The Long Term Stability of the Le Fort I Osteotomy

Dr. GEOFF DANCE

B.D.Sc. , FRACDS (OMS).

Oral Maxillofacial Surgery Unit

Faculty of Dentistry

The University of Adelaide

South Australia

1999

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Abstract

The Le Fort I osteotomy is a surgical procedure designed to correct certain types of maxillary deformities. It enables the maxilla to be repositioned within certain limits in three dimensions. These shifts can be performed leaving the maxillary arch intact or the arch can be cut into segments and expanded or compressed. Bone grafts may or may not be required. The procedure has gained world wide acceptance and has been widely performed over the last three decades . It was however first described last century. The maxilla is shifted into a preplanned position and fixated via various methods, however over a period of time relapse has been shown to occur.

The aim of this research was to measure relapse and to identify the factors that influence relapse over a long period of time (minimum of one year). The incidence and timing of relapse has been documented in many studies. These have largely been conflictive and inconclusive. Most of these studies have been of short duration.

The research is a retrospective study based on cephalometric analysis of pre and post operative radiographs to determine the extent of relapse. Patients who had undergone a Le Fort I osteotomy in the period 1984 to 1997 at the Royal Adelaide Hospital were included if they had a complete set of lateral cephalograms and other records greater than one year post surgery. Out of 287 patients undergoing this procedure, 100 fulfilled these requirements.

Utilising a standardised approach these cephalograms were analysed to determine changes in the maxillae from pre to post surgery, and then post surgery to greater than one year. This quantified the amount and direction of movement with the original surgery and also any long term post surgical

instability.

After a review of the literature various factors that may influence the stability of the surgery were identified. These included whether orthodontics were utilised or not, the direction of movement, the magnitude of movement, concurrent mandibular surgery, the type of fixation, the use of bone grafts, and segmental versus non segmental treatments. The age, sex and growth status of the patient were also assessed for their influence on stability, as was the experience of the surgeon performing the operation.

A close examination of the errors of method was undertaken and discussed. This identified limitations that are inherent in this form of study. The major factors identified and addressed were accurate landmark identification.

This study showed that all Le Fort I osteotomies have a degree of post surgical instability. As has been found in other short term studies the direction of maxillary movement altered the amount of instability post surgery. Advancement osteotomies are more stable than the superior repositioned maxilla, which in turn are more stable than the inferior repositioned maxilla.

The occurrence of the instability was within the first twelve months after the operation was performed. After minor early instability the Le Fort I osteotomy can be considered stable in the long term.

Instability with superior repositioning can occur either in a further superior direction or relapse in an inferior direction. Identification of aetiological factors that may aid the recognition of the patients in each of these groups prior to surgery was not achieved.

No significant difference in stability could be assigned to age or gender. Whether orthodontic treatment was performed or not had no influence on the stability of the Le Fort I osteotomy. The type of fixation used at surgery generally had no bearing on the amount of post-surgical instability. In the inferiorly repositioned group there was a slight improvement in stability when bone plates were used rather than intra-osseous wiring.

Bone graft use, growth in the patient, and the experience of the surgeon performing the Le Fort I osteotomy had no effect on the amount of long term stability. Concurrent mandibular osteotomies performed with the maxillary osteotomy also had no influence on the long term stability of the Le Fort I procedure. Segmentalised maxillae, either for transverse or vertical discrepancies in the maxilla, had similar relapse rates as one piece maxillary osteotomies.

This study confirms that the Le Fort I osteotomy is versatile, robust and essentially stable.

Declaration

This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Dental Surgery. I declare that the text of this thesis has not been previously published or written by another person except where due reference is made. The findings are the results of my personal investigations. No part of this work has been previously submitted for a degree in any University.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Geoff Dance,

B.D.Sc. (Melb), F.R.A.C.D.S. (O.M.S.).

The University of Adelaide,

December 1999.

Acknowledgements

This research study on the Long Term Stability of the Le Fort I Osteotomy is submitted as part requirement for the Master of Dental Science , Oral and Maxillofacial Surgery at the University of Adelaide , South Australia.

Many thanks must be given to my supervisors , Professor Alastair Goss and Dr. Robert H.B. Jones, for their direction and support during this project which commenced in 1995. The advice of the other consultants within the unit was also greatly appreciated - Dr Paul Duke, Dr Paul Sambrook and Dr Miles Doddridge. Thanks must also go to those consultants and registrars who performed the surgery on patients up to fifteen years prior to this study who have since left the unit. Particular thanks is directed to Professor Henk Tideman, former Professor of Oral and Maxillofacial Surgery, University of Adelaide (1983 - 1989), currently Professor of Oral and Maxillofacial Surgery, University of Hong Kong.

Professor Goss provided constant encouragement , guidance and constructive criticism which enabled me not only to complete the research component of the Masters degree but the four years of clinical experience that culminated in the successful completion of my Fellowship examinations.

Dr. Jones has always been a source of inspiration in both my personal and professional life. He has taught me a great deal about the finer points of academic pursuits and surgical skills. On a personal level the support of my partner Jodie, has enabled me to endure the low points and revel in the highs. Thank you Jodie.

Geoff Dance

December 1999

I

Introduction

Chapter 1 : The Le Fort osteotomy for the correction of the maxillary position in three dimensions.

1.1 Overview and Aims

Dentofacial deformity involving deficiencies or excesses of the maxilla are common to all populations. These may be of both a cosmetic and functional concern to the individual involved.

Various possible maxillary problems that can occur in isolation or in conjunction with other facial deformities can be corrected with a surgical approach to obtain a more desirable functional and aesthetic unit (Chapter 2). The Le Fort 1 osteotomy is a proven surgical technique used world wide to address these deformities. It can be used to alter the position of the maxilla within certain limits in three dimensions of space.

The technique, risks and morbidity of this operation are well documented (Chapter 2). Relapse associated with this technique has been researched in the short term but long term studies are few in number.

The degree of surgical movement and relapse can be analysed utilising cephalometric evaluation. Cephalometry, is an extensive subject, and is discussed in chapter 3, including the use of appropriate land marks. Relapse in terms of the surgery and final position of the occlusion are discussed in Chapter 4.

The review of the literature identified a number of variations that may play a role in the occurrence of relapse and at what interval they occur. These factors are discussed in chapter 5 , including the role of pre and post surgery orthodontics.

The biomechanics of bone plates and other fixtures_are discussed in chapter 6. The material and methods, results and errors are presented in chapters 8 and 9 followed by discussion ,chapters 11 , 12 ,and the conclusions.

The aims of this study were to :

1) Retrieve data from the files of the OMF unit of patients who had undergone maxillary surgery.

2) To examine lateral head radiographs to help determine the presence of relapse in 2 planes ,vertical and anteroposteriorly, over an extended period of time.

3) To establish whether certain variables affect the degree and timing of relapse. These include:

Gender

Age at the time of operation

Use of bone grafts

Surgeons

Concurrent mandibular surgery

Fixtures (wire or plates)

The investigation involved 100 patients who had Le Fort 1 maxillary osteotomies in isolation or conjunction with other surgical procedures. It included maxillae repositioned in all 3 planes of space and examined both horizontal and vertical relapse.

II

Review of the Literature

Review of the Literature.

Chapter 2 : Dentofacial discrepancies involving the maxilla.

2.1 History

The first recorded maxillary osteotomy was performed by Van Langerbeck in 1859. Via an extraoral approach he divided the maxilla horizontally and displaced it inferiorly to gain access to a tumour. A down fracture of the maxilla was also performed by Cheever who used it to gain access to a nasopharyangeal mass in 1864. (Drommer 1986, The History of the Le Fort I osteotomy).

In 1921 Hermann Wassmund in Germany attempted to correct a dentofacial deformity by maxillary osteotomy. He did not fully mobilise the maxilla but applied orthopaedic forces post surgically.

In 1934 Auxhauser published his method of mobilisation of the maxilla for correction of an anterior open bite.

Schuchardt (1942) further developed the procedure noting that the previous incomplete osteotomies were not sufficient to enable anterior repositioning of the maxilla. He advised pterygomaxillary dysfunction to accomplish this.

Converse et al in the Journal of Plastic Reconstructive Surgery in 1952 described the use of maxillary osteotomy to correct developmental malformations of the jaw. They described a retromolar and transpalatal osteotomy in conjunction with a maxillary dentoalveolar osteotomy.

Prior to 1965 dentofacial deformities were usually treated by mandibular procedures alone. The results were often considered less than satisfactory as they failed to address the actual site of the deformity. Many authors published their experiences with Le Fort 1 osteotomies in the late 1960's and early 1970's including Obwegeser, Willmar, and Epker et al. Epker reported stable results with this procedure.

Bell et al was the first to examine the biological basis of Le Fort 1 osteotomies. He found the procedure to be based on sound principles with his histological / microangiographical study.

Epker published in 1983 the results of his research into the vascularisation of the maxilla and its application to maxillary procedures. He found that the blood supply to the buccal alveolus, peridontium and teeth are from the posterior superior alveolar vessels. The palatal blood supply is from the greater palatine vessels and the buccal labial attached gingiva and adjacent free mucosa are supplied via the underlying bone.

Many comprehensive descriptions of the maxillary osteotomy have been published since. (Kieh et al 1968, Proffit et al 1970, Nelson et al 1977, Araujo et al 1978, Epker et al 1980, Maloney et al 1981, Kahnberg et al 1988 etc.)

2.2 Classifications of Maxillary Discrepancies.

Maxillary components of dentofacial deformities may be associated with specific facial syndromes and congenital anomalies but these are rare. Most Le Fort procedures are undertaken on patients with isolated jaw and teeth discrepancies.

Some cases can be attributed to specific causes such as asymmetries, Treacher Collins syndrome, clefts and trauma but in most cases it is considered a complex interaction between hereditary susceptibility, environmental influences on growth, and cellular and tissue responses to growth promoting agents.

Classically dentofacial deformities are described according to Angle's classification (Angle 1907). The Angle classification of malocclusion primarily refers to characteristics related to the antero-posterior or saggital plane. The original Angle classification was based entirely on the dental relationships but was linked to skeletal relationships by reference to the position of the maxillary first molar. Angle observed that the maxillary first molar is found under the 'key ridge' of the maxilla, which is the lateral buttress of the zygomatic arch. Angle considered this relationship a biological benchmark and made it the basis for his classification.

Based on this theory Angle believed the problems of malocclusion related to the antero-posterior plane of space were due

1. solely to malposition of the teeth within the arches (Class I).
2. to a distal position of the mandibular molar (and by inference, the mandible) (Class II).

3.to a mesial position of the mandibular molar (Class III).

(Bell et al 1986)

Class II dentofacial deformities are associated with either a combination of maxillary prognathism or mandibular retrognathism. These horizontal discrepancies can also be complicated by vertical discrepancies resulting in a skeletal open bite or a deep overbite (Class II Div. II). Transverse discrepancies can also coexist.

Class III dentofacial deformities can be either true or pseudo mandibular prognathism. Pseudo mandibular prognathism is usually a reflection of a hypoplastic maxilla in the antero-posterior direction. Clinically these patients present with a concave facial profile with an obtuse nasolabial angle, a retrusive upper lip and a narrow alar base.

Vertical maxillary excess can occur in conjunction with the above discrepancies or in isolation. It presents in many forms with seven different forms being described by Schendel et.al. (1985) and Delaire et al (1981).

These seven groups included:

1. Maxillary vertical excess (V.M.E.) with vertical chin excess.

2. Patients with short upper lips and no maxillary skeletal deformities. (Giving an impression of V.M.E.).

3. Total maxillary excess with pre maxillary abasement. V.M.E. with chin excess exaggerated by lowering of the total pre maxilla.

4.Maxillary excess with palatal rotation (Counter- clockwise or clockwise).

5.Maxillary excess with 'abasement' of the posterior palate. V.M.E. with lowering of the posterior palate.

6.Maxillary excess with pre maxillary elevation. Posterior V.M.E. is greater . Pre maxillary segment is rotated superiorly.

7.Posterior maxillary deficiency with anterior excess.

All except one are bony related (the exception being individuals with short lips and vertical excess in the chin). The most common presentation is vertical excess in the maxillary alveolus (Schendel et al 1985). These broad categories are clinically useful for vertical maxillary excess with or without an openbite.

The other main group of patients that may require Le Fort osteotomies are those patients that have severe facial asymmetry. Most of these would be included in the developmental group, including entities such as hemifacial hypertrophy, hemifacial microsomia, cleft lips and palates, condylar hypognathism or hyperplasia leading to secondary asymmetrical growth of the maxilla. Other asymmetries include patients with Rombergs syndrome, and growth disturbances secondary to trauma, surgery and irradiation.

2.3 Incidence.

The prevalence of dentofacial deformities severe enough to warrant surgical correction has not been systematically studied. Some American data gives an approximate idea on the extent of the problem.

Proffit et al (1970) estimates the median of the American population that would benefit from maxillary surgery for skeletal Class II's, III's and anterior open bite to be 2.6%. This percentage, although it sounds small, would represent some half a million individuals in the U.S.A. or in Australia 50,000 individuals. These though, are estimates, but do show dentofacial deformities which could require surgery are prevalent.

Severe crowding of the teeth in the white American population was 27%. (Kelly 1977).

