossible to estimate an error rate or percentage estimate of individuality (such as exists for DNA). It is important that forensic odontology has valid scientific methods and therefore validity studies to support their work. It is essential to know which processes are currently validated and where improvements need to be made.

This research will contribute to the forensic odontology discipline in the following ways:

- Overview of how dental identification is conducted in Australia
    - Increased understanding in the forensic odontology community of how identification is performed across the country
- Provide an insight into the variation in AM transcription
- Create and test a standard operating procedure and computer-aided method to improve consistency in the evaluation and transcription of AM dental records

Research Questions

1) Is the dental identification workflow process uniform across Australia?
2) Does the Australian forensic odontology community consider the USA reports relevant to the process of identification by dental comparison?
3) How do the content and complexity of dental records vary?
4) What are the sources of error and variation in the AM transcription process?
5) Can a standard operating procedure and a computer-assisted method improve the accuracy and consistency of the final transcribed AM dental data?

Scope of Thesis

Chapter Two is presented as a published manuscript exploring the uniformity of dental identification practice across Australia.

Chapter Three explores the content and complexity of AM dental records and how they vary between cases.

Chapter Four details a pilot study, investigating the influence of dental record content and complexity on data transcription accuracy and uniformity.

Chapter Five further explores variation in AM data transcription focusing on inter-operator differences.

Chapter Six discusses automation and standardisation and ways it might be implemented in the AM phase.

Chapter Seven describes the creation of a computer-assisted transcription process using the knowledge of variation discovered in Chapters Four and Five and the approach outlined in Chapter Six.

Chapter Eight tests the computer-assisted method 'Antemortem Dental Data Entry' including an alpha test, amendments, and beta test.

Chapter Nine discusses the research findings, concludes the research, and highlights future direction.

The appendices include additional work relevant to the thesis including:

I) Commentary paper publication:

Sims, CA, Berketa, J & Higgins, D 2020, 'Is human identification by dental comparison a scientifically valid process?', *Science & Justice*, vol. 60, no. 5, pp. 403-405

II) Ethics approval

III) Learning module created for 5th-year dental students in conjunction with transcription task

IV) Constructed dental records for international variation transcription task

V) REDCap® codebook

VI) REDCap® /'Shazam' HTML and CSS coding

VII) 'Antemortem Dental Data Entry (ADDE) Guidelines' instruction manual

VIII) Presentations and awards

CHAPTER 2: DENTAL IDENTIFICATION PRACTICES ACROSS AUSTRALIA

Before creating a computer-assisted method of antemortem transcription and associated protocol, it is imperative to understand the process of data collation and interpretation, to determine where errors and variations may arise and to understand the needs of the profession. This chapter presents a published manuscript reporting on a survey of Australian forensic odontologists with the aim of ascertaining if dental identification is practised uniformly across Australia and if the profession considers the reports from the USA relevant.

Statement of Authorship

Title of Paper	Dental Identification practices across Australia
Publication Status	☑ Published ☐ Accepted for Publication ☑ Submitted for Publication ☑ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Storer, C.A., Berketa, J. and Higgins, D., 2021. Dental identification practices across Australia. *Australian Journal of Forensic Sciences*, pp.1-14.

Principal Author

Name of Principal Author (Candidate)	Catherine Storer		
Contribution to the Paper	Designed survey, evaluated analysed and interpreted data, wrote manuscript, and acted as corresponding author.		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	24/08/2022

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	John Berketa		
Contribution to the Paper	Helped to evaluate and edit the manuscript.		
Signature		Date	29/08/2022

Name of Co-Author	Denice Higgins		
Contribution to the Paper	Supervised data collection, helped with analysis, evaluated and edited the manuscript.		
Signature		Date	29/08/2022

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Dental identification practices across Australia

Catherine A. Storer, John Berketa and Denice Higgins

Forensic Odontology Unit, University of Adelaide, Adelaide, Australia

ABSTRACT

Dental comparison has been a trusted primary method of human identification for centuries, with its processes evolving with advances in knowledge and technology. However, the scientific validity of the processes has never been rigorously tested. Recent publications have examined the validity of various forensic science opinion disciplines which have highlighted the need for the profession to conduct robust scientific studies of the methods of dental identification. This study explores variation in the processes employed throughout the entire workflow of dental identification, and the opinions of Australian practitioners regarding the current application of and need for validation. Current practitioners and those undergoing postgraduate training in forensic odontology were asked to complete a survey of 26 questions. Twenty-four participants with varying levels of experience and current involvement in dental identification completed the survey. Results show variation in radiographic technology used as well as differing reliance on various comparison techniques. Opinions on reporting statistics and the use of a dental pattern database provide interesting insight into potential applications in the validation of dental identification.

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KEYWORDS
Forensic odontology; feature comparison; dental identification; human identification; validation

Introduction

The two major reports – National Academy of Science (NAS)[1] and The President's Council of Advisors on Science and Technology (PCAST)[2] – evaluating the validity of forensic feature comparison methods do not specifically mention identification by dental comparison. However, dental identification is a feature comparison method as defined by the PCAST report[2]. During the dental identification process, data collected from antemortem records and postmortem remains are compared to determine if they originate from the same source. As dental comparison is one of three primary scientific methods used in disaster victim identification, it is essential that the methods employed in the process are scientifically valid. Validation and reliability of techniques is required for the practice to be legally acceptable. Although dental identification has been used for centuries[3] and is considered reliable by forensic science and the law[1,4,5], long term application and anecdotal evidence of reliability is not sufficient to scientifically validate a technique. Had current admissibility standards been present when dental identification was first introduced, rigorous research would have been required for the method to be accepted[6].

CONTACT Catherine A. Storer catherine.storer@adelaide.edu.au

Dental identification is made up of multiple phases, utilizing variable techniques, all of which must demonstrate validity for the overall process to be deemed scientifically valid. In the context of forensic science, PCAST advocates two levels of validity:

(1) Foundational validity – the method must be repeatable (the same result by the same examiner), reproducible (the same result by a different examiner), and accurate (false negative and false positive rates known).
(2) Validity as applied – the practical use of the valid method must be demonstrated by practitioners[2,7].

While PCAST has been widely read and is accepted within United States courts of law, not all forensic science practitioners agree with the applicability of these standards to all forensic processes[8,9].

The PCAST report focuses on the binary conclusions 'match or non-match', which allow measurement of false positive and false negative rates. However, as highlighted by responses to PCAST, these rates cannot be derived for feature comparison methods such as dental identification, as these have within-source variability and use a categorical scale to form a conclusion, rather than a match/no match approach[8,9]. In dental identification the information available for comparison varies from case to case in both quality and quantity complicating validation of data interpretation techniques. With regards to antemortem information this variation is largely due to variable standards of record creation and storage between dental practitioners and varying levels of dental attendance by patients. While guidelines exist for maintaining dental records[10,11] they are often quite broad and not necessarily adhered to[12]. Due to the categorical nature of the conclusion scales adopted i.e. opinion of the likelihood of identity[13] and the subjective nature of the process even if two examiners follow the same steps, they may still not reach the same conclusion. This does not necessarily mean that one is wrong. If, for instance, the opinions reached is 'possible identification', whether the end result of the identification process as found by the coroner is a match or not, the conclusion reached in odontology is not necessarily an error. As dental identification involves multiple types of data and a non-binary conclusion, it will be a challenge to find a way to measure the overall reliability, accuracy and error rates of the process.

As with error rates, assigning a statistical probability to an opinion conclusion is problematic due to the lack of sufficient validated empirical data. There are no large databases that record the frequency of dental characteristics or how individualizing each feature is. Additionally, the occurrence of dental features and interventions are not independent of each other and so the product rule cannot be applied. A database has been created in the United States to give a statistical likelihood to dental patterns, namely Odontosearch 3.2[14]. The database consists of 9730 records from United States civilians from the Third National Health and Nutrition Examination Survey (NHANES III) and 19,422 military personnel from the Tri-Service Comprehensive Oral Health Survey (TSCOHS). Dental data collected via clinical examination in both surveys and radiographs in the TSCOHS survey were converted into a generic and a detailed coding format for the purposes of Odontosearch[15]. The generic format recorded missing, restored, and virgin teeth while the detailed format provided restoration surface information[16]. While this is a useful tool and has been used in some studies[17,18], the database does have some limitations. The NHANES III survey did not include radiographs and provided no procedures on how to decide between teeth within the same class when one or more were missing[19]. In addition, the original data did not include charting for the occlusal surface of anterior teeth and Odontosearch does not include third molars. The original surveys were not designed for forensic purposes. The lack of detail and non-standardized charting lead to discrepancies when comparing a post mortem dental pattern to a dental pattern in the program, therefore reducing the validity of the result. The application of this database to other population groups may also be an issue due to differences in access to dental care and types of treatment available.

This study aims to provide an understanding of the variability of processes used for dental identification in Australia to better inform future validation research. We also explore practitioner's opinions on the relevance of validation recommendations, namely the PCAST[2] and NAS[1] reports and the use of databases such as Odontosearch 3.2[14].

Methods

An overview of the current dental identification techniques used in Australia, and opinions of Australian odontologists and odontology students were analysed through a survey. Table 1 outlines the survey questions and answer options. Questions were split into five categories:

(1) General experience and dental identification involvement.
(2) Antemortem (AM) phase
(3) PostMortem (PM) phase
(4) Reconciliation phase
(5) Opinions on the need for validation, the forensic reports from the United States of America, and statistical inference using databases.

Ethics approval was provided by the University of Adelaide, approval number: H-2018-252. The survey was set up online using Google Forms. Participants were able to choose their answers from multiple choice options and checkbox lists where multiple answers could apply. The option to clarify or expand on answers was also available.

Results were analysed with Excel and SPSS using descriptive statistics, Fishers exact test and correlation testing.

Participant selection

The survey was made available to Australian forensic odontologists who are members of The Australian Society of Forensic Odontology (AuSFO) via link on the AuSFO website. An email invitation was also sent to known Australian odontologists who are not members of the society and to forensic odontology students. Additional paper copies of the survey were completed at the AuSFO Symposium in Sydney, October 2019. All participants remained anonymous.

Table 1. List of survey questions.

	Question	Possible Answers
1	Are you currently involved in forensic odontology case work?	Yes/No
2	Have you been involved in identification in multiple victim incidents	Yes/No
3	How many identification cases on average do you undertake per year?	Less than 5/5-20/20-50/More than 50
4	Do you routinely examine the AM data prior to the PM examination?	Yes/No/Dependent on what is available
5	If you have viewed the AM data prior to PM examination, does this influence what you look for or what techniques you use in PM examination?	Yes/No/Dependent on what is available
6	Please expand on your answers from questions 4 and 5	Short Answer
7	Do you usually undertake PM examinations?	Alone/With another odontologist/No/Other
8	What type of radiographic images would you routinely use for PM examination?	Periapical, Bitewing, CT, Other
9	Which techniques do you use in the PM stage of identification case work? (select all that apply) (a) Radiographs (b) Extra-oral Photographs (c) Intra-oral Photographs (d) Impressions	Choice of: Routinely OR Only if present in AM data
10	What data have you used for the reconciliation stage of identification case work? (a) Written Records (b) Radiographs (c) Facial Comparison (d) Dentures (e) Oral Appliances (f) Dental Casts (g) Photographs (h) Rugae Patterns	Choice of Routinely, Infrequently or Never
11	Would you establish an identity on written AM records alone, i.e. no radiographs or photographs available?	Yes/No
12	Please expand on your answer to question 11	Short Answer
13	Do you think we should report on error rate or statistical probability for our opinion in dental identification?	Yes/No
14	Please expand on your answer to question 13	Short Answer
15	Do you think there is a need to validate dental identification techniques to the standard accepted by the courts (i.e. Daubert)?	Yes/No
16	Please expand on your answer to question 15	Short Answer
17	Do you think there is a need to validate dental identification techniques to the standard outlined in the PCAST report?	Yes/No
18	Please expand on your answer to question 17	Short Answer
19	Do you consider dental identification by comparison to be a pattern matching technique?	Yes/No
20	Please expand on your answer to question 19	Short Answer
21	Do you think an Australian version of Odontosearch would be useful?	Yes/No/Maybe
22	Please expand on your answer to question 21	Short Answer
23	If an Australian database like Odontosearch did exist would you use it to aid your conclusion of identity?	Yes/No/Maybe
24	Please expand on your answer to question 23	Short Answer
25	If an Australian database like Odontosearch did exist would you use it to add statistical probability to case reports?	Yes/No/Maybe
26	Please expand on your answer to question 25	Short Answer

Results

Twenty-four individuals participated in the survey, 19 (79%) indicated current involvement in casework and 15 (62.5%) said they had been involved in mass casualty incidents. The volume of annual casework undertaken is summarized in Table 2.

Table 2. Volume of casework undertaken per year.

No. of cases	No. of participants
Less than 5	8
5 to 20	4
20 to 50	4
More than 50	8

Antemortem phase (questions 4–6)

Eight (33.33%) participants said they don't view AM information before conducting a PM examination, five (20.84%) said they would, and 11 (45.83%) participants responded that it would be dependent on the information available (Figure 1 – inner circle).

Interestingly, of the eight who said they don't view any AM data prior to the PM examination, six (75%) answered that if they did view the AM information it would influence what they looked for in their PM examination. Only one of these eight participants said they would not be influenced by viewing the AM data first (Figure 1– outer circle).

When clarifying their answers, 10 of the 14 participants who expanded on their response highlighted that viewing the AM data enables odontologists to match the

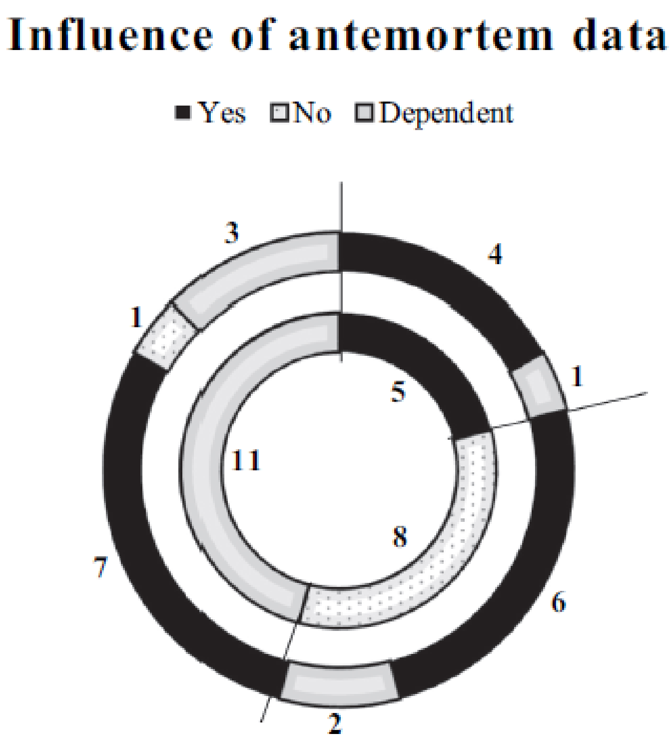

Figure 1. Influence of antemortem data. The inner circle represents the number of individuals responses to question 4: 'Do you routinely examine the AM data prior to the PM examination?' The outer circle represents responses to question 5: 'If you have viewed the AM data prior to PM examination, does this influence what you look for or what techniques you use in PM examination?', dependent on the response to question 4.

angulations of their radiographs or photographs which improves comparison. Two participants commented on the ability to check for unusual features found in the AM during their examination, and two (who were against viewing the AM) stated that it introduced bias and all PM examinations should be undertaken in the same way regardless of what known information is present.

Postmortem phase (questions 7–9)

In the PM phase of dental identification, two thirds of participants (16) stated that they work alongside another odontologist whilst a third (8) worked alone or with mortuary technicians. Figure 2 shows the number of participants that use each radiograph type and how many use multiple types in their PM examinations. Periapical radiographs are the most widely used radiographs with a total of 49%, nine participants (37.5%) use this method alone. CT follows at 27% with four participants (16.66%) solely using this technique. Bitewings are the least commonly used radiograph at 24%, there were no participants that used this type of radiograph alone, or in conjunction with CT it is always used either in conjunction with periapical radiographs or with CT and periapicals combined. Six participants (25%) use all three radiograph types to collect their PM data.

Other forms of PM data used for comparison include photographs and dental casts obtained by taking impressions. Figure 3 shows the frequency with which odontologists collect these data types and how they chose which they would collect. This showed radiographs were the most routinely used method (n = 17), whilst impressions were most commonly used if present in AM data (n = 15).

Reconciliation phase (questions 10–12)

The reconciliation phase uses multiple sources of dental information to make comparisons. Participants were asked how often they use the following information: Written Records, Radiographs, Dental Casts, Dentures, Photographs, Facial Comparison, Oral Appliances and Rugae Patterns. Figure 4 displays the frequency of participant responses.

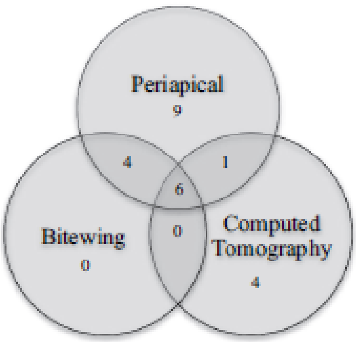

Figure 2. Postmortem radiograph types used by participants. Figure 2 illustrates the number of participants (n = 24) who use only one, two (overlapping circles) or all three (centre overlap) radiograph types.

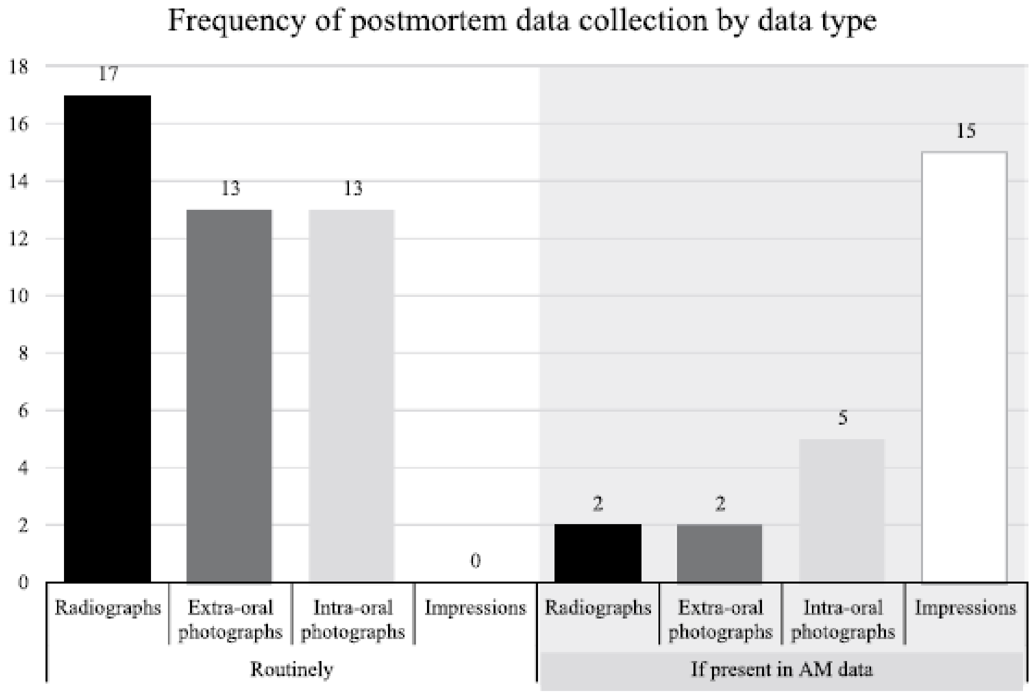

Figure 3. Postmortem data collection. Figure 3 displays the frequency of data collection by type in the postmortem phase of dental identification. These are broken into two groups, those taken as part of routine procedure (left four columns) and those taken only if there is comparable antemortem data available (right four columns).

Participants were asked if, during the reconciliation phase, they would establish an identity when the only available records are written notes (i.e. no photographs or radiographs). Thirteen answered no (54.17%) whilst the other 11 (45.83%) replied that they would. Of the 13 that answered no, nine (69.23%) were actively participating in casework and of those that said yes, 10 (90.9%) were active practitioners. Hence no trend with current experience was seen. Of the 10 active practitioners that said yes, eight qualified this by saying the records would have to be thorough, complex and comprehensive. Similarly, of the nine that said no, three commented 'unless the records were thorough.' Table 3 shows the number of respondents who qualified their original answer with reasoning for their response.

Odontologist opinions (questions 13–26)

The final section of the survey considered odontologists opinions on the relevance of the PCAST report to dental identification, as well as their thoughts on the need for validation of various standard processes and reporting of error rates.

Figure 5 summarizes participant's opinions. Those who disagreed with reporting error rates and probability suggest that those limitations should be taken into consideration before a conclusion is reached, rather than giving a probability of the conclusion itself.

A Fisher's exact test was performed in order to determine if the four categories in Figure 5 were related to whether the participants had read the PCAST report. No

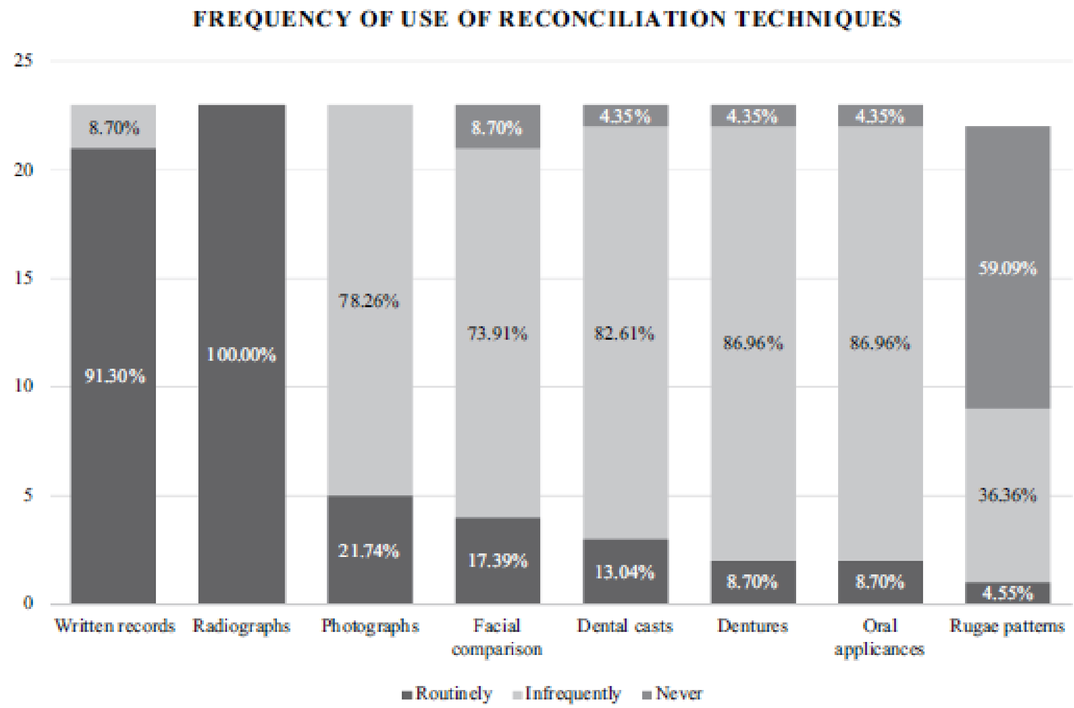

Figure 4. Frequency of use of reconciliation techniques. Figure 4 illustrates the percentage of participants who use the various techniques available at the reconciliation stage of dental identification. Written records and radiographs are the most routinely used techniques with rugae patterns being the least used.

Table 3. Qualifying statements for establishing identity from written records alone.

Answer	Qualifying statement	Respondents
Yes	AM records contain interesting features which are well documented	3
	AM records must be thorough, complex and comprehensive	8
	No discrepancies present	1
No	Risk of human error	5
	Requires subjective comparison	4
	Not enough information	2
	Unless AM records are thorough	3

significant results were found ($p > 0.05$). The result closest to statistical significance was $p = 0.07$, which related participants' opinion of whether they thought dental identification was a pattern matching technique. Of those participants who have read the report in full or in part (62.5%), none disagreed. Of those who hadn't read the report (37.5%), three disagreed and six agreed. One participant who read the report in part did not provide an opinion on classification as a pattern matching technique.

Participants were also asked if they would use a database like Odontosearch 3.2 if one existed for an Australian population. Table 4 shows the frequency of answers to the three questions asked, one participant did not respond to all three questions. Half the respondents thought a similar database would be useful, whilst only a quarter thought they would use it. A moderate correlation was found between answers for each of the questions as seen in Table 5. For those that said they would use the database to aid in

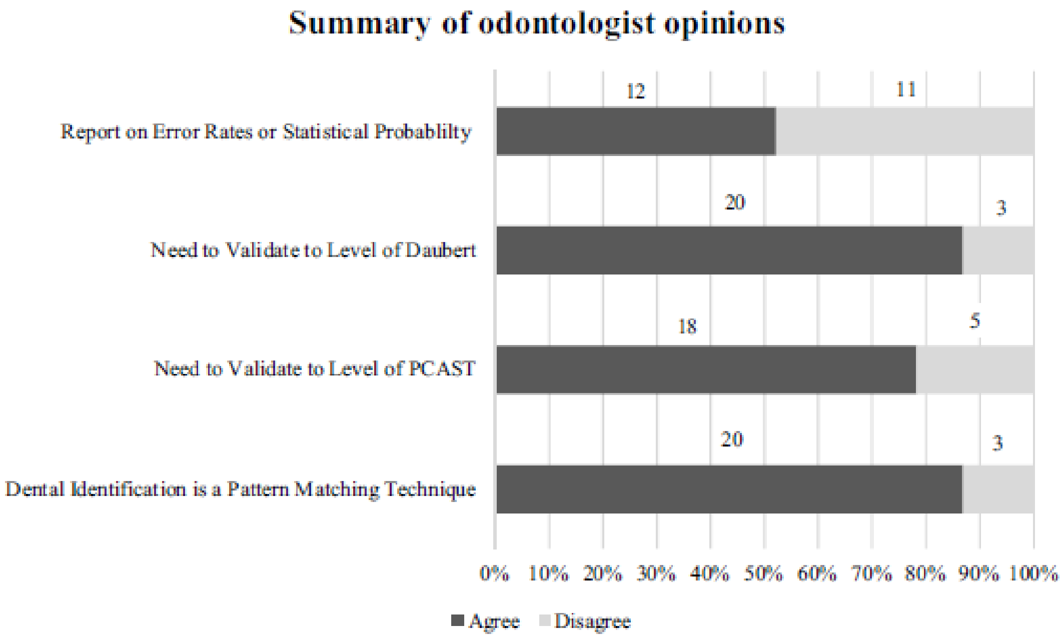

Figure 5. Summary of odontologist opinions. Figure 5 indicates the level of agreement of participants to questions:13. Do you think we should report on error rate or statistical probability for our opinion in dental identification?15. Do you think there is a need to validate dental identification techniques to the standard accepted by the courts (i.e. Daubert)?17. Do you think there is a need to validate dental identification techniques to the standard outlined in the PCAST report?19. Do you consider dental identification by comparison to be a pattern matching technique?

their conclusions (n = 6), all but one also agreed, they would use it to assign statistical probability in their reports. Interestingly, one participant who thought the database would be useful, decided they would not use it to aid their conclusions, but would use it to add a statistical probability to their reports.

Discussion

This study aimed to explore the variability in processes used in dental identification, and to explore practitioner opinions regarding the need for practice validation. Twenty-four odontologists with a range of experience answered questions relating to the three phases of dental identification.

Table 4. Frequency of answers to survey questions relating to Odontosearch.

	Yes		No		Maybe	
Survey question	N =	%	N =	%	N =	%
Do you think an Australian version of Odontosearch would be useful?	12	52.17	2	8.7	9	39.13
If an Australian database like Odontosearch did exist would you use it to aid your conclusion of identity?	6	26.09	2	8.7	15	65.22
If an Australian database like Odontosearch did exist would you use it to add statistical probability to case reports?	6	26.09	3	13.04	14	60.87

Table 5. Correlation coefficients for questions relating to Odontosearch.

	Question 21	Question 23	Question 25
Question 21: Do you think an Australian version of Odontosearch would be useful?	1		
Question 23: If an Australian database like Odontosearch did exist would you use it to aid your conclusion of identity?	0.388356	1	
Question 25: If an Australian database like Odontosearch did exist would you use it to add statistical probability to case reports?	0.405424	0.438634	1

Responses indicate differences in practice related to technology available, e.g. the use of CT images, and in frequency of data types used in reconciliation, thus, variation exists in the way casework is conducted and how decisions are made.

Antemortem data collected from dental records represents the last known oral status of an individual. Two participants who did not agree with viewing the AM data before the PM examination commented that having this knowledge could create bias, influencing the examination to focus on what the practitioner expects to find. It has been suggested that cognitive bias resulting from extraneous information can affect an outcome[20]. However, it could be argued that some information, for example knowledge of the angle at which an image was taken, is not extraneous. Most participants agree that this can help guide the taking of images to improve comparison. Previous studies have highlighted the improved comparability between AM and PM radiographs when angulation is as consistent as possible[21–23]. The ability to replicate the angulation of radiographs was the only reason participants gave as to why they would view the AM data first. Page et al. do not advocate this practice and suggest removing this opportunity for bias by having different examiners involved in the various phases of the process[20]. In this study we did not explore the extent of interaction with AM records prior to PM examination. It would have been interesting to distinguish between simply viewing the type of data available and the meticulous examination of images and records to form a picture of the oral status. Odontologists answers may have varied had the question been more precise or separated into multiple questions.

In the PM phase, the Odontologist is responsible for deciding which types of dental data to collect, limited by availability of comparable material and existing technology. Almost half of participants use CT imaging alone or in conjunction with other radiograph types. The increased use of CT scans is indicative of the profession embracing new technology and incorporating it into their identification techniques. The advantages of using CT include its non-invasive nature, the ability to reformat three dimensional images to mimic plain film radiographs, and the ability to provide a detailed depiction of the teeth and surrounding structures including jaws and sinuses[24].

Routine use of radiographs and intra and extra-oral photographs in the PM phase is expected, as these methods record the data present in an objective way and most AM records will have images available for comparison. The collection of radiographs and photographs for all cases also appears in the IOFOS guidelines[13]. It is also expected that impressions are not a routine data collection technique, as the process is difficult to achieve PM due to limited access to the oral cavity and the cold temperature delaying setting time. If a dental cast is not present in the AM data, there is little that a PM cast can be compared to, which makes impression taking an unnecessary procedure and waste of materials. The frequency of impression use may increase with the frequency of digital scanning, which is an up and coming technology in forensic odontology[25].

Reconciliation requires adequate evidence and detail in both AM and PM data for a comparison to be made. The most routinely used data types in the reconciliation phase are written records and radiographs as these are the most readily available AM. Rugae patterns are rarely used despite the fact that there are many studies evaluating their reliability[26–29]. The lack of AM dental casts providing rugae data prevents routine use. The other questioned data types showed similar levels of infrequency, with photographs being the most used data type of these. These results are to be expected as written records and radiographs have been shown to occur more often in AM records than other types of data[12,30,31]. While these studies evaluated the completeness of dental records, they did not report on the presence of rarer data types such as dental casts and photographs (with the exception of Stow et al.[12]).

Although practitioners were divided on reaching a conclusion of 'identity established' based on written records alone, their reasoning was consistent. They unanimously stated that without images there is no objective information to rely on, hence clinical notes must be complete and detailed with the treatment, and/or dental condition displaying significantly individualizing features. Also, they believed that in these cases discrepancies between the AM and PM data should be minimal, if present at all. These responses highlight the importance of radiographic images both AM and PM to improve the likelihood of a confident conclusion.

The second half of the survey aimed to gain insight into the profession's opinions on published validity guidelines, the use of frequency datasets and error rates, and how they related to dental identification.

Reporting on error rates and statistical probabilities split the respondents in half. Many participants highlighted that there are no databases to generate statistics, and therefore any number given is inaccurate and open to interpretation. Those who agreed with including these qualifiers commented that reporting error rate is an aspect of the scientific process behind a conclusion, making results more valid and improving standardization. The issue of not having a database was also brought up. However, it was suggested to highlight this as a limitation of the technique as opposed to assigning it an error rate. Others mentioned the difficulty in coming up with a statistical 'number' due to the many factors that would contribute to it and also mentioned the difficulties in establishing an error rate unless an identification had been made using another primary identifier. Most participants agreed that dental identification should be validated, and error rates and statistical probability investigated. However, it is well understood that appropriate studies and controls as well as accurate databases are required before reporting on them is an option. Gremaud[17] suggests using a likelihood ratio considering the two hypotheses that the deceased corresponds to the presumed identity, and that the deceased corresponds to someone else. While this approach adds a statistical probability to an identification conclusion, it still requires the calculation of meaningful prior probabilities.

When asked about using a database such as Odontosearch 3.2 with Australian data, participants added qualifiers to their answers. Most related to the need for a wide population sample and the validity of statistical accuracy of the database, whilst others said they would only use it for cases involving a lot of complex work. Respondents were cautious to use it before seeing it in action and highlighted the need for a robust statistical approach. Gremaud[17] used the Odontosearch 3.2 database to illustrate the proposed formula for a likelihood ratio approach. There was no mention of issues with statistical accuracy or population in the paper. Steadman et al. describes the data set as robust and a good representation of the population of the United States[18]. Odontosearch 3.2 could provide a suitable framework for an Australian based data set, and deeper understanding of the program and increased knowledge of the mathematics behind it may improve confidence in its use.

Limitations

The sample size for this survey was small, participants were selected from the Australian population of forensic odontologists and forensically trained dentists. At 24 responses, approximately half of practitioners replied. In addition to this, not all questions were answered by all participants. When analysing the data, it was found that the questions were not specific enough to draw out the desired level of detail. In some instances, it was not clear why participants responded the way they did. Other questions should have had binary answer choices eliminating the fence sitting option of 'maybe'. This may have prompted the respondents to qualify their answers in more detail. Additionally, it would have been interesting to discover how well Australian odontologists follow the IOFOS and AuSFO guidelines in their local casework. Despite these limitations, answers from the survey provided a useful insight into the practice of dental identification and the opinion of odontologists on various issues.

Conclusion

Forensic odontology is practiced differently across Australia depending on the technology available as well as the content and quality of AM dental data. This variation, however, does not necessarily have any bearing on the validity of any of the techniques used. The results of this study provide a foundation for future research into the entire process of dental identification.

Despite the limitations highlighted, this survey provides a snapshot into techniques used in Australia as well as opinions concerning the validation and error rate reporting of dental identification. Regardless of whether the standards outlined in PCAST are agreed upon, forensic odontology needs to show that its dental identification methods are founded in science. As a profession, it should be agreed upon as to how we support our conclusions. If error rate is impractical due to the nature of our conclusions, we need to find another way to support our opinions that follows unambiguous scientific criteria and does not rely on experience alone. A uniform approach to validation standards and methods, and the sharing and combining of results would facilitate the establishment of robust and valid dental identifications.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Catherine A. Storer http://orcid.org/0000-0002-8077-0413

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CHAPTER 3: COMPLEXITY OF ANTEMORTEM RECORDS

'The type and quality of AM records from which the AM profile is compiled will affect the selection of the comparison process to be used and the level of confidence in the overall outcome' – Alex Forrest, 2019

Anecdotally, forensic odontologists are aware of the potential complexities and limitations of both collecting antemortem data, and the data itself. Antemortem dental data take many forms, varying in both content and presentation. Some of these variables can increase the risk of inaccuracies in the final transcription. While dental records have been analysed in terms of meeting legislative criteria, or their accuracy, no empirical research has been conducted to investigate the level of variability in records.

This study aims to evaluate diversity in the contents of dental records received by the Forensic Odontology Unit, University of Adelaide, and how it impacts the complexity of the evaluation, interpretation, and transcription of antemortem information.

Materials and Methods

One hundred sets of dental records received for forensic identification investigations from 2018 to 2022 at the Forensic Odontology Unit, University of Adelaide were randomly selected for analysis. Cases were included in the study if the full set of antemortem data was available for analysis. Exclusion criteria included cases where hardcopy dental records were referenced but in archive, cases that did not progress with dental identification and cases with primary or mixed dentition. The information collected is outlined in Table 4. Data was ascertained from the case information file and cross-checked by assessing the AM records themselves. The number of appointments was determined by counting each date on the clinical notes where there was evidence of attendance. The period of attendance was calculated by subtracting the first appointment date from the final appointment date. To ascertain the potential impact of AM records, information from the final transcription was also collected (Table 5). The time difference between the last record and transcription date was calculated by subtracting the final treatment date from the date the AM records were analysed. Descriptive statistics were employed to describe the data obtained.

Table 4: Data Collected from Identification Cases

Data Collected	Details
Dental Clinic Information	▪ Number of clinics supplying records ▪ Private or Public ▪ Dental Software used ▪ Number of Operators ▪ Duplication of information ▪ Original or copies of records
Period of attendance	▪ From first to last record (years)
Dental Data Types ▪ Digital or non-digital ▪ Number	▪ Written Records ▪ Dental Chart – presence and number ▪ Intra-oral Radiographs – presence and number o Periapical o Bitewing o Occlusal ▪ Extra-oral Radiographs o Panoramic o Lateral Cephalometric o Computerised Tomography (CT) o Other plain films ▪ Intra-oral Photographs ▪ Extra-oral Photographs ▪ Dental Casts ▪ Appliances
Specialist Correspondence	▪ Present or not
Lab Forms	▪ Present or not

Table 5: Data Collected from Final Antemortem Transcription

Data Collected	Details
Recency of records	Time difference between last record and transcription date (years)
Number of INTERPOL codes present on the final odontogram	Each three-letter code and each surface were counted as one data point (E.g.: 'mam' is one data point, and 'uif MOD' is 4 data points)
Number of occurrences of specific codes in each odontogram as a percentage of total teeth (total teeth = 32)	▪ Missing ▪ Untreated Disease ▪ Restored Teeth ▪ Implants ▪ No Information Available

Results

Data was gathered from 100 dental identification cases, with dental records supplied from 153 clinics. Most cases (56%) consisted of records supplied by one clinic, 37% by two clinics, 4% by three clinics and 3% by four clinics. Private clinics accounted for 49.02%, Public clinics 37.91% and radiology providers 13.07%. Ninety-nine clinics (64.71%) provided original records, 31 (20.26%) provided only copies of their data and 23 (15.03%) provided a combination of both.

AM data sets covered time periods ranging from 33 years and 1 month to a single visit, with a mean time of 11 years and 11 months. The greatest number of appointments recorded in a data set was 180, covering a period of 30 years and 11 months. The most appointments in the shortest time were three in six days. The least over the longest period was two appointments in 15 years and 3 months. The average number of appointments and operators was calculated using the median to prevent outliers from affecting results. Patients attended an average of 1.36 times per year, and each operator conducted 2.63 appointments. This average attendance correlates with the recommended 6-12 month recall appointments and being seen by one operator for these appointments. With an increase in different operators, there is also an increased risk of contradictions within the dental records.

The time difference between last known dental visit and AM transcription ranged from 45 years and 6 months to 4 days with a mean time of 4 years and 9 months. While the time difference does not impact what can be discovered within the dental record for transcription, it can have a great impact on differences seen between AM and PM data in the reconciliation stage.

Variation in Data Supplied

Clinics varied in number and type of dental data supplied for antemortem evaluation. The different data types, whether they are digital or hard-copy and the number of cases that include that data are presented in Table 6, and Figure 4 shows a breakdown of each radiograph type.

Table 6: Data Types and Format of Supplied Records

N=100	Treatment Notes	Chart	Dental Casts	Radiographs		Photographs	
				Intra-oral	Extra-oral	Intra-oral	Extra-oral
Electronic/digital only	58	57	0	36	32	7	5
Handwritten/non-digital only	10	12	3	31	18	0	1
Combination	31	12	0	13	12	0	0
Nil Available	1	19	97	20	38	93	94

At least six different dental software systems were used in the creation of electronic records, the program used was unknown for four of the clinics. Of the 100 cases analysed, 56% consisted of original records, 13% supplied copies only and 31% comprised a combination of originals and copies of documents and/or images. Three clinics supplied dental appliances, a mouthguard, a partial denture and a wax-up of a full upper and full lower denture. Eighteen cases contained specialist correspondence and six included laboratory forms.

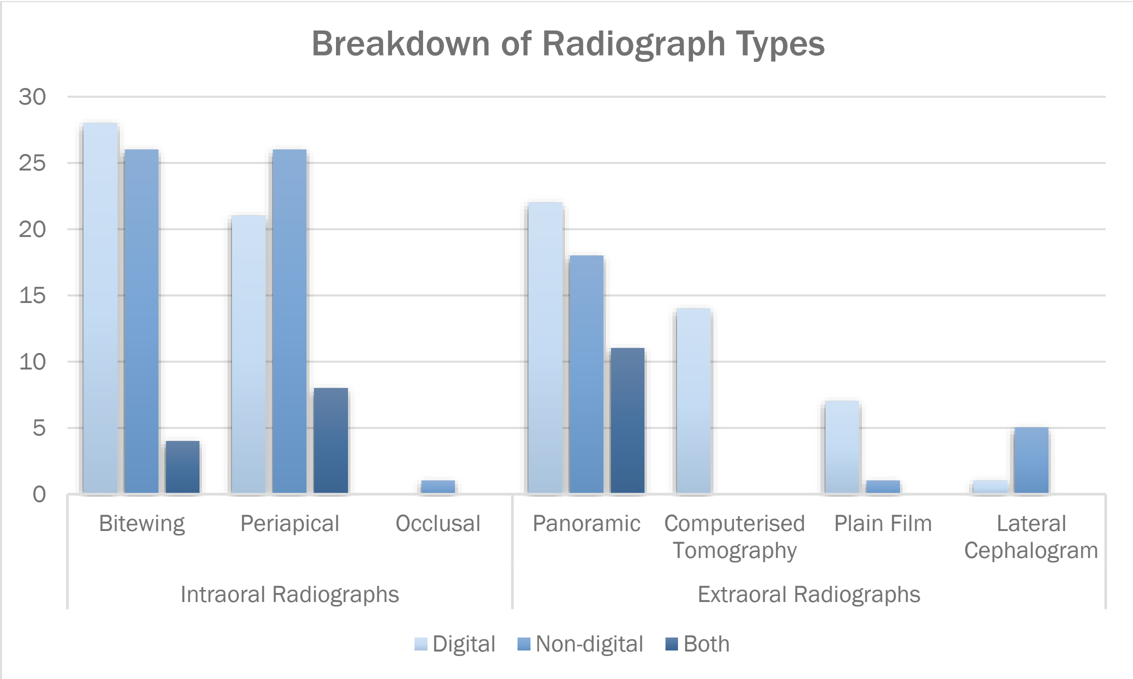


Figure 4: Breakdown of Radiograph Types

Final Transcription Information

While there are 32 teeth in a complete adult dentition, each tooth can have multiple codes assigned to it to describe its status or treatment. For the 100 cases, there was a total of 3,599 three-letter codes (Figure 5). Missing teeth accounted for the highest percentage (23.03%) of codes, followed by present (17.48%) and no treatment (17.28%), if these categories were combined, present, unrestored teeth would occur more often than missing teeth at 34.76%. Simple restorations make up the next highest percentage (25.72%) followed by no information available (6.20%).

Occlusal surfaces were the most filled (34.37%) followed by vestibular surfaces (18.17%). Interestingly, mesial and distal surfaces were fairly even at 16.30% and 16.82% respectively (Figure 6).

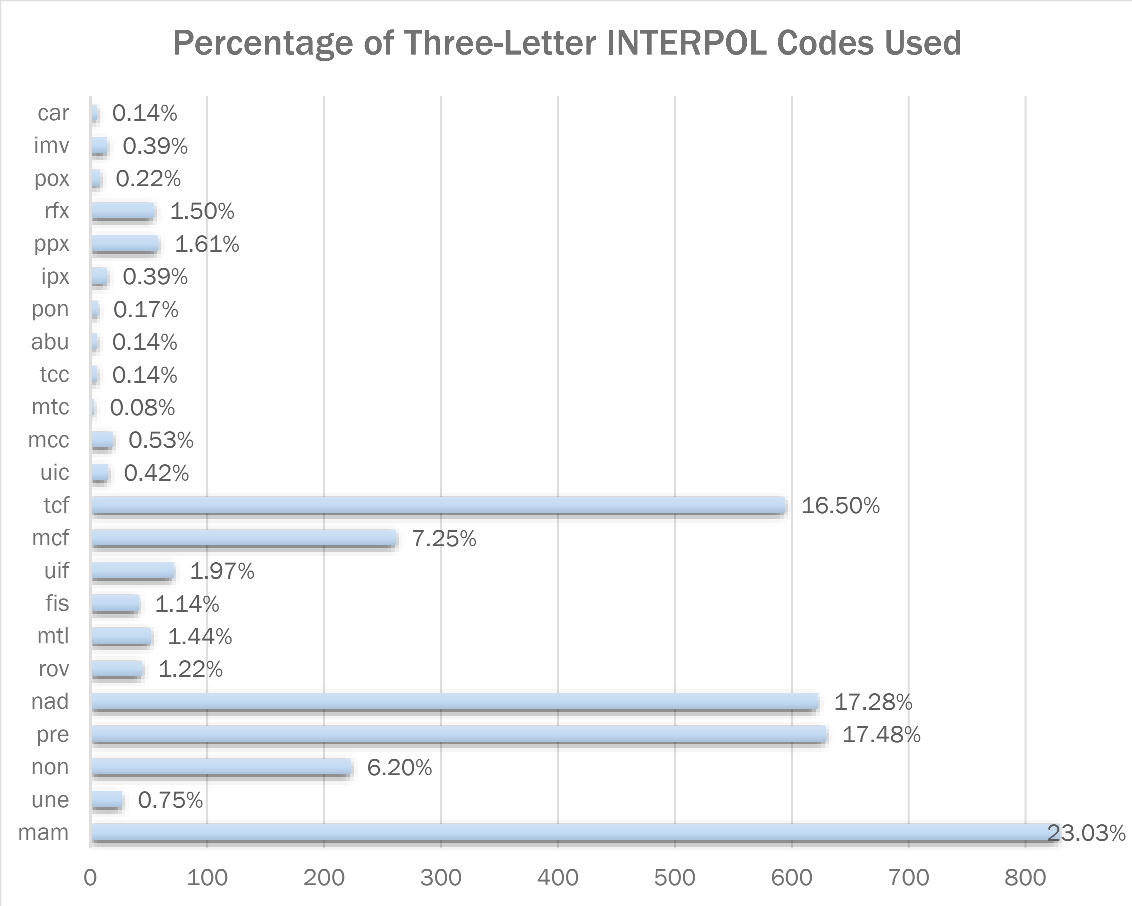


Figure 5: Percentage of Three-letter INTERPOL Codes Used in Final Transcriptions

A full description of these codes can be found on the INTERPOL website and are presented in Chapter 4, Figure 14, page 97.

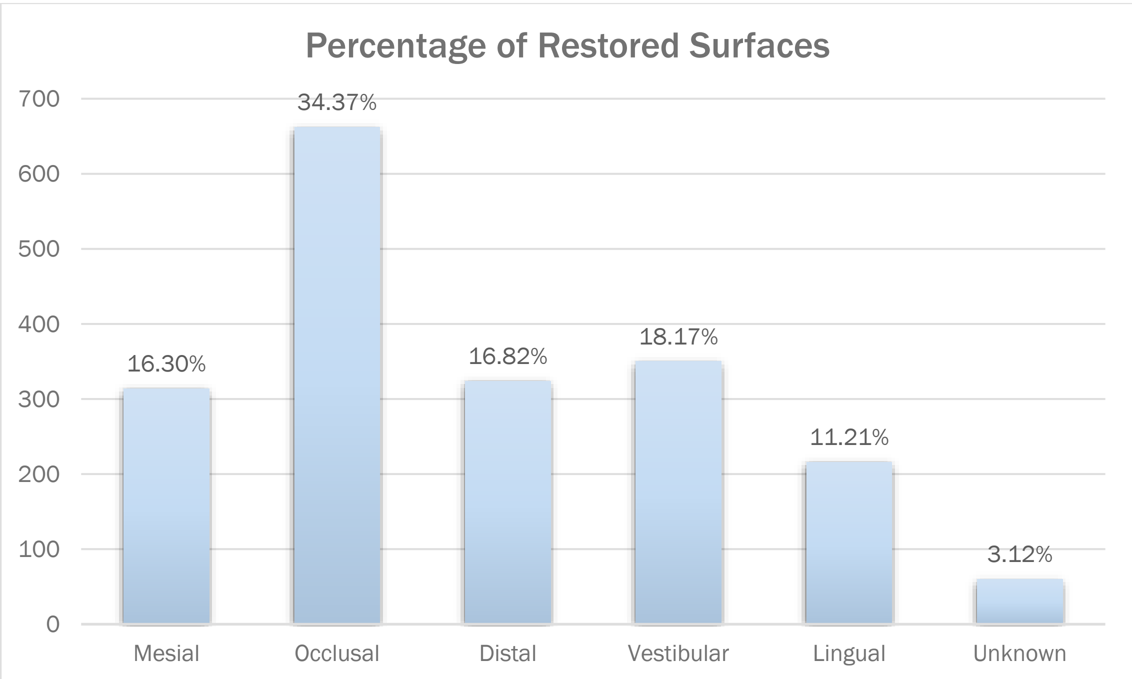


Figure 6: Percentage of Surfaces Recorded as Restored

Each three-letter code and each tooth surface, where applicable, were counted as one data point for a total of 5,525 data points, 25.62% of which consisted of more than one per tooth. Figure 7 displays the percentage occurrence of more than one data point per tooth.

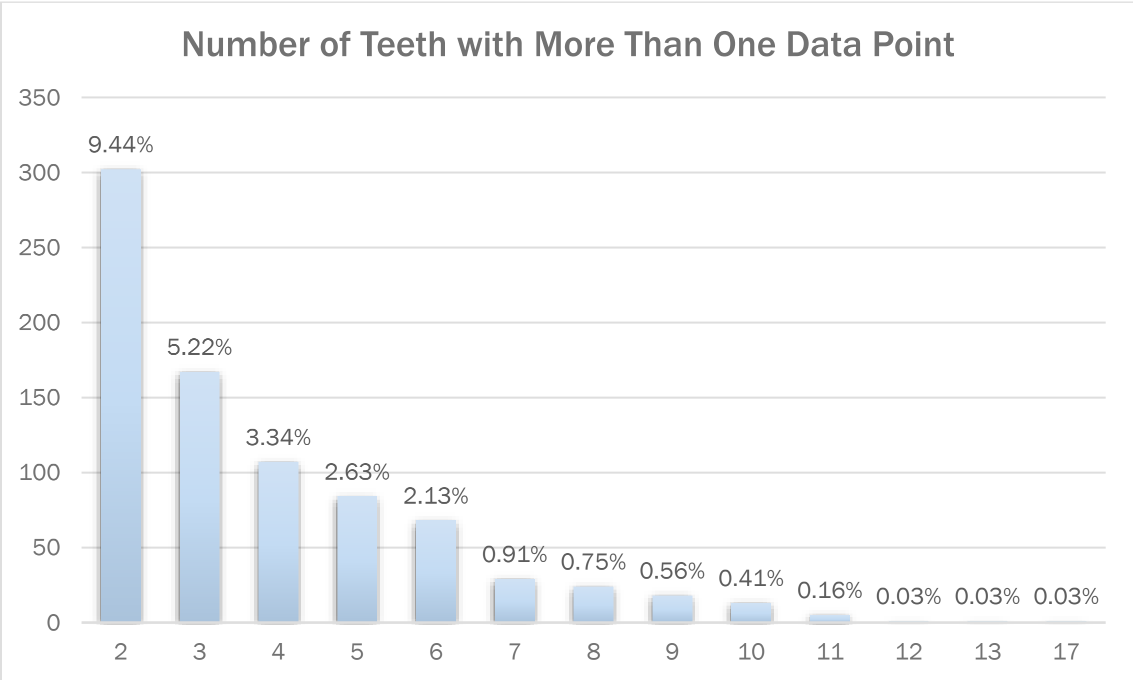


Figure 7: Number of Teeth with More Than One Data Point

Seventeen data points were the most for any one tooth and 145 was the most for an individual case. The first and second molars had the most data points (Figure 8) and the third molars and lower anterior teeth had the least number of data points.

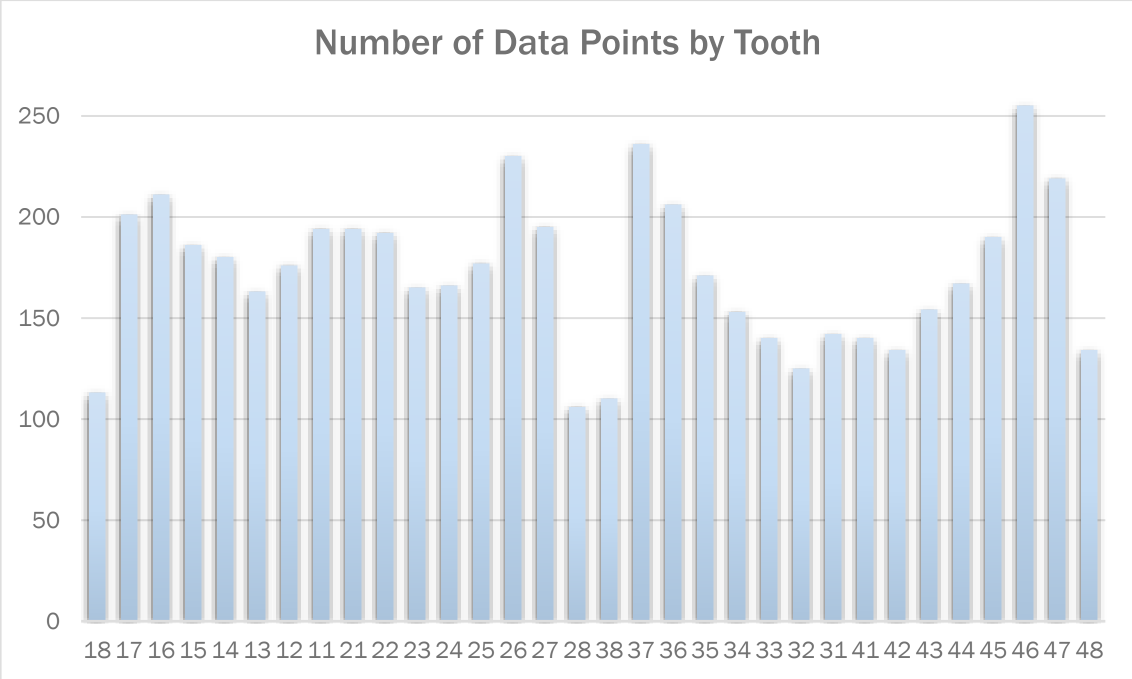


Figure 8: Number of Data Points by Tooth

Third molars had the highest percentage of missing and no information codes, while the lower anterior teeth had the highest percentage of present with no treatment. The first and second molars had the highest percentage of restorations followed by the upper anterior teeth. As expected, this is reflected in the number of data points for those teeth. However, a greater number of data points in the upper anterior teeth, compared to the difference between restored percentages suggests that they are more likely to have multiple restorations per tooth than molars.

Cases with a high percentage of teeth with no information tended to correlate with minimal, or no radiographs. However, this did not reduce the number of overall data points in these cases as the few teeth that were recorded had multiple treatments.

Impact on Evaluation and Transcription

The impact of this variation in data supplied on the evaluation and transcription of information was investigated by comparing the number of data points in each case to the data types they contained. Data points and number of radiographs (intra- and extraoral) were compared to the time covered by the dental records (Figure 9). While a general increase in radiographs over time is expected, there is no clear trend in the number of data points in the final transcription.

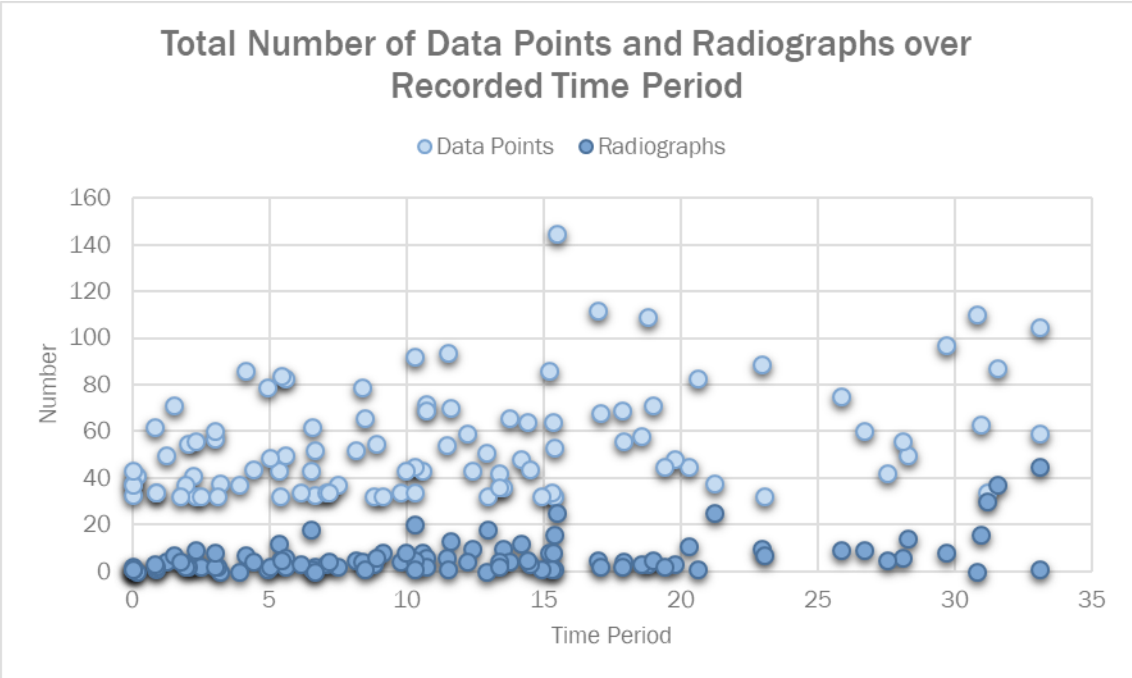


Figure 9: Time Covered by Dental Records and the Corresponding Number of Radiographs and Final Transcription Data Points

The number of no-information codes was compared to the number of intraoral radiographs (bitewing and periapical) and the number of dental charts (Figure 10). As expected, the number decreases with an increasing number of 'non' codes. However, in most cases where at least one non-code was recorded, dental charts were present. This indicates that even though there is a ‘record’ of all 32 teeth, they are often evaluated as being incomplete or unreliable.

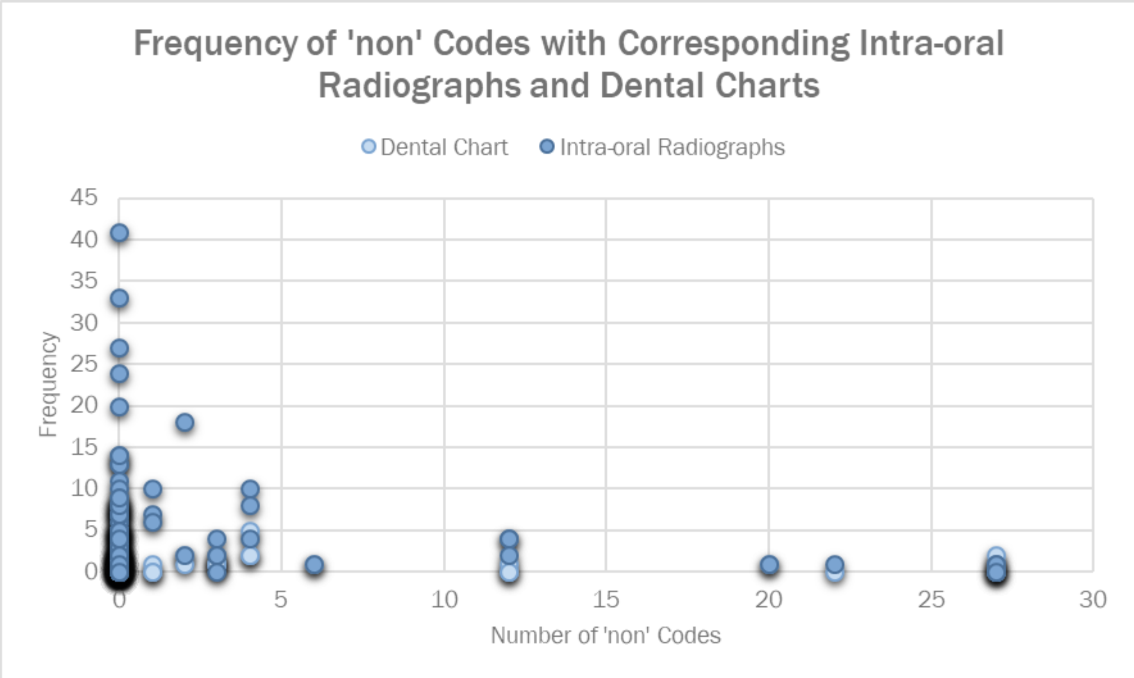


Figure 10: Frequency of No-information Codes Compared to the Number of Intra-oral Radiographs and Dental Charts Present in the Corresponding Dental Records

Radiographs from the previous figure were broken down into periapical and bitewing types (Figure 11). In cases where there were no ‘non’ codes, there was a high number of periapical radiographs, which decreased as the ‘non’ codes increased. In the cases where more than half the teeth were assigned a code of ‘non’, there was only one periapical radiograph present and no bitewings. At least one set of bitewings was present in two cases with 12 ‘non’ codes, indicating in these cases that only the posterior teeth were documented in all record forms. Large numbers of bitewings are also associated with the presence of two to four ‘non’ codes. In these cases, there are no periapical radiographs, except for one case, indicating that historical bitewings will not necessarily provide any additional information.

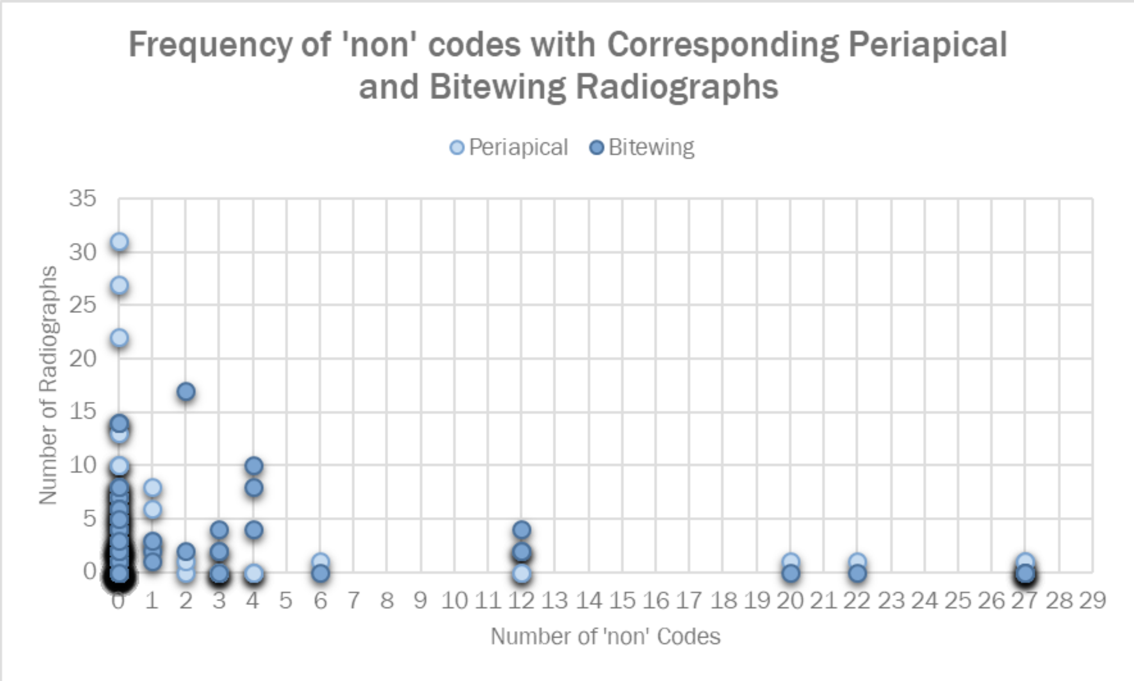


Figure 11: Frequency of No-information Codes Compared to the Number of Periapical and Bitewing Radiographs Present in the Corresponding Dental Records

Changes in Dental Records Received

A study of dental records received for dental comparison by the Forensic Odontology Unit, University of Adelaide was conducted by Stow, James and Richards (2016) examining 100 dental records received between 2008 and 2013. While this study focused on forensic value and adherence to record-keeping guidelines, there are some comparable features (Figure 12).

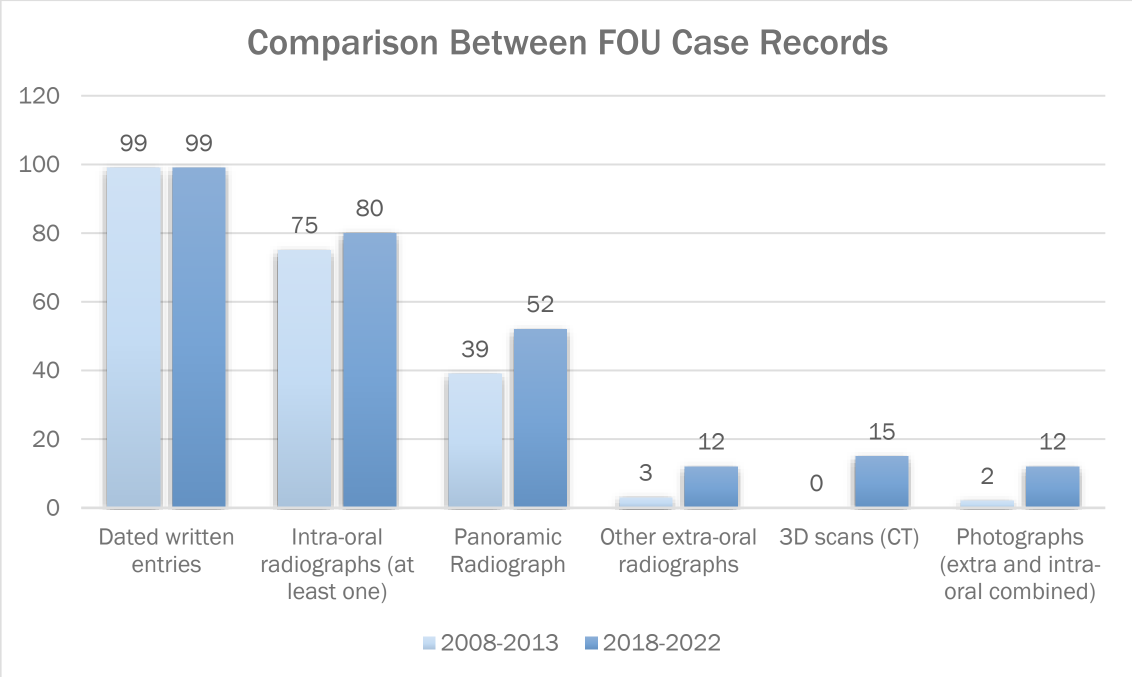


Figure 12: Comparison Between Forensic Odontology Unit Case Records

While clinical notetaking has remained constant, the inclusion of images has increased. This may be due to more clinics retaining digital data, increased knowledge of dental practitioners on what to provide, and progress in antemortem data collection by the Forensic Odontology Unit (access to radiology databases). Comparing these studies has limitations including different data collection techniques for different purposes, and the small sample size of both studies. Stow, James and Richards (2016) also concluded that having to decipher the clinical records provided can decrease the rate of progress of when conducting a dental identification.

Discussion

Numerous clinics supplying records for the same individual can be helpful by increasing the amount of information available for analysis. However, complications can arise as the forensic odontologist must reconcile that each set of dental records and images originates from the same individual. Names can be misspelt, dates of birth be recorded incorrectly, and images filed under the wrong patient. The need to reconcile can also be necessary when no errors are present, such as when people change their names or use aliases. If any erroneous data is not discovered at this stage, it can cause major complications at the reconciliation phase. This task can be made even more difficult when one or more identifying features are not present. These identifying features include name, date of birth and address. Stow, James and Richards (2016) found that 99% of records analysed had the patients first and last name while only 91% included a date of birth and 25% of radiographs were not labelled.

Clinical Notes

Treatment notes can be handwritten or digital, and while typed records are easier to read, both have their disadvantages. Handwritten notes can be laborious to read, interpret and analyse, and may be illegible (Petju et al. 2007; Stow, James & Richards 2016). Electronic records may be less detailed as practitioners likely rely more on saved pre-recorded notes and hence disregard more unusual findings. Both electronic and hardcopy clinical notes are subject to the personal shorthand of the treating practitioner (Hill, IR 1988). Additionally, photocopies of handwritten notes reduces clarity on an already difficult to decipher text (Petju et al. 2007), it is also possible that parts of the record will be cut-off the copy. Print outs of treatment summaries from computer programs are not always chronological and can repeat the same information. It is also not always easy to tell which part is a treatment plan and which is treatment that has been completed on computerised notes.

Dental Charts

All dental computer software and built for purpose paper patient cards contain a graphical dental chart displaying all teeth. These graphical depictions of the teeth are then removed or coloured based on the status of that tooth. There is a lack of standardisation of these colours, symbols and abbreviations both internationally and within the same country (Capitaneanu 2021). Unless the chart is in colour and the forensic odontologist knows what each colour, symbol, letter or number means, the pictorial treatments cannot be deciphered without a legend, which rarely accompanies the chart. Dental charts are also notorious for not being completed. Stow, James and Richards (2016) found that only 56% of charts were complete with 29% being incomplete. Only 22% of the charts present were current (created within 12 months). Digital charts can be updated without changing the date making it often difficult to know when the data is entered. This means that the forensic odontologist must use all records available, knowledge of dental diseases and their experience to determine if a chart has been filled out accurately or completely. These complexities were reflected in the current study showing that some form of dental chart was present in 68.18% of cases that had 'non' codes.

Radiographs

Radiographs are an essential dental record type for identification. They are a picture of the dental status and are less subject to human error. Their presence within the dental record received varies and while the clinical notes indicate radiographs have been taken, they are not always supplied. Their presentation can also impact on their suitability. Non-digital radiographs are subjected to chemical stains and degrade over time, so while they may be available, ascertaining any useful information from them may be problematic. Copies or printed scans of digital radiographs and photographs can also lose clarity obscuring relevant details. Due to the limitations of radiographs from angulation, processing and storage, it is necessary to combine and cross reference data from both images and written information (Mitsea, Karayianni & Tsiklakis 2021). While usually the more images the better, the type of radiograph and its field of view is relevant to the amount of information available. For example, a panoramic radiograph shows the entire mouth, therefore there is information available for every tooth. One of these radiographs can be much more pertinent to transcription than 10 periapical radiographs of the same area or four sets of bitewings, as shown by the number of 'non' codes used when these radiographs were present in the record. At least one type of radiograph was present in 94% of the dental records evaluated which is higher than previous studies have found, 50% in Borrman et al. (1995), 59% in Wadhwani, Shetty and Sreelatha (2017) and 75% in Stow, James and Richards (2016). In comparison, a full panoramic image was found in 52% of records in the current study, 39% in Stow, James and Richards (2016) and 35% in Waleed et al. (2015). It is important to note that this variation may be due to the year of the study and related technology available as well as the country in which the study was conducted.

The Effect of Time

Non-contemporary notes may contain treatment codes that differ from current convention and material brand names no longer on the market are meaningless. Dental records that span numerous years with regular appointments are more likely to provide data across the dentition and include more radiographs. They can, however, be long and laborious to decipher. With multiple treatments on the same tooth, the forensic odontologist must determine if the new treatment replaced the old, or if it is an addition. The longer records are, and the more operators treating the individual the more likely errors, such as the misnaming of teeth, can take place. In communication with a colleague, it was reported that they had a set of records that indicated the same tooth had been removed three times.

Records that span a long time but have few appointments, particularly when the individual only attends for emergencies, tend to lack an overview of the dentition, and focus only on the issue at hand on the day. If a general examination and charting is conducted, differences recorded between appointments may also indicate that the individual has attended another dental clinic.

Generally, the closer the last appointment is to when the antemortem transcription takes place, the more likely the dentition will be the same as the postmortem. However, this relies on the content and quality of the records provided. This also depends on the level of disease. An individual with extensive restorations or active disease is more likely to have dental changes over time than an individual who has consistently had no disease.

Limitations

In addition to the exclusion criteria, cases were also excluded from the study when photocopied records were missing dates as the number of appointments was unable to be recorded. In handwritten records, it was sometimes difficult to determine the number of operators as not all had signatures. This was estimated based on handwriting differences. Some cross-over with government clinics and private oral surgeons made it difficult to determine which appointments and hospital surgeries occurred privately and which were under the public system.

Conclusion

The contents of dental records were explored for their diversity, complexity and the potential impact they had on the ability of odontologists to accurately evaluate, analyse and transcribe data. From this study, it is evident that no two dental records are alike and there are multiple components that affect this variation. Each of these components has its own set of challenges when it comes to the analysis, interpretation, and evaluation of the data. Thus, when transcribing data, interpretation of, and reliance on different data types will be case and operator dependent. The accuracy of an antemortem transcription is how well it reflects the dental records, not how well it 'matches' a postmortem data set.

Examining AM data transcription variation between multiple operators across cases of varying complexity will allow an understanding of what features of the records sets are most reliable and which can lead to variation or error.

CHAPTER 4: VARIATION PILOT STUDY

The previous chapter clearly demonstrated the large variation in presentation and content of antemortem records. However, the impact this variation has on the accuracy and consistency of the final transcription is still unknown. This chapter aims to assess the accuracy and variation of antemortem dental data transcription using dental records of varying complexity. It aims to answer the question: what are the sources of error and variation in the antemortem transcription process? This information will allow the creation of methodologies to improve the evidentiary value of antemortem transcription. Ethical approval was provided by the University of Adelaide, approval number: H-2018-252 (Appendix II).

Materials and Methods

To test the variability in antemortem transcription, three simulated cases were developed. Each case had varying levels of data available and varied in complexity. Participants were asked to transcribe this data onto a fillable pdf using modified INTERPOL dental codes.

Practicing forensic odontologists may seem the most likely candidates for participation in this task, however, there are multiple limitations. In Australia, there are very few odontologists and they have differing levels of education, experience, and recency of practice. Variations in approach and accuracy are therefore highly likely. They are also regularly asked to participate in research and may suffer from participation fatigue causing a lack of enthusiasm and attention to detail. It was determined that the research question would be best answered using participants with a more consistent level of experience. Hence, final-year dental students were selected as they are all relatively the same age, have the same level of dental education and have the same experience in forensic odontology.

An education module was devised with four sections, two relating to an introduction to forensic odontology as a specialty with specific attention to dental identification (See Appendix III). The third section introduced the research project and requirements of the participants and offered a practice case with answers provided. The fourth section included the three mock cases. Students were asked to download a fillable pdf, input their answers, and then upload it again. Returned PDF files were then exported to Microsoft Excel and deidentified before data analysis.

To ensure the module was comprehensive and the task instructions were clear, the module was first given to a final-year representative to test. The module was then uploaded to a canvas blackboard and all final-year students were given access. Unfortunately, despite multiple attempts to encourage students to participate, participant numbers remained low. To increase participant numbers, forensic odontology graduate diploma students were also invited to participate. While their experience in general dentistry and reading dental records is greater than that of the final-year dental students, their experience with forensic odontology and assessing and translating the data onto a standardised form is similar.