Further analysing this , they found that 5% of the population had severe malocclusion that might be considered handicapping. Of this 5% it is not possible to say which would be treatable with surgery rather than orthodontic camouflaging and also what percentage of the group would require maxillary surgery as part of their treatment plan.

There are fewer studies on the prevalence of malocclusions in Australian populations. Eshoko et al (1994) and a similar study by Tod et al (1997) found the incidence of malocclusion that required intervention with orthodontic treatment to be about 6% in Australian school children and adults. Again no specific study has examined the prevalence of patients that would benefit from adjunctive surgery.

Extrapolation of American data to Australian circumstances appears to be justified. Cons et al (1983) compared malocclusions between Australia , the German Democratic Republic and the United States of America and found them to be essentially the same.

2.4 Maxillary Growth - Normal growth patterns of the maxilla.

The facial skeleton grows downward and forwards from the anterior cranial base and increases in size sagittally, vertically and transversely. This is partly as a result of sutural growth and partly as a result of periosteal remodelling. Sutural growth is important initially , but continues at a fairly slow rate until after puberty. Subsequently all changes are secondary to periosteal remodelling. Farrer (1984) reviewed the effects of growth on the facial profile:

1.Males tended to grow more in all directions , commencing and finishing later in life (13 - 18 years). Most female growth occurs between 8 - 13 years and stops by 15 years.
2. Males attained relatively longer faces compared to females who display relatively deeper faces. Facial convexity flattened with age for both sexes but the effect was greater in males.
3. The faces of 12 year old females did not differ significantly from those in adulthood except in dimension. In contrast, the faces of 12 year old males underwent marked change by adulthood.

Bjork (1955) inserted small tantallium implants into the maxillae of growing children and radiographically monitored their descent, and thus the movement of the maxillae, relative to the anterior cranial base. The maxillae exhibits a variable degree of rotation. The rotation of the maxillae is masked by periosteal activity. Thus the maxillae grows in length, in height and in breadth by a combination of sutural activity and periosteal remodelling.

The increase in height of the maxilla occurs due to sutural growth at the frontal and zygomatic bones and appositionally on the lower aspects of the alveolar process in association with the eruption of teeth. Enlow and Bang (1965) found that bone was added to the maxillae superiorly and posteriorly. The superior additions occurred on the orbital surfaces as well as the supramaxillary sutures. The principle posterior addition is in the region of the maxillary tuberosity. These additions together produce a translocation of the maxillae downwards and forward.

The maxillary alveolar arch undergoes apposition of bone on the buccal periosteal surface of the arch and also posteriorly at the tuberosity (the most active region of deposition) , whereas there is resorption of bone anterior to the root of the maxillary zygomatic process. This results in an increase in width and length of the maxillary arch. The arch also increases in height with deposition of bone at its inferior surface.

The hard palate is carried downwards and forwards by the above growth changes of the arch. It does however undergo growth and remodelling changes of its own which accentuate this movement and result in a great enlargement of the height of the nasal cavity. The floor of the nasal cavity and maxillary sinuses are resorptive, while the roof of the oral cavity shows deposition.

Enlow (1968) concluded that the combined growth patterns of the palate and alveolar arch result in the growth in the length, width and height of the alveolar arches, and to the descent of the palate and hence the increase in height of the nasal cavity. These changes are essentially remodelling growth that takes place in virtually all parts of the entire bone. The other main growth force on the maxilla is sutural growth. This occurs with the aid of growth at the nasal septal cartilage, thrusting the bone downwards and forwards. Moss et al (1968) has extensively reviewed the role of the nasal septal cartilage in midfacial growth. He concluded the growth of the cartilage was secondary to and compensatory for prior passive translation of the midfacial bones. Siegal (1976), on the contrary, showed septal resection does influence growth of the face. The effect he found depended upon the amount of septum removed and the timing of resection during growth. Some limited septal resection can be undertaken without producing undesirable effects on growth. It is generally accepted now that the cartilaginous nasal septum is an important factor influencing vertical and sagittal growth of the maxilla.(Grymer et al. 1997).

The composition of the two growth forces results in downward and forward movement of the maxilla and regional increases in size.

There is individual variation in the direction of growth. Some it is predominately forward, others downwards (Scott, 1967). There is a tendency for growth to be downwards in the first decade and more vertical during the second decade (Bjork 1964). During the first decade, particularly the period of two to three years of age most active growth is at the sutures. After the end of the first decade growth is predominately due to surface deposition.

Antero-posterior maxillary growth is largely complete by the initiation of puberty and that subsequent growth is in the vertical plane (Singh and Savara, 1966, 1968). Buschang et al (1986) found that in contrast to mandibular growth, maxillary growth does not display characteristic acceleration during adolescence. Bishara et al (1984) found in a review of facial growth that 90 - 95 % of growth was complete in girls at aged 13 -14 years. In boys of the same age only 75 -85% of growth was complete.

Growth has been recognised as a factor in relapse in mandibular surgery. (Schendel et al 1978). Research into the result of growth on long term relapse in maxillary procedures has been more in tune with the effect that surgery can have on growth. Many authors have explored this question with particular reference to performing surgery earlier during growth. Timing of orthognathic surgery in the cleft palate patient is controversial. Some authors consider that early surgery restricts potential growth of the malformed maxilla condemning the patient to further surgery or a deficient middle third. This applies to the closure of the cleft palate and its affect on transverse growth (Fried et al 1980). For the non cleft patient completion of the dentition or concurrent mandibular surgical needs dictate when surgery is undertaken.

2.5 Surgery for the treatment of maxillary discrepancies.

Procedures for mid third facial surgery depend on the diagnosis and objectives perceived by the patient and clinician. Numerous maxillary procedures can be performed ranging from single tooth osteotomies, segmented osteotomies , to whole jaw osteotomies.These can be done in conjunction with each other including the use of higher level mid third osteotomies (High Le Fort I, Le Fort II, Le Fort III, and also zygomatic osteotomy). Any of these can be performed with the range of mandibular procedures and genioplasties. Rapid maxillary expansion is another maxillary procedure to increase transverse dimensions.

Certain specific maxillary osteotomies will be described briefly for historic interest. These osteotomies still have a place in the repertoire of the orthognathic surgeon.

Wassmund's technique for anterior maxillary subapical osteotomy was described in 1935. It is designed to adjust the anterior segmental position in three dimensions maintaining the facial and palatal soft tissue pedicles. Access to the bone is obtained via a vertical incision between the canine and premolar. Subperiosteal dissection is carried forward to the nasal aperture. The same approach is performed on the opposite side and a palatal tunnel is also created. The bone is then cut through to the palate maintaining the palatal mucosa; the cuts are easier if a tooth is removed.

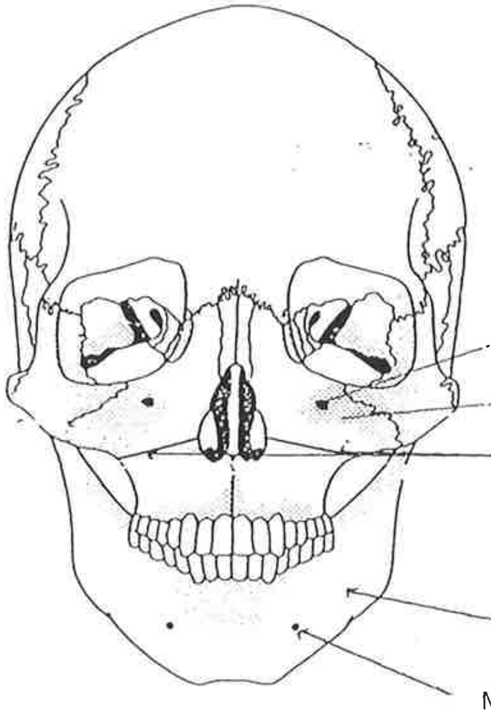
The Wunderer technique is similar to the Wassmund except a palatal flap is made, the anterior segment blood supply being obtained from the labial pedical.

Complications in both these techniques include persistent periodontal defects at the osteotomy sites between teeth. Devitalisation of the teeth due to the loss of blood supply is also reported. This leads to tooth death and the possibility of abscess formation.

Posterior maxillary subapical osteotomy is used to correct isolated unilateral posterior crossbite maxillary transverse excess or deficiency, posterior openbite or vertical maxillary excess with a posterior component. The surgery is done completely from the buccal side.Access for the vertical anterior cut is created by removal of a tooth or use of orthodontically created spaces . A horizontal high vestibule incision is made and tunnels performed to achieve this vertical cut; horizontal cuts are then performed. Access palatally may not be required but if necessary runs parallel to the palatine vessels and can be achieved via a transantral approach to maintain the integrity of the palatal mucosal tissues. This procedure has been essentially superseded by the Le Fort I osteotomy for vertical maxillary excess.

Osteotomies of the maxilla are traditionally described by comparison with the common fracture patterns of the mid third of the facial skeleton named after the work of Rene' Le Forte (1901). These are called the Le Fort 1, Le Fort 2 and Le Fort 3 fractures.

Figure 2.1 Le Fort fracture levels.



To perform the standard Le Fort I maxillary osteotomy as an elective osteotomy ,via an intra oral, approach consideration must be given to the adequate blood supply of the segments.

Bell et al examined the biological basis of low level maxillary mobilisation in a series of papers commencing in 1969. They studied the vascularisation and revascularisation of bony healing in a variety of osteotomies performed on Rhesus monkeys.

Turvey and Fonseca examined the anatomy of the maxillary artery in cadavers and found the Le Fort 1 osteotomy could be done safely without compromising the blood supply to the bony segments.

Other works have examined the blood flow as an indication of post operative change. Nelson et al found a significant reduction in blood flow immediately following osteotomy but showed rapid re-perfusion in the post surgical phase.

In designing access incisions to the maxilla clinical experience has shown that as long as a reduced supply to the maxillary segments is maintained from at least one source then the tissue should not be devascularised. This is possible in the maxilla due to the extensive collateral circulation.

The blood supply to the maxilla is palatal or vestibular in origin rather than depending on distal branches of the external carotid artery. As long as a broadly based well attached palatal or vestibular mucogingival pedicle is kept on at least one side of any segment to be mobilised, it should have an adequate blood supply to ensure the vitality of that segment post surgery. Siebert et al. (1997) utilising cadaver studies , showed the vascular supply of the mobilised Le Fort I maxillary segment is by the ascending palatine branch of the facial artery and the anterior branch of the ascending pharyngeal artery in addition to the rich mucosal alveolar anastomotic network overlying the maxilla.

Access incisions used intra orally include horseshoe incisions where a horizontal cut is made through the buccolabial mucoperiosteum, well above the attached gingival margin at the level of the maxillary teeth apices. Multiple vertical vestibular incisions may also be used to maintain multiple pedicles including an anterior one (eg. Four piece maxillary osteotomies) , or a combination of palatal and vestibular incisions depending on the requirements of the surgery.

2.5.1. South Australian Technique.

In this series of patients the surgery was performed by a number of consultants and registrars utilising a broadly standardised approach (Refer to Appendix II).

Stage 1: The patient was an initially sent for consultation with the O.M.F. surgeon. A treatment planned was formulated and presurgical orthodontic treatment carried out by an orthodontic registrar.

Stage 2: As per an established protocol, orthognathic patients receiving treatment in the Oral and Maxillofacial Surgery Unit (University of Adelaide, South Australia) commenced an eight week lead in time once a surgery date was established. During this time a final work up is performed which includes re -examination, clinical photographs (both intra and extraorally), new radiographs, and working/ study models mounted on semi adjustable articulators. The radiographs are analysed and surgical treatment objectives (S.T.O.) re- determined. Model surgery is performed upon the articulated models and occlusal wafer/s made.

The patient commences this eight week lead in time in passive orthodontic retention with surgical wires / high hat pins placed by the treating orthodontist.

In anticipation of blood loss it had been the policy of this unit for patients to pre-donate two units of blood. This practice has been examined by a number of authors with the result that only the more complicated (segmented) osteotomy and Le Fort II and III osteotomies via an extra oral approach need blood transferred post operatively (Dance et al 1997 , Moening et al.1995).

Informed consent is obtained for the surgery and the patient is reviewed by the anaesthetist.

Stage 3: The patient is given a hypotensive anaesthetic (by reduction of cardiac output and peripheral resistance) to help reduce potential blood loss and improve visibility at the operative field. Haemodilution is also utilised to reduce blood loss. The patient's head is elevated to reduce systolic blood pressure. (Anti Trendelenburg position.) (Van De Perre et al 1996).

After draping and preparing the patient, local anaesthetic is used containing adrenaline (2% lignocaine 1:80,000 adrenaline or 1% lignocaine 1:100,000 adrenaline) also to minimise bleeding and to improve visibility during the procedure. This is injected into the mucobuccal tissues of the entire anterior maxilla.

Stage 4: The incision is made from tooth 15 to 25 just anterior to the zygomatic buttress. The incision is made with diathermy. This incision leaves the palatal pedicle intact and vestibular pedicle posterior to the molars.

The incision passes through mucosa, muscle and periosteum, the superior tissues being elevated to expose the lateral maxillary wall. The inferior tissues are left attached to bone to maintain vascularity via the posterior pedicle. The infraorbital neurovascular bundle represents the most superior extent of the exposure. Posteriorly towards the tuberosity and pterygoids tunnelling under the mucoperiosteum is performed leaving the vestibular pedicle intact.