Case Creation

Three cases representing the variation in dental records discovered in Chapter 3 were created and can be found in Appendix IV.

The first case consisted of one appointment recorded electronically with two digital radiographs of the same area and an incomplete electronic dental chart. Records were simulated to be five years before the transcription date.

Case 2 contained handwritten clinical notes covering five appointments with a gap of 18 years between the first two and the last three. Two hardcopy partial charts were provided, one from each time period. Radiographs included a digital panoramic radiograph from the first time period and two digital periapical radiographs of different areas dated more recently. The last appointment was four years before the transcription date. Incorrect nomenclature in tooth naming, varying notation conventions, messy handwriting, and personal shorthand were also included in this case.

The third case consisted of electronic clinical notes covering a period of 25 years with 14 appointments. One digital chart in greyscale with no legend was included as were two digital radiographs of the same tooth, and six scanned images of non-digital radiographs covering four sextants. Electronic records from a second clinic were also included, containing three appointments that took place during the 25 years of the first records. Multiple incompatible treatments were recorded for one tooth and incorrect nomenclature was present. Some appointments had extensive notes while others had too little. The greyscale chart simulated the difficulty in differentiating restoration types. The latest appointment was dated four years before the transcription date.

Creation of the 'Odontologist Consensus'

Testing accuracy and variation requires a 'correct' answer. However, there is no way to know the ground truth in antemortem transcription. To this end, a 'consensus code' was created. Each simulated case was completed by two senior odontologists and two experienced forensically trained dentists as if they were part of regular casework. The final codes obtained from each person were discussed, and a consensus was reached. Guidelines created from the discussion are presented in Figure 13.

Radiographs

- When only visible on a radiograph, restorations were given the code ‘uif’ (unidentified filling)
- Unerupted third molars were given the code ‘une’ (unerupted) as opposed to ‘imx’ (impacted)
- Information on radiographs was given the highest weighting of evidentiary value as the image is not reliant on human input

Dental Chart

- If the chart was the only source of information for third molars, they were given a code of ‘non’ (no information) as often they are charted as missing when they are unerupted
- If the operator deems the chart as incomplete and/or unreliable, and the information is not entered elsewhere, teeth were given the ‘non’ code
- Information on charts was given the lowest weighting of evidentiary value as they are often incomplete and are reliant on human input

Written Records

- If a tooth had caries noted with no visual record of missing tooth structure, the caries was not recorded
- If visual evidence was available depicting missing tooth structure the code ‘mtl’ (marked tooth loss) was used
- While information in radiographs is given higher weighting, the dates of written records were often cross-referenced to ensure accuracy of the final code

Figure 13: Guidelines for the Selection of Codes (Odontologist Consensus)

To reflect the information gathered in Chapter 3, the total number of codes and surfaces of each simulated case were calculated to a total number of data points (Table 7).

Table 7: Components of Simulated Cases

		Case 1	Case 2	Case 3
Three-letter codes	Present	2	12	8
	Missing	19	11	15
	Restored	0	11	11
	No information	10	0	1
	Other	2	3	0
Surfaces	Mesial	1	5	4
	Occlusal	1	7	7
	Distal	1	6	3
	Vestibular	0	1	5
	Lingual	0	1	4
	Unknown	1	4	0
Total Number of Data Points		37	61	58

Coding Convention

Transcription guidelines were given to participants. These instructions represent what is available from the INTERPOL guidelines for dental identification with minor modifications. Figure 14, Figure 15, and Figure 16 display the information available in the learning module.

Figure 14 lists the three-letter codes and their definitions, no detailed information on how to decide between codes or when they should be selected was provided. Figure 15 displays the information available on nomenclature including how to present the three-letter codes and tooth surfaces where relevant. Although there is varied nomenclature available for tooth surfaces, to avoid confusion, INTERPOL uses standardised terminology.

Figure 16 provides additional instruction on transcription adapted from what is available from INTERPOL. No additional instructions were given as it was important to know how the participants performed based on current guidelines.

These codes are used to represent treatment, all codes are three letters and written in lower case. Restoration codes should be followed with surfaces involved in UPPER case, if the surfaces are unknown a * is recorded after the code.

	Code	Definition
BRIDGES	abu	Abutment Tooth
	pon	Pontic
CROWN PATHOLOGY	mtl	Marked Tooth Loss
CROWNS	uic	Unidentified Crown
	mcc	Metal Ceramic Crown
	mtc	Metal Coloured Crown
	tcc	Tooth Coloured Crown
FILLINGS	fis	Fissure Sealant
	uif	Unidentified Filling
	mcf	Metal Coloured Filling
	tcf	Tooth Coloured Filling
ROOT	ipx	Implant
	ppx	Parapulpal Pin
	rfx	Root Filling
	pox	Post
STATUS	mam	Missing Antemortem
	une	Unerupted
	non	No Information
	pre	Tooth Present (No other information)
	nad	No abnormality detected (evident in records)
	rov	Retained Root

Figure 14: Adapted from INTERPOL Primary Codes

Tooth Designation and Surface Names

As there are many ways to name teeth and variation in the names for tooth surfaces, INTERPOL uses a standard notation as follows:

FDI notation: Quadrants numbered 1-4 and teeth numbered 1-8.

Surface Codes:

M – Mesial

O – Occlusal (includes incisal surfaces for anteriors)

D – Distal

V – Vestibular (Buccal, Labial)

L – Lingual (Palatal)

Coding Convention: Treatment code in lower case TOOTH SURFACES IN UPPER CASE

e.g.: tcf MOD, mtl DOL, uif MODVL

Figure 15: Tooth Designation, Surface Names and Coding Convention

The final chart should convey what the dentition most likely looked like at the last dental appointment recorded.

- Records are read in reverse date order, most recent to historical. If a tooth is extracted you don't need to list previous treatments. A tooth may have a number of treatments, if one clearly replaces the other, only the most recent should be recorded.
- Check radiographs are orientated correctly, and casts/photos clearly identify the missing person.
- Using case notes and charts (begin with most recent) enter codes and comments onto form.
- Using the latest radiographs, enter codes onto form - if your only source of information for a restoration is a radiograph use uif (unidentified filling). Don't include V or L except as a comment. If in doubt in regard to surfaces restored, make the lesser treatment. Only list surfaces you are certain are involved, if unsure use an *.
- If you would like to make a comment that is not an accepted code, type double quotation marks – " – then write your comment (This is a feature necessary on the software for searching).

Figure 16: Transcription Instructions

Data Analysis

Each tooth in each case was given a binary score depending on whether it agreed or disagreed with the odontologist consensus. The number of variations per tooth along with the frequency of number of variations was also assessed. Each answer was also given a score of variation type as seen in Table 8, which were devised using those found in the literature as a guide. When deciding on the binary outcome, variation type 1 was counted towards the consensus when only nomenclature was incorrect, the remaining were considered as a variation from the consensus. Categorising the answers this way allowed evaluation of the reason for variations and if they were consistent across cases and between participants. The data source type (i.e., radiograph, written records, dental chart) was also recorded for each tooth to enable an analysis of whether the source of information affects the likelihood of variation.

Table 8: Variation Type Definitions

Variation Type and Definition	
0	Correct code
1	Correct code, incorrect nomenclature e.g., Mam should me mam
2	Correct code, could have more detail e.g., pre when could be mtl, 5 surface filling when clearly written as two separate 3 surface and 2 surface fillings
3	Additional code needed
4	Correct code category but incorrect material e.g., mcf instead of tcf (includes not using uif when only information is radiographical)
5	Incorrect surfaces
6	No surfaces listed when needed
7	Correct code, previous treatment listed e.g., listing all treatment when mam, listing treatment that has clearly been replaced
8	Correct code, wrong tooth (transposing) e.g., 26 mam, 27 tcf instead of 26 tcf, 27 mam (must always have a pair or potentially 3 for molar teeth)
9	Use of non when radiographical information available
10	No code
11	Incorrect code

Each tooth was also assigned a complexity score based on how straightforward or ambiguous the dental data appeared in the dental records (Table 9), this information was also used to assess whether number or type of variation is affected by the complexity of the source material. Finally, the participants written responses to questions regarding the transcription were collated and analysed.

Table 9: Complexity Scores

1	▪ Records contain one code for the tooth (multiple data sources give the same code) ▪ State of the tooth is clearly written/visible with no conflicting information ▪ No cross-referencing between data sources and treatment dates needed ▪ No decision making necessary ▪ Includes when no information is present
2	▪ Records contain more than one code for the tooth (multiple data sources may give a different code) ▪ State of the tooth is clearly written/visible with no conflicting information ▪ No cross-referencing between data sources and treatment dates needed ▪ May have to decide between past treatment and current status
3	▪ Records contain one or more codes for the tooth (multiple data sources may give a different code) ▪ State of the tooth is not clearly written/visible and there is some conflicting information ▪ Cross-referencing between data sources and treatment dates is needed ▪ Some complex decision making required to arrive at final codes (including which data source to assign more importance)
4	▪ Records contain more than one code for the tooth (multiple data sources give different codes) ▪ State of the tooth is not clearly written or visible or there is conflicting information (e.g., a tooth has been mis-charted, and treatment has been recorded on two different teeth where only one exists) ▪ Cross-referencing between data sources and checking treatment dates is required ▪ Complex decision making is required to arrive at final codes (including which data source to assign more importance) ▪ May have to decide between past treatment and current status

Results

Ten participants completed all three cases, providing 30 case transcriptions for analysis. Thirty-two teeth were recorded per case for a total of 96 teeth, each recorded 10 times. Six final-year dental students (BDS) and four Forensic Odontology Graduate Diploma students (GDIP) participated. Descriptive statistics were employed to analyse the data and assess variation. It was decided that, due to the small number of participants, any additional statistical analysis would not be meaningful.

The least amount of dental data available occurred in Case 1, variation from the consensus code was the most at 40.94%. This case had an incomplete dental chart, little detail in the clinical notes and radiographs showed little of the dentition. Participants had to decide between coding ‘present’ and ‘no information’ on the one quadrant that was not charted.

Case 2 had the most codes in the final transcription and was the only case to include all teeth radiographically. Variation from the consensus code was 33.13%. While information was available for every tooth, the panoramic image was 22 years old and with the level of treatment depicted change in the dentition would be expected.

Case 3 had the least variation from consensus code at 28.13%. This case had the most teeth that were recorded as missing or having treatment in the dental records and although in greyscale, it had a complete dental chart. The radiographs, while not the most recent, were the clearest of all three cases.

When dental students were compared to graduate diploma students, it was found that variation occurred in 39.76% and 25.52% of codes respectively (Figure 17). Across all cases, graduate diploma students performed better than dental students.

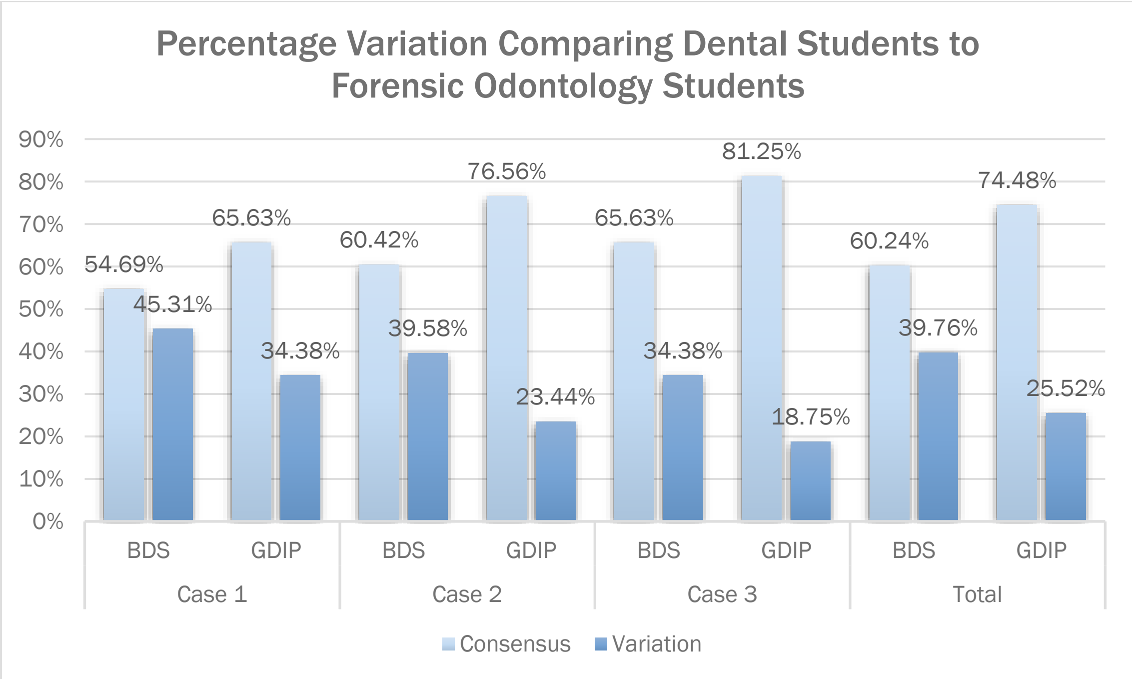


Figure 17: Percentage Variation Comparing Dental Students to Forensic Odontology Students

Each data point (three-letter code and tooth surface) was assessed for consensus. Each code and surface that agreed with the consensus was classified 'correct' and each code that disagreed with the consensus or was a code in addition to the total number of data points for that tooth was classified 'incorrect'. The number of additional codes entered was then calculated by subtracting the correct and incorrect data points from the total data points for that tooth. Figure 18 displays the number and percentage of correct data points as well as the number of additional codes recorded per case. These values and percentages were also calculated to compare experience levels in forensic odontology (Figure 19).

Note: Correct data point percentage was calculated from the total data points in the consensus code, not the total data points provided by participants. Additional data points were those exceeding the number assigned to the consensus code.

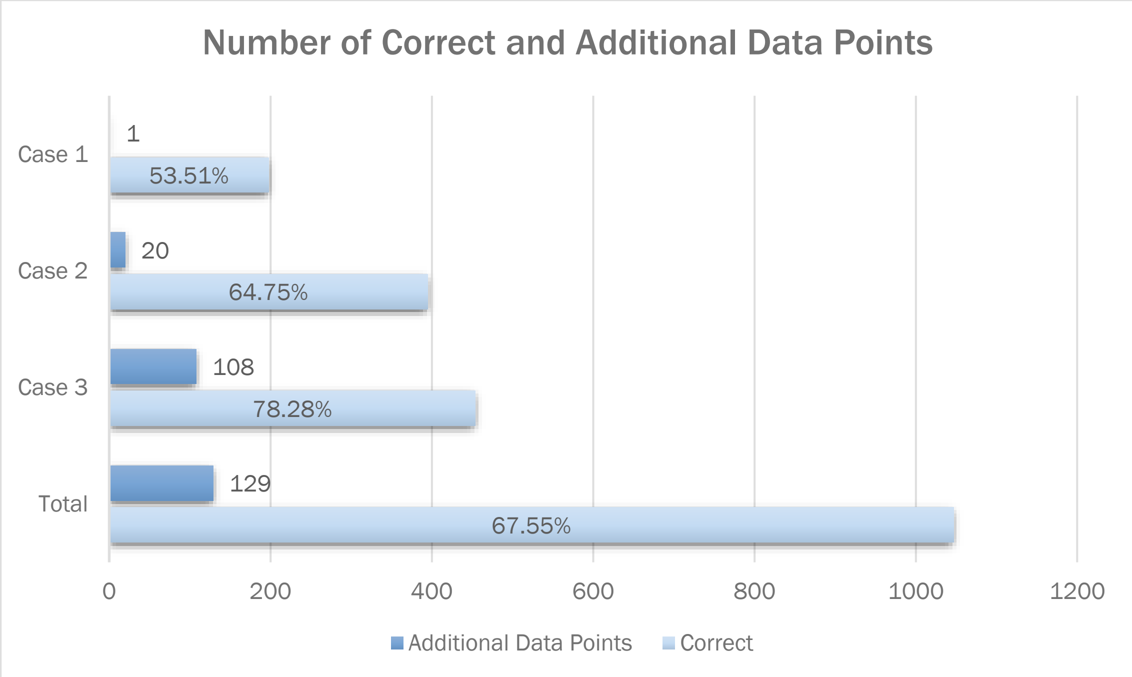


Figure 18: Number of Correct and Additional Data Points per Case

Data Points present in the consensus code for Case 1 – 37, Case 2 – 61, Case 3 – 58, for a Total of 156.

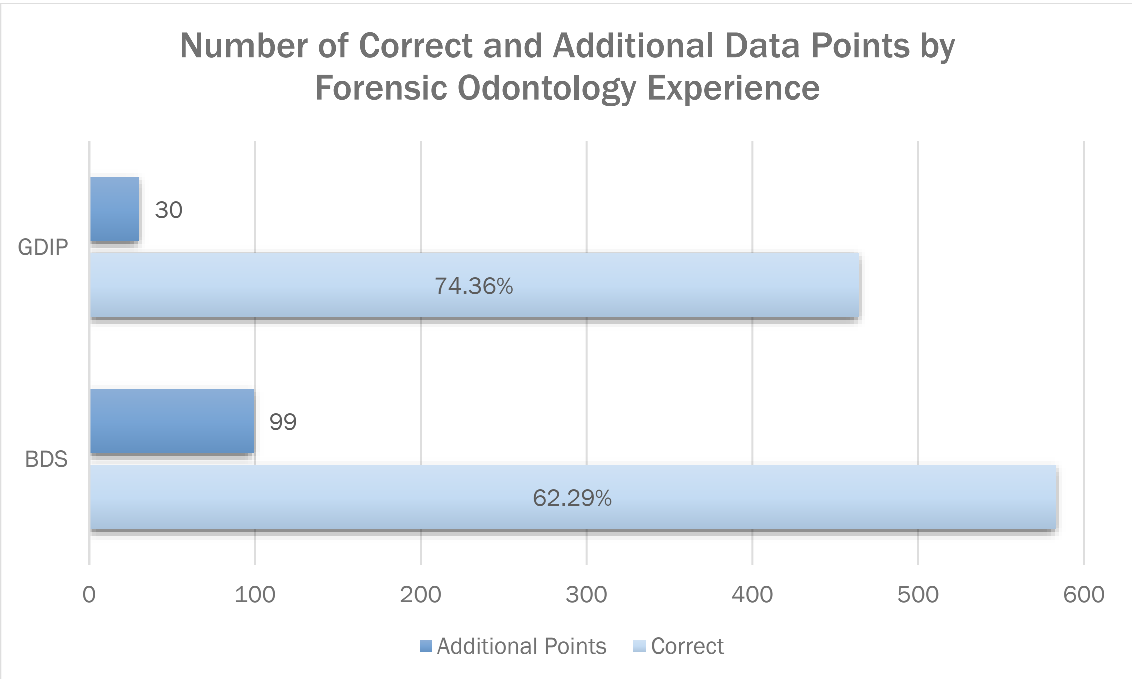


Figure 19: Correct and Additional Data Points by Experience Level

GDIP group consisted of four participants, BDS group had six participants. The total number of data points in the consensus code was 156.

Although the percentage of data points that agreed with the consensus points increased over the cases, so too did the number of additional data points recorded. Graduated diploma students were more likely to supply the correct data points and provided less additional points. Increased accuracy and a decrease in extraneous information is important to the reconciliation phase of dental identification as these superfluous codes makes reconciling discrepancies a more arduous task and may inadvertently cause teeth to be excluded due to a seeming 'decrease' in the extent of treatment.

The percentage of agreement with the consensus was compared to the consensus code for each tooth to determine if variation was affected by the types of treatment or status. It was found that most teeth were recorded correctly when the code was 'mam', or 'pre', but the majority of teeth with the code 'non' were recorded incorrectly. For teeth with restorations or missing tooth structure the number of consistencies and variations were similar in all except 'uif' where the majority did not conform to the consensus code. This indicates more variation when the choice of code requires more detail than whether a tooth is present or not. The number of incorrect or additional data points assigned per tooth was also much higher when further detail was required.

The number of code variations for each tooth in each case was counted. Any nomenclature differences or alternate ordering of tooth surfaces were classified as the same code. For example, Mam/mam, or tcf MODL/tcf DOML. One variation indicates that all answers were the same while 10 variations mean that all answers were different. Figure 20 shows the number of variations per tooth as well as the percentage of times that number of variations occurs. In total, all participants gave the same answer for 25 teeth (26.04%) while all participants gave a different answer for one tooth (1.04%). Most teeth had two variants (46.88%). There is a general inverse trend, with the frequency of variants decreasing as the number of different codes used increases.

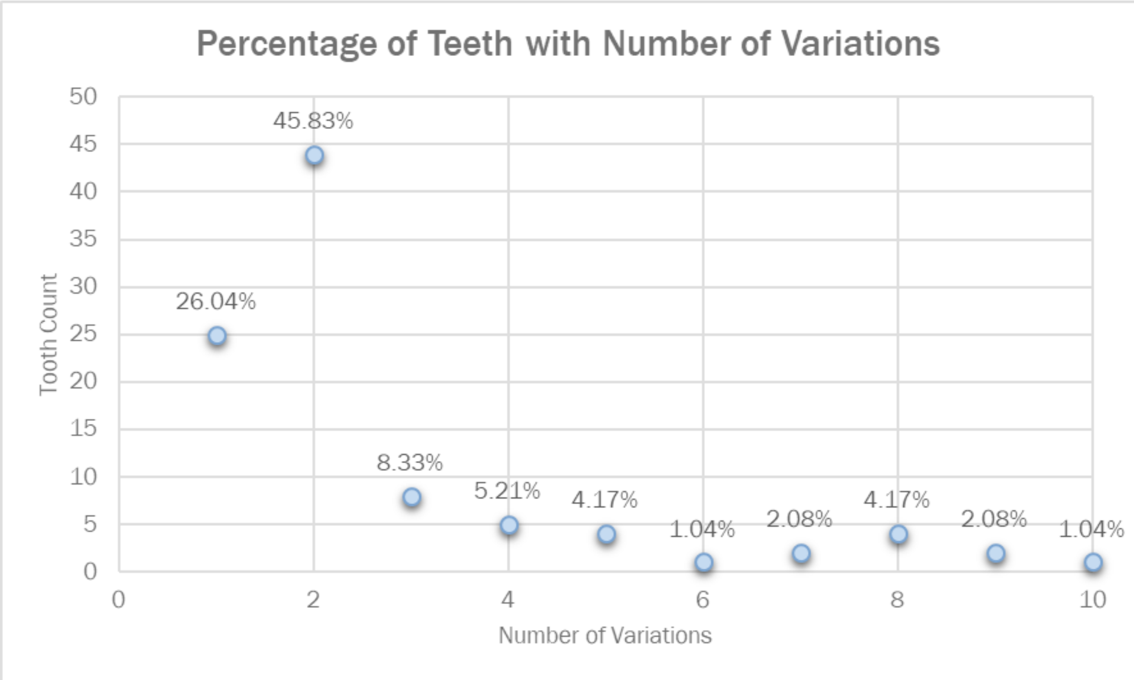


Figure 20: Overall Count of Variation Per Tooth

A corresponding number, or series of numbers (0-11), was assigned to the answers for each tooth based on any difference from the consensus code. The responses for some teeth had more than one variation type. The number and associated percentage of occurrence of each variation type per case, in total and by student type is displayed in Table 10.

Table 10: Count and Percentage of Variation Type

	Case 1		Case 2		Case 3		Total		BDS		GDIP	
	N	%	N	%	N	%	N	%	N	%	N	%
0	165	47.97	199	52.79	210	56.60	574	52.56	289	42.44	285	69.51
1	25	7.27	43	11.41	39	10.51	107	9.80	88	12.92	19	4.63
2	3	0.87	12	3.18	5	1.35	20	1.83	12	1.76	8	1.95
3	1	0.29	12	3.18	13	3.50	26	2.38	16	2.35	10	2.44
4	0	0.00	45	11.94	24	6.47	69	6.32	51	7.49	18	4.39
5	0	0.00	10	2.65	9	2.43	19	1.74	12	1.76	7	1.71
6	25	7.27	12	3.18	6	1.62	43	3.94	43	6.31	0	0.00
7	2	0.58	3	0.80	6	1.62	11	1.01	11	1.62	0	0.00
8	0	0.00	12	3.18	8	2.16	20	1.83	16	2.35	4	0.98
9	0	0.00	6	1.59	0	0.00	6	0.55	6	0.88	0	0.00
10	1	0.29	0	0.00	1	0.27	2	0.18	2	0.29	0	0.00
11	122	35.47	23	6.10	49	13.24	194	17.78	135	19.82	59	14.39

See Table 8 for definitions

Just under two-thirds of the answers were in total agreement with the consensus but approximately 20% were incorrect. Most of the remaining variation was due to nomenclature differences (counted as correct in the binary scoring) or a variation in restorative material recorded. Interestingly, 0.55% of variation was due to recoding no information present when a radiograph was available, which occurred six times in Case 2 by the same student.

Differences in variation were noted between graduate and undergraduate students. The graduate diploma students did not record any type 6, 7, 9 and 10 variations, agreed with the consensus more often and provided the wrong code less often. Although graduate diploma students were more likely to record the correct code, they missed additional or more detailed information (types 2 and 3) more often than dental students.

Of the 96 teeth, 61 were given a complexity score of 1, 27 scored 2, four scored 3 and four scored 4. Tooth data complexity was compared to overall variation (Figure 21). In general, the more complex the data, the more variations occurred. With those teeth having complexity scores of 1 showing lower levels of variation than any other complexity group.

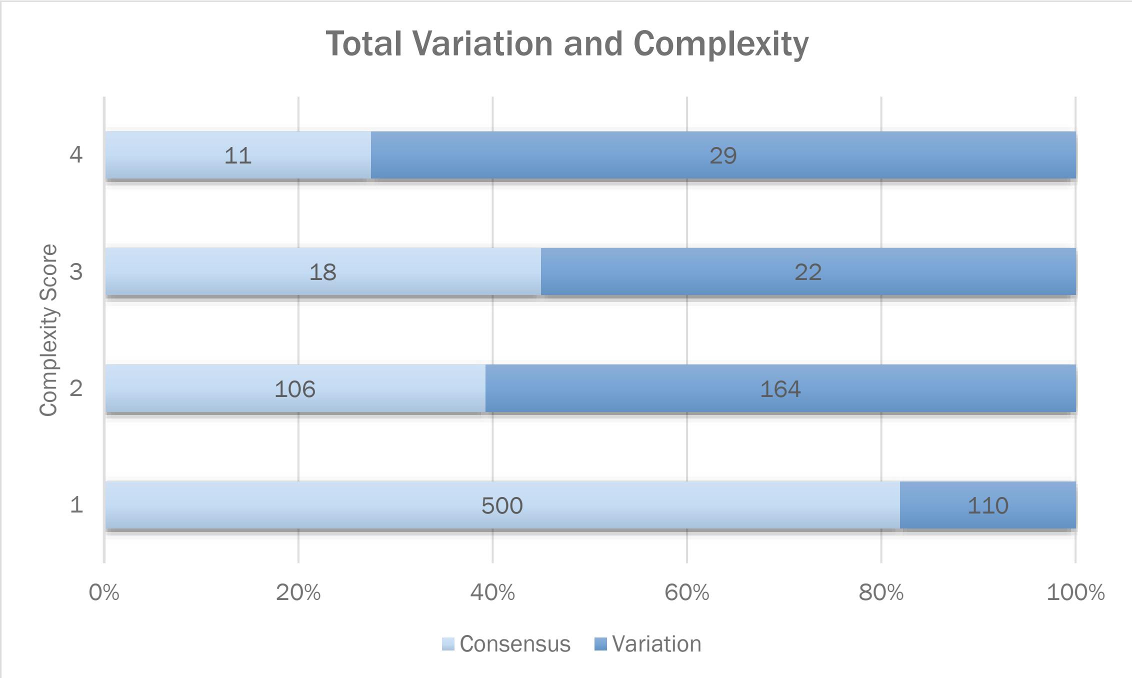


Figure 21: Overall Variation and Complexity

The frequency of variation was compared to the type of dental record in which the information was found. For 34 of the 96 teeth data was obtained solely from charts, two from both written records and charts, 36 from both radiographs and charts, and 24 from all record types. The most variation occurred when information was derived from written records and charts only, followed by chart alone, and the least variation occurred when radiographs were involved. Odontology students showed less variation in data transcription from all record types except for written records and charts where variation was equal between the groups (Figure 22).

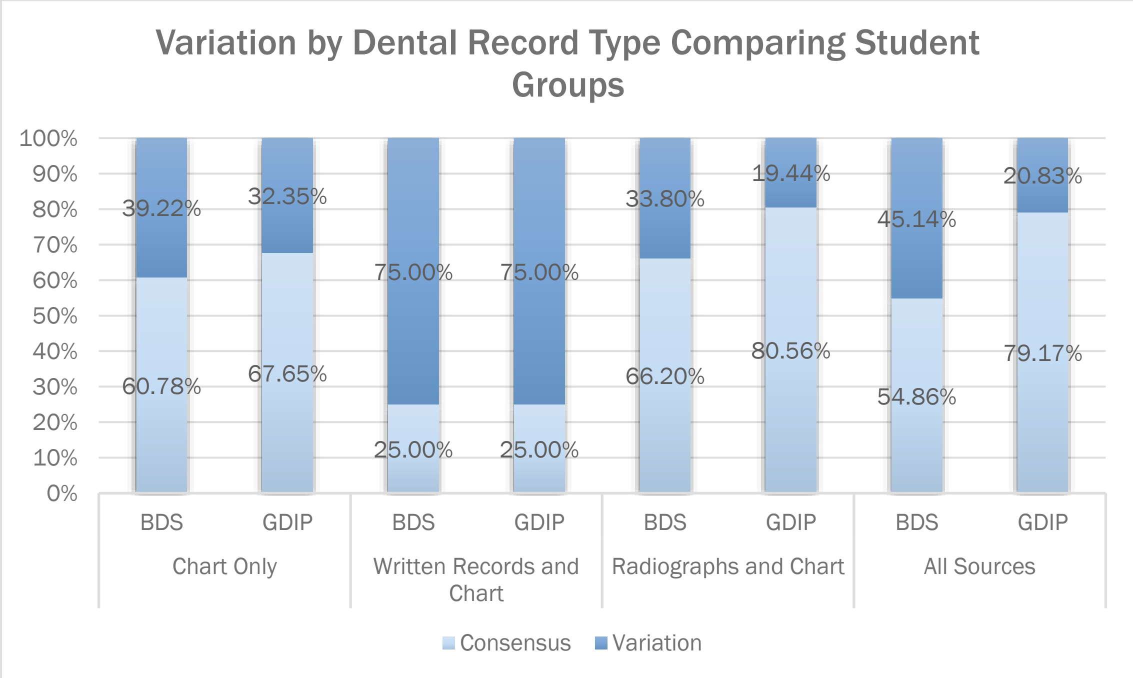


Figure 22: Variation by Dental Record Type Comparing Student Groups

Data source was also calculated as a percentage of consensus and variation codes (Figure 23). The highest percentage of consensus codes were obtained from records including radiographs and dental charts (40.79%). This percentage decreases to 24.41% when all data sources are present. This decrease may indicate that more data sources create more confusion or ambiguity as they do not always agree with each other. Where no radiographs were present in the record, only 34.81% contributed to agreement with the consensus code.

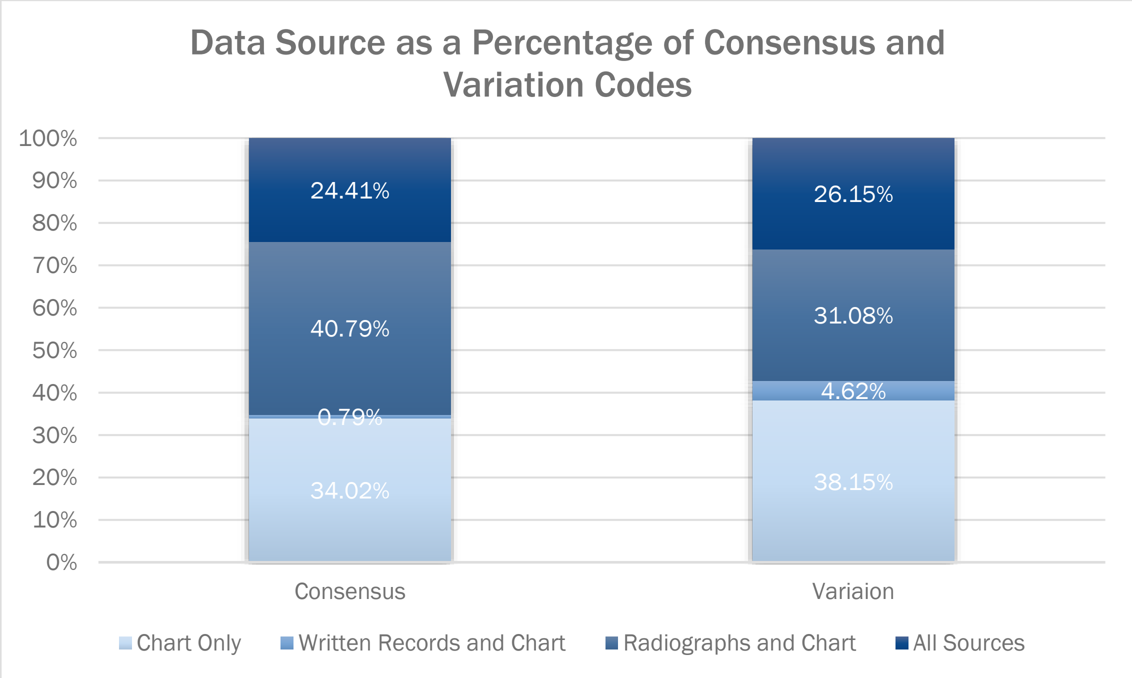


Figure 23: Data Source as a Percentage of Consensus and Variation Codes

After completing each case, participants were asked to comment on the following:

- Which AM data type did you rely on the most?
- Where there any teeth you had trouble with when deciding on a code? Why did you find it difficult?
- Is there any additional information or instruction that would have made the task easier to more understandable?
- Do you have any other comments?

Of the ten participants, nine answered the questions. Data source reliance was summed for each case, there is no clear trend across the cases. Eight of the nine participants relied on written records for cases 1 and 3 and one relied on the dental chart (different participants in each case). Case 2 saw four of the nine participants choose radiographs, three choose the dental chart and two the written records. It is interesting that radiographs were the selected the most in this case but were not chosen for the other cases. This may be because this was the only case to include a panoramic radiograph showing all of the teeth in pictorial form.

Difficulties reported by the participants included being unsure of how to code particular treatments or conditions, not understanding the codes used in the dental records, and trouble determining restoration surfaces from radiographs. Most participants commented on the inconsistent records across all three cases, with particular note of the dental chart in case 1.

The additional information participants would have liked mostly centred around improved detail, accuracy, and amount of information available. Participants would have also liked a legend for interpretation of the dental charts and a more detailed explanation of the difference between INTERPOL codes ‘nad’ and ‘pre’.

Discussion

This pilot study was conducted to assess variation in antemortem data transcription and the influence of dental record complexity. The small sample size limited the statistical analysis possible, however, interesting insights were gained.

One third of codes provided were inconsistent with the consensus code. Inconsistency in code recording would most likely make automatic searching programs less effective. While studies have not explicitly assessed this, it is a sentiment shared by many papers discussing disaster victim identification (Schuller-Götzburg & Suchanek 2007; de Valck 2017; Forrest 2019). Inconsistent codes can cause mismatches putting the correct identification at a lower rank and thus extending the comparison process. Adams and Aschheim (2016) explored the difference between algorithms when using detailed versus simplified coding systems. While they noted that detailed codes performed better even with intentional coding inconsistencies, they discovered for simulated disasters 93.75% of individuals were able to be identified after only 5% of recommended matching records were compared. In their example, this would include 20 comparisons. For a larger population, a comparison of 5% of records (200) would lead to 73.25% matched identifications. When they applied their algorithms to two actual disasters, at the 5% threshold, 68.25% and 70.42% of individuals were matched. Logically, it can be extrapolated that with improved dental record accuracy, antemortem transcription accuracy and standardisation, and code standardisation between antemortem and postmortem, the vast numbers of comparisons required during the reconciliation phase can be reduced.

Inconsistencies in coding may affect the efficiency of matching but actual errors in transcription can lead to errors in reconciliation. This study demonstrated errors in 20% of answers, including recording treatments not provided which may result in an irreconcilable discrepancy leading to exclusion of identity. Potential causes of the errors recorded include:

- General
    - Poor knowledge of treatment codes used in dental records
    - Charting pre when more information is available for the tooth (although this is best practice if unsure about the treatment)
    - Not charting all treatment available in the dental records
    - Charting additional treatment that was not present in the dental records
    - Recording a treatment or status in a sound tooth or a missing tooth
    - Recording teeth as missing when they are present
- Misuse of codes
    - ‘mtl’
        - Chart whole missing teeth
        - Decay not supported by an image

    - ‘non’
        - Teeth missing on a radiograph
    - ‘tcf’ or ‘mcf’
        - Instead of ‘uif’ when information only available radiographically
- Dental chart interpretation errors
    - Assuming material from greyscale chart or one with no colour legend
    - Charting decay as a restoration
    - Charting decay instead of a restoration
    - Heavy reliance on dental chart
- Radiograph interpretation errors
    - Incorrect tooth charted
    - Transposition
    - Not using radiographs as primary data source
- Nomenclature and Charting Convention
    - Not following instructions
    - Writing ‘decay’ instead of using an allowed code followed by a “comment e.g.: tcf V “decay MV
- Extended analysis of records
    - Charting everything written in the notes instead of last known status e.g.: charting a tooth as missing and having a restoration
    - Not combining information from multiple data types to form an answer
    - Not charting information from the most recent data source – not comparing dates
    - Writing treatment for two adjacent teeth that are both recorded as being missing and having treatment when the radiograph shows only one is present

Direct statistical comparison between variation found in this study and the previous studies which comment on variation between practitioners is not possible for various reasons. This study focused on the antemortem phase, using dental records (incomplete set of data) to create a record of the dental status in codes. Other studies used skeletal remains, and various radiograph types of whole dentitions (complete set of records). Some studies compared radiograph types (Kirchhoff et al. 2008; Murphy et al. 2012; Jensen et al. 2020) others compared examiners to each other (Rasmusson & Borrman 1992; Sand, Rasmusson & Borrman 1994) and one used pictorial recording rather than codes (Kirchhoff et al. 2008). However, the types of errors that appeared in each study can be viewed in Table 11.

Three studies (Rasmusson & Borrman 1992; Sand, Rasmusson & Borrman 1994; Leow & Higgins 2020) found that the greatest discrepancies between examiners were the over or under extension of restorations. This study found this to be the second most common variation behind recording treatment or tooth status in a missing tooth. Surface recording errors and not recording restorations or tooth status when present were the two errors reported in all studies. Confusion of teeth or transposition was also a feature found in most of the studies, with premolars and molars being the most at risk (Rasmusson & Borrman 1992; Sand, Rasmusson & Borrman 1994).

Table 11: Comparison of Variation found in Pilot Study and Previous Studies

Study	Variation Pilot Study	Rasmusson and Borrman (1992)	Sand et al. (1994)	Kirchhoff et al. (2008)	Murphy et al. (2012)	Leow and Higgins (2020)	Jensen et al. (2020)
Number of Participants	N= 10	N=12	N=16	N=3	N=2	N=19	N=2
Records Used for Evaluation	Dental Records and Radiographs	Skeletal Remains	Skeletal Remains and Radiographs	CT only (Compared to Panoramic)	CBCT MPR (Compared to Panoramic	PMCT MPR and Panoramic	CT only (Compared to Panoramic
Treatment or status recorded in sound tooth	✓	✓		✓	✓		
No restoration or status recorded when present	✓	✓	✓	✓	✓	✓	✓
Tooth recorded as missing when present	✓		✓		✓		
Confusion of teeth	✓	✓	✓			✓	✓
Treatment or status recorded in missing tooth	✓		✓	✓			
Incorrect filling material	✓					✓	
More or less surfaces recorded	✓	✓	✓	✓	✓	✓	✓
Incorrect restoration type (crown instead of filling)	✓				✓	✓	✓

Experience was also an important factor in variation levels. Graduate Diploma students achieved a higher rate of consistency with the consensus code and lower rates across all other variation types except for missing detail available in the records (types 2 and 3). This is reflective of other studies that assess the variation between practitioners. Kirchhoff et al. (2008) compared the accuracy of a forensic odontologist, a forensic pathologist and a radiologist, finding the odontologist had the best accuracy. Sand, Rasmusson and Borrman (1994) found that dentists had a mean error of 28 in comparison to the student's mean error of 40. Other studies that look at matching radiographs also found that those with more experience made fewer errors, whilst not always statistically significant (MacLean, Kogon & Stitt 1994; Pinchi et al. 2012; Page, M. et al. 2018).

Variation from the consensus code occurred most often when information was found in the written record and chart, or just in the chart. There are a few factors that might have caused this. None of the charts were colour coded and therefore restorations of different materials, and indications of dental caries can all look similar and therefore be confused for one another. Another possible cause is that the participants weren’t familiar with some of the dental codes used, as these describe the materials involved in restorations. Participants also did not change the naming of surfaces to the convention indicated for the study.

The greatest number of different codes recorded occurred when the information was available on the written record and chart, radiographs and chart, or all three sources. A further look at the treatment of these teeth revealed why this is so. For teeth whose data included a radiograph, the largest variations were seen due to nomenclature differences in recording caries and the material and surfaces involved in restorations. For those that did not include radiographs, the variations were due to the combination of number, material, and surfaces of restorations. Variation in the surfaces reported was the most common cause of number of different codes per tooth.

It is generally accepted within the forensic odontology community that radiographs have a higher evidentiary value than written notes or the dental chart due to their more objective nature (Forrest 2019). The dental chart is the most unreliable form of dental data as it depends on input from the treating practitioner and as found in the literature, is often not complete (Hill, IR 1988; Stow, James & Richards 2016; Brown & Jephcote 2017; Stow & Higgins 2019). Assessing accuracy based on the source of the data showed that the answers that most correlated with the odontologists' consensus occurred when radiographs were present. This finding helps support the generally accepted idea that radiographs are the most important and reliable form of dental data. However, most participants revealed that they relied on the other methods more. This could be due to their inexperience with forensic odontology and the knowledge that written records and charts can be flawed, finding the radiographs difficult to interpret or their ability to view multiple records and make determinations of chronology by examining the dates of each data type.

Difficulties and additional information desired during the transcription process can be divided into two categories, those arising at the dental record level and those at the AM transcription level. Of the five issues causing difficulties, only one cannot be addressed at the AM transcription stage. We have no control over the consistency of the records we receive. The other issues, however, can be addressed with definitions of codes, — both of those used in dental records and those used on the standardised forms — and transcription guidelines.

In the additional information section, the opposite is true, only one of these comments can be addressed at the transcription stage, the improvement of definitions and usage of the INTERPOL codes. All other information suggested that could improve the ease of the task or make it more understandable, are issues arising at the dental record level, i.e.: what do chart colours mean, the need for completed charts, radiographs taken should be included within the record, and more accurate records.

While one continuous page of records in date order would be helpful, this does not occur when multiple forms of dental records are available and cannot feasibly be created before assessing the records for dental identification purposes. It is up to the forensic odontologist to be aware of the dates of records and continually cross-check them when deciding on treatment codes.

While a larger data set is necessary to make clear conclusions as to statistical significance, this pilot study provides sufficient information to ascertain areas that can be improved upon, and test if these improvements are successful.

Commonly recurring themes of variation include incorrect coding nomenclature, assuming restoration material from chart or radiograph, missing restorations radiographically when they are not recorded on the chart and transposition of teeth. Additionally, too many or too few restoration surfaces or not recording any surfaces and recording a written note of decay as a restoration or missing tooth structure with no visual indication.

Areas that are the most subjective, and difficult to standardise are those that require decisions based on knowledge of the dental processes, such as correctly naming teeth, judging the presence and extension of restorations from radiographs and deciding if more contemporary treatment overrides or is additional to previous treatment. Twenty instances of transposition were recorded (variation type 8). When teeth of the same class are missing, it can be difficult to decide which tooth remains, especially if there has been movement since extraction. As dental records can often mention two teeth when only one is present, it is up to the examiner to take careful note of what has been recorded, and what can be seen visually and use their expertise in tooth anatomy and oral disease and processes to determine which tooth is most likely present. It is difficult to remove subjectivity from this decision. Guidelines can indicate to choose the tooth based on anatomy and not mouth position; however, this does not remove subjectivity. Previous treatment was recorded along with current treatment or tooth status 11 times (variation type 7), all by the same participant. While this could be a lack of understanding of the instructions, it is an important point to keep in mind that if this occurs it can affect the reconciliation by appearing as though the antemortem tooth has more treatment than postmortem, which will result in a non-match, this is also true of recording more restoration surfaces than are present.

Results also indicate that more education in the field leads to fewer variations in final transcription. An experienced practitioner with an understanding of the variation in dental records and knowledge of dental disease would have a better ability to judge whether clinical notes and dental charts are complete and accurate as this assessment is subjective. Guidelines should highlight that if unsure of the accuracy of data, a code of lesser treatment such as present or no information should be used to prevent erroneous non-matches to postmortem data.

Even with explicit instructions, with free reign to write, differences will occur. A digital entry system that does not allow codes or surface names that differ to the convention would be a simple and effective way of reducing this variation. This would also aid in avoiding the omission of surfaces when they are required by a code, such as for restorations. Surface codes were not provided when required (variation type 6) in 3.94% of instances.
Repeating the study with greater numbers of experienced forensic odontologists would provide an interesting comparison and would be more reflective of the variation in transcription. These results can then be used to compare to a more objective method. This

method must devise a way to reduce the determined causes of variation to improve the reliability and repeatability of the antemortem process and final transcription. Some variation in final transcription could affect the final reconciliation outcome, others will not. The aim of a computer-assisted method is uniformity. The results of this pilot study have highlighted many areas in need of improvement to accomplish standardisation of the antemortem process.

Conclusion

This pilot study aimed to discover the sources of error and variation in antemortem transcription and the impact of the antemortem record on charting differences. It shows that approximately one-third of all answers provided varied from the consensus code. This is not ideal. While it may not lead to an exclusion, during reconciliation with postmortem records this level of variability may lead to slower comparisons, more discrepancies needing explanation or conclusions of less certainty, possible or probable. For a smooth and timely reconciliation, antemortem data of the greatest accuracy and detail are required.

While this study has a limited number of participants, it clearly shows that record complexity and training influence the level of variation. A similar study involving trained odontologists would improve on this knowledge of where error and variation occurs, and if experience affects the consensus rate of dental features reported. This understanding of error and variation will encourage odontologists to be aware of potential shortfalls when conducting their evaluation and analysis of antemortem records.

CHAPTER 5: VARIATION IN ANTEMORTEM TRANSCRIPTION

The pilot study reported in the previous chapter demonstrated the influence of data complexity on the consistency of antemortem transcription and suggested that training was important. While simple nomenclature variation may not affect the identification outcome, transcription errors might cause an erroneous outcome. This chapter evaluates antemortem transcriptions produced by experienced forensic odontologists to determine what variance exists, where it occurs and what might cause it.

Materials and Methods

Participants

- International specialist forensic odontologists were asked to participate in an online transcription exercise
- Due to the anonymous nature of the task, demographic data was not collected

Dental records

- The records to be transcribed were those used for Case 2 in Chapter 4 with slight modification
  - The clinical notes were copied into an electronic format
  - The two charts were combined to make one, partially complete, monochromatic, handwritten dental chart
- The number of data points recorded for each tooth and the dental record source of each point was calculated for the consensus. A data point was counted as each three-letter code and each tooth surface including * for unknown, for example, tcf MODL tcf DV ppx is a total of nine data points and uif M is two data points

- Whether or not the different dental record types were consistent for each tooth was also documented
- A level of complexity, based on the perceived ambiguity of the information in the record, was assigned to each tooth using a scale described in the previous chapter (See Chapter 4, Table 9, page 100 for definitions of categories)

Participant instruction

The odontologists were provided with a participant information sheet, the case records, and a fillable pdf input sheet. They were advised that the dental records used FDI notation and to use the modified INTERPOL coding list provided when completing the form. Participants were also asked a series of questions after they completed the transcription (Table 12).

Table 12: Post-transcription Questions

1	Which AM data type did you rely on the most?	Written Records Dental Chart Radiographs
2	Where there any teeth you had trouble with when deciding on a code? Why did you find it difficult?	
3	Is there any additional information or instruction that would have made the task easier or more understandable?	
	Questions Regarding General Casework	
4	Do you give dental records an evidentiary value before you transcribe them? (Quality they will provide to a potential comparison?)	Yes – unofficially Yes – part of standard operating procedures No
5	Do you think any of these data sources have a higher evidentiary weighting that the others? (In terms of accuracy of data in AM information only)	Written Records Radiographs Dental Chart Dental Casts Photographs CT
6	Why/why not?	
7	Do you have any other comments?	

Data Analysis

- Variations from the consensus code were noted and categorised into types as described in Chapter 4, Table 8 on page 99
- The number of different responses per tooth was calculated, one variation indicates that all codes for the tooth were the same, 22 variations, all codes were different
- The number of data points recorded by each participant for each tooth was calculated
- To assess transcription error rather than the way the codes were written all type 1 variations were combined with type 0, including incorrect use of capitalisation, punctuation, record dates and anything after double quotation marks. The order of surfaces for restorations was also not considered a variation, for example, tcf MO and tcf OM would be counted as the same answer. However, tcf MO and tcf M* were counted as separate variations
- The correlation between record complexity, number of data points and error was examined

Results

Twenty-two international-forensic odontologists responded to the questionnaire. Due to the anonymous nature of the task, it is unknown where these odontologists practice.

Dental records

Most teeth had only one data point in the consensus code, the maximum number of points was nine which was seen in one tooth. Twenty of the 32 teeth showed agreement across dental record types. Of the 12 teeth that showed disagreement across record types, seven had only one data point, the rest had two or more (see Table 13 for details).

As a dental chart represents all 32 teeth it is considered that teeth with no notation are present. Only half of the teeth (16) had treatment or status recorded. Ten teeth, or their anatomic location, appear in radiographs twice and information regarding seven teeth could be found in the written clinical record.

Table 13: Dental Record Content and Code Summary

Tooth (FDI)	Consensus Code	Data Source	Data Points [a]	Complexity Score [b]	Record Consistency [c]
18	mam	CH^ XRAY	1	1	Agree
17	pre	CH^ XRAY	1	4	Disagree
16	mam	CH XRAY	1	4	Disagree
15	pre	CH XRAY	1	1	Agree
14	pre	CH XRAY	1	1	Agree
13	pre	CH XRAY	1	1	Agree
12	pre	CH XRAY	1	1	Agree
11	uif M	CH XRAY	2	2	Disagree
21	uif M* uif D*	CH XRAY^^	6	2	Disagree
22	mam	WR CH XRAY^^	1	2	Disagree
23	mam	WR CH^ XRAY^^	1	1	Agree
24	uif MO* mtl D*	CH XRAY^^	7	2	Disagree
25	uif DO	CH^ XRAY^^	3	1	Agree
26	uif O	CH^ XRAY^^	2	1	Agree
27	uif O	CH^ XRAY	2	1	Agree
28	une	CH^ XRAY	1	3	Disagree
38	mam	CH^ XRAY	1	1	Agree
37	mam	CH^ XRAY^^	1	2	Disagree
36	mam	WR CH^ XRAY^^	1	1	Agree
35	mam	WR CH^ XRAY^^	1	3	Disagree
34	uif DO uif MO	CH^ XRAY^^	6	2	Disagree
33	pre	CH XRAY	1	1	Agree
32	pre	CH XRAY	1	1	Agree
31	pre	CH XRAY	1	1	Agree
41	pre	CH XRAY	1	1	Agree
42	pre	CH XRAY	1	1	Agree
43	pre	CH XRAY	1	1	Agree
44	pre	CH XRAY	1	1	Agree
45	mam	WR CH^ XRAY	1	1	Agree
46	mam	CH^ XRAY	1	1	Agree
47	tcf MODL tcf DV ppx	WR CH^ XRAY	9	3	Disagree
48	mam	WR CH^ XRAY	1	2	Disagree

Note. WR – Written clinical record. CH – Dental Chart. XRAY – Radiographs.

[a] Number of three-letter codes and individual tooth surface codes. [b] Complexity Score assigned to each tooth based on ambiguity of dental records. [c] Whether data concerning the tooth was consistent across all sources in which it appeared in the records.

^ Treatment or status recorded on the dental chart. ^^ Appeared in more than one radiograph.

Participant responses

Variation from the consensus code across all participants was 25.99%, individually, variation ranged from 3.13% (one code) to 46.88% (15 codes) as displayed in Figure 24.

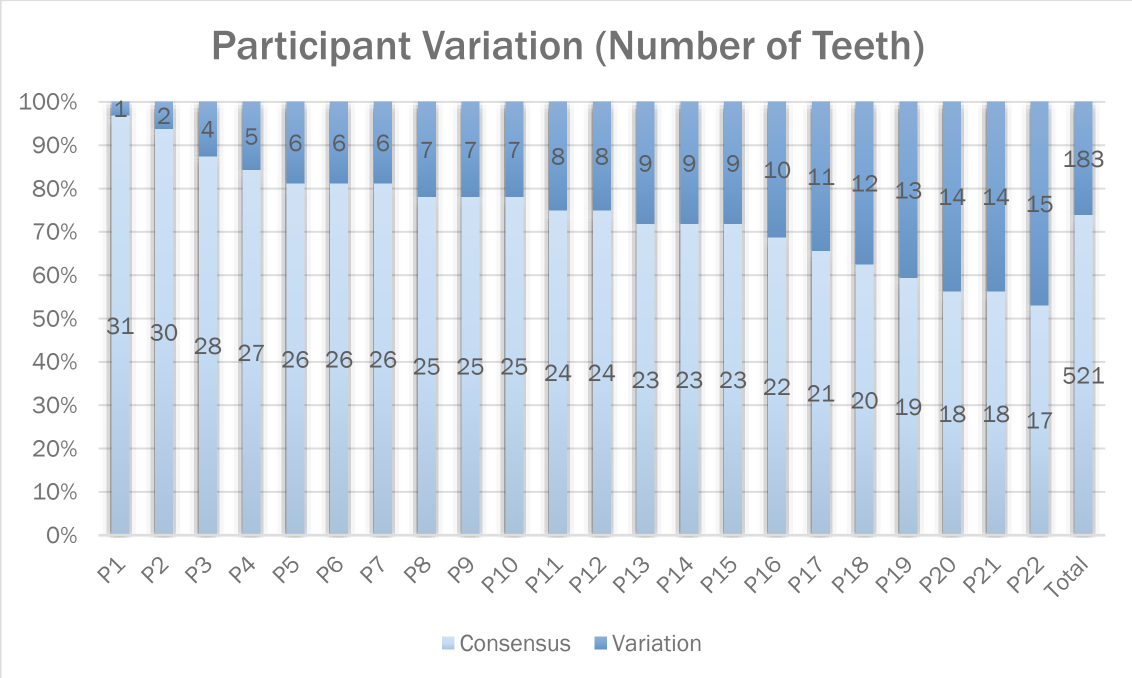


Figure 24: Participant Variation

Across all participants, agreement with consensus and nomenclature variation occurred at 38.85% and 35.04% respectively, this shows an overall agreement with the consensus of 73.89%. The frequency of each variant is documented in Table 14.

The most frequent variation was type 4 (10.10%) – correct code category, incorrect material. In all cases but one, this was due to a failure to use ‘uif’ (unidentified filling) when charting from a radiograph as instructed. The one exception was the recording of a metal-coloured filling instead of a tooth-coloured filling.

Table 14: Frequency of Variation Types

	Variation Type	Participant Count and Percentage	
		N	%
0	Consensus agreement	296	38.85
1	Different nomenclature	267	35.04
2	More detail available	14	1.84
3	Additional code missed	22	2.89
4	Incorrect material	77	10.10
5	Incorrect surfaces	20	2.62
6	No surfaces when required	0	0
7	Previous treatment recorded	3	0.39
8	Transposition	22	2.89
9	Incorrect use of 'non'	0	0
10	No code	0	0
11	Incorrect code	41	5.38

Transposition occurred in 2.89% of cases, most concerning the upper right molars, 17 and 16. While the dental chart indicates the 17 is missing, it is evident from the radiograph that it is in fact the 16 that is missing and 17 is present. Two participants also transposed treatment between the lower molars 37 and 47.

For each tooth at least one variation from the consensus was recorded, the highest number of differences was 21, which occurred twice. Most teeth had 4 or less variations.

For each tooth, Table 15 displays data from the dental records including number of data points in the consensus code, the complexity score, and whether information was consistent across record types. Also displayed is the data collected from participants including the average number of data points and different codes per tooth, and the percentage of those responses that agreed with the consensus code.

Table 15: Comparison of Data Points, Number of Different Codes and Variation Per Tooth

Tooth	Consensus Code Data Points [a]	Complexity [b]	Record Consistency [c]	Average Data Points Recorded [d]	Different Codes [e]	Consensus Agreement [f]
14	1	1	Agree	1	7	68.75%
13	1	1	Agree	1	7	68.75%
38	1	1	Agree	1	3	68.75%
36	1	1	Agree	1	2	68.75%
32	1	1	Agree	1	7	68.75%
31	1	1	Agree	1	7	68.75%
41	1	1	Agree	1	7	68.75%
43	1	1	Agree	1	7	68.75%
44	1	1	Agree	1	7	68.75%
46	1	1	Agree	1	3	68.75%
18	1	1	Agree	1	3	65.63%
23	1	1	Agree	1	4	65.63%
45	1	1	Agree	1	3	65.63%
15	1	1	Agree	1	7	62.50%
12	1	1	Agree	1	8	62.50%
22	1	2	Disagree	1	5	62.50%
35	1	3	Disagree	1	5	62.50%
33	1	1	Agree	1	9	62.50%
42	1	1	Agree	1	10	59.38%
48	1	2	Disagree	1	6	59.38%
28	1	3	Disagree	1	10	56.25%
16	1	4	Disagree	1	5	40.63%
17	1	4	Disagree	1	8	34.38%
21	6	2	Disagree	4	21	31.25%
37	1	2	Disagree	4	15	25.00%
11	2	2	Disagree	2	12	21.88%
25	3	1	Agree	3	7	21.88%
27	2	1	Agree	2	8	21.88%
47	9	3	Disagree	7	15	18.75%
26	2	1	Agree	2	9	15.63%
34	6	2	Disagree	5	18	15.63%
24	7	2	Disagree	4	21	9.38%

Note. Columns within the box represents data found in the dental records, columns to the right are participant responses and associated data.

[a] Number of three-letter codes and individual tooth surface codes. [b] Complexity Score assigned to each tooth based on ambiguity of dental records. [c] Whether data concerning the tooth was consistent across all sources in which it appeared in the records. [d] Average number of three-letter codes and individual tooth surface codes recorded across all participants. [e] Differing codes for each tooth (1: all the same code 22: all recorded different codes). [f] Percentage of agreement where nomenclature differences were counted as correct codes.

Consistency with the consensus was higher when there was only one data point in the consensus code and the average number of data points recorded. Additionally, most of these teeth had information consistent across the data sources.

Consistency with the consensus was lower when the recording of tooth surfaces was required, resulting in higher numbers of different codes being recorded. For these teeth there were also a higher number of data points and disagreement between data sources.

As seen in Table 16 when consistent information was found in all three data types 96.97% of answers agreed with the consensus code, but when the three data types disagreed, this went down to 73.86%. When the information was only found in the chart and the radiographs, but they were consistent, 84.76% agreed with the consensus, which decreased to 42.61% when the data sources disagreed.

Table 16: Variation from the Consensus Code based on Record Type and Consistency

Data Type and Agreement	Consensus	Variation	Total
All Record Types	**129**	**25**	**154**
Agreed	64	2	66
Disagreed	65	23	88
Chart and Radiographs	**392**	**158**	**550**
Agreed	317	57	374
Disagreed	75	101	176
Total	**521**	**183**	**704**

Participants were more likely to record a code agreeing with the consensus when the complexity score of that tooth was 1 (86.59%). Interestingly a complexity score of 2 resulted in less consensus (46.75%) than complexity score 3 (68.18%) and 4 (54.55%) as shown in Figure 25.

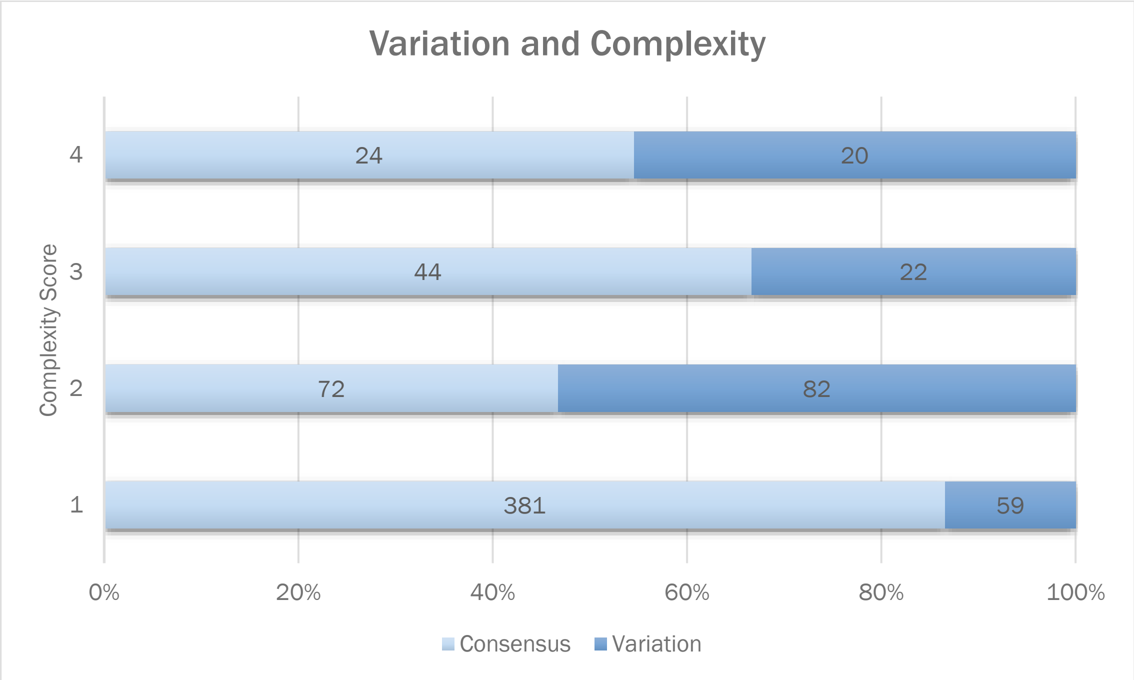


Figure 25: Variation by Complexity Score

Odontologist Opinions

Odontologists were asked a series of questions after they completed the transcription. The first set of questions was regarding the case at hand. Most participants recorded that they relied on radiographs as the primary source of information, none chose the dental chart, and one participant did not answer the question (Figure 26).

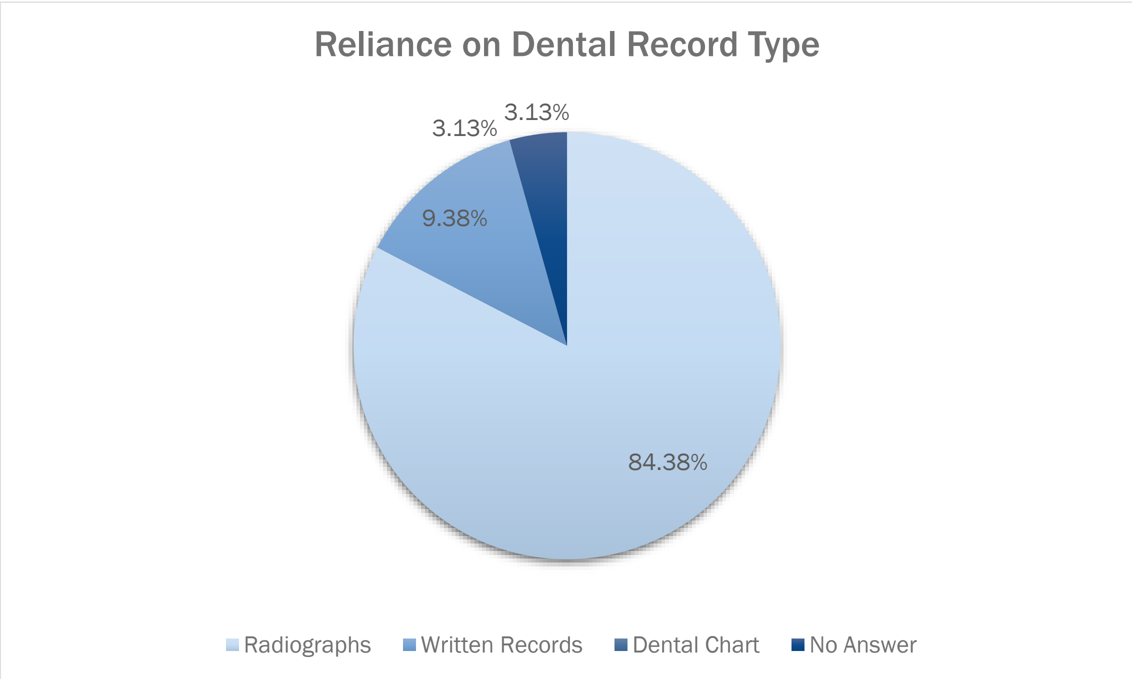


Figure 26: Participants' Reliance of Dental Record Types

Question 2 asked: Were there any teeth you had trouble with when deciding on a code? Why did you find it difficult? Answers are summarised in Table 17. Most of the issues arose from discrepancies between the written information, chart, and radiographs, with a few issues arising from difficulty in interpreting information from poor quality radiographs, or from the angle they were taken.

Table 17: Issues Arising from Conventional Method

Participant Difficulty	No. of participants
16/17 Transposition	10
24	2
22/23	3
Questioned 47 or 37 mentioned in records	3
Difficulty deciding whether teeth were restored or present or not from panoramic radiograph	5
Difficulty in assessing restorations based on radiograph angles	2
Comment on deciding between ‘pre’ from 1999 and ‘non’ from 2017	1
Noted the discrepancy between chart and OPG for 28 ‘une’	3
Missing treatment records due to changes between 1999 and 2017	2
Noted error in records referring to 46 as 36	1

Three participants mentioned the need to use ‘uif’ when the information is only on the radiograph and one also mentioned recording the lesser treatment if in doubt, and vestibular and lingual surfaces should not be assumed from radiographs.

Two participants mentioned they thought there was an error in the records with the tooth described as 47 being the 37. Based on the treatment visible in the 1999 radiograph, this is a safe assumption. However, the written record describing treatment on the 47 was created in 2017, with a radiograph taken two months prior showing the 37 as missing.

Ten participants commented on the potential for the 16 and 17 to have been recorded incorrectly, and four mentioned they decided on the 17 as being present from the radiograph. Of the ten that mentioned the potential error, seven correctly coded the 17 as present and the 16 as missing. Overall, 12 participants recorded it this way and ten coded 17 as missing and 16 as present.

One participant picked up that the 36 was mentioned in the notes regarding the fourth quadrant and commented that they assumed it was supposed to say 46.

Question 3 asked: Is there any additional information or instruction that would have made the task easier or more understandable? Table 18 summarises the responses, which indicate a desire for more detailed, up-to-date, and complete dental records, whether written, chart or radiographs. Again participants suggested using the lesser treatment code for AM data, not guessing the restoration type and only specifying if it is in the written records and not assuming surfaces V or L from radiographs, but rather adding a comment after the code. Another participant suggested an interesting addition to the transcription form: “An entry box on the chart page itself allowing for indication of the last recorded data for each tooth would make it easier to determine the possibility of natural/disease-related tooth loss against time”.

Table 18: Additional Information Desired by Participants

Additional Information Desired	Number of participants
Intra-oral photographs	3
Better quality or more recent radiographs	4
More written records	4
Date on odontogram	4
Complete odontogram	2
Odontogram legend or colour version	2
Always use lesser treatment code in AM	1
Don’t guess restoration type, only use if noted in written records	1
Don’t guess V or L from radiograph add as comment after	1

General Casework Questions

Eighty percent of all participants evaluate the value of the dental records, with half of these having the requirement as part of their standard operating procedures. Radiographs were almost unanimously selected as the record type with the most evidentiary value. Figure 27 shows the percentage of participants who chose each data type (more than one could be selected).

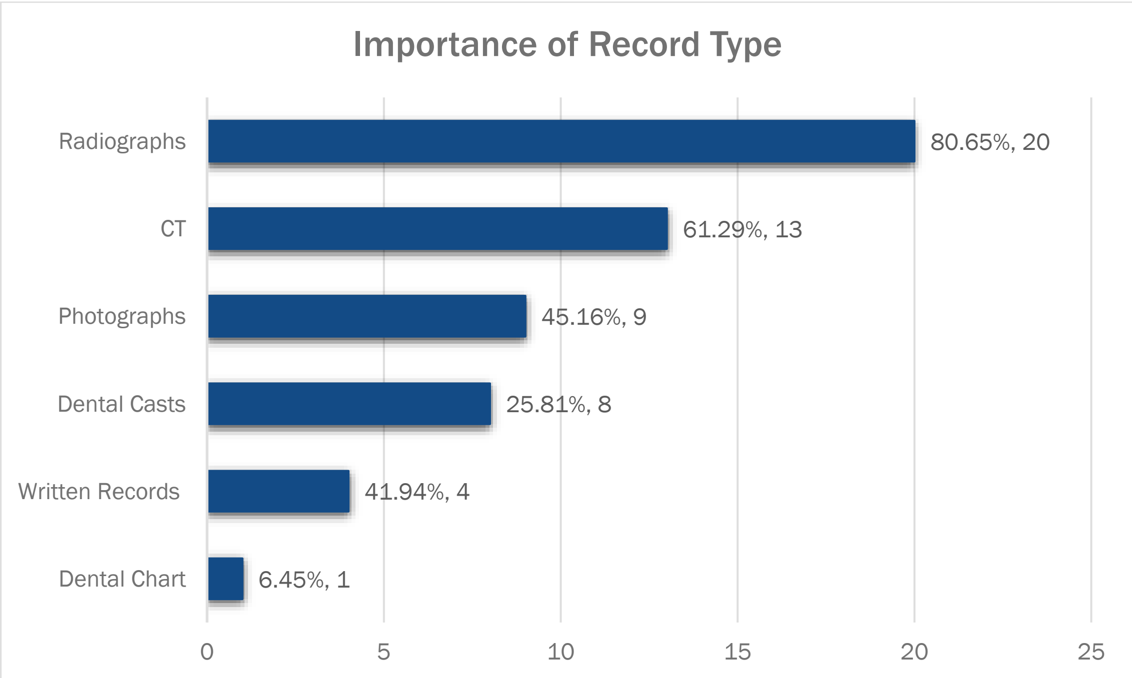


Figure 27: Evidentiary Value of Dental Record Types

Participants were then asked to comment on their choices. Table 19 shows a breakdown of the responses to each data type. Participants commented on both the advantages and disadvantages of the different data types.

Table 19: Advantages and Disadvantages of Dental Record Types

Data Source	Advantages	Disadvantages
Written Records	Provide specific information such as restoration material and surfaces (1) Accurate records instrumental for good AM data (1)	Omissions/errors/Opinion/ Subjective (9)
Radiographs	No human errors/Trueness of the source/Objective (4) Image of features at the time they are taken (4) (Or CT) Mandatory for an established ID (1) Good quality instrumental for good AM data (1) Direct visual comparison (2) Shows information not visible intraorally (1)	Limitations: currency and area covered (1)
Dental Chart		Omissions/errors/Opinion/ Ambiguous/Subjective (10)
Dental Casts	No human errors/ Objective (2) Capture information on that date (1) Direct visual comparison (1) Sometimes restorations are visible (1) Useful for special characteristics (1)	Major changes may follow their creation (1) Don't show enough detail (1) Often not labelled or dated (1)
Photographs	No human errors/Trueness of the source/Objective (3) Capture information on that date/record of a point in time (1) Direct visual comparison (1)	
CT	No human errors/Trueness of the source (2) Image of features at the time they are taken (4) (Or radiographs) mandatory for an established ID (1) Direct visible comparison (2)	Limitations: currency and area covered (1) Rarely available AM (2) Scatter with metal restorations (1)
All sources	All sources should be assessed on their merits and considered in every case (1) All elements of the dental record have value in providing data for an ID. Giving one more importance can lead to dentists being advised to provide just those elements (1) All have value depending on quality, quantity and currency and likely ability to be compared to AM data (1) All have more or less value, best way is to use them all if available (1)	

Discussion

The aim of this study was to examine antemortem dental data transcription performed by expert forensic odontologists to gain an understanding of the frequency and likely causes of variance in the creation of odontograms for human identification purposes.

Nomenclature differences accounted for 35.04% of variation type, when they were included in the consensus there was still 25.99% variation. While the identification conclusion may not be affected by nomenclature differences, reaching it can be problematic. In the case of a mass disaster, when there is reliance on a computer to sort through antemortem and postmortem forms variation may cause the algorithm to skip over potential ‘matches’ as the codes are different, even though what they represent is the same. These differences also increase the challenge for the odontologist when it comes to reconciling the two sets of data. It is important to note that the participants are all experienced forensic odontologists who are familiar with INTERPOL codes, and they may not have read the directions carefully and may be used to using other versions of the codes which could account for the number of nomenclature differences recorded.

Ten teeth were more often recorded as a variation from the consensus code and, these teeth also recorded a higher number of variations between participants and a higher number of data points in the consensus code. Most differences were caused by assuming the restoration material used from the radiographic image. While this is based on experience and may be a safe assumption most of the time, different materials have varying radiodensities and through regular casework, it has been shown that these assumptions are not always correct. In the case of a mass disaster, this could have major implications on software sorting and the efficiency of reconciliation. Recording teeth as present when more information is available, or incorrect surface selection suggests difficulty in interpreting radiographs when they are the only source of information for restorations. When the dental chart also recorded the restorations present, participants still recorded different tooth surfaces which may indicate the odontologist's reluctance to trust a dental chart. Recording previous treatment from radiographs and not cross-checking dates of written treatment also led participants to assume transposition of teeth rather than continued dental treatment of the same tooth.

Frequency of agreement with the consensus code based on the number of data sources and their consistency suggests that while more information sources are better, whether they agree with each other or not is more of a predictor of whether the final code will be accurate.

Anecdotally, it would be expected that complexity would affect the accuracy of the final codes recorded. However, there was more agreement with the consensus code for teeth with a complexity score of 3 and 4 than there was for a complexity score of 2. On closer examination, teeth that were given a complexity score of 2 were those that were recorded on the chart and radiographs only, which recorded different information and involved restorations. Complexity scores 3 and 4 were assigned to teeth that had differing treatment on all three record types or required some cross-checking of dates and knowledge of tooth anatomy and correct naming, however, the final code was a simpler ‘pre’, ‘mam’ or ‘une’. The score was based on my own knowledge and experience as currently there is no scientifically researched method for assigning complexity. The complexity scale assigned, as I defined it, was a measure of difficulty in interpreting the records, not the complexity of the treatment they represented. These results show that complexity also arises from having to assign surface codes without written information and when the number of data points required is higher. Other explanations include skewed results due to the small number of participants, or complexity of the records themselves has no effect. Further research including more participants and more variety of dental records is required to further evaluate the effect of dental record and treatment complexity.