The nasal aperture is then exposed by raising the nasal mucosa of the lateral nasal wall. The floor of the nose, the septopremaxillary ligament and transverse nasalis muscle are transected exposing the anterior nasal spine.

Stage 5: Once the soft tissue is reflected the bony osteotomy cuts are made. The nasal spine is protected at the labial nasal wall and a reciprocating saw is used to make the osteotomy cut from the buttress to the piriform fossa. The saw is reversed and the cut extended posteriorly to the back of the maxilla. This is repeated on the opposite side . If the maxilla is to be superiorly positioned a second cut is performed the first cut. The required distance being measured in millimetres.

The nasal septum is divided from the nasal floor using the septal osteotome. The osteotomy cuts along the lateral nasal wall are emphasised with an osteotome. Care must be taken not to damage the greater palatine vessel.

These manoeuvres separate the maxilla centrally, anteriorly and laterally. Posteriorly two alternatives are used. Pterygomaxillary dysjunction is achieved by placing a curved osteotome between the maxilla and pterygoid plates angling it medially and inferiorly and hitting it with a mallet. A finger is placed on the plates for orientation of the hamular notch region enabling tactile sense of the osteotome passing between the maxilla and pterygoid plates. This is performed bilaterally. Some surgeons prefer to detach the maxilla via the maxillary tuberosity using a large osteotome. This minimises the risks of unfavourable pterygoid plate fractures (and possible base of skull fractures) and the involvement of the pterygoid venous plexus.

Stage 6: The maxilla is then down fractured using either finger pressure or forceps (Rowes disimpaction forceps) designed for the purpose. It is also mobilised by anterior force applied by placing the curved osteotome behind the maxillary tuberosity in conjunction with a wire placed through the anterior nasal spine.

As the maxilla is mobilised the nasal tissues are dissected from the bony nasal floor. Bone is removed from the vomer and nasal crest of the maxilla and the lateral nasal walls. If this is not done free movement of the maxilla is prevented, or if the maxilla is being repositioned superiorly buckling of the nasal septum will occur resulting in unaesthetic soft tissue changes in the nose. The nasal spine is also reduced. Once some movement is obtained the maxilla can be bought forward fracturing any remaining posterior attachments.

The descending palatine vessels can usually be visualised at this stage. Bleeding can occur by direct damage to these vessels and also from the pterygoid plexus associated with the pterygoid muscles. This can be controlled, if it is excessive ,by local anaesthetic with a vasoconstrictor or by packing. This is rarely required.

Upper third molars may be removed if it will not compromise the maxillae vestibular pedicles. Often they can be removed if partially developed when the maxilla is down fractured via the superior approach.

If the maxilla is to be segmented for expanding transverse discrepancies or for differential impaction in the treatment of open bite this is performed prior to placing the maxilla in the splint. With the maxilla down fractured the appropriate cuts are made superiorly. These can be a horseshoe on the palate or midline, care being taken not to perforate the palatal mucosa.

Horseshoe shape palatal cuts allow greater expansion and disperses the resulting soft tissue tension. It also places the osteotomy cuts over the thicker soft tissue of the lateral part of the palate which is less likely to rupture.

Cuts between dentoalveolar segments are then performed as needed and tunnelling is required under the buccal mucosa between teeth. The roots of the teeth must be far enough apart to avoid damage. A small osteotome is suitable for these cuts. If narrowing of a space is required interdental bone needs to be removed without damaging the adjacent soft tissue and teeth.

Bone removal from the medial and posterior areas needs to be performed in order to allow free movement of the maxilla. Once the bone has been mobilised the occlusal splint is positioned and wired with inter-maxillary fixation to the mandible thus creating a maxillomandibular complex. The complex is then rotated upwards ensuring the condyles remain in the glenoid fossa. Premature bony contacts are removed. The vertical position is now reviewed to ensure the maxilla is in the desired inferior or superior position.

Good bony contact should be obtainable with most maxillary repositioning . Bone grafts are needed for certain movements including large expansions , inferior repositioning of the maxilla and large advancements.

If on superior repositioning the inferior turbinates prevent movement they are reduced in height with scissors. Nasal mucosa is inspected for tears and sutured as needed. Other bleeding points are addressed. Any sinus pathology (polyps) are removed.

Stage 7: The maxilla is then fixated with wires for earlier cases (1982 - 1986) in the study. These included wires placed either side of the piriform fossa and bilateral circumzygomatic wires. All later cases (1987 - present day) were fixated with bone plates and screws (chapter 6). Plates are usually placed over the zygomatic buttress and just lateral to the piriform fossa making four in total. They need to be contoured to the bone otherwise they could displace the maxilla from it's desired new position. Four hole plates are usually used with two screws on either side of the osteotomy cuts. The screws were all 2 mm diameter being 5 or 7 mm's long.

Stage 8: Bone grafts are placed as appropriate to ensure bone to bone contact is present to prevent non union. Autogenous bone when required in this series of patients was obtained locally from the the osteotomy cuts, chin region, or if more bone was required from the ilium.This is performed before the orthognathic surgery or simultaneously by another surgical team.

A description of bone harvesting from the anterior ilium is given in Appendix I. All bone used was nonvascularised corticocancellous blocks.

Stage 9: The inter-maxillary fixation is released and the occlusion in the splint is checked. Closure of soft tissue is then completed. Mandibular and other procedures are then performed as planned.

Stage 10: Soft tissue closure can involve simple primary closure of the vestibular cuts or it may include alar cinching or single/double V-Y closure of the lip.V-Y closure of the circumvestibular incision was investigated by Carlotti et. al.(1986). Benefits are thought to include maintenance of the vermilion height and elimination of lip shortening.

Maxillary osteotomies result in changes to the external nasal morphology.

Anterior or superior repositioning of the maxilla can alter the nasal septum and alar bases. The magnitude of change does not correspond to the magnitude of maxillary shift (Mansour et. al. 1981). The changes can sometimes be beneficial eg. widening of the alar bases after superior repositioning for vertical maxillary excess will improve airflow. If flaring of the alars is not desirable, alar cinching is performed.

All patients received antimicrobial prophylaxis using intravenous penicillin or cepthalothin. The regime varies between surgeons as shown in the literature (Ruggles and Har 1984, Olten et al 1991). The regime for cepthalothin was 1g perioperatively then eight divided doses (four times daily for two days). Patients also received 8mg dexamethasone perioperatively and then four divided doses post operatively (8mg twice daily for two days) as per the unit's protocol.

2.6 Bone Grafting

Bone grafts are an essential adjunct to orthognathic surgery , stabilising the bony fragments and encouraging bone growth and healing. They act as scaffolding for the growth of new bone. Epker suggested they served three basic purposes: to accelerate osseous healing, to serve as a physical step and to provide a matrix for secondary reconstruction.

Bone is a unique connective tissue in that it heals and repairs not by scar formation but by cellular regeneration. It regenerates from osteoprogenitor cells found within bone marrow, endosteum, and in periosteum. The bone marrow cells are stem cell precursors that can differentiate into any of the connective tissue lineages. This population of cells diminishes with age, thus bone graft survival is influenced by age.

Bone is formed from osteogenesis, osteoconduction and osteoinduction. Osteogenesis is the formation of bone from osteoprogenitor cells. This is achieved in the adult orthognathic patient by transplanting these cells. Osteoconduction is defined as the formation of new bone from host derived or transplanted osteoprogenitor cells allowing a biological or alloplastic framework. This is of importance in orthognathic surgery when corticocancellous grafts are placed at the osteotomy site. Osteoinduction involves the formation of bone heterotrophically by allowing undifferentiated mesenchymal cells , under the influence of bone morphogenetic proteins (B.M.P.'s), to transform into osteoblasts that can produce bone. Autogenesis bone contains B.M.P.'s but in recent years B.M.P.'s have also been isolated and reproduced utilising genetic recombinant techniques. This may be the technique of choice in the future of providing new bone at osteotomy sites (Elima 1993, Solheim 1998).

Orthognathic surgery utilises bone grafts in two main fashions:

1) cancellous cellular marrow grafts , or
2) corticocancellous block grafts.

Cancellous cellular grafts are essentially transplantation of osteoprogenitor cells in concentration. It consists of endosteal osteoblasts and marrow stem cells. Because of their particular nature they survive initial grafting obtaining their oxygen and nutrients by diffusion and then in growth of capillaries provides for their ongoing requirements. Osteoid production then commences. It is proposed that the release of B.M.P. (bone morphogenetic proteins) also hastens this process. This "phase one" bone is replaced by lamellar bone with a greater mineral content (Urist 1965, Marx et al 1998).

Corticocancellous bone is usually harvested from the iliac crest (Van der Wal et al 1986). This includes cortical and adjacent cancellous bone. This is often used in orthognathic surgery as it provides instant rigidity and thus early stability. It's one main drawback is it's inherent lack of osteoprogenitor cells and it's solid mass prevents early revascularisation. It's main use as previously mentioned is as an osteoconduction framework for bone formation from cells derived from the host bone.

Bone from the ribs, clavicle, tibia and calvarium have all been documented for craniofacial reconstruction (Marx et al 1988, Laurie et al 1984).

The ilium has many advantages over the other sites, particularly the ability to transplant large concentrations of osteocompetant cells. In Le Fort osteotomy sites particular bone and cancellous marrow grafts are difficult to use due to their lack of form.

Bone grafts placed should be mechanically locked into position particularly in the buttress areas with wedging, wires or screw fixation. Bone plates alone are not considered adequate to promote good bone healing.

Care must always be taken not to place bone grafts where they can be displaced into the sinus leading to sequestration formation, associated nasal discharge and foul odour.

Allogenic bone grafts, due to the risk of infection and poor patient acceptance, are not indicated in elective orthognathic surgery (Luyk et al 1985, Holmes et al 1988, Waite et al 1996). Alloplastic material such as hydroxyapatite has been used and does stabilise the osteotomy sites, but is not replaced by bone. It is also associated with a greater incidence of tissue dehiscence. Allogenic bone grafts were not used in this study.

2.7 Complications of Maxillary Procedures

Complications for maxillary procedures can be divided into three main groups these being intraoperative complications, immediate post operative complications,and delayed post operative complications.

An excellent review by Van De Perre et al (1996) examined the perioperative morbidity in orthognathic surgery for some two thousand and forty nine patients . Of the patients having maxillary procedures the major complication was severe haemorrhage (about 2%). Other complications in this series ,including aseptic necrosis, were minimal.

2.7.1 Intraoperative complications.

Intraoperative complications in Le Fort I osteotomies have been reported as:

a) Airway loss.

In all maxillofacial procedures the airway can be compromised. In Van de Perre study, two patients required urgent tracheotomy due to respiratory distress. Both patients had undergone subapical osteotomies of the mandible whilst one had also had an anterior segmental osteotomy of the maxilla. In these cases respiratory distress was caused by excessive swelling of the floor of the mouth.

b) Haemorrhage at the time of surgery.

This is of major concern with maxillary surgery. In Van de Perre's study twenty two patients (one percent of the study population , being two percent of the maxillary group) suffered major blood loss requiring transfusion of two or more units of packed cells. All of these patients had Le Fort I or posterior supra apical maxillary osteotomies.

Bleeding can be minimised by the use of controlled hypotensive general anaesthesia, positioning the patient in a slight anti- trendelenburg position, and the use of local anaesthetic containing adrenaline. Blood transfusion should be avoided in young healthy patients undergoing elective surgery due to the associated morbidity (Jeter and Spivey 1995). When anticipating maxillary surgery the option of pre-donating autologous blood should be discussed with the patient.

Turvey et al suggested that the vessels at greatest risk of damage are the internal maxillary artery, the posterior superior alveolar artery and the greater palatine arteries. There is a theoretical risk to the major vessels entering the base of skull. When the pterygoid plates are fractured this can lead to base of skull fractures leading to the tearing of the great veins. This has not been recorded in the literature as occurring during orthognathic surgery.

c) Loss of vascularity.

Loss of vascularity to the osteotomised segment is a constant and real risk. It can lead can lead to pulpal necrosis, periodontal defects, loss of bony segments or the worst possible sequela, the complete aseptic necrosis of the entire maxilla (Lanighan et al. 1990).

The greater the number of segments the maxilla is divided into, the greater the chance of disruption of its blood supply. The greatest number of fragments is considered to be four. Great care must be observed when handling the tissues during segmentalisation including copious amounts of irrigation when sectioning the bone. Damage to the palatal mucosa is considered an important contributing factor to avascular necrosis. Compromised vascularity can occur in a one piece maxilla if it is excessively intruded, advanced or retruded.

Splints with palatal bars left in situ post expansion of the palate can obstruct the blood supply particularly after post operative swelling. This must be taken into consideration when constructing the splint.

Loss of large segments of both hard and soft tissue have been recorded in the literature. Minor vascular compromise can lead to loss of the interdental papilla, loss of gingival attachment and bony defects. Kinking of the pedicles and hence the blood supply has been suggested as the cause of greater tissue loss (Sher et al. 1984).

If vascularity is compromised, kinking or constriction of the soft tissue pedicles should be considered. If noted immediately the maxilla may have to be returned to its original position. If noted post operatively exposed bone from soft tissue loss should be irrigated several times daily. If it is mobile it should be stabilised. Hyperbaric oxygen could be of some benefit. It does not prevent or reverse the development of aseptic necrosis once it has started , but may limit its ultimate extent.