The odontologists who participated in this research favoured visual representations of the dental status over written ones. While each has its advantages and disadvantages, visual representations, in particular radiographs, show a snapshot of what the dentition looked like at the time and are not subject to human error. These sentiments agree with previous studies that describe written records as subjective interpretations with shorthand and varying notation systems which often include errors (Keiser-Nielsen 1980; Whittaker & MacDonald 1989; Clement 1998; Forrest 2019). Dental charts can also contain errors and with no legend to explain the variable symbols and colours used in different software, can lead to a lack of information (Whittaker & MacDonald 1989; Capitaneanu 2021). Radiographs are objective, visually recording what is present with a high specificity (Forrest 2019; Mitsea, Karayianni & Tsiklakis 2021) but care must be taken in interpretation, such as the vestibular or lingual restoration surfaces (Keiser-Nielsen 1980), CTs are also a highly valued data source as they provide a 3D representation and can simulate radiographs (Forrest 2019).

Forensic odontologists can analyse antemortem records and determine which elements are complete and where errors are present. However, in this study, it was determined that in some instances they can also assume errors where there are none due to the lack of information present in the records. Odontologists' answers to the question asking about additional information also indicate that a lot of data that would help with dental identifications are not often present in a dental record. Incompleteness is the most common cause of a lack of information (Keiser-Nielsen 1980; Clement 1998; Stow & Higgins 2019). This highlights the importance of complete and accurate records from general and specialist dental practitioners.

Limitations

This study involved a small sample size of 22 participants completing one antemortem transcription. A variety of cases with different data content would improve results and provide more insight into how odontologists analyse data, where variations occur and improve our ability to standardise the process.

As participants were international and the dental records used Australian Dental Association treatment billing codes, some variation may be due to not understanding what these codes represent. Additionally, billing codes can change over time and old codes may not be recognised. This highlights the importance of engaging odontologists from the country of origin for victims of mass disasters or providing a glossary of terms likely to be encountered.

Conclusion

Variation in antemortem transcription between odontologists is evident when given the same information, no two participants provided the same final codes for each tooth. Most differences were due to varying ways of describing the same tooth status and assigning material type and restored surfaces from radiographs. These variations may impact the efficiency of searches in disaster situations and cause odontologists to have to decipher codes for their final reconciliations. Some of these variation types can be improved through standardisation and better guidelines in the use of codes. However, some variation types, namely those that rely on subjective interpretation, can never be completely removed.

A set of standardised codes, guidelines, and a method to implement them would likely reduce the variation based on nomenclature and may also improve variation in the description of restorations and their surfaces.

CHAPTER 6: AUTOMATION AND STANDARDISATION OF ANTEMORTEM TRANSCRIPTION

‘Standards reduce variability resulting from the idiosyncratic tendencies of the individual examiner’ – National Research Council, 2009

The primary goal of this study is to develop a protocol for creating accurate and reproducible collated antemortem dental datasets. This relies upon reducing the subjectivity of the antemortem transcription process. Transcription includes the evaluation, analysis, interpretation, and collation of the data from dental records into a standardised format. Basic instructions currently exist for this process, e.g.: IOFOS body identification guidelines (IOFOS 2017, 2018) and INTERPOL's DVISys code definitions. However, there is no detailed guidance for ambiguous, incomplete, or incorrect records, or detailed definitions of similar codes and when they should be employed. Hence traditional methodologies rely heavily on training and experience, which can be problematic in the event of a mass disaster, where general dental professionals help transcribe multiple cases which can include international dental records. More detailed definitions of the dental codes, concise specific instructions (particularly when deciding on ambiguous information) and alerts for missed or incompatible entries would facilitate consistent transcriptions even for novice practitioners, improving accuracy. Another avenue for improvement is to increase the objectivity of the process, decreasing the chance of human error. This can be facilitated using a computer-assisted method.

This chapter investigates current dental identification related software and dental recording guidelines used in previous clinical studies. Guidelines for clinical studies aim to calibrate the operators gathering the data and is therefore a good place to start for improvement of standardisation. Properties and procedures discovered will form a basis for AM evaluation and transcription specific protocols, adapting them where required to suit forensic purposes.

Current Programs

Software has been developed to aid the forensic odontologist in matching antemortem and postmortem dental information to expediate identification for both single cases and multiple casualty events. Software programs noted in the literature are presented in Table 20 (Anuja & Doggalli 2018; Loomis 2018). While each system has varying capabilities, and uses different coding methods and searching algorithms, their purpose, from a dental point of view, is the same. Essentially they store, sort and match antemortem and postmortem records (Al-Amad et al. 2007).

Data entry varies among the programs, some allowing keyboard code entries and others only allowing use of the mouse (Torpet 2005; Al-Amad et al. 2007). Restrictions are placed on the codes that can be entered to ensure uniformity and comparability of AM and PM data sets (Torpet 2005). Secondary codes or free text entry is also available in some programs. Searches are performed providing the best possible matches between AM and PM data (Al-Amad et al. 2007; Adams & Aschheim 2016), a timely and objective way to supply the odontologist with records to compare when a database can contain hundreds or thousands of missing persons and unidentified bodies.

Table 20: Dental Identification Computer Software

CAMPI	<u>Computer-assisted postmortem identification</u> ▪ First program of its type, developed in 1980s and used by USA military and forensic odontologists ▪ Comparison of dental codes from AM and PM records produces a list of possible matches for manual comparison by a forensic odontologist
WinID3	<u>Windows Identification 3</u> ▪ Expanded version of CAMPI ▪ Used in numerous mass disasters in the USA ▪ Compares all AM and PM records against each other and provides a list of possible matches ▪ Displays tables with most dental hits, least dental matches, most restoration hits, and most identifier matches ▪ Does not eliminate data with explainable differences ▪ Manual comparison by a forensic odontologist is required to form an identification conclusion
ADIS	<u>Automated Dental Identification System</u> ▪ Developed in Japan ▪ Designed for accurate and timely identification with minimal human intervention ▪ Searches to find dental records that have a number of similarities based on image comparison ▪ Manual comparison by a forensic odontologist is required to form an identification conclusion
DVISys	<u>Disaster Victim Identification System International</u> ▪ Developed in Denmark and used by INTERPOL for disaster victim identification, including the Boxing Day tsunami in 2004 ▪ Used for DVI and missing persons databases ▪ Involves all disaster identification disciplines ▪ Searches for similarities between AM and PM databases and labels codes as match, potential match and non-match ▪ Provides a list of potential matches based on these results ▪ Manual comparison by a forensic odontologist is required to form an identification conclusion
UVIS/UDIM	<u>Unified Victim Identification System/Dental Identification Module</u> ▪ Used for DVI and missing persons databases ▪ Involves all disaster identification disciplines ▪ Dental component developed in consultation with forensic odontologists in the USA ▪ Dental search and comparison system, displays explainable and unexplainable discrepancies ▪ Manual comparison by a forensic odontologist is required to form an identification conclusion
DAVID Web	<u>Disaster and Victim Identification</u> ▪ Developed in Melbourne, Australia ▪ Resembles INTERPOL forms ▪ AM and PM data entry and dental match searches for final manual reconciliation by a forensic odontologist

Each software program uses its own version of an algorithm that compares antemortem and postmortem data sets. For each data point (or tooth) the program will compare AM data against all possible PM data (or vice versa) and provide an outcome of match, mismatch or possible match (Adams & Aschheim 2016). Based on this, a ranked series of possible matches is presented (Al-Amad et al. 2007; Adams & Aschheim 2016; Anuja & Doggalli 2018).

WinID3 presents various lists based on its different algorithms, the most widely used ranks by number of exact matches, then by possible matches (Adams & Aschheim 2016). UDIM takes into account percentages of explainable and unexplainable discrepancies and fragmentation as well as being designed to compensate for common coding errors (Adams & Aschheim 2016; Anuja & Doggalli 2018). The ranking system used by DVI Sys is based on a unique value assigned to code comparisons (Adams & Aschheim 2016), a hierarchical system which reflects progressive disease and treatment modalities (Torpet 2005). It has four searching modes (Torpet 2005) including targeted search for specific codes or treatment. DAVID Web assigns quantitative values to each dental characteristic depending on its significance or rarity in the community, the rarer a feature, the greater the weight. Weights differ when comparing AM to PM and vice versa, somewhat taking into account possible biologically explainable changes over time (Clement et al. 2006; Al-Amad et al. 2007).

Once the program has sorted, compared and provided a list of possible matches, the data sets are then manually compared by a forensic odontologist (Loomis 2018; Forrest 2019). This includes a thorough comparison of the records, both codes and images available (Al-Amad et al. 2007; Adams & Aschheim 2016; Anuja & Doggalli 2018), as well as detailed evaluation of any discrepancies to determine if they are scientifically or biologically explainable. Odontology is not alone in the need for manual comparison after a computerised search. AFIS – Automated Fingerprint Identification System also requires a fingerprint examiner to verify the result and make their conclusion (Australian Police 2012). 'Qualitative judgement will always be at the centre of forensic science evidence evaluation' (Evett et al. 2017).

While these programs are effective for their purpose, their output is still dependent on the quality of information entered and successful, timely outcomes are more likely when good quality data are available. Common issues relating to the data input include (Torpet 2005; Clement et al. 2006; Sweet 2006; Manica 2014; Adams & Aschheim 2016):

- Lack of compliance and understanding of codes
- Ambiguous coding situations
- Variation in the way codes are used
- Unclear how to chart the extent of restorations (true of PM examination as well)
- Common mis-charting of molars and premolars when not all teeth are present
- Colour dental charts presented in greyscale
- Radiographs
    - Incorrectly mounted or mislabelled
    - Ambiguity in using 2D radiographs to interpret 3D restorations
    - Ambiguity of surface designations
        - Precise location cannot be determined without written documentation
    - Ambiguity caused by superimposition of teeth and restorations
    - Poor quality copies or low digital resolution

Clement et al. (2006) discuss how using numerous codes for similar findings creates variation in records during both AM and PM collection. This in turn leads to issues with the matching software as well as confusing those tasked with comparing data sets. Matches that could easily be determined go undetected due to erroneous incompatibility.

These limitations are the focus of the new computer-assisted method for antemortem transcription. It is not intended to be another matching system; it will focus on standardisation of an earlier step in the dental identification process with the aim of improving reconciliation outcomes. Figure 28 presents a basic outline of the dental identification procedure, where the current software programs aid the process, and the area the new method aims to address.

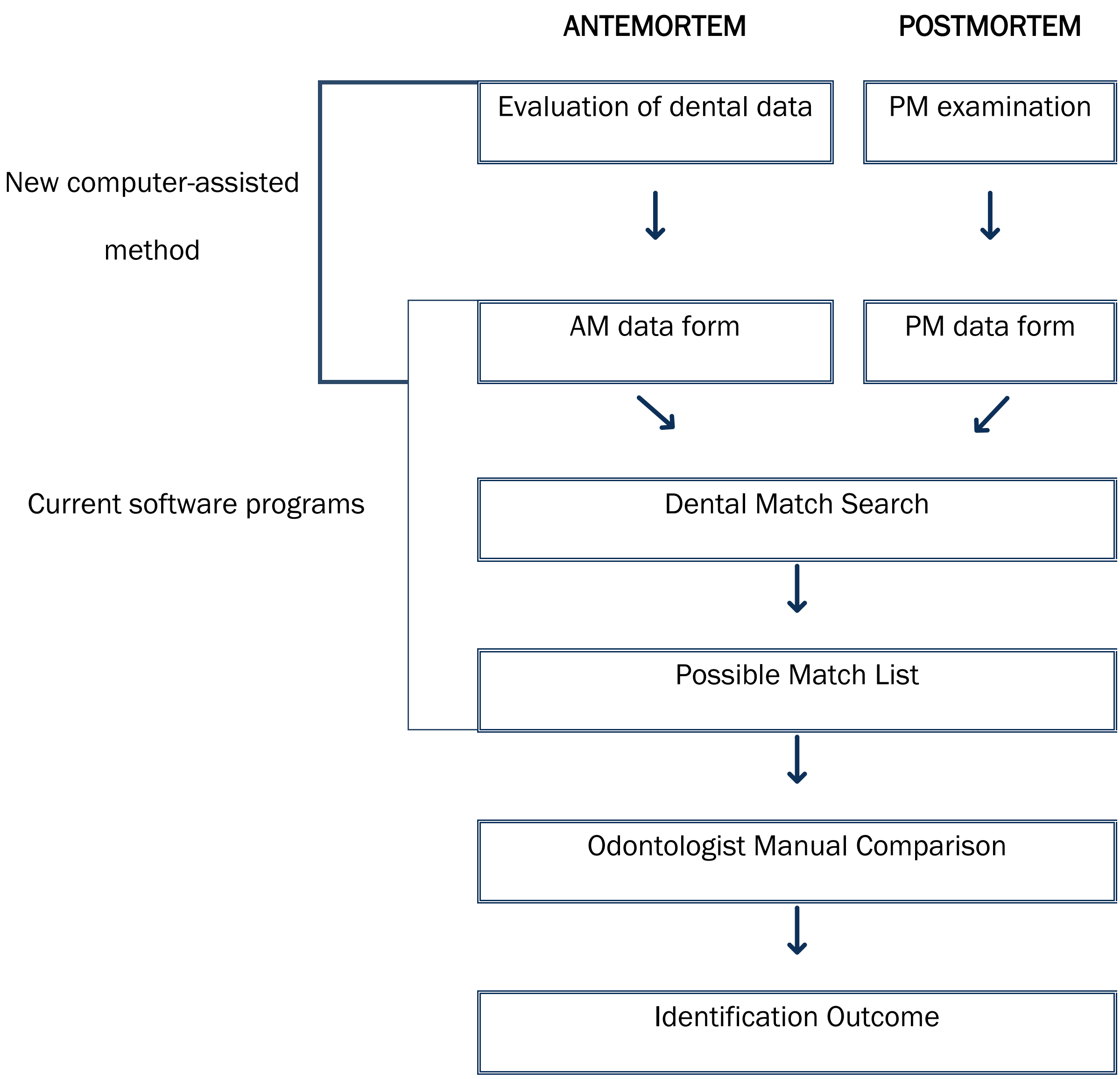


Figure 28: Outline of Dental Identification Process

Towards Standardisation

Standardisation of antemortem transcription requires consistency in the interpretation and recording of dental records between odontologists. In order to form guidelines around this, knowing what interpretation and evaluation is needed for different dental record types is essential (Figure 29).

Rules are required to reduce the variation in clinical judgement and the need for decision-making. No literature could be found attempting to provide detailed guidelines for antemortem interpretation and transcription, therefore clinical surveys were reviewed as to their data collection methods and guidelines with a particular focus on rules that can translate to antemortem transcription, and the specific needs outlined in Figure 29. National studies of oral health are concerned with the Decayed, Missing and Filled (DMF) status of the population, therefore a lot of what is important for disease evaluation will not be required from a forensic perspective and conversely, elements that are not important for a health survey are essential from a forensic perspective. However, guidelines for consistent charting and recording are common to both and rules applied in these surveys can be transferred to antemortem transcription and subsequently postmortem examination.

Written Records

- Interpretation of codes used to describe treatment performed
- Interpretation of written shorthand
- Current stage of multi-staged treatment
- Restoration Materials
- Restoration Surfaces
- Treatment performed vs. treatment planned
- Determine if tooth designation is correct

Radiographs

- Ensure correct orientation
- Determine tooth designation of teeth present
- Evaluate disease present
- Determine restorations present
- Determine restoration surfaces (within the ability of a 2-dimensional image)

Dental Chart

- Determine if a base chart, including historical treatment, has been completed
- Determine if the chart is accurate and logical based on knowledge of dental disease and progress

Photographs

- Determine correct orientation
- Determine tooth designation of teeth visible
- Determine the material and extent of restorations

Dental Casts

- Physical casts – determine damage to cast versus damage to dentition
- Determine teeth present
- Determine restorations present
- Determine restoration surfaces

Combination

- Determine if radiographs reflect information in the chart and written record
- Determine if treatment has been performed since the radiographs, photographs and/or casts were taken

Figure 29: Analysis of Dental Record Data Types

Published papers from The National Study of Adult Oral Health, 2017-18 (Chrisopoulos, Ellershaw & Luzzi 2020; Do et al. 2020) describe the following features to ensure inter-examiner reliability:

- Logic checks and skip sequences to reduce the likelihood of recording errors
- Examiners receive a manual describing the examination protocol
- Simple and clear codes
- Training program for examiners
- Testing of examiners against a gold standard
    - Areas of difference were discussed, and the rationale for the decision was explored by the trainers and examiners

Figure 30 displays key features from the National Health and Nutrition Examination Survey guidelines (NHANES 2004, 2018).

NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY 2018

PROGRAM FEATURES	Data collection program
	▪ Guide through the protocol
	▪ Keep track of where the examination is up to
	▪ Record the entered codes
	▪ Performs edits on data collection
	  o Checks data is within appropriate range
	  o Won't allow data entry if it is inconsistent with previous data (e.g.: won't allow caries recording on a tooth stated as missing on tooth count)
	Sequence of assessments and each assessment has its own sequence protocol
	▪ Every exam follows the same step-by-step sequence
	▪ Each exam is conducted systematically from quadrant one to four
	Select whether entry is complete or incomplete at the end of a section

TOOTH STATUS	▪ A tooth is present if any part of the crown is visible above the gingiva
	▪ Teeth are recorded by the space they occupy in the mouth (maximum of 32 spaces)
	  o Third molars are not scored, if a second molar is missing and the third molar has drifted into the space, the second molar is recorded as missing
	  o If teeth have drifted or gaps are closed, chart tooth number by anatomy, not the position held
	▪ All premolars extracted for orthodontic reasons are recorded as first premolars missing
	▪ If a tooth is rotated use anatomical surfaces rather than position
	▪ If both primary and secondary teeth are present, the secondary tooth is recorded
	▪ For supernumerary teeth, it must be decided which is the 'legitimate' occupier of the space
	▪ Teeth that are banded or bracketed for orthodontics are examined in the usual manner with visible surfaces scored
	▪ Permanent root present recorded when crown is more than 90% destroyed by caries or trauma

RESTORATIONS	▪ Anterior teeth: proximal filling involves the adjacent vestibular or lingual surface when it extends at least one-third of the distance to the opposite proximal surface ▪ Posterior teeth: a proximal restoration should extend more than a millimetre past the line angle before it involves the adjacent vestibular or lingual surface
FISSURE SEALANTS	▪ Only recorded on molars, premolars, and lingual surface of lateral incisors ▪ Only in grooves or pits of the tooth (lingual, occlusal, buccal) ▪ Recorded when any part of the surface remains covered ▪ If sealant material is used but it extends past pits and grooves, score as a restoration

Figure 30: NHANES Recording Guidelines Relevant to Antemortem Transcription

As these surveys are designed to assess population oral health they prioritise disease, omit third molars and ignore primary and supernumerary teeth if the permanent one is present. However, in forensic odontology, all teeth must be recorded and retained primary teeth and supernumeraries are valuable in an identification. While recording caries can be helpful to compare to postmortem data, it is important not to overstate the level of disease as larger areas of disease and restorations in antemortem data than in the postmortem data is not logical and can lead to erroneous exclusions.

Do et al. (2020) also emphasise the importance of having a small number of highly trained examiners to minimise variability. While a small number of highly trained examiners is ideal, in a disaster situation where time is essential, the transcription task is often given to many examiners over a period of weeks to ensure data entry is time efficient. While the role of dental antemortem data transcription should always be in the hands of those with dental training, a computer program can reduce the need for high level training and experience in AM transcription. This will free up forensic odontologists for the postmortem and reconciliation phases.

Development of New Guidelines and Code Definitions

Based on the standards from oral health surveys, the decisions forensic odontologists need to make when evaluating dental records and the drawbacks of current computer software, guidelines were developed to assist in the creation and function of a computer-assisted transcription method (Table 21). Minimalist instruction on code usage and transcription protocol lead to the expansion of INTERPOL’s original code definitions to include a brief statement on when each code should be used in more detail with less ambiguity. The developed guidelines were also expanded into the same categories as INTERPOLs original code table to enable more certainty of code usage in any given situation. These guidelines

(Table 22) ensure that each person undertaking antemortem evaluation and transcription is following the same protocol, which will reduce variation.

Table 21: Guidelines to Improve Standardisation

Visual data (radiographs, photographs and dental casts) should be relied upon more than written data (written notes and dental chart)	▪ Tooth designation is based on anatomy rather than position o Including when written information disagrees (e.g.: if a sole molar is anatomically a second molar, but written records record it as a first molar, in the AM transcription it is recorded as a second molar)
Dates of treatment should always be cross checked to ensure the correct recording of any treatment after radiograph dates	▪ Presence or absence of treatment o Restorations o Root Canal Treatment o Unerupted teeth o Retained roots
Radiograph limitations	▪ Restoration materials cannot be recorded from a radiograph alone ▪ Restoration surfaces vestibular and lingual cannot be determined from a radiograph ▪ These should only be recorded if there is corroborating written information
Assessing completeness of dental charts	▪ Assess whether chart is representative of what is recorded in the written records and radiographs ▪ If a judgement is made that the chart is incomplete, do not rely upon it for information o State the lesser treatment of no information available if necessary ▪ If the only recording of missing third molars is the chart, they should be coded as no information available
Recording teeth	▪ Teeth are recorded based on anatomy, not position ▪ Both primary and secondary teeth should be recorded if the predecessor remains o Primary tooth entered as a comment after the permanent tooth code
Recording disease	▪ Dental caries should not be recorded as missing tooth structure unless there is visual evidence of cavitation o Otherwise record it as a comment ▪ Other dental disease should be recorded in the appropriate section of the AM form
Extent of restorations	▪ If unsure as the extent of restorations always choose a lesser treatment for antemortem data o Treatment can be extended over time but never reduced ▪ A mismatch will occur if antemortem treatment is larger than postmortem treatment
Multi-stage treatment is not recorded until completed	▪ Root canal treatment is only recorded when obturation has been completed o Prior to this the restoration should be recorded with a comment afterwards stating root canal has been commenced ▪ Crowns are only recorded once they have been cemented o Temporary crowns should be recorded as a 5-surface restoration (tcf MODVL) with a comment stating it is a temporary crown

Table 22: INTERPOL Codes with Expanded Descriptions and Transcription Guidelines

Status	mam	Missing antemortem	Written or visual evidence that the tooth is not present.
	une	Unerupted	Written or visual evidence that the tooth is present but not in the oral cavity.
	non	No information	No information about a tooth is present in any of the records or information is only on the chart, which is unreliable.
	pre	Tooth present	Written or visual evidence that the tooth is present, however there is no information on the status of the tooth. Includes teeth partially visible on radiographs.
	nad	No abnormality detected	Written evidence that the tooth is present and that it is a sound/virgin tooth. Should not be used as an equivalent to pre.
	rov	Retained root	Written or visual evidence of a remaining root with no crown structure.
	▪ Teeth are identified by anatomy rather than the position they hold in the mouth (e.g.: if there has been mesial drift of a 47 due to extraction of a 46 with space closed the 46 should be coded as missing and the 47 as present) ▪ Unerupted and impacted teeth are charted as unerupted (une) if all tooth parts are not in the oral cavity ▪ If there is not written or visual evidence of a tooth the code non should be selected. This includes when the only evidence of third molars missing is the chart. If the chart is incomplete or unreliable, also use non ▪ A tooth is present (pre) if any part of the tooth crown has erupted through the gingiva ▪ If both deciduous tooth and its successor are present, the permanent tooth is coded and a comment made in regards to the status of the deciduous tooth ▪ If a supernumerary tooth is present, it is recorded in a comment, and the legitimate tooth coded ▪ No abnormality detected (nad) is only charted when there is written evidence of a sound tooth or when radiographs are of good quality with good angulation and the tooth can be clearly seen ▪ If a tooth crown is destroyed by caries or trauma but the root remains the code retained root (rov) is used ▪ Retained root is also recorded for roots remaining under replacements such as dentures and bridges ▪ If orthodontic brackets or bands are present, the tooth is coded as if there were none and the bracket mentioned in a comment. If the condition of the tooth cannot be seen due to the bracket and there is no written record or chart of the tooth use pre		
Crown Pathology	mtl	Marked tooth loss	Written or visual evidence of present teeth that are missing tooth structure which has not been replaced. This code includes tooth surface selection.
	▪ Marked tooth loss (mtl) is recorded in cases of missing tooth structure and fractured or missing restorations ▪ If any part of the restoration remains, this is charted as a restoration and the missing surfaces charted as mtl. ▪ Caries is only charted as mtl when there is visual evidence of cavitation		

Table 22 (Continued): INTERPOL Codes with Expanded Descriptions and Transcription Guidelines

Fillings	fis	Fissure sealant	Written evidence of a fissure sealant. This code includes tooth surface selection.
	uif	Unidentified filling	A filling is present, however there is no written information on the material used. This code should also be used when the only evidence of a filling in found on a radiograph or a chart. This code includes tooth surface selection.
	mcf	Metal coloured filling	Written evidence of any metal material used in a restoration. This code includes tooth surface selection.
	tcf	Tooth coloured filling	Written evidence of any tooth-coloured material used in a restoration, this includes composite and GIC as well as inlays. This code includes tooth surface selection.
	▪ Fissure sealants (fis) can only be recorded when any part of the fissure system remains covered, and only on molars, premolars, and the lingual surface of upper lateral incisors. Pits and groove surfaces can be charted i.e.: occlusal, vestibular, or lingual. If it extends past these it should be coded as a restoration (tcf) ▪ Interproximal restorations should extend at least 1mm onto an adjacent surface for it be considered a filled surface ▪ Occlusal restorations should extend over the mesial and distal ridges for those surfaces to be considered filled ▪ All restorations charted from radiographs should be given the code unidentified filling (uif) ▪ Inlays and onlays and veneers are coded as a restoration tooth coloured filling (tcf) and metal coloured filling (mcf) dependent on material and followed by the surfaces they cover. A comment can be made that the restoration is an inlay, onlay or veneer ▪ Multiple restorations on the same tooth that are not connected should be coded separately		
Crowns	uic	Unidentified crown	Evidence of a crown, however the material used is not specified, or only on radiographs.
	mcc	Metal ceramic crown	Ceramic bonded to metal crown specified in written record.
	mtc	Metal coloured crown	Metal crown (gold/amalgam/stainless steel) specified in written record.
	tcc	Tooth coloured crown	Written evidence of a porcelain/ceramic only crown
	▪ When crowns are charted from the radiograph, or if there is no information on the material of which it is composed, a code of unidentified crown (uic) is used		
Bridges	abu	Abutment tooth	The tooth is being used as a support for a bridge pontic. If the tooth itself is crowned, it should have the abu code as well as a crown code.
	pon	Pontic	A bridge is replacing a missing tooth. This code should be in addition to mam (missing tooth) and a crown code for the material of the pontic.
	▪ When a missing tooth has been replaced with a bridge pontic, the code missing antemortem (mam), pontic (pon) as well as the crown material should be applied ▪ Adjacent abutment teeth should be coded abutment (abu) as well as the crown material or a comment in the case of maryland bridges ▪ Pontic (pon) should not be used for denture teeth. If required a comment can be made after the missing (mam) code. E.g.: mam “denture tooth ▪ Guidelines from crown materials should be followed when describing abutments and pontics		

Table 22 (Continued): INTERPOL Codes with Expanded Descriptions and Transcription Guidelines

Root	ipx	Implant	Missing tooth is replaced by an implant. This code should be in addition to mam (missing tooth) as well as a crown code if there is one present.
	ppx	Parapulpal pin	Written or visual evidence of pin supported restoration. If a restoration is present, it should also include the relevant filling code.
	rfx	Root filling	Written or visual evidence of obturation. Should also include codes of crown treatments such as a crown, restoration, missing tooth structure or retained root.
	pox	Post	Written or visual evidence of a post, should include a rfx (root canal) as well as any crown treatments.
	▪ Implant replaced teeth should be coded with missing antemortem (mam), implant (ipx) and a crown material if one is in place. Guidelines for crown material should be applied ▪ Parapulpal pins (ppx) should be coded for each pin present ▪ Teeth with root canal filling (rfx) codes should also be coded for the restoration or status of the tooth using relevant guidelines ▪ Root canal filling (rfx) code should only be applied if obturation has taken place. If the treatment was started and never finished code the restoration only and make a comment regarding the unfinished root treatment ▪ When a post (pox) is present, a root canal filling (rfx) code is also required to indicate the tooth has been obturated as well as any restorative coding ▪ The material of the post (pox) does not need to be recorded in code; however, it is useful to make a comment on the material used if it is detailed in the written records		

Computer-Assisted Transcription

An important issue in moving from 'examiner' to 'software' is highlighted by Evett et al. (2017). While computer software may seem more objective, taking away the human factor, it must be understood that the program itself was human created and therefore subjective judgements are not eliminated. Therefore, while the process is repeatable, reproducible and can reduce bias, it is not in itself, objective. 'It is bias arising from cognitive effects that is the enemy, not subjectivity' (Evett et al. 2017). Thus, while a computer-assisted method will not remove the subjectivity of the evaluation and interpretation, it can guide odontologists through the dental records with criteria for addressing complex decisions to make the final transcription standardised, repeatable, reproducible and enable proficiency testing to show its validity in dental identification.

Key Features

The objectives of the computer-assisted method and the solutions to the variation types assessed in the previous studies (Table 23), can be achieved through the following features:

- Limited free text input
- Reverse-chronological guided data entry
- Limit treatment options depending on the dental record type
- Require surface input when relevant treatment or statuses are entered
- Alert when entering data for a tooth that already has been entered
    - Option to add treatment or status to the tooth
- Alert when two incompatible treatments or conditions are entered
    - Option to choose which treatment to keep

- Alert when no data has been entered for a tooth after the user signals all data entry is complete
- Final options to choose codes for each tooth where multiple treatments or conditions were recorded
    - Including dates and data source corresponding to treatment/status entered so the user doesn't have to search through the record to find which treatment came last or where they found the information
- Detailed guidelines for decision making
- Detailed description of codes and when they should be used

Table 23: Methods to Reduce Variation Types Found in Variation Studies

	Variation Type	Computer-Assisted Solution
1	Correct code, incorrect nomenclature	Nomenclature errors will be reduced by the user not being responsible for writing the final code. The program will provide the codes based on the questions answered for each tooth.
2	Correct code, could have more detail	List all treatments or statuses entered for the user to choose which to apply.
3	Additional code needed	Multiple treatments entered will be displayed for user to choose any/all that apply.
4	Correct code category but incorrect material	Program will only allow materials to be selected if the record type enables the user to do so (e.g.: Radiograph entry will only list unknown material as an option).
5	Incorrect surfaces	Achieved through related guidelines and inability to choose vestibular or lingual surfaces from radiographic data sources.
6	No surfaces listed when needed	If a restoration or tooth structure loss is selected, a list of tooth surfaces will appear.
7	Correct code, previous treatment listed	List all treatments or statuses entered for the user to choose which to apply.
8	Correct code, wrong tooth (transposing – must have a pair)	Achieved through related guidelines.
9	Use of non when radiographical information available	Radiograph data entry prompts for teeth present dependent on the location and type of radiograph entered. If a panoramic is selected, data for all teeth will need to be entered.
10	No code	Software will highlight when nothing has been entered for a tooth and will prompt the user to choose no information or return to enter the relevant data.
11	Wrong code	Achieved through related guidelines and the user not being responsible for entering the final code.

Process

The computer-assisted method will lead the user on a linear path through the data entry process as outlined in Figure 31. INTERPOL coding convention and FDI notation were selected due to their widespread international use.

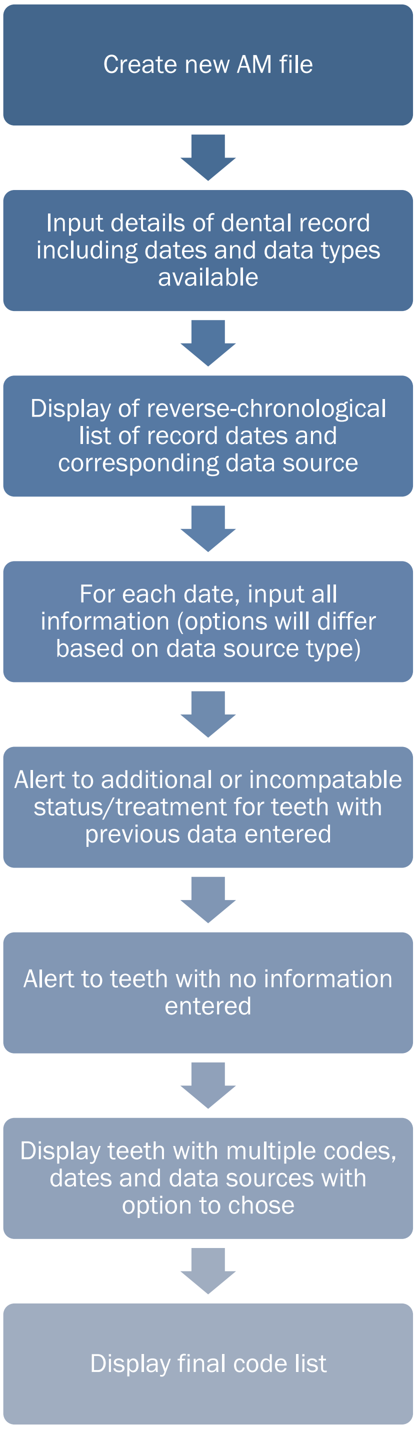


Figure 31: Computer-assisted Method Process Outline

Wireframes

In order to visualise the process of the computer-assisted method, and how each element would interact, a wireframe was created. 'A wireframe is a layout of a web page that demonstrates what interface elements will exist on key pages' (ExperienceUX). The following figures provide a visual example of the screens associated with the process outlined in Figure 31.

AM Case Selection (Figure 32):

- Table with list of all antemortem cases in the database
- Option to create a new antemortem case
- Option to edit and input data
- Option to view final odontogram/list of codes

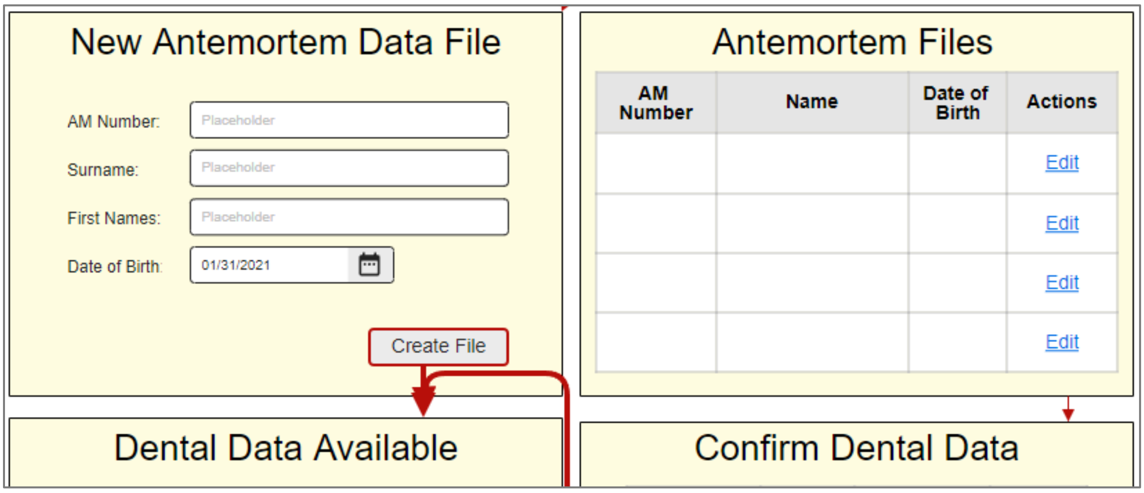


Figure 32: Case Selection Wireframe

Dentist Information (Figure 33):

- Details of record provider including surgery name, address, and phone number
- Record contents and dates including written records, images, and other data sources

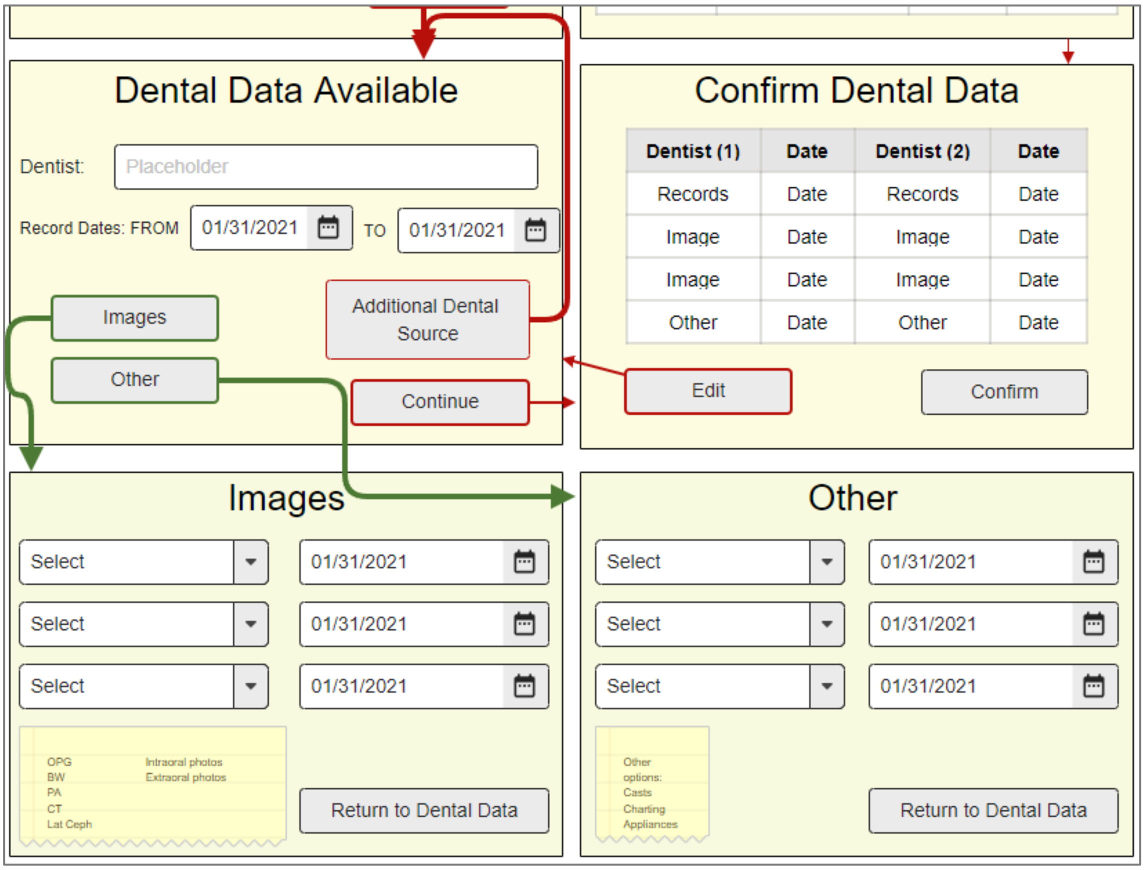


Figure 33: Dentist Information Input Wireframe

Code Entry (Figure 34):

- List of records available as entered in previous screen in reverse-chronological order
- Selection of treatment date, tooth treated, code and surfaces if applicable
    - Select from list or checkboxes, no free text
    - Notes section to include additional information not used to create final code list (free text)
- Option to chart from an image displays a new screen (Figure 35)
- Alerts if information is recorded in the incorrect order or if an image is available between treatment dates entered
- Option to bring up code definitions to help user decide which is most applicable

Image Data Entry (Figure 35):

- Each tooth selected from the ‘chart from image’ screen in Figure 34 is displayed
- Codes and surfaces where relevant as well as notes section are available for input
    - Code and surface options will differ for radiographs for information that is not discernible from the image

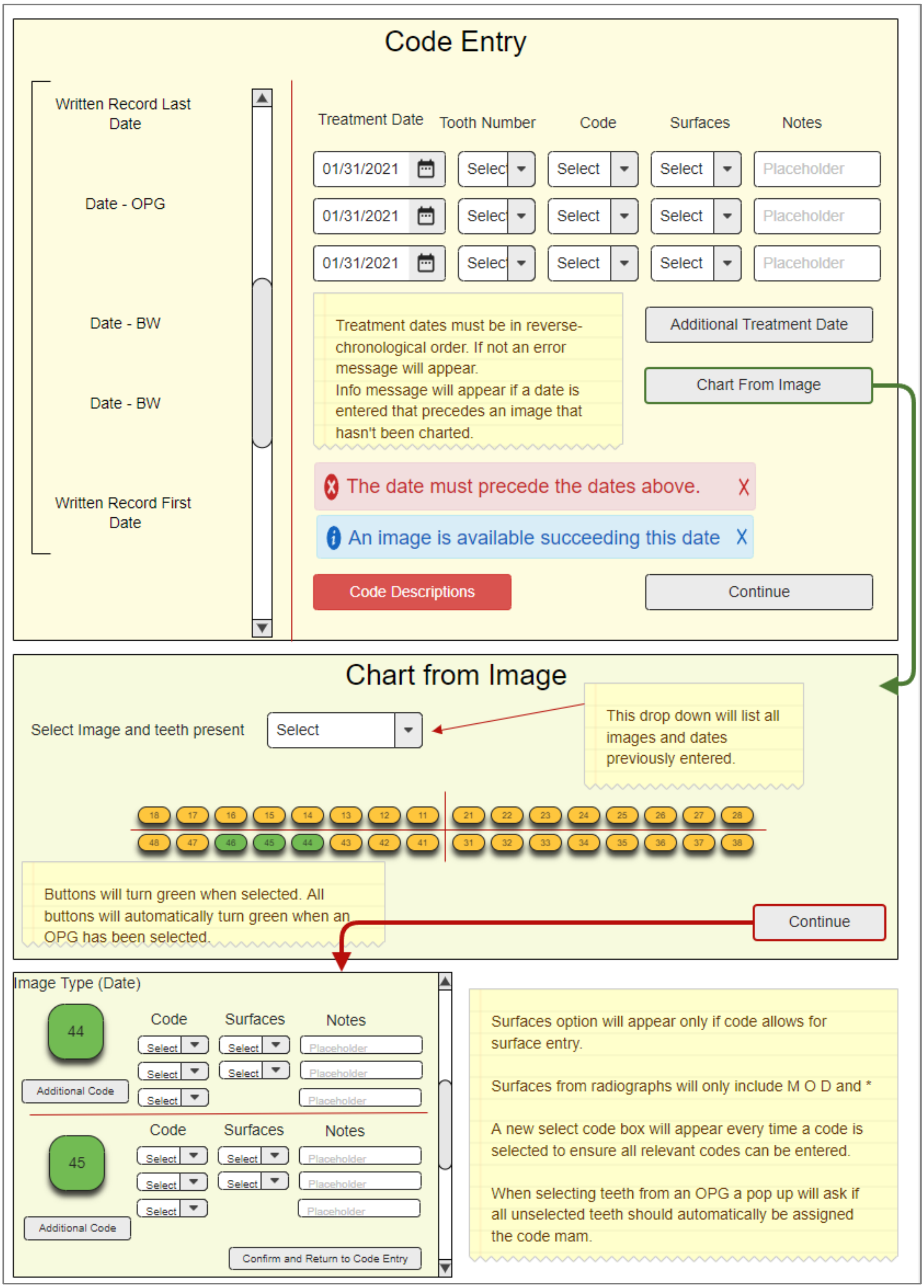


Figure 34: Code Entry Input Wireframe

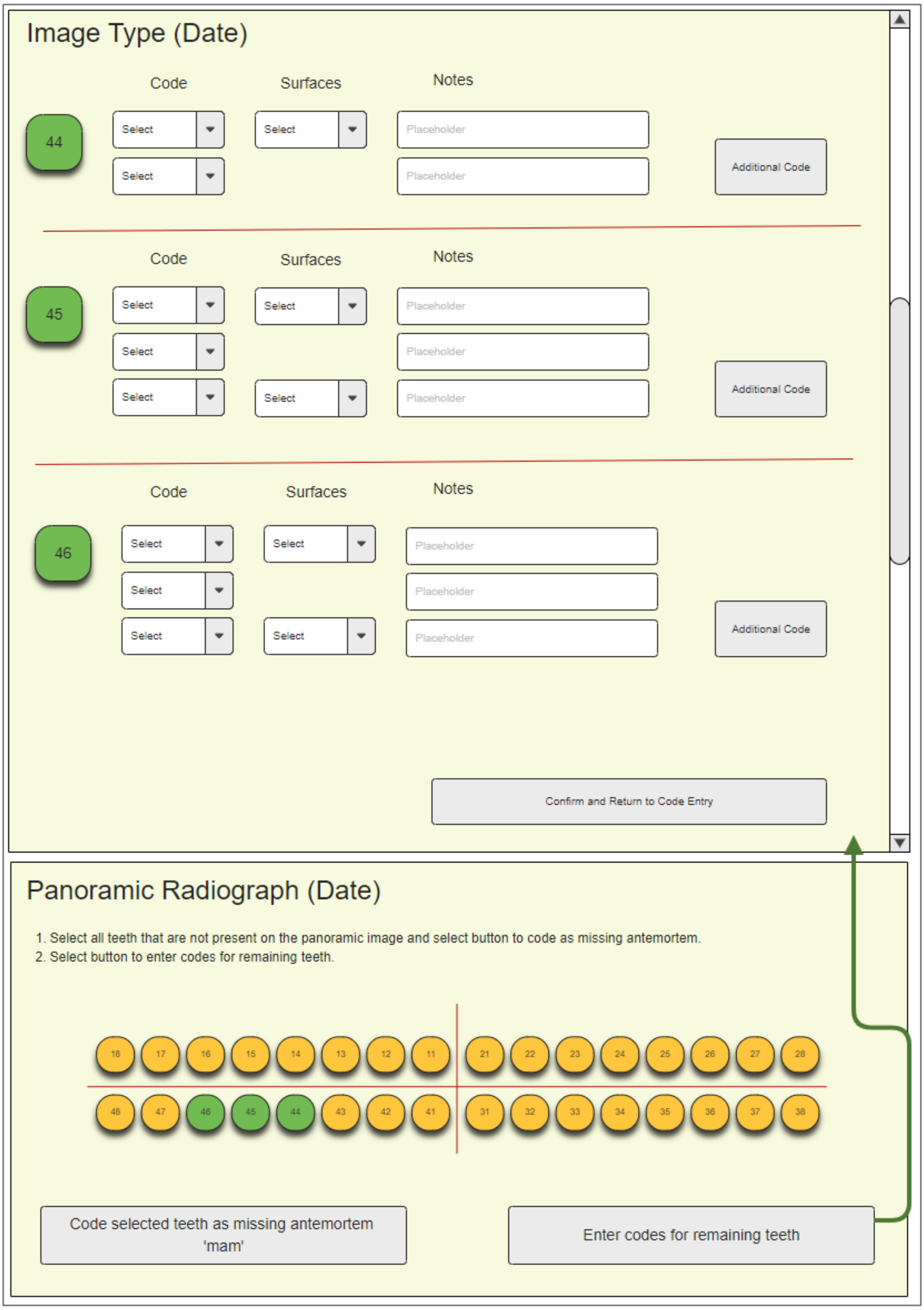


Figure 35: Image Data Entry Input Wireframe

Pop-Ups and Alerts (Figure 36):

- After all input sections have been completed, an alert will appear indicating records and teeth that have not had any information entered
    - Option to choose 'no information available' for teeth
    - Option to return to code entry to input data
- After the no entry found alert is no longer triggered, a 'multiple entries found' alert will appear
    - List of all teeth that have multiple entries
    - Choice of any or all treatment/status options for that tooth for user to select
    - Information on the date and data source of that treatment/status entry is available

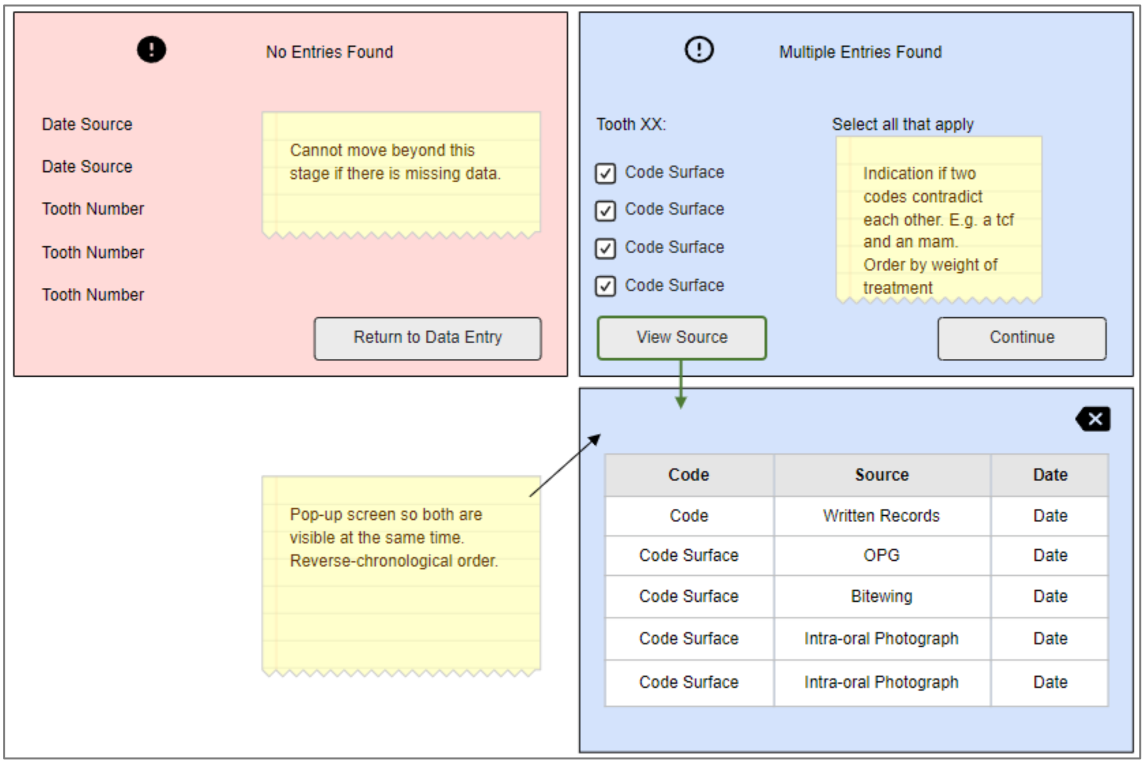


Figure 36: Pop-ups and Alerts Wireframe

Final Code List (Figure 37):

- A final odontogram will be presented similar to the INTERPOL 600 form
- Each code associated with the tooth will appear
    - Option to return to data entry to change codes
    - Option to confirm final antemortem data entry

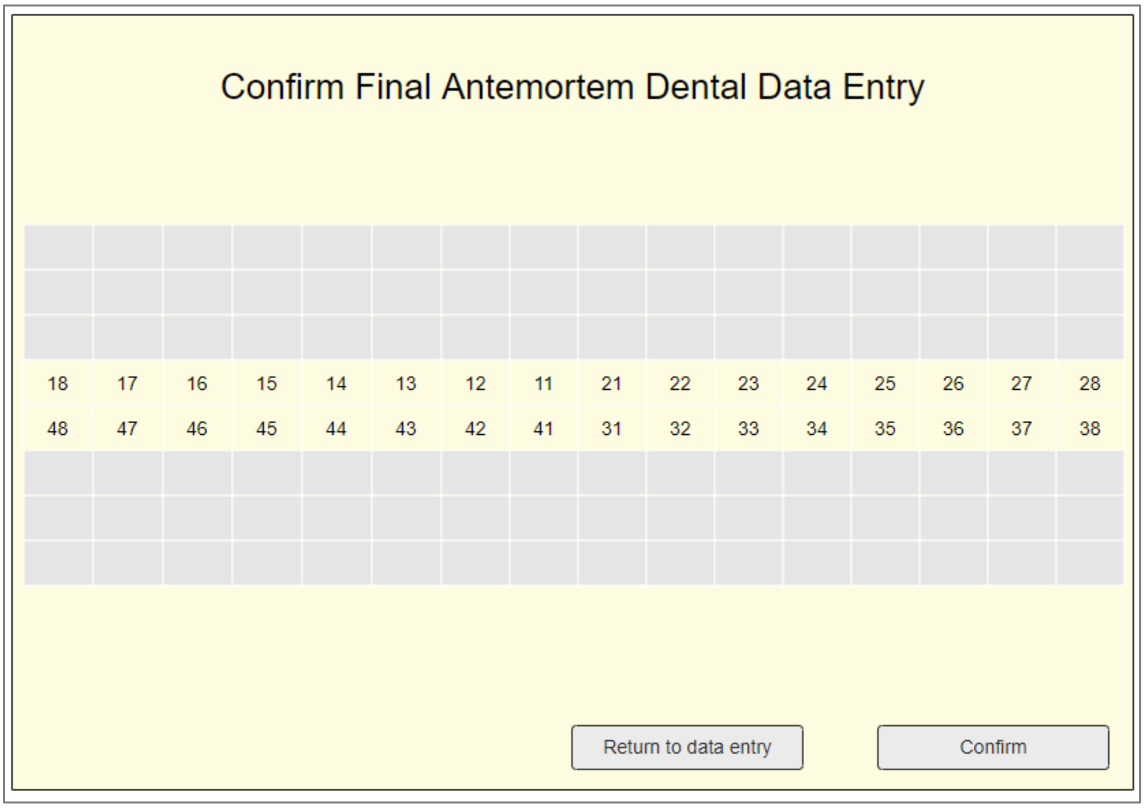


Figure 37: Final Code List

Conclusion

Development of antemortem dental data transcription specific guidelines with increased detail of codes used ensures that each dental practitioner analysing dental data will be as calibrated as possible for consistency. The creation of a computer-assisted method will incorporate these guidelines and code usage as well as standardise data input, remove what variation it can, and alert users when data is missing or incompatible, thus reducing transcription errors. This computer-assisted method will also enable the antemortem process to be tested for proficiency and reliability.

CHAPTER 7: CREATION OF COMPUTER-ASSISTED DATA ENTRY

Antemortem Dental Data Entry (ADDE) was created with REDCap® reflecting the process outline and wireframes, discussed in Chapter 6, as closely as possible. A user manual was created detailing the use of each form and includes the guidelines and code definitions developed previously (Appendix V).

REDCap®

REDCap® electronic data capture tools hosted at the University of Adelaide (Harris et al. 2009; Harris et al. 2019) was selected to draft the computer-assisted method as it is capable of performing most of the key features desired and did not require advanced coding experience. Due to the nature of a database software in comparison to the desired functions, it is understood that some intended features will not be implementable. To achieve the required workflow, complex branching logic and calculations was required. A REDCap® add-in called 'Shazam' was employed to improve presentation, which was achieved through HTML and CSS coding.

REDCap® Instrument Creation

REDCap® works with a series of 'instruments', or forms, containing a list of 'fields', or questions. 'Branching logic' allows only the relevant fields to be displayed based on previous input. 'Piping' allows answers from previous instruments to be displayed where necessary on any instrument. REDCap® also has a feature that allows multiple inputs of the same instruments over time, called longitudinal data collection and each instance of entry is called an 'arm'. Instruments can then be linked and presented as a survey for users to enter data.

The name and basic purpose of each instrument created for ADDE is presented in Figure 38. Due to programming restrictions, only forms for the three most common dental data types were created (i.e.: written records, dental charts and radiographs).

Each of the data input forms contained multiple fields concerning the state of the tooth, which was repeated for all 32 teeth. Branching logic was used to display only the teeth selected, or those commonly seen on the radiograph type selected. Branching logic also enabled irrelevant questions to be hidden, based on selections, for example if a tooth was selected as missing, no field asking for treatment, such as restorations, appeared. A chart outlining the status and treatment options as well as the corresponding flow on questions is displayed in Figure 39.

Calculations were used to determine which teeth had no data entered and those that met the criteria were displayed to ensure all available data had been entered. Further calculations were employed to determine which teeth and treatment would be displayed on the multiple codes list. Branching logic was used to display the data source of each treatment/status shown. The code list on the final instrument used branching logic to determine which code to display based on all previous instruments.

All instruments, fields and branching logic is shown in Appendix VI. HTML and CSS coding used to improve the presentation using 'Shazam' are shown in Appendix VII.

Dentist Information — Input Form

- Details of record provider including surgery name, address and phone number
- Record contents and dates (e.g.: written records, radiographs, dental chart etc.)

Written Record — Input Form

- The user is prompted to input date of appointment and select the tooth treated
- For each tooth selected, a series of choices regarding the status and treatment of the tooth are presented with single choice or checkbox selections

Radiographs — Input Form

- Entry of dental data found in radiographs only
- The user is presented with all teeth commonly visible in radiographs identified when inputing dental record contents
- Similar choices to written record input with differences approriate to radiograph interpretation

Dental Chart — Input Form

- All teeth are presented to the user with the same series of choices as previous input forms

Missing Information — Information Check and Selection Form

- After all input forms have been completed, this form will highlight any teeth that have not had any information entered
- The user has a choice of 'no information available' or to return to the input forms and enter the data

Calculations — Background Form

- No input required by the user
- Calculates which information to display in Multiple Codes form based on the data entered in previous forms

Multiple Codes — Selection Form

- This form highlights all teeth that have multiple, different choices selected on the input forms
- Choices and corresponding record sources will be displayed
- The user selects any number of treatments they wish to keep

Final Odontogram — Information Check Form

- A final list of all the teeth and their corresponding INTERPOL codes will be presented
- The user can then accept this as the final representation of antemortem dental information or return to data input as required

Figure 38: Process Overview for REDCap®

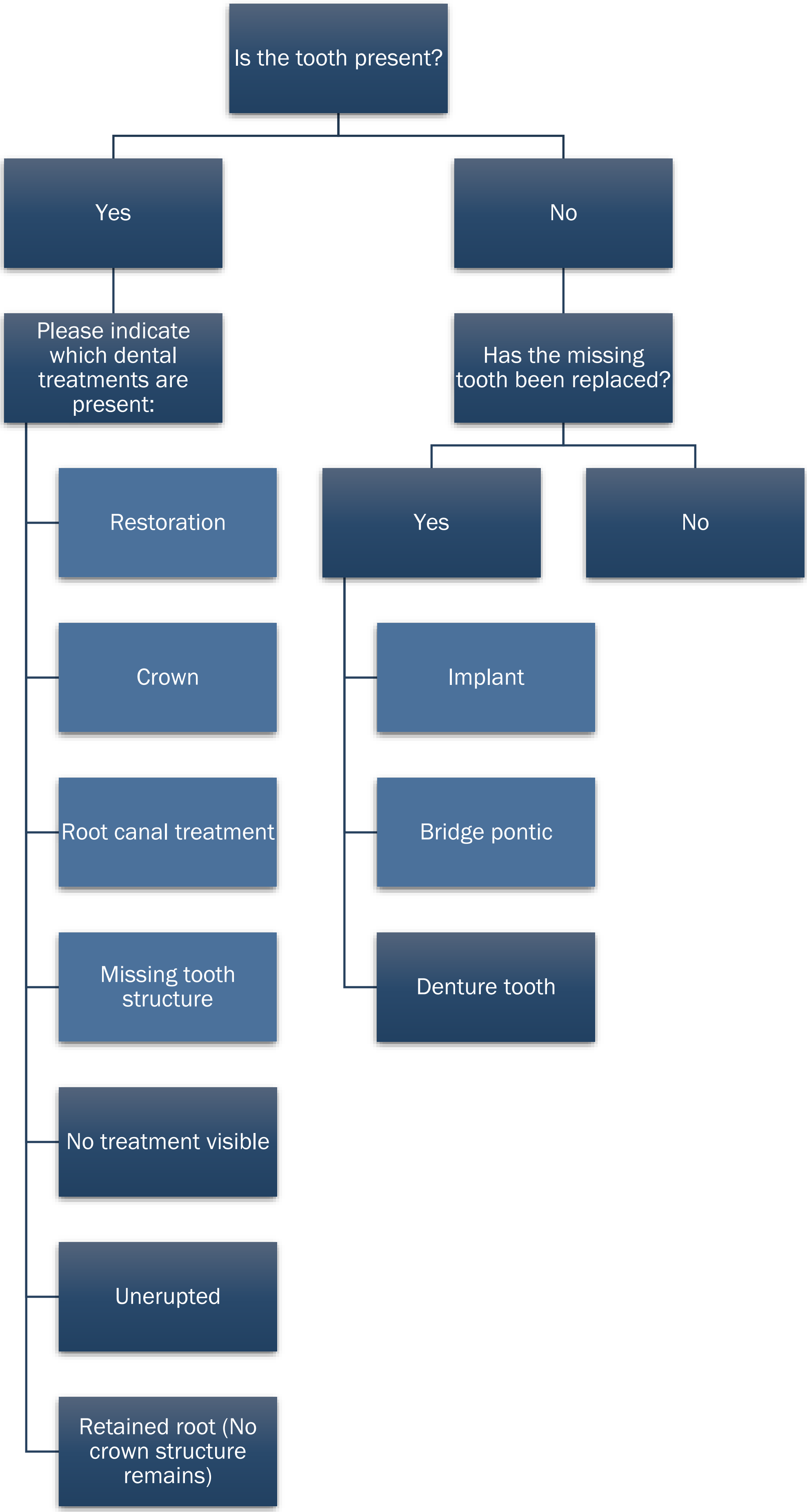
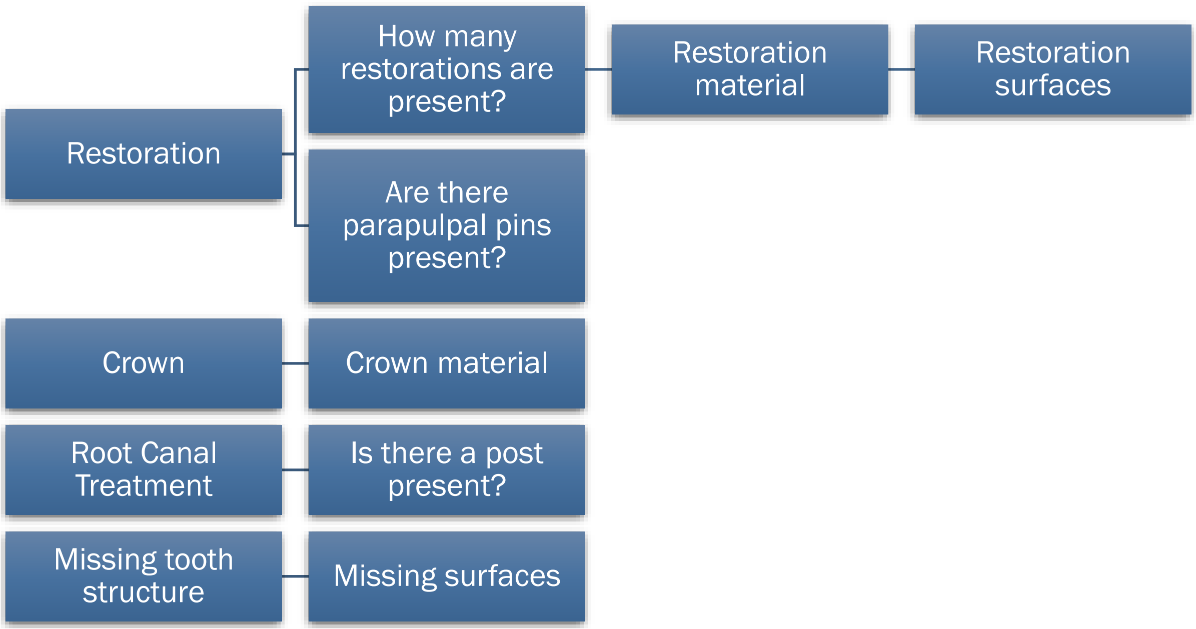


Figure 39: Flowchart of tooth status questions

Dental treatments continued:



Missing tooth replacement continued:

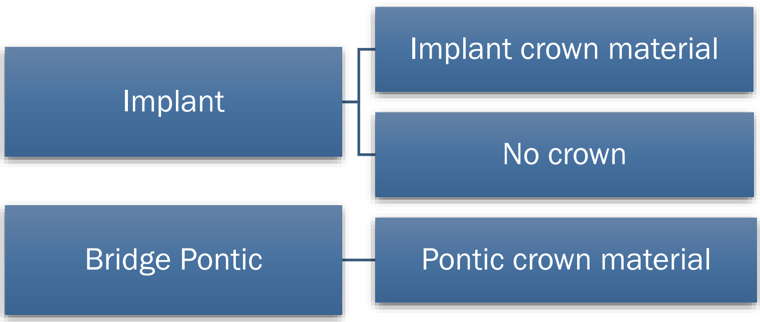


Figure 39 (continued): Flowchart of tooth status questions

Each form created for data entry in ADDE is displayed below with a summary of its purpose, structure and how standardisation of recording tooth status and treatment is improved while minimising the decision making required.

Dental Record Entry

The first form documents the details of the dental records available (Figure 40). It is divided into two sections, the first, details of the providing dental clinic, and second, details of the data available within the dental records.

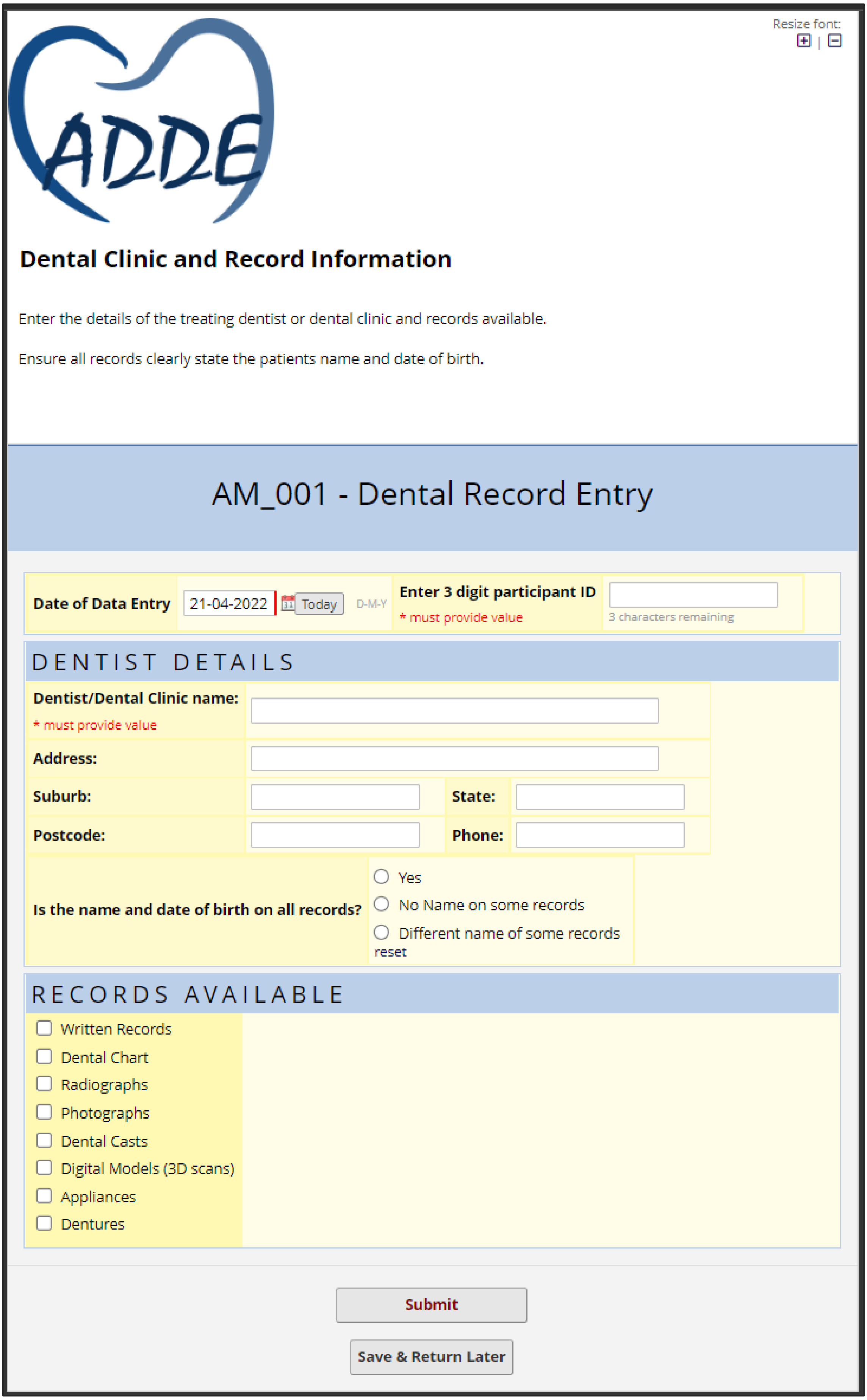
Dentist Details

Fields are available to document the name, location and contact details of the dental clinic supplying the antemortem data. Quality assurance is present in the form of an identifying question, asking if the name and date of birth are present on all records. This prompts the user to analyse the data available to ensure they can reconcile that all available records are of the person for whom the record is named. A warning is displayed if not all records have identifying features, or if the identifying features are different (Figure 41).

Records Available

A list of the most common dental data types is displayed with checkbox selection. When a selection is made, further entry fields appear for recording details including date of creation, and for images, their location (Figure 42). In the case of radiographs, multiple options for a location of identifying information and exposure date within the record are available. This is an additional assurance that all records correspond to the same individual. The location of intra-oral radiographs is also asked to ensure the Radiograph Entry form only displays the corresponding teeth.

By only allowing the additional fields of selected data types to appear, the user is not overwhelmed by numerous input fields, and is less likely to miss entering important information, or recording it incorrectly.



Resize font:

ADDE

Dental Clinic and Record Information

Enter the details of the treating dentist or dental clinic and records available.

Ensure all records clearly state the patients name and date of birth.

AM_001 - Dental Record Entry

Date of Data Entry	21-04-2022 Today D-M-Y	**Enter 3 digit participant ID** * must provide value	3 characters remaining

DENTIST DETAILS

Dentist/Dental Clinic name: * must provide value			
Address:			
Suburb:		**State:**	
Postcode:		**Phone:**	

Is the name and date of birth on all records?

- Yes
- No Name on some records
- Different name of some records

reset

RECORDS AVAILABLE

- Written Records
- Dental Chart
- Radiographs
- Photographs
- Dental Casts
- Digital Models (3D scans)
- Appliances
- Dentures

Submit

Save & Return Later

Figure 40: Dental Record Entry Form

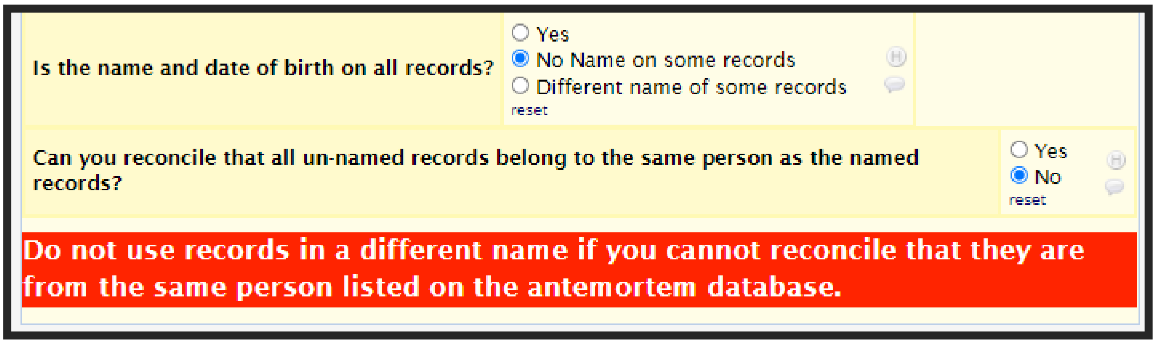


Figure 41: Quality Assurance Warning

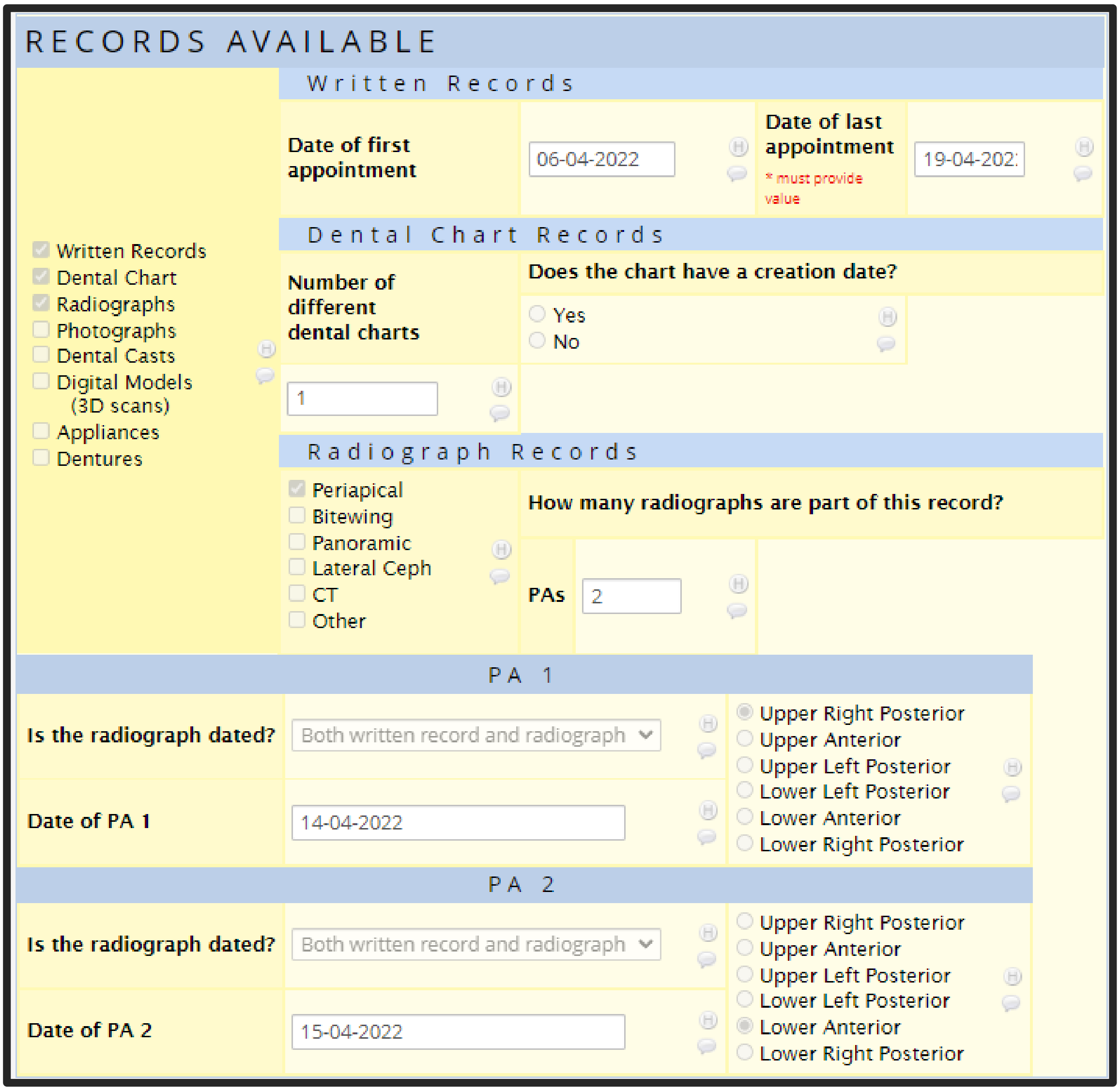
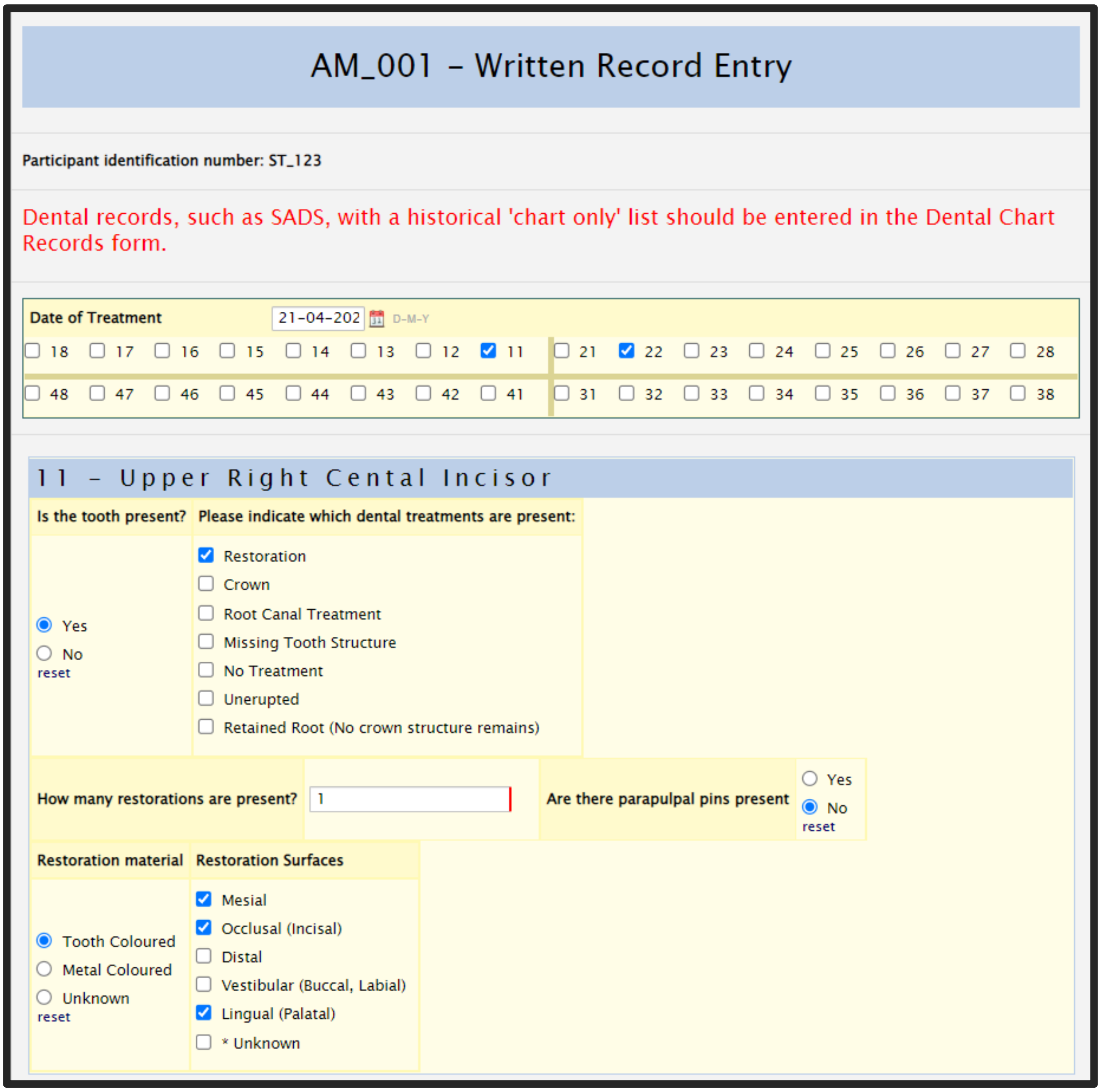


Figure 42: Record Selection

Written Record Entry

All information from the written clinical notes is entered on the Written Record Entry form (Figure 43). When a treatment date is entered and a tooth selected, the user is lead through a series of questions in a linear manner to ascertain the status or treatment present for that tooth (as in Figure 39). Each additional tooth selected will prompt a new series of questions. By allowing the user to make selections using choice buttons and checkboxes instead of free text entry, the result is not reliant on the appropriate entry of a code, which may differ between users due to interpretation of ambiguous definitions. Standardisation is also achieved for surface designation as the user selects from a list rather than entering their preferred term.