Lanighan et al (1990) review of avascular necrosis of the maxilla after orthognathic surgery made the following recommendations.

1.Preserve the descending palatine arteries when ever possible. Bell in his studies did show these can be ligated with minimal change to the vascularity of the maxilla (supported by research by Bays 1993, Dodson et al 1997) but it will decrease the overall supply. These vessels can also be kinked when intruding the maxilla.

2. Divide the maxilla into as few segments as possible.Try to avoids small segments anteriorly.

3. Avoid compression of the palatal mucosa with a splint or palatal bar.

4. Avoid significant transverse expansions. Consider using surgically assisted orthodontic palatal expansion. Also consider constriction in the mandible.Use a horseshoe shape cut instead of a mid palatal cut.

5. Have good preoperative orthodontic separation of the teeth when segmentalising to avoid damaging teeth and interdental bone.

6. Avoid disimpaction forceps as they can crush/ damage palatal mucosa.

7. Other suggestions made to avoid compromising the maxilla's vascular supply include minimising the degree of hypotensive anaesthetic, avoiding electrocautery and having patients stop smoking in the post operative period.

d) Intraoperative cardiac problems.

If cardiac problems occur during surgery in young patients they are usually due to the trigemino-vagal reflex which causes extreme bradycardia.This necessitates immediate anticholinergic therapy with atropine to avoid the possibility of asystole. (Aitkenhead et al 1996). This is extremely rare in orthognathic surgery but may occur.

e) Unfavourable fracture / Osteotomy Pattern.

This is a poorly described sequela in maxillary osteotomies. The fragile labial maxillary bone often`shatters' on sectioning with no detrimental effect on the osteotomy outcome.

Poor dysjunction of the posterior maxilla can delay down fracturing of the maxilla but if the maxilla is properly mobilised it will not affect the final positioning of the maxilla Fractures at the pterygoid plates and even the cranial base do occur. The posterior dysjunction of the pterygoid plates is essentially performed blindly. As such unfavourable fracture patterns can occur involving high fractures of the pterygoid plates, fractures of the pterygopalatine canals, or via the superior part of the maxillary sinus (Wikkely et al. 1975).

Several studies have examined the incidence of these fractures. Langihan et al (1993 & 1995) found low level pterygoid plate fractures in 26 out of 32 sides during Le Fort I osteotomies. None lead to base of skull fractures. He uses a micro-oscillating saw in preference to an osteotome . Precious et al (1993) found a high incidence of pterygoid plate fractures with what ever technique used. Renick et al (1991) utilising post surgical computerised tomography found an incidence of pterygoid plate fractures to be 58.4%. 8% of these were multiple fractures. 37.5 % were low level and 25% were high. None lead to undue complications such as major bleeding, C.S.F. leak or orbital compartment syndrome.

If the pterygoid plates fracture inappropriately it makes mobilisation more difficult and can lead to inadvertent poor positioning , stability and hence increase the likelihood of relapse. It also increases the chance of neurovascular insult.

Difficulty repositioning the maxilla once mobilised can be due to bony interferences due to unfavourable fracture patterns. Interference can be found in the lateral maxillary wall, nasal walls, septum or tuberosity region.Impacted third molars could also impede the planned movement. Movements planned on the model surgery may not be able to be replicated in surgery eg. posterior repositioning.

The most likely interferences will occur when the maxilla is being superiorly or posteriorly positioned. Superior repositioning can cause buckling of the septum or be prevented by the inferior turbinates. Hence they need to be reduced. Posterior repositioning of the whole maxillae is prevented by the technical difficulties of removing bone to allow this movement and the very high risk of causing avascular necrosis by 'crimping' the blood supply.

Widening of the maxilla for transverse deficiencies is often restricted by the tough palatal soft tissue. Horseshoe palatal cuts rather than a midline palatal cut allow greater expansions.

Maxillary over-impaction can occur due to injudicious bone removal; lack of bony contact and extreme masticatory forces post-operatively.Poor surgical planning is probably the most common cause.

f) Dentoalveolar Injuries.

Trauma to the teeth and their periodontal support occurs most often during segmentalisation of the maxilla but root tips can be cut with poorly placed low Le Fort I bony cuts.

Damaged teeth may need extraction or post operative endodontic therapy. Damage to teeth can be minimised with pre-surgery orthodontic treatment to create sufficient space between teeth, periapical radiographs to determine the direction of the roots, and the use of chisels rather than saws or burrs to section the bone.

It must be remembered that teeth that do not respond to pulp testing (thermal or electrical) do not necessarily need endodontics as their nerve supply has been altered by the surgery but not there blood supply. Al-Din et al (1996) in their study of sensory nerve disturbances following Le Fort I osteotomy found that after six months 78% of teeth that had positive vitality prior to surgery to an electric pulp testing had regained their response to the test.

Degenerative and atrophic pulpal changes have been demonstrated in animal studies, utilising microangiographic and histological investigations, after repositioning of dento-osseous segments (Scheideman et al 1985). Di et al (1988) examined human teeth after Le fort I osteotomy. They removed third molars an average of forty months post - surgery. They showed the majority of teeth had an intact pulpal circulation and normal pulpal histology up to 6.5 years after the surgery. A very small number of teeth showed asymptomatic dystrophic degeneration. This included the formation of multiple pulpal stones, diffuse radicular calcification and fibrosis of the pulp. They suggested these changes may be secondary to transient ischaemia during surgery or simple variation from normal.

g)Anaesthetic problems are less common with modern techniques. In maxillary surgery with an airway shared by the surgeon and anaesthetist, inadvertent damage to the endotracheal tube can occur. Usually this can be corrected with packing around the tube. Occasionally the tube may need to be replaced. This can be difficult if the maxilla has been mobilised and intraoperative bleeding restricts visibility.

The anaesthetist must also be aware of potential injury to the alar rim from pressure necrosis from the endotracheal tube.

There have been several reports of emphysema in the head and neck tissues following orthognathic surgery. (Nanini et al 1986, Edwards et al. 1986) This is probably due to patients increasing intranasal pressure post-operatively rather than during surgery.

Subcutaneous air should be treated with antibiotics and observation. The more serious pneumomediastinus is treated initially in a similar fashion but with cardiac monitoring, pulmonary physiotherapy , oxygen and intravenous fluids. Occasionally chest drains in the mediastinum may be necessary (Edwards et al 1986).

2.7.2 Immediate postoperative complications

a) Haemorrhage

Haemorrhage can be a problem in the early recovery phase. It can become profuse as the patient's blood pressure returns to physiological levels or higher when the local anaesthetic wears off. In this event the immediate diagnosis of the site and extent is difficult. Posterior/anterior nasal packing may be all that is needed to control bleeding. Returning the patient to theatre and re exploring the osteotomy sites with packing is rarely required but is preferably done earlier rather than later. Embolisation of a bleeding vessel via an angiogram may be occasionally indicated.

Delayed (Secondary) haemorrhage up to 9 days post operatively has been recorded (Langihan et al 1984). Bleeding is most likely from the greater palatine artery, the maxillary artery, or the pterygoid plexus of veins. Secondary haemorrhage occurred usually day 5 to 7 post surgery (Langihan 1984).

b) Neurosensory /motor deficit .

Nerve lesions post maxillary surgery are less problematic than those related to mandibular surgery. Careful surgical technique is the best measure of avoiding nerve injury. Sectioning of the nasopalatine nerve and possibly the anterior and middle superior alveolar nerves will occur but is of minimal consequence to the patient.

Injury to the maxillary division of the trigeminal nerve has not been as well studied in it's relationship to maxillary orthognathic surgery as mandibular surgery. In comparison studies related to nerve injury associated with mandibular surgery is comprehensive (Westermark et al 1998, August et al 1998, Blomquist et al 1998). There are no reported incidence of facial nerve palsy following maxillary osteotomies. In mandibular osteotomies it has been reported particularly after extra-oral approaches but also during large mandibular setbacks (Piecuch et al 1982, Jones et al. 1991).

Many patients will experience decreased sensation following a standard Le Fort I osteotomy over the anterior teeth, oral mucosa, and the distribution of the infraorbital nerve sensory supply. This particular nerve is easily visualised during the procedure but is subject to traction injuries. This will lead to a neuropraxia and recovery is normally complete by one month. Al- Din et al (1996) stated all of their patients had complete return of cold sensation, pin prick sensation and fine touch after 6 weeks. Higher osteotomies involving the orbital rims can lead to a neuropraxia or axonotmesis of the infraorbital dermatome.

c) Fistulas- oronasal or oroantral.

Fistulas are relatively rare but if they do occur are related to soft tissue injury during surgery. Burrs , chisels and saws can perforate the mucosa. They usually will close spontaneously with supportive therapy, including antibiotics and decongestants which prevent sinus and nasal infections. A coverage splint to prevent food contamination may be of benefit. If these things fail further surgery is indicated.

d) Septal deviation Septal deviation after maxillary intrusion can occur if insufficient bone is removed from the palate and vomer. If septal deviation is noted post surgery it can be manipulated immediately, re-operated on, or a formal septoplasty should be performed at a latter date.

e) Changes in nasal anatomy.
Flaring of the alar bases will occur which creates an unaesthetic nose on impaction of the maxilla. Nasal cinching will overcome this cosmetic problem.

Logically, superior repositioning of the maxilla would lead to diminished nasal air space. Turvey et. al. (1984) and other authors have shown the opposite to be true because resistance within the nasal passages has found to be a function of size, shape, and length of the cavity. The primary determinate to the magnitude of resistance is the smallest cross-sectional area of the airway. Thus the most constricted area can be the result of enlarged turbinates, septal deviations, the presence of polyps, adenoidal tissue and the shape of the anterior nares. Superior repositioning of the maxilla has a direct effect on the anterior nares. It causes flaring from the usual narrow slits seen in patients particularly with long face syndrome, preoperatively , to a more ovoid form post surgery. They found this increase in nasal aperture allowed decreased resistance to ventilation. Other nasal changes resulting in decreased resistance included changes in the septum and turbinates.

2.7.3 Delayed Post Operative Complications.

a)Nonunion of the Maxilla

Delayed or nonunion of the maxilla after surgery is the result of similar factors that cause nonunion at traumatic fracture sites. Compromised blood supply due to poor tissue handling , very large shifts, particularly in the inferior direction, or because of previous surgery, such as in the cleft patient, may delay healing. Patients may subject the maxilla to early loading post surgery or parafunctional activity.This can also be a problem when post operative premature contacts concentrates forces in one region. If there is insufficient bone contact healing may also be impaired. This is often the case in large movements. Hence the need for bone grafting. Although non union is uncommon in the maxilla, when it does occur its early recognition can remove the cause and return the patient to a normal post operative course. If it is still a problem re-operation with aggressive removal of fibrous tissue , bone grafts and rigid internal fixation is required (Van Sickels et al 1990).

b) Epiphora.

Tearing of the eye or epiphora may occur after maxillary osteotomy surgery. It is usually temporary caused by soft tissue swelling of the nasolacrimal duct. If the duct is directly damaged by the surgery , that is, damage to its exit beneath the inferior turbinate or within its bony canal with a high bony cut , it could be permanent. This is usually the case if it persists for longer than three weeks.

Persistent epiphora can lead to recurrent dacryocystitis and conjunctivitis. A surgical shunt may be needed to correct this problem .(Dacrocystorhinotomy) (Della Rocca et al 1988).

c) Post operative hypomobility.

Restricted movement of the temperomandibular joint is uncommon after isolated maxillary surgery but does occur after mandibular surgery. It is suggested this is due to scarring, atrophy of the muscles of mastication after prolonged maxillo-mandibular fixation (MMF) or if excessive posterior maxillary inferior repositioning. These problems are avoided with early mobilisation, jaw exercises or physiotherapy.

d)Temperomandibular joint dysfunction.

The relationship between patients with dentofacial deformities and TMJ disorders has not been fully elucidated. Upton et al. (1984) studied 102 patients with dental class II, and III relationships with and without open bite malocclusions and found no increase in the incidence of TMJ problems as compared with class I relationships.

When the malocclusion is related to an underlying skeletal abnormality severe enough to warrant orthognathic surgery the incidence of TMJ disorders is higher than the normal population. White et al. (1992) examined 75 orthognathic patients and found 49.3% had TMD pre-surgery. Interestingly 89% of these patients improved post surgically, but some got worse and some previously asymptomatic patients developed symptoms.

Condylar remodelling or resorption is often thought to be related only to mandibular surgery. It is of concern because of related TMJ dysfunction and symptoms. It is also a cause for postsurgical relapse. Hoppenreijs et al (1998) examined this problem in a large series of 259 patients undergoing orthognathic surgery. Various variables were examined to determine risk groups more likely to suffer this complication. They found females with anterior openbite associated with a high mandibular plane angle, short ramus height, low ratio of posterior to anterior facial height, finger or spike shaped condyles, or condyles with a posterior inclination of the condylar neck were in the high risk group for condylar resorption. There was also increased risk if these patients were having a bilateral sagittal split osteotomy as part of a bimaxillary procedure.

It was interesting to note that condylar remodelling and resorption did occur in isolated Le Fort I osteotomies. It occurred in 9% of patients having this operation alone. They suggested that biomechanical loading due to autorotation of the mandible is probably the main cause in this group of patients. In comparison, patients having two jaw surgery , the incidence of condylar resorption was 23%.

e) Post- surgical relapse.

Relapse post surgery was originally discussed by Proffit in 1970. This is discussed in greater detail in Chapter 5 and in the Discussion , chapter 12.

f) Social factors.

Dickerson et al examined recovery after isolated Le fort I osteotomies compared to isolated mandibular saggital split osteotomies . They found that patients who had a maxillary procedure took longer to return to school or work (50% by 4 weeks). This was probably due to the greater estimated blood loss and length of the operation than their mandibular counterparts who returned to work and full activity on average 1- 2 weeks earlier.

g) Psychological factors.

Psychological problems are a relative contraindication to surgery . Screening for patients with potential problems maybe achieved by interview and questionnaires. Patients identified as having particular problems can be referred for further psychological evaluation . This can minimise some unfavourable post surgery problems and litigation. (P.J. Sambrook, 1989).

The psychological assessment of patients requesting orthognathic treatment is now considered a vital and integral part of the overall assessment procedure (Cunningham et al 1998). It allows identification of potential problems at an early stage before irreversible decisions have been made. Particularly patients suffering from body dysmorphic disorder (DSM - IV). These are individuals with a normal appearance who present requesting treatment, usually to multiple surgeons, because they believe they have a defect. The majority of these patients have a body image identity problem focused on facial features.

Phillips et al (1998), found patients with dentofacial disharmony seeking treatment experienced a high level of psychological stress that warrants intervention.

Several studies have examined patients satisfaction levels post orthognathic surgery. Cunningham et al (1995) found most patients were highly satisfied with the results of surgery. Most stating they would reelect to have the surgery. Most of the studies found that patients had improved self confidence and social skills after treatment. Pogrel et al (1994) found it was impossible to identify psychologically "bad risk" orthognathic patients pre-operatively. They also stated that it may be unnecessary since most patients do well psychologically after orthognathic surgery, regardless of their preoperative psychological profile. There have been several studies to try and predict which patients may be unsatisfied with orthognathic surgical outcomes, even though the surgeon and orthodontist perceive the treatment as successful. Van Steenbergen et al (1996) found only one variant could suggest post operative dissatisfaction. This was in patients that showed evidence in pre-operative screens of poor self concept. Self conceptualisation had no bearing on the severity of facial disharmony as assessed by the surgeon and orthodontist.

More recently Hatch et al (1999) examined psychological function in class II orthognathic patients. They also found that pre surgical psychological function does not determine satisfaction with surgical outcome. They found those that were initially dissatisfied, improved up to two years post surgery.

If there is concern further psychiatric assessment and counselling should be undertaken.

Chapter 3 : Cephalometry.

3.1 Introduction.

Cephalometry is scientific measurement of the head (Broder 1955). The aim of cephalometrics is to provide a repeatable, standardised means of assessing and recording the facial skeleton in relationship to the cranial base.

They are used to

1) classify facial abnormalities related to the dentition
2) as a means of projecting growth and developmental patterns of the facial components by utilising serial radiographs.
3) as an aid in treatment planning
4) to aid in comparison of the before, active and after phases of treatment.

The first lateral head radiographs were performed in the 1920's. Their practical use in orthodontics commenced in the 1930's. Broadbent et al published his standardised methods for producing cephalometric radiographs utilising a special holder called a cephalostat. The cephalostat makes it possible to position and reposition the patient's head in a predetermined relationship of the x-ray beam and Frankfort plane.

The most commonly used cephalometric examination is the lateral view. The posteroanterior skull projection is useful in facial asymmetries and lateral skull growth.

Qualitative measurements are obtained based on certain landmarks and lines of references. The measurements of angles and lengths made are compared to 'average ' values in an aid to diagnosis facial irregularities. These 'average' values are determined by cross sectional studies of people of similar age and racial background.

Cephalometrics gained popularity initially in the 1950's and 1960's as a research tool and then as a clinical tool by orthodontists. Its usefulness in orthognathic surgery was first shown by Brodie (1955). He found it was an acceptable means of monitoring the progress of surgical manipulation of the facial skeleton. Since cephalometics have been used in the planning of orthognathic surgery, to help in diagnosis, and to predict both hard and soft tissue post surgical outcomes. Serial cephalometrics have been routinely used to determine long term outcome and to review possible relapse. (Proffit et al 1996).

The science of cephalometrics depends on the stability of the cranial base. It is used as a point of reference as it shows little change after 7 years of age. The rest of the facial skeleton is related to these points of reference particularly the maxilla and mandible.

It must always be remembered that cephalometrics is only one component of treatment planning being an important adjunct to the clinical examination. They are limited by the fact that they are a two dimensional representation of a three dimensional situation. In treating the individual the objectives of surgery should not be to create normal cephalometric values, but to provide a functioning interlocking occlusion with a harmonious facial balance.

Many analysis have been published through the 60's, 70's and 80's including Ricketts analysis, Steiners and McNamaras analysis. With the rapid development of computers over the same three decades and the more recent development of digitisers and scanners computerised cephalometrics is readily available and provides rapid analysis.

The accuracy of cephalograms is relative and not absolute. According to Houston (1983) if any study using measurements is to be of value , it is imperative that error analysis be undertaken and reported. Many sources of errors appear in the literature, as do the techniques needed to reduce these errors. (Midghart et al, Martinoni et al, Houston, and Seppo.)

Houston (1983) and Bushang et al (1987) divided error into systemic and random patterns. Systematic errors are those introduced by the effects of the observer analysing the cephalomat and the equipment used. These errors will occur if there is a permanent fault in the apparatus or if its calibration is incorrect. Brown et al. (1970) minimised these errors by standardising the equipment and technique of analysis.

Observer bias occurs from subconscious weighting of data collection.As an example when measurements are repeated several times, a range of values that cluster about a particular value are obtained. The variations between values can be considered random errors. These errors will occur due to difficulties in landmark identification and equivocal landmark definition.

The conventional process of recording data from lateral cephalometrics involves several steps which will be subject to potential sources of error. These steps include the taking of the lateral head radiograph, its tracing and identification of landmarks, the recording of observations and measuring the observation.

Gravely and Murray Benzies (1974) classified errors into two broad categories- projection errors and tracing errors. Projection errors being those that occur when converting a three dimensional object (the skull) into a two dimensional radiograph. Potential errors will occur in relation to the relative position of the x-ray tube, the object and the film.

Tracing errors arise primarily from incorrect landmark identification due to loss of clarity of the landmarks, blurring of the image and poor film contrast and emulsion grain.

Hing (1989) summarises the potential errors in the obtaining and recording of cephalometric data into six categories including

1.Errors of projection.

2.Errors of landmark identification.

3.Errors of digitising

4.Errors of measurements.

5.Errors attributable to operator variability

6.Errors of superimposition.

3.2 Errors of Projection

Errors of projection will occur when a three dimensional object is projected onto a two dimensional film. This problem has been well documented in the literature. (Van Aken et al 1963 , Moyers and Bookstein 1979, Ahlqvist et al 1983). Baumrind and Frantz (1971) described lateral cephalograms as distorted enlargements.

Carlson (1967) divided the potential errors of taking cephalograms into geometric and non geometric errors. Non geometric errors included those resulting form the positioning of the patient into the cephalostat, operator errors generally and also those relating to the radiographic film properties.

Geometric errors are specifically related to the distortion associated with projecting a 3D object onto a 2D film. The inherent property of x-rays to travel along straight lines diverging from their source (the cone ,which is essentially a small area or point) results in enlargement and distortion in cephalometry. Carlson explained the departures from parallelism between the median (centre of the object- imaginary line through the ear rods) and the periphery .This results in areas of " geometric unsharpness". Eliasson et al. (1982) and Ahlqvist et al. (1983) agreed that major errors would occur if there was misalignment between the x-ray source , the cephalostat, the film or the subject. (Fig 7.1).

Several studies have examined and quantified the relative precision and accuracy of the projection. Hallert (1964) defined precision as a quality associated with a class of observations and referring to the closeness of replicated or repeated observations around a mean. Accuracy is the closeness of observations , computations or estimates to the true values or values assumed to be true.

To compensate for the projection errors tables have been formulated to accommodate potential enlargement (Bergenson 1980.)

These projection errors have the potential to be significant but are reduced to an insignificant level by attention to detail. They are of lesser importance than other forms of error (Carlson 1967 , Houston 1986). Ahlqvist studied the magnitude of projection errors on length measurements in cephalometry and concluded that if a rotation of the object (the skull) was less than 5 degrees the error of measurements extrapolated to less than 1%.

3.3 Errors of Landmark Identification.

Imprecise landmark identification and inaccuracy of landmark definition are considered the greatest source of random error in cephalometrics.(Graber 1958, Miller et al 1966, Broch et al 1981, Houston 1983, and Chate 1987) Broch et al extends this to say if a digitiser is used it is " the only source of error"!

The reliability of landmark identification depends on five factors according to Broch et al (1981).

1.Characteristics of the cranial structures;

2.The general quality of the head plate

3. Degree of blurring of the anatomical structures caused by secondary radiation or movement of the subject during exposure;

4. Precision of the recording method.

5. Accuracy of the operator.

The magnitude of error was noted to vary greatly from landmark to landmark but fortunately , the distribution of error for given landmarks which having been extensively studied, have their own characteristics usually following an elliptical envelop of error which varied from 0.25 mm to several millimetres. (Richardson, 1966; Baumind and Frantz 1971; Broch et al 1981) Savara et al (1966) reports the error of landmark identification to be five times that due to measurement.

The difference between landmark identification probably reflects the complexity of the regional anatomy. Superimposition of other structures interferes with the clarity. The better the contrast the easier and more accurate landmark identification is. (Baumrind et al 1971 and Vincent and West 1987).

Another major problem of landmark identification is the use of vague definitions that are prone to varying interpretations. Baumind et al used gonion point as a good example of this. It is defined as the point where the ramus and body of the mandible meet. When different observers were asked to plot this point, tremendous inter observer variation was found. Savage et al (1987) agrees with this observation and suggests more precise landmark definitions but the problem then is acquiring universal acceptance.

Landmarks were divided into two broad groups by Moyers and Bookstein (1979). They refer firstly to 'anatomical' landmarks that are true biological foci identified by some feature of the local morphology. These can usually be located with minimal inter observer variability. The other landmark type is referred to as 'extremal'. These points are defined by the maximum or minimum of some geometric point. Menton or pogonion are examples . They will change position depending on the horizontal reference plane and the amount of jaw opening. This jaw 'movement ' may be relative being caused by improper orientation of the cephalogram or in longitudinal studies being caused by growth or surgery.

Baumrind and Frantz (1971) found machine porion, sella and the upper incisal edge were the most reproducible landmarks. Gonion and lower incisal root apex were considered the least reliable.

To reduce errors in the identification of landmarks, Houston (1983) recommended that duplicate tracings be made and to average the landmarks identified on each tracing rather than the measurements replicated and averaged. Baumrind and Millar (1980) suggested that tracings be repeated four times which would halve the random error.

Eriksen and Solow (1991) encourage more thorough definitions of the reference points. They emphasis the need for the observer to have a good knowledge of radiographic anatomy and to use radiographic films with high quality images.

Gravely and Murray Benzies (1974) felt that image quality was not so important , they noted that clarity often varied from one anatomical site to another on the same film. Hurst et al (1978) compared landmark identification using xeroradiographic cephalograms and conventional cephalograms. He compared the identification accuracy of fourteen landmarks. He found only four (point A ,upper incisal tip , infradental, and menton) landmarks were more accurately determined on the xeroradiogram, while two landmarks on the conventional cephalogram (point B and condylion) were more accurately determined.

The suggestion of using multiple tracings to reduce the random error of landmark identification was disputed by Brown (1973). He suggests it is probably not necessary provided that the measuring techniques were carefully scrutinised and an intra observer replicability study was performed to assess the variability of error.

Liou et al (1998) examined the validity of using fixation screws / wires as alternative landmarks for cephalometric evaluation after Le Fort I osteotomies. They found that the reproducibility of the hardware as landmarks was higher than that of skeletal landmarks. They suggest that when the skeletal landmarks are altered or no longer exist after the operation, the fixation screws /wires could be used as alternatives to measure the maxillary postoperative stability. This is only useful if the hardware has not already been removed.

3.4 Errors of superimposition

Superimposition is used in two ways in cephalometrics. It is used in longitudinal studies of individual patients cephalograms , comparing changes in individual landmarks with time. This is achieved by utilising an anatomical plane and superimposing the films or their tracings.

Superimposition is also used when multiple tracings of the same master lateral cephalogram are made. The tracings are then compared to determine variation and thus error in landmark identification. Several studies (Vincent and West 1987, Broch 1981, and Baumrind et al 1971) have examined the potential error of landmark identification utilising multiple tracings. Methods used of registering the tracings to the radiograph include marking points, pin pricks, or punching holes and then using the pins to register the position. Broch (1981) investigated the error associated with superimposition of tracings on cephalograms. He measured the difference between two registrations of the SN line relative to a third point. With the use of a digitiser the difference or error between the two was 0.03 mm. in both the X and Y directions.

Superimposition is a well recognised technique for comparing serial lateral cephalograms of an individual patient over time. Bjork (1963) described how cephalograms could be superimposed by sliding one over the other using predetermined reference points. He used the 'best fit' cranial base as the reference point.