AM_001 – Written Record Entry

Participant identification number: ST_123

Dental records, such as SADS, with a historical 'chart only' list should be entered in the Dental Chart Records form.

Date of Treatment 21-04-202 D-M-Y

18 17 16 15 14 13 12 11 21 22 23 24 25 26 27 28

48 47 46 45 44 43 42 41 31 32 33 34 35 36 37 38

11 – Upper Right Cental Incisor

Is the tooth present? Yes No reset

Please indicate which dental treatments are present: Restoration, Crown, Root Canal Treatment, Missing Tooth Structure, No Treatment, Unerupted, Retained Root (No crown structure remains)

How many restorations are present? 1

Are there parapulpal pins present Yes No reset

Restoration material: Tooth Coloured, Metal Coloured, Unknown reset

Restoration Surfaces: Mesial, Occlusal (Incisal), Distal, Vestibular (Buccal, Labial), Lingual (Palatal), * Unknown

Figure 43: Written Record Entry Form

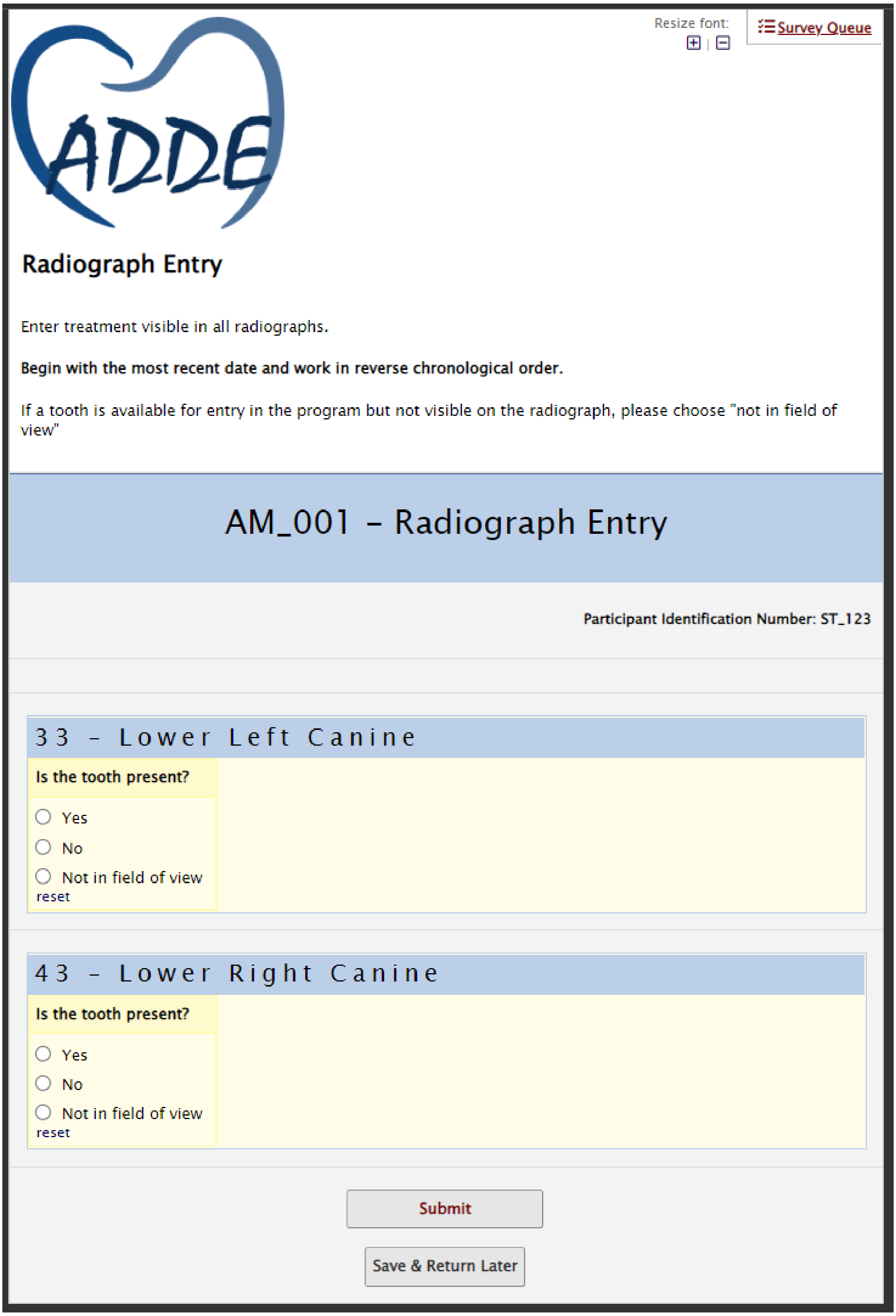
Each treatment date is entered on a new instance of this form. Entries should start from the most recent appointment as information is carried forward through each instance. When the last treatment date has been entered, all teeth and information from the whole written record should be present.

Radiograph Entry

All information available in any type of radiograph is entered here (Figure 44). Information should be entered in reverse chronological order as all appearances of the tooth are amalgamated. Tooth options appear based on the radiograph types and locations entered in the Dental Record Entry form. All questions reflect the Written Record Entry form with some exceptions. While a radiographs location is indicative of which teeth should appear, positioning during exposure can vary. Therefore, the option 'Not in field of view' is added to the first question regarding tooth presence. Additionally, as radiographs are a greyscale, two-dimensional representation or three-dimensional structures, some information can be limited, including differentiating restoration materials and tooth surfaces restored. Therefore, there is no restoration material option and no option to choose vestibular or lingual surfaces when describing the extent of the restoration. Only displaying teeth corresponding to the location of radiographs reduces the number of teeth available for data entry, thus reducing the potential to enter information for the wrong tooth including cross midline transcription.

Chart Entry

All information from all dental charts contained in the record is entered here (Figure 45). If multiple charts are present information is amalgamated as with the Radiograph Entry form. It is up to the user to decide on the accuracy and completeness of the chart and to not include data in which they are not confident.



Resize font:

Survey Queue

Radiograph Entry

Enter treatment visible in all radiographs.

Begin with the most recent date and work in reverse chronological order.

If a tooth is available for entry in the program but not visible on the radiograph, please choose "not in field of view"

AM_001 – Radiograph Entry

Participant Identification Number: ST_123

33 – Lower Left Canine

Is the tooth present?

- Yes
- No
- Not in field of view

reset

43 – Lower Right Canine

Is the tooth present?

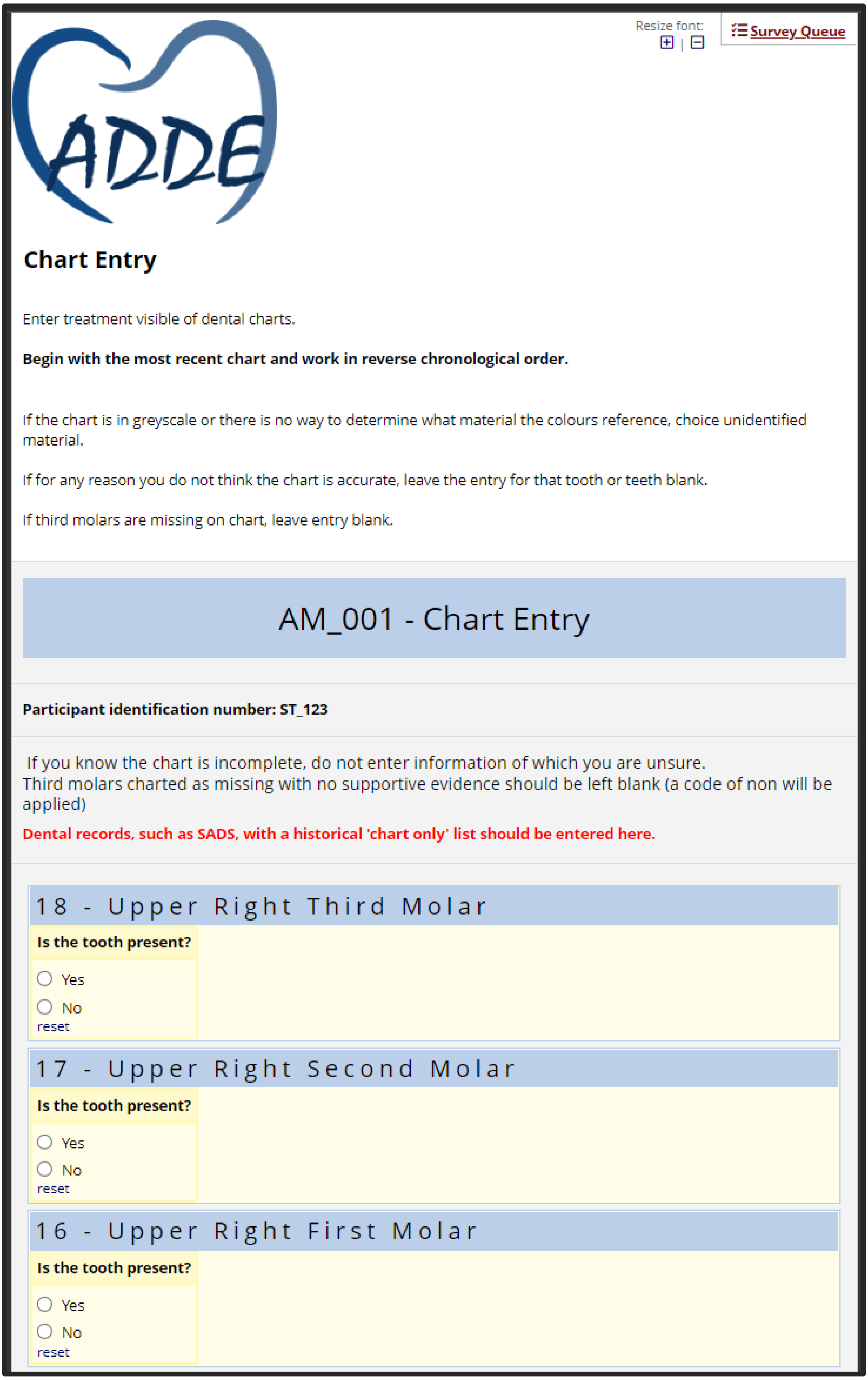
- Yes
- No
- Not in field of view

reset

Submit

Save & Return Later

Figure 44: Radiograph Entry Form



Resize font:

Survey Queue

Chart Entry

Enter treatment visible of dental charts.

Begin with the most recent chart and work in reverse chronological order.

If the chart is in greyscale or there is no way to determine what material the colours reference, choice unidentified material.

If for any reason you do not think the chart is accurate, leave the entry for that tooth or teeth blank.

If third molars are missing on chart, leave entry blank.

AM_001 - Chart Entry

Participant identification number: ST_123

If you know the chart is incomplete, do not enter information of which you are unsure.
Third molars charted as missing with no supportive evidence should be left blank (a code of non will be applied)

Dental records, such as SADS, with a historical 'chart only' list should be entered here.

18 - Upper Right Third Molar

Is the tooth present?

Yes

No

reset

17 - Upper Right Second Molar

Is the tooth present?

Yes

No

reset

16 - Upper Right First Molar

Is the tooth present?

Yes

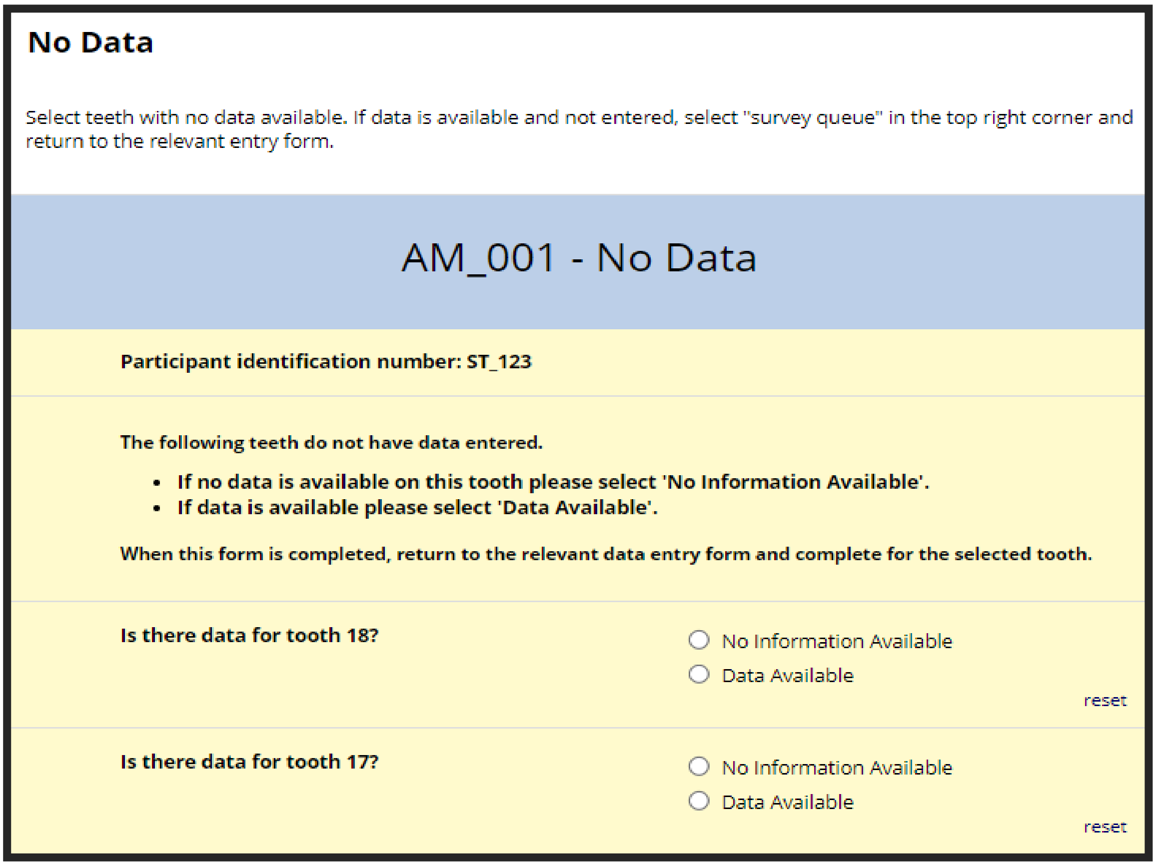
No

reset

Figure 45: Chart Entry Form

No Data

The No Data form alerts the user to any teeth that have no information (Figure 46). Calculations for each tooth determine if any selections have been made on any of the three input forms. If no selections were made, or 'not in field of view' selected on the Radiograph Entry form, the corresponding teeth will appear. This form highlights missing data and will not allow a blank entry for any tooth. The user has the option to return to the input forms and enter the appropriate information, or, if no information regarding the tooth exists in the dental record, they can select the corresponding option, and this becomes that tooth's recorded entry. The user cannot move past this form until all teeth have a recorded entry.


No Data

Select teeth with no data available. If data is available and not entered, select "survey queue" in the top right corner and return to the relevant entry form.

AM_001 - No Data

Participant identification number: ST_123

The following teeth do not have data entered.

- **If no data is available on this tooth please select 'No Information Available'.**
- **If data is available please select 'Data Available'.**

When this form is completed, return to the relevant data entry form and complete for the selected tooth.

Is there data for tooth 18?
No Information Available
Data Available
reset

Is there data for tooth 17?
No Information Available
Data Available
reset

Figure 46: No Data Form

Calculations

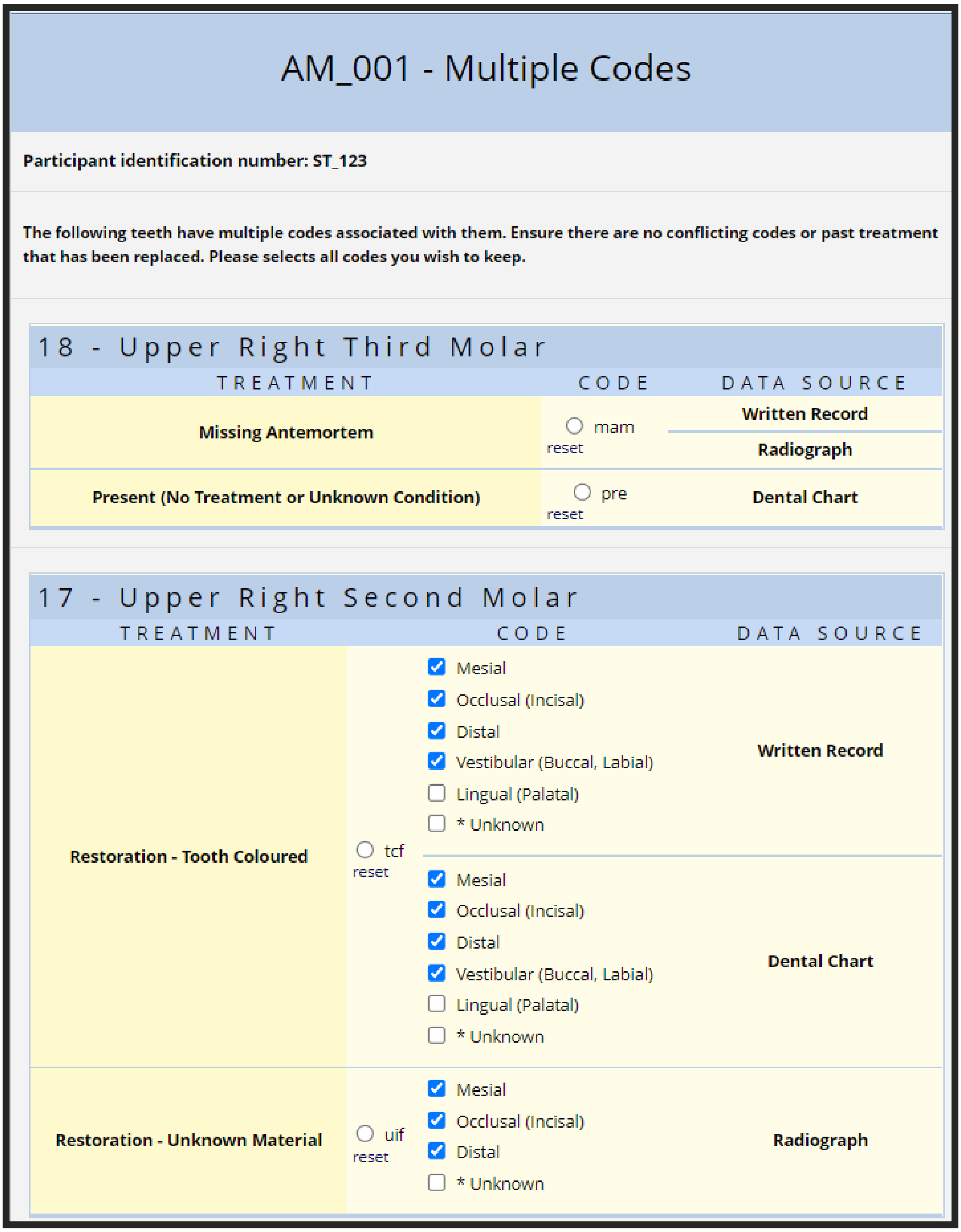
This instrument requires no input and exists so that the program can display information in the next two instruments. For each treatment or status associated with each tooth, calculations determine whether more than one entry has been made, and if so, whether those entries are the same across the three data entry forms. This allows teeth with multiple, different codes to be displayed on the following form, and single or duplicated entries to bypass this and appear on the final form. Users need to select the 'submit' button to save and send the unseen calculations and move to the next form.

Multiple Codes

Each tooth, for which multiple treatments or conditions were entered, will be displayed with all selected information present, including the treatment, INTERPOL code and data source from which it was obtained (Figure 47). The user must select which treatments to keep. It may be necessary to review the dental record to ensure the correct treatment is selected.

Radiographs are the data source with the highest objectivity and therefore hold more weight. For example, if a tooth is recorded present on a chart and is missing on the radiograph, this tooth should be recorded as missing. However, it is important to ensure a written record entry did not come after the radiograph was taken as subsequent treatment may not be recorded visually. The user must also decide if treatments from two different data sources are the same. For example, an unknown material restoration from a radiograph may be the same restoration as the tooth-coloured material recorded in the dental record. If this the case, only the tooth-coloured restoration should be selected.

The decision-making process cannot be taken away from the user at this point, and the selection of which codes to keep is up to experience and knowledge. However, the way the information is displayed prompts to user to evaluate which treatments are more likely based on data source and which to choose if there are incompatible options. It also enables to user to quickly check dates of information as it is evident which data source the information originated from, removing the need to trawl through all the dental records again, looking for one particular entry.



AM_001 - Multiple Codes

Participant identification number: ST_123

The following teeth have multiple codes associated with them. Ensure there are no conflicting codes or past treatment that has been replaced. Please selects all codes you wish to keep.

18 - Upper Right Third Molar

TREATMENT	CODE	DATA SOURCE
Missing Antemortem	○ mam reset	**Written Record** / **Radiograph**
Present (No Treatment or Unknown Condition)	○ pre reset	**Dental Chart**

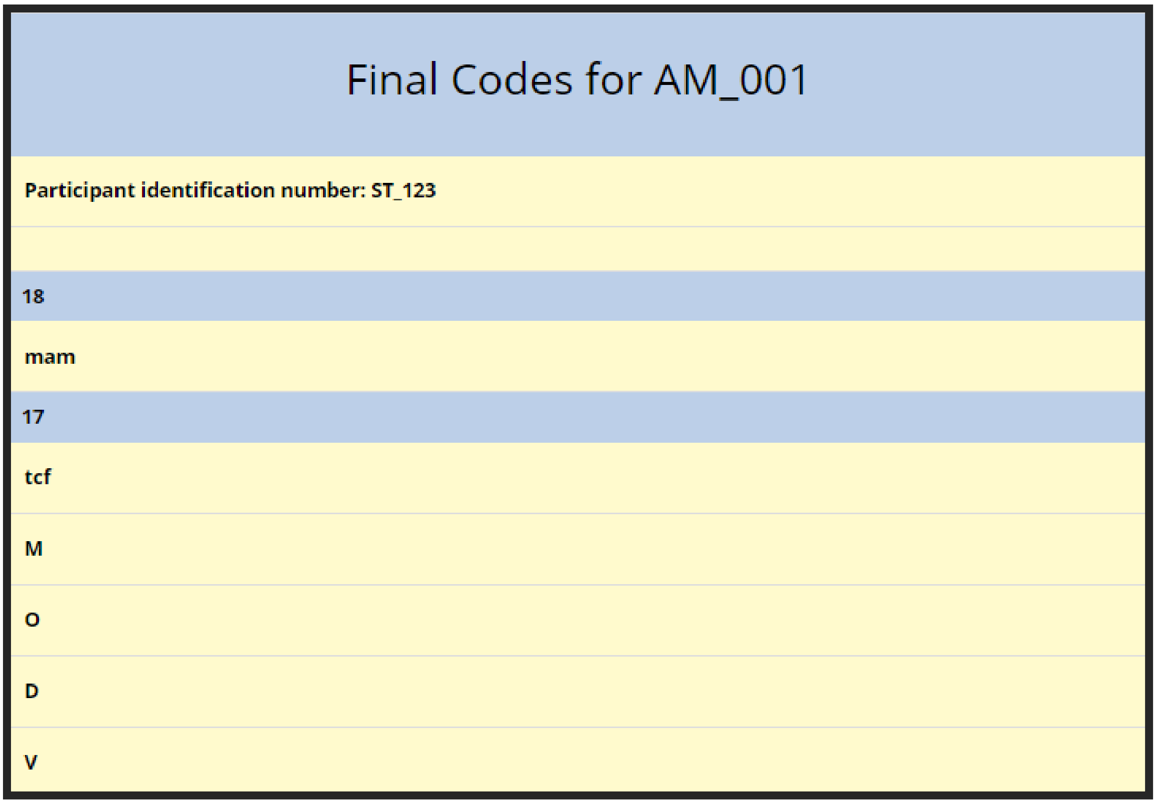
17 - Upper Right Second Molar

TREATMENT	CODE		DATA SOURCE
Restoration - Tooth Coloured	○ tcf reset	[x] Mesial [x] Occlusal (Incisal) [x] Distal [x] Vestibular (Buccal, Labial) [ ] Lingual (Palatal) [ ] * Unknown	**Written Record**
		[x] Mesial [x] Occlusal (Incisal) [x] Distal [x] Vestibular (Buccal, Labial) [ ] Lingual (Palatal) [ ] * Unknown	**Dental Chart**
Restoration - Unknown Material	○ uif reset	[x] Mesial [x] Occlusal (Incisal) [x] Distal [ ] * Unknown	**Radiograph**

Figure 47: Multiple Codes Form

Final Odontogram

This instrument requires no input. It is a summary of the INTERPOL codes for each tooth based on input into the previous instruments (Figure 48). Branching logic incorporating the outcomes from all previous fields and calculations enables the appropriate treatment codes to be displayed under their corresponding tooth. This is the final quality assurance screen as the user must go over the data to ensure every tooth is present and everything is correct.


Final Codes for AM_001

Participant identification number: ST_123

18

mam

17

tcf

M

O

D

V

Figure 48: Final Odontogram Form

Limitations of Using REDCap®

REDCap® has excellent features for entering and maintaining a database and is very user-friendly with the ability to perform more complex actions with additional coding. It provided a great baseline for creating a computer-assisted method without the need for extensive and complex software development. However, because of this, there were limitations in what the final product could do, simply because REDCap® was not designed for the intended purpose. Desired features that could not be implemented include:

- Option to enter an unlimited number of charts and radiographs
    - This could not be open ended, each had to be created and individually coded as to when to be visible
- Reverse chronological order of dental records to allow the user to follow in the correct date order
- Alerts to signal the user when information was being entered on a tooth that already had an entry
- Data source and date shown on the multiple codes form rather than just the source to order likelihood of final code and prevent the user from having to cross check dates and treatments
- Alert the user when two incompatible codes had been selected

REDCap® add-in 'Shazam' improved user design and experience using HTML and CSS coding. However, there was a limited amount of code that could be saved and therefore all desired features were not possible to create. User design and interface features that could not be implemented:

- Recording the details of multiple dental clinic records
- Option to select all missing teeth before treatment questions for radiographs and chart to reduce the repetitive nature of entry

- On the No Data form, selecting that data needs to be entered brings up a prompt asking which data type to navigate to, removing the need for the user to manually navigate.
- Presentation of the final odontogram to mimic that of the INTERPOL forms
    - This would have improved the visual presentation and made the review process easier as it would be displayed in a format in which the user was familiar

In retrospect, a built for purpose software program would better accomplish the goals of the computer-assisted method. However, due to the evolving nature of the research and coming to the creation of a program late in the project and the steep learning curve of complex coding, this was not possible. Built for purpose software would be the next step in development should the results from testing and user feedback be favourable. Translation into multiple languages with an end user language option would also enable the worldwide use of the program.

CHAPTER 8: TESTING THE COMPUTER-ASSISTED METHOD

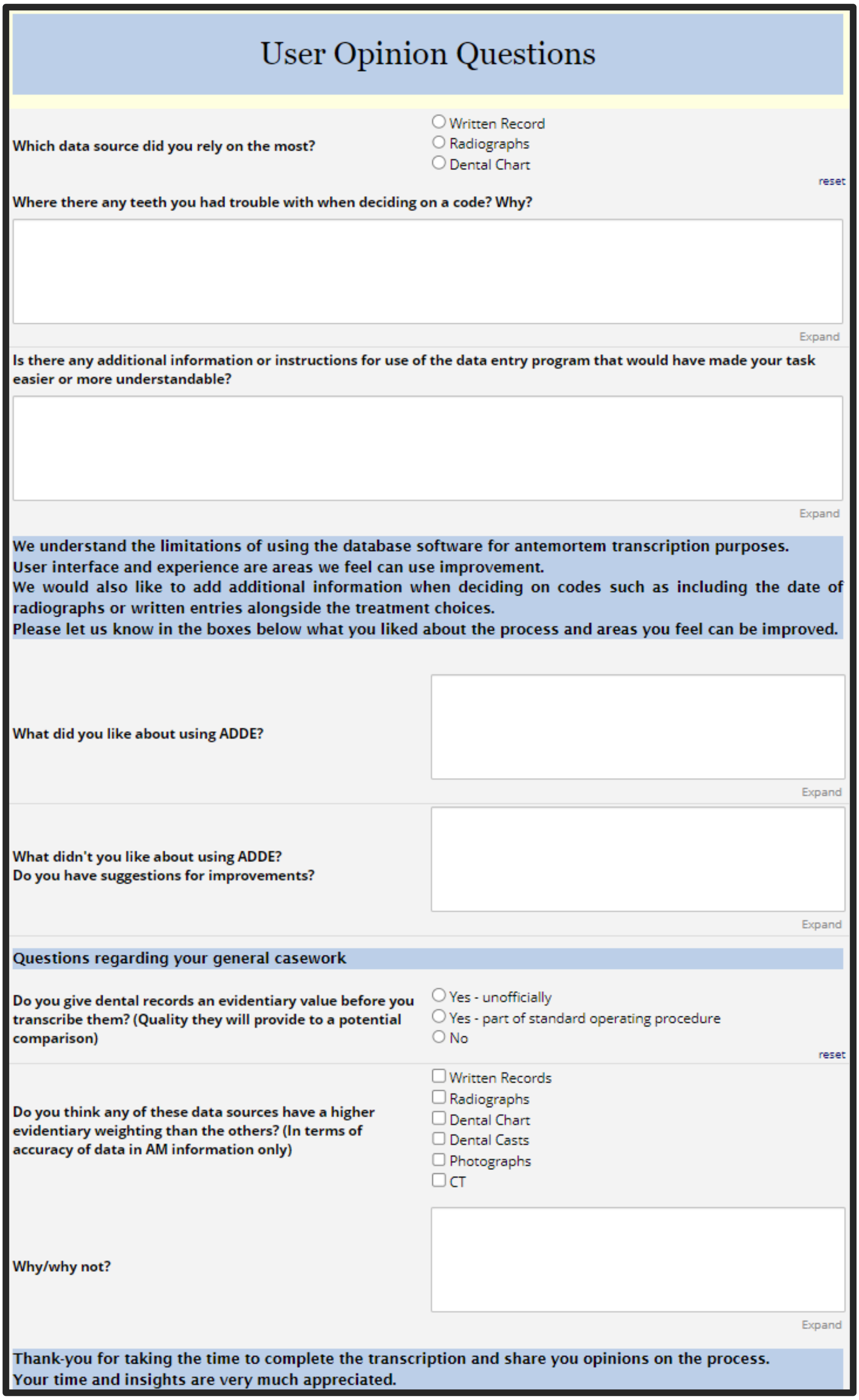
The primary aim of the computer-assisted method is to improve standardisation in the final transcription codes and to reduce subjectivity in decisions and ambiguous situations. The final stage in creation is to test the methodology to see if it functions as planned. This chapter incorporates an alpha test to ensure the program itself is working properly and a beta test to explore how well the program meets its aims of reducing variation.

Testing Methods

Testing was achieved in two stages. The alpha test was undertaken by a small group to test for issues in the use of the method and for user feedback. Once required fixes were complete, the beta test was performed by practicing forensic odontologists to test how well it achieved its aims as well as to gain feedback from its intended users.

Alpha Test

Participants for the alpha test include forensic odontologists and forensic odontology students at the University of Adelaide. Part of this group participated in the previous pilot study (Chapter 4). Participants were sent an email with the case information and the new guidelines developed, see Appendix IV and V. A separate email was sent with a link to the computer-assisted transcription survey to ensure all answers remained anonymous. Case 1 was sent first to allow for feedback on the system before Cases 2 and 3 were completed. After sending Case 1, an additional form was created to record participants opinions on the process (Figure 49).



User Opinion Questions

Which data source did you rely on the most?
- Written Record
- Radiographs
- Dental Chart

reset

Where there any teeth you had trouble with when deciding on a code? Why?

Expand

Is there any additional information or instructions for use of the data entry program that would have made your task easier or more understandable?

Expand

We understand the limitations of using the database software for antemortem transcription purposes.
User interface and experience are areas we feel can use improvement.
We would also like to add additional information when deciding on codes such as including the date of radiographs or written entries alongside the treatment choices.
Please let us know in the boxes below what you liked about the process and areas you feel can be improved.

What did you like about using ADDE?

Expand

What didn't you like about using ADDE?
Do you have suggestions for improvements?

Expand

Questions regarding your general casework

Do you give dental records an evidentiary value before you transcribe them? (Quality they will provide to a potential comparison)
- Yes - unofficially
- Yes - part of standard operating procedure
- No

reset

Do you think any of these data sources have a higher evidentiary weighting than the others? (In terms of accuracy of data in AM information only)
- Written Records
- Radiographs
- Dental Chart
- Dental Casts
- Photographs
- CT

Why/why not?

Expand

Thank-you for taking the time to complete the transcription and share you opinions on the process.
Your time and insights are very much appreciated.

Figure 49: Post-transcription Questions for Computer-assisted Method

Beta Test

Feedback from the Alpha test was assessed, and changes were made to the survey incorporating user feedback and bug fixes. International forensic odontologists were invited to be part of the testing, all responses remained anonymous. Participants were provided with the same antemortem records as those used in the previous variation study undertaken by international odontologists, the 'ADDE' user manual and guidelines, and a link to the online survey. Participants were also asked the same series of questions after they completed the transcription (Figure 49).

ADDE Alpha Test

The alpha test was completed by forensic odontologists and forensic odontology graduate diploma students for a total of six responses. The resulting codes and feedback provided direction for improvement of the survey and allowed defective coding to be fixed. Descriptive statistics were employed to analyse the data in the same manner as the pilot study to provide an indication as to whether the computer-assisted method improved upon accuracy and standardisation.

While the comparison of results from this test to those from the pilot study was insightful, the main reason for the alpha test was to find and fix any issues with the program and take user feedback on board.

User Comments

Positive comments regarding ADDE included the systematic nature of recording the data and that the process was self-explanatory and easy to follow. One participant commented that slowing down the process helped them to pay more attention to each stage and type of record. Participants also liked the Multiple Codes form with the ability to easily review discrepancies and errors.

The main criticism was the time it took and the cumbersome nature of data entry. The fact the survey opened a new tab every time the participants wanted to go back and change data was also confusing, and the need to move through every form again after correcting data for it to be saved was also an issue raised.

The positive comments were encouraging as the systematic nature of data entry and easy ability to decide between conflicting or multiple codes were some of the main aims of the program. The criticisms were all centred around user experience and are fully acknowledged limitations of the database and survey-based nature of this method. Except for multiple tabs opening, the guidelines written for ADDE express that this is the nature of the survey and describe how to navigate through. Unfortunately, no changes regarding these issues could be made as it is a fundamental functioning of the REDCap® (Harris et al. 2009; Harris et al. 2019) survey system.

Issues Arising from Transcription Completion

Numerous issues arose during the test from both the user and the programming itself. Straightforward fixes were possible in some circumstances including making fields that were commonly not completed, mandatory. Other fixes required adjusting or rewriting the branching logic code that enabled selections to appear correctly on the Multiple Code and Final Odontogram forms. Table 24 shows issues arising from input error and

Table 25 displays issues found with the program itself. Both tables include the changes made to accommodate these issues, or a comment on why changes were not possible.

Table 24: User Input Issues and Corrections

User Input Issues	Changes Made
No chosen status/treatment option when the tooth was selected as being present causing these teeth to not appear on the Final Odontogram form.	The status/treatment option was made a mandatory field.
Selected both mam and pre on the Multiple Codes form and no review of the Final Odontogram form to remove one of them.	Unable to fix this with current capabilities, ideally a pop-up would notify the user that these codes are incompatible.
Restoration selected from treatment list, but no details entered.	Selection of restoration surfaces was made a mandatory field.
No information for a tooth appeared on the Final Odontogram form as no option was selected from the Multiple Codes form.	Difficult to change with current capabilities, ideally the program would not allow the user to continue until an option for each tooth was selected.

Table 25: ADDE Issues and Corrections

Program Issues	Changes Made
Pop-up error alert on the Radiograph Entry form stated branching logic errors for teeth 33 and 43.	Branching logic fixed.
The possibility to choose both restoration and no treatment from the treatment list meant that both present and restoration code showed on the Final Odontogram form.	To fix this an additional question for each tooth on each form would be necessary. This was deemed to negatively impact on user experience and so no changes were made. Ideally selecting both would not be possible and a pop-up warning would appear to indicate this.
Some codes appeared on the Final Odontogram form when they were not selected or not an option on the Multiple Codes form e.g.: restoration surface codes.	Branching logic was changed to show these codes if it was the only entry for the tooth or if it was selected on the Multiple Codes form.
Missing tooth structure and restoration surface codes only appeared on the Final Odontogram form when they were present on the Multiple Code form rather than also appearing if it was the only entry for the tooth and therefore not required on the Multiple Codes form.	Branching logic changed on the Final Odontogram form to show these codes when they were the sole entry for a tooth and did not appear on the Multiple Codes form.
Surfaces did not appear correctly on the Final Odontogram form (e.g.: MOD was selected but it appeared as separate MO and OD). When there was only one entry for a tooth, the wrong surface codes appeared on the Final Odontogram form.	Changed branching logic on surface codes on the Final Odontogram form. Changed branching logic to associate surface codes with the material of the restoration selected.
The unidentified filling code ‘uif’ appeared when it shouldn’t, and corresponding surfaces appeared incorrectly on the Final Odontogram form.	The code ‘uif’ now appears on the Final Odontogram form when surfaces are entered on the Multiple Codes form or if they are the only entry for a tooth. Surfaces for ‘uif’ now appear when only recorded on the Radiograph Entry form as opposed to just on the Multiple Codes form. ‘uif’ 1 and 2 surfaces changed to appear correctly based on the Multiple Code form selections.
Missing tooth structure code ‘mtl’ did not show on the Final Odontogram form when selected on the Multiple Codes form, only the associated surfaces appeared. The code also incorrectly appeared when it was not selected on Multiple Code form.	Changed branching logic of ‘mtl’ to appear correctly.
The written record data source for code ‘mtl’ did not show on the Multiple Code form.	Changed branching logic so that ‘written record’ appeared correctly on Multiple Code form.
Codes for parapulpal pins ‘ppx’ and missing antemortem ‘mam’ showed on the Final Odontogram form when there were not selected on the Multiple Codes form.	Branching logic adjusted so that codes for ‘ppx’ and ‘mam’ appeared, or didn’t, when appropriate.

Alpha Test and Pilot Study Comparison

Variation from the consensus code was 20.31%, 28.91% and 17.97% in Case 1, Case 2 and Case 3, respectively, with an overall variation of 22.40%, which is an overall improvement from the conventional method used in the pilot study (Figure 50).

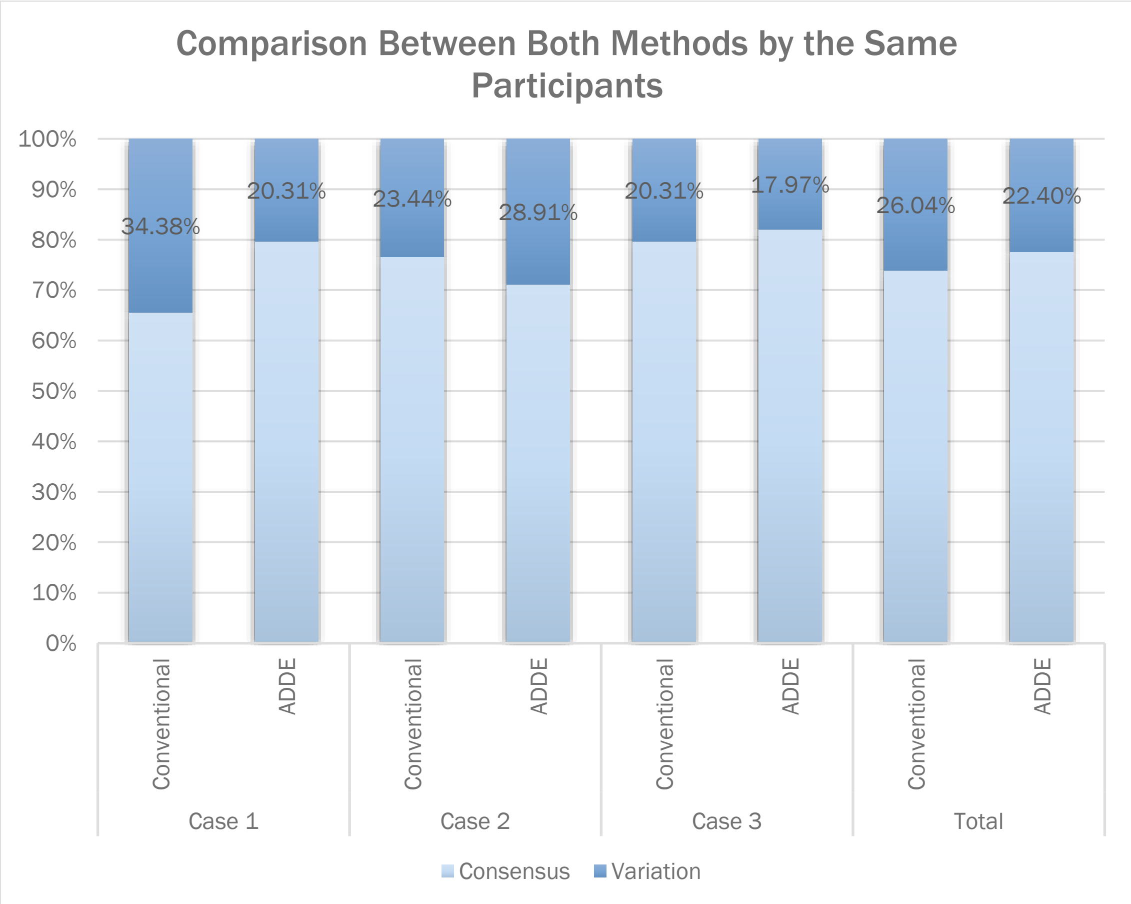


Figure 50: Comparison between Pilot Study and Alpha Test

Table 26 shows the changes between each of the 11 types of variation. The drop from 4.65% to 0% in nomenclature differences shows an improvement in standardisation and the decrease of 3.22% in incorrect codes used also shows an improvement in accuracy. The two variation types that increased using the computer-assisted method are 7 – previous treatment code and 10 – no code entered. Evaluation of the surveys indicated that these variations were due to issues with the programming or the participants not selecting an option on the Multiple Codes form. While no statistical insights can be gained, these changes are encouraging in meeting the new methods goals.

Table 26: Percentage of Total Variation Type and Difference between Both Methods

Variation Type	Conventional	Computer-assisted	Change (%)
0	69.19%	76.37%	7.18%
1	4.65%	0.00%	-4.65%
2	1.96%	0.50%	-1.46%
3	2.20%	1.49%	-0.71%
4	4.40%	3.73%	-0.67%
5	1.71%	1.49%	-0.22%
6	0.00%	0.00%	0.00%
7	0.00%	0.75%	0.75%
8	0.98%	0.50%	-0.48%
9	0.00%	0.00%	0.00%
10	0.00%	3.48%	3.48%
11	14.91%	11.69%	-3.22%

0: Correct code (agrees with odontologist consensus

1: Correct code, condition and/or surfaces, wrong nomenclature

2: Correct code, more detail available in records

3: Additional code needed (available in records)

4: Correct code category but incorrect material e.g., mcf instead of tcf

5: Incorrect surfaces (including L and V from radiographs)

6: No surfaces listed when needed

7: Correct code used, however, previous, irrelevant treatment listed

8: Correct codes transposed (incorrectly naming teeth) must have a pair

9: Use of non when radiographical information is available

10: No code

11: Incorrect code

ADDE Beta Test

The computer-assisted method was sent to approximately 200 international-forensic odontologists. Unfortunately, odontologists outside of Australasia were unable to access the online survey forms. Nine responses were received.

User input issues arising in the alpha test that resulted in changing form fields to mandatory were resolved in the beta test, unfortunately, those that could not be adjusted with the current capabilities of the program perpetuated. All programming issues were resolved.

Opinions on ADDE

Participants were asked two questions about using ADDE. What they liked and didn't like, and if they had suggestions for improvements. The positive and negative aspects are listed in Table 27. One participant recommended an area for explanations of why users chose certain codes and to record non-coded items such as pathology or surgical hardware.

Table 27: Odontologist Opinions on ADDE

Positive	Negative
▪ Simple ▪ Systematic ▪ Digital ▪ All information collated ▪ Approach each tooth individually ▪ Compare different data types to each other ▪ Easy to see if an error was made ▪ Quality checks	▪ Had trouble changing the codes for some teeth ▪ Separation of data input ▪ Want to reconcile all aspects together ▪ Calculations page was ambiguous ▪ Data entry was slow ▪ Time consuming

Beta Test and Variation Study Comparison

Variation from the consensus code ranged from 3.13% (2 participants) to 31.25% with an average of 15.63%. It is likely this rate was greatly impacted by the fact that answers were missing. It is predicted that if these answers were included, the variation rate would be smaller again. While no statistical inference can be made, there was an improvement on variation rate from the conventional method completed by international forensic odontologists (Figure 51).

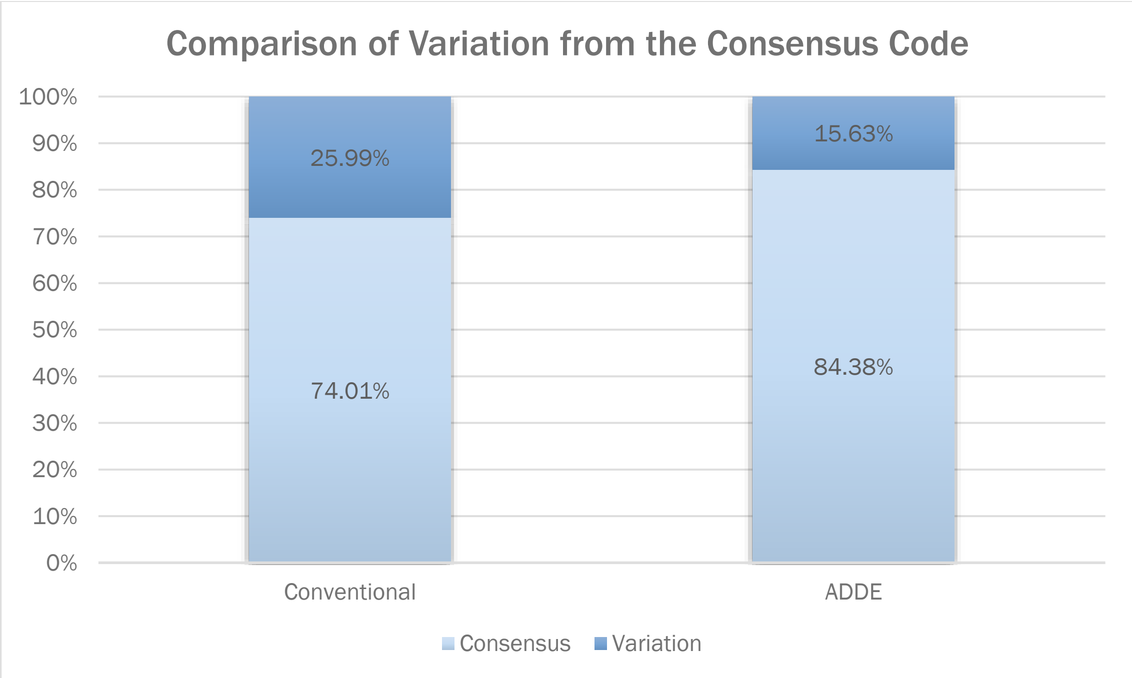


Figure 51: Comparison of Variation Between Both Methods

When the number of different codes for each tooth supplied by the participants was calculated, it was found that almost half (46.88%) had the same code. As the number of different codes increased, generally, the frequency decreased. Table 28 shows a comparison of percentage of teeth with differing final codes (one variation indicates that all answers were the same).

Table 28: Number of Difference Answers Provided in the Conventional and Computer-Assisted Methods

No. Different Answers	Conventional (n= 32)		ADDE (n=32)	
1	0	0.00%	15	46.88%
2	1	3.13%	8	25.00%
3	4	12.50%	2	6.25%
4	1	3.13%	1	3.13%
5	3	9.38%	3	9.38%
6	1	3.13%	2	6.25%
7	9	28.13%	0	0.00%
8	3	9.38%	1	3.13%
9	2	6.25%		
10	2	6.25%		
12	1	3.13%		
15	2	6.25%		
18	1	3.13%		
21	2	6.25%		

Frequency of variation types from the conventional method and the beta test of ADDE were also compared. The most important change in variation types was that no nomenclature differences were recorded with the computer-assisted method and there was no variation based on restoration material type. Variation types 7 and 10 did not appear in the conventional method, however, did in the computer-assisted method. It is likely that both were a result of the limitations of ADDE and selecting too many, or no options on the Multiple Codes input form. Variations caused by incorrect codes reduced from 5.38% to 3.38%. Variation types most likely to cause irreconcilable errors include incorrect or missing tooth surfaces and transposition errors. The rate of these variations occurring were similar across both methods.

As with the variation study, average number of data points recorded by participants, number of different codes per tooth and percentage agreement with the consensus code were calculated (Table 15).

Table 29: Comparison of Data Points, Number of Different Codes and Variation Per Tooth

Consensus Code	No. Data Points in Consensus Code	Complexity	Data Agreement	Average No. Data Points Recorded	No. Different Final Codes	Agreement with Consensus (%)
mam	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
uif DO	1	1	Agree	1	1	100%
mam	1	1	Agree	1	1	100%
mam	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
pre	1	1	Agree	1	1	100%
mam	1	1	Agree	1	1	100%
mam	3	1	Agree	3	2	100%
pre	1	1	Agree	1	2	89%
mam	1	2	Disagree	1	2	89%
mam	1	1	Agree	1	2	89%
uif O	1	3	Disagree	1	2	89%
mam	1	2	Disagree	1	2	89%
mam	2	1	Agree	2	3	89%
une	1	3	Disagree	1	3	78%
uif DO uif MO	6	2	Disagree	6	5	78%
pre	1	4	Disagree	1	2	56%
mam	1	4	Disagree	1	2	56%
uif M	2	2	Disagree	2	5	56%
uif M* uif D*	2	1	Agree	2	5	56%
uif MO* mtl D*	6	2	Disagree	4	6	56%
uif O	7	2	Disagree	5	8	56%
tcf MODL tcf DV ppx	9	3	Disagree	8	4	44%
mam	1	2	Disagree	3	6	33%

Both methods resulted in the same teeth incurring the most different answers. However, the percentage agreement with the consensus code is much higher than in the conventional method. Only two teeth were recorded as mostly incorrect in the computer-assisted version. This indicates that while variation still occurs in surface description, the inability to assign surfaces from radiographs reduces the mis-recording of assumed surfaces. As a percentage of responses, unknown surface (*) was selected more in the computer-assisted method.

The impact of the dental data source on agreement with the consensus code was evaluated (Table 30). When all three data types were consistent 96.30% of codes agreed with the consensus, which decreased to 77.78% when the data types disagreed, a similar result was seen in the conventional method. When the chart and the radiographs were the only sources of information, and they were consistent, 96.08% agreed with the consensus, when they disagreed this reduced to 58.33%. This is a significant improvement over the conventional methods 84.76% and 42.61% respectively.

Table 30: Dental Data Source and Agreement

Data Type and Agreement	Consensus	Variation	Total
All Record Types	**54**	**9**	**63**
Agreed	26	1	27
Disagreed	28	8	36
Chart and Radiographs	**189**	**36**	**225**
Agreed	147	6	153
Disagreed	42	30	72
Total	**243**	**45**	**288**

These results reflect what was found in the conventional method study (Chapter 5), that the data source the information is gathered from is not as important as whether multiple data sources say the same thing. The difference in results between the conventional method and computer-assisted method shows that providing the user with a comparison between treatments selected from all data sources, especially when they differ, greatly increases the likelihood of the correct code being chosen.

Odontologist Opinions

In relation to the case being transcribed, eight participants relied on radiographs while one reported that they relied on the dental chart as the primary source of information. The issues they found with the records include:

- Transposition of the 16 and 17
- Possible transposition of the 37 and 47
- 28 unerupted or missing
- 37 present or missing
- Anterior teeth were hard to see on the panoramic radiograph
- It was difficult to assess restorations based on the radiograph angles

One participant elaborated on why they chose the codes they did for these teeth. Reasons related to appearance and spatial relation of teeth on radiographs, relying on radiographs over the dental chart and ‘erring on the side of caution’ - recording treatment that would not create an erroneous exclusion on comparison.

In their general casework four participants (44.44%) unofficially give an evidentiary value to their AM records. Three (33.33%) do so as part of their standard operating procedure and two (22.22%) replied that they didn’t assess the value at all.

All participants selected radiographs as an important data source in the AM dental record. The spread of responses is shown in Figure 52.

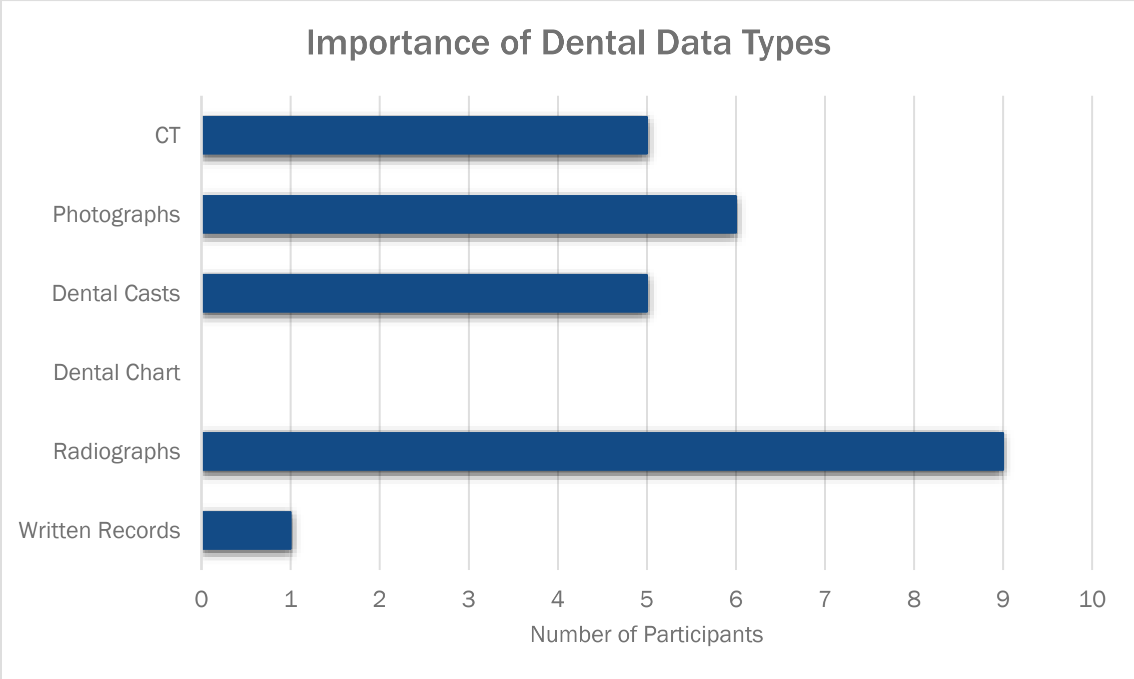


Figure 52: Importance of Dental Data Types

One participant who elaborated on their selections stated that all should be taken into consideration equally. Another participant commented on the fact that there is a lack of information provided concerning what the entries on a dental chart actually represent, although reconciling against radiographs can assist. A common sentiment among the participants was that images are objective, individualistic and not subject to human error.

Discussion

ADDE has shown, with this small beta test, to improve on the standardisation of the final antemortem transcription. It has also shown that displaying the different treatments found in the various record types helps the user to select the correct treatment. The guidelines developed also increase specificity of the use of codes and their descriptions to improve consistency, an issue highlighted in the National Research Council (2009) report.

While the beta test has improved on the issues raised in the alpha test, some problems still perpetuate. Teeth were not being represented on the final odontogram due to participants not selecting options on the Multiple Codes form. On one occasion, two incompatible statuses were selected (present and missing). These issues could be easily resolved by creating a pop-up alert to advise the user of incompatible treatments, and not allowing the user to move past the multiple codes stage without selecting anything. Despite this, overall agreement with the consensus code increased and no nomenclature or restoration material variations were recorded. Variations involving transposition and tooth surfaces are a result of individual decision and while this may be improved with following specific guidelines, this subjective judgment will never be removed entirely. Another area of individual judgement evident from the beta test is not recording relevant treatment present in the records (variation types 2 and 3). A computer-assisted method cannot highlight to the user if they have missed anything present in the record. However, one participant discussed their choices that lead to these variation types which may be applicable to other participants. While they were aware restorations were evident on the radiographs, they were unsure as there was no accompanying written information. They decided to record the lesser treatment of present. When coding antemortem data, it shows foresight to record the lesser treatment when unsure as it has implications on a dental match search and reconciliation at a later stage.

Use of a computer-assisted method for proficiency and reliability testing requires the programming behind the method to be built for purpose with the inclusion of the desired features that were not possible to include in this first iteration. For example, working through a timeline of records rather than approaching each record type separately as well as including the date of the selected treatment next to the data source when choosing from multiple codes. All negative aspects of ADDE raised by participants can also be addressed and improved through new program creation.

To meet the scientific criteria of reliable principles and methods, a procedure must be reproducible and consistent (President's Council of Advisors on Science and Technology 2016). While participant numbers were small, this computer-assisted method has shown improvement in both reproducibility and accuracy (i.e.: different individuals obtaining the same results and obtaining correct results.) The method also shows promise with its ability to be used for proficiency testing and repeatability testing.

Limitations

The biggest limitation of the beta test was the small sample, with only nine participants no solid inferences can be made and there is not a broad range of opinions and comments on the functionality of the method. For an unknown reason some international participants were unable to access the link to the online forms, significantly reducing the potential number of responses.

The database software was also a limitation, as it was not designed for this purpose. Potential information was not able to be laid out as desired and alerts to previous entries, no entries and incompatible entries was not possible.

Conclusion

The computer-assisted antemortem transcription method improves standardisation and reduces the number of variations recorded between users. While overall variation was reduced, there will always be some differences between people based on the subjective nature of interpretation from radiographs, progression of treatment and assigning the most recent treatment. The beta test showed that, while improvements are required, the computer-assisted method, ADDE, achieved its aims to improve standardisation, accuracy and aid users in their decision making.

Further development of the computer-assisted method to accomplish all its original goals and functions requires a new program to be designed and built allowing for significantly more information to be entered, while making the user experience as streamlined as possible, including an option for multiple user languages. The output of such a program would also be in a format compatible with dental match searching software so that it can be implemented in current practice. Other functions to improve user experience and calibration include the ability to view guidelines from within the program as well as visual and written tooth anatomy descriptions to aid users in selection of teeth when not all are present. The use of an interactive odontogram will improve ease of entry and provide a visual representation of the treatment and statuses selected. These improvements will allow the program to be used for reliability and proficiency testing of the antemortem phase of dental identification.

CHAPTER 9: DISCUSSION AND CONCLUSION

The importance of validating the scientific method used in all feature comparison forensic science disciplines has been raised over the past decade with a push for each to demonstrate through empirical validation studies that they are scientifically based (National Research Council 2009; President's Council of Advisors on Science and Technology 2016). While studies assessing the validation of using radiographs in the reconciliation phase of dental identification have been performed (Borrman & Grondahl 1990, 1992; Ekstrom, Johnsson & Borrman 1993; MacLean, Kogon & Stitt 1994; Kogon, McKay & MacLean 1995; Kogon & MacLean 1996; Pretty et al. 2003; Soomer et al. 2003; Fridell & Ahlqvist 2006; Wenzel, Richards & Heidmann 2010; Pinchi et al. 2012; Balla & Forgie 2017; Page et al. 2018), no research has been published validating all stages of the dental identification process.

This body of research initially set out to devise a method of validation for dental identification. To facilitate this, it was important to first outline the exact steps required to reach the final identification outcome. The initial study surveying Australian forensic odontologists revealed that the practice of dental identification between practitioners and jurisdictions varies considerably (Storer, Berketa & Higgins 2021). While practitioners agree that validation is necessary, these differences in practice make the development of accuracy testing and validation processes challenging and a mammoth task if all phases are to be considered. Consequently, considering the absence of literature on the antemortem phase I chose to narrow my focus to this stage of dental identification. Testing of validity and accuracy first requires a standard methodology to be devised. The President's Council of Advisors on Science and Technology (2016) report calls for a ‘reproducible and consistent procedure’ when establishing foundational validity. Chiam et al. (2019) also found, when reviewing previous validation studies, that the design and methodology were diverse and therefore results could not be compared or combined. They concluded that the discipline would benefit from a consistent model and framework for validation research. To date no studies exploring a detailed standard methodology for the antemortem phase have been reported. While this phase beings with locating an individual's dentist and collecting the corresponding dental records, this task is routinely carried out by Police (this may differ in other jurisdictions and countries). Thus, the forensic odontologists first task in the antemortem phase is evaluation and transcription of the received dental data.

The development of a standard operating procedure for AM dental record transcription would require an in-depth understanding of what constitutes a data set. The review of multiple sets of dental records provided for actual dental identification casework (Chapter 3) revealed a wide variety and number of data types. Additionally, records also varied in presentation, volume, legibility, and accuracy (Hill 1988; Borrman et al. 1995; De Valck 2006; Petju et al. 2007). Almost all the dental records examined contained written clinical notes including item billing numbers indicating treatment performed and many had an accompanying dental chart. Although not assessed in this research, previous studies found that dental charts provided were often not comprehensive (Hill 1988; Zahrani 2005; Petju et al. 2007; Stow, James & Richards 2016; Brown & Jephcote 2017). Most of the records included radiographs of some type, with intraoral records being the most predominant, this was consistent with radiographs types reported by Stow, James and Richards (2016) and Waleed et al. (2015). Surprisingly only just over half of the records included bitewings, which are the main diagnostic films used in routine dentistry. Half of the records included panoramic images displaying the complete dentition and supporting structures.

It is evident from this study that odontologists are often forced to make decisions based on subjective records, such as clinical notes and dental charts. Information regarding all teeth and oral structures is not contained in these records and they can be misleading. A recent study concluded that the evidentiary value of dental records was influenced by their recency, the content (clinical notes, radiographs etc) and the number of individualising features documented (Maley & Higgins 2022). Hence, the variety, quality and completeness of dental records provided for antemortem evaluation directly impact the reconciliation outcome. The biggest issue from a forensic perspective highlighted by my investigation was that records generally only depict treatment provided by that particular practitioner over a limited period of time, not the entire dentition and all treatment present in the mouth. This is reflected in the literature, with multiple studies reporting that in the records examined practitioners do not document the existing dental condition on examination, and only chart treatment required or that they have completed (Fischman 1987; Hill 1988; Borrman et al. 1995; Petju et al. 2007; Waleed et al. 2015; Brown & Jephcote 2017; Stow & Higgins 2019). The time span of these studies indicates this lack of record keeping is an ongoing issue yet to be addressed on an individual basis. It would be beneficial if dental practitioners recorded where their patients had previously been treated and conducted baseline charting more often, also suggested by Brown and Jephcote (2017). Even in general clinical practice this is important as a lack of record keeping has implications for dental practitioners in terms of legal documentation in the event of complaints or negligence cases as well as supplying information for forensic dental identification. Continuing education regarding record keeping and its forensic relevance has been recommended by various studies that have evaluated antemortem records (Delattre & Stimson 1999; Waleed et al. 2015; Stow, James & Richards 2016; Stow & Higgins 2019). This increased awareness of the forensic identification process may encourage dental professionals to not only collect and retain more data but also ensure that they provide all the data they have rather than just the parts they consider relevant.

While each set of antemortem records examined differed, it was unclear how this would impact transcription outcomes. The pilot study (Chapter 4) explored the causes of variation and the overall accuracy of transcriptions. Three sets of dental records with differing antemortem data content were used. The presence and extension of restorations, as well as the absence of images, caused the most variation. As was found in a previous study (Sand et al 1994), it was evident when comparing dental students and forensic odontology students (dentists) that training and experience mattered. Despite instruction on using codes, participants still employed more familiar nomenclature. This lack of adherence to the instructions may be improved through familiarity with the process; however, it also indicates that ambiguous instructions and definitions of codes need to be addressed. For example, many participants wrote ‘caries’ or ‘decay’ as they couldn’t find a code suited for this tooth condition. To gain a deeper understanding of the causes of variation and the effect of data available in the dental record, participation by dental professionals with specific training in antemortem record evaluation, interpretation, and analysis were required.

Forensic odontologists from across the world familiar with INTERPOL standards participated in a single transcription task (Chapter 5). The results confirm previous studies (Sand, Rasmusson & Borrman 1994; Kirchhoff et al. 2008) which found improved results were obtained by those with more experience.

Interestingly, codes and syntax varied a lot between practitioners. Despite not being as pronounced as in international dental records as found by Manica (2014) it is still interesting that such variation can occur despite using a standardised coding system. The discrepancy between the number of variations and the overall accuracy reflects previous observations that diverse codes, with essentially the same meaning, cause a lack of uniformity. This can needlessly complicate the reconciliation process by creating ambiguous records that are confusing to other practitioners (Torpet 2005; Clement et al. 2006). The study highlighted the need to develop a protocol for increasing standardisation among practitioners and removing or at least reducing, the ability to enter free text and non-current codes. Interestingly, it was found that dental data content and complexity had a greater impact on the accuracy than which data type contained the information. Treatment that required a more subjective assessment, particularly restorations and their surfaces, resulted in more variation even though the complexity of finding the information in the records was minimal. Variation types assessed in both studies informed the first step in the creation of a guide to improve standardisation and accuracy.

Guidelines for antemortem transcription were explored and developed based on the variation types and causes discovered, and the interpretation and evaluation required for each dental record data type. Operator calibration guides for clinical dental data collection were also investigated and adapted with necessary changes for forensic purposes. I believe that these standards will improve the consistency of codes selected and may help odontologists make decisions in ambiguous situations.

Further defining the current INTERPOL codes would likely improve clarity and remove the cross-over of their use and in turn, the discrepancies faced during reconciliation. For example, the code ‘pre – tooth present’ and ‘nad – no abnormality detected’ could be used interchangeably as a tooth with no treatment has no abnormality and is also simply present. However, with the additional guidelines of only using ‘nad’ when there is written or visual evidence that the tooth is sound and not as an equivalent to ‘pre’, and to use ‘pre’ when there is evidence of the tooth's presence but no information on its status (such as partially visible in radiographs) users are left in no doubt as to which code should be used. Increasing detail and specificity in these definitions also ensures that a code is available for most tooth statuses, conditions, and treatments striking a balance between sufficient codes to differentiate treatments and a confusing abundance of codes (Clement et al. 2006).

The ultimate goal of this research was to improve standardisation to inform a standard operating procedure for the evaluation and transcription of dental data. With guidelines created, it was necessary to test them and receive feedback from the profession. While this could be accomplished using the same method as the previous studies, it would be cumbersome and time-consuming for participants. I decided to streamline the process using a computer-assisted method to test the new guidelines and definitions. Additionally, it would have the added benefit of removing some of the subjective decisions required and eliminate the ability to use non-current codes.

A lot of time was spent exploring options for the creation of computer software for antemortem transcription. Ultimately, due to availability and user-friendliness, the database software REDCap® (Harris et al. 2009; Harris et al. 2019) was chosen. There was a workaround for most of the features desired and the survey format was ideal for participation. Even though REDCap® was very user-friendly, to create the method with a system not designed to do so, a lot of coding of branching logic and calculations was required to ensure a reasonable flow of questions and to maximise ease of user experience.

The creation of the computer-assisted method, 'Antemortem Dental Data Entry (ADDE)', and its subsequent alpha test provided promising results with an overall improvement in the level of variation and the elimination of nomenclature differences. This suggests that a standardised method and inability to enter codes other than those in the instructions would improve the uniformity of the final transcription and remove the need to interpret different codes and work through unnecessary discrepancies when comparing to the postmortem record.

The alpha test aimed to test the software design and use. It was instrumental in highlighting errors within the REDCap® branching logic, such as multiple codes appearing when they were not selected and surface codes visible on the Final Odontogram form without their relevant three-letter treatment code. User errors identified included no selection from the treatment/status list, selecting multiple, incompatible codes on the Multiple Codes form and not entering material or surface details for selected restorations. This information was used to recode those areas creating issues as well as improve the user experience and user guidelines. Unfortunately, not all user errors were able to be addressed by the programming available and these errors continued into the beta test.

The beta test was conducted using the same case as the previous validation study with all programming issues raised in the alpha test amended where possible. The main aim of this test was to assess whether the new guidelines and procedure aided in increasing accuracy and reliability. International forensic odontologists participated, however, the testing was significantly hampered by the inability of some international odontologists to access the online forms.

The main finding from the beta test was the decrease in variation and increase in accuracy of the final codes in the dental transcription. Variation from the consensus code decreased and there was no variation caused by nomenclature differences. The number of variations per tooth also decreased. Variation types that persisted throughout each of these studies were surface selection and transposition. Even with detailed guidelines, these are decisions that must be made by the individual and while reduced, cannot be eliminated. The beta test still found that variation was more likely to occur when multiple data sources were inconsistent. However, the overall accuracy when data was inconsistent improved when compared to the previous study. This suggests that being able to view all treatment recorded from all data sources together with the ability to select from the list improves the user's capability to decide between the differing data.

This study showed the potential to increase standardisation, accuracy, and reliability in antemortem dental data transcription. The guidelines used increased specificity and consistency of code use, which would lead to a reconciliation phase that is not hampered by discrepancies caused by nomenclature errors or ambiguous coding. ADDE improved the final quality of antemortem data transcription, however, a program designed and built from scratch would address all these issues and could be disseminated internationally for trial and feedback.

Conclusion

This body of research aimed to improve the accuracy, reproducibility, and repeatability of dental data transcription in the antemortem phase of dental identification through a standardised methodology. Standardisation is an important step towards validation and reliability testing of a forensic science methodology.

Through the assessment of variation and its causes as well as the creation of guidelines and detailed code definitions, differences between practitioners can be minimised. The creation of a computer-assisted method for completing transcription provided a more time efficient and structured tool for testing these new guidelines. Using this method showed that the negative effect of contradicting information across the data types in the antemortem record was reduced with the ability to easily compare all treatment noted for a tooth. While further testing with a larger number of participants is required for statistical analysis, results are promising as accuracy was increased and the number of different codes used per tooth was reduced.

When both antemortem and postmortem data collection is conducted using the same detailed guidelines, the number of ambiguous comparisons will be reduced leading to more time efficient and less laborious reconciliation and identification.

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APPENDICES

Publication: Commentary Paper
Ethics Approval
Learning Module for 5th Year Dental Students
Constructed Dental Records
REDCap® Codebook
REDCap®/Shazam HTML and CSS
ADDE Guidelines
Presentations and Awards

Appendix I – Publication: Commentary Paper

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Principal Author

Name of Principal Author (Candidate)	Catherine Storer (nee Sims)		
Contribution to the Paper	Performed literature search, analysis of papers, wrote the manuscript and acted as corresponding author.		
Overall percentage (%)	90%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
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Name of Co-Author	John Berketa		
Contribution to the Paper	Helped to evaluate and edit the manuscript.		
Signature		Date	29/08/2022

Name of Co-Author	Denice Higgins		
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Is human identification by dental comparison a scientifically valid process?☆

Catherine A. Sims*, John Berketa, Denice Higgins

Forensic Odontology Unit, University of Adelaide, Australia

1. Introduction

In recent years there have been multiple reports scrutinising forensic science pattern matching or 'feature-comparison' methods [1,2]. These reports highlight where various forensic science disciplines lack appropriate scientific evidence of the validity of their techniques. While not specified in these reports, components of dental identification can be considered as feature-comparison. Identification accounts for the majority of odontology case work and is a key method for identification in disaster situations. The dental identification process has been documented as being well established in the forensic science disciplines [2–4]. However, no reference for this statement was evident. The basic techniques used in dental identification have been employed for centuries and are accepted and considered reliable by forensic science and the law. However, history and anecdotal evidence is insufficient to prove a technique scientifically reliable and valid. Evidence based science requires appropriate published validation studies.