With this technique relative displacement of structures with time can be assessed. The planes most commonly used include the anterior cranial base, the line sella- nasion, the palatal plane, and the mandibular border.

Houston and Lee (1985) examined the accuracy of five different methods of superimposition on cranial base structures.
1.Direct superimposition of the lateral cephalograms.
2. The Adams Blink Comparator (a device which produces a virtual superimposition by looking through a viewer with the two films placed side by side.)
3.The subtraction technique.
4.Registrations of tracing on the cranial base.
5.Tracings on the S-N line, registered at sella.
All techniques had appreciable errors but the method with the least was superimposing on sella- nasion. They cautioned the operator that nasion with growth may drift vertically. They hence expressed the importance of calculating and expressing the method error when superimposing serial cephalograms. Battagel (1993) agreed with these findings and supported the idea of performing and quantifying an error study for all cephalometric investigations.

Baumrind (1971) investigating errors in superimposition divided them into primary or secondary errors. Primary errors are biologically induced judgment errors resulting from an attempt to obtain biological best fit. Hence the landmarks are not correctly aligned. Secondary errors are the result of the effect of the primary error on distant landmarks. They give the example of a landmark that lies 100 mm. from the centre of rotation . With a rotational error of only 1 degree, the displacement of this distant point is 1.74 mm.

A number of authors have addressed the problem of superimposition error and have proposed techniques to minimise it. The use of punching holes at selected fiducial points (, that is, assumed as fixed basis of comparison) on the radiograph, and transferring them to the other radiograph is accepted by many authors (Baumrind et al 1971 2nd paper, Broch et al. 1981 , Strabun and Danielsen 1982, Vincent and West , 1987).

Bjork and Solow (1962) suggested marking the reference points on the radiograph prior to performing the measurements. They found that this did not improve the accuracy of registering the landmarks.

Sluiter et al (1985) used computers in superimposing cephalograms. They eliminated the use of punch holes serving as fiducial landmarks by employing the physical dimensions of each radiograph or tracing itself and using computer transformations to calculate the vector of displacement and rotation of the second film compared to the first. The magnitude of error was found to be much lower than other methods used.

Superimposition is not the only technique for comparing serial cephalograms of patients over time (Baumrind et al 1976) . Each of the individuals films are measured separately identifying the same set of landmarks and performing the same measurements. These are then compared and the difference is the change that has occurred with time. Baumrind states that this individual film method and the superimpositional method are not mutually exclusive and as such can both be used.

3.5 Errors of digitising.

Errors associated with digitising are considered minimal. Several authors (Bergin et al 1978, Broch et al 1981, Bondevik et al 1981, and Richardson 1981.) have stated that the only source of error when using a digitiser is in landmark identification. Both Broch et al (1981) and Savage et al. (1987) found the error associated with replicating the coordinate system to be negligible for both axes. (about 0.03 mm.) Bondevik et al (1981) found errors of digitisation to be in the order of less than 0.1 mm. whereas manual tracing was in the order of 0.5 mm. in the two planes of space.

Richardson (1981) compared hand tracing to computerised digitisation. He found the computerised technique to be quicker but both had similar precision. Bergin et al (1978) and Broch et al (1981) found digitising to be more accurate than measuring distances manually.

Erikson and Solow (1991) examined the precision and linearity of the digitising tablet.

Errors of linearity are caused by the distortion of the x and y coordinates of the digitising tablet due to electromagnetic fields over the entire surface not being uniform. If a digitiser is not linear, a given line segment will be recorded as having different lengths depending on where it is placed on the digitising surface.

Nimkarn et al (1995) compared computer cephalometrics to conventional tracings. This study included the use of scanners. They found the measurements found with computer methodology were reproducible for most parameters studied. (although point B was found to be unreliable in the vertical plane.) The combined errors for video imaging , digitising of the image and the software were not significant. Of interest is they did find that the parameters related to the horizontal plane from the computerised method were 0.7 to 1.0 mm greater than those obtained from the hand tracing. They believe this to be due to some horizontal magnification.

The use of scanners and the ability to scan cephalograms directly has created a new step into cephalometrics. Oliver (1991) compared five different methods of analysing cephalograms. He used two computerised methods, one utilising direct digitisation of the radiograph, and the other digitising an enhanced video image of the radiograph. These were compared with each other but also to single manual tracing. This tracing was also digitised via both the computer techniques. He found that direct digitisation is less precise than both the traditional method and digitisation of the tracing. The use of enhancing capabilities of computer software packages was found not to produce any significant improvement in the precision of the cephalometric variables studied.

Forsyth et al (1996) assessed an automated computer system and found the accuracy was less than that of manual tracing. Of particular problem was landmark identification of poorly defined structures where there was a poor signal to noise ratio. In another paper in 1996 he does see the future of digitising cephalograms to be computer based. Advantages stated include storage of images and analysis, enhancement of images for more accurate landmark identification, reduced exposure of patients to radiation, and the potential for future automated cephalometric analysis.

3.6 Errors of Measurements.

The basic units of analysis are angles measured in degrees and distances or lines measured in millimetres. Measurements in degrees or millimetres can be treated as absolute or relative, or they may be related to each other to express proportional correlations. (Rakosi 1982).

In measuring distances and angles errors will occur. As most authors believe the main source of error in cephalometrics is landmark identification the technique of manual tracing or digitising the radiograph should have little influence on the values obtained (Cohen,1984 ; Sandler 1988). Other authors may agree with this but have found that digitising procedures will have less associated error (Broch et al 1981; Bondevik et al ,1991). Gravely and Murray-Benzies (1974) found measurement error associated with the thickness of the pencil line and the perceptive limit of the operators eye. Bjork back in 1947 included mechanical errors associated with the use of the protractors, rulers and line drawing. Callipers for line measurements are significantly more accurate .(Carlsson 1967). It has been previously discussed under Errors of digitisation the advantages and disadvantages of computerised analysis.

Baumrind and Frantz (1971) believed that measurement error was frequently underestimated but could be reduced by using digitising, performing a second independent series of measurements and calculating the mean.

Bergersen (1980) discussed the importance of enlargement compensation and described a method to accurately calculate distances based on structures that did not lie on the midsagittal plane. He combined a lateral and frontal cephalogram and used triangulated areas to obtain the desired measurement. Errors in all measured planes did not exceed 0.7%. from these findings Bergersen was able to construct compensation tables for accurate interpretation.

3.7 Selection of a Suitable Line of Reference.

Cephalometry involves the comparison of either serial or longitudinal radiographs. This is achieved by superimposition of either the radiographs or the tracings of these radiographs. (Manually or via digitisation.) They can also be compared by taking standardised measurements of landmarks and comparing them to the mean of a similar population group or by comparing them to that individuals previous films taken at a previous time. Changes being found being related to growth, orthodontics, surgery or possibly errors ,that have been discussed previously.

To compare films either by superimposition or on an individual basis a standard line of reference is needed. Many lines of reference have been proposed over the years but no one line has fitted the ideal. According to Steiner (1953) and Wei (1968) the ideal line of reference should:

1. Superimpose easily.
2. Remain perfectly stable despite growth so that craniofacial variations elsewhere can be clearly demonstrated.
3. Be based on reference points with an infinitesimal envelop of error which does not vary when the head deviates from the true profile position.

No one line can fit all of these requirements completely. Some lines however are more reliable than others. One major problem is that there are no absolutely fixed points in the growing human skull (face or cranium). There are however relatively stable landmarks.(Krogman ,!951).

Most recent orthognathic literature utilises the planes Frankfort horizontal or sella- nasion. Frankfort horizontal represents bilateral points (, that is,. not midline structures) and is thus more subject to error. Sella-nasion , being two median landmarks is considered more reliable. An alternative is the SN-7 line which is a variant of SN. It was proposed by Burstone (1978).

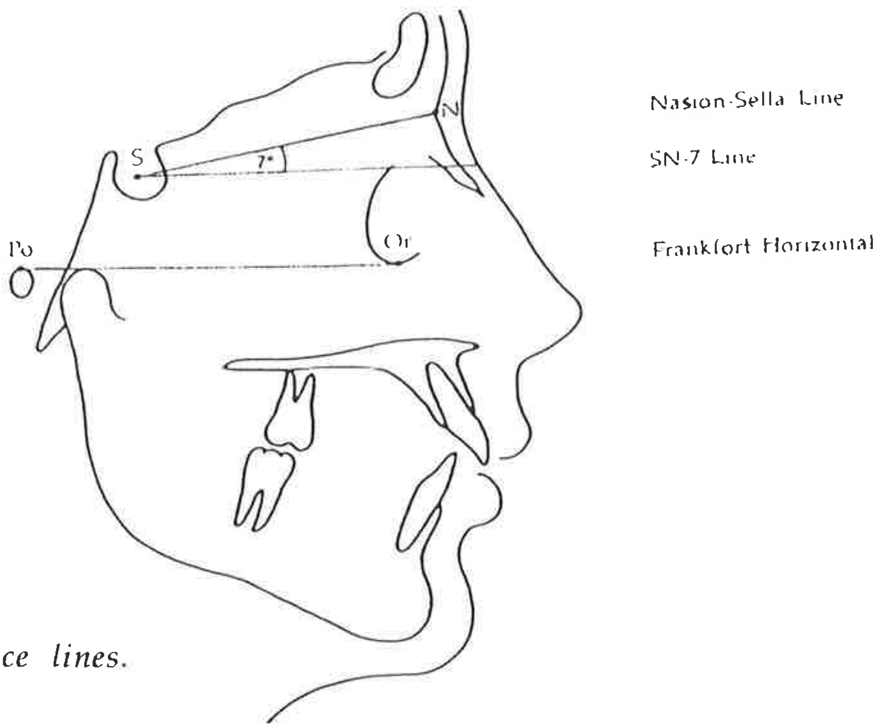


Figure 3. 1 reference lines.

The Frankfort horizontal line is defined as a line passing through the upper periphery of the external auditory canals and the lowest point of the orbit. (Krogman 1957). It was first described by Vow Ihering in 1872 and is firmly a part of cephalometric analysis. Its wide acceptance relates to its of use in the clinical setting and its close approximation to the natural head position. (Bjerin, 1957).

It does however have certain limitations. One particular problem is the unreliability of porion. Downs (1952) was one of the first to point out the inaccuracies of this landmark. It is poorly distinguishable radiographically and is often a substantial distance from the ear rods of the cephalostat. Also the external auditory meati are not always symmetrical.

Ricketts (1981) stressed the problems of using *machine* porion, , that is,. the position of the ear rods and that true porion was often located a great distance away (often up to 1.0 cm.). Even true porion is difficult to locate due to possible misinterpretation, relating to the complexity of the underlying middle ear. (Koski et al , 1956; Chate 1987)

The nasion sella line extends from nasion, being defined as the most anterior point on the nasofrontal suture, to sella, the midpoint of sella turcica (Krogman 1951). This line has been considered the most reliable as it changes least in the growing human skull.
(Wei, 1968).

Steiner (1953) agrees with many other authors and added that its other great benefits include the ease of recognising the landmarks, there reproducibility, the fact that the landmarks are midline structures.

There have been several authors that have shown displacement of both nasion and sella with growth. Bjork and Skieller's (1983) in a longitudinal study showed an upward displacement of nasion, which they suggested was growth at the frontonasal suture. They also suggested that enlargement of the pituitary gland could cause downward displacement of sella.

Bjork (1955) found the growth of the outer surface of the frontal bone which caused forward extension of the anterior cranial fossa was complete by 10 years of age and the shape of the fossa remained stable from then on. SN thus being stable in the adolescent years .

Baumrind and Frantz (1971- 76.) showed some unreliability of nasion. In the horizontal plane it is a very easy and accurate landmark to locate. However large errors can occur in the vertical plane. This gives it an elliptical envelope of error that when compared to other landmarks is relatively low.

Other researchers have compared the accuracy of superimposing cranial base structures to nasion-sella line. Ghafari et al (1987) found minimal differences between the two. In contrast Pancherz et al (1984) found superimposition of the cranial base to be less accurate when compared to nasion-sella line. They suggested the difference being related to the difficulties of identifying the cranial base due to intricate anatomy, variation in film density ,and distortion.

The nasion-sella line has distinct advantages over the Frankfort horizontal line. Unfortunately it does not orientate the cephalogram to the postural horizontal of the patient. Hence to address this Burstone (1978) proposed the SN-7 line . The aim of this line is to exploit the advantages of the nasion-sella line whilst orientating the cephalostat to the natural head position (that is, taking advantage of the positive attributes of the Frankfort horizontal). This reorientates the head so that the influence of extremal landmarks is minimised. The number of 7 degrees is the average value between the SN line and Frankfurt horizontal. Several studies have shown this (Bjerin ,1957: Wei, 1968.).

No single line fulfils the ideal criteria. Nasion-sella is the best compromise having several distinct advantages including ease of location and its low method error when it is used for superimposition. (Houston and Lee, 1985)

In summary the suitability of cephalometry for the analysis of segment migration following orthognathic surgery has been questioned. Some authors have suggested that the sum of method errors discussed above may in fact approach or even exceed the magnitude of the therapeutic change obtained by surgery (Broadway et al 1963, Houston 1983). Cephalometrics does have certain limitations with regards to both precision and accuracy and this fact must be born in mind when interpreting results of studies using these techniques (Wall et al 1996).

Chapter 4 Relapse following Orthognathic Surgery.

4.1 Defining post surgical relapse.

Relapse is defined by Reichenbach (cited by Lindorf 1986) as "a postoperative approximation of the teeth to the preoperative state". Paulus (cited by Lindorf 1986) considered relapse to be present whenever changes in the occlusion ,such as open bite , occur during the postoperative period.

These definitions describe changes in the occlusion only but ignore the underlying skeletal bases. Reitzik (1988) addresses this by interpreting relapse as a 'return to the preoperative state'. This is probably the better definition as it encompasses both the skeletal and occlusal changes.

Stability has always been of concern to the orthognathic surgeon. Postsurgical relapse has been one of the more discussed complications of orthognathic surgery. Reichenbach and Paulus considered relapse as an unfavourable change at the occlusal level that brought the postoperative occlusion back.

4.2 Measurement of Post Surgical Relapse.

Relapse following maxillary osteotomy has been the subject of several studies (Carlotti et al 1987, Larsen et al 1989, Wardrop et al 1989, Proffit et al 1987.) Surgical changes of the the osseous components of the midface disrupt the preoperative homeostasis. The reestablishment of the steady state occurs after surgery with adaptation of the involved soft tissues.

No ideal method of quantifying relapse exists. This relates more to the anatomical complexity of the region being studied as well as the multitude of potential variables that would affect relapse. Some of these may mask or be mistaken for relapse eg. growth.

Researchers in the literature have generally assessed relapse by looking at occlusal changes (both clinically and in the analysis of study models) and assessing both dental changes and skeletal changes on radiographs (cephalograms) . This gives a quantifiable record of pre surgery anatomy, the changes that have occurred with surgery and also long term postsurgical changes. MacIntosh (1981) included a study of occlusal casts in conjunction with cephalometric soft tissue profile to assess relapse but however found that this method was not satisfactory.

The other documented method is the placement of metallic implants into patients jaws to act as a stable landmark for serial cephalograms (Wade 1988). This has the ethical implications of inserting alloplastic implants into patients jaws. Generally this is ethically unacceptable in Australia. Rosenquist et al (1986) also reports using implanted markers to assess relapse.

Relapse is often expressed as a percentage change of the initial surgical movement. Some researchers have reported a figure as being average relapse for a sample. This is sometimes expressed as a lincar measurement and sometimes as a percentage of the average advancement. As Kierl (1990) noted relapse can potentially occur in either direction so the commonly used method of reporting average relapse can be misleading. Other studies focus on the number of patients within a sample who experienced relapse.

Burstone et al. (1978) describes a cephalometric analysis specifically for use in orthognathic surgery. Its use is threefold; as an aid in diagnosis, as a tool for simulating surgery, and to evaluate surgical changes. With cephalometrics researchers have looked at a variety of landmarks and even at markers implanted at the time of surgery. Results have been expressed in many different forms either as linear measurements, relapse as a percentage of the advancement or the percentage of patients experiencing relapse. This makes it difficult to compare the results of different studies.

Cephalometrics has become the most widely accepted method of assessing relapse although no standard system of landmarks has been universally accepted.

Ayoub et al. (1993) report on the use of finite element analysis for the evaluation stability following genioplasty. Finite element analysis is a system of mathematical modelling best known for its application in engineering. The authors report that this method of analysis is capable of separating changes due to repositioning from those of remodelling. They define repositioning as failure of a bone segment to maintain its position in relation to adjacent bones, whereas remodelling is a combination of bone resorption and apposition causing shape changes rather than positional changes. Generally the mathematics involved in finite element analysis are extremely complex, however Sameshima and Melnick (1995) describe a computer programme which greatly simplifies the concept for use in cephalometric analysis.

4.3 Early, Intermediate and long term relapse.

Many studies of the timing of relapse in mandibular osteotomies have been undertaken (Carlotti et al 1987, Larsen et al 1989, Proffit et al 1987, Wardrop et al 1989, Wolford et al 1981, Bell et al 1981).

Skeletal relapse of the mandible was found to occur early when the patient was in maxillo -mandibular fixation (MMF) . This being reduced with the introduction of rigid internal fixation. Most studies show that relapse after this 6 week period is minimal with very little change by 6 months . Much fewer studies extend past 12 months. Relapse studies of the maxilla generally make little comment on when post surgical relapse occurs . This probably reflects the fact that few studies extend longer than 12 months also. Most relapse in these studies occurring in the first 6 months.

It is worth noting that the definition of short and long term relapse varies. The Americans consider 6 months or more as long term whereas European studies define 5 years as or more as long term . This particular study incorporated reviews greater than 12 months as long term. This period was chosen as postsurgical orthodontics has usually concluded so that any morphological changes will be independent of any active treatment.

Carlotti et al (1987) examined 18 patients who underwent maxillary advancement. Those who showed skeletal changes post surgery had done so in the first 5 months.Patients having inferior repositioning of the maxilla also had most of their relapse in the first 3 months (Quejada et al 1987,Bell et al 1981), stabilising by 6 months .None of these studies went longer than a year. With superior repositioning of the maxilla most "unstable " patients had continued movement in the direction of the surgical change , that is,. further intrusion in the first 6 weeks , then inferior movement over the next 11 months back to the surgical position. (Proffit et al 1996).

Chapter 5 Factors associated with post surgical relapse following Le Fort I osteotomy.

5.1 Introduction.

Bell et al. (1986) commented that there were three essential criteria that need to be fulfilled to achieve a successful outcome from orthognathic surgery. These are the restoration of normal jaw function, the creation of optimal facial aesthetics, and the maintenance of long term stability.

Proffit and White (1970) were among the first to mention relapse after surgical-orthodontic therapy. They felt that relapse could be avoided by concentrating on eliminating the original causes contributing to the presenting malocclusion as much as possible, and by not operating while the patients are growing.

The causes of relapse are considered to be multi factorial. Stability after surgical repositioning of the jaws varies a great deal. Proffit et al (1996) suggests the most important factors in order of severity to be the direction of movement, the type of fixation used and the surgical technique that was employed. There are probably many other factors at play some as yet are probably unrecognised.

Wardrop and Wolford listed factors contributing to instability of maxillary osteotomies including inappropriate pre surgical orthodontics,perioperative complications, inadequate maxillary mobilisation during down fracture, inadequate stabilisation techniques and lack of bone grafts or poor bone graft technique.

Schmitz et al. (1995) suggests a multiple of factors can be implicated in affecting the stability of maxillary osteotomies. These being categorised into dental, osseous , surgical and experimental components.

Dental component involves the tooth position and is influenced by both the orthodontic positioning and the surgical repositioning. The osseous component of relapse involves movement of internal maxillary landmarks. In their study this was an anterior- superior movement of the anterior maxilla, but the other landmarks were stable. Surgical component of relapse encompasses demographic factors associated with patient selection,as well as procedural events eg. the use of rigid fixation or bone grafts, growth or osteoplasty of maxillary landmarks. Growth was found not to influence stability.Experimental component of relapse includes all the factors designed to assess and control the outcome of the data. He emphasises the importance of critically reviewing the design components and possible source of errors. This is particularly true of for the cephalometric landmarks of ANS , and PNS.

Factors implicated will be discussed under the following headings.

1.Orthodontics.
2.Direction of repositioning.
3.Magnitude of shift of the maxilla.
4.Influence of bimaxillary surgery.
5.Plating versus wire fixation.
6.Segmental versus single piece osteotomy.
7.Muscular interaction.
8.Vascular considerations of the osseous segments.
9.Growth of skeletal structures.

5.2 Orthodontics and Occlusion.

Treatment planning of the orthognathic patient requires close cooperation between the orthodontist and surgeon. Pre surgical orthodontics should include elimination of dental compensations and alignment of the individual arches . This often results in an initial worsening of the occlusion .

Pre surgical orthodontics has been found to be one of the factors affecting stability of orthognathic surgery (Welch, 1989). Overall stability will be enhanced when the surgically moved segments fit well at the time of surgery because major orthodontic changes are avoided following surgery (Epker et al 1995).

Orthodontic relapse is a problem for both non surgical and surgical cases but there are particular situations in the surgical patient that deserve particular attention. Sadowsky et al examined long term, stability in non surgical patients reviewing results up to thirty five years post treatment. They categorised post treatment results into eleven variables and whether the patients occlusion was within an ideal range. Ninety four percent obtained the ideal occlusion at the end of treatment. Seventy two percent of the study group had at least one variable outside the normal range at long term follow up, showing some degree of relapse will occur. The most common long term problem was an increase in overjet and overbite. The second most common problem was increased mandibular crowding. In conclusion though all patients had substantial change from their original occlusion and thus defining 'success ' will vary between practitioners and patients.

In another review of orthodontic relapse El -Mangoury (1979) examined 50 patients with orthodontic treatment alone. They examined variables such as class I and class II dental malocclusions. There was no significant interaction between the two groups. Extraction and non extraction cases and the gender of the patient were also examined and again no difference in stability or relapse was found.

Orthodontic preparation of the orthognathic patient can prevent correct skeletal correction.The most common reason being gross malalignment or protrusion/ retrusion of the incisors preventing the desired antero-posterior jaw repositioning. It has been shown that pre surgical orthodontics , due to various intermediate occlusal interferences can affect vertical and horizontal dimensions (Vasir et al 1991). There has been some suggestion that a lack of occlusal intercuspation could predispose to relapse.

Several specific orthodontic objectives need to be discussed in relation to maxillary osteotomies. These objectives must be clear both to the surgeon and orthodontist. With planned segmental procedures for both transverse maxillary discrepancies, and also for differential vertical changes. The orthodontist needs to create spaces (unless an extraction space can be used.) to perform interdental surgical osteotomies. This decreases possible damage to teeth which can lead to tooth ankylosis (Legan ,1992).

Extrusion of anterior teeth or intrusion of posterior teeth pre surgically and extrusion of anterior teeth post surgically must be avoided. This is most relevant in patients with open bite. If such a patient subsequently has a surgical procedure to correct vertical maxillary discrepancy, the vertical correction performed orthodontically is subject to relapse post surgically resulting in reopening of the bite. (Epker et al 1995).

The orthodontist thus in such cases needs to be cautious with "vertical mechanics " . Inappropriate vertical mechanics can occur if the open bite is partially closed with orthodontics when

1.Levelling of an excessive maxillary curve of spee by using continuous arch wires from molar to molar.

2.Levelling of the reverse curve of spee in the mandible.

3.Using posterior vertical elastics - leads to unpredictable stability with tooth extrusion.

To prevent these problems Epker suggests the use of segmental arch wires. This allows each section to find its own level , preventing unstable extrusion of anterior teeth. Thus prior to surgical management of an anterior open bite the intrusion of the incisors or maintaining their pretreatment level whenever possible is recommended. Doing so will make the open bite worse prior to surgery but relapse of incisor intrusion following surgery will only serve to maintain the bite closed.

Orthodontic maxillary expansion in individuals older than 16 to 18 years of age is accomplished by dental tipping with little or no orthopaedic movement. This is inherently unstable (Epker et al. 1995). Relapse following orthodontic maxillary expansion will cause a posterior crossbite but will also have an influence on the anterior relationship. It reopens the bite anteriorly due to an increase in the effective posterior vertical dimension as there is a cusp to cusp relationship instead of cusp to fossa occlusion. Therefore any expansion in this age group should be surgery alone or surgically assisted maxillary expansion.

Thus orthodontics may contribute to relapse. The risk of relapse is increased if orthodontic treatment tries to achieve a functional occlusion prior to surgery.

Consequently , teeth are placed in an unstable position relative to their alveolar foundation, ignoring the underlying skeletal dysplasia (West and McNeill, 1981). Treatment of anterior open bite is an excellent example of this. If the anterior open bite is closed by orthodontic extrusion of the incisors and then surgery performed, the incisor teeth will tend to return to their original position , that is, become 'intruded'. This will result again in the creation of a post surgery open bite.

Carlotti in a personal communication with Law (1989) suggested that in his experience postoperative orthodontic changes due to inadequate pre surgical dental compensations accounted for 75% of the postoperative relapse in rigidly immobilised Le Fort I osteotomies.

5.3 Direction of repositioning the maxilla.

The direction in which the maxilla moves has a dramatic effect on the resultant stability. This has been studied by many authors (Schendel et al 1976, Epker 1981, Rondahl et al 1988, Bailey et al 1993, Proffit et al 1987, 1996.). Proffit et al (1996) published his hierarchy of stability. They have found that superior repositioning of the maxilla is the most stable procedure. This is followed , in order ,by anterior shift of the maxilla, a combination of maxillary impaction and mandibular advancement, maxilla forward with the mandible being setback. Inferior repositioning of the maxilla and increasing its transverse dimension were found to be the most unstable.

MORE ↑	Maxilla up.
	Mandible forward.
	Maxilla forward.
STABLE	Maxilla up + Mandible forward.
PREDICTABLE	Maxilla forward + Mandible back.
	Mandible back.
↓	Maxilla down.
LESS	Maxilla wider.

Figure 5.1 Diagram hierarchy of stability (Proffit , Turvey and Phillips 1996).