Multiple forms of validation study are available depending on what is being tested. Studies of objective methods (those not influenced by opinion) should have empirical studies undertaken, while subjective methods (those that rely on human judgement) should have 'black-box' studies undertaken [1]. Ultimately black-box studies aim to test a method during regular casework without the practitioner knowing they are being tested.

In order to appropriately determine the scientific validity of dental identification, the process must be analysed to highlight which components lend themselves to empirical study (objective) and which should be investigated by 'black-box' studies (subjective).

2. The dental identification process

Dental identification is conducted in three phases. Antemortem – gathering information from dental records of a known individual, Postmortem – dental examination of the unknown deceased, and Reconciliation – comparison of the two data sets.

The antemortem phase involves collection of dental data from one or multiple sources such as general dentists and/or specialist dentists. Within those records the data can be presented in many forms, including but not limited to written records, clinical charting, photographs and radiographs. Written notes and dental charting are highly subjective forms of data. They are a written representation of the opinion of the dentist as to a person's oral status. Good records require three features, completeness, accuracy and detail. However, written records are often minimal and are prone to human error. Radiographs are the most common form of objective data; they are a pictorial representation of the oral status and are less subject to error. The transcription from dental notes to standardised forms can be both objective and subjective. First, an opinion on the completeness and accuracy of records is required before transcribing what is present.

The postmortem phase is conducted by forensically trained dentists or specialist forensic odontologists. They complete a dental examination, much like an examination performed in life by a dentist, and take a full mouth series of radiographs. These details are also transcribed on to a standardised form. As with the antemortem phase, the recording of dental features is somewhat subjective, relying on the odontologists interpretation of what is present.

The reconciliation phase involves the comparison of the antemortem and postmortem data sets. This is accomplished using the standardised forms obtained from the previous phases. This includes comparison of written codes, charting and any supporting data such as radiographs and photographs.

The first step in comparison is to objectively identify areas of discrepancy. Where do the codes not match? When these data points are found, the odontologist then subjectively, using their experience and dental knowledge, forms an opinion as to whether these discrepancies can be reconciled. Irreconcilable discrepancies would suggest the data sets are not from the same person. Once the discrepancies have been reconciled an opinion is then formed as to the evidentiary weight of each concordant point. An identification conclusion is then given determining the likelihood that both data sets originated from the same source. As such, if two points don't match it doesn't automatically make it an exclusion, just as if they do match, it doesn't automatically guarantee an established identity. Deciding on a conclusion of identity is also subjective. What is necessary for an established conclusion for one person might only be enough information to warrant a probable conclusion from a different practitioner. While there are definitions of

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* Corresponding author at: Forensic Odontology Unit, University of Adelaide, 5005, Australia.
E-mail address: catherine.sims@adelaide.edu.au (C.A. Sims).

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the available conclusions, they are also subject to individual opinion and interpretation.

It is evident that dental identification uses both subjective and objective methods with the added difficulty of them being subconsciously intertwined. For example, when reconciling discrepancies, a subjective process is being undertaken, however the odontologist may perceive the explanations as facts rather than opinions. Thus, it is evident that there cannot be a 'one size fits all' validation study for dental identification.

3. On Computer automation

Computer systems like Plass data's DVI System International have been frequently used in disaster situations and have proven to be efficient search engines. They are objective, searching for multiple instances of the same dental codes. Results appear as a series of possible matches in decreasing order of likelihood, much like the Automated Fingerprint Identification System (AFIS) used by Police agencies worldwide [5]. This is invaluable in disaster situations where there are a large number of deceased, as this substantially reduces the list of potential comparisons to be reviewed. Manual reconciliation is still required in all cases whether one or multiple potential matches are highlighted. The software cannot make the decision as to whether they originate from the same individual. The odontologist reviews all relevant data, reconciles any discrepancies and forms an opinion on the likelihood of identity. Again, this verification is also necessary when using the AFIS system for fingerprint analysis [5]. It is not possible to make the process completely objective and automated as this final stage is heavily reliant on dental knowledge and experience in areas such as dental disease, growth and development, dental interventions, and radiograph interpretation.

4. The literature

In searching the literature, no published studies addressing the validation of the entire dental identification process could be found. Studies that do exist focus on the validation of specific techniques used in reconciliation, including comparison of radiographs [3,6,7], cone beam computed tomography [8] and palatal rugae [9], video superimposition [10], and virtual autopsy [11]. Research on other aspects of the process have been published [12–14]; however, none of them aim to validate the casework process or are case reports. The process of radiographic comparison has received the most attention. However, studies examining this process do not reflect real casework scenarios. They present radiographs as isolated data and offer a simple binary (match/non-match) option for conclusion. Whereas, in casework, there are usually multiple types of data to aid in the comparison and there are a series of conclusions that cover a range of 'certainty' of the identification. Published research is also available evaluating dentists' awareness and importance of antemortem data [15], postmortem procedures and differences between examiner outcomes [16,17]. While raising interesting points further investigation is required as these are generally not true validation studies. Guidelines from professional organisations such as INTERPOL also exist providing a step by step process for the three phases. However, they do not specifically address details within each step and do not comment on decision making processes or evidentiary value of data. This is left to the opinion of the odontologist.

5. Where to go from here?

From gaps in the literature, active participation in casework and discussion with other members of the odontology profession, it is evident that more robust validation research is required. However, prior to these studies being undertaken, it would be prudent to take a step back and determine which type of study is appropriate for each part of the process. All phases should be addressed. Testing the comparison of data sets is invalidated if the data itself is inaccurate or unreliable.

Potentially, a number of the subjective areas could be made more objective through more specific definitions and guidelines. For example, how do you determine both the accuracy and completeness of an antemortem record? What is the evidentiary weight of different data types? What is the difference in evidentiary weight of different dental treatments or morphological features? While there are no databases providing a statistical probability of features, can we form a hierarchy of importance for the data we are interested in? Guidelines will provide an objective basis for dental identification without being restrictive on experience and the freedom of the practitioner to form an opinion.

Investigation into the validation studies of latent fingerprint examination is worth exploring to provide guidance in validation for forensic odontology as the methodology behind feature-comparison and reliance on expert opinion is similar. There are also studies that were approved by reports commissioned by the United States government, into the justification of feature comparison methods, that could potentially provide a framework for dental identification validation studies [1,18–22].

Forensic odontology is an important tool in human identification, both in regular casework and disaster situations. It is impossible at this stage to answer whether the process is scientifically valid as appropriate studies have not been performed. It is imperative for the profession to support the processes of dental identification with evidence-based studies. However, the importance and necessity of expert knowledge, experience and opinion cannot be denied. Efforts to further the science of dental identification should focus on ways to objectively support the odontologists opinion and decision making, rather than trying to bypass it in an attempt at automation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix II – Ethics Approval

RESEARCH SERVICES
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY
THE UNIVERSITY OF ADELAIDE

LEVEL 4, RUNDLE MALL PLAZA
50 RUNDLE MALL
ADELAIDE SA 5000 AUSTRALIA

TELEPHONE +61 8 8313 5137
FACSIMILE +61 8 8313 3700
EMAIL hrec@adelaide.edu.au

CRICOS Provider Number 00123M

Our reference 33217

13 July 2021

Dr Denice Higgins
School of Biological Sciences

Dear Dr Higgins

ETHICS APPROVAL No:	H-2018-252
PROJECT TITLE:	Dental Identification by Pattern Making - Variation and Reliability of Techniques

Thank you for your responses to the matters raised. The requested amendments in the revised application provided on 13/07/2021 have been approved by the Health & Medical Sciences Low Risk Review Group.

The ethics amendment for the above project has been reviewed by the Low Risk Human Research Ethics Review Group (Faculty of Health and Medical Sciences) and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research 2007 (Updated 2018)* involving no more than low risk for research participants.

You are authorised to commence your research on:	15/11/2018
The ethics expiry date for this project is:	30/11/2021

NAMED INVESTIGATORS:

Chief Investigator:	Dr Denice Higgins
Student - Postgraduate Masters by Coursework:	Dr Catherine Alexandra Storer
Associate Investigator:	Dr John Berketa

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled Annual Report on Project Status is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/research-services/oreci/human/reporting/. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the information sheet and the signed consent form to retain. It is also a condition of approval that you immediately report anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol or project investigators; and
- the project is discontinued before the expected date of completion.

Yours sincerely,

Ms Alison Harwood
Secretary

The University of Adelaide

THE UNIVERSITY of ADELAIDE

RESEARCH SERVICES
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY
THE UNIVERSITY OF ADELAIDE

LEVEL 4, RUNDLE MALL PLAZA
50 RUNDLE MALL
ADELAIDE SA 5000 AUSTRALIA

TELEPHONE +61 8 8313 5137
FACSIMILE +61 8 8313 3700
EMAIL hrec@adelaide.edu.au

CRICOS Provider Number 00123M

Our reference 33217

14 December 2021

Dr Denice Higgins
School of Biological Sciences

Dear Dr Higgins

ETHICS APPROVAL No: H-2018-252
PROJECT TITLE: Improving scientific validity of antemortem dental data transcription

Thank you for your emails and amended application dated 26.11.2021 and 7.12.2021 and annual report dated 7.12.2021. The request to expand the recruitment methods and an extension of three years has been approved by the Secretariat.

The ethics amendment for the above project has been reviewed by the Secretariat, Human Research Ethics Committee and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research 2007 (Updated 2018)* involving no more than low risk for research participants.

You are authorised to commence your research on: 15/11/2018
The ethics expiry date for this project is: 30/11/2024

NAMED INVESTIGATORS:

Chief Investigator:	Dr Denice Higgins
Student - Postgraduate Masters by Coursework:	Dr Catherine Alexandra Storer
Associate Investigator:	Dr John Berketa

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled Annual Report on Project Status is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/research-services/oreci/human/reporting/. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the information sheet to retain. It is also a condition of approval that you immediately report anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol or project investigators; and
- the project is discontinued before the expected date of completion.

Yours sincerely,

Ms Amy Lehmann
Secretary

The University of Adelaide

RESEARCH SERVICES
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY
THE UNIVERSITY OF ADELAIDE

LEVEL 4, RUNDLE MALL PLAZA
50 RUNDLE MALL
ADELAIDE SA 5000 AUSTRALIA

TELEPHONE +61 8 8313 5137
FACSIMILE +61 8 8313 3700
EMAIL hrec@adelaide.edu.au

CRICOS Provider Number 00123M

Our reference 33217

16 August 2022

Dr Denice Higgins
School of Biological Sciences

Dear Dr Higgins

ETHICS APPROVAL No: H-2018-252
PROJECT TITLE: Improving scientific validity of antemortem dental data transcription

Thank you for your emails and revised applications dated 17.06.2022 and 18.08.2022 requesting an amendment. The request to undertake additional recruitment to conduct testing of a computer assisted transcription procedure has been approved.

The ethics amendment for the above project has been reviewed by the Low Risk Human Research Ethics Review Group (Faculty of Health and Medical Sciences) and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research 2007 (Updated 2018)* involving no more than low risk for research participants.

You are authorised to commence your research on:	15/11/2018
The ethics expiry date for this project is:	30/11/2024

NAMED INVESTIGATORS:

Chief Investigator:	Dr Denice Higgins
Student - Postgraduate Masters by Coursework:	Dr Catherine Alexandra Storer
Associate Investigator:	Dr John Berketa

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled Annual Report on Project Status is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/research-services/oreci/human/reporting/. Prior to expiry, ethics approval may be extended for a further period.

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- proposed changes to the protocol or project investigators; and
- the project is discontinued before the expected date of completion.

Yours sincerely,

Ms Amy Lehmann
Secretary

The University of Adelaide

Appendix III – Learning Module for 5th Year Dental Students

01: Forensic Odontology

Introduction

Forensic Odontology is the branch of dentistry that applies dental science to the law. It involves the recognition, examination, documentation, preservation, interpretation and analysis of dental and oro-facial evidence; and presentation of opinion related to this evidence to the courts of law.

Learning Objectives

In this module you will gain a brief insight into the scope of practice of forensic odontology including:

- Bitemark Analysis
- Age Estimation
- Dental Identification

01.1: Forensic Odontology: Bitemarks

Pattern Injury Analysis

Bitemarks are defined as:

Pattern Injury Analysis

A mark made by the teeth, either alone or in combination with other mouth parts*

Trace Evidence for Biological Analysis

Whittaker DK and MacDonald DG (1989). *A Colour Atlas of Forensic Dentistry*. Wolfe Medical Publications, London UK.

Possible cases include human bites on other humans and inanimate objects as well as animal bites to humans and other animals.

Characteristics of a human bite:

- Circular or Oval U shaped arches, separated at ends
- Within each arch, separate marks (bruising, abrasion or laceration)
- Partial bites
- Suction marks
- Tooth imprints

We cannot identify someone through their bitemark.

- They are either excluded or fail to be excluded from potentially causing the injury

So why bother?

We can give our opinion on:

- whether an injury could have been made by teeth or not
- whether the injury was caused by animal or human dentition

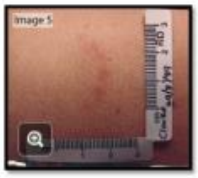
Value of Bitemarks

ANIMAL

- Possible determination of species
- Peri-mortem or postmortem preditation

HUMAN

- Can show and demonstrate pain, suffering and mutilation
- Can be offensive as well as defensive
- Usually demonstrates violence (Human bites occur in assaults and sexual assaults)
- May corroborate or contradict a victim statement
- Can exclude a suspect
- Multiple bites can show a pattern of abuse (child abuse)



A Famous Bitemark:

Ted Bundy

Found guilty in the late 70s and early 80s, bitemark evidence was used in his trial.


Watch more about Ted Bundy on Netflix

[Conversations with a Killer: The Ted Bundy Tapes | Official Trailer [HD] | Netflix (https://www.youtube.com/watch?v=n1UJgrNRcvI)](https://www.youtube.com/watch?v=n1UJgrNRcvI)

(https://www.youtube.com/watch?v=n1UJgrNRcvI)

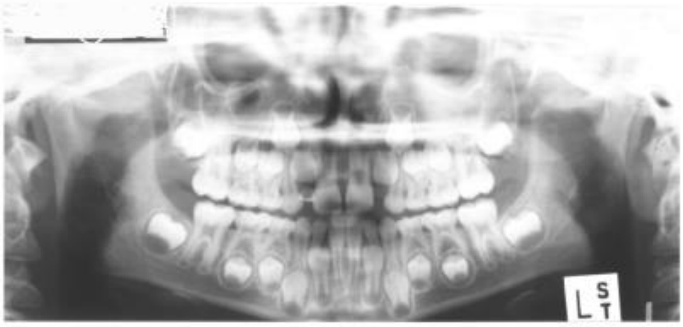
[Extremely Wicked, Shockingly Evil and Vile | Official Trailer [HD] | Netflix (https://www.youtube.com/watch?v=mdMtnvMJcDA)](https://www.youtube.com/watch?v=mdMtnvMJcDA)

(https://www.youtube.com/watch?v=mdMtnvMJcDA)

01.2: Forensic Odontology: Age Estimation

Age Estimation

Using known eruption, exfoliation and root closure times, it is possible to estimate an individuals age range.



To Assist Identification

When identifying the remains of children it can be difficult to get a result through the usual dental identification techniques. This is due to limited dental appointments, few, if any dental images and the rapid change of dentition in a short period of time.

An age estimation can help narrow down possible identification to known victims. For example, if there are multiple children in a car accident, they can be differentiated by age even if no records are available.

Legal Age

We can be asked to provide an estimation if there is any question of age:

- Criminal court cases can often take place years after the alleged offence. For young adults this can mean the difference between getting tried as a minor or an adult.
- Refugees or immigrants may have no known date of birth and are given one, which may not be accurate.

Age Estimation Methods

There are many methods used for age estimation based on different populations and focusing on certain aspects, for example third molars.

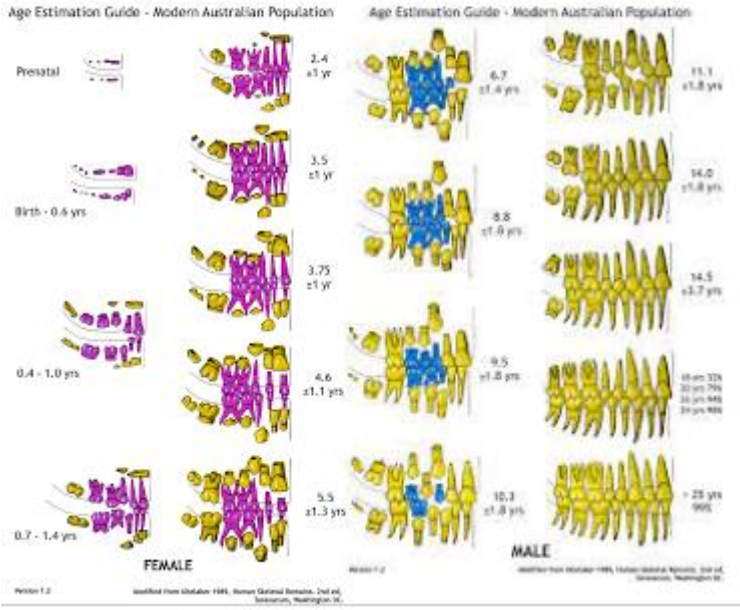
Often an age estimation is reached using multiple methods and adjusting for population if necessary. An estimation is always given in a range, for example, 11-13 years or 12 years +/- 2 years. These ranges are smaller the younger a person is and tend to span multiple years in adolescents.

Common techniques include:

Blenkin and Taylor 2012 (see images)

Demerjian 1976

London Atlas 2009: atlas_of_tooth_development_in_English.pdf



01.3: Forensic Odontology: Identification

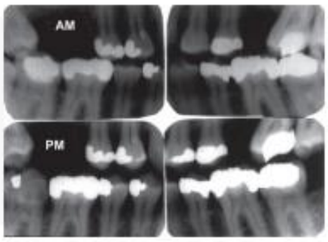
Human Identification

The law requires that everyone who dies is identified. But how is this achieved when the person is no longer visually recognisable?

There are three primary, or scientific, methods of human identification:

- DNA
- Fingerprint Comparison
- Dental Comparison





Scientific identification is the comparison of 2 sets of data: Antemortem (before death) and Postmortem (after death). All techniques rely on pattern recognition and matching. The overall result is dependent on the value of the pattern ie) the individuality of patterns, pattern stability (no or predictable change) and rate of occorrence of features present in a population.

Dental Identification

The majority of forensic odontology case work is dental identification.

Situations where it is most helpful include:

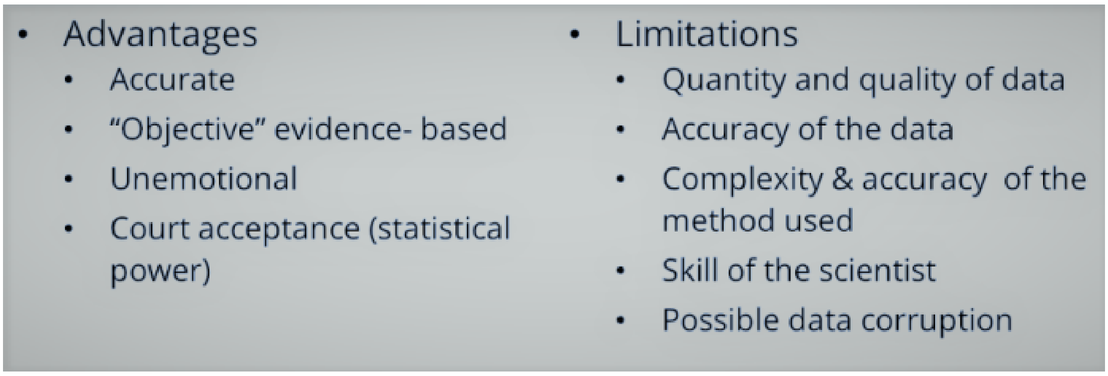
- Incineration
- Trauma
- Decomposition
- Skeletonised
- Multiple deaths
- DNA collection from teeth

Why do we use teeth to identify people?

- **Highly Individual**

- Morphologic features
- Introduced artefacts (dental treatment)

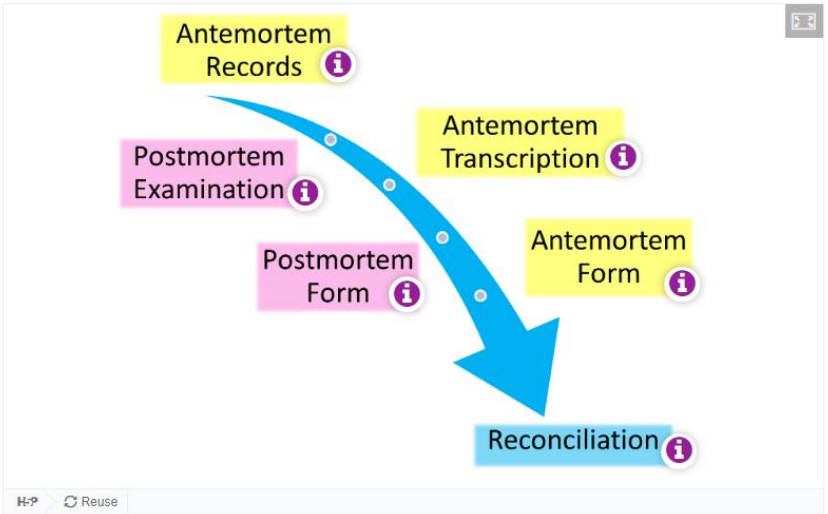
- **Resist Destruction**
  - Enamel is the hardest substance in the human body
  - Teeth are the last skeletal element to decompose and they are resistant to heat
- **Existence of Dental Data**
  - Most people have visited a dentist
  - Far more people will have dental records than DNA or fingerprint records
- **Rapid**
  - Once all information is gathered an opinion can be given promptly

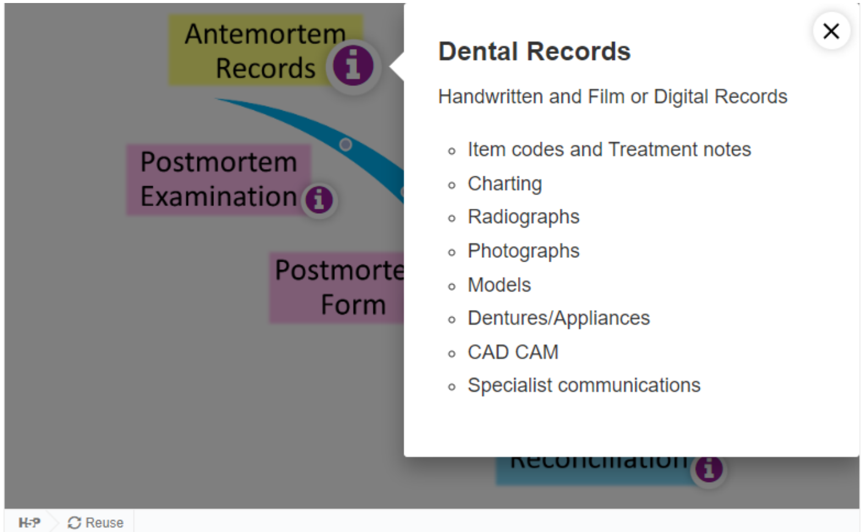


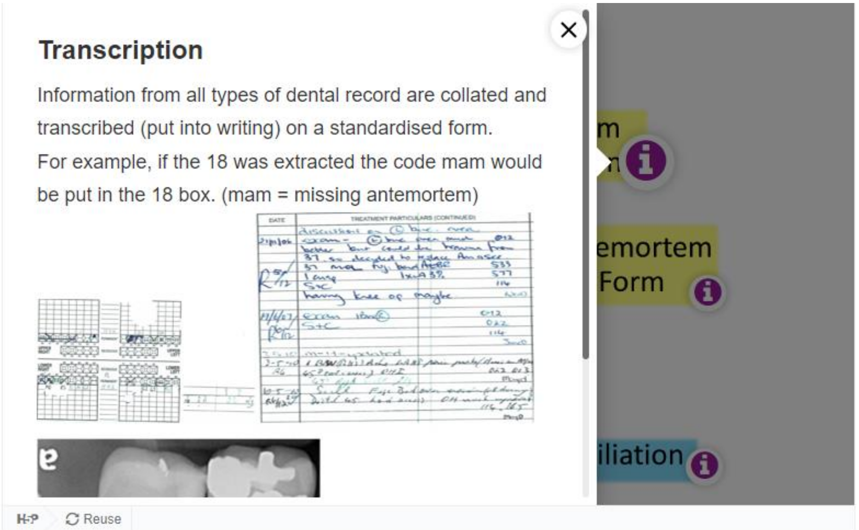
How do we use teeth to identify people?

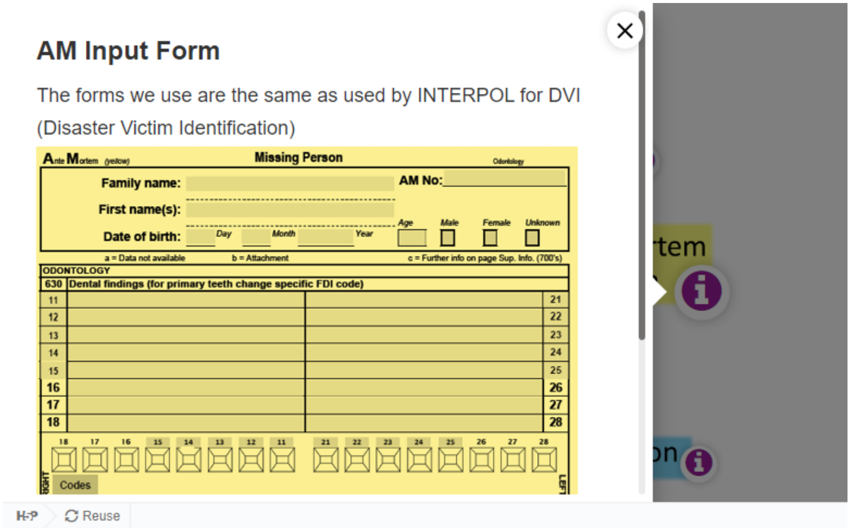
This is achieved by gathering AM - antemortem (before death) dental data and PM - postmortem (after death) dental data. This data is then transcribed into a standardised format for comparison. The data is reconciled and an opinion reached.

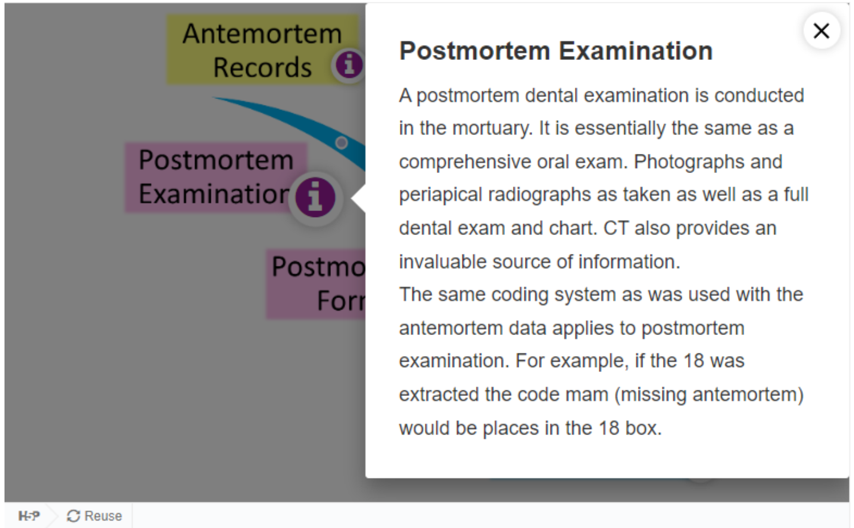
Click on the icons below to find out more about this process:

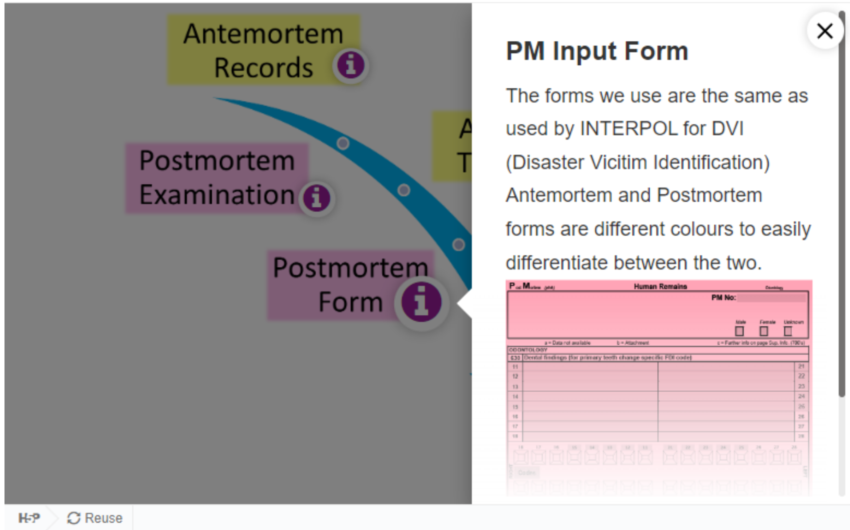

Antemortem Records
Antemortem Transcription
Postmortem Examination
Antemortem Form
Postmortem Form
Reconciliation
H-P Reuse

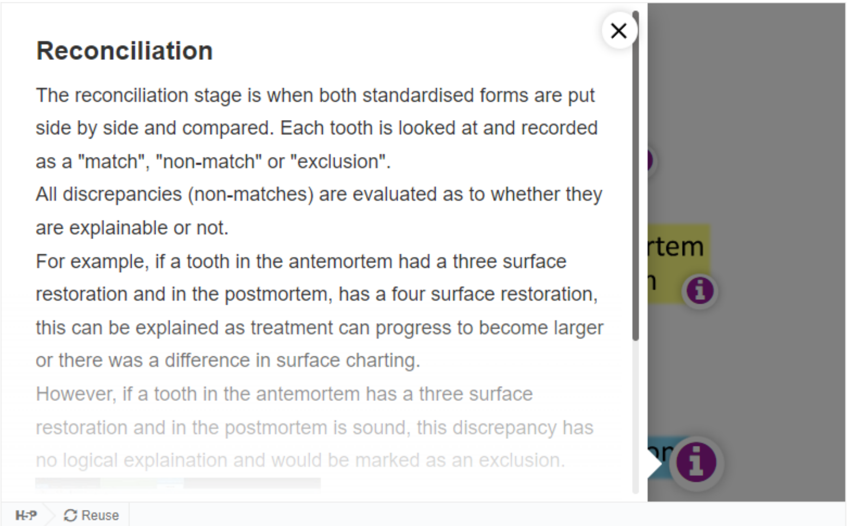

Antemortem Records
Postmortem Examination
Dental Records
Handwritten and Film or Digital Records
Item codes and Treatment notes
Charting
Radiographs
Photographs
Models
Dentures/Appliances
CAD CAM
Specialist communications
H-P Reuse

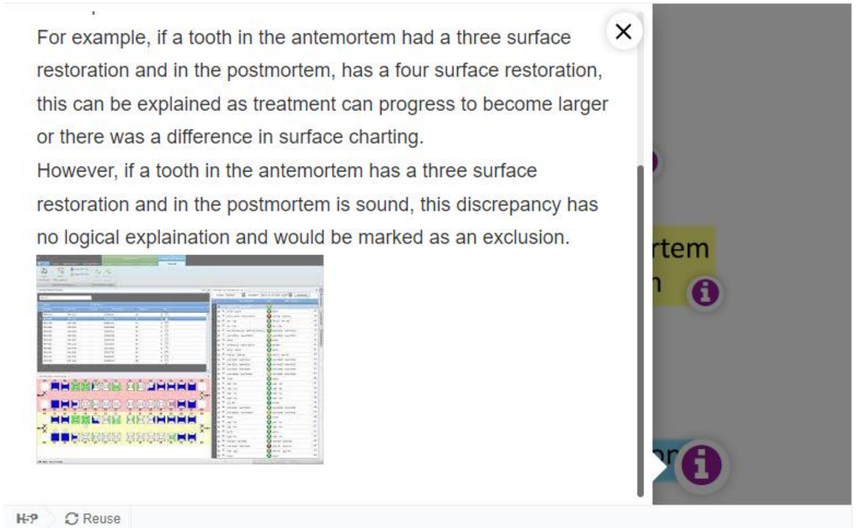

Transcription
Information from all types of dental record are collated and transcribed (put into writing) on a standardised form.
For example, if the 18 was extracted the code mam would be put in the 18 box. (mam = missing antemortem)
H-P Reuse


AM Input Form
The forms we use are the same as used by INTERPOL for DVI (Disaster Victim Identification)
Ante Mortem (yellow)
Missing Person
Family name:
AM No:
First name(s):
Date of birth:
ODONTOLOGY
630 Dental findings (for primary teeth change specific FDI code)
Codes
H-P Reuse


Antemortem Records
Postmortem Examination
Postmo
For
Postmortem Examination
A postmortem dental examination is conducted in the mortuary. It is essentially the same as a comprehensive oral exam. Photographs and periapical radiographs as taken as well as a full dental exam and chart. CT also provides an invaluable source of information.
The same coding system as was used with the antemortem data applies to postmortem examination. For example, if the 18 was extracted the code mam (missing antemortem) would be places in the 18 box.
H-P
Reuse


Antemortem Records
Postmortem Examination
Postmortem Form
PM Input Form
The forms we use are the same as used by INTERPOL for DVI (Disaster Vicitim Identification)
Antemortem and Postmortem forms are different colours to easily differentiate between the two.
H-P
Reuse


Reconciliation
The reconciliation stage is when both standardised forms are put side by side and compared. Each tooth is looked at and recorded as a "match", "non-match" or "exclusion".
All discrepancies (non-matches) are evaluated as to whether they are explainable or not.
For example, if a tooth in the antemortem had a three surface restoration and in the postmortem, has a four surface restoration, this can be explained as treatment can progress to become larger or there was a difference in surface charting.
However, if a tooth in the antemortem has a three surface restoration and in the postmortem is sound, this discrepancy has no logical explaination and would be marked as an exclusion.
tem
H-P
Reuse


For example, if a tooth in the antemortem had a three surface restoration and in the postmortem, has a four surface restoration, this can be explained as treatment can progress to become larger or there was a difference in surface charting.
However, if a tooth in the antemortem has a three surface restoration and in the postmortem is sound, this discrepancy has no logical explaination and would be marked as an exclusion.
tem
H-P
Reuse

Opinion of Identity Conclusions

The conclusion reached at the end of reconciliation represents a likelihood of the person named in the dental records to be the same as the deceased. Five conclusion options are available:

Established: The postmortem and antemortem data match in sufficient detail to establish that they are from the same individual, there are no irreconcilable discrepancies.

Probable: Specific characteristics correspond between postmortem and antemortem data but postmortem or antemortem data or both are limited.

Possible: There is nothing that excludes the identity but postmortem or antemortem data or both are minimal.

Insufficient Evidence: The available information is insufficient to form the basis for a conclusion.

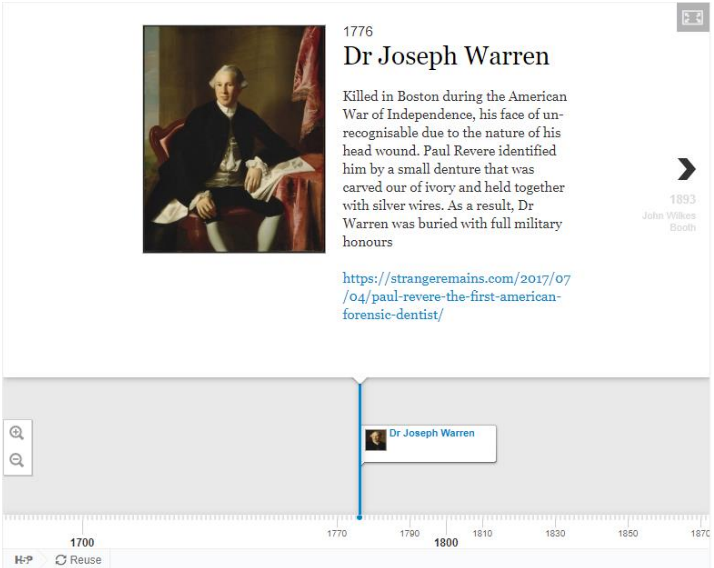
Excluded: The postmortem and antemortem data are clearly inconsistent.

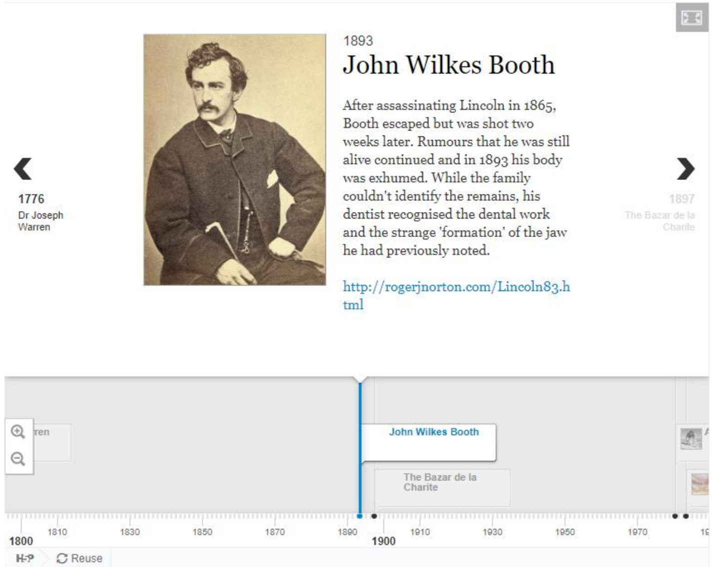
A case's conclusion is highly dependent of the availability, legibility and quality of antemortem dental records!

01.4: Forensic Odontology: Identification and Mass Disasters

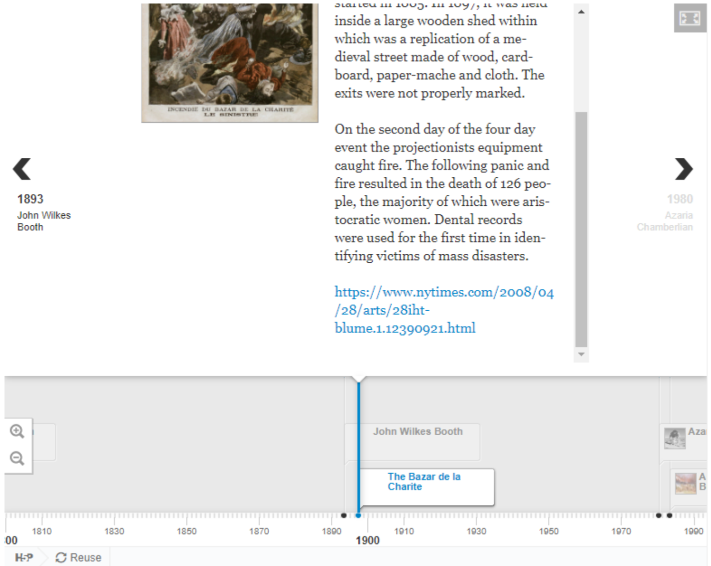
Scroll through the timeline to look at cases and mass disasters, with a focus on Australia, where dental identification played a role.

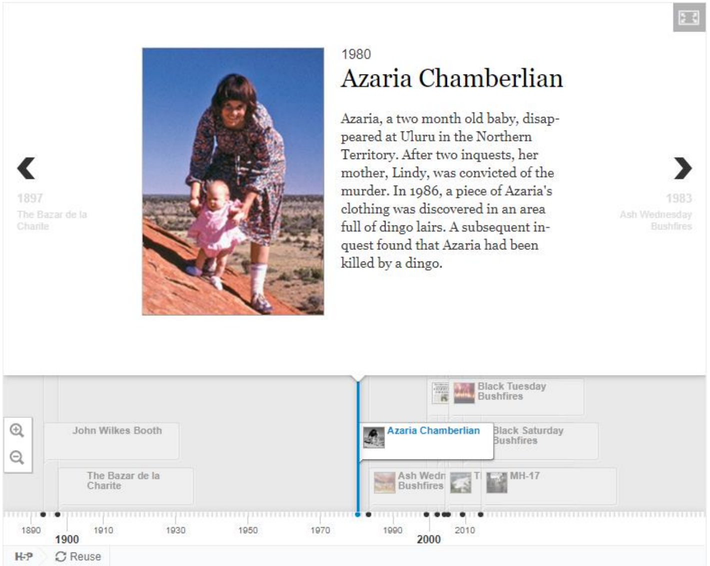
Please note, additional reading and videos are for interest only, the content of which may be distressing.

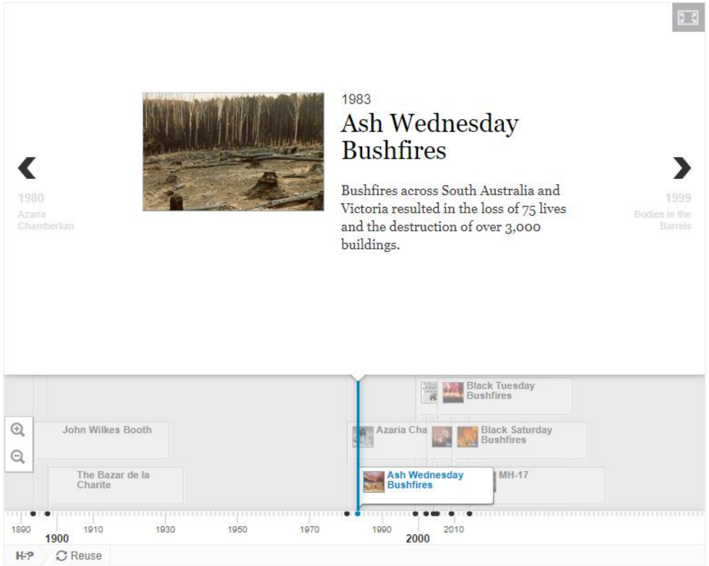

1776
Dr Joseph Warren
Killed in Boston during the American War of Independence, his face of un-recognisable due to the nature of his head wound. Paul Revere identified him by a small denture that was carved our of ivory and held together with silver wires. As a result, Dr Warren was buried with full military honours
https://strangeremains.com/2017/07/04/paul-revere-the-first-american-forensic-dentist/
1893
John Wilkes Booth
Dr Joseph Warren
1700
1770
1790
1800
1810
1830
1850
Reuse

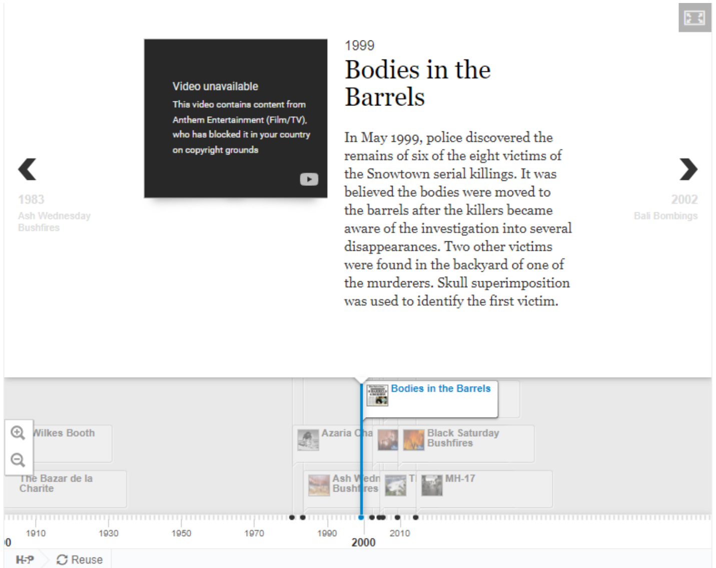

1893
John Wilkes Booth
After assassinating Lincoln in 1865, Booth escaped but was shot two weeks later. Rumours that he was still alive continued and in 1893 his body was exhumed. While the family couldn't identify the remains, his dentist recognised the dental work and the strange 'formation' of the jaw he had previously noted.
http://rogerjnorton.com/Lincoln83.html
1776
Dr Joseph Warren
1897
The Bazar de la Charite
John Wilkes Booth
The Bazar de la Charite
1800
1810
1830
1850
1870
1890
1900
1910
1930
1950
1970
Reuse

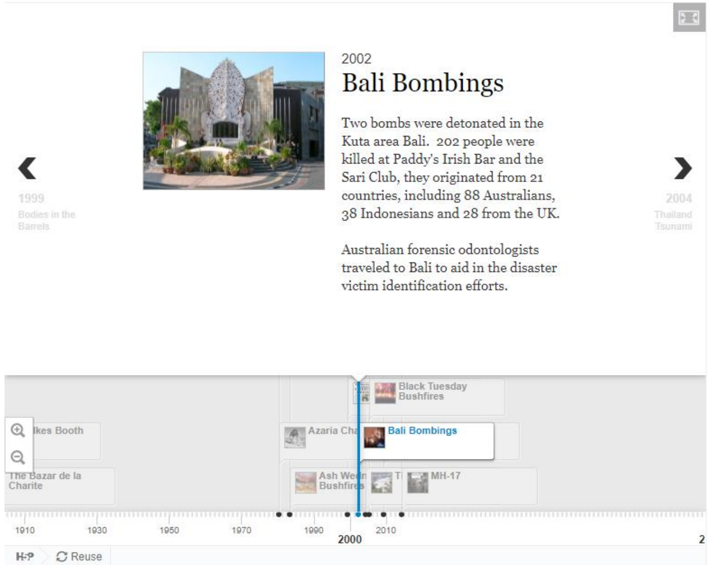

Le Petit Journal
1897
The Bazar de la Charite
The Bazar de la Charite was an annual charity held in Paris, it was started in 1885. In 1897, it was held inside a large wooden shed within which was a replication of a medieval street made of wood, cardboard, paper-mache and cloth. The exits were not properly marked.
On the second day of the four day event the projectionists equipment caught fire. The following panic and fire resulted in the death of 126 people, the majority of which were aris-
1893
John Wilkes Booth
1980
Azaria Chamberlian
John Wilkes Booth
The Bazar de la Charite
1810
1830
1850
1870
1890
1900
1910
1930
1950
1970
1990
Reuse


inside a large wooden shed within which was a replication of a medieval street made of wood, cardboard, paper-mache and cloth. The exits were not properly marked.
On the second day of the four day event the projectionists equipment caught fire. The following panic and fire resulted in the death of 126 people, the majority of which were aristocratic women. Dental records were used for the first time in identifying victims of mass disasters.
https://www.nytimes.com/2008/04/28/arts/28iht-blume.1.12390921.html
1893
John Wilkes Booth
1980
Azaria Chamberlian
John Wilkes Booth
The Bazar de la Charite
1810
1830
1850
1870
1890
1900
1910
1930
1950
1970
1990
Reuse

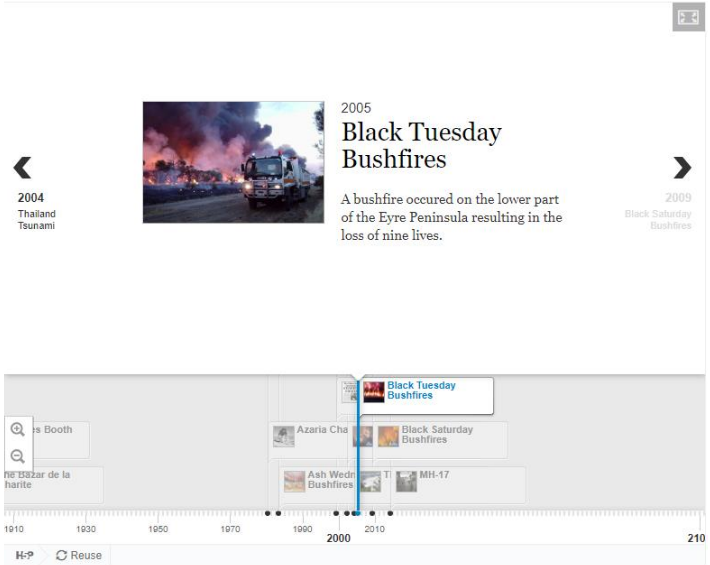

1980
Azaria Chamberlian
Azaria, a two month old baby, disappeared at Uluru in the Northern Territory. After two inquests, her mother, Lindy, was convicted of the murder. In 1986, a piece of Azaria's clothing was discovered in an area full of dingo lairs. A subsequent inquest found that Azaria had been killed by a dingo.
1897
The Bazar de la Charite
1983
Ash Wednesday Bushfires
Black Tuesday Bushfires
John Wilkes Booth
Azaria Chamberlian
Black Saturday Bushfires
The Bazar de la Charite
MH-17
1900
2000
Reuse

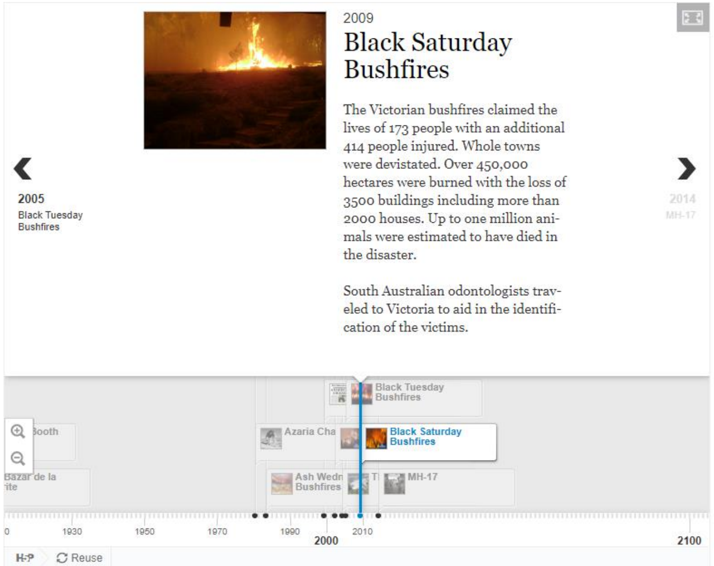

1983
Ash Wednesday Bushfires
Bushfires across South Australia and Victoria resulted in the loss of 75 lives and the destruction of over 3,000 buildings.
1980
Azaria Chamberlian
1999
Bodies in the Barrels
Black Tuesday Bushfires
John Wilkes Booth
Black Saturday Bushfires
The Bazar de la Charite
Ash Wednesday Bushfires
MH-17
1900
2000
Reuse

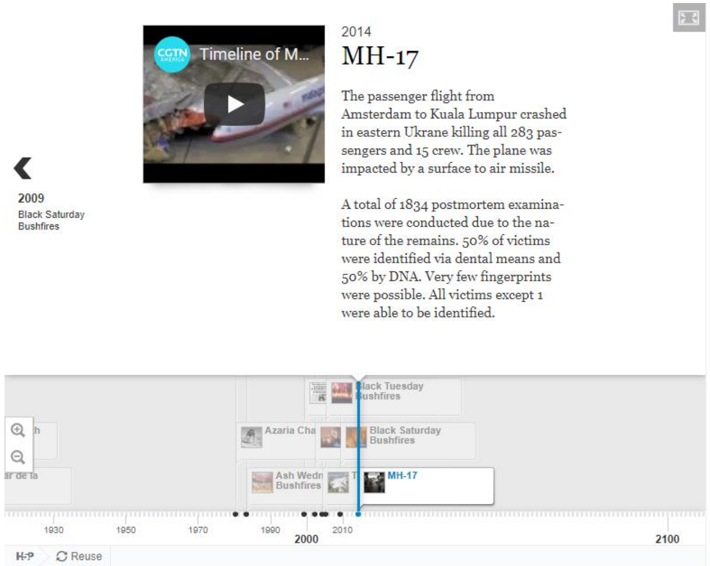

Video unavailable
This video contains content from Anthem Entertainment (Film/TV), who has blocked it in your country on copyright grounds
1999
Bodies in the Barrels
In May 1999, police discovered the remains of six of the eight victims of the Snowtown serial killings. It was believed the bodies were moved to the barrels after the killers became aware of the investigation into several disappearances. Two other victims were found in the backyard of one of the murderers. Skull superimposition was used to identify the first victim.
1983
Ash Wednesday Bushfires
2002
Bali Bombings
Bodies in the Barrels
Black Saturday Bushfires
MH-17
2000
Reuse


2002
Bali Bombings
Two bombs were detonated in the Kuta area Bali. 202 people were killed at Paddy's Irish Bar and the Sari Club, they originated from 21 countries, including 88 Australians, 38 Indonesians and 28 from the UK.
Australian forensic odontologists traveled to Bali to aid in the disaster victim identification efforts.
1999
Bodies in the Barrels
2004
Thailand Tsunami
Black Tuesday Bushfires
Bali Bombings
MH-17
2000
Reuse


Tsunami Ani...
2004
Thailand Tsunami
An earthquake, 9.1 on the Richter scale, with a 1200km fault line displaced 30m3 of water. Over 10 countried were affected with water sweeping inland for up to 1.5km. 280,000 people were killed including 160,00 in Indonesia and 8,200 in Thailand.
A massive international disaster victim identification effort was undertaken.
As of May 2005, just under 1200 of the 1474 victims who had been identified were done so by dental identi-
2002
Bali Bombings
2005
Black Tuesday Bushfires
Black Tuesday Bushfires
Azaria Cha
Black Saturday Bushfires
Ash Wedn Bushfires
Thailand Tsunami
1910
1930
1950
1970
1990
2000
2010
Reuse


2005
Black Tuesday Bushfires
A bushfire occured on the lower part of the Eyre Peninsula resulting in the loss of nine lives.
2004
Thailand Tsunami
2009
Black Saturday Bushfires
Black Tuesday Bushfires
Azaria Cha
Black Saturday Bushfires
Ash Wedn Bushfires
MH-17
1910
1930
1950
1970
1990
2000
2010
Reuse


2009
Black Saturday Bushfires
The Victorian bushfires claimed the lives of 173 people with an additional 414 people injured. Whole towns were devistated. Over 450,000 hectares were burned with the loss of 3500 buildings including more than 2000 houses. Up to one million animals were estimated to have died in the disaster.
South Australian odontologists traveled to Victoria to aid in the identification of the victims.
2005
Black Tuesday Bushfires
2014
MH-17
Black Tuesday Bushfires
Azaria Cha
Black Saturday Bushfires
Ash Wedn Bushfires
MH-17
1930
1950
1970
1990
2000
2010
2100
Reuse


Timeline of M...
2014
MH-17
The passenger flight from Amsterdam to Kuala Lumpur crashed in eastern Ukrane killing all 283 passengers and 15 crew. The plane was impacted by a surface to air missile.
A total of 1834 postmortem examinations were conducted due to the nature of the remains. 50% of victims were identified via dental means and 50% by DNA. Very few fingerprints were possible. All victims except 1 were able to be identified.
2009
Black Saturday Bushfires
Azaria Cha
Black Saturday Bushfires
Ash Wedn Bushfires
MH-17
1930
1950
1970
1990
2000
2010
2100
Reuse

02: The Importance of Dental Records

Introduction

This section of the module will detail the importance of keeping thorough, accurate and legible dental records.

Learning Objectives

- Why do we keep dental records?
- How will my record keeping effect the dental identification process?
- What are the features of good dental records?

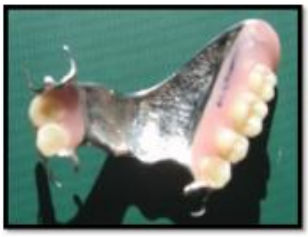
02.1: Dental Records

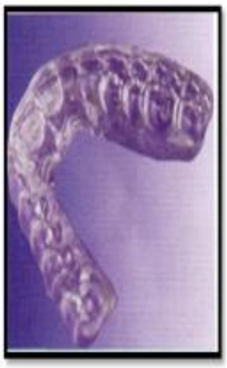
Why do we keep records?

- Every day use:
  - Diagnosis & Treatment planning
  - Progression of disease/treatment success
  - Communication with patients
  - Communication with dentists & specialists
  - Consent to treatment
  - Dento-legal purposes
- Forensic Purposes
- Research Purposes

What makes up a dental record?

- Written
  - Appointment notes by dental and clerical staff
  - Medical history
  - Consent documents
  - Copies of correspondence
- Visual
  - Radiographs
  - Photographs
  - 3D scans
- Physical
  - Stone casts
  - Crowns, bridges, dentures
  - Mouthguards/nightguards
  - Fluoride/bleaching trays





02.2: Dental Records

How does record keeping effect dental identification?

As we saw with the range of identification conclusions, our ability to form an opinion is heavily reliant on antemortem information. Therefore, the better the dental records, the more likely a w informed opinion.

But what makes one dental record better than another? Is there such a thing as a bad dental record? The bigger the better, right? More notes, more images, more information?

Three important aspects of good dental records are detail, accuracy and legibility.

DETAIL

Detail is the difference between knowing a tooth has a restoration and knowing which surfaces that restoration covers.

Common errors include:

- Notes for a comprehensive exam - "NAD"
- No base chart
- Images not labelled with patient name or date taken

ACCURACY

Ensuring all information is correct including patient details, treatment numbers, tooth numbers, materials used.

Common errors include:

- Patient name misspelt or incorrect date of birth
- Incorrect tooth designation
  - Charting the 32 as extracted rather than the 42
  - Three surface restoration on the 26 rather than the 27
- Incorrect codes used
  - Charting a temporary restoration for endodontic treatment as a 531
- Incorrect charting
  - Charting the 8s as missing if there is no image to show they aren't just unerupted

LEGIBILITY

How well can dental records be read by someone? A dental record can have excellent detail and be very accurate, but if it cannot be read and interpreted, it cannot be used.

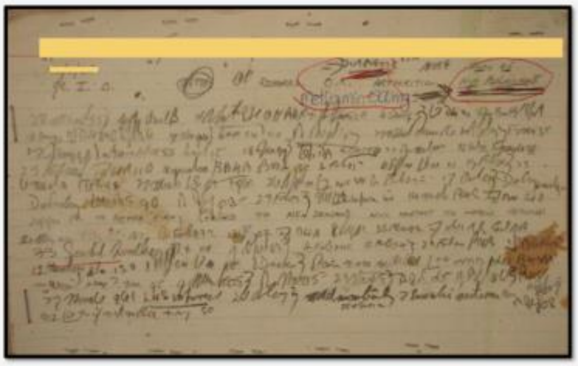
Common errors include:

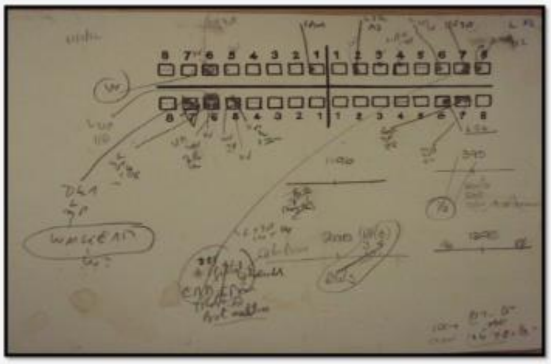
- Poor handwriting
- Non-standard abbreviations
- Photocopies - including scans/photos of non-digital radiographs

Look through the slides below and consider how the records in each scenario fit the three aspects above. Then click the expandable boxes to find out.

Scenario 1

Antemortem information consisted of 12 handwritten cards and 10 pairs of mounted, but not labeled, bitewing films ranging from 1960 to 2010. A medical history and dental chart were also included.





1 / 3

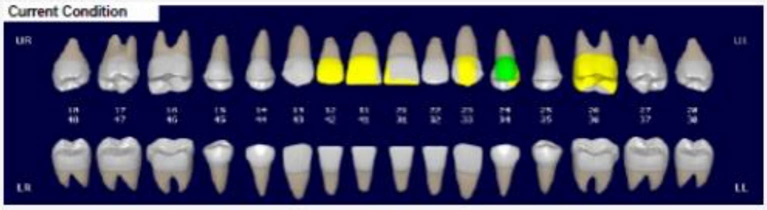
Scenario 1

While these records are quite extensive and cover a large period of time, the most obvious issue is their legibility. It is very difficult to know the level of detail and accuracy when it is difficult to dicipher what has been written. Fortunately, with so many pairs of bitewings, it may be possible to tell which are the most recent and this will provide a good starting point.

Scenario 2

Antemortem records available as shown. One treatment entry, a dental chart and a right hand side bitewing radiograph.

521(11,La), 523(21,MIP) 1 carp articaine 4% 1:100k adren infil B of 21
21 prep MIPL, decay removed. Primer, SE Bond, Accolade SRO, Herculite XRV A2
11 Buccal primer, SE Bond, Herculite XRV A2
Occ checked, adj, polished. POIG. BY



◂ 2 / 3 ▸

H-P Reuse

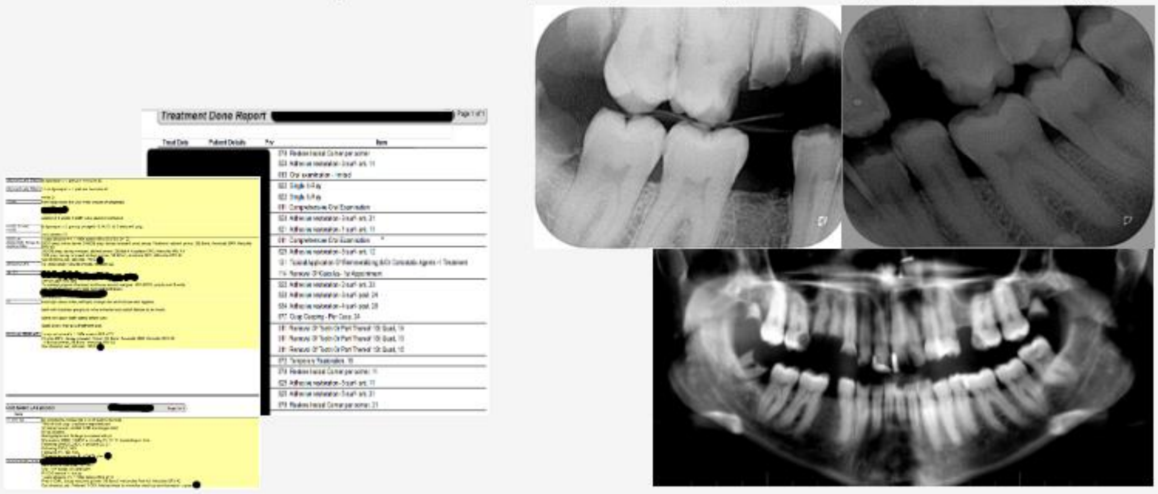
Scenario 2

With the vast majority of dental records now being digital legibility is less of an issue, however shorthand can still be tricky to interpret. While these records provide detail in the treatment completed they are not complete. Some treatment is visible on the dental chart, however when you compare it to the radiograph it is clear that a comprehensive exam was not charted. This casts doubt on the accuracy of the dental chart. Essentially the only information we can rely on is the upper anterior restorations and the bitewing radiograph.

If there is conflict in treatment notes/chart/radiographs always look at the radiographs for your answer (as long as you are sure they belong to that persons record!)

Scenario 3

Antemortem records include multiple written records, two digital bitewings and one digital panoramic radiograph.



3 / 3

H-P Reuse

Scenario 3

These records are much more complete and comprehensive. The records are detailed and their accuracy is easily determined as a panoramic radiograph is present. In this case we have some information about all 32 teeth.

02.3: Dental Records

Features of good dental records

Identification Data
- Name
- Date of Birth
- Phone Contact
- Address
- Emergency Contact

Medical History
- Health Conditions
- Medications
- Previous Surgeries

Appointment Records
- Clinical Examination
- Diagnosis
- Treatment Plan
- Treatment Provided

Consent
- Documentation of Verbal Consent
- Any Signed Written Consent

Images
- Name
- Date of Birth
- Date Taken

Other Documentation
- Lab Forms
- Specialist Correspondence

DETAILED

ACCURATE

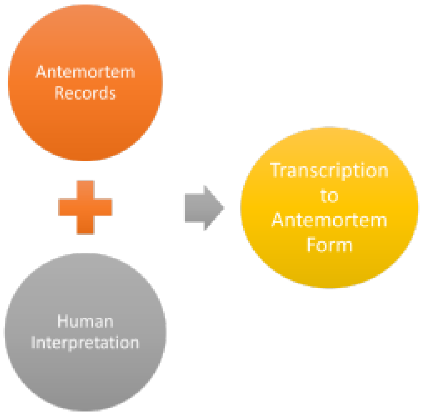
LEGIBLE

03: My Research

Improving Scientific Validity of Antemortem Dental Data Transcription

With the scientific validity of multiple forensic science techniques coming under scrutiny in the last decade, my research explores the accuracy and repeatability of the antemortem transcription process. If multiple people are given the same antemortem records, what is the variability in the codes written on the standardised form?

In addition to this I will be looking at creating a way to make the transcription process more objective, i.e. less prone to human interpretation and the variation it causes. This process will then be tested in a similar way to this task and the differences assessed.



Research aims

- Evaluate the variation in antemortem data transcription using current methodology.
- Develop a standardised, computer aided transcription procedure.
- Validate computer aided procedure.

How you can help

By participating in this transcription task you will be instrumental in the collection of data needed to evaluate the variation in interpretation of records using the current methodology. The results will become more robust the larger the number of participants.

This task will also help you practice reading and interpreting other clinicians records as well as evaluating and interpreting radiographs.

Please read the participant information sheet before completing the tasks

03.1: INTERPOL Forms and Codes

How-To

This section will give you the guidelines for completing the AM input forms and a definition of the codes to use.

The information given is what is currently available to guide the transcription process, as discussed in the last section it is very general. Do your best, and again, THIS IS NOT A TEST OF YOUR ABILITY, it is a test of the guidelines and the variation in codes used, given the same information.

If you have any questions please post them in the Discussion section. While I will do my best to answer them, I cannot give away anything that may effect the results.

Thank-you again for your participation!!

03.2: Transcription Guidelines

Names, Codes and Conventions

INTERPOL codes

These codes are used to represent treatment, all codes are three letters and written in lower case. Restoration codes should be followed with surfaces involved in UPPER case, if the surfaces are unknown a * is recorded after the code:

	Code	Definition
Bridges	abu	Abutment Tooth
	pon	Pontic
Crown Pathology	mtl	Marked tooth loss
Crowns	uic	Unidentified crown
	mcc	Metal ceramic crown
	mtc	Metal coloured crown
	tcc	Tooth coloured crown
Fillings	fis	Fissure sealant
	uif	Unidentified filling
	mcf	Metal coloured filling
	tcf	Tooth coloured filling
Root	ipx	Implant
	ppx	Parapulpal pin
	rfx	Root filing
	pox	Post
Status	mam	Missing antemortem
	une	Unerupted
	non	No information
	pre	Tooth present (no other information)
	nad	No abnormality detected (evident in records)
	rov	Retained root

Tooth Designation and Surface Names:

As there are many different ways to name teeth and variation in the names for tooth surfaces, INTERPOL uses a standard notation as follows:

FDI notation: Quadrants numbered 1-4 and Teeth numbered 1-8

Surface Codes:

M - Mesial

O - Occlusal (includes Incisal surfaces for anteriors)

D - Distal

V - Vestibular (Buccal, labial)

L - Lingual (Palatal)

Coding convention:

treatment code in lower case TOOTH SURFACE IN UPPER CASE

e.g.: tcf MOD

Data Extraction

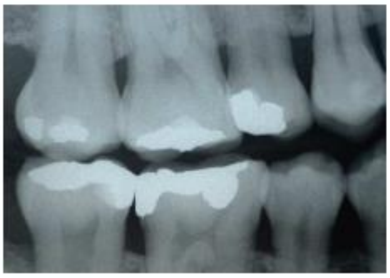
The final chart should convey what the dentition most likely looked like at the last dental appointment recorded.

1. Records are read in reverse date order, most recent to historical. If a tooth is extracted you you don't need to list previous treatments. A tooth may have a number of treatments, if one clearly replaces the other only the most recent is recorded.
2. Check radiographs are orientated correctly, and casts/photos clearly identify Missing Person
3. Using case notes & charts (begin most recent) enter codes & comments onto form
4. Using the latest radiographs, enter codes onto form (if your only source of information for a restoration is a radiograph use uif (unidentified filling). Don't include V or L except as a comment) If in doubt in regards to surfaces restored, make the lesser treatment. Only list surfaces you are certain are involved, if unsure use a *.
5. If you would like to make a comment that is not an accepted code type double quotation marks - " - then write your comment (This is a feature necessary on the software for searching purposes)

03.3: Transcription practice

If you would like to participate in the research and would like to practice the transcription process with feedback, please complete the following. This is not compulsory and is for your own information.

10/12/2020	512	47 MO	LA Amalgam
	513	46 DOB	Amalgam
21/01/2021	013		CC: RHS broken tooth OE: 17 tooth structure lost around amalgam. Pt agreed to redo today
	022		RHS BW taken
	533	17 DOP	LA Removed amalgam Etch, bond, A3 CR
30/01/2021	531	25 O	A3 CR
	533	26 MOD	Amalgam



Fill in the code for each tooth. All boxes must be filled in to see the solution.

18

17

16

15

14

48

47

46

45

44

25

26

Submit

04: Mock Cases for Transcription

Introduction

Following, there are three sets of *made up* dental records. Use the images and notes in each to fill in the antemortem form. It may be easier to open as many new tabs as are necessary so that you can have easy access to the form, the records and the guidelines and codes.

Cases

AM_001: Constance Adamson

AM_002: Maximus Reed

AM_003: Vernon Freeman

Please download the fillable pdf document in the assignments section and upload it again once you have completed the tasks. ***Transcription Response Forms*** ***(https://myuni.adelaide.edu.au/courses/67327/assignments/225185)***

Thank-you

04.1: AM_001 Constance Adamson

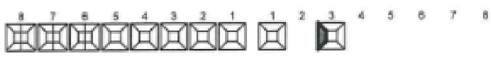
Dental Records:

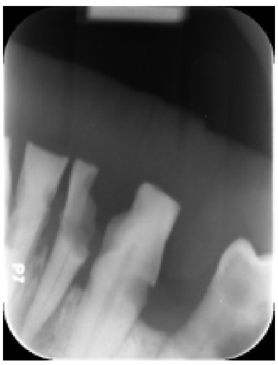
South Australian Dental Service

Name	Constance	Adamson	
Address	10 Overcroft Rise		
DOB	12/10/1954	UR	99546
Phone	555-234	Consent Status	Adult Client

Medical History:

Treatment History	Details	
Historical:		
Chart Only	311 18	
Chart Only	311 17	
Chart Only	311 16	
Chart Only	311 15	
Chart Only	311 14	
Chart Only	311 13	
Chart Only	311 11	
Chart Only	311 12	
Chart Only	311 21	
Chart Only	311 22	
Chart Only	311 23	
Chart Only	311 24	
Chart Only	311 25	
Chart Only	311 26	
Chart Only	311 27	
Chart Only	311 28	
Chart Only	311 38	
Chart Only	311 37	
Chart Only	311 36	
Chart Only	311 34	
29/06/16	#CONSENT	
29/06/16	#PATIENT_ID	
29/06/16	013	CC: Continuous pain on the lower left OE: Large carious lesions 32 and 35
29/06/16	DECAY 35 MOLB	
29/06/16	DECAY 32 DILB	
29/06/16	DECAY 33 MES	
29/06/16	022 35	Gross decay and bone loss
29/06/16	022_SUB 32	Gross decay and bone loss
29/06/16	311 35	Simple exo with forceps, gauze placed, POIG
29/06/16	311 SUB/Q 32	Simple exo with forceps, gauze placed, POIG





04.2: AM_002 Maximus Reed

Dental Records:

MReed Case Notes.pdf

MReed Charts.pdf

Image taken 02/06/1999

Image taken 01/06/2017

Image taken 12/12/2017

Woodbridge Dentist
2/18 Woodbridge Road

Patient Details:
Name Maximus Reed
Address 16 Bronte Point
Date of Birth 18/02/1963

Date	Item No.	Comments
01/06/99 D1	013	CC: Pain lower right - severe OE: PE 48, inflamed gingiva 23 mobile ++ - also causing pt issues. Refered for OPG and exo $\frac{\;\|3}{8\|\;}$
20/06/99 D1		Correspondence from OS. Exo $\frac{\;\|3}{8\|\;}$ healing well on review
20/07/99 D1	011	Full exam & chart S/C NV: 6 months
01/06/17 D4	013	CC: Pain lower left, very sore to pressure OE: 35 TTP +++ heavily restored
	022	PA shows RCT and large apical lucency
	311	Consent to extraction. LA - ligno Elevator & forceps simple exo POIG NV: Full exam and review exo

09/08/17 013 CC: Broken filling
D4 OE: Fractured 47 MODL and DB
Consent to restore

534 47 MODL and seperate DB
531 Etch, prime, CR A3 left pins intact

Advised poor prognosis as 45 and 36
are missing

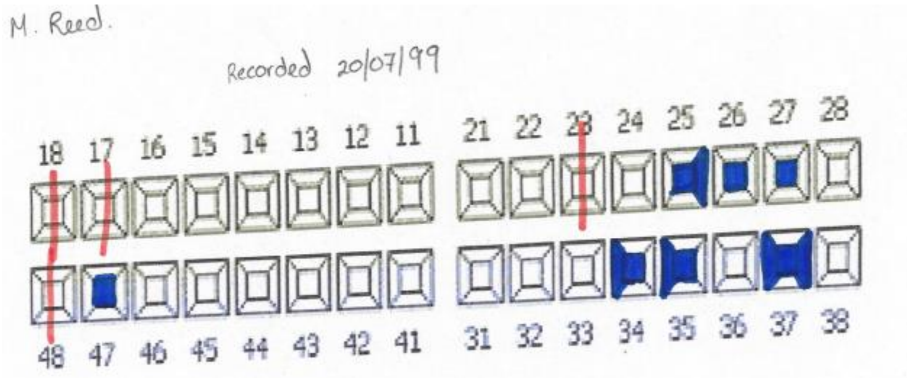
12/12/17 013 CC: Pain at the front, sore when
D7 eating

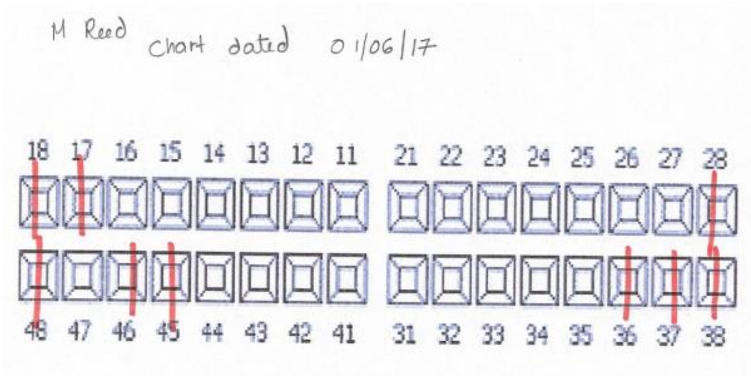
OE: 22 carious root stump
TTP +++

022 Consent to PA.
22 root remains
Consent to exo

311 22 simple exo POIG.

NV: Comprehensive exam.





04.3: AM_003 Vernon Freeman

Dental Records:

Dental Records VFreeman SADS.docx

Dental Records VFreeman.docx

Image taken 15/08/02

Image taken 30/09/04

Image taken 17/09/03

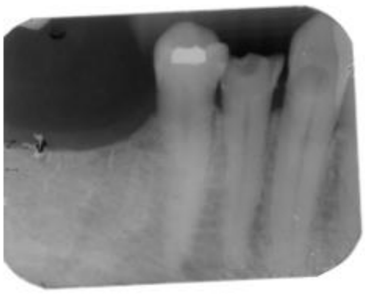
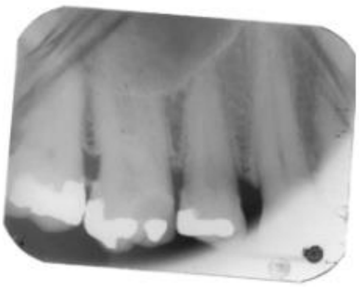


Image taken 29/04/03



South Australian Dental Service

Name	Vernon	Freeman	
Address	28 Wingfield Meadows		
DOB	14/04/1958	UR	98076
Phone	555-829	Consent Status	Adult Client

Medical History: High blood pressure, type 2 diabetes

Treatment History	**Details**	
Historical:		
Chart Only	311 16	
Chart Only	311 15	
Chart Only	311 21	
Chart Only	311 22	
Chart Only	311 24	
Chart Only	311 25	
Chart Only	311 26	
Chart Only	311 36	
Chart Only	311 46	
Chart Only	311 47	
Chart Only	513 17 MES	
Chart Only	513 17 OCC	
Chart Only	513 17 OCC	
Chart Only	513 17 PAL	
Chart Only	513 17 PAL	
Chart Only	512 14 OCC	
Chart Only	512 14 DIS	
Chart Only	511 13 PAL	
Chart Only	512 27 MO	
Chart Only	513 37 MOB	
Chart Only	511 35 OCC	
Chart Only	511 43 BUC	
Chart Only	511 45 OCC	
Chart Only	537 13 BUC	
Chart Only	721E 15,12-22, 24-26	
11/07/02	013	
11/07/02	022	PA 16
11/07/02	912 16	16 MO dressing
11/07/02	537 13 BUC	
15/08/02	013	CC: Anterior tooth ache OE: Broken 22, Very TTP, no swelling Pt consent to exo 22
15/08/02	022	PA 22
15/08/02	LA_CITANEST	1 Carpule
15/08/02	311 22	Simple exo, elevator and forceps, gauze placed, POIG
29/04/03	013	CC: Pain upper right, not constant, hurts to eat, started a few weeks ago.

South Australian Dental Service

		OE: 15 and 16 TTP. 16 Large MO caries, heavy calc 15,16,17 Discussed with pt. 16 most likely cause. Pt wants exo
29/04/03	022 16	
29/04/03	024 15	
29/04/03	311 16	Exo, gauze POIG
29/04/03	LA_CITANEST	
29/04/03	114	Supra and Sub calc removed from 16,17
17/09/03	011	CC: Bad teeth but no pain OE: Anterior cross bite, class II div II Arrested caries evident Keep as many teeth as possible to support PU Discussed treatment plan, including amalgam restoration for 44. Pt consents
17/09/03	022_BW	
17/09/03	024_BW	2PA
17/09/03	141	OHI, toothbrush and written OH info given
03/12/03	514 27 MDOBP	1 cit. Fuji bond, amalgam
28/01/04	537 43 BUC	CR A3 Fbond
28/01/04	514 44 DMOB	Amalgam Fbond
28/01/04	575 44	Pin placed
11/02/04	311 11	Exo 12, 11 elevators 2xXylo Gauze placed, POIG
11/02/04	311_2ND/Q 12	
19/02/04	013	CC: Pain from extractions, consistent. Has been using salt water mouth rinse and taking Panadol. Still swollen. OE: Swelling 11,12 gingival area. Hypergranulation in both sockets
19/02/04	986	Curetted tissues, bleeding induced, packed with alvogyl. NS Mouthrise given
19/02/04	LA_XYLOCAINE	1 carpule B infiltration
19/02/04	927	Amoxil 500mg 5/7
10/03/04	531 35 BUC	CR A3 etch Fbond no LA
10/03/04	114	Cavitron, advised warm salt water
30/09/04	013	CC: Sore gums, LHS upper and lower. Painful for a couple of weeks and sensitive to cold but not everytime. Feels its from gums not teeth OE: Q2 only 23 and 26 remain, no caries, not TTP. Gum not sure on palpation
30/09/04	022	Ridge between remaining teeth. No pathology, discussed with pt
30/09/04	141	OHI chx mouthwash
18/01/05	013	45
18/01/05	022 45	

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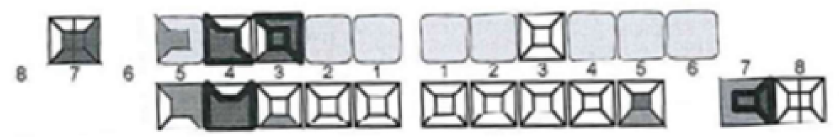
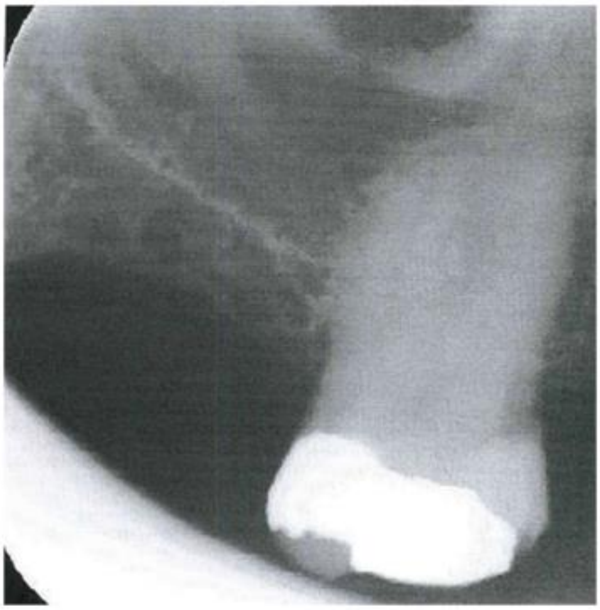
South Australian Dental Service

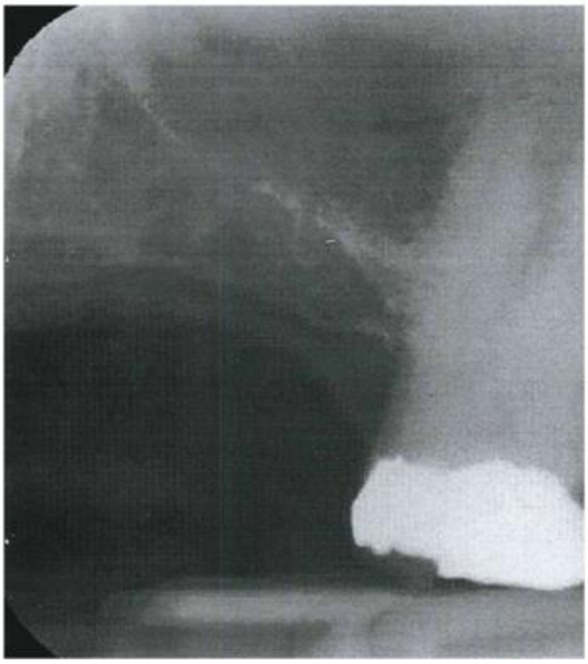
18/01/05	533 45	CR A3
29/01/10	013	CC: Broken tooth OE: 37 broken MB cusp
29/01/10	534 37 MOLB	
29/01/10	577 37	
12/07/17	013	
12/07/17	022	
12/07/17	DEFECT 27 DOP	
12/07/17	141	
12/07/17	DEFECT 37 DO	
12/07/17	533 27 DOP	Retention cut into amalgam CR A3, checked denture fit
12/07/17	LOCAL_ANAESTH	
12/07/17	DECAY 13 IB	
21/09/17	DECAY 44 DMOB	
21/09/17	DECAY 13 MB	
21/09/17	DECAY 14 DOP	
21/09/17	DECAY 37 OCC	
21/09/17	#MH_UPDATE_NOCH	
21/09/17	022	27 calcification of RC chamber
21/09/17	311	Simple exo elevator and forceps, gauze placed, POIG
21/09/17	013	26 Heavily restored, very TTP, history of pain. Decay



South Australian Dental Service

Name	Vernon Freeman
DOB	14/04/1958
Date	21/09/17





DR. G BLACK 273 MILLER STREET

VERNON FREEMAN

28 WINGFIELD MEADOWS

DOB: 14/04/1958

Date	ID	Item No.	Tooth	Notes
27/03/07	1	011 114 141		Caries noted 15, 44, 37 PT consented to restoration of 15 today, NV restore 44
		532	15 DO	LA infiltration lignospan 1 carpule. Caries removed. Etch, prime, bond CR A3.5
03/03/07	1	534	44 MOBD	LA IAN block lignospan 1 carpule. Caries removed. Etch, prime, bond CR A3.5 NV: 37
13/04/07	1	532	37 DO	LA IAN block lignospan 1 carpule. Caries removed. Etch, prime, bond CR A3.5 NV: 6 month review

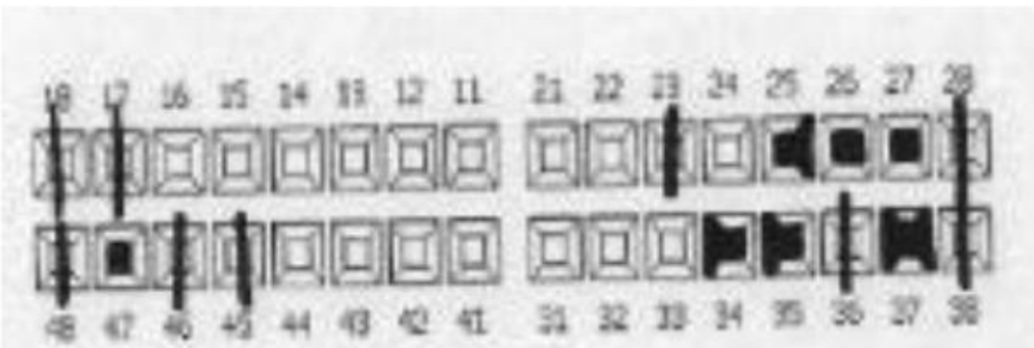
Appendix IV – Constructed Dental Records for Variation Study

Woodbridge Dental Clinic
2/18 Woodbridge Road

NOTE: FDI system used

Patient details:
Name: Maximus REED
Address: 16 Bronte Point
Date of Birth: 18/02/1963

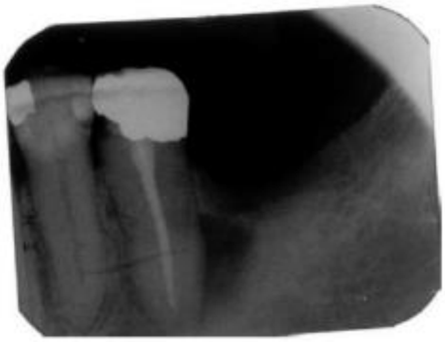
Date	Operator	Item No.	Tooth No.	Comments
01/06/1999	D1	013		Complains of severe pain – lower right Exam: Partially erupted 48, inflamed gingiva 23 very mobile, also causing issues Referred for OPG and extraction of 23 and 48
20/06/1999	D1		23 48	Letter from oral surgeon. Exo 23 and 48, healing well on review
20/07/1999	D1	011		Full examination and chart completed Scale and clean Next visit: 6 months
01/06/2017	D4	013 022 311	35	Pain lower left, very sore to pressure Exam: 35 TTP, heavily restored PA shows RCT and large apical lucency Consent to extraction LA – lignospan Elevator and forceps, simple exo Post-op instructions given NV: Full exam and review exo
09/08/2017	D4	013 534 531	47	Broken filling Exam: Fractured 47 MODL and DB Consent to restore
				47 MODL and separate DB Etch, prime, composite A3, left pins intact Advised poor prognosis as 45 and 36 are missing
12/12/2017	D7	013 022 311	22	Pain at the front, sore when eating Exam: 22 carious root stump, very painful to pressure Consent to PA – 22 root remains, consent to exo 22 simple extraction, post-op instructions given NV: Comprehensive exam



Woodbridge Dental Clinic
2/18 Woodbridge Road

Panoramic – 02/06/1999

Periapical – 01/06/2017



Periapical – 12/12/2017

Appendix V – ADDE Guidelines

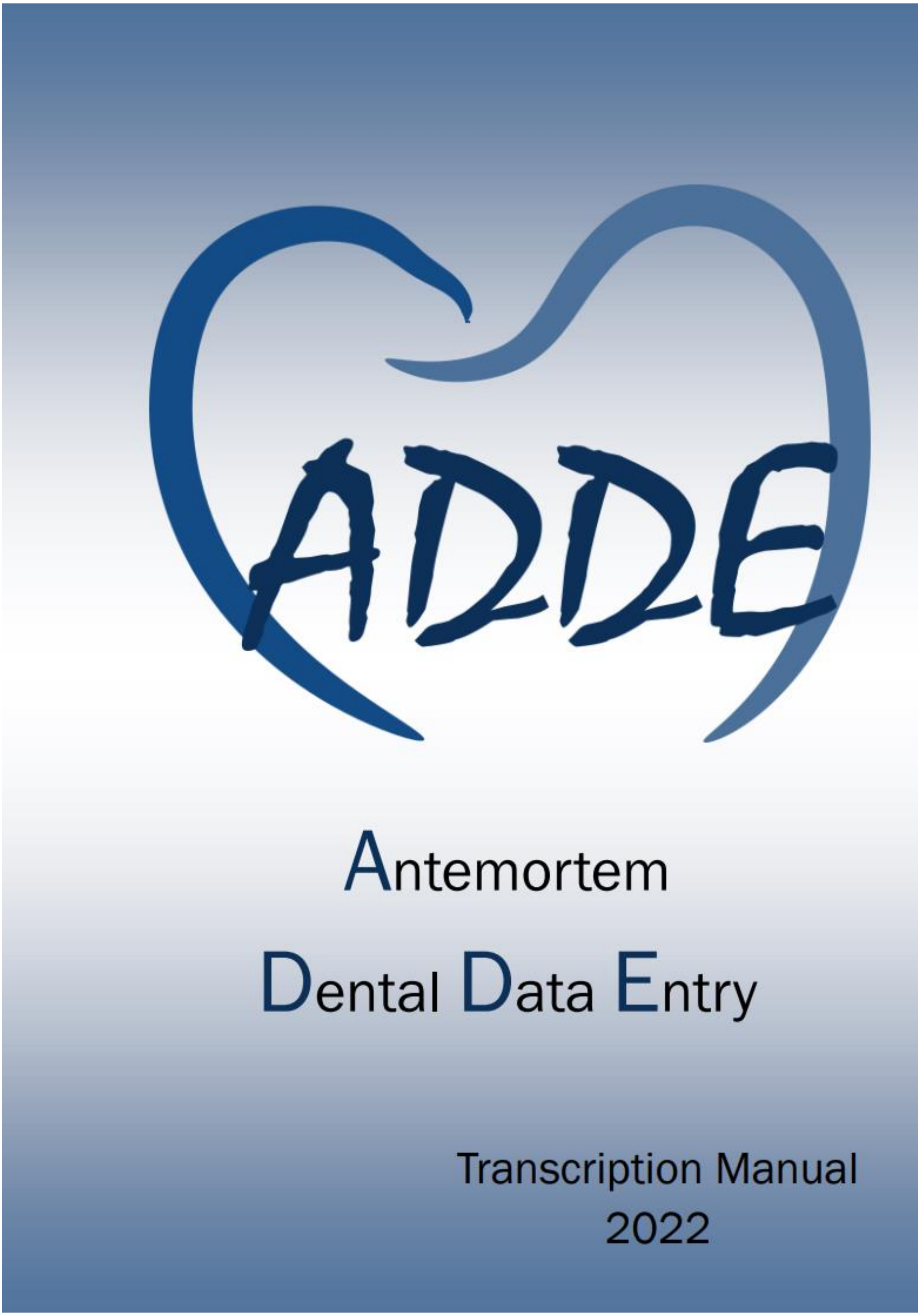


Table Of Contents

1

Overview of the Antemortem Dental Data Entry Program

Introduction

Antemortem Dental Data Entry (ADDE) was created to reduce variation in antemortem transcription to improve dental identification outcomes. ADDE aims to guide the user through the dental records available, asking questions of tooth status and producing a written odontogram following INTERPOL codes. This process removes the need for the user to write the three letter codes and prevents mis-recording of codes and tooth surfaces. ADDE also records where tooth information came from (e.g.: radiograph or chart) to allow the user to select the appropriate and most up to date treatment. Ultimately the aim of ADDE is to produce INTERPOL codes for each tooth that reflects an accurate, last known dental status.

Program Structure

ADDE uses the database software REDCap® - Research Electronic Data Capture. Each database is called a project and uses forms called instruments to collect data. Each antemortem missing person has a separate arm within the project to prevent mixing data. Within each arm the data collection instruments are listed in order for completion. When opened, each instrument displays a form for data entry. Form sets (called surveys) for each missing persons are distributed via email for completion (one email per case). Chapter two discusses the use of these forms in more depth.

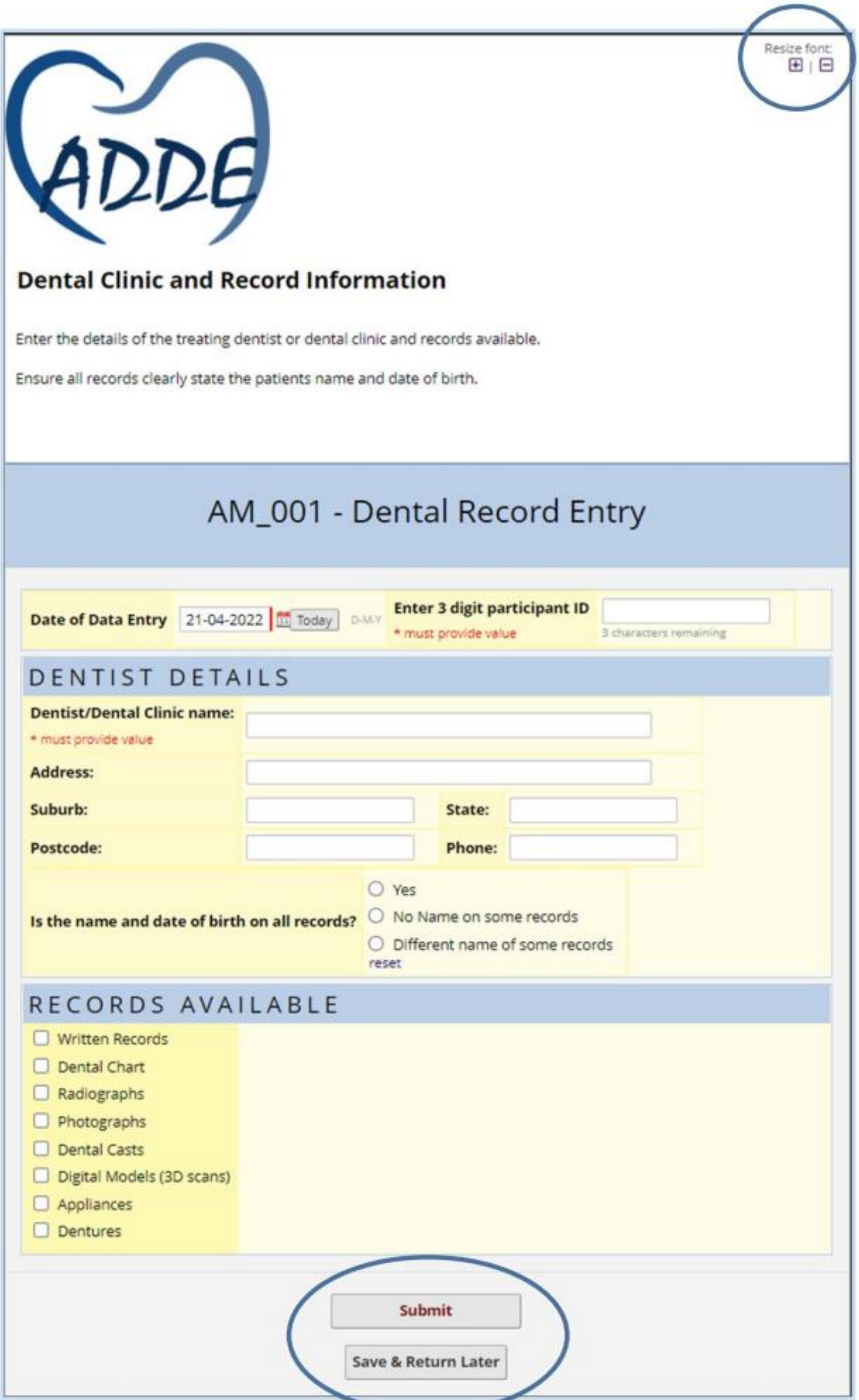
Navigating Through The Forms

Following the link in the invitation to participate email will open a new window displaying the first form, dental clinic and record information. All forms follow the same basic format and are filled in from the top down.

Figure 1-1 displays the Dental Clinic and Record Information form highlighting the following:

- The text size can be increased or decreased using the + and — symbols in the top right hand corner.
- At the bottom of the form there is a submit button and a save and return button.
    - Submit will save the data entered and navigate through to the next form.
    - Save and return allows the information entered to be saved and continued at a later time.

Forms must be filled in in the order they appear as subsequent forms rely on previous information entered.


Resize font:

ADDE

Dental Clinic and Record Information

Enter the details of the treating dentist or dental clinic and records available.

Ensure all records clearly state the patients name and date of birth.

AM_001 - Dental Record Entry

Date of Data Entry 21-04-2022 Today D-M-Y

Enter 3 digit participant ID
* must provide value
3 characters remaining

DENTIST DETAILS

Dentist/Dental Clinic name:
* must provide value

Address:

Suburb: State:

Postcode: Phone:

Is the name and date of birth on all records?
- Yes
- No Name on some records
- Different name of some records

reset

RECORDS AVAILABLE

- Written Records
- Dental Chart
- Radiographs
- Photographs
- Dental Casts
- Digital Models (3D scans)
- Appliances
- Dentures

Submit

Save & Return Later

Figure 1-1: Dental Clinic and Record Information Form

Accessing Previous Forms

Once the record entry forms have been filled out, it is possible to navigate back if data entry needs to be adjusted. In order to do this use the option in the top right Survey Queue corner. A pop up window will allow a choice of forms to return to, see Figure 1-2. Select the edit response option. This should only be used to navigate backwards, not forwards.

The submit button should always be used to move forwards through the forms otherwise the information will not be saved and sent.

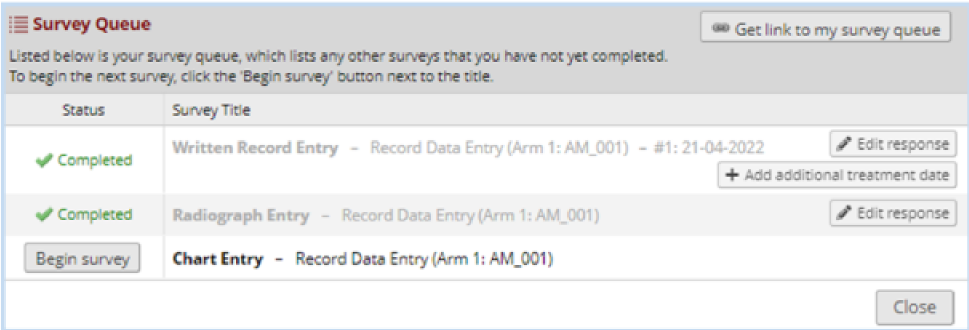


Figure 1-2: Survey Queue provides the ability to return and edit previous responses.

Repeated Form Entry

The written record entry form differs as multiple entries of the same form are required when the dental records contain more than one treatment date. Figure 1-3 shows the navigation buttons at the bottom of the Written Record Entry form. For each additional treatment date, the add additional treatment date button should be selected. On the final treatment date, select submit.

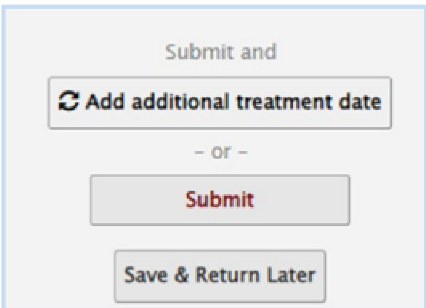


Figure 1-3: Written Record Entry navigation buttons

Data Entry Types

ADDE uses five types of data entry fields, see Figure 1-4:

1. **Date**
   Input data in DD/MM/YYYY format or select image for calendar menu.

2. **Short Text**
   Enter letters or numbers. Additional entry boxes may appear.

3. **Checkboxes**
   Square boxes indicate multiple choices can be selected. These choices may cause additional entry boxes to appear.

4. **Dropdown Menu**
   Click the arrow and choose the relevant option.

5. **Radio Buttons**
   Round buttons indicate only one choice can be selected. These choices may cause additional entry boxes to appear.

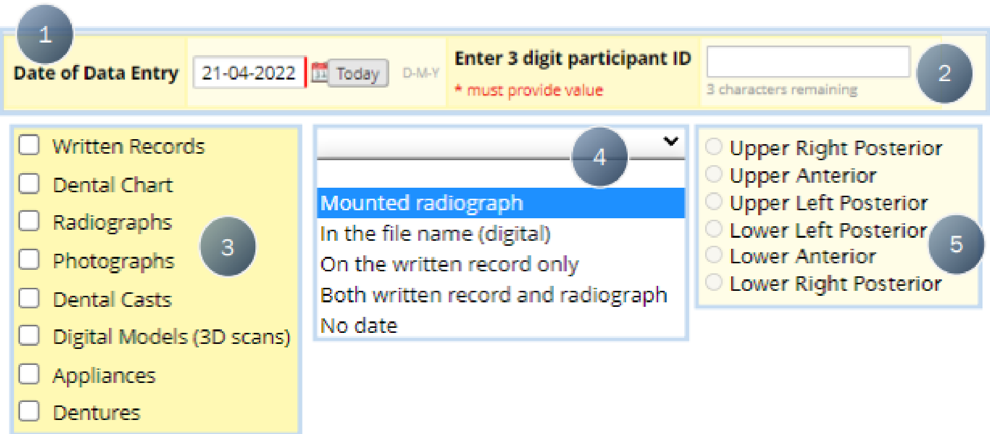


Figure 1-4: Data Entry Types

Undoing selections

All data entry and selections can be deleted or changed. For data entry types date, short text and dropdown menu, simply reselect or type the new entry. For checkboxes, click the selected checkbox to uncheck it. Radio buttons cannot be unclicked, to undo these selections click ‘reset’ located close to the relevant radio button list. Dependent options will disappear when checkboxes or radio buttons are unselected.

Program Flow

Each section of ADDE is introduced below with a brief summary of its purpose, the forms should be moved through in this order (Table 1-1). Detailed guidelines on filling out the forms is covered in Chapter 2.

Table 1-1: Instrument Overview

Dental Record Entry	Details of available dental records are entered. This includes dental clinic, data types and dates as well as details of any radiographs available.
Written Record Entry	All information from the written clinical notes are entered. Each treatment date is entered on a new instance of this form. Entries should start from the most recent appointment as information is carried forward through each instance.
Radiograph Entry	All information available in any type of radiograph is entered here. Tooth options appear based on the radiograph types and locations entered in the Dental Record Entry instrument.
Chart Entry	All information from any dental charts is entered here. It is up to the user to decide on the accuracy and completeness of the chart and not include data in which they are not confident.
No Data	This instrument alerts the user to any teeth that have not had any data entered. Options here are to select no data available or return to previous instruments to enter details.
Calculations	This instrument requires no input and exists so that the program can display information in the next two instruments.
Multiple Codes	For each tooth where multiple codes were entered, a box will display with that information as well as the record type it was gathered from. The user must select which treatments to keep.
Final Odontogram	This instrument requires no input. It is a summary of the INTERPOL codes for each tooth based on input into the previous instruments.

Data Flow

Each form for dental data entry has a series of questions for each tooth. The flow of questions is outlined in Figure 1-5 to provide a big picture view of the intent behind the forms.

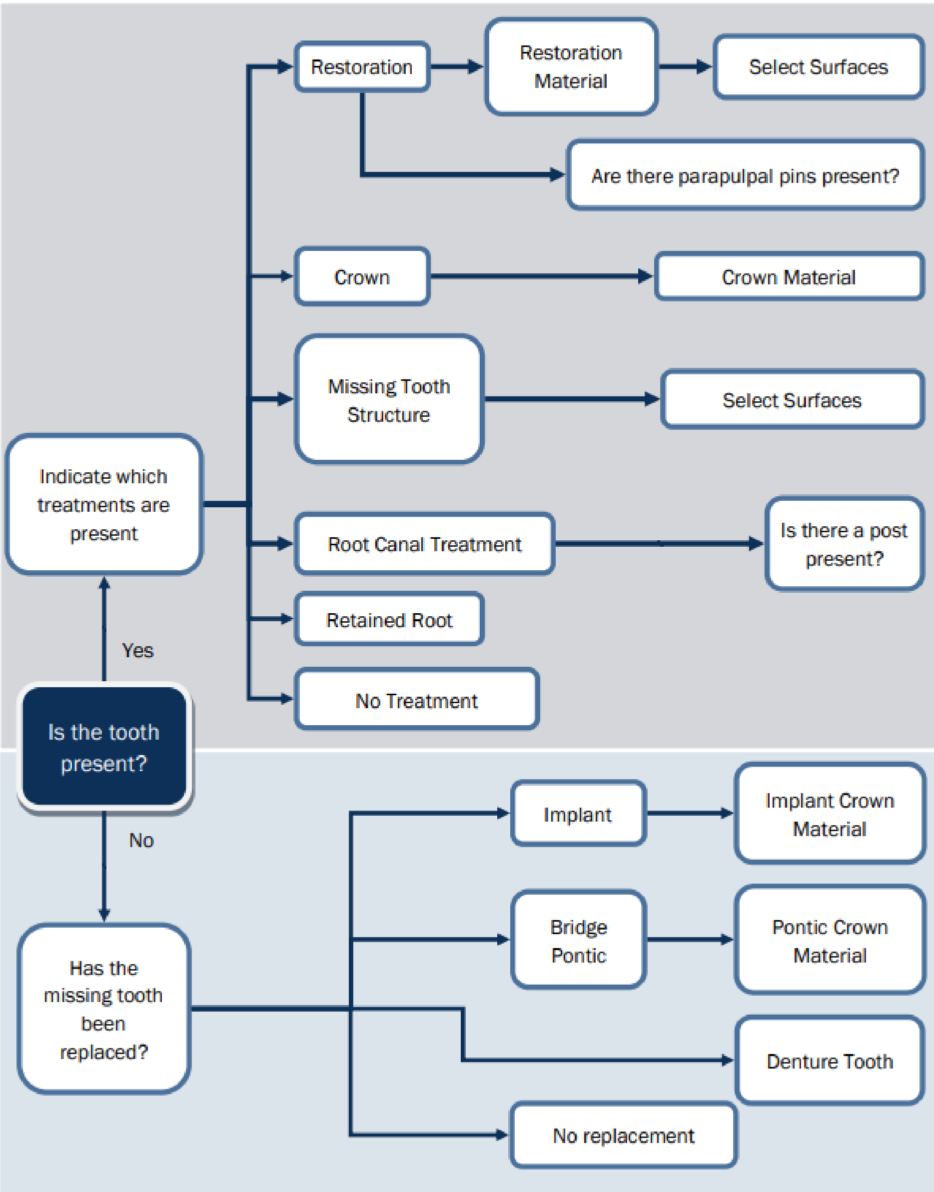


Figure 1-5: Data Entry Flowchart

2

Overview of Antemortem Dental Data Entry Forms

Introduction

Chapter 2 details each of the data entry forms and how they should be used. Each form is described in the order in which they should be entered. The order of entry is important as information entered effects the option of the subsequent forms.

Data entry is in the order: Written Records, Radiographs, Chart.

This order enables to user to enter known treatment and determine when the radiographs were taken to better inform the radiograph data entry. The dental chart is the last form to be entered as it is often the most unreliable due to partial or total incompletion. The information gained in transcribing the written records and radiographs will inform the user as to the likely accuracy and completeness of the dental chart.

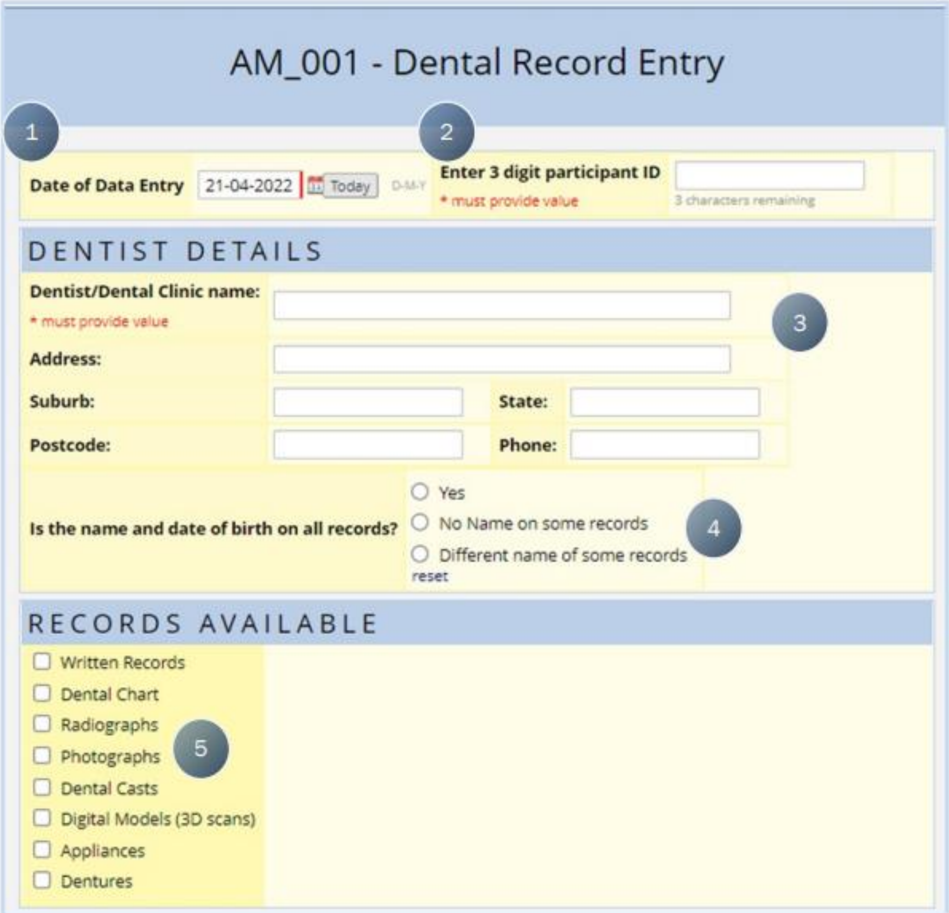
The final three forms are quality checking and determining tooth status when more than one has been entered. The final odontogram will display the last known dental status of the missing person.

Each form displays the antemortem case number and the name of the instrument in a purple box at the top, followed by the data entry fields. Each user is given a unique code (participant ID) that is shown at the top of the form to keep track of who completes which antemortem transcription.

For guidelines on how to determine treatment or tooth status in ambiguous situations, see Chapter 3.

Dental Record Entry

The **Dental Record Entry** form is where all details of the treating dentist and their records are entered (Figure 2-1).


AM_001 - Dental Record Entry

1 Date of Data Entry 21-04-2022 Today D-M-Y

2 Enter 3 digit participant ID
* must provide value
3 characters remaining

DENTIST DETAILS

Dentist/Dental Clinic name:
* must provide value

3

Address:

Suburb: State:

Postcode: Phone:

Is the name and date of birth on all records?
- Yes
- No Name on some records
- Different name of some records

reset

4

RECORDS AVAILABLE

- Written Records
- Dental Chart
- Radiographs
- Photographs
- Dental Casts
- Digital Models (3D scans)
- Appliances
- Dentures

5

Figure 2-1: Dental Record Entry Form

1 **Date of Data Entry**
The date the form is filled in. Select the TODAY button for the current date.

2 **Participant ID**
The users unique number is entered on the form and automatically filled in on all subsequent forms.

3 **Dentist Details**
Enter all relevant dental clinic details.

4

Quality Check

This question and its subsequent expansions checks that all information is reviewed to ensure everything represents the same source (ie.:patient). If option 2 or 3 are selected, the following box (Figure 2-2) will appear and ask for reconciliation between the records.

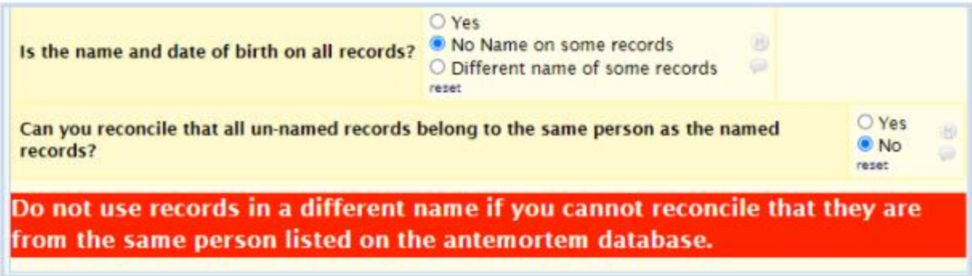


Figure 2-2: Reconciling Different Records

5

Records Available

Select all record types available. Each selection will cause another box to appear to enter relevant details (Figure 2-3).

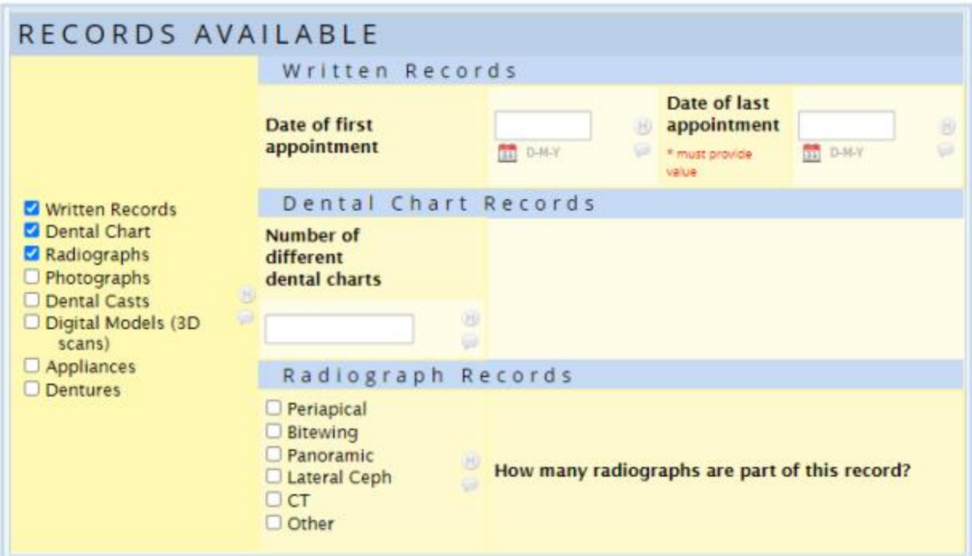


Figure 2-3: Records Available Expansion Boxes

Entering Radiograph Details

Enter the number of radiographs available for each type selected in the checkbox list. Further details boxes will appear for each radiograph (Figure 2-4). The user will be asked to select how the radiograph is dated from a drop down list. This is another quality check point to ensure that radiographs belong to the antemortem records, are viewed in the correct order, and can be cross referenced with the written records. The location of periapical radiographs must be completed to enable the **Radiograph Entry** form to display the correct tooth numbers.

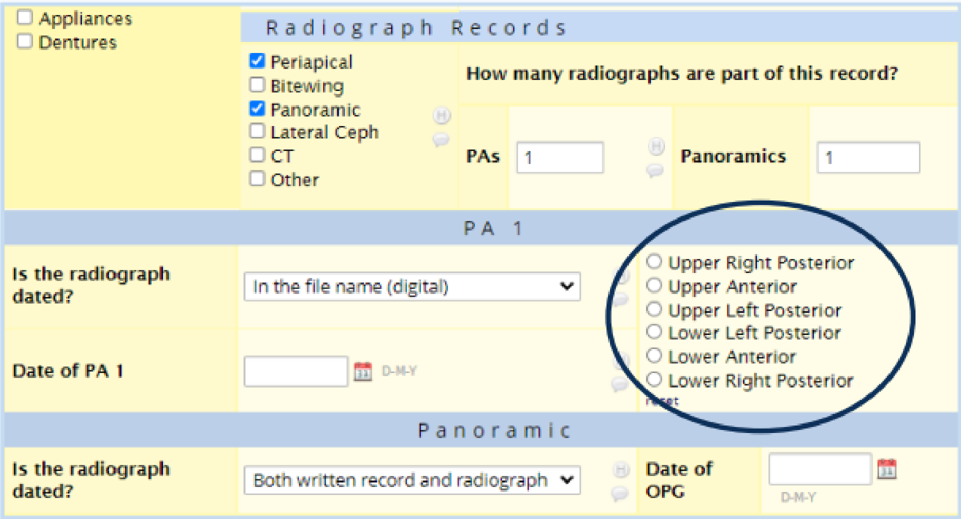


Figure 2-4: Radiograph details expansion boxes

Corresponding tooth numbers are displayed in figure 2-5. In the case of a radiograph that shows a mix of selected teeth, ie a periapical that shows 13 through 16, select an additional PA, record the same date, and select anterior for one and posterior for the other. This will ensure all teeth visible are available for data input on the **Radiograph Entry** form.

Upper Right Posterior | Upper Anterior | Upper Left Posterior

18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38

Lower Right Posterior | Lower Anterior | Lower Left Posterior

Figure 2-5: Tooth designation corresponding to radiograph location.

Written Record Entry

The **Written Record Entry** form is where all information contained within the written clinical notes is entered (Figure 2-6). Any historical or chart only treatment is to be included on the **Chart Entry** form. When information has been entered for one appointment, select add 'additional treatment date'. If it is the final appointment in the written records select 'submit'.

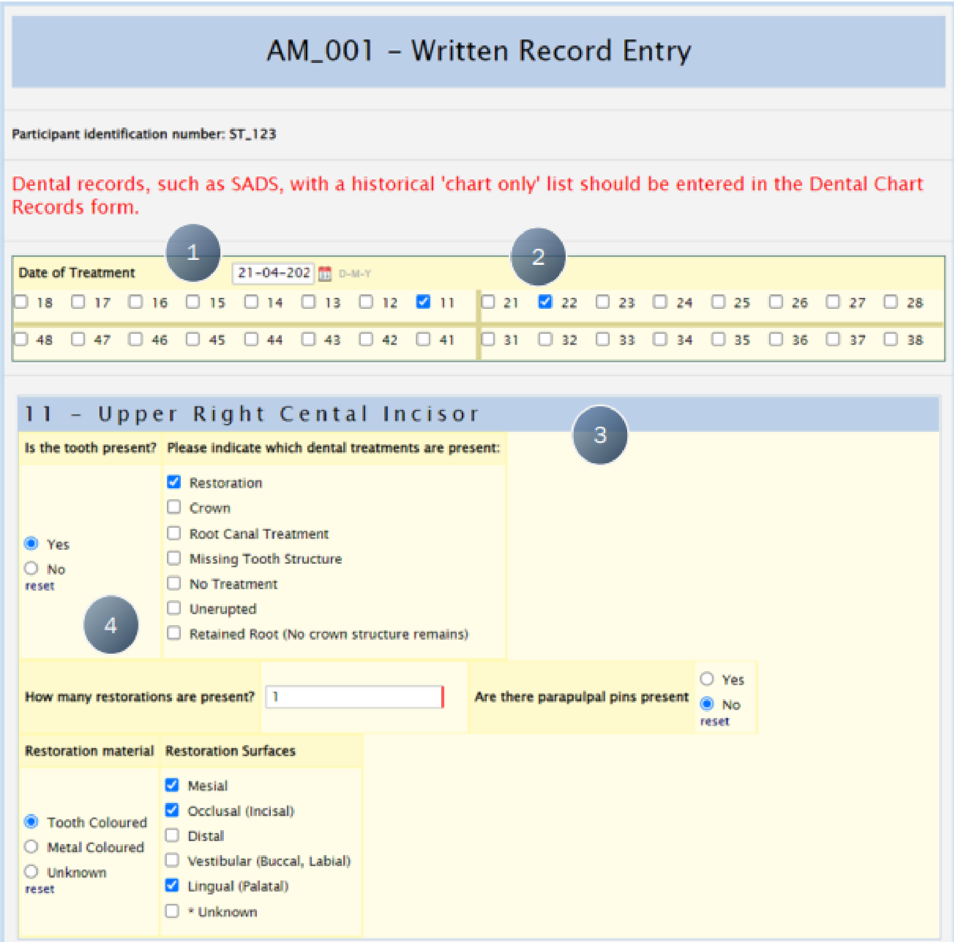


Figure 2-6: Written Record Entry form

1. Enter treatment date, begin at the most recent dental appointment.
2. Select all teeth that received dental intervention on that date.
3. A new box for each tooth will appear below in quadrant order.
4. Select options given to enter the treatment provided. When a selection is made a new box will appear for further details.

Radiograph Entry

Teeth displayed reflect the radiograph choices selected on the **Dental Record Entry** form. For example: selecting a periapical of the posterior upper right will display teeth 18 to 13 inclusive, if a panoramic was selected, all 32 will be available for data input.

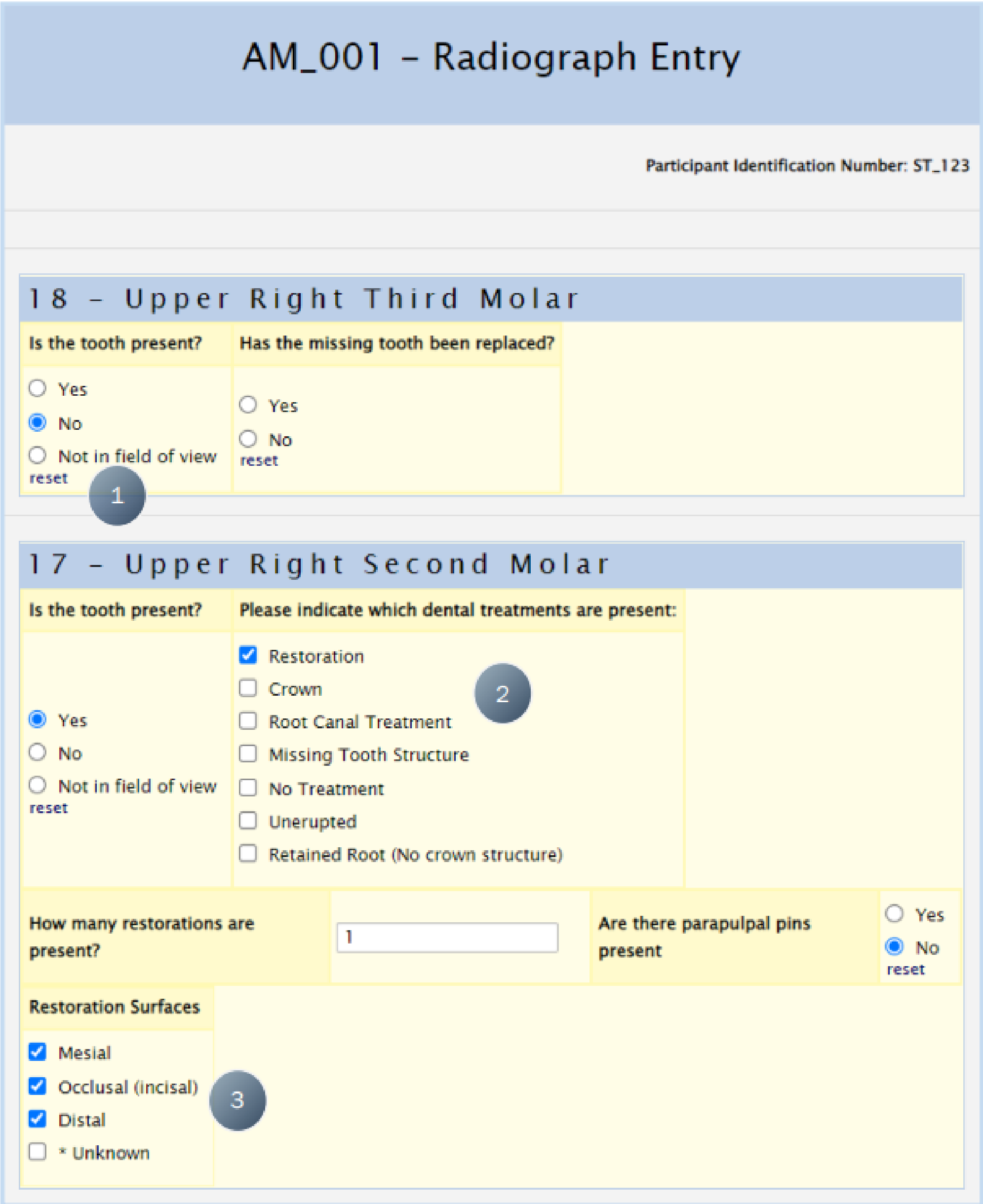
It is understood that for periapical and bitewing radiographs, the teeth shown can be variable and may not appear on the image e.g.: a third molar on a bitewing. Other information can also be limited on a radiograph, including restoration materials and surfaces restored. Therefore, while the **Radiograph Entry** form follows the same process as the **Written Entry** form, there are a few key differences, as shown in Figure 2-7.

1. When selecting present or absent, a third option - not in field of view - allows the user to indicate that there is no information available about this tooth from the image.

2. When a restoration is selected, there is no option to choose filling materials, all restorations charted from radiographs as charted as unidentified fillings. This includes crowns and missing tooth replacements.

3. When selecting surfaces for restorations and marked tooth loss, only four options are available out of the usual six. This reflects the fact that a 3D object is being represented in a 2D format and it is not possible to determine if a restoration or cavitation/fracture extends to the vestibular or lingual surfaces.

   If the user believes a restoration extends onto these surfaces, a comment can be made, such as: "possible extension to V or L"



AM_001 – Radiograph Entry

Participant Identification Number: ST_123

18 – Upper Right Third Molar

Is the tooth present?
- Yes
- No
- Not in field of view
reset

Has the missing tooth been replaced?
- Yes
- No
reset

1

17 – Upper Right Second Molar

Is the tooth present?
- Yes
- No
- Not in field of view
reset

Please indicate which dental treatments are present:
- Restoration
- Crown
- Root Canal Treatment
- Missing Tooth Structure
- No Treatment
- Unerupted
- Retained Root (No crown structure)

2

How many restorations are present? 1

Are there parapulpal pins present
- Yes
- No
reset

Restoration Surfaces
- Mesial
- Occlusal (incisal)
- Distal
- * Unknown

3

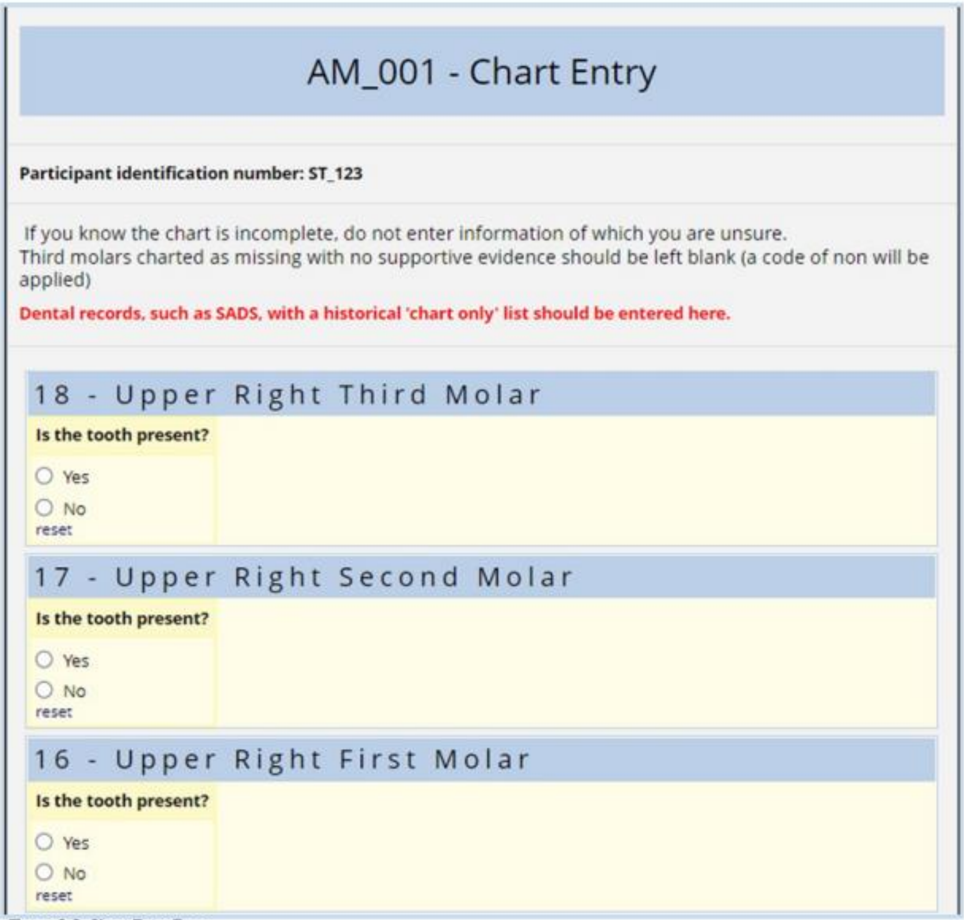
Figure 2-7: Radiograph Entry Form

Chart Entry

The **Chart Entry** form follows the same process as the **Written Entry** form, however each tooth is available for entry. Any historical or 'chart only' records should be entered here. The **Chart Entry** form (Figure 2-8) is the last data entry form as the user will be able to identify the accuracy and completeness of the chart through examining other records. It is up to the discretion and experience of the user to determine if the chart is an appropriate data source.

Leave the tooth field blank if the chart is incomplete or inaccurate for that tooth.

If third molars are charted as absent leave them blank, they are charted as no information available. This is due to the fact that often in a clinical setting, when not visible in the oral cavity they are charted as missing when they may be unerupted.


AM_001 - Chart Entry

Participant identification number: ST_123

If you know the chart is incomplete, do not enter information of which you are unsure.
Third molars charted as missing with no supportive evidence should be left blank (a code of non will be applied)

Dental records, such as SADS, with a historical 'chart only' list should be entered here.

18 - Upper Right Third Molar

Is the tooth present?

Yes
No
reset

17 - Upper Right Second Molar

Is the tooth present?

Yes
No
reset

16 - Upper Right First Molar

Is the tooth present?

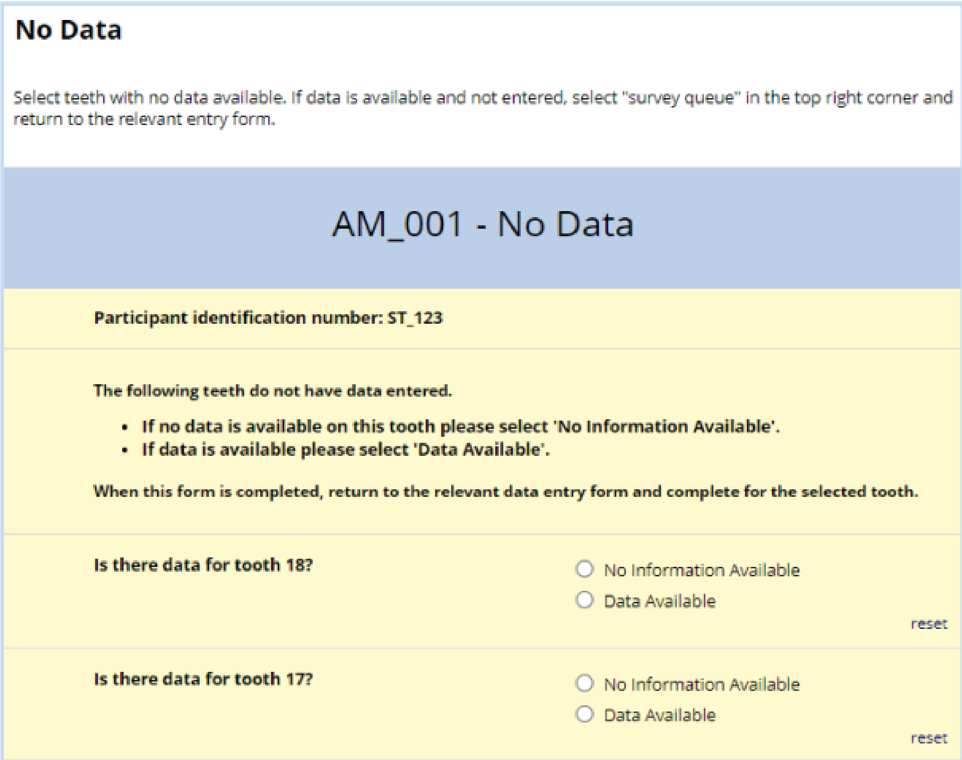
Yes
No
reset

Figure 2-8: Chart Entry Form

No Data

The **No Data** form acts as a quality check stage as well as letting the program know which teeth should be assigned the no data available code, non.

Any tooth that has not had any data entered in the previous three forms will be displayed, see Figure 2-9.


No Data

Select teeth with no data available. If data is available and not entered, select "survey queue" in the top right corner and return to the relevant entry form.

AM_001 - No Data

Participant identification number: ST_123

The following teeth do not have data entered.

- **If no data is available on this tooth please select 'No Information Available'.**
- **If data is available please select 'Data Available'.**

When this form is completed, return to the relevant data entry form and complete for the selected tooth.

Is there data for tooth 18? No Information Available / Data Available reset

Is there data for tooth 17? No Information Available / Data Available reset

Figure 2-9: No Data Form

If there is no data for a tooth in any of the records, select the 'No Information Available' radio button.

When information is available but not yet recorded, select the 'Data Available' radio button.

For those teeth with the second option selected, select survey queue in the top right corner and navigate to the relevant data entry form. Once the data is entered, select submit and move through the forms as before, do not return to the **No Data** form via the survey queue as changes made will not be reflected.

Once all information on the **No Data** form is accurate select 'submit' and to move onto the next form.

Calculations

The **Calculations** page is responsible for assessing all input data to determine how many entries per tooth have been recorded, and if the tooth status recorded is the same for each entry. All teeth with more than one different status will be displayed in the next form, **Multiple Codes**.

No input is necessary on the **Calculations** form, once loaded, select 'submit' to save the calculations and continue to the next form.

Multiple Codes

When more than one treatment or status is entered for a tooth, the **Multiple Codes** form (Figure 2-10) will display all entered data and the source of information. This form is designed help the user decide which treatment or tooth status to keep for the final odontogram.

Each tooth is displayed in its own box and only those teeth with multiple entries will appear. The source of data is displayed inline with the treatment code so that the user can quickly refer to the relevant information to determine which treatment should be kept. While this form aims to remove any past treatment that has been replaced and therefore not relevant to the odontogram or clear up any ambiguity, multiple treatments can be chosen if they reflect the current tooth status.

Once all information is accurate select 'submit' to move to the final form.

1. Treatment column: Description of the treatment or tooth status entered.
2. Code column: INTERPOL code of the treatment or tooth status entered.
3. Displays tooth surfaces for INTERPOL codes that require them.
4. Data Source column: Represents which dental record type the information was entered from, enabling the user to easily review if necessary.

Note:

Please be patient as this page may take some time to load.

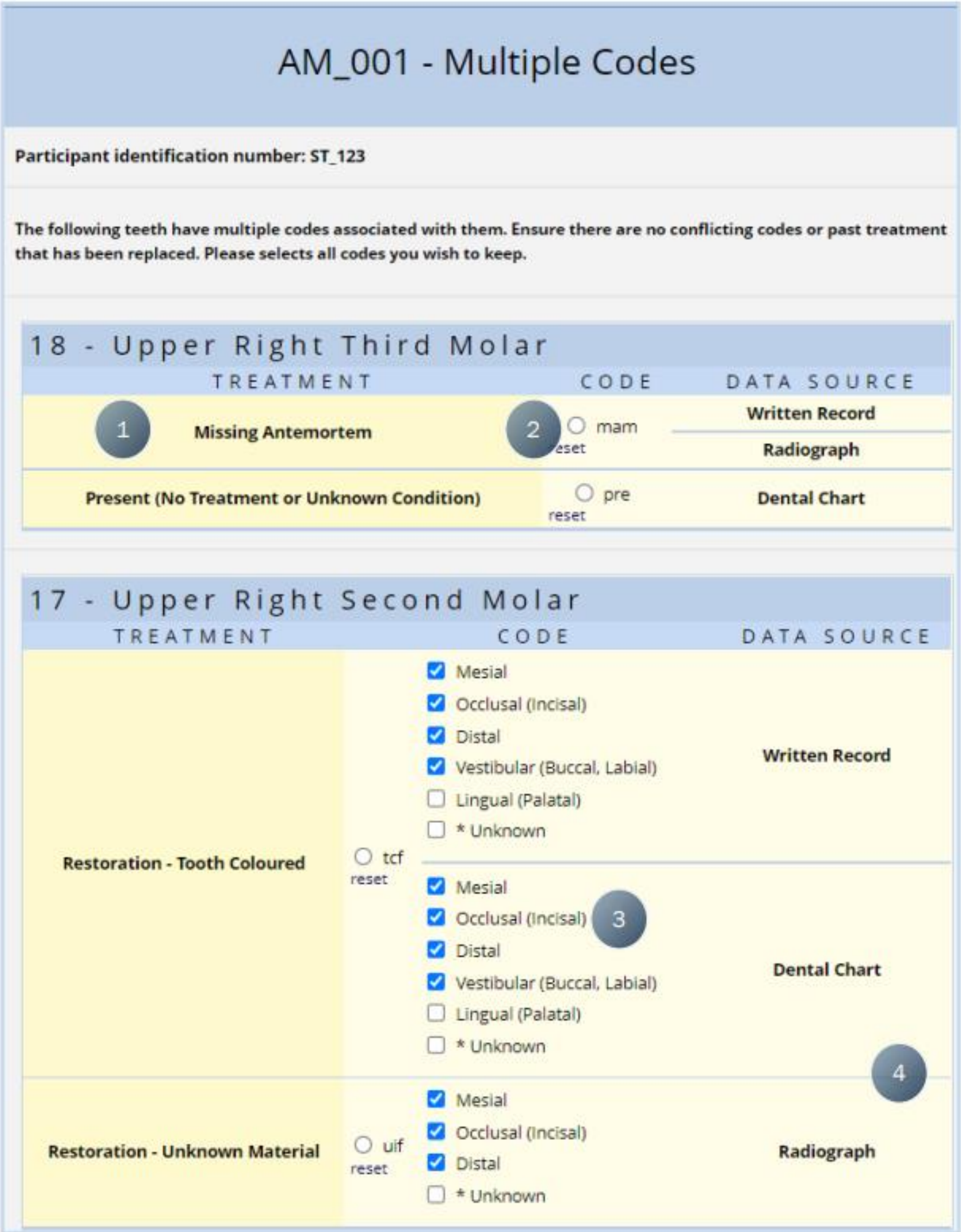


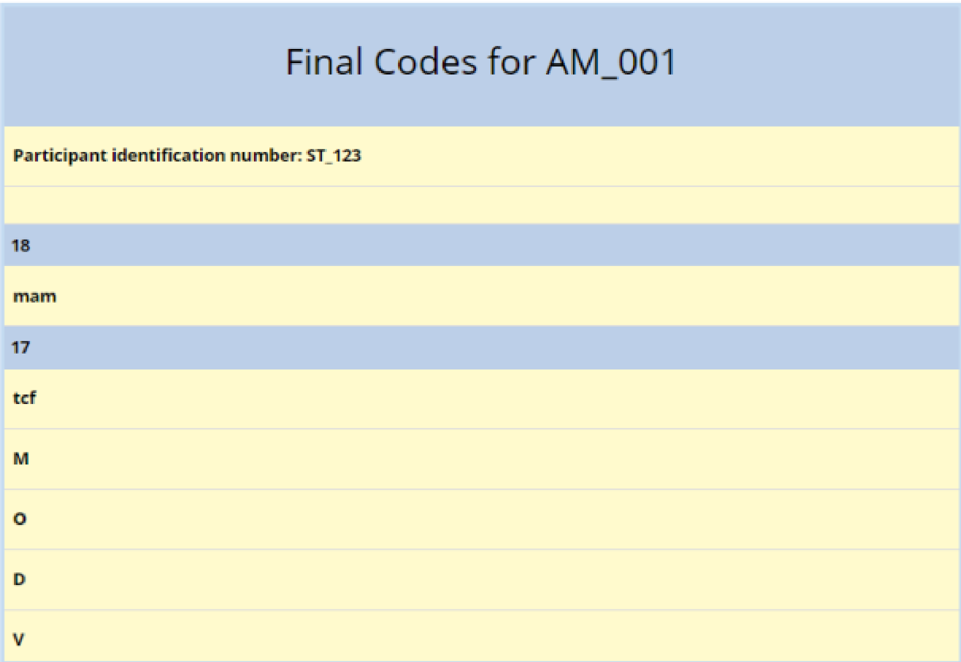
Figure 2-10: Multiple Codes Form

Final Odontogram

The **Final Odontogram** form displays the most recent known dental status of the missing person. Each tooth is paired with the INTERPOL codes than describe the tooth status based on all previous entries (see figure 2-11 for example).

There is no data entry on this form. The information is checked for accuracy by the user. If any information is incorrect, it is possible to return to previous forms, via the survey queue option, to update the data. However, if this occurs, the **No Data**, **Calculations** and **Multiple Codes** instruments must be opened and saved again to account for any differences in the calculations required to produce the final odontogram.

Once satisfied that the information is accurate, select 'submit' to finish the antemortem data entry.



Final Codes for AM_001

Participant identification number: ST_123

18

mam

17

tcf

M

O

D

V

Figure 2-11: Example of Final Odontogram Form

3

Transcription Guidelines

Introduction

Guidelines, codes and tooth surfaces are standardised to reduce confusion and mis-recording, and aid the user in making choices to improve uniformity. This section covers nomenclature used in ADDE as well as more detailed guidelines on how to analyse, interpret and transcribe antemortem dental data.

Tooth Notation

Teeth are numbered using the FDI nomenclature and are deemed to have five surfaces regardless of position. Each surface is given one name to reduce confusion and mis-recording.

Mesial

Occlusal—Occlusal, Incisal

Distal

Vestibular—Vestibular, Buccal, Labial, Facial

Lingual—Lingual, Palatal

INTERPOL Codes

ADDE uses INTERPOL codes which are presented in Table 3-1a and 3-1b , along with a more detailed description of when each code should be used. The user does not need to know these codes in order to complete the data entry forms, however the **Final Odontogram** form does present the information in this code format.

The following subheadings present guidelines for selecting the appropriate code in situations that may require some decision making. Following these guidelines will reduce the variation between users and increase the objectivity of the final outcome.

Table 3-1a: INTERPOL Codes and Definitions

	Code	Definition and Usage
Status	mam	**Missing antemortem** Written or visual evidence that the tooth is not present.
	une	**Unerupted** Written or visual evidence that the tooth is present but not in the oral cavity.
	non	**No information** No information about a tooth in any of the records. If a tooth is only recorded on a chart use this code.
	pre	**Tooth present** Written or visual evidence that the tooth is present, however the is no information on the status of the tooth.
	nad	**No abnormality detected** Written evidence that the tooth is present and that it is a sound/virgin tooth.
	rov	**Retained root** Written or visual evidence of a remaining root with no crown structure.
Crown Pathology	mtl	**Marked tooth loss** Written or visual evidence of present teeth that are missing tooth structure which has not been replaced. This code includes tooth surface selection.
Fillings	fis	**Fissure sealant** Written evidence of a fissure sealant. This code includes tooth surface selection.
	uif	**Unidentified filling** A filling is present, however there is no written information on the material used. This code should also be used when the only evidence of a filling in found on a radiograph or a chart. This code includes tooth surface selection.
	mcf	**Metal coloured filling** Written evidence of any metal material used in a restoration. This code includes tooth surface selection.
	tcf	**Tooth coloured filling** Written evidence of any tooth coloured material used in a restoration, this includes composite and GIC as well as inlays. This code includes tooth surface selection.

Table 3-1b: INTERPOL Codes and Definitions

	Code	Definition and Usage
Crowns	uic	**Unidentified crown** Evidence of a crown, however the material used is not specified.
	mcc	**Metal ceramic crown** Ceramic bonded to metal crown specified in written record.
	mtc	**Metal coloured crown** Metal crown (gold/amalgam/stainless steel) specified in written record.
	tcc	**Tooth coloured crown** Written evidence of a porcelain/ceramic only crown.
Bridges	abu	**Abutment tooth** This code should be used when the tooth is being used as a support for a bridge pontic. If the tooth itself is crowned it should have the abu code as well as a crown code.
	pon	**Pontic** This code should be used when a bridge is replacing a missing tooth. This code should be in addition to mam (missing tooth) and a crown code for the material of the pontic.
Root	ipx	**Implant** This code should be used when an implant is replacing a missing tooth. This code should be in addition to mam (missing tooth) as well as a crown code if there is one present.
	pps	**Parapulpal pin** Written or visual evidence of pin supported restoration. If a restoration is present it should also include a filling code.
	rfx	**Root filling** Written or visual evidence of obturation. Should also include codes of crown treatments such as a crown, restoration, missing tooth structure or retained root.
	pox	**Post** Written or visual evidence of a post, should include a rfx (root canal) as well as any crown treatments.

Tooth Status

- Teeth are identified by anatomy (utilising radiographic and/or oral imaging assessment) rather than the position they hold in the mouth. For example: if there has been mesial drift due to extraction of a 46 with space closed the 46 should be coded as missing antemortem (mam).
- Unerupted and impacted teeth are charted as unerupted (une) if all tooth parts are not in the oral cavity.
- If there is not written or visual evidence of a tooth the code non should be selected. This includes when the only evidence of third molars missing is the chart.
- A tooth is present (pre) if any part of the tooth crown has erupted through the gingiva.
- If both deciduous tooth and its successor are present, the permanent tooth is coded and a comment made in regards to the status of the deciduous tooth.
- If a supernumerary tooth is present, it is recorded in a comment, and the legitimate tooth coded.
- No abnormality detected (nad) is only charted when there is written evidence of a sound tooth.
- If a tooth crown is destroyed by caries or trauma but the root remains the code retained root (rov) is used.
- Retained root is also recorded for roots remaining under replacements such as dentures and bridges.
- If orthodontic brackets to band are present, the tooth is coded as if there were none and the bracket mentioned in a comment.

Crown Pathology

- Marked tooth loss (mtl) is recorded in cases of missing tooth structure and fractured or missing restorations.
- If any part of the restoration remains, this is charted as a restoration and the missing surfaces charted as mtl.
- Caries is only charted as mtl when there is visual evidence of cavitation.

Fillings

- Fissure sealants (fis) can only be recorded, when any part of the fissure system remains covered, and only on molars, premolars and the lingual surface of upper lateral incisors. Pits and groove surfaces can be charted ie: occlusal, vestibular or lingual. If it extends past these it should be coded as a restoration (tcf).
- Recorded when any part of the fissure system remains covered.
- Interproximal restoration should extend at least 1mm onto an adjacent surface for it be considered a filled surface
- Occlusal restorations should extend over the mesial and distal ridges for those surfaces to be considered filled.
- All restorations charted from radiographs should be given the code unidentified filling (uif).
- Inlays and onlays are coded as a restoration tooth coloured filling (tcf) and metal coloured filling (mcf) depended on material followed by the surfaces they cover. A comment can be made that the restoration is an inlay or an onlay.

Crowns

- When crowns are charted from the radiograph, or if there is no information on the material used a code of unidentified crown (uic) is used.

Bridges

- When a missing tooth has been replaced with a bridge the code pontic (pon) as well as the crown material and missing antemortem (mam) should be applied .
- Adjacent abutment teeth should be coded abutment (abu) as well as the crown material or a comment in the case of maryland bridges.

Root

- Implant replaced teeth should be coded with missing antemortem (mam), implant (ipx) and a crown material if one is in place.
- Parapulpal pins (ppx) should be coded for each pin present.
- Teeth with root canal filling (rfx) codes should also be coded for the restoration or status of the tooth.
- Root canal filling (rfx) code should only be applied if obturation has taken place. If the treatment was started and never finished code the restoration only and make a comment in regards to the unfinished root treatment.
- When a post (pox) is present, a root canal filling (rfx) code is also required to indicate the tooth has been obturated as well as any restorative coding.
- The material of the post (pox) does not need to be recorded in code, however it is useful to make a comment on the material used if it is detailed in the written records.

Appendix VI – REDCap Codebook

The codebook displays the variables, labels and attributes of each field within each instrument that makes up ADDE. Each instrument represents a form within the survey. Written Record Entry, Radiograph Entry, Chart Entry, No Data, Calculations, Multiple Codes and Final Odontogram instruments employ the same code repeated 32 times. for each tooth. Only the code for tooth 18 is presented as the coding is extensive.

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
	Instrument: Dental Record Entry (dental_record_entry) Enabled as survey		
1	record_id	Record ID	text
2	entry_date	Section Header: *[arm-label] - [instrument-label]* Date of Data Entry	text (date_dmy) Field Annotation: @TODAY
3	dentist_details		descriptive
4	dent_name	Dentist/Dental Clinic name:	text, Required
5	dent_address	Dentist/Dental Clinic Address:	text
6	dent_sub	Clinic Suburb	text
7	dent_state	Clinic State	text
8	dent_postcode	Clinic postcode	text (postalcode_australia)
9	dent_phone	Clinic phone	text (phone_australia)
10	name_dob	Is the name and date of birth on all records?	radio 1 Yes 2 No Name on some records 3 Different name of some records
11	reconcile Show the field ONLY if: [name_dob] = '2' OR [name_dob] = '3'	Can you reconcile that all un-named records belong to the same person as the named records?	yesno 1 Yes 0 No
12	alert Show the field ONLY if: [reconcile] = '0'	Do not use records in a different name if you cannot reconcile that they are from the same person listed on the antemortem database.	descriptive
13	record_type	Select record types available	checkbox, Required 99 record_type___99 Written Records 98 record_type___98 Dental Chart 97 record_type___97 Radiographs 96 record_type___96 Photographs 95 record_type___95 Dental Casts 94 record_type___94 Digital Models (3D scans) 93 record_type___93 Appliances 92 record_type___92 Dentures Custom alignment: LV

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
14	date_from Show the field ONLY if: [record_type(99)] = '1'	Date of first appointment	text (date_dmy) Field Annotation: @HIDEBUTTON
15	date_to Show the field ONLY if: [record_type(99)] = '1'	Date of last appointment	text (date_dmy), Required Field Annotation: @HIDEBUTTON
16	chart_no Show the field ONLY if: [record_type(98)] = '1'	Number of different dental charts	text (number)
17	chart_create Show the field ONLY if: [chart_no]>0	Does the chart have a creation date?	yesno 1 Yes 0 No
18	date_create Show the field ONLY if: [chart_create]=1	Date of chart creation	text (date_dmy) Field Annotation: @HIDEBUTTON
19	chart_create_2 Show the field ONLY if: [chart_no]>1	Does the second chart have a creation date?	yesno 1 Yes 0 No
20	date_create_2 Show the field ONLY if: [chart_create_2] = '1'	Date of chart creation	text (date_dmy) Field Annotation: @HIDEBUTTON
21	radio_type Show the field ONLY if: [record_type(97)] = '1'	Select types of radiographs available	checkbox 99 radio_type___99 Periapical 98 radio_type___98 Bitewing 97 radio_type___97 Panoramic 96 radio_type___96 Lateral Ceph 95 radio_type___95 CT 94 radio_type___94 Other
22	pa_no Show the field ONLY if: [radio_type(99)] = '1'	Number of PAs	text (number)
23	bw_no Show the field ONLY if: [radio_type(98)] = '1'	Number of BWs	text (number)

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
24	opg_no Show the field ONLY if: [radio_type(97)] = '1'	Number of OPGs	text (number)
25	img_pa_1 Show the field ONLY if: [pa_no]>0	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date
26	pa_date_1 Show the field ONLY if: [img_pa_1] = '1' or [img_pa_1] = '2' or [img_pa_1] = '3' or [img_pa_1] = '4'	Date of PA 1	text (date_dmy) Field Annotation: @HIDEBUTTON
27	pa_loc_1 Show the field ONLY if: [pa_no]>0	Location of PA 1	radio 879 Upper Right Posterior 855 Upper Anterior 869 Upper Left Posterior 469 Lower Left Posterior 455 Lower Anterior 479 Lower Right Posterior
28	img_pa_2 Show the field ONLY if: [pa_no]>1	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date
29	pa_date_2 Show the field ONLY if: [img_pa_2] = '1' or [img_pa_2] = '2' or [img_pa_2] = '3' or [img_pa_2] = '4'	Date of PA 2	text (date_dmy) Field Annotation: @HIDEBUTTON
30	pa_loc_2 Show the field ONLY if: [pa_no]>1	Location of PA 2	radio 879 Upper Right Posterior 855 Upper Anterior 869 Upper Left Posterior 469 Lower Left Posterior 455 Lower Anterior 479 Lower Right Posterior

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
31	img_pa_3 Show the field ONLY if: [pa_no]>2	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date
32	pa_date_3 Show the field ONLY if: [img_pa_3] = '1' or [img_pa_3] = '2' or [img_pa_3] = '3' or [img_pa_3] = '4'	Date of PA 3	text (date_dmy) Field Annotation: @HIDEBUTTON
33	pa_loc_3 Show the field ONLY if: [pa_no]>2	Location of PA 3	radio 879 Upper Right Posterior 855 Upper Anterior 869 Upper Left Posterior 469 Lower Left Posterior 455 Lower Anterior 479 Lower Right Posterior
34	img_pa_4 Show the field ONLY if: [pa_no]>3	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and 5 No date
35	pa_date_4 Show the field ONLY if: [img_pa_4] = '1' or [img_pa_4] = '2' or [img_pa_4] = '3' or [img_pa_4] = '4'	Date of PA 4	text (date_dmy) Field Annotation: @HIDEBUTTON
36	pa_loc_4 Show the field ONLY if: [pa_no]>3	Location of PA 4	radio 879 Upper Right Posterior 855 Upper Anterior 869 Upper Left Posterior 469 Lower Left Posterior 455 Lower Anterior 479 Lower Right Posterior

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
37	img_pa_5 Show the field ONLY if: [pa_no]>4	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date
38	pa_date_5 Show the field ONLY if: [img_pa_5] = '1' or [img_pa_5] = '2' or [img_pa_5] = '3' or [img_pa_5] = '4'	Date of PA 5	text (date_dmy) Field Annotation: @HIDEBUTTON
39	pa_loc_5 Show the field ONLY if: [pa_no]>4	Location of PA 5	radio 879 Upper Right Posterior 855 Upper Anterior 869 Upper Left Posterior 469 Lower Left Posterior 455 Lower Anterior 479 Lower Right Posterior
40	img_pa_6 Show the field ONLY if: [pa_no]>5	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date
41	pa_date_6 Show the field ONLY if: [img_pa_6] = '1' or [img_pa_6] = '2' or [img_pa_6] = '3' or [img_pa_6] = '4'	Date of PA 6	text (date_dmy) Field Annotation: @HIDEBUTTON
42	pa_loc_6 Show the field ONLY if: [pa_no]>5	Location of PA 6	radio 879 Upper Right Posterior 855 Upper Anterior 869 Upper Left Posterior 469 Lower Left Posterior 455 Lower Anterior 479 Lower Right Posterior
43	img_pa_7 Show the field ONLY if: [pa_no]>6	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
44	pa_date_7 Show the field ONLY if: [img_pa_7] = '1' or [img_pa_7] = '2' or [img_pa_7] = '3' or [img_pa_7] = '4'	Date of PA 7	text (date_dmy) Field Annotation: @HIDEBUTTON
45	pa_loc_7 Show the field ONLY if: [pa_no]>6	Location of PA 7	radio 879 Upper Right Posterior 855 Upper Anterior 869 Upper Left Posterior 469 Lower Left Posterior 455 Lower Anterior 479 Lower Right Posterior
46	img_pa_8 Show the field ONLY if: [pa_no]>7	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date
47	pa_date_8 Show the field ONLY if: [img_pa_8] = '1' or [img_pa_8] = '2' or [img_pa_8] = '3' or [img_pa_8] = '4'	Date of PA 8	text (date_dmy) Field Annotation: @HIDEBUTTON
48	pa_loc_8 Show the field ONLY if: [pa_no]>7	Location of PA 8	radio 879 Upper Right Posterior 855 Upper Anterior 869 Upper Left Posterior 469 Lower Left Posterior 455 Lower Anterior 479 Lower Right Posterior
49	img_bw_1 Show the field ONLY if: [bw_no]>0	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
50	bw_date_1 Show the field ONLY if: [img_bw_1] = '1' or [img_bw_1] = '2' or [img_bw_1] = '3' or [img_bw_1] = '4'	Date of BW	text (date_dmy) Field Annotation: @HIDEBUTTON
51	bw_loc_1 Show the field ONLY if: [bw_no]>0	Location of Bitewing 1	radio 733 Right 633 Left
52	img_bw_2 Show the field ONLY if: [bw_no]>1	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date
53	bw_date_2 Show the field ONLY if: [img_bw_2] = '1' or [img_bw_2] = '2' or [img_bw_2] = '3' or [img_bw_2] = '4'	Date of BW	text (date_dmy) Field Annotation: @HIDEBUTTON
54	bw_loc_2 Show the field ONLY if: [bw_no]>1	Location of Bitewing 2	radio 733 Right 633 Left
55	table_opg Show the field ONLY if: [opg_no]>0		descriptive
56	img_opg Show the field ONLY if: [opg_no]>0	Is the radiograph dated?	dropdown 1 Mounted radiograph 2 In the file name (digital) 3 On the written record only 4 Both written record and radiograph 5 No date
57	opg_date_1 Show the field ONLY if: [img_opg] = '1' or [img_opg] = '2' or [img_opg] = '3' or [img_opg] = '4'	Date of OPG	text (date_dmy) Field Annotation: @HIDEBUTTON
58	dental_record_entry_complete	Section Header: *Form Status* Complete?	dropdown 0 Incomplete 1 Unverified 2 Complete

Instrument: **Written Record Entry** (written_record_entry) Enabled as survey			
#	**Variable / Field Name**	**Field Label** ***Field Note***	**Field Attributes (Field Type, Validation, Choices, Calculations, etc.)**
59	wr_label	[arm-label] - [instrument-label]	descriptive
60	wr_instruction	Each treatment date should be entered on a new form. Entries from previous forms will be included, please do not delete these on subsequent forms. To remove a selection with a round button, click 'reset' To remove a selection with a checkbox, re-click the box	descriptive
61	wr_date_tth_table		descriptive
62	tx_date	Treatment Date	text (date_dmy), Required Field Annotation: @HIDEBUTTON
63	wr_tooth_no_1	Quadrant 1	checkbox 18 wr_tooth_no_1___18 18 17 wr_tooth_no_1___17 17 16 wr_tooth_no_1___16 16 15 wr_tooth_no_1___15 15 14 wr_tooth_no_1___14 14 13 wr_tooth_no_1___13 13 12 wr_tooth_no_1___12 12 11 wr_tooth_no_1___11 11 Custom alignment: LH Field Annotation: @DEFAULT='[wr_tooth_no_1:checked:value][previous-instance]'
64	wr_tooth_no_2	Quadrant 2	checkbox 21 wr_tooth_no_2___21 21 22 wr_tooth_no_2___22 22 23 wr_tooth_no_2___23 23 24 wr_tooth_no_2___24 24 25 wr_tooth_no_2___25 25 26 wr_tooth_no_2___26 26 27 wr_tooth_no_2___27 27 28 wr_tooth_no_2___28 28 Custom alignment: LH Field Annotation: @DEFAULT='[wr_tooth_no_2:checked:value][previous-instance]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
65	wr_tooth_no_3	Quadrant 3	checkbox 31 wr_tooth_no_3___31 31 32 wr_tooth_no_3___32 32 33 wr_tooth_no_3___33 33 34 wr_tooth_no_3___34 34 35 wr_tooth_no_3___35 35 36 wr_tooth_no_3___36 36 37 wr_tooth_no_3___37 37 38 wr_tooth_no_3___38 38 Custom alignment: LH Field Annotation: @DEFAULT='[wr_tooth_no_3:checked:value][previous-instance]'
66	wr_tooth_no_4	Quadrant 4	checkbox 48 wr_tooth_no_4___48 48 47 wr_tooth_no_4___47 47 46 wr_tooth_no_4___46 46 45 wr_tooth_no_4___45 45 44 wr_tooth_no_4___44 44 43 wr_tooth_no_4___43 43 42 wr_tooth_no_4___42 42 41 wr_tooth_no_4___41 41 Custom alignment: LH Field Annotation: @DEFAULT='[wr_tooth_no_4:checked:value][previous-instance]'
67	label_wr_18 Show the field ONLY if: [wr_tooth_no_1(18)] = '1' OR [wr_tooth_no_1(18)][previous-instance] = '1'		descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)		
68	wr_pres_18	Is the tooth present?	radio		
	Show the field ONLY if:		99	Yes	
	[wr_tooth_no_1(18)] = '1'		1	No	
			Custom alignment: LV		
			Field Annotation: @DEFAULT='[wr_pres_18:value][previous-instance]'		
69	wr_treat_18	Please indicate which dental treatments are present:	checkbox, Required		
	Show the field ONLY if:		99	wr_treat_18___99	Restoration
	[wr_pres_18] = '99'		98	wr_treat_18___98	Crown
			2	wr_treat_18___2	Root Canal Treatment
			3	wr_treat_18___3	Missing Tooth Structure
			4	wr_treat_18___4	No Treatment Visible
			5	wr_treat_18___5	Unerupted
			6	wr_treat_18___6	Retained Root (No crown structure remains)
			Custom alignment: LV		
			Field Annotation: @DEFAULT='[wr_treat_18:checked:value][previous-instance]'		
70	wr_rest_no_18	How many restorations are present?	text (number), Required		
	Show the field ONLY if:		Custom alignment: LV		
	[wr_treat_18(99)] = '1'		Field Annotation: @DEFAULT='[wr_rest_no_18][previous-instance]'		
71	wr_rest_mat_18	Restoration material	radio, Required		
	Show the field ONLY if:		7	Tooth Coloured	
	[wr_rest_no_18] >0		8	Metal Coloured	
			9	Unknown	
			Custom alignment: LV		
			Field Annotation: @DEFAULT='[wr_rest_mat_18:value][previous-instance]'		
72	wr_rest_surf_18	Restoration Surfaces	checkbox, Required		
	Show the field ONLY if:		111	wr_rest_surf_18___111	Mesial
	[wr_rest_mat_18] = '7' or [wr_rest_mat_18] = '8' or [wr_rest_mat_18] = '9'		112	wr_rest_surf_18___112	Occlusal (Incisal)
			113	wr_rest_surf_18___113	Distal
			114	wr_rest_surf_18___114	Vestibular (Buccal, Labial)
			115	wr_rest_surf_18___115	Lingual (Palatal)
			116	wr_rest_surf_18___116	* Unknown
			Custom alignment: LV		
			Field Annotation: @DEFAULT='[wr_rest_surf_18:checked:value][previous-		

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
73	wr_rest_mat_2_18 Show the field ONLY if: [wr_rest_no_18] >1 OR [wr_rest_no_18][previous-instance] >1	Second Restoration material	radio, Required 7 Tooth Coloured 8 Metal Coloured 9 Unknown Custom alignment: LV Field Annotation: @DEFAULT='[wr_rest_mat_2_18:value][previous-instance]'
74	wr_rest_surf_2_18 Show the field ONLY if: [wr_rest_mat_2_18] = '7' or [wr_rest_mat_2_18] = '8' or [wr_rest_mat_2_18] = '9'	Second Restoration Surfaces	checkbox, Required 111 wr_rest_surf_2_18___111 Mesial 112 wr_rest_surf_2_18___112 Occlusal (Incisal) 113 wr_rest_surf_2_18___113 Distal 114 wr_rest_surf_2_18___114 Vestibular (Buccal, Labial) 115 wr_rest_surf_2_18___115 Lingual (Palatal) 116 wr_rest_surf_2_18___116 * Unknown Custom alignment: LV Field Annotation: @DEFAULT='[wr_rest_surf_2_18:checked:value][previous-
75	wr_pin_18 Show the field ONLY if: [wr_treat_18(99)] = '1'	Are there parapulpal pins present	radio 10 Yes 99 No Custom alignment: LV Field Annotation: @DEFAULT='[wr_pin_18:value][previous-instance]'
76	wr_post_18 Show the field ONLY if: [wr_treat_18(2)] = '1'	Is there a post present?	radio 11 Yes 99 No Custom alignment: LV Field Annotation: @DEFAULT='[wr_post_18:value][previous-instance]'
77	wr_crown_18 Show the field ONLY if: [wr_treat_18(98)] = '1'	Crown Material	radio 12 Porcelain/Ceramic Bonded to Metal material 13 Metal coloured material (metal only) 14 Tooth coloured material (no metal) 15 Unknown material Custom alignment: LV Field Annotation: @DEFAULT='[wr_crown_18:value][previous-instance]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
78	wr_mtl_surf_18 Show the field ONLY if: [wr_treat_18(3)] = '1'	Missing Tooth Structure Surfaces:	checkbox 111 wr_mtl_surf_18___111 Mesial 112 wr_mtl_surf_18___112 Occlusal (Incisal) 113 wr_mtl_surf_18___113 Distal 114 wr_mtl_surf_18___114 Vestibular (Buccal, Labial) 115 wr_mtl_surf_18___115 Lingual (Palatal) 116 wr_mtl_surf_18___116 * Unknown Surfaces Custom alignment: LV Field Annotation: @DEFAULT='[wr_mtl_surf_18:checked:value][previous-
79	wr_repl_18 Show the field ONLY if: [wr_pres_18] = '1'	Has the missing tooth been replaced?	radio 99 Yes 1 No Custom alignment: LV Field Annotation: @DEFAULT='[wr_repl_18:value][previous-instance]'
80	wr_tth_repl_18 Show the field ONLY if: [wr_repl_18] = '99'	Missing Tooth Replacement	radio 16 Implant 17 Bridge Pontic 99 Denture Tooth Custom alignment: LV Field Annotation: @DEFAULT='[wr_tth_repl_18:value][previous-instance]'
81	wr_repl_impcrown_18 Show the field ONLY if: [wr_tth_repl_18] = '16'	Implant Crown Material	radio 12 Porcelain/Ceramic Bonded to Metal material 13 Metal coloured material (metal only) 14 Tooth coloured material (no metal) 15 Unknown material 1 No Crown Custom alignment: LV Field Annotation: @DEFAULT='[wr_repl_impcrown_18:value][previous-
82	wr_repl_poncrown_18 Show the field ONLY if: [wr_tth_repl_18] = '17'	Pontic Crown Material	radio 12 Porcelain/Ceramic Bonded to Metal material 13 Metal coloured material (metal only) 14 Tooth coloured material (no metal) 15 Unknown material Custom alignment: LV Field Annotation: @DEFAULT='[wr_repl_poncrown_18:value][previous-

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
	Instrument: Radiograph Entry (radiograph_entry) Enabled as survey		
580	xray_instruction	Section Header: *[arm-label] - [instrument-label]* To remove a selection with a round button, click 'reset'To remove a selection with a checkbox, re-click the box	descriptive
581	radiograph_entry		descriptive
582	label_18 Show the field ONLY if: [first-event-name][radio_type(97)] = '1' or [first-event-name][pa_loc_1] = '879' or [first-event-name][pa_loc_2] = '879' or [first-event-name][pa_loc_3] = '879' or [first-event-name][pa_loc_4] = '879' or [first-event-name][pa_loc_5] = '879' or [first-event-name][pa_loc_6] = '879' or [first-event-name][pa_loc_7] = '879' or [first-event-name][pa_loc_8] = '879' or [bw_loc_1] = '733' or [bw_loc_2] = '733'		descriptive
583	xray_pres_18 Show the field ONLY if: [first-event-name][radio_type(97)] = '1' or [first-event-name][pa_loc_1] = '879' or [first-event-name][pa_loc_2] = '879' or [first-event-name][pa_loc_3] = '879' or [first-event-name][pa_loc_4] = '879' or [first-event-name][pa_loc_5] = '879' or [first-event-name][pa_loc_6] = '879' or [first-event-name][pa_loc_7] = '879' or [first-event-name][pa_loc_8] = '879' or [first-event-name][bw_loc_1] = '733' or [first-event-name][bw_loc_2] = '733'	Is the tooth present?	radio 99 Yes 1 No 98 Not in field of view Custom alignment: LV

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)		
584	xray_treat_18 Show the field ONLY if: [xray_pres_18] = '99'	Please indicate which dental treatments are present:	checkbox, Required		
			9	xray_treat_18__9	Restoration
			15	xray_treat_18__15	Crown
			2	xray_treat_18__2	Root Canal Treatment
			3	xray_treat_18__3	Missing Tooth Structure
			4	xray_treat_18__4	No Treatment Visible (Including partially visible teeth)
			5	xray_treat_18__5	Unerupted
			6	xray_treat_18__6	Retained Root (No crown structure)
			Custom alignment: LV		
585	rest_no_18 Show the field ONLY if: [xray_treat_18(9)] = '1'	How many restorations are present?	text (number), Required Custom alignment: LV		
586	xray_rest_surf_18 Show the field ONLY if: [rest_no_18] >0	Restoration Surfaces	checkbox, Required		
			111	xray_rest_surf_18__111	Mesial
			112	xray_rest_surf_18__112	Occlusal (incisal)
			113	xray_rest_surf_18__113	Distal
			116	xray_rest_surf_18__116	* Unknown
			Custom alignment: LV		
587	xray_rest_surf_2_18 Show the field ONLY if: [rest_no_18] > 1	Second Restoration Surfaces	checkbox, Required		
			111	xray_rest_surf_2_18__111	Mesial
			112	xray_rest_surf_2_18__112	Occlusal (incisal)
			113	xray_rest_surf_2_18__113	Distal
			116	xray_rest_surf_2_18__116	* Unknown
			Custom alignment: LV		

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
588	xray_pin_18 Show the field ONLY if: [xray_treat_18(9)] = '1'	Are there parapulpal pins present	radio 10 Yes 99 No Custom alignment: LV
589	xray_post_18 Show the field ONLY if: [xray_treat_18(2)] = '1'	Is there a post present?	radio 11 Yes 99 No Custom alignment: LV
590	xray_mtl_surf_18 Show the field ONLY if: [xray_treat_18(3)] = '1'	Missing Tooth Structure Surfaces:	checkbox 111 xray_mtl_surf_18__111 Mesial 112 xray_mtl_surf_18__112 Occlusal (incisal) 113 xray_mtl_surf_18__113 Distal 116 xray_mtl_surf_18__116 * Unknown Custom alignment: LV
591	xray_repl_18 Show the field ONLY if: [xray_pres_18] = '1'	Has the missing tooth been replaced?	radio 99 Yes 1 No Custom alignment: LV
592	xray_tth_repl_18 Show the field ONLY if: [xray_repl_18] = '99'	Missing Tooth Replacement	radio 16 Implant 18 Bridge Pontic 99 Denture Tooth Custom alignment: LV
593	xray_repl_impcrown_18 Show the field ONLY if: [xray_tth_repl_18] = '16'	Implant Crown Present	radio 15 Replacement Crown Present 1 No Crown Custom alignment: LV

Instrument: **Chart Entry** (chart_entry) Enabled as survey			
#	**Variable / Field Name**	**Field Label** ***Field Note***	**Field Attributes (Field Type, Validation, Choices, Calculations, etc.)**
967	ch_label	[arm-label] - [instrument-label]	descriptive
968	ch_descriptive	If you know the chart is incomplete, do not enter information of which you are unsure.Third molars charted as missing with no supportive evidence should be left blank (a code of non will be applied) To remove a selection with a round button, click 'reset'To remove a selection with a checkbox, re-click the box	descriptive
969	label_ch_q1		descriptive
970	ch_pres_18	Is the tooth present?	radio 99 Yes 1 No Custom alignment: LV
971	ch_treat_18 Show the field ONLY if: [ch_pres_18] = '99'	Please indicate which dental treatments are present:	checkbox, Required 99 ch_treat_18__99 Restoration 98 ch_treat_18__98 Crown 2 ch_treat_18__2 Root Canal Treatment 4 ch_treat_18__4 No Treatment Visible 5 ch_treat_18__5 Unerupted Custom alignment: LV
972	ch_rest_no_18 Show the field ONLY if: [ch_treat_18(99)] = '1'	How many restorations are present?	text (number), Required Custom alignment: LV
973	ch_rest_mat_18 Show the field ONLY if: [ch_rest_no_18] >0	Restoration material	radio, Required 7 Tooth Coloured 8 Metal Coloured 9 Unknown Custom alignment: LV

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
974	ch_rest_surf_18 Show the field ONLY if: [ch_rest_mat_18] = '7' or [ch_rest_mat_18] = '8' or [ch_rest_mat_18] = '9'	Restoration Surfaces	checkbox, Required 111 ch_rest_surf_18__111 Mesial 112 ch_rest_surf_18__112 Occlusal (Incisal) 113 ch_rest_surf_18__113 Distal 114 ch_rest_surf_18__114 Vestibular (Buccal, Labial) 115 ch_rest_surf_18__115 Lingual (Palatal) 116 ch_rest_surf_18__116 * Unknown Custom alignment: LV
975	ch_rest_mat_2_18 Show the field ONLY if: [ch_rest_no_18] >1 d	Second Restoration material	radio, Required 7 Tooth Coloured 8 Metal Coloured 9 Unknown Custom alignment: LV
976	ch_rest_surf_2_18 Show the field ONLY if: [ch_rest_mat_2_18] = '7' or [ch_rest_mat_2_18] = '8' or [ch_rest_mat_2_18] = '9'	Second Restoration Surfaces	checkbox, Required 111 ch_rest_surf_2_18__111 Mesial 112 ch_rest_surf_2_18__112 Occlusal (Incisal) 113 ch_rest_surf_2_18__113 Distal 114 ch_rest_surf_2_18__114 Vestibular (Buccal, Labial) 115 ch_rest_surf_2_18__115 Lingual (Palatal) 116 ch_rest_surf_2_18__116 * Unknown Custom alignment: LV
977	ch_pin_18 Show the field ONLY if: [ch_treat_18(99)] = '1'	Are there parapulpal pins present	radio 10 Yes 99 No Custom alignment: LV
978	ch_post_18 Show the field ONLY if: [ch_treat_18(2)] = '1'	Is there a post present?	radio 11 Yes 99 No Custom alignment: LV

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
979	ch_crown_18 Show the field ONLY if: [ch_treat_18(98)] = '1'	Crown Material	radio 12 Porcelain/Ceramic Bonded to Metal material 13 Metal coloured material (metal only) 14 Tooth coloured material (no metal) 15 Unknown material Custom alignment: LV
980	ch_repl_18 Show the field ONLY if: [ch_pres_18] = '1'	Has the missing tooth been replaced?	radio 99 Yes 1 No Custom alignment: LV
981	ch_tth_repl_18 Show the field ONLY if: [ch_repl_18] = '99'	Missing Tooth Replacement	radio 16 Implant 17 Bridge Pontic 99 Denture Tooth Custom alignment: LV
982	ch_repl_impcrown_18 Show the field ONLY if: [ch_tth_repl_18] = '16'	Implant Crown Material	radio 12 Porcelain/Ceramic Bonded to Metal material 13 Metal coloured material (metal only) 14 Tooth coloured material (no metal) 15 Unknown material 1 No Crown Custom alignment: LV
983	ch_repl_poncrown_18 Show the field ONLY if: [ch_tth_repl_18] = '17'	Pontic Crown Material	radio 12 Porcelain/Ceramic Bonded to Metal material 13 Metal coloured material (metal only) 14 Tooth coloured material (no metal) 15 Unknown material Custom alignment: LV

Instrument: **No Data** (no_data) Enabled as survey			
#	**Variable / Field Name**	**Field Label** ***Field Note***	**Field Attributes (Field Type, Validation, Choices, Calculations, etc.)**
1422	desc	Section Header: *[arm-label] - [instrument-label]* The following teeth do not have data entered. If no data is available on this tooth please select 'No Information Available'. If data is available please select 'Data Available'. When this form is completed, return to the relevant data entry form and complete for the selected tooth. If no teeth are listed below, all have at least one entry, select submit to continue. To remove a selection with a round button, click 'reset'	descriptive
1423	entered_18	18 Entered	calc Calculation: if(([wr_pres_18][last-instance] = '' and Field Annotation: @HIDDEN
1424	no_data_18 Show the field ONLY if: [entered_18] = '0'	Is there data for tooth 18?	radio 19 No Information Available 99 Data Available
1425	blank_entry_18	Are at least two blank?	calc Calculation: if(([wr_pres_18][last-instance] = '' AND Field Annotation: @HIDDEN

Instrument: **Calculations** (calculations) Enabled as survey			
#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
1520	calc1_18	MAM if wr = mam AND xray = mam RETURN 0 ELSE 1	calc Calculation: if([wr_pres_18][last-instance] = '1' AND [xray_pres_18] = '1', 0,1) Field Annotation: @HIDDEN-SURVEY
1521	calc2_18	MAM if wr = mam AND ch = mam RETURN 0 ELSE 1	calc Calculation: if([wr_pres_18][last-instance] = '1' AND [ch_pres_18] = '1',0,1) Field Annotation: @HIDDEN-SURVEY
1522	calc3_18	MAM if xray = mam AND ch = mam RETURN 0 ELSE 1	calc Calculation: if([ch_pres_18] = '1' AND [xray_pres_18] = '1',0,1) Field Annotation: @HIDDEN-SURVEY
1523	rfxcalc1_18	RFX if wr AND xray indicate rfx RETURN 0 ELSE 1	calc Calculation: if(([wr_treat_18(2)][last-instance] = 1 AND [xray_treat_18(2)]=1), 0,1) Field Annotation: @HIDDEN-SURVEY
1524	rfxcalc2_18	RFX if ch AND xray indicate rfx RETURN 0 ELSE 1	calc Calculation: if(([ch_treat_18(2)] = 1 AND [xray_treat_18(2)]=1), 0,1) Field Annotation: @HIDDEN-SURVEY
1525	rfxcalc3_18	RFX if ch AND wr indicate rfx RETURN 0 ELSE 1	calc Calculation: if(([ch_treat_18(2)] = 1 AND [wr_treat_18(2)][last-instance]=1), 0,1) Field Annotation: @HIDDEN-SURVEY
1526	mtlcalc1_18	MTL if wr = mtl AND xray = mtl RETURN 0 ELSE 1	calc Calculation: if(([wr_treat_18(3)][last-instance] = 1 AND [xray_treat_18(3)]=1), 0,1) Field Annotation: @HIDDEN-SURVEY
1527	precalc1_18	PRE if wr = pre AND xray = pre RETURN 0 ELSE 1	calc Calculation: if(([wr_treat_18(4)][last-instance] = 1 AND [xray_treat_18(4)]=1), 0,1) Field Annotation: @HIDDEN-SURVEY
1528	precalc2_18	PRE if ch = pre AND xray = pre RETURN 0 ELSE 1	calc Calculation: if(([ch_treat_18(4)] = 1 AND [xray_treat_18(4)]=1), 0,1) Field Annotation: @HIDDEN-SURVEY
1529	precalc3_18	PRE if wr = pre AND ch = pre RETURN 0 ELSE 1	calc Calculation: if(([ch_treat_18(4)] = 1 AND [wr_treat_18(4)][last-instance]=1), 0,1) Field Annotation: @HIDDEN-SURVEY

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
1530	unecalc1_18	UNE	calc Calculation: if([wr_treat_18(5)][last-instance]='1' AND [xray_treat_18(5)]='1', 0 ,1) Field Annotation: @HIDDEN-SURVEY
1531	unecalc2_18	UNE	calc Calculation: if([wr_treat_18(5)][last-instance]='1' AND [ch_treat_18(5)]='1', 0 ,1) Field Annotation: @HIDDEN-SURVEY
1532	unecalc3_18	UNE	calc Calculation: if([ch_treat_18(5)]='1' AND [xray_treat_18(5)]='1', 0 ,1) Field Annotation: @HIDDEN-SURVEY
1533	rovcalc_18	ROV if wr = rov AND xray = rov RETURN 0 ELSE 1	calc Calculation: if(([wr_treat_18(6)][last-instance] = 1 AND [xray_treat_18(6)]=1), 0,1) Field Annotation: @HIDDEN-SURVEY
1534	matcalc1_18	RESTORATION ONE MATERIAL if wr1 material = ch1 material OR ch2 material RETURN 0 ELSE 1	calc Calculation: if(([wr_rest_mat_18][last-instance] = [ch_rest_mat_18]) OR ([wr_rest_mat_18][last-instance] = [ch_rest_mat_2_18]),0,1) Field Annotation: @HIDDEN-SURVEY
1535	matcalc2_18	RESTORATION ONE MATERIAL if wr1 material = uif AND xray1 OR xray2 = rest RETURN 0 ELSE 1	calc Calculation: if(([wr_rest_mat_18][last-instance] = 9 AND [xray_treat_18(9)]=1) OR ([wr_rest_mat_18][last-instance] = 9 AND [rest_no_18]>1),0,1) Field Annotation: @HIDDEN-SURVEY
1536	matcalc3_18	RESTORATION ONE MATERIAL if ch material = uif AND xray1 OR xray2 = rest RETURN 0 ELSE 1	calc Calculation: if(([ch_rest_mat_18]= 9 AND [xray_treat_18(9)]=1) OR ([ch_rest_mat_18]= 9 AND [rest_no_18]>1),0,1) Field Annotation: @HIDDEN-SURVEY
1537	mat2calc1_18	RESTORATION TWO MATERIAL if wr2 material = ch1 material OR ch2 material RETURN 0 ELSE 1	calc Calculation: if(([wr_rest_mat_2_18][last-instance] = [ch_rest_mat_18]) OR ([wr_rest_mat_2_18][last-instance] = [ch_rest_mat_2_18]),0,1) Field Annotation: @HIDDEN-SURVEY
1538	mat2calc2_18	RESTORATION TWO MATERIAL if wr2 material = uif AND xray1 OR xray2 = rest RETURN 0 ELSE 1	calc Calculation: if(([wr_rest_mat_2_18][last-instance] =9 AND [xray_treat_18(9)]=1) OR ([wr_rest_mat_2_18][last-instance] =9 AND [rest_no_18]>1),0,1) Field Annotation: @HIDDEN-SURVEY

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
1539	mat2calc3_18	RESTORATION TWO MATERIAL	calc
		if ch2 material = uif AND xray1 OR xray2 = rest RETURN 0 ELSE 1	Calculation: if(([ch_rest_mat_2_18]= 9 AND [xray_treat_18(9)]=1) OR ([ch_rest_mat_2_18]= 9 AND [rest_no_18]>1),0,1)
			Field Annotation: @HIDDEN-SURVEY
1540	mcalc_18	RESTORATION SURFACES M	calc
		if wr AND ch surfaces (M) RETURN 0 ELSE 1	Calculation: if(([wr_rest_surf_18(111)][last-instance] = '1' AND [ch_rest_surf_18(111)] = '1') OR ([wr_rest_surf_2_18(111)][last-instance] = '1' AND [ch_rest_surf_2_18(111)] = '1') OR ([wr_rest_surf_18(111)][last-instance] = '1' AND [ch_rest_surf_2_18(111)] = '1') OR ([wr_rest_surf_2_18(111)][last-instance] = '1' AND [ch_rest_surf_18(111)] = '1') ,0,1)
		(compares all restorations to each other)	Field Annotation: @HIDDEN-SURVEY
1541	ocalc_18	RESTORATION SURFACES O	calc
		if wr AND ch surfaces (O) RETURN 0 ELSE 1	Calculation: if(([wr_rest_surf_18(112)][last-instance] = '1' AND [ch_rest_surf_18(112)] = '1') OR ([wr_rest_surf_2_18(112)][last-instance] = '1' AND [ch_rest_surf_2_18(112)] = '1') OR ([wr_rest_surf_18(112)][last-instance] = '1' AND [ch_rest_surf_2_18(112)] = '1') OR ([wr_rest_surf_2_18(112)][last-instance] = '1' AND [ch_rest_surf_18(112)] = '1') ,0,1)
		(compares all restorations to each other)	Field Annotation: @HIDDEN-SURVEY
1542	dcalc_18	RESTORATION SURFACES D	calc
		if wr AND ch surfaces (D) RETURN 0 ELSE 1	Calculation: if(([wr_rest_surf_18(113)][last-instance] = '1' AND [ch_rest_surf_18(113)] = '1') OR ([wr_rest_surf_2_18(113)][last-instance] = '1' AND [ch_rest_surf_2_18(113)] = '1') OR ([wr_rest_surf_18(113)][last-instance] = '1' AND [ch_rest_surf_2_18(113)] = '1') OR ([wr_rest_surf_2_18(113)][last-instance] = '1' AND [ch_rest_surf_18(113)] = '1') ,0,1)
		(compares all restorations to each other)	Field Annotation: @HIDDEN-SURVEY
1543	vcalc_18	RESTORATION SURFACES V	calc
		if wr AND ch surfaces (V) RETURN 0 ELSE 1	Calculation: if(([wr_rest_surf_18(114)][last-instance] = '1' AND [ch_rest_surf_18(114)] = '1') OR ([wr_rest_surf_2_18(114)][last-instance] = '1' AND [ch_rest_surf_2_18(114)] = '1') OR ([wr_rest_surf_18(114)][last-instance] = '1' AND [ch_rest_surf_2_18(114)] = '1') OR ([wr_rest_surf_2_18(114)][last-instance] = '1' AND [ch_rest_surf_18(114)] = '1') ,0,1)
		(compares all restorations to each other)	Field Annotation: @HIDDEN-SURVEY
1544	lcalc_18	RESTORATION SURFACES L	calc
		if wr AND ch surfaces (L) RETURN 0 ELSE 1	Calculation: if(([wr_rest_surf_18(115)][last-instance] = '1' AND [ch_rest_surf_18(115)] = '1') OR ([wr_rest_surf_2_18(115)][last-instance] = '1' AND [ch_rest_surf_2_18(115)] = '1') OR ([wr_rest_surf_18(115)][last-instance] = '1' AND [ch_rest_surf_2_18(115)] = '1') OR ([wr_rest_surf_2_18(115)][last-instance] = '1' AND [ch_rest_surf_18(115)] = '1') ,0,1)
		(compares all restorations to each other)	Field Annotation: @HIDDEN-SURVEY

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
1545	ucalc_18	RESTORATION SURFACES U*	calc
		if wr AND ch surfaces (U*) RETURN 0 ELSE 1	Calculation: if(([wr_rest_surf_18(116)][last-instance] = '1' AND [ch_rest_surf_18(116)] = '1') OR ([wr_rest_surf_2_18(116)][last-instance] = '1' AND [ch_rest_surf_2_18(116)] = '1') OR ([wr_rest_surf_18(116)][last-instance] = '1' AND [ch_rest_surf_2_18(116)] = '1') OR ([wr_rest_surf_2_18(116)][last-instance] = '1' AND [ch_rest_surf_18(116)] = '1') ,0,1)
		(compares all restorations to each other)	Field Annotation: @HIDDEN-SURVEY
1546	pincalc1_18	PPX	calc
		if wr = xray RETURN 0 ELSE 1	Calculation: if([wr_pin_18][last-instance] = [xray_pin_18], 0, 1)
			Field Annotation: @HIDDEN-SURVEY
1547	pincalc2_18	PPX	calc
		if wr = ch RETURN 0 ELSE 1	Calculation: if([wr_pin_18][last-instance] = [ch_pin_18], 0, 1)
			Field Annotation: @HIDDEN-SURVEY
1548	pincalc3_18	PPX	calc
		if xray = ch RETURN 0 ELSE 1	Calculation: if([ch_pin_18] = [xray_pin_18], 0, 1)
			Field Annotation: @HIDDEN-SURVEY
1549	postcalc1_18	POX	calc
		if wr = xray RETURN 0 ELSE 1	Calculation: if([wr_post_18][last-instance] = [xray_post_18], 0, 1)
			Field Annotation: @HIDDEN-SURVEY
1550	postcalc2_18	POX	calc
		if wr = ch RETURN 0 ELSE 1	Calculation: if([wr_post_18][last-instance] = [ch_post_18], 0, 1)
			Field Annotation: @HIDDEN-SURVEY
1551	postcalc3_18	POX	calc
		if xray = ch RETURN 0 ELSE 1	Calculation: if([ch_post_18] = [xray_post_18], 0, 1)
			Field Annotation: @HIDDEN-SURVEY
1552	crowncalc1_18	CROWN	calc
		if wr crown is uif and xray is uif RETURN 0 ELSE 1	Calculation: if([wr_crown_18][last-instance] = '15' AND [xray_treat_18(15)] = '1',0,1)
			Field Annotation: @HIDDEN-SURVEY
1553	crowncalc2_18	CROWN	calc
		if ch crown material = wr crown material RETURN 0 ELSE 1	Calculation: if(([wr_crown_18][last-instance] = [ch_crown_18]),0,1)
			Field Annotation: @HIDDEN-SURVEY

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
1554	crowncalc3_18	CROWN if ch crown is uif and xray is uif RETURN 0 ELSE 1	calc Calculation: if([ch_crown_18] = '15' AND [xray_treat_18(15)] = '1',0,1) Field Annotation: @HIDDEN-SURVEY
1555	impcalc_18	IMX if wr AND xray indicate imx RETURN 0 ELSE 1	calc Calculation: if([wr_tth_repl_18][last-instance] = [xray_tth_repl_18],0,1) Field Annotation: @HIDDEN-SURVEY
1556	impcalc_2_18	IMX if wr AND ch indicate imx RETURN 0 ELSE 1	calc Calculation: if([wr_tth_repl_18][last-instance] = [ch_tth_repl_18],0,1) Field Annotation: @HIDDEN-SURVEY
1557	impcalc_3_18	IMX if xray AND ch indicate imx RETURN 0 ELSE 1	calc Calculation: if([xray_tth_repl_18] = [ch_tth_repl_18],0,1) Field Annotation: @HIDDEN-SURVEY
1558	poncalc_18	PON if wr = uic AND xray = uic RETURN 0 ELSE 1	calc Calculation: if([wr_tth_repl_18][last-instance] = '17' AND [xray_tth_repl_18] = '18',0,1) Field Annotation: @HIDDEN-SURVEY
1559	poncalc_2_18	PON if wr AND ch indicate pon RETURN 0 ELSE 1	calc Calculation: if([wr_tth_repl_18][last-instance] = [ch_tth_repl_18],0,1) Field Annotation: @HIDDEN-SURVEY
1560	poncalc_3_18	PON if xray AND ch indicate pon RETURN 0 ELSE 1	calc Calculation: if([xray_tth_repl_18] = '18' AND [ch_tth_repl_18] = '17',0,1) Field Annotation: @HIDDEN-SURVEY
1561	impcrowncalc_18	IMX CROWN AND wr indicates imx crown if ch imx crown material = wr imx crown material RETURN 0 ELSE 1	calc Calculation: if(([wr_repl_impcrown_18][last-instance] = [ch_repl_impcrown_18]),0,1) Field Annotation: @HIDDEN-SURVEY
1562	poncrowncalc_18	PON CROWN if ch pon crown material = wr pon crown material RETURN 0 ELSE 1	calc Calculation: if(([wr_repl_impcrown_18][last-instance] = [ch_repl_impcrown_18]),0,1) Field Annotation: @HIDDEN-SURVEY

Instrument: **Multiple Codes** (multiple_codes) Enabled as survey			
#	**Variable / Field Name**	**Field Label** ***Field Note***	**Field Attributes (Field Type, Validation, Choices, Calculations, etc.)**
2897	desc2	Section Header: *[arm-label] - [instrument-label]* The following teeth have multiple codes associated with them. Ensure there are no conflicting codes or past treatment that has been replaced. Please selects all codes you wish to keep. To remove a selection with a round button, click 'reset'To remove a selection with a	descriptive
2898	mc_table_18 Show the field ONLY if: [blank_entry_18] = '1'		descriptive
2899	mc_mam_18 Show the field ONLY if: ((([calc1_18] = '0' AND [ch_pres_18] = '99') OR ([calc2_18] = '0' AND [xray_pres_18] = '99') OR ([calc3_18] = '0' AND [wr_pres_18][last-instance] = '99')) OR ((([wr_pres_18][last-instance] <> '1' AND [xray_pres_18] <> '1' AND [ch_pres_18] = '1') OR ([wr_pres_18][last-instance] <> '1' AND [xray_pres_18] = '1' AND [ch_pres_18] <> '1') OR ([wr_pres_18][last-instance] = '1' AND [xray_pres_18] <> '1' AND [ch_pres_18] <> '1')) OR ((([wr_pres_18][last-instance]='' OR [xray_pres_18]='' OR [ch_pres_18]='') AND ([wr_pres_18][last-instance]='1' OR [xray_pres_18]='1' OR [ch_pres_18]='1') AND ([calc1_18] = '1' AND [calc2_18]='1' AND [calc3_18]='1'))	mam	radio 1 mam
2900	mc_rfx_18 Show the field ONLY if: [blank_entry_18] = '1' AND ([rfxcalc1_18] = '1' OR [rfxcalc2_18] = '1' OR [rfxcalc3_18] = '1') AND ([wr_treat_18(2)][last-instance] = '1' OR [xray_treat_18(2)] = '1' OR [ch_treat_18(2)] = '1')	rfx	radio 2 rfx
2901	mc_mtl_18 Show the field ONLY if: [mtlcalc1_18] = '1' AND ([wr_treat_18(3)][last-instance] = '1') OR ([xray_treat_18(3)] = '1')	mtl	radio 3 mtl

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2902	mc_pre_18 Show the field ONLY if: ((([precalc1_18] = '0' AND [ch_pres_18] = '1') OR ([precalc2_18] = '0' AND [xray_pres_18] = '1') OR ([precalc3_18] = '0' AND [wr_pres_18][last-instance] = '1')) OR (([wr_treat_18(4)][last-instance] <> '1' AND [xray_treat_18(4)] <> '1' AND [ch_treat_18(4)] = '1') OR ([wr_treat_18(4)][last-instance] <> '1' AND [xray_treat_18(4)] = '1' AND [ch_treat_18(4)] <> '1') OR ([wr_treat_18(4)][last-instance] = '1' AND [xray_treat_18(4)] <> '1' AND [ch_treat_18(4)] <> '1')) OR ((([wr_pres_18][last-instance]='' OR [xray_pres_18]='' OR [ch_pres_18]='') AND ([wr_treat_18(4)][last-instance] = '1' OR [xray_treat_18(4)]='1' OR [ch_treat_18(4)]='1') AND ([precalc1_18] = '1' AND [precalc2_18]='1' AND [precalc3_18]='1'))	pre	radio 4 pre
2903	mc_une_18 Show the field ONLY if: [blank_entry_18] = '1' AND ([unecalc1_18] = '1' OR [unecalc2_18] = '1' OR [unecalc3_18] = '1') AND ([wr_treat_18(5)][last-instance] = '1' OR [xray_treat_18(5)] = '1' OR [ch_treat_18(5)] = '1')	une	radio 5 une
2904	mc_rov_18 Show the field ONLY if: [rovcalc_18] = '1' AND ([wr_treat_18(6)][last-instance] = '1' OR [xray_treat_18(6)] = '1')	rov	radio 6 rov
2905	mc_tcf_18 Show the field ONLY if: [blank_entry_18]='1' AND (([wr_rest_mat_18][last-instance] = '7' OR [ch_rest_mat_18] = '7') AND ([matcalc1_18] = '1' OR [matcalc2_18] = '1' OR [matcalc3_18] = '1')) OR (([wr_rest_mat_2_18][last-instance] = '7' OR [ch_rest_mat_2_18] = '7') AND ([mat2calc1_18] = '1' OR [mat2calc2_18] = '1' OR [mat2calc3_18] = '1'))	tcf	radio 7 tcf
2906	mc_mcf_18 Show the field ONLY if: [blank_entry_18]='1' AND (([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18] = '8') AND ([matcalc1_18] = '1' OR [matcalc2_18] = '1' OR [matcalc3_18] = '1')) OR (([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18] = '8') AND ([mat2calc1_18] = '1' OR [matcalc2_18] = '1' OR [matcalc3_18] = '1'))	mcf	radio 8 mcf
2907	mc_uif_18 Show the field ONLY if: [blank_entry_18]='1' AND (([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18] = '9' OR [xray_treat_18(9)] = '1') AND ([matcalc1_18] = '1' OR [matcalc2_18] = '1' OR [matcalc3_18] = '1')) OR (([wr_rest_mat_2_18][last-instance] = '9' OR [ch_rest_mat_2_18] = '9' OR ([xray_treat_18(9)] = '1' AND [rest_no_18]>1)) AND ([mat2calc1_18] = '1' OR [mat2calc2_18] = '1' OR [mat2calc3_18] = '1'))	uif	radio 9 uif
2908	mc_ppx_18 Show the field ONLY if: ([wr_pin_18][last-instance] = '10' OR [xray_pin_18] = '10' OR [ch_pin_18] = '10') AND ([pincalc1_18] = '1' OR [pincalc2_18] = '1' OR [pincalc3_18] = '1')	ppx	radio 10 ppx

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2909	mc_pox_18 Show the field ONLY if: ([wr_post_18][last-instance] = '11' OR [xray_post_18] = '11' OR [ch_post_18] = '11') AND ([postcalc1_18] = '1' OR [postcalc2_18] = '1' OR [postcalc3_18] = '1')	pox	radio 11 pox
2910	mc_mcc_18 Show the field ONLY if: ([wr_crown_18][last-instance] = '12' OR [ch_crown_18] = '12') AND [crowncalc2_18] = '1'	mcc	radio 12 mcc
2911	mc_mcc_2_18 Show the field ONLY if: ([wr_repl_impcrown_18][last-instance] = '12' OR [ch_repl_impcrown_18] = '12') AND [impcrowncalc_18] = '1'	mcc implant	radio 12 mcc
2912	mc_mcc_3_18 Show the field ONLY if: ([wr_repl_poncrown_18][last-instance] = '12' OR [ch_repl_poncrown_18] = '12') AND [poncrowncalc_18] = '1'	mcc pon	radio 12 mcc
2913	mc_mtc_18 Show the field ONLY if: ([wr_crown_18][last-instance] = '13' OR [ch_crown_18] = '13') AND [crowncalc2_18] = '1'	mtc	radio 13 mtc
2914	mc_mtc_2_18 Show the field ONLY if: ([wr_repl_impcrown_18][last-instance] = '13' OR [ch_repl_impcrown_18] = '13') AND [impcrowncalc2_18] = '1'	mtc implant	radio 13 mtc
2915	mc_mtc_3_18 Show the field ONLY if: ([wr_repl_poncrown_18][last-instance] = '13' OR [ch_repl_poncrown_18] = '13') AND [poncrowncalc_18] = '1'	mtc pon	radio 13 mtc
2916	mc_tcc_18 Show the field ONLY if: ([wr_crown_18][last-instance] = '14' OR [ch_crown_18] = '14') AND [crowncalc2_18] = '1'	tcc	radio 14 tcc
2917	mc_tcc_2_18 Show the field ONLY if: ([wr_repl_impcrown_18][last-instance] = '14' OR [ch_repl_impcrown_18] = '14') AND [impcrowncalc_18] = '1'	tcc implant	radio 14 tcc
2918	mc_tcc_3_18 Show the field ONLY if: ([wr_repl_poncrown_18][last-instance] = '14' OR [ch_repl_poncrown_18] = '14') AND [poncrowncalc_18] = '1'	tcc pon	radio 14 tcc

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2919	mc_uic_18 Show the field ONLY if: ([wr_crown_18][last-instance] = '15' OR [ch_crown_18] = '15' OR [xray_treat_18(15)] = '1') AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	uic	radio 15 uic
2920	mc_uic_2_18 Show the field ONLY if: ([wr_repl_impcrown_18][last-instance] = '15' OR [xray_repl_impcrown_18] = '15' OR [ch_repl_impcrown_18] = '15') AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	uic implant	radio 15 uic
2921	mc_uic_3_18 Show the field ONLY if: ([wr_repl_poncrown_18][last-instance] = '15' OR [xray_tth_repl_18]='18' OR [ch_repl_poncrown_18] = '15') AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	uic pon	radio 15 uic
2922	mc_imx_18 Show the field ONLY if: ([wr_tth_repl_18] = '16' OR [xray_tth_repl_18] = '16' OR [ch_tth_repl_18] = '16') AND ([impcalc_18] = '1' OR [impcalc_2_18] = '1' OR [impcalc_3_18] = '1')	imx	radio 16 imx
2923	mc_imx_nocrown_18 Show the field ONLY if: ([wr_tth_repl_18][last-instance] = '16' OR [xray_tth_repl_18] = '16' OR [ch_tth_repl_18] = '16') AND ([wr_tth_repl_18][last-instance] != [xray_tth_repl_18] OR [xray_tth_repl_18] != [ch_tth_repl_18] OR [ch_tth_repl_18] != [wr_tth_repl_18][last-instance]) AND ([wr_repl_impcrown_18]='1' OR [xray_repl_impcrown_18] = '1' OR [ch_repl_impcrown_18] = '1')	imx - no crown	radio 1 No Crown
2924	mc_pon_18 Show the field ONLY if: ([wr_tth_repl_18] = '17' OR [xray_tth_repl_18]= '18' OR [ch_tth_repl_18]= '17') AND ([poncalc_18] = '1' OR [poncalc_2_18] = '1' OR [poncalc_3_18] = '1')	pon	radio 17 pon
2925	mc_pon_uic_18 Show the field ONLY if: [xray_tth_repl_18] = '18' AND (([ch_tth_repl_18] = '17' AND [ch_repl_poncrown_18] != '15') OR ([wr_tth_repl_18][last-instance] = '17' AND [wr_repl_poncrown_18][last-instance] != '15'))	pon uic	radio 18 pon uic

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2926	mc_surf_tcf_all_18 Show the field ONLY if: ([wr_rest_mat_18][last-instance] = '7' OR [ch_rest_mat_18] = '7' OR [wr_rest_mat_2_18][last-instance] = '7' OR [ch_rest_mat_2_18] = '7') AND ([mcalc_18]='0' AND [ocalc_18]='0' AND [dcalc_18]='0' AND [vcalc_18]='0' AND [lcalc_18]='0' AND [ucalc_18]='0')	tcf all surfaces	checkbox 111 mc_surf_tcf_all_18__111 Mesial 112 mc_surf_tcf_all_18__112 Occlusal (Incisal) 113 mc_surf_tcf_all_18__113 Distal 114 mc_surf_tcf_all_18__114 Vestibular (Buccal, Labial) 115 mc_surf_tcf_all_18__115 Lingual (Palatal) 116 mc_surf_tcf_all_18__116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_18:checked:value][last-instance]'
2927	mc_surf_tcf_all_2_18 Show the field ONLY if: ([wr_rest_mat_2_18][last-instance] = '7' OR [ch_rest_mat_2_18] = '7') AND [mat2calc1_18] = '0' AND ([mcalc_18]='0' AND [ocalc_18]='0' AND [dcalc_18]='0' AND [vcalc_18]='0' AND [lcalc_18]='0' AND [ucalc_18]='0')	tcf all surfaces 2	checkbox 111 mc_surf_tcf_all_2_18__111 Mesial 112 mc_surf_tcf_all_2_18__112 Occlusal (Incisal) 113 mc_surf_tcf_all_2_18__113 Distal 114 mc_surf_tcf_all_2_18__114 Vestibular (Buccal, Labial) 115 mc_surf_tcf_all_2_18__115 Lingual (Palatal) 116 mc_surf_tcf_all_2_18__116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_2_18:checked:value][last-instance]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2928	mc_surf_mcf_all_18 Show the field ONLY if: ([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18] = '8') AND [matcalc1_18] = '0' AND ([mcalc_18]='0' AND [ocalc_18]='0' AND [dcalc_18]='0' AND [vcalc_18]='0' AND [lcalc_18]='0' AND [ucalc_18]='0')	mcf all surfaces	checkbox 111 mc_surf_mcf_all_18__111 Mesial 112 mc_surf_mcf_all_18__112 Occlusal (Incisal) 113 mc_surf_mcf_all_18__113 Distal 114 mc_surf_mcf_all_18__114 Vestibular (Buccal, Labial) 115 mc_surf_mcf_all_18__115 Lingual (Palatal) 116 mc_surf_mcf_all_18__116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_18:checked:value][last-instance]'
2929	mc_surf_mcf_all_2_18 Show the field ONLY if: ([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18] = '8') AND [mat2calc1_18] = '0' AND ([mcalc_18]='0' AND [ocalc_18]='0' AND [dcalc_18]='0' AND [vcalc_18]='0' AND [lcalc_18]='0' AND [ucalc_18]='0')	mcf all surfaces 2	checkbox 111 mc_surf_mcf_all_2_18__111 Mesial 112 mc_surf_mcf_all_2_18__112 Occlusal (Incisal) 113 mc_surf_mcf_all_2_18__113 Distal 114 mc_surf_mcf_all_2_18__114 Vestibular (Buccal, Labial) 115 mc_surf_mcf_all_2_18__115 Lingual (Palatal) 116 mc_surf_mcf_all_2_18__116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_2_18:checked:value][last-instance]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2930	mc_surf_uif_all_18 Show the field ONLY if: ([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18]='9') AND ([mcalc_18]='0' AND [ocalc_18]='0' AND [dcalc_18]='0' AND [vcalc_18]='0' AND [lcalc_18]='0' AND [ucalc_18]='0')	uif all surfaces	checkbox 111 mc_surf_uif_all_18__111 Mesial 112 mc_surf_uif_all_18__112 Occlusal (Incisal) 113 mc_surf_uif_all_18__113 Distal 114 mc_surf_uif_all_18__114 Vestibular (Buccal, Labial) 115 mc_surf_uif_all_18__115 Lingual (Palatal) 116 mc_surf_uif_all_18__116 * Unknown Surfaces Field Annotation: @DEFAULT='[wr_rest_surf_18:checked:value][last-instance]'
2931	mc_surf_uif_all_2_18 Show the field ONLY if: ([wr_rest_mat_2_18][last-instance] = '9' AND [ch_rest_mat_2_18] = '9') AND ([mcalc_18]='0' AND [ocalc_18]='0' AND [dcalc_18]='0' AND [vcalc_18]='0' AND [lcalc_18]='0' AND [ucalc_18]='0')	uif all surfaces 2	checkbox 111 mc_surf_uif_all_2_18__111 Mesial 112 mc_surf_uif_all_2_18__112 Occlusal (Incisal) 113 mc_surf_uif_all_2_18__113 Distal 114 mc_surf_uif_all_2_18__114 Vestibular (Buccal, Labial) 115 mc_surf_uif_all_2_18__115 Lingual (Palatal) 116 mc_surf_uif_all_2_18__116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_2_18:checked:value][last-instance]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2932	mc_surfaces_wr1_18 Show the field ONLY if: [blank_entry_18] = '1' AND ([wr_rest_mat_18][last-instance] = '7') AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	WR Surfaces tcf 1	checkbox 111 mc_surfaces_wr1_18___111 Mesial 112 mc_surfaces_wr1_18___112 Occlusal (Incisal) 113 mc_surfaces_wr1_18___113 Distal 114 mc_surfaces_wr1_18___114 Vestibular (Buccal, Labial) 115 mc_surfaces_wr1_18___115 Lingual (Palatal) 116 mc_surfaces_wr1_18___116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_18:checked:value][last-instance]'
2933	mc_surfaces_wr2_18 Show the field ONLY if: [blank_entry_18]='1' AND [wr_rest_mat_2_18][last-instance] = '7' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	WR Surfaces tcf 2	checkbox 111 mc_surfaces_wr2_18___111 Mesial 112 mc_surfaces_wr2_18___112 Occlusal (Incisal) 113 mc_surfaces_wr2_18___113 Distal 114 mc_surfaces_wr2_18___114 Vestibular (Buccal, Labial) 115 mc_surfaces_wr2_18___115 Lingual (Palatal) 116 mc_surfaces_wr2_18___116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_2_18:checked:value][last-instance]'
2934	mc_surfaces_wr3_18 Show the field ONLY if: [blank_entry_18]='1' AND [wr_rest_mat_18][last-instance] = '8' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	WR Surfaces mcf 1	checkbox 111 mc_surfaces_wr3_18___111 Mesial 112 mc_surfaces_wr3_18___112 Occlusal (Incisal) 113 mc_surfaces_wr3_18___113 Distal 114 mc_surfaces_wr3_18___114 Vestibular (Buccal, Labial) 115 mc_surfaces_wr3_18___115 Lingual (Palatal) 116 mc_surfaces_wr3_18___116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_18:checked:value][last-instance]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2935	mc_surfaces_wr4_18 Show the field ONLY if: [blank_entry_18]='1' AND [wr_rest_mat_2_18][last-instance] = '8' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	WR Surfaces mcf 2	checkbox 111 mc_surfaces_wr4_18__111 Mesial 112 mc_surfaces_wr4_18__112 Occlusal (Incisal) 113 mc_surfaces_wr4_18__113 Distal 114 mc_surfaces_wr4_18__114 Vestibular (Buccal, Labial) 115 mc_surfaces_wr4_18__115 Lingual (Palatal) 116 mc_surfaces_wr4_18__116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_2_18:checked:value][last-instance]'
2936	mc_surfaces_wr5_18 Show the field ONLY if: [blank_entry_18]='1' AND [wr_rest_mat_18][last-instance] = '9' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	WR Surfaces uif 1	checkbox 111 mc_surfaces_wr5_18__111 Mesial 112 mc_surfaces_wr5_18__112 Occlusal (Incisal) 113 mc_surfaces_wr5_18__113 Distal 114 mc_surfaces_wr5_18__114 Vestibular (Buccal, Labial) 115 mc_surfaces_wr5_18__115 Lingual (Palatal) 116 mc_surfaces_wr5_18__116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_18:checked:value][last-instance]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2937	mc_surfaces_wr6_18 Show the field ONLY if: [blank_entry_18]='1' AND [wr_rest_mat_2_18][last-instance] = '9' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	WR Surfaces uif 2	checkbox 111 mc_surfaces_wr6_18__111 Mesial 112 mc_surfaces_wr6_18__112 Occlusal (Incisal) 113 mc_surfaces_wr6_18__113 Distal 114 mc_surfaces_wr6_18__114 Vestibular (Buccal, Labial) 115 mc_surfaces_wr6_18__115 Lingual (Palatal) 116 mc_surfaces_wr6_18__116 * Unknown Field Annotation: @DEFAULT='[wr_rest_surf_2_18:checked:value][last-instance]'
2938	mc_surfaces_xray1_18 Show the field ONLY if: [blank_entry_18] = '1' AND [xray_treat_18(9)] = '1'	Xray Surfaces 1	checkbox 111 mc_surfaces_xray1_18__111 Mesial 112 mc_surfaces_xray1_18__112 Occlusal (Incisal) 113 mc_surfaces_xray1_18__113 Distal 116 mc_surfaces_xray1_18__116 * Unknown Field Annotation: @DEFAULT='[xray_rest_surf_18:checked:value]'
2939	mc_surfaces_xray2_18 Show the field ONLY if: [blank_entry_18] = '1' AND [xray_treat_18(9)] = '1' AND [rest_no_18]>1	Xray Surfaces 2	checkbox 111 mc_surfaces_xray2_18__111 Mesial 112 mc_surfaces_xray2_18__112 Occlusal (Incisal) 113 mc_surfaces_xray2_18__113 Distal 116 mc_surfaces_xray2_18__116 * Unknown Field Annotation: @DEFAULT='[xray_rest_surf_2_18:checked:value]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2940	mc_surfaces_ch1_18 Show the field ONLY if: [blank_entry_18]='1' AND [ch_rest_mat_18] = '7' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	Chart Surfaces tcf 1	checkbox 111 mc_surfaces_ch1_18__111 Mesial 112 mc_surfaces_ch1_18__112 Occlusal (Incisal) 113 mc_surfaces_ch1_18__113 Distal 114 mc_surfaces_ch1_18__114 Vestibular (Buccal, Labial) 115 mc_surfaces_ch1_18__115 Lingual (Palatal) 116 mc_surfaces_ch1_18__116 * Unknown Field Annotation: @DEFAULT='[ch_rest_surf_18:checked:value]'
2941	mc_surfaces_ch2_18 Show the field ONLY if: [blank_entry_18] = '1' AND [ch_rest_mat_2_18] = '7' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	Chart Surfaces tcf 2	checkbox 111 mc_surfaces_ch2_18__111 Mesial 112 mc_surfaces_ch2_18__112 Occlusal (Incisal) 113 mc_surfaces_ch2_18__113 Distal 114 mc_surfaces_ch2_18__114 Vestibular (Buccal, Labial) 115 mc_surfaces_ch2_18__115 Lingual (Palatal) 116 mc_surfaces_ch2_18__116 * Unknown Field Annotation: @DEFAULT='[ch_rest_surf_2_18:checked:value]'
2942	mc_surfaces_ch3_18 Show the field ONLY if: [blank_entry_18]='1' AND [ch_rest_mat_18] = '8' AND ([matcalc1_18] = '1' OR [matcalc2_18] = '1' OR [matcalc3_18] = '1')	Chart Surfaces mcf1	checkbox 111 mc_surfaces_ch3_18__111 Mesial 112 mc_surfaces_ch3_18__112 Occlusal (Incisal) 113 mc_surfaces_ch3_18__113 Distal 114 mc_surfaces_ch3_18__114 Vestibular (Buccal, Labial) 115 mc_surfaces_ch3_18__115 Lingual (Palatal) 116 mc_surfaces_ch3_18__116 * Unknown Field Annotation: @DEFAULT='[ch_rest_surf_18:checked:value]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2943	mc_surfaces_ch4_18 Show the field ONLY if: [blank_entry_18]='1' AND [ch_rest_mat_2_18] = '8' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	Chart Surfaces mcf 2	checkbox 111 mc_surfaces_ch4_18__111 Mesial 112 mc_surfaces_ch4_18__112 Occlusal (Incisal) 113 mc_surfaces_ch4_18__113 Distal 114 mc_surfaces_ch4_18__114 Vestibular (Buccal, Labial) 115 mc_surfaces_ch4_18__115 Lingual (Palatal) 116 mc_surfaces_ch4_18__116 * Unknown Field Annotation: @DEFAULT='[ch_rest_surf_2_18:checked:value]'
2944	mc_surfaces_ch5_18 Show the field ONLY if: [blank_entry_18]='1' AND [ch_rest_mat_18] = '9' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	Chart Surfaces uif 1	checkbox 111 mc_surfaces_ch5_18__111 Mesial 112 mc_surfaces_ch5_18__112 Occlusal (Incisal) 113 mc_surfaces_ch5_18__113 Distal 114 mc_surfaces_ch5_18__114 Vestibular (Buccal, Labial) 115 mc_surfaces_ch5_18__115 Lingual (Palatal) 116 mc_surfaces_ch5_18__116 * Unknown Field Annotation: @DEFAULT='[ch_rest_surf_18:checked:value]'
2945	mc_surfaces_ch6_18 Show the field ONLY if: [blank_entry_18]='1' AND [ch_rest_mat_2_18] = '9' AND ([mcalc_18]='1' OR [ocalc_18]='1' OR [dcalc_18]='1' OR [vcalc_18]='1' OR [lcalc_18]='1' OR [ucalc_18]='1')	Chart Surfaces uif 2	checkbox 111 mc_surfaces_ch6_18__111 Mesial 112 mc_surfaces_ch6_18__112 Occlusal (Incisal) 113 mc_surfaces_ch6_18__113 Distal 114 mc_surfaces_ch6_18__114 Vestibular (Buccal, Labial) 115 mc_surfaces_ch6_18__115 Lingual (Palatal) 116 mc_surfaces_ch6_18__116 * Unknown Field Annotation: @DEFAULT='[ch_rest_surf_2_18:checked:value]'

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2946	mc_surfaces_mtl_wr_18 Show the field ONLY if: [blank_entry_18] = '1' AND [wr_treat_18(3)][last-instance]='1'	mtl Surfaces wr	checkbox 111 mc_surfaces_mtl_wr_18___111 Mesial 112 mc_surfaces_mtl_wr_18___112 Occlusal (Incisal) 113 mc_surfaces_mtl_wr_18___113 Distal 114 mc_surfaces_mtl_wr_18___114 Vestibular (Buccal, Labial) 115 mc_surfaces_mtl_wr_18___115 Lingual (Palatal) 116 mc_surfaces_mtl_wr_18___116 * Unknown Surfaces Field Annotation: @DEFAULT='[wr_mtl_surf_18:checked:value][last-
2947	mc_surfaces_mtl_xray_18 Show the field ONLY if: [blank_entry_18] = '1' AND [xray_treat_18(3)]='1'	mtl Surfaces xray	checkbox 111 mc_surfaces_mtl_xray_18___111 Mesial 112 mc_surfaces_mtl_xray_18___112 Occlusal (Incisal) 113 mc_surfaces_mtl_xray_18___113 Distal 114 mc_surfaces_mtl_xray_18___114 Vestibular (Buccal, Labial) 115 mc_surfaces_mtl_xray_18___115 Lingual (Palatal) 116 mc_surfaces_mtl_xray_18___116 * Unknown Field Annotation: @DEFAULT='[xray_mtl_surf_18:checked:value]'
2948	wr1_18 Show the field ONLY if: [wr_pres_18][last-instance] = '1' AND ((([calc1_18] = '0' AND [ch_pres_18] = '99') OR ([calc2_18] = '0' AND [xray_pres_18] = '99') OR ([calc3_18] = '0' AND [wr_pres_18][last-instance] = '99')) OR (([wr_pres_18][last-instance] <> '1' AND [xray_pres_18] <> '1' AND [ch_pres_18] = '1') OR ([wr_pres_18][last-instance] <> '1' AND [xray_pres_18] = '1' AND [ch_pres_18] <> '1') OR ([wr_pres_18][last-instance] = '1' AND [xray_pres_18] <> '1' AND [ch_pres_18] <> '1')) OR (([wr_pres_18][last-instance]='' OR [xray_pres_18]='' OR [ch_pres_18]='') AND ([wr_pres_18][last-instance]='1' OR [xray_pres_18]='1' OR [ch_pres_18]='1') AND ([calc1_18] = '1' AND [calc2_18]='1' AND [calc3_18]='1')))	Written Record	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2949	wr2_18 Show the field ONLY if: [blank_entry_18] = '1' AND ([rfxcalc1_18] = '1' OR [rfxcalc2_18] = '1' OR [rfxcalc3_18] = '1') AND [wr_treat_18(2)][last-instance] = '1'	Written Record	descriptive
2950	wr4_18 Show the field ONLY if: [wr_treat_18(4)][last-instance] = '1' AND ((([precalc1_18] = '0' AND [ch_pres_18] = '1') OR ([precalc2_18] = '0' AND [xray_pres_18] = '1') OR ([precalc3_18] = '0' AND [wr_pres_18][last-instance] = '1')) OR (([wr_treat_18(4)][last-instance] <> '1' AND [xray_treat_18(4)] <> '1' AND [ch_treat_18(4)] = '1') OR ([wr_treat_18(4)][last-instance] <> '1' AND [xray_treat_18(4)] = '1' AND [ch_treat_18(4)] <> '1') OR ([wr_treat_18(4)][last-instance] = '1' AND [xray_treat_18(4)] <> '1' AND [ch_treat_18(4)] <> '1')) OR (([wr_pres_18][last-instance]='' OR [xray_pres_18]='' OR [ch_pres_18]='') AND ([wr_treat_18(4)][last-instance] = '1' OR [xray_treat_18(4)]='1' OR [ch_treat_18(4)]='1') AND ([precalc1_18] = '1' AND [precalc2_18]='1' AND [precalc3_18]='1')))	Written Record	descriptive
2951	wr6_18 Show the field ONLY if: ([rovcalc_18] = '1') AND [wr_treat_18(6)][last-instance] = '1'	Written Record	descriptive
2952	wr10_18 Show the field ONLY if: ([pincalc1_18] = '1' OR [pincalc2_18] = '1' OR [pincalc3_18] = '1') AND [wr_pin_18][last-instance] = '10'	Written Record	descriptive
2953	wr11_18 Show the field ONLY if: ([postcalc1_18] = '1' OR [postcalc2_18] = '1' OR [postcalc3_18] = '1') AND [wr_post_18][last-instance] = '11'	Written Record	descriptive
2954	wr12_18 Show the field ONLY if: [wr_crown_18][last-instance] = '12' AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	Written Record	descriptive
2955	wr13_18 Show the field ONLY if: [wr_crown_18][last-instance] = '13' AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	Written Record	descriptive
2956	wr14_18 Show the field ONLY if: [wr_crown_18][last-instance] = '14' AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	Written Record	descriptive
2957	wr15_18 Show the field ONLY if: [wr_crown_18][last-instance] = '15' AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	Written Record	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2958	wr16_18 Show the field ONLY if: ([wr_tth_repl_18][last-instance] = '16' OR [xray_tth_repl_18] = '16' OR [ch_tth_repl_18] = '16') AND ([wr_tth_repl_18][last-instance] != [xray_tth_repl_18] OR [xray_tth_repl_18] != [ch_tth_repl_18] OR [ch_tth_repl_18] != [wr_tth_repl_18][last-instance]) AND [wr_tth_repl_18][last-instance]='16'	Written Record	descriptive
2959	wr17_18 Show the field ONLY if: ([wr_tth_repl_18][last-instance] = '17' OR [xray_tth_repl_18] = '17' OR [ch_tth_repl_18] = '17') AND ([wr_tth_repl_18][last-instance] != [xray_tth_repl_18] OR [xray_tth_repl_18] != [ch_tth_repl_18] OR [ch_tth_repl_18] != [wr_tth_repl_18][last-instance]) AND [wr_tth_repl_18][last-instance]='17'	Written Record	descriptive
2960	xray1_18 Show the field ONLY if: [xray_pres_18] = '1' AND ((([calc1_18] = '0' AND [ch_pres_18] = '99') OR ([calc2_18] = '0' AND [xray_pres_18] = '99') OR ([calc3_18] = '0' AND [wr_pres_18][last-instance] = '99')) OR (([wr_pres_18][last-instance] <> '1' AND [xray_pres_18] <> '1' AND [ch_pres_18] = '1') OR ([wr_pres_18][last-instance] <> '1' AND [xray_pres_18] = '1' AND [ch_pres_18] <> '1') OR ([wr_pres_18][last-instance] = '1' AND [xray_pres_18] <> '1' AND [ch_pres_18] <> '1')) OR (([wr_pres_18][last-instance]='' OR [xray_pres_18]='' OR [ch_pres_18]='') AND ([wr_pres_18][last-instance]='1' OR [xray_pres_18]='1' OR [ch_pres_18]='1') AND ([calc1_18] = '1' AND [calc2_18]='1' AND [calc3_18]='1')))	Radiograph	descriptive
2961	xray2_18 Show the field ONLY if: [blank_entry_18] = '1' AND ([rfxcalc1_18] = '1' OR [rfxcalc2_18] = '1' OR [rfxcalc3_18] = '1') AND [xray_treat_18(2)] = '1'	Radiograph	descriptive
2962	xray4_18 Show the field ONLY if: [xray_treat_18(4)] = '1' AND ((([precalc1_18] = '0' AND [ch_pres_18] = '1') OR ([precalc2_18] = '0' AND [xray_pres_18] = '1') OR ([precalc3_18] = '0' AND [wr_pres_18][last-instance] = '1')) OR (([wr_treat_18(4)][last-instance] <> '1' AND [xray_treat_18(4)] <> '1' AND [ch_treat_18(4)] = '1') OR ([wr_treat_18(4)][last-instance] <> '1' AND [xray_treat_18(4)] = '1' AND [ch_treat_18(4)] <> '1') OR ([wr_treat_18(4)][last-instance] = '1' AND [xray_treat_18(4)] <> '1' AND [ch_treat_18(4)] <> '1')) OR (([wr_pres_18][last-instance]='' OR [xray_pres_18]='' OR [ch_pres_18]='') AND ([wr_treat_18(4)][last-instance] = '1' OR [xray_treat_18(4)]='1' OR [ch_treat_18(4)]='1') AND ([precalc1_18] = '1' AND [precalc2_18]='1' AND [precalc3_18]='1')))	Radiograph	descriptive
2963	xray6_18 Show the field ONLY if: ([rovcalc_18] = '1') AND [xray_treat_18(6)] = '1'	Radiograph	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2964	xray10_18 Show the field ONLY if: ([pincalc1_18] = '1' OR [pincalc2_18] = '1' OR [pincalc3_18] = '1') AND [xray_pin_18] = '10'	Radiograph	descriptive
2965	xray11_18 Show the field ONLY if: ([postcalc1_18] = '1' OR [postcalc2_18] = '1' OR [postcalc3_18] = '1') AND [xray_post_18] = '11'	Radiograph	descriptive
2966	xray15_18 Show the field ONLY if: [xray_treat_18(15)] = '1' AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	Radiograph	descriptive
2967	xray16_18 Show the field ONLY if: ([wr_tth_repl_18][last-instance] = '16' OR [xray_tth_repl_18] = '16' OR [ch_tth_repl_18] = '16') AND ([wr_tth_repl_18][last-instance] != [xray_tth_repl_18] OR [xray_tth_repl_18] != [ch_tth_repl_18] OR [ch_tth_repl_18] != [wr_tth_repl_18][last-instance]) AND [xray_tth_repl_18]='16'	Radiograph	descriptive
2968	xray18_18 Show the field ONLY if: ([wr_tth_repl_18][last-instance] = '17' OR [xray_tth_repl_18] = '17' OR [ch_tth_repl_18] = '17') AND ([wr_tth_repl_18][last-instance] != [xray_tth_repl_18] OR [xray_tth_repl_18] != [ch_tth_repl_18] OR [ch_tth_repl_18] != [wr_tth_repl_18][last-instance]) AND [xray_tth_repl_18]='17'	Radiograph	descriptive
2969	ch1_18 Show the field ONLY if: [ch_pres_18] = '1' AND ((([calc1_18] = '0' AND [ch_pres_18] = '99') OR ([calc2_18] = '0' AND [xray_pres_18] = '99') OR ([calc3_18] = '0' AND [wr_pres_18][last-instance] = '99')) OR (([wr_pres_18][last-instance] <> '1' AND [xray_pres_18] <> '1' AND [ch_pres_18] = '1') OR ([wr_pres_18][last-instance] <> '1' AND [xray_pres_18] = '1' AND [ch_pres_18] <> '1') OR ([wr_pres_18][last-instance] = '1' AND [xray_pres_18] <> '1' AND [ch_pres_18] <> '1')) OR (([wr_pres_18][last-instance]='' OR [xray_pres_18]='' OR [ch_pres_18]='') AND ([wr_pres_18][last-instance]='1' OR [xray_pres_18]='1' OR [ch_pres_18]='1') AND ([calc1_18] = '1' AND [calc2_18]='1' AND [calc3_18]='1')))	Dental Chart	descriptive
2970	ch2_18 Show the field ONLY if: [blank_entry_18] = '1' AND ([rfxcalc1_18] = '1' OR [rfxcalc2_18] = '1' OR [rfxcalc3_18] = '1') AND [ch_treat_18(2)] = '1'	Dental Chart	descriptive

#	Variable / Field Name	Field Label Field Note	Field Attributes (Field Type, Validation, Choices, Calculations, etc.)
2971	ch4_18 Show the field ONLY if: [ch_treat_18(4)] = '1' AND ((([precalc1_18] = '0' AND [ch_pres_18] = '1') OR ([precalc2_18] = '0' AND [xray_pres_18] = '1') OR ([precalc3_18] = '0' AND [wr_pres_18][last-instance] = '1')) OR (([wr_treat_18(4)][last-instance] <> '1' AND [xray_treat_18(4)] <> '1' AND [ch_treat_18(4)] = '1') OR ([wr_treat_18(4)][last-instance] <> '1' AND [xray_treat_18(4)] = '1' AND [ch_treat_18(4)] <> '1') OR ([wr_treat_18(4)][last-instance] = '1' AND [xray_treat_18(4)] <> '1' AND [ch_treat_18(4)] <> '1')) OR ((([wr_pres_18][last-instance]='' OR [xray_pres_18]='' OR [ch_pres_18]='') AND ([wr_treat_18(4)][last-instance] = '1' OR [xray_treat_18(4)]='1' OR [ch_treat_18(4)]='1') AND ([precalc1_18] = '1' AND [precalc2_18]='1' AND [precalc3_18]='1')))	Dental Chart	descriptive
2972	ch10_18 Show the field ONLY if: ([pincalc1_18] = '1' OR [pincalc2_18] = '1' OR [pincalc3_18] = '1') AND [ch_pin_18] = '10'	Dental Chart	descriptive
2973	ch11_18 Show the field ONLY if: ([postcalc1_18] = '1' OR [postcalc2_18] = '1' OR [postcalc3_18] = '1') AND [ch_post_18] = '11'	Dental Chart	descriptive
2974	ch12_18 Show the field ONLY if: [ch_crown_18] = '12' AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	Dental Chart	descriptive
2975	ch13_18 Show the field ONLY if: [ch_crown_18] = '13' AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	Dental Chart	descriptive
2976	ch14_18 Show the field ONLY if: [ch_crown_18] = '14' AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	Dental Chart	descriptive
2977	ch15_18 Show the field ONLY if: [ch_crown_18] = '15' AND ([crowncalc1_18] = '1' OR [crowncalc2_18] = '1' or [crowncalc3_18] = '1')	Dental Chart	descriptive
2978	ch16_18 Show the field ONLY if: [ch_tth_repl_18]='16' AND [ch_repl_impcrown_18]='1'	Dental Chart	descriptive
2979	ch17_18 Show the field ONLY if: ([wr_tth_repl_18][last-instance] = '17' OR [xray_tth_repl_18] = '17' OR [ch_tth_repl_18] = '17') AND ([wr_tth_repl_18][last-instance] != [xray_tth_repl_18] OR [xray_tth_repl_18] != [ch_tth_repl_18] OR [ch_tth_repl_18] != [wr_tth_repl_18][last-instance]) AND [ch_tth_repl_18]='17'	Dental Chart	descriptive

Instrument: **Final Odontogram** (final_odontogram) Enabled as survey			
#	**Variable / Field Name**	**Field Label** *Field Note*	**Field Attributes (Field Type, Validation, Choices, Calculations,**
5523	fo_table	Section Header: *Final Codes for [arm-label]*	descriptive
5524	non_18 Show the field ONLY if: [no_data_18] = '19'	Section Header: *18* non	descriptive
5525	mam_18 Show the field ONLY if: [mc_mam_18]='1' OR ([blank_entry_18]='0' AND ([wr_pres_18][last-instance] = '1' OR [xray_pres_18] = '1' OR [ch_pres_18] = '1')) OR (([wr_pres_18][last-instance] = '' AND [calc3_18] = '0') OR ([xray_pres_18] = '' AND [calc2_18] = '0') OR ([ch_pres_18] = '' AND [calc1_18] = '0')) OR ([calc1_18] = '0' AND [calc2_18] = '0' AND [calc3_18] = '0')	mam	descriptive
5526	pre_18 Show the field ONLY if: [mc_pre_18]='4' OR ((([precalc1_18] = '0' AND [precalc2_18] = '0' AND [precalc3_18] = '0') OR ([blank_entry_18]='0')) AND ([wr_treat_18(4)][last-instance] = '1' OR [xray_treat_18(4)] = '1' OR [ch_treat_18(4)] = '1')) OR (([wr_treat_18(4)][last-instance] <> '1' AND [precalc2_18]='0') OR ([xray_treat_18(4)] <> '1' AND [precalc3_18]='0') OR ([ch_treat_18(4)] <> '1' AND [precalc1_18]='0'))	pre	descriptive
5527	une_18 Show the field ONLY if: [mc_une_18] = '5' OR ([blank_entry_18]='0' AND ([wr_treat_18(5)][last-instance] = '1' OR [xray_treat_18(5)] = '1' OR [ch_treat_18(5)] = '1')) OR ([unecalc1_18] = '0' AND [unecalc2_18] = '0' AND [unecalc3_18] = '0')	une	descriptive
5528	rov_18 Show the field ONLY if: [mc_rov_18] = '6' OR ([rovcalc_18] = '0' AND ([wr_treat_18(6)][last-instance] = '1' OR [xray_treat_18(6)] = '1'))	rov	descriptive
5529	mtl_18 Show the field ONLY if: [mc_mtl_18] = '3' OR ([mtlcalc1_18] = '0' AND [ch_pres_18]='' AND ([wr_treat_18(3)][last-instance] = '1' OR [xray_treat_18(3)] = '1')) OR ([blank_entry_18]='0' AND ([wr_treat_18(3)][last-instance] = '1' OR [xray_treat_18(3)] = '1'))	mtl	descriptive
5530	m_mtl_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_mtl_surf_18(111)][last-instance] = '1' OR [xray_mtl_surf_18(111)]='1')) OR (([mc_mtl_18]='3') AND ([mc_surfaces_mtl_wr_18(111)] = '1' OR [mc_surfaces_mtl_xray_18(111)] = '1'))	M	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5531	o_mtl_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_mtl_surf_18(112)][last-instance] = '1' OR [xray_mtl_surf_18(112)]='1')) OR (([mc_mtl_18]='3') AND ([mc_surfaces_mtl_wr_18(112)] = '1' OR [mc_surfaces_mtl_xray_18(112)] = '1'))	O	descriptive
5532	d_mtl_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_mtl_surf_18(113)][last-instance] = '1' OR [xray_mtl_surf_18(113)]='1')) OR (([mc_mtl_18]='3') AND ([mc_surfaces_mtl_wr_18(113)] = '1' OR [mc_surfaces_mtl_xray_18(113)] = '1'))	D	descriptive
5533	v_mtl_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_mtl_surf_18(114)][last-instance] = '1' OR ([mc_mtl_18]='3') AND [mc_surfaces_mtl_wr_18(114)] = '1'))	V	descriptive
5534	l_mtl_18 Show the field ONLY if: [blank_entry_18]='0' AND ([wr_mtl_surf_18(115)][last-instance] = '1' OR ([mc_mtl_18]='3') AND [mc_surfaces_mtl_wr_18(115)] = '1')	L	descriptive
5535	u_mtl_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_mtl_surf_18(116)][last-instance] = '1' OR [xray_mtl_surf_18(116)]='1')) OR (([mc_mtl_18]='3') AND ([mc_surfaces_mtl_wr_18(116)] = '1' OR [mc_surfaces_mtl_xray_18(116)] = '1'))	*	descriptive
5536	tcf_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_18][last-instance] = '7' OR [ch_rest_mat_18] = '7')) OR ([mc_tcf_18] = '7' AND ([wr_rest_mat_18][last-instance] = '7' OR [ch_rest_mat_18] = '7'))	tcf	descriptive
5537	m_t_18 Show the field ONLY if: ([blank_entry_18]='0' AND (([wr_rest_mat_18][last-instance]='7' AND [wr_rest_surf_18(111)][last-instance] = '1') OR ([ch_rest_mat_18]='7' AND [ch_rest_surf_18(111)] = '1'))) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_18(111)] = '1' OR [mc_surfaces_wr1_18(111)] = '1' OR [mc_surfaces_ch1_18(111)] = '1'))	M	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5538	o_t_18 Show the field ONLY if: ([blank_entry_18]='0' AND (([wr_rest_mat_18][last-instance]='7' AND [wr_rest_surf_18(112)][last-instance] = '1') OR ([ch_rest_mat_18]='7' AND [ch_rest_surf_18(112)] = '1'))) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_18(112)] = '1' OR [mc_surfaces_wr1_18(112)] = '1' OR [mc_surfaces_ch1_18(112)] = '1'))	O	descriptive
5539	d_t_18 Show the field ONLY if: ([blank_entry_18]='0' AND (([wr_rest_mat_18][last-instance]='7' AND [wr_rest_surf_18(113)][last-instance] = '1') OR ([ch_rest_mat_18]='7' AND [ch_rest_surf_18(113)] = '1'))) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_18(113)] = '1' OR [mc_surfaces_wr1_18(113)] = '1' OR [mc_surfaces_ch1_18(113)] = '1'))	D	descriptive
5540	v_t_18 Show the field ONLY if: ([blank_entry_18]='0' AND (([wr_rest_mat_18][last-instance]='7' AND [wr_rest_surf_18(114)][last-instance] = '1') OR ([ch_rest_mat_18]='7' AND [ch_rest_surf_18(114)] = '1'))) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_18(114)] = '1' OR [mc_surfaces_wr1_18(114)] = '1' OR [mc_surfaces_ch1_18(114)] = '1'))	V	descriptive
5541	l_t_18 Show the field ONLY if: ([blank_entry_18]='0' AND (([wr_rest_mat_18][last-instance]='7' AND [wr_rest_surf_18(115)][last-instance] = '1') OR ([ch_rest_mat_18]='7' AND [ch_rest_surf_18(115)] = '1'))) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_18(115)] = '1' OR [mc_surfaces_wr1_18(115)] = '1' OR [mc_surfaces_ch1_18(115)] = '1'))	L	descriptive
5542	u_t_18 Show the field ONLY if: ([blank_entry_18]='0' AND (([wr_rest_mat_18][last-instance]='7' AND [wr_rest_surf_18(116)][last-instance] = '1') OR ([ch_rest_mat_18]='7' AND [ch_rest_surf_18(116)] = '1'))) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_18(116)] = '1' OR [mc_surfaces_wr1_18(116)] = '1' OR [mc_surfaces_ch1_18(116)] = '1'))	*	descriptive
5543	tcf_2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_2_18][last-instance] = '7' OR [ch_rest_mat_2_18] = '7')) OR ([mc_tcf_18]='7' AND ([wr_rest_mat_2_18][last-instance] = '7' OR [ch_rest_mat_2_18] = '7'))	tcf	descriptive
5544	m_t2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_surf_2_18(111)][last-instance] = '1' OR [ch_rest_surf_2_18(111)] = '1')) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_2_18(111)] = '1' OR [mc_surfaces_wr2_18(111)] = '1' OR [mc_surfaces_ch2_18(111)] = '1'))	M	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5545	o_t2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_2_18][last-instance]='7' OR [ch_rest_mat_2_18]='7') AND ([wr_rest_surf_2_18(112)][last-instance] = '1' OR [ch_rest_surf_2_18(112)] = '1')) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_2_18(112)] = '1' OR [mc_surfaces_wr2_18(112)] = '1' OR [mc_surfaces_ch2_18(112)] = '1'))	O	descriptive
5546	d_t2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_surf_2_18(113)][last-instance] = '1' OR [ch_rest_surf_2_18(113)] = '1')) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_2_18(113)] = '1' OR [mc_surfaces_wr2_18(113)] = '1' OR [mc_surfaces_ch2_18(113)] = '1'))	D	descriptive
5547	v_t2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_surf_2_18(114)][last-instance] = '1' OR [ch_rest_surf_2_18(114)] = '1')) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_2_18(114)] = '1' OR [mc_surfaces_wr2_18(114)] = '1' OR [mc_surfaces_ch2_18(114)] = '1'))	V	descriptive
5548	l_t2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_surf_2_18(115)][last-instance] = '1' OR [ch_rest_surf_2_18(115)] = '1')) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_2_18(115)] = '1' OR [mc_surfaces_wr2_18(115)] = '1' OR [mc_surfaces_ch2_18(115)] = '1'))	L	descriptive
5549	u_t2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_surf_2_18(116)][last-instance] = '1' OR [ch_rest_surf_2_18(116)] = '1')) OR ([mc_tcf_18]='7' AND ([mc_surf_tcf_all_2_18(116)] = '1' OR [mc_surfaces_wr2_18(116)] = '1' OR [mc_surfaces_ch2_18(116)] = '1'))	*	descriptive
5550	mcf_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18] = '8')) OR ([mc_mcf_18]='8' AND ([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18] = '8'))	mcf	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5551	m_m_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18]='8') AND ([wr_rest_surf_18(111)][last-instance] = '1' OR [ch_rest_surf_18(111)] = '1')) OR [mc_mcf_18]='8' AND ([mc_surf_mcf_all_18(111)] = '1' OR [mc_surfaces_wr3_18(111)] = '1' OR [mc_surfaces_ch3_18(111)] = '1')	M	descriptive
5552	o_m_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18]='8') AND ([wr_rest_surf_18(112)][last-instance] = '1' OR [ch_rest_surf_18(112)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_18(112)] = '1' OR [mc_surfaces_wr3_18(112)] = '1' OR [mc_surfaces_ch3_18(112)] = '1'))	O	descriptive
5553	d_m_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18]='8') AND ([wr_rest_surf_18(113)][last-instance] = '1' OR [ch_rest_surf_18(113)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_18(113)] = '1' OR [mc_surfaces_wr3_18(113)] = '1' OR [mc_surfaces_ch3_18(113)] = '1'))	D	descriptive
5554	v_m_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18]='8') AND ([wr_rest_surf_18(114)][last-instance] = '1' OR [ch_rest_surf_18(114)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_18(114)] = '1' OR [mc_surfaces_wr3_18(114)] = '1' OR [mc_surfaces_ch3_18(114)] = '1'))	V	descriptive
5555	l_m_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18]='8') AND ([wr_rest_surf_18(115)][last-instance] = '1' OR [ch_rest_surf_18(115)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_18(115)] = '1' OR [mc_surfaces_wr3_18(115)] = '1' OR [mc_surfaces_ch3_18(115)] = '1'))	L	descriptive
5556	u_m_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_18][last-instance] = '8' OR [ch_rest_mat_18]='8') AND ([wr_rest_surf_18(116)][last-instance] = '1' OR [ch_rest_surf_18(116)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_18(116)] = '1' OR [mc_surfaces_wr3_18(116)] = '1' OR [mc_surfaces_ch3_18(116)] = '1'))	*	descriptive
5557	mcf_2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18] = '8')) OR ([mc_mcf_18]='8' AND ([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18] = '8'))	mcf	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5558	m_m2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18]='8') AND ([wr_rest_surf_2_18(111)][last-instance] = '1' OR [ch_rest_surf_2_18(111)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_2_18(111)] = '1' OR [mc_surfaces_wr4_18(111)] = '1' OR [mc_surfaces_ch4_18(111)] = '1'))	M	descriptive
5559	o_m2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18]='8') AND ([wr_rest_surf_2_18(112)][last-instance] = '1' OR [ch_rest_surf_2_18(112)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_2_18(112)] = '1' OR [mc_surfaces_wr4_18(112)] = '1' OR [mc_surfaces_ch4_18(112)] = '1'))	O	descriptive
5560	d_m2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18]='8') AND ([wr_rest_surf_2_18(113)][last-instance] = '1' OR [ch_rest_surf_2_18(113)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_2_18(113)] = '1' OR [mc_surfaces_wr4_18(113)] = '1' OR [mc_surfaces_ch4_18(113)] = '1'))	D	descriptive
5561	v_m2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18]='8') AND ([wr_rest_surf_2_18(114)][last-instance] = '1' OR [ch_rest_surf_2_18(114)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_2_18(114)] = '1' OR [mc_surfaces_wr4_18(114)] = '1' OR [mc_surfaces_ch4_18(114)] = '1'))	V	descriptive
5562	l_m2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18]='8') AND ([wr_rest_surf_2_18(115)][last-instance] = '1' OR [ch_rest_surf_2_18(115)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_2_18(115)] = '1' OR [mc_surfaces_wr4_18(115)] = '1' OR [mc_surfaces_ch4_18(115)] = '1'))	L	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5563	u_m2_18 Show the field ONLY if: ([blank_entry_18]='0' AND ([wr_rest_mat_2_18][last-instance] = '8' OR [ch_rest_mat_2_18]='8') AND ([wr_rest_surf_2_18(116)][last-instance] = '1' OR [ch_rest_surf_2_18(116)] = '1')) OR ([mc_mcf_18]='8' AND ([mc_surf_mcf_all_2_18(116)] = '1' OR [mc_surfaces_wr4_18(116)] = '1' OR [mc_surfaces_ch4_18(116)] = '1'))	*	descriptive
5564	uif_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18] = '9' OR [xray_treat_18(9)]='1') AND ([mc_surfaces_xray1_18(111)]= '1' OR [mc_surfaces_xray1_18(112)]= '1' OR [mc_surfaces_xray1_18(113)]= '1' OR [mc_surfaces_xray1_18(116)]= '1' OR [mc_surfaces_wr5_18(111)]= '1' OR [mc_surfaces_wr5_18(112)]= '1' OR [mc_surfaces_wr5_18(113)]= '1' OR [mc_surfaces_wr5_18(114)]= '1' OR [mc_surfaces_wr5_18(115)]= '1' OR [mc_surfaces_wr5_18(116)]= '1' OR [mc_surfaces_ch5_18(111)]= '1' OR [mc_surfaces_ch5_18(112)]= '1' OR [mc_surfaces_ch5_18(113)]= '1' OR [mc_surfaces_ch5_18(114)]= '1' OR [mc_surfaces_ch5_18(115)]= '1' OR [mc_surfaces_ch5_18(116)]= '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18] = '9' OR [xray_treat_18(9)]='1'))	uif	descriptive
5565	m_u_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_18(111)] = '1' OR [mc_surfaces_wr5_18(111)] = '1' OR [mc_surfaces_xray1_18(111)] = '1' OR [mc_surfaces_ch5_18(111)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18] = '9' OR [xray_treat_18(9)]='1') AND ([wr_rest_surf_18(111)][last-instance] = '1' OR [ch_rest_surf_18(111)] = '1' OR [xray_rest_surf_18(111)]='1'))	M	descriptive
5566	o_u_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_18(112)] = '1' OR [mc_surfaces_wr5_18(112)] = '1' OR [mc_surfaces_xray1_18(112)] = '1' OR [mc_surfaces_ch5_18(112)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18] = '9' OR [xray_treat_18(9)]='1') AND ([wr_rest_surf_18(112)][last-instance] = '1' OR [ch_rest_surf_18(112)] = '1' OR [xray_rest_surf_18(112)]='1'))	O	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5567	d_u_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_18(113)] = '1' OR [mc_surfaces_wr5_18(113)] = '1' OR [mc_surfaces_xray1_18(113)] = '1' OR [mc_surfaces_ch5_18(113)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18] = '9' OR [xray_treat_18(9)]='1') AND ([wr_rest_surf_18(113)][last-instance] = '1' OR [ch_rest_surf_18(113)] = '1' OR [xray_rest_surf_18(113)]='1'))	D	descriptive
5568	v_u_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_18(114)] = '1' OR [mc_surfaces_wr5_18(114)] = '1' OR [mc_surfaces_ch5_18(114)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18] = '9') AND ([wr_rest_surf_18(114)][last-instance] = '1' OR [ch_rest_surf_18(114)] = '1'))	V	descriptive
5569	l_u_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_18(115)] = '1' OR [mc_surfaces_wr5_18(115)] = '1' OR [mc_surfaces_ch5_18(115)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18] = '9') AND ([wr_rest_surf_18(115)][last-instance] = '1' OR [ch_rest_surf_18(115)] = '1'))	L	descriptive
5570	u_u_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_18(116)] = '1' OR [mc_surfaces_wr5_18(116)] = '1' OR [mc_surfaces_xray1_18(116)] = '1' OR [mc_surfaces_ch5_18(116)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_18][last-instance] = '9' OR [ch_rest_mat_18] = '9' OR [xray_treat_18(9)]='1') AND ([wr_rest_surf_18(116)][last-instance] = '1' OR [ch_rest_surf_18(116)] = '1' OR [xray_rest_surf_18(116)]='1'))	*	descriptive
5571	uif_2_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([wr_rest_mat_2_18][last-instance] = '9' OR [ch_rest_mat_2_18] = '9' OR [rest_no_18]>1) AND ([mc_surfaces_xray2_18(111)]= '1' OR [mc_surfaces_xray2_18(112)]= '1' OR [mc_surfaces_xray2_18(113)]= '1' OR [mc_surfaces_xray2_18(116)]= '1' OR [mc_surfaces_wr6_18(111)]= '1' OR [mc_surfaces_wr6_18(112)]= '1' OR [mc_surfaces_wr6_18(113)]= '1' OR [mc_surfaces_wr6_18(114)]= '1' OR [mc_surfaces_wr6_18(115)]= '1' OR [mc_surfaces_wr6_18(116)]= '1' OR [mc_surfaces_ch6_18(111)]= '1' OR [mc_surfaces_ch6_18(112)]= '1' OR [mc_surfaces_ch6_18(113)]= '1' OR [mc_surfaces_ch6_18(114)]= '1' OR [mc_surfaces_ch6_18(115)]= '1' OR [mc_surfaces_ch6_18(116)]= '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_2_18][last-instance] = '9' OR [ch_rest_mat_2_18] = '9' OR [rest_no_18]>1))	uif	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5572	m_u2_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_2_18(111)] = '1' OR [mc_surfaces_wr6_18(111)] = '1' OR [mc_surfaces_xray2_18(111)] = '1' OR [mc_surfaces_ch6_18(111)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_2_18][last-instance] = '9' OR [ch_rest_mat_2_18] = '9' OR [rest_no_18]>1) AND ([wr_rest_surf_2_18(111)][last-instance] = '1' OR [ch_rest_surf_2_18(111)] = '1' OR [xray_rest_surf_2_18(111)]='1'))	M	descriptive
5573	o_u2_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_2_18(112)] = '1' OR [mc_surfaces_wr6_18(112)] = '1' OR [mc_surfaces_xray2_18(112)] = '1' OR [mc_surfaces_ch6_18(112)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_2_18][last-instance] = '9' OR [ch_rest_mat_2_18] = '9' OR [rest_no_18]>1) AND ([wr_rest_surf_2_18(112)][last-instance] = '1' OR [ch_rest_surf_2_18(112)] = '1' OR [xray_rest_surf_2_18(112)]='1'))	O	descriptive
5574	d_u2_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_2_18(113)] = '1' OR [mc_surfaces_wr6_18(113)] = '1' OR [mc_surfaces_xray2_18(113)] = '1' OR [mc_surfaces_ch6_18(113)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_2_18][last-instance] = '9' OR [ch_rest_mat_2_18] = '9' OR [rest_no_18]>1) AND ([wr_rest_surf_2_18(113)][last-instance] = '1' OR [ch_rest_surf_2_18(113)] = '1' OR [xray_rest_surf_2_18(113)]='1'))	D	descriptive
5575	v_u2_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_2_18(114)] = '1' OR [mc_surfaces_wr6_18(114)] = '1' OR [mc_surfaces_ch6_18(114)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_2_18][last-instance] = '9' OR [ch_rest_mat_2_18] = '9') AND ([wr_rest_surf_2_18(114)][last-instance] = '1' OR [ch_rest_surf_2_18(114)] = '1'))	V	descriptive
5576	l_u2_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_2_18(115)] = '1' OR [mc_surfaces_wr6_18(115)] = '1' OR [mc_surfaces_ch6_18(115)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_2_18][last-instance] = '9' OR [ch_rest_mat_2_18] = '9') AND ([wr_rest_surf_2_18(115)][last-instance] = '1' OR [ch_rest_surf_2_18(115)] = '1'))	L	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5577	u_u2_18 Show the field ONLY if: ([mc_uif_18] = '9' AND ([mc_surf_uif_all_2_18(116)] = '1' OR [mc_surfaces_wr6_18(116)] = '1' OR [mc_surfaces_xray2_18(116)] = '1' OR [mc_surfaces_ch6_18(116)] = '1')) OR ([blank_entry_18] = '0' AND ([wr_rest_mat_2_18][last-instance] = '9' OR [ch_rest_mat_2_18] = '9' OR [rest_no_18]>1) AND ([wr_rest_surf_2_18(116)][last-instance] = '1' OR [ch_rest_surf_2_18(116)] = '1' OR [xray_rest_surf_2_18(116)]='1'))	*	descriptive
5578	ppx_18 Show the field ONLY if: [mc_ppx_18] = '10' OR (([wr_pin_18][last-instance] = '10' OR [xray_pin_18] = '10' OR [ch_pin_18] = '10') AND ([blank_entry_18]='0' OR ([pincalc1_18]='0' AND [pincalc2_18]='0' AND [pincalc3_18]='0')))	ppx	descriptive
5579	rfx_18 Show the field ONLY if: [mc_rfx_18] = '3' OR ([blank_entry_18] = '0' AND ([wr_treat_18(2)][last-instance] = '1' OR [xray_treat_18(2)] = '1' OR [ch_treat_18(2)] = '1')) OR ([blank_entry_18] = '1' AND ([rfxcalc1_18] = '0' AND [rfxcalc2_18] = '0' AND [rfxcalc3_18] = '0'))	rfx	descriptive
5580	pox_18 Show the field ONLY if: [mc_pox_18] = '11' OR (([wr_post_18][last-instance] = '11' OR [xray_post_18] = '11' OR [ch_post_18] = '11') AND (([blank_entry_18] = '0') OR ([wr_post_18][last-instance] <> '' AND [xray_post_18] <> '' AND [ch_post_18] <>'')))	pox	descriptive
5581	mcc_18 Show the field ONLY if: [mc_mcc_18]='12' OR ([blank_entry_18] = '0' AND ([wr_crown_18][last-instance] = '12' OR [ch_crown_18] = '12')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	mcc	descriptive
5582	mcc_imx_18 Show the field ONLY if: [mc_mcc_2_18]='12' OR ([blank_entry_18]='0' AND ([wr_repl_impcrown_18][last-instance] = '12' OR [ch_repl_impcrown_18] = '12')) OR ([blank_entry_18]='1' AND ([crowncalc1_18] = '0' OR [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	mcc	descriptive
5583	mcc_pon_18 Show the field ONLY if: [mc_mcc_3_18]='12' OR ([blank_entry_18] = '0' AND ([wr_repl_poncrown_18][last-instance] = '12' OR [ch_repl_poncrown_18] = '12')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	mcc	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5584	mtc_18 Show the field ONLY if: [mc_mtc_18]='13' OR ([blank_entry_18] = '0' AND ([wr_crown_18][last-instance] = '13' OR [ch_crown_18] = '13')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	mtc	descriptive
5585	mtc_imx_18 Show the field ONLY if: [mc_mtc_2_18]='13' OR ([blank_entry_18] = '0' AND ([wr_repl_impcrown_18][last-instance] = '13' OR [ch_repl_impcrown_18] = '13')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	mtc	descriptive
5586	mtc_pon_18 Show the field ONLY if: [mc_mtc_3_18]='13' OR ([blank_entry_18] = '0' AND ([wr_repl_poncrown_18][last-instance] = '13' OR [ch_repl_poncrown_18] = '13')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	mtc	descriptive
5587	tcc_18 Show the field ONLY if: [mc_tcc_18]='14' OR ([blank_entry_18] = '0' AND ([wr_crown_18][last-instance] = '14' OR [ch_crown_18] = '14')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	tcc	descriptive
5588	tcc_imx_18 Show the field ONLY if: [mc_tcc_2_18]='14' OR ([blank_entry_18] = '0' AND ([wr_repl_impcrown_18][last-instance] = '14' OR [ch_repl_impcrown_18] = '14')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	tcc	descriptive
5589	tcc_pon_18 Show the field ONLY if: [mc_tcc_3_18]='14' OR ([blank_entry_18] = '0' AND ([wr_repl_poncrown_18][last-instance] = '14' OR [ch_repl_poncrown_18] = '14')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	tcc	descriptive

#	Variable / Field Name	Field Label *Field Note*	Field Attributes (Field Type, Validation, Choices, Calculations,
5590	uic_18 Show the field ONLY if: [mc_uic_18]='15' OR ([blank_entry_18] = '0' AND ([wr_crown_18][last-instance] = '15' OR [ch_crown_18] = '15' OR [xray_treat_18(15)] = '1')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	uic	descriptive
5591	uic_pon_18 Show the field ONLY if: [mc_uic_3_18]='15' OR ([blank_entry_18] = '0' AND ([wr_repl_poncrown_18][last-instance] = '15' OR [ch_repl_poncrown_18] = '15' OR [xray_tth_repl_18]='18')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	uic	descriptive
5592	uic_imx_18 Show the field ONLY if: [mc_uic_2_18]='15' OR ([blank_entry_18] = '0' AND ([wr_repl_impcrown_18][last-instance] = '15' OR [ch_repl_impcrown_18] = '15' OR [xray_repl_impcrown_18] = '15')) OR ([blank_entry_18] = '1' AND ([crowncalc1_18] = '0' AND [crowncalc2_18] = '0' AND [crowncalc3_18] = '0'))	uic	descriptive
5593	imx_18 Show the field ONLY if: ([mc_imx_18] = '16' OR [mc_imx_nocrown_18] ='1') OR (([wr_tth_repl_18][last-instance] = '16' OR [xray_tth_repl_18] = '16' OR [ch_tth_repl_18] = '16') AND (([blank_entry_18] = '0') OR ([wr_tth_repl_18][last-instance] <> '' AND [xray_tth_repl_18] <> '' AND [ch_tth_repl_18] <>'')))	imx	descriptive
5594	pon_18 Show the field ONLY if: [mc_pon_18] = '17' OR ([blank_entry_18] = '0' AND ([wr_tth_repl_18][last-instance] = '17' OR [xray_tth_repl_18] = '18' OR [ch_tth_repl_18] = '17')) OR ([blank_entry_18] = '1' AND ([poncalc_18] = '0' AND [poncalc_2_18] = '0' AND [poncalc_3_18] = '0'))	pon	descriptive

Instrument: **User Opinions** (user_opinions) Enabled as survey			
#	**Variable / Field Name**	**Field Label** ***Field Note***	**Field Attributes (Field Type, Validation, Choices, Calculations, etc.)**
7797	question_1	Section Header: *User Opinion Questions* Which data source did you rely on the most?	radio 1 Written Record 2 Radiographs 3 Dental Chart
7798	question_2	Where there any teeth you had trouble with when deciding on a code? Why?	notes Custom alignment: LH
7799	question_3	Is there any additional information or instructions for use of the data entry program that would have made your task easier or more understandable?	notes Custom alignment: LH
7800	para_1	We understand the limitations of using the database software for antemortem transcription purposes. User interface and experience are areas we feel can use improvement. We would also like to add additional information when deciding on codes such as including the date of radiographs or written entries alongside the treatment choices.Please let us know in the boxes below what you liked about the process and areas you feel can be improved.	descriptive
7801	question_4	What did you like about using ADDE?	notes
7802	question_5	What didn't you like about using ADDE? Do you have suggestions for improvements?	notes
7803	para_2	Questions regarding your general casework	descriptive
7804	question_6	Do you give dental records an evidentiary value before you transcribe them? (Quality they will provide to a potential comparison)	radio 1 Yes - unofficially 2 Yes - part of standard operating procedure 3 No
7805	question_7	Do you think any of these data sources have a higher evidentiary weighting than the others? (In terms of accuracy of data in AM information only)	checkbox 1 question_7___1 Written Records 2 question_7___2 Radiographs 3 question_7___3 Dental Chart 4 question_7___4 Dental Casts 5 question_7___5 Photographs 6 question_7___6 CT
7806	question_8	Why/why not?	notes
7807	para_3	Thank-you for taking the time to complete the transcription and share you opinions on the process. Your time and insights are very much appreciated.	descriptive
7808	user_opinions_complete	Section Header: *Form Status* Complete?	dropdown 0 Incomplete 1 Unverified 2 Complete

Appendix VII – REDCap/Shazam HTML and CSS

HTML

The external module ‘Shazam’ was used to create the appearance of the forms in REDCap® to improve the user interface, user experience and to prevent the form being one long line of questions.

Each form that employs html formatting is listed below with its respective code.

Written Record Entry, Radiograph Entry and Multiple Codes forms employed the same code repeated 32 times. for each tooth. Only the code for tooth 18 is presented.

Chart Entry form repeated the same code 4 times, one for each quadrant, only quadrant one is presented.

Dental Record Entry

```
<div id='tableDiv'>
    <table colspan = '20'>
    <tr>
        <td colspan='2' class='shazam question'>entry_date:label </td>
        <td colspan='10' class='shazam answer'>entry_date</td>
    </tr>

</table>
</div>


<div id='tableDiv'>
    <h2 class='dentist'> DENTIST DETAILS </h2>
    <table colspan = '20'>
        <tr>
            <td colspan='5' class='shazam question'> dent_name:label</td>
            <td colspan='15' class='shazam answer'> dent_name </td>
        </tr>
        <tr>
            <td colspan='5' class='question'> Address: </td>
            <td colspan='15' class='shazam answer'> dent_address </td>
        </tr>

        <tr>
            <td colspan='5' class='question'> Suburb: </td>
            <td colspan='5' class='shazam answer'> dent_sub </td>
            <td colspan='5' class='question'> State: </td>
            <td colspan='5' class='shazam answer'> dent_state </td>
        </tr>
        <tr>
            <td colspan='5' class='question'> Postcode: </td>
            <td colspan='5' class='shazam answer'> dent_postcode</td>
            <td colspan='5' class='question'> Phone:</td>
            <td colspan='5' class='shazam answer'> dent_phone </td>
        </tr>
        </table>
        <table colspan = '20'>
        <tr>
            <td colspan='10' class='shazam question'>name_dob:label</td>
            <td colspan='10' class='shazam answer'> name_dob </td>
        </tr>
        </table>
        <table colspan = '20'>
        <tr>
            <td colspan='10' class='shazam question' data-shazam-mirror-visibility = 'reconcile'> reconcile:label </td>
            <td colspan='10' class='shazam answer' data-shazam-mirror-visibility = 'reconcile'> reconcile </td>
        </tr>
    </table>
    <p colspan = '20' class='shazam warning' data-shazam-mirror-visibility='alert'> alert:label </p>
</div>


<div id="tableDiv">

    <h2 class='dentist'> RECORDS AVAILABLE </h2>
    <table style="background-color: #fffde7">
        <tr>
            <td colspan='5' rowspan='10' class='shazam leftside'>record_type</td>
            <th colspan='15' class='shazam title' data-shazam-mirror-visibility= 'date_from'> Written Records </th>
        </tr>
        <tr>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility= 'date_from'> date_from:label </td>
            <td colspan='4' class='shazam answer' data-shazam-mirror-visibility= 'date_from'> date_from </td>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
```

```
            'date_to'> date_to:label </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='date_to'> date_to </td>
        </tr>
        <tr>
            <th colspan='15' class='title' data-shazam-mirror-visibility='chart_no'> Dental Chart Records </th>
        </tr>
        <tr>
            <td colspan='3' rowspan='2' class='shazam question' data-shazam-mirror-visibility='chart_no'> chart_no:label </td>
            <td colspan='12' class='shazam question' data-shazam-mirror-visibility='chart_create'> chart_create:label </td>
        </tr>
        <tr>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='date_create'> date_create </td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='chart_create'> chart_create </td>

        </tr>
        <tr>
            <td colspan='3' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='chart_no'> chart_no </td>
            <td colspan='12' class='shazam question' data-shazam-mirror-visibility='chart_create_2'> chart_create_2:label </td>
        </tr>

        <tr>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='date_create_2'> date_create_2 </td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='chart_create_2'> chart_create_2 </td>

        </tr>
        <tr>
            <th colspan='15' class='title' data-shazam-mirror-visibility='radio_type'> Radiograph Records </th>
        </tr>
        <tr>
            <td colspan='3' rowspan='2' align='middle' class='shazam question' data-shazam-mirror-visibility='radio_type'> radio_type </td>
            <td colspan='12' class='question' data-shazam-mirror-visibility='radio_type'> How many radiographs are part of this record?</td>
        </tr>
        <tr>
            <td colspan='2' class='shazam question' data-shazam-mirror-visibility='pa_no'> PAs </td>
            <td colspan='2' class='shazam answer' data-shazam-mirror-visibility='pa_no'> pa_no </td>
            <td colspan='2' class='shazam question' data-shazam-mirror-visibility='bw_no'> BWs </td>
            <td colspan='2' class='shazam answer' data-shazam-mirror-visibility='bw_no'> bw_no </td>
            <td colspan='2' class='shazam question' data-shazam-mirror-visibility='opg_no'> Panoramics </td>
            <td colspan='2' class='shazam answer' data-shazam-mirror-visibility='opg_no'> opg_no </td>
        </tr>
    </table>


    <table colspan='20'>

        <!-- PA 1 and 2 -->
        <tr>
            <th class='subtitle' colspan='20' data-shazam-mirror-visibility='img_pa_1'>PA 1</th>
        </tr>
        <tr>
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            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='img_pa_1'> img_pa_1:label</td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='img_pa_1'> img_pa_1 </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='pa_loc_1'> pa_loc_1 </td>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='pa_date_1'> pa_date_1:label </td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='pa_date_1'> pa_date_1</td>
        </tr>
        <tr>
            <th class='subtitle' colspan='20' data-shazam-mirror-visibility='img_pa_2'>PA 2</th>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='img_pa_2'> img_pa_2:label</td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='img_pa_2'> img_pa_2 </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='pa_loc_2'> pa_loc_2 </td>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' style="empty-cell:show;" data-shazam-mirror-visibility='pa_date_2'> pa_date_2:label </td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='pa_date_2'> pa_date_2 </td>
        </tr>

        <!-- PA 3 and 4 -->
        <tr>
            <th class='subtitle' colspan='20' data-shazam-mirror-visibility='img_pa_3'>PA 3</th>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='img_pa_3'> img_pa_3:label</td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='img_pa_3'> img_pa_3 </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='pa_loc_3'> pa_loc_3 </td>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='pa_date_3'> pa_date_3:label </td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='pa_date_3'> pa_date_3 </td>
        </tr>
        <tr>
            <th class='subtitle' colspan='20' data-shazam-mirror-visibility='img_pa_4'>PA 4</th>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='img_pa_4'> img_pa_4:label</td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='img_pa_4'> img_pa_4 </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='pa_loc_4'> pa_loc_4 </td>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='pa_date_4'> pa_date_4:label </td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='pa_date_4'> pa_date_4 </td>
        </tr>

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        <!-- PA 5 and 6 -->
        <tr>
            <th class='subtitle' colspan='20' data-shazam-mirror-visibility='img_pa_5'>PA 5</th>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='img_pa_5'> img_pa_5:label</td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='img_pa_5'> img_pa_5 </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='pa_loc_5'> pa_loc_5 </td>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='pa_date_5'> pa_date_5:label </td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='pa_date_5'> pa_date_5 </td>
        </tr>
        <tr>
            <th class='subtitle' colspan='20' data-shazam-mirror-visibility='img_pa_6'>PA 6</th>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='img_pa_6'> img_pa_6:label</td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='img_pa_6'> img_pa_6 </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='pa_loc_4'> pa_loc_6 </td>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='pa_date_6'> pa_date_6:label </td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='pa_date_6'> pa_date_6 </td>
        </tr>

        <!-- PA 7 and 8 -->
        <tr>
            <th class='subtitle' colspan='20' data-shazam-mirror-visibility='img_pa_7'>PA 7</th>
        </tr>
        <tr>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='img_pa_7'> img_pa_7:label</td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='img_pa_7'> img_pa_7 </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='pa_loc_7'> pa_loc_7 </td>
        </tr>
        <tr>
            <td colspan='2' class='shazam question' data-shazam-mirror-visibility='pa_date_7'> pa_date_7:label </td>
            <td colspan='8' class='shazam answer' data-shazam-mirror-visibility='pa_date_7'> pa_date_7 </td>
        </tr>
        <tr>
            <th class='subtitle' colspan='20' data-shazam-mirror-visibility='img_pa_8'>PA 8</th>
        </tr>
        <tr>
            <td colspan='5' class='shazam question' data-shazam-mirror-visibility='img_pa_8'> img_pa_8:label</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='img_pa_8'> img_pa_8 </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='pa_loc_8'> pa_loc_8 </td>
        </tr>
        <tr>
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            <td colspan='2' class='shazam question' data-shazam-mirror-visibility='pa_date_8'> pa_date_8:label </td>
            <td colspan='8' class='shazam answer' data-shazam-mirror-visibility='pa_date_8'> pa_date_8 </td>
        </tr>

        <!-- OPG 1 and 2 -->
        <tr>
            <th class='subtitle' colspan='20' data-shazam-mirror-visibility='img_opg'>Panoramic</th>
        </tr>
        <tr>
            <td colspan='5' class='shazam question' data-shazam-mirror-visibility='img_opg'> img_opg:label</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='img_opg'> img_opg </td>
            <td colspan='5' class='shazam question' data-shazam-mirror-visibility='opg_date_1'> opg_date_1:label </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='opg_date_1'> opg_date_1 </td>
        </tr>
    </table>
</div>


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Written Record Entry

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<div id = odontgram>
    <table colspan = '20'>
        <tr>
            <td colspan='5' class='shazam date'>Date of Treatment</td>
            <td colspan='5' class='shazam date'>tx_date</td>
        </tr>
        <tr>
            <td colspan='10' class='shazam max1'> wr_tooth_no_1</td>
            <td colspan='10' class='shazam max2'> wr_tooth_no_2</td>
        </tr>
        <tr>
            <td colspan='10' class='shazam mand1'> wr_tooth_no_4</td>
            <td colspan='10' class='shazam mand2'> wr_tooth_no_3</td>
        </tr>
    </table>
</div>
```

```
<div id = "tableDiv">
<h3 class='dentist'> 18 - Upper Right Third Molar</h3>

<table colspan='20'>

    <tr>
        <td colspan='2' class='shazam question'>wr_pres_18:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility='wr_treat_18'>wr_treat_18:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility='wr_repl_18'>wr_repl_18:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='wr_repl_impcrown_18'>wr_repl_impcrown_18:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='wr_repl_poncrown_18'>wr_repl_poncrown_18:label</td>


    </tr>
    <tr>
        <td colspan='2' class='shazam answer'>wr_pres_18</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='wr_treat_18'>wr_treat_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='wr_repl_18'>wr_repl_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='wr_tth_repl_18'>wr_tth_repl_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='wr_repl_impcrown_18'>wr_repl_impcrown_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='wr_repl_poncrown_18'>wr_repl_poncrown_18</td>

    </tr>

</table>


<table colspan='20'>
    <tr>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='wr_rest_no_18'>wr_rest_no_18:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='wr_rest_no_18'>wr_rest_no_18</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='wr_pin_18'>wr_pin_18:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='wr_pin_18'>wr_pin_18</td>
    </tr>
</table>

<table>
    <tr>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='wr_rest_mat_18'>wr_rest_mat_18:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='wr_rest_surf_18'>wr_rest_surf_18:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='wr_rest_mat_2_18'>wr_rest_mat_2_18:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='wr_rest_surf_2_18'>wr_rest_surf_2_18:label</td>
    </tr>
    <tr>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='wr_rest_mat_18'>wr_rest_mat_18</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='wr_rest_surf_18'>wr_rest_surf_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='wr_rest_mat_2_18'>wr_rest_mat_2_18</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='wr_rest_surf_2_18'>wr_rest_surf_2_18</td>
    </tr>
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</table>

<table colspan='20'>
    <tr>
        <td colspan='8' class='shazam question' data-shazam-mirror-visibility='wr_crown_18'>wr_crown_18:label</td>
        <td colspan='4' class='shazam question' data-shazam-mirror-visibility='wr_post_18'>wr_post_18:label</td>
        <td colspan='8' class='shazam question' data-shazam-mirror-visibility='wr_mtl_surf_18'>wr_mtl_surf_18:label</td>
    </tr>
    <tr>
        <td colspan='8' class='shazam answer' data-shazam-mirror-visibility='wr_crown_18'> wr_crown_18</td>
        <td colspan='4' class='shazam answer' data-shazam-mirror-visibility='wr_post_18'>wr_post_18</td>
        <td colspan='8' class='shazam answer' data-shazam-mirror-visibility='wr_mtl_surf_18'>wr_mtl_surf_18</td>
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</table>
</div>
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Radiograph Entry

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<div id = "tableDiv">
<h3 class='dentist'> 18 - Upper Right Third Molar</h3>

<table colspan='20'>

    <tr>
        <td colspan='2' class='shazam question'>xray_pres_18:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility=
        'xray_treat_18'>xray_treat_18:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility=
        'xray_repl_18'>xray_repl_18:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility=
        'xray_repl_impcrown_18'>xray_repl_impcrown_18:label</td>
    </tr>
    <tr>
        <td colspan='2' class='shazam answer'>xray_pres_18</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility=
        'xray_treat_18'>xray_treat_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
        'xray_repl_18'>xray_repl_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
        'xray_tth_repl_18'>xray_tth_repl_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
        'xray_repl_impcrown_18'>xray_repl_impcrown_18</td>
    </tr>

</table>

<table colspan='20'>
    <tr>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
        'rest_no_18'>rest_no_18:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility=
        'rest_no_18'>rest_no_18</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
        'xray_pin_18'>xray_pin_18:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility=
        'xray_pin_18'>xray_pin_18</td>
    </tr>
</table>

<table>
    <tr>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility=
        'xray_rest_surf_18'>xray_rest_surf_18:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility=
        'xray_rest_surf_2_18'>xray_rest_surf_2_18:label</td>
        <td colspan='2' class='shazam question' data-shazam-mirror-visibility=
        'xray_post_18'>xray_post_18:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility=
        'xray_mtl_surf_18'>xray_mtl_surf_18:label</td>
    </tr>
    <tr>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility=
        'xray_rest_surf_18'>xray_rest_surf_18</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility=
        'xray_rest_surf_2_18'>xray_rest_surf_2_18</td>
        <td colspan='2' class='shazam answer' data-shazam-mirror-visibility=
        'xray_post_18'>xray_post_18</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility=
        'xray_mtl_surf_18'>xray_mtl_surf_18</td>
</table>

</div>
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Dental Chart Entry

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<div id = 'tableDiv'>
<h3 class='dentist'> 18 - Upper Right Third Molar</h3>

<table colspan='20'>
    <tr>
        <td colspan='2' class='shazam question'> ch_pres_18:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_treat_18'>ch_treat_18:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_repl_18'>ch_repl_18:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_impcrown_18'>ch_repl_impcrown_18:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_poncrown_18'>ch_repl_poncrown_18:label</td>
    </tr>
    <tr>
        <td colspan='2' class='shazam answer'>ch_pres_18</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='ch_treat_18'>ch_treat_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_18'>ch_repl_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_tth_repl_18'>ch_tth_repl_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_impcrown_18'>ch_repl_impcrown_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_poncrown_18'>ch_repl_poncrown_18</td>
    </tr>
</table>

<table colspan='20'>
    <tr>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_no_18'>ch_rest_no_18:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_no_18'>ch_rest_no_18</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_pin_18'>ch_pin_18:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_pin_18'>ch_pin_18</td>
    </tr>
</table>

<table>
    <tr>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_18'>ch_rest_mat_18:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_18'>ch_rest_surf_18:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_2_18'>ch_rest_mat_2_18:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_2_18'>ch_rest_surf_2_18:label</td>
    </tr>
    <tr>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_18'>ch_rest_mat_18</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_18'>ch_rest_surf_18</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_2_18'>ch_rest_mat_2_18</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_2_18'>ch_rest_surf_2_18</td>
    </tr>
</table>

<table colspan='20'>
    <tr>
        <td colspan='8' class='shazam question' data-shazam-mirror-visibility='ch_crown_18'>ch_crown_18:label</td>
```

```
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='ch_post_18'>ch_post_18:label</td>
        </tr>
        <tr>
            <td colspan='8' class='shazam answer' data-shazam-mirror-visibility='ch_crown_18'> ch_crown_18</td>
            <td colspan='4' class='shazam answer' data-shazam-mirror-visibility='ch_post_18'>ch_post_18</td>
        </tr>
    </table>
    </div>

    <div id = 'tableDiv'>
    <h3 class='dentist'> 17 - Upper Right Second Molar</h3>

    <table colspan='20'>
        <tr>
            <td colspan='2' class='shazam question'> ch_pres_17:label</td>
            <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_treat_17'>ch_treat_17:label</td>
            <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_repl_17'>ch_repl_17:label</td>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_impcrown_17'>ch_repl_impcrown_17:label</td>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_poncrown_17'>ch_repl_poncrown_17:label</td>
        </tr>
        <tr>
            <td colspan='2' class='shazam answer'>ch_pres_17</td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='ch_treat_17'>ch_treat_17</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_17'>ch_repl_17</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_tth_repl_17'>ch_tth_repl_17</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_impcrown_17'>ch_repl_impcrown_17</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_poncrown_17'>ch_repl_poncrown_17</td>
        </tr>
    </table>

    <table colspan='20'>
        <tr>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_no_17'>ch_rest_no_17:label</td>
            <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_no_17'>ch_rest_no_17</td>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_pin_17'>ch_pin_17:label</td>
            <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_pin_17'>ch_pin_17</td>
        </tr>
    </table>

    <table>
        <tr>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_17'>ch_rest_mat_17:label</td>
            <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_17'>ch_rest_surf_17:label</td>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_2_17'>ch_rest_mat_2_17:label</td>
            <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_2_17'>ch_rest_surf_2_17:label</td>
        </tr>
        <tr>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_17'>ch_rest_mat_17</td>
            <td colspan='7' class='shazam answer' data-shazam-mirror-visibility=
```

```
        'ch_rest_surf_17'>ch_rest_surf_17</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
        'ch_rest_mat_2_17'>ch_rest_mat_2_17</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility=
        'ch_rest_surf_2_17'>ch_rest_surf_2_17</td>
    </tr>
</table>

<table colspan='20'>
    <tr>
        <td colspan='8' class='shazam question' data-shazam-mirror-visibility=
        'ch_crown_17'>ch_crown_17:label</td>
        <td colspan='4' class='shazam question' data-shazam-mirror-visibility=
        'ch_post_17'>ch_post_17:label</td>
    </tr>
    <tr>
        <td colspan='8' class='shazam answer' data-shazam-mirror-visibility=
        'ch_crown_17'> ch_crown_17</td>
        <td colspan='4' class='shazam answer' data-shazam-mirror-visibility=
        'ch_post_17'>ch_post_17</td>
    </tr>
</table>
</div>

<div id = 'tableDiv'>
<h3 class='dentist'> 16 - Upper Right First Molar</h3>

<table colspan='20'>
    <tr>
        <td colspan='2' class='shazam question'> ch_pres_16:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility=
        'ch_treat_16'>ch_treat_16:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility=
        'ch_repl_16'>ch_repl_16:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
        'ch_repl_impcrown_16'>ch_repl_impcrown_16:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
        'ch_repl_poncrown_16'>ch_repl_poncrown_16:label</td>
    </tr>
    <tr>
        <td colspan='2' class='shazam answer'>ch_pres_16</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility=
        'ch_treat_16'>ch_treat_16</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
        'ch_repl_16'>ch_repl_16</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
        'ch_tth_repl_16'>ch_tth_repl_16</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
        'ch_repl_impcrown_16'>ch_repl_impcrown_16</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
        'ch_repl_poncrown_16'>ch_repl_poncrown_16</td>
    </tr>
</table>

<table colspan='20'>
    <tr>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
        'ch_rest_no_16'>ch_rest_no_16:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility=
        'ch_rest_no_16'>ch_rest_no_16</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
        'ch_pin_16'>ch_pin_16:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility=
        'ch_pin_16'>ch_pin_16</td>
    </tr>
</table>

<table>
    <tr>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
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            'ch_rest_mat_16'>ch_rest_mat_16:label</td>
            <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_16'>ch_rest_surf_16:label</td>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_2_16'>ch_rest_mat_2_16:label</td>
            <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_2_16'>ch_rest_surf_2_16:label</td>
        </tr>
        <tr>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_16'>ch_rest_mat_16</td>
            <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_16'>ch_rest_surf_16</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_2_16'>ch_rest_mat_2_16</td>
            <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_2_16'>ch_rest_surf_2_16</td>
        </tr>
    </table>

    <table colspan='20'>
        <tr>
            <td colspan='8' class='shazam question' data-shazam-mirror-visibility='ch_crown_16'>ch_crown_16:label</td>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility='ch_post_16'>ch_post_16:label</td>
        </tr>
        <tr>
            <td colspan='8' class='shazam answer' data-shazam-mirror-visibility='ch_crown_16'> ch_crown_16</td>
            <td colspan='4' class='shazam answer' data-shazam-mirror-visibility='ch_post_16'>ch_post_16</td>
        </tr>
    </table>
    </div>

    <div id = 'tableDiv'>
    <h3 class='dentist'> 15 - Upper Right Second Premolar</h3>

    <table colspan='20'>
        <tr>
            <td colspan='2' class='shazam question'> ch_pres_15:label</td>
            <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_treat_15'>ch_treat_15:label</td>
            <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_repl_15'>ch_repl_15:label</td>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_impcrown_15'>ch_repl_impcrown_15:label</td>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_poncrown_15'>ch_repl_poncrown_15:label</td>
        </tr>
        <tr>
            <td colspan='2' class='shazam answer'>ch_pres_15</td>
            <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='ch_treat_15'>ch_treat_15</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_15'>ch_repl_15</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_tth_repl_15'>ch_tth_repl_15</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_impcrown_15'>ch_repl_impcrown_15</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_poncrown_15'>ch_repl_poncrown_15</td>
        </tr>
    </table>

    <table colspan='20'>
        <tr>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_no_15'>ch_rest_no_15:label</td>
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        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_no_15'>ch_rest_no_15</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_pin_15'>ch_pin_15:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_pin_15'>ch_pin_15</td>
    </tr>
</table>

<table>
    <tr>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_15'>ch_rest_mat_15:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_15'>ch_rest_surf_15:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_2_15'>ch_rest_mat_2_15:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_2_15'>ch_rest_surf_2_15:label</td>
    </tr>
    <tr>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_15'>ch_rest_mat_15</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_15'>ch_rest_surf_15</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_2_15'>ch_rest_mat_2_15</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_2_15'>ch_rest_surf_2_15</td>
    </tr>
</table>

<table colspan='20'>
    <tr>
        <td colspan='8' class='shazam question' data-shazam-mirror-visibility='ch_crown_15'>ch_crown_15:label</td>
        <td colspan='4' class='shazam question' data-shazam-mirror-visibility='ch_post_15'>ch_post_15:label</td>
    </tr>
    <tr>
        <td colspan='8' class='shazam answer' data-shazam-mirror-visibility='ch_crown_15'> ch_crown_15</td>
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</table>
</div>

<div id = 'tableDiv'>
<h3 class='dentist'> 14 - Upper Right First Premolar</h3>

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        <td colspan='2' class='shazam question'> ch_pres_14:label</td>
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        <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_repl_14'>ch_repl_14:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_impcrown_14'>ch_repl_impcrown_14:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_poncrown_14'>ch_repl_poncrown_14:label</td>
    </tr>
    <tr>
        <td colspan='2' class='shazam answer'>ch_pres_14</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='ch_treat_14'>ch_treat_14</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_14'>ch_repl_14</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
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            'ch_tth_repl_14'>ch_tth_repl_14</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
            'ch_repl_impcrown_14'>ch_repl_impcrown_14</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
            'ch_repl_poncrown_14'>ch_repl_poncrown_14</td>
        </tr>
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    <table colspan='20'>
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            'ch_rest_no_14'>ch_rest_no_14:label</td>
            <td colspan='7' class='shazam answer' data-shazam-mirror-visibility=
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            <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
            'ch_pin_14'>ch_pin_14:label</td>
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            'ch_pin_14'>ch_pin_14</td>
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    <table>
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            'ch_rest_mat_14'>ch_rest_mat_14:label</td>
            <td colspan='7' class='shazam question' data-shazam-mirror-visibility=
            'ch_rest_surf_14'>ch_rest_surf_14:label</td>
            <td colspan='3' class='shazam question' data-shazam-mirror-visibility=
            'ch_rest_mat_2_14'>ch_rest_mat_2_14:label</td>
            <td colspan='7' class='shazam question' data-shazam-mirror-visibility=
            'ch_rest_surf_2_14'>ch_rest_surf_2_14:label</td>
        </tr>
        <tr>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
            'ch_rest_mat_14'>ch_rest_mat_14</td>
            <td colspan='7' class='shazam answer' data-shazam-mirror-visibility=
            'ch_rest_surf_14'>ch_rest_surf_14</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
            'ch_rest_mat_2_14'>ch_rest_mat_2_14</td>
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            'ch_rest_surf_2_14'>ch_rest_surf_2_14</td>
        </tr>
    </table>

    <table colspan='20'>
        <tr>
            <td colspan='8' class='shazam question' data-shazam-mirror-visibility=
            'ch_crown_14'>ch_crown_14:label</td>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility=
            'ch_post_14'>ch_post_14:label</td>
        </tr>
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            <td colspan='8' class='shazam answer' data-shazam-mirror-visibility=
            'ch_crown_14'> ch_crown_14</td>
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            'ch_post_14'>ch_post_14</td>
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    </div>

    <div id = 'tableDiv'>
    <h3 class='dentist'> 13 - Upper Right Canine</h3>

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            'ch_treat_13'>ch_treat_13:label</td>
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            'ch_repl_13'>ch_repl_13:label</td>
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        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_impcrown_13'>ch_repl_impcrown_13:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_poncrown_13'>ch_repl_poncrown_13:label</td>
    </tr>
    <tr>
        <td colspan='2' class='shazam answer'>ch_pres_13</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='ch_treat_13'>ch_treat_13</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_13'>ch_repl_13</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_tth_repl_13'>ch_tth_repl_13</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_impcrown_13'>ch_repl_impcrown_13</td>
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<table colspan='20'>
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        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_no_13'>ch_rest_no_13</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_pin_13'>ch_pin_13:label</td>
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<table>
    <tr>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_13'>ch_rest_mat_13:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_13'>ch_rest_surf_13:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_2_13'>ch_rest_mat_2_13:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_2_13'>ch_rest_surf_2_13:label</td>
    </tr>
    <tr>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_13'>ch_rest_mat_13</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_13'>ch_rest_surf_13</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_2_13'>ch_rest_mat_2_13</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_2_13'>ch_rest_surf_2_13</td>
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</table>

<table colspan='20'>
    <tr>
        <td colspan='8' class='shazam question' data-shazam-mirror-visibility='ch_crown_13'>ch_crown_13:label</td>
        <td colspan='4' class='shazam question' data-shazam-mirror-visibility='ch_post_13'>ch_post_13:label</td>
    </tr>
    <tr>
        <td colspan='8' class='shazam answer' data-shazam-mirror-visibility='ch_crown_13'> ch_crown_13</td>
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<div id = 'tableDiv'>
<h3 class='dentist'> 12 - Upper Right Lateral Incisor</h3>

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        <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_repl_12'>ch_repl_12:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_impcrown_12'>ch_repl_impcrown_12:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_poncrown_12'>ch_repl_poncrown_12:label</td>
    </tr>
    <tr>
        <td colspan='2' class='shazam answer'>ch_pres_12</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='ch_treat_12'>ch_treat_12</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_12'>ch_repl_12</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_tth_repl_12'>ch_tth_repl_12</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_impcrown_12'>ch_repl_impcrown_12</td>
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        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_no_12'>ch_rest_no_12</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_pin_12'>ch_pin_12:label</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_pin_12'>ch_pin_12</td>
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<table>
    <tr>
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        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_12'>ch_rest_surf_12:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_2_12'>ch_rest_mat_2_12:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_2_12'>ch_rest_surf_2_12:label</td>
    </tr>
    <tr>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_12'>ch_rest_mat_12</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_12'>ch_rest_surf_12</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_rest_mat_2_12'>ch_rest_mat_2_12</td>
        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_surf_2_12'>ch_rest_surf_2_12</td>
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<table colspan='20'>
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        <td colspan='4' class='shazam question' data-shazam-mirror-visibility='ch_post_12'>ch_post_12:label</td>
    </tr>
    <tr>
        <td colspan='8' class='shazam answer' data-shazam-mirror-visibility='ch_crown_12'> ch_crown_12</td>
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<div id = 'tableDiv'>
<h3 class='dentist'> 11 - Upper Right Central Incisor</h3>

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        <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_treat_11'>ch_treat_11:label</td>
        <td colspan='6' class='shazam question' data-shazam-mirror-visibility='ch_repl_11'>ch_repl_11:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_impcrown_11'>ch_repl_impcrown_11:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_repl_poncrown_11'>ch_repl_poncrown_11:label</td>
    </tr>
    <tr>
        <td colspan='2' class='shazam answer'>ch_pres_11</td>
        <td colspan='6' class='shazam answer' data-shazam-mirror-visibility='ch_treat_11'>ch_treat_11</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_11'>ch_repl_11</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_tth_repl_11'>ch_tth_repl_11</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_impcrown_11'>ch_repl_impcrown_11</td>
        <td colspan='3' class='shazam answer' data-shazam-mirror-visibility='ch_repl_poncrown_11'>ch_repl_poncrown_11</td>
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        <td colspan='7' class='shazam answer' data-shazam-mirror-visibility='ch_rest_no_11'>ch_rest_no_11</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_pin_11'>ch_pin_11:label</td>
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</table>

<table>
    <tr>
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        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_11'>ch_rest_surf_11:label</td>
        <td colspan='3' class='shazam question' data-shazam-mirror-visibility='ch_rest_mat_2_11'>ch_rest_mat_2_11:label</td>
        <td colspan='7' class='shazam question' data-shazam-mirror-visibility='ch_rest_surf_2_11'>ch_rest_surf_2_11:label</td>
    </tr>
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            <td colspan='7' class='shazam answer' data-shazam-mirror-visibility=
            'ch_rest_surf_11'>ch_rest_surf_11</td>
            <td colspan='3' class='shazam answer' data-shazam-mirror-visibility=
            'ch_rest_mat_2_11'>ch_rest_mat_2_11</td>
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    <table colspan='20'>
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            'ch_crown_11'>ch_crown_11:label</td>
            <td colspan='4' class='shazam question' data-shazam-mirror-visibility=
            'ch_post_11'>ch_post_11:label</td>
        </tr>
        <tr>
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Multiple Codes

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<div id='tableDiv'>
    <h3 class='dentist'>18 - Upper Right Third Molar </h3>
    <table style='width: 100%;' colspan='20'>
        <tr>
            <th class='title' colspan='5'>TREATMENT</th>
            <th class='title' colspan='10'>CODE</th>
            <th class='title' colspan='5'>DATA SOURCE</th>
        </tr>

        <!--mam-->
        <tr>
            <td colspan='5' rowspan='3' class='question' data-shazam-mirror-visibility='mc_mam_18'> Missing Antemortem</td>
            <td colspan='10' rowspan='3' class='shazam answer' data-shazam-mirror-visibility='mc_mam_18'> mc_mam_18</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='wr1_18'> wr1_18:label</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='xray1_18'> xray1_18:label </td>
        </tr>
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            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='ch1_18'> ch1_18:label </td>
        </tr>

        <!--pre-->
        <tr>
            <td colspan='5' rowspan = '3' class='question' data-shazam-mirror-visibility='mc_pre_18'> Present (No Treatment or Unknown Condition)</td>
            <td colspan='10' rowspan = '3' class='shazam answer' data-shazam-mirror-visibility='mc_pre_18'> mc_pre_18</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='wr4_18'> wr4_18:label</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='xray4_18'> xray4_18:label</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='ch4_18'> ch4_18:label </td>
        </tr>

        <!--une-->
        <tr>
            <td colspan='5' class='question' data-shazam-mirror-visibility='mc_une_18'> Unerupted </td>
            <td colspan='10' class='shazam answer' data-shazam-mirror-visibility='mc_une_18'> mc_une_18</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_une_18'> Radiograph</td>
        </tr>

        <!--rov-->
        <tr>
            <td colspan='5' class='question' data-shazam-mirror-visibility='mc_rov_18'> Retained Root (No Crown Structure) </td>
            <td colspan='10' class='shazam answer' data-shazam-mirror-visibility='mc_rov_18'> mc_rov_18</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='wr6_18'> wr6_18:label </td>
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        <!--mtl-->
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            <td colspan='5' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='mc_mtl_18'>mc_mtl_18</td>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_mtl_wr_18'> mc_surfaces_mtl_wr_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_mtl_wr_18'>Written Record</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_mtl_xray_18'> mc_surfaces_mtl_xray_18</td>
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        <!--tcf-->
        <tr>
            <td colspan='5' rowspan='4' class='question' data-shazam-mirror-visibility='mc_tcf_18'> Restoration - Tooth Coloured </td>
            <td colspan='5' rowspan='4' class='shazam answer' data-shazam-mirror-visibility='mc_tcf_18'>mc_tcf_18</td>
            <td colspan='5' rowspan='2' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surf_tcf_all_18'> mc_surf_tcf_all_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_tcf_all_18'>Written Record</td>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_wr1_18'> mc_surfaces_wr1_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_wr1_18'>Written Record</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_tcf_all_18'>Dental Chart</td>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_ch1_18'> mc_surfaces_ch1_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_ch1_18'>Dental Chart</td>
        </tr>
        <tr>
            <td colspan='5' rowspan='2' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surf_tcf_all_2_18'>mc_surf_tcf_all_2_18 </td>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_wr2_18'> mc_surfaces_wr2_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_wr2_18'>Written Record</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_tcf_all_2_18'>Written Record</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_ch2_18'> mc_surfaces_ch2_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_ch2_18'>Dental Chart</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_tcf_all_2_18'>Dental Chart</td>
        </tr>

        <!--mcf-->
        <tr>
            <td colspan='5' rowspan='4' class='question' data-shazam-mirror-visibility='mc_mcf_18'> Restoration - Metal Coloured </td>
            <td colspan='5' rowspan='4' class='shazam answer' data-shazam-mirror-visibility='mc_mcf_18'>mc_mcf_18</td>
            <td colspan='5' rowspan='2' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surf_mcf_all_18'> mc_surf_mcf_all_18 </td>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility=
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            'mc_surfaces_wr3_18'> mc_surfaces_wr3_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_wr3_18'>Written Record</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_mcf_all_18'>Written Record</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_ch3_18'> mc_surfaces_ch3_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_ch3_18'>Dental Chart</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_mcf_all_18'>Dental Chart</td>
        </tr>
        <tr>
            <td colspan='5' rowspan='2' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surf_mcf_all_2_18'>mc_surf_mcf_all_2_18 </td>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_wr4_18'> mc_surfaces_wr4_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_wr4_18'>Written Record</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_mcf_all_2_18'>Written Record</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_ch4_18'> mc_surfaces_ch4_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_ch4_18'>Dental Chart</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_mcf_all_2_18'>Dental Chart</td>
        </tr>

        <!--uif-->
        <tr>
            <td colspan='5' rowspan='6' class='question' data-shazam-mirror-visibility='mc_uif_18'> Restoration - Unknown Material </td>
            <td colspan='5' rowspan='6' class='shazam answer' data-shazam-mirror-visibility='mc_uif_18'>mc_uif_18</td>
            <td colspan='5' rowspan='6' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surf_uif_all_18'> mc_surf_uif_all_18 </td>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_wr5_18'> mc_surfaces_wr5_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_wr5_18'>Written Record</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_uif_all_18'>Written Record</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_ch5_18'> mc_surfaces_ch5_18 </td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_ch5_18'>Dental Chart</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_uif_all_18'>Dental Chart</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_xray1_18'> mc_surfaces_xray1_18</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_xray1_18'>Radiograph</td>

        </tr>
        <tr>
            <td colspan='5' rowspan='3' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surf_uif_all_2_18'>mc_surf_uif_all_2_18 </td>
            <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility=
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        'mc_surfaces_wr6_18'> mc_surfaces_wr6_18</td>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_wr6_18'>Written Record</td>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_uif_all_2_18'>Written Record</td>
    </tr>
    <tr>
        <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_ch6_18'> mc_surfaces_ch6_18 </td>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_ch6_18'>Dental Chart</td>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surf_uif_all_2_18'>Dental Chart</td>
    </tr>
    <tr>
        <td colspan='5' class='shazam questionsurf' data-shazam-mirror-visibility='mc_surfaces_xray2_18'> mc_surfaces_xray2_18</td>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='mc_surfaces_xray2_18'>Radiograph</td>
    </tr>

    <!--ppx-->
    <tr>
        <td colspan='5' rowspan='3' class='question' data-shazam-mirror-visibility='mc_ppx_18'> Parapulpal Pins </td>
        <td colspan='10' rowspan='3' class='shazam answer' data-shazam-mirror-visibility='mc_ppx_18'> mc_ppx_18</td>
        <td colspan='5' rowspan='3' class='shazam answer' data-shazam-mirror-visibility='wr10_18'>wr10_18:label</td>
    </tr>
    <tr>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='xray10_18'> xray10_18:label </td>
    </tr>
    <tr>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='ch10_18'>ch10_18:label</td>
    </tr>

    <!--rfx-->
    <tr>
        <td colspan='5' rowspan='3' class='question' data-shazam-mirror-visibility='mc_rfx_18'> Root Canal Filling </td>
        <td colspan='10' rowspan='3' class='shazam answer' data-shazam-mirror-visibility='mc_rfx_18'> mc_rfx_18</td>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='wr2_18'> wr2_18:label </td>
    </tr>
    <tr>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='xray2_18'> xray2_18:label</td>
    </tr>
    <tr>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='ch2_18'>ch2_18:label </td>
    </tr>

    <!--pox-->
    <tr>
        <td colspan='5' rowspan='3' class='question' data-shazam-mirror-visibility='mc_pox_18'> Post </td>
        <td colspan='10' rowspan='3' class='shazam answer' data-shazam-mirror-visibility='mc_pox_18'> mc_pox_18</td>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='wr11_18'>wr11_18:label</td>
    </tr>
    <tr>
        <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='xray11_18'>xray11_18:label</td>
    </tr>
```

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        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='ch11_18'>ch11_18:label</td>
        </tr>

        <!--mcc-->
        <tr>
            <td colspan='5' rowspan='2' class='question' data-shazam-mirror-visibility='mc_mcc_18'> Crown - Metal Ceramic </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='mc_mcc_18'> mc_mcc_18</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='wr12_18'>wr12_18:label</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='ch12_18'> ch12_18:label</td>
        </tr>

        <!--mtc-->
        <tr>
            <td colspan='5' rowspan='2' class='question' data-shazam-mirror-visibility='mc_mtc_18'> Crown - Metal Coloured </td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='mc_mtc_18'> mc_mtc_18</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='wr13_18'>wr13_18:label</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='ch13_18'> ch13_18:label </td>
        </tr>

        <!--tcc-->
        <tr>
            <td colspan='5' rowspan='2' class='question' data-shazam-mirror-visibility='mc_tcc_18'> Crown - Tooth Coloured (No Metal)</td>
            <td colspan='10' rowspan='2' class='shazam answer' data-shazam-mirror-visibility='mc_tcc_18'> mc_tcc_18</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='wr14_18'> wr14_18:label </td>
        </tr>
        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='ch14_18'>ch14_18:label</td>
        </tr>

        <!--uic-->
        <tr>
            <td colspan='5' rowspan='3' class='question' data-shazam-mirror-visibility='mc_uic_18'> Crown - Unknown Material </td>
            <td colspan='10' rowspan='3' class='shazam answer' data-shazam-mirror-visibility='mc_uic_18'> mc_uic_18</td>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='wr15_18'>wr15_18:label</td>
        </tr>
        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='xray15_18'> xray15_18:label </td>
        </tr>
        <tr>
            <td colspan='5' class='shazam answer' data-shazam-mirror-visibility='ch15_18'> ch15_18:label </td>
        </tr>
    </table>
</div>
```

CSS

```
#tableDiv {
    border: 2px solid #bccfe8;
    margin:5px 5px 0px 5px;
    background-color: #fffde7;
}
.question {
    background-color: #fffacd;
    border-bottom: 2px solid #bccfe8;
    padding: 5px;
    font-family: Lucida Sans;
    font-size: 14px;
    text-align: center;
}
.answer {
    background-color: #fffde7;
    border-bottom: 2px solid #bccfe8;
    padding: 5px;
    font-family: Lucida Sans;
    font-size: 14px;
    text-align: center;
}
.questionsurf {
    background-color: #fffde7;
    border-bottom: 2px solid #bccfe8;
    padding: 5px;
    font-family: Lucida Sans;
    font-size: 14px;
}
.dentist {
    font-family: Georgia;
    font-size: 22px;
    background-color: #bccfe8;
    border: 5px solid #bccfe8;
    margin-bottom: 0px;
    letter-spacing: 5px;
}
.warning {
    background-color: #FF2400;
    color: white;
    font-weight: bold;
    font-family: Lucida Sans;
    font-size: 19px;
}
.title {
    background-color: #c6daf5;
    padding-left: 20px;
    letter-spacing: 5px;
    font-family: Georgia;
    font-size: 16px;
    text-align: center;
}
.subtitle {
    background-color: #bccfe8;
    border: 2px solid #bccfe8;
    text-align: center;
    letter-spacing: 5px;
    font-family: Georgia;
    font-size: 16px;
}
.leftside {
    background-color: #fff9b4;
    font-family: Lucida Sans;
    font-size: 14px;
    padding-left: 10px;

```

Appendix VIII – Presentations and Awards

2019

Adelaide Dental School, Colgate Research Day – Research presentation

Title: Dental Identification by Pattern Matching – Variation and Reliability of Techniques

Prize for best HDR presentation (Masters and PhD)

AuSFO Conference – Research presentation

Title: Dental Identification by Pattern Matching – Variation and Reliability of Techniques

Gerry Dalitz Award for best presentation

2020

Florey Postgraduate Research Conference –Poster presentation

Title: Variation and Decision Making in Antemortem Dental Record Transcription

Prize for best presentation in Oral Health Applied category

2021

Florey Postgraduate Research Conference –Poster presentation

Title: Accuracy and Variation in Transcription of Antemortem Dental Data

2022

ANZFSS Conference – Poster presentation

Title: Software Assisted Antemortem Transcription for Dental Identification

Scholarships

Winifred E. Preedy Postgraduate Scholarship – 2019

Research Training Program Scholarship – 2020-2022

Oliver Rutherford Turner Supplementary Scholarship – 2020