Many studies have examined superior repositioning of the maxilla.(Schendel et al 1976, Epker 1981, Rondahl et al 1988, Bailey et al 1993, Proffit et al 1987, 1991 & 1996, Teuscher et al 1982, Carlotti et al 1987, Loius et al 1993, Hoffman et al 1994, Egbert et al 1995, Waite et al 1996.) Superior repositioning of the maxilla is typically performed in the patient with excessive exposure of the upper anterior teeth with the lips at rest (> 3.5 mm.), and a long lower third facial height.

The impaction of the maxilla came into prominence in the late 1960's. Initially there was concern that this procedure would create an excessive interocclusal rest space. This was found not to be the case as postural or rest position of the mandible rotates upward and forward so that the interocclusal rest space is maintained (Proffit et al 1987). It is probably this physiological adaption that plays a major role in stability.

Post surgical movement after repositioning of the maxilla in a superior position has been shown in most studies. This movement though is also in a superior direction so is not considered relapse but probably could be referred to as instability. Bailey et al (1993) provides a five year review of superiorly repositioned maxilla's. They found that the skeletal relationships were quite stable. They did find in about 20% of their study group that there was downward movement of the maxilla and/ or eruption of the maxillary teeth. This lead to downward and backwards rotation of the mandible and a tendency toward reoccurrence of overjet rather than open bite. They found no correlating factors to why this particular group did show relapse, in that they didn't appear different to the other eighty percent.

Proffit et al 1987 found that during the early post surgical phase there was a tendency to move further upwards. All of these patients had a period of intermaxillary fixation. The posterior maxilla was found to be vertically stable in 90% of the patients, and anterior maxilla in 80%. After the first 6 weeks the posterior maxilla showed 100% stability whilst the anterior maxilla in 20 % of patients had moved in a downward direction. They also examined multiple variables to identify at risk patients but no correlations were found.

In conclusion all studies agree that the superior repositioning of the maxilla is a stable and predictable manoeuvre.

Anterior repositioning of the maxilla has also been found to be a reasonably stable manoeuvre. It also has been examined by several authors for post surgery stability (Teuscher et al 1982, Carlotti et al 1987, Proffit et al 1991, Loius et al 1993, Hoffman et al 1994, Egbert et al 1995, Waite et al 1996).It is indicated for class III patients with a component of maxillary deficiency.

Carlotti et al. (1987) studied thirty patients having this movement . The osteotomy sites being fixated with wire. Eight cases had larger than planned postoperative movements. They attributed this to preoperative orthodontic flaring of the central incisors. They found that suspension wires and bone grafting were sufficient to obtain stability in movements up to 11 mm.

Proffit (1996) showed an 80% chance that the maxilla would stay essentially where it was placed post surgically and a 20% chance of modest relapse. There was no difference between the different types of fixation. Araujo et al (1978) found between 31% and 68% regression of a total maxillary advancement in a group of patients when no bone grafts were used. In a group of patients in whom they placed bone grafts between the maxillary tuberosity and the pterygoid plates relapse was measured at between 0 to 5%. They and other authors have suggested that some of the relapse seen may be due to scar retraction, interference with the nasal septum, inadequate mobilisation and fixation, and non passive positioning of the maxilla.

Teuscher et al (1982) followed 16 patients who had maxillary advancement for a minimum of one year . None had relapsed. They did however find that the upper lip lost 44% of its forward projection within one year. This was due partly to swelling reduction between the immediate post operative cephalogram and that taken one year post surgery.

Inferior repositioning of the maxilla is considered unstable. The degree of relapse reported varies considerably. Quejada et al. (1987) noted 50% of the relapse in osteotomies stabilised with wire fixation occurred in the period of I.M.F. immediately post operatively. The remaining relapse occurred in the next 6 months. They found in their series of patients ,fixated with suspension wires and MMF, that the average relapse was 24% of the original surgery. Based on their results these authors practice inferior repositioning with more displacement anteriorly, and less posteriorly. They found that this inferior repositioning of the maxilla by altering the palatal plane was inherently more stable than a direct downward shift of the whole maxilla.

Hedemark and Freihoffer (1978) found in 12 of their patients having inferior repositioning of the maxilla that most relapsed. All of their cases were fixated with wire osteosynthesis.They concluded it was a very unstable procedure and over correction was recommended. Van Sickels et al (1996) found relapse occurred with rigid fixation.Wessburg and Epker (1981) discussed the possibility of increased masticatory muscle activity after inferior repositioning of the maxilla leading to increased tendency to relapse.

Baker et al. (1992) examined four year stability in 19 patients after inferior repositioning. Fourteen patients were stable. Five showed greater than 30% relapse. This tended to be in patients who had greater than 5 mm. inferior repositioning. They found bone grafts and/or bony contact to be essential to minimise relapse especially with moves greater than 3 mm.They agreed with Wessburg that the primary force in relapse is the lengthening of the mandibular elevator muscles and miniplates cannot overcome this force.

Perez et al. (1997) followed twenty eight patients after Le Fort I osteotomy downgrafts for the correction of vertical maxillary deficiency. They used rigid fixation and bone grafts. Eighty percent showed good stability with relapse of less than 2 mm in a superior direction over sixteen months. The mean amount of postoperative relapse represented 28% of the total surgical movement.

The inherent instability of this inferior repositioning results from force against the displaced maxilla during dental occlusion (Proffit 1996). Three approaches toward improving vertical stability have been suggested. These include placement of heavy fixation bars from the zygomatic arch to the maxillary posterior teeth, interposition of hydroxyapatite grafts for immediate mechanical stability, or use of a simultaneous ramus osteotomy to minimise stretching of the elevator muscles and decrease occlusal forces until healing is more advanced.

Transverse maxillary expansion is probably the least stable of all maxillary procedures. Proffit (1996) has analysed a group of patients from the University of North Carolina, utilising study models.They found that the greatest relapse occurred in the second molar region which had the greatest expansion at surgery. About 50% on average was lost in this area. More than 2 mm. of relapse occurred in two thirds of the patients. The instability was probably due to elastic rebound of the stretched palatal mucosa. Proffit suggests that relapse can be minimised by over correction in the first instance, the use of a palatal bar or a heavy orthodontic wire during healing, followed by palatal covering retainer for the first post surgical year. Pogrel et al (1992) has suggested that surgically assisted maxillary expansion, should improve stability.

5.4 Magnitude of Shift of the Maxilla.

Correlation between magnitude of surgical movement and relapse has been found to be importance in mandibular osteotomies (Wade 1988). The maxilla is more restricted in its range of movements in three dimensions due to biological constraints particularly vascular supply.

Maxillary advancement is possibly more unstable with extremely large shifts. Studies have shown (Freihofer 1977, Kaminishi et al 1983) that shifts up to 7 mm are very stable. Araujo et al (1978), showed stability of shifts up to 6 mm. but suggested shifts greater than this needed bone grafts to make them stable. Carlotti et al (1987), found maxillary anterior advancements up to 11 mm. to be very stable when bone grafts are used. Waite et al (1996) compared large maxillary advancements (average 10 mm.) with and without genial bone grafts. Those with bone grafts had significantly less relapse. They discussed instability will occur as movements greater than 4 mm. left a substantial bony gap at the lateral maxillary wall. More recently Gurstein et al. (1998) found greater postsurgical displacement when the maxilla had large surgical advancements, received wire fixation and no bone grafts.

Louis et. al. (1993) studied patients having maxillary advancements for the correction of sleep apnoea. There patients received rigid fixation with miniplates. Although not statistically significant they found the greater the advancement the more likely some relapse.

No correlation was made in the amount of superior repositioning and post surgery relapse. (Proffit 1987).

Bailey et al (1993) in their 5 year follow up of surgical repositioning found no correlation with the magnitude of impaction and postsurgical relapse.

Little is mentioned on correlations with relapse and the magnitude of inferior repositioning of the maxilla. Quejada et al (1987) examined relapse in this surgical group. They found a lack of correlation between the amount of surgical change and the amount of relapse . The reason for this finding they stated as unclear. They suggested that the magnitudes of inferior repositioning achieved in their series (av. 4.4 mm.) were insufficient to surpass the adaptive capability of the masticatory muscles.

5.5 Influence of bimaxillary surgery.

Stability of the maxilla may be influenced by concomitant surgery to the mandible. This being mainly due to the decreased masticatory forces found after two jaw surgery. Some authors have noted that when wire osteosynthesis is utilised and the mandible advanced the maxillary position is severely influenced, showing some relapse particularly if the mandible is advanced a large amount.(Skoczylas, et al 1988) . Hoffman et al. (1994) examined the combined skeletal stability of maxillary and mandibular advancement. They followed 15 patients for 12 months. They concluded that two jaw advancement surgery undertaken to correct horizontal facial deficiency is a surgically predictable and a relatively stable procedure up to 12 months postoperatively. The need to follow these patients over a greater time period was mentioned, but not done, to examine long term stability.

Several authors have found greater stability when two jaw surgery is performed. Brammer et al (1980), Moser and Freihofer (1980) both suggested improved stability occurs over single jaw surgery due to physiologic muscle splinting.

Law et al (1989) examined combined maxillary and mandibular osteotomies. These were treated with rigid internal fixation. They found that relapse rates for the maxilla and the mandible were the same as in single jaw procedures. That is the jaws can be considered to act individually of each other.

Skoczylas et al (1988) examined relapse in bimaxillary surgery comparing rigid and nonrigid fixation. They found no statistical difference between the two groups although they found variation in the MMF group to be greater.

Hiranka and Kelly (1987) examined early relapse, the first 6 weeks, in bimaxillary surgery. All patients were placed in MMF. They found the maxilla was stable in most situations but when the maxilla was moved in an inferior / anterior direction in conjunction with a mandibular setback , there was a tendency for the maxilla to move posteriorly with the mandible as it settled. They theorised that the elevator muscles of the mandible in conjunction with the suprahyoid muscles may have brought about further posterior settling of the mandible which was translated to the maxilla via the wire MMF.

Proffit et al. (1991) examined 51 patients who underwent two jaw surgery. They found better vertical stability with two jaw surgery. They found with inferior repositioning with concurrent surgery of the mandibular ramus actually improved the maxilla's stability. This was also suggested by Wardrop et al (1989) when they presented their results on inferior repositioning of the maxilla stabilised with hydroxyapatite implants.

Hennes et al (1988) examined a similar group of patients . These patients having rigid fixation for their bimaxillary surgery. They found the advancement of the mandible had no effect on the postsurgical stability of the maxilla. It has been shown that mandibular advancement is more stable due to concurrent maxillary surgery (Throckmorton , 1980).

Hennes disagrees with this finding . He felt that mandibular stability was not related to impaction of the maxilla, and in his series he found the mandibular advancement to be relatively stable. LaBanc et al. (1982) expresses the other view. They found in their series of 100 patients that two jaw surgery was less stable than single jaw surgery.

In a study by Kahnberg and Ridell (1988) in which bimaxillary surgery was performed to correct prognathism, it was found that maxillary relapse occurred in the vertical direction only, and skeletal relapse of the mandible occurred in both vertical and horizontal directions was also evident but no more than in mandibular surgery cases alone. They found that the amount of relapse tended to be less in bimaxillary surgery than in single jaw surgery as the moves are proportioned between the maxilla and mandible. This implies that the greater the movement the greater the relapse.

Ayoub et al. (1997) compared the stability of bimaxillary surgery between two centres (U.K. & U.S.A.). They found in both groups that the maxilla was stable when moved anteriorly and/ or impacted. It was inherently more stable than the mandibular procedure.

Most recently Bothur et al. (1998) examined the stability of isolated Le Fort I operations in comparison with two jaw procedures, which included patients having a sagittal split mandibular advancement. They found no postoperative difference between the two groups concluding the maxillary osteotomy is just as stable in two jaw procedures as it is when operated on in isolation.

5.6 Plating vs wire fixation.

Osteotomy sites are stabilised after repositioning by mechanical means. This includes the use of wiring or bone plates and screws. The initial stability of the repositioned bones is dependent on the ability of these appliances to resist internal and external forces. They probably have little or no bearing on long term stability at the osteotomy sites and become a non functioning implant.

Initially all facial osteotomies were stabilised with inter osseous wires in conjunction with maxillo-mandibular fixation. Rigid fixation was adapted to oral maxillofacial procedures from developments in general orthopaedics. Compression plates were reported in the surgical literature initially in the 1930's (Luhr 1981). Early attempts of rigid fixation in the maxillofacial region utilised these orthopaedic devises with mixed results. Since the introduction of specialised instruments the results have become more predictable.

Essentially two main techniques have been used for stabilising maxillary osteotomies. The first technique used a combination of inter osseous wires ,skeletal suspension wires and maxillomandibular fixation. The second group utilises rigid internal fixation techniques. Before the wide spread use of rigid internal fixation some surgeons were using the rigid adjustable pin system (RAP). It has been utilised for superior, inferior and maxillary advancements. It is a bone - dentition arrangement rather than bone to bone. Its advantages are the ability to make post operative adjustments to the final position of the maxilla. One drawback is the need to have a further surgical procedure to have the pins removed. It is not indicated in segmental osteotomies. Bays (1986) examined the stability of this system over an average of 30 months and found it to be excellent. This system however is no longer used.

Wire fixation is no longer used much in orthognathic surgery with the advent of internal fixation techniques. In our unit there was a change from routine intermaxillary fixation (or more precisely maxillo -mandibular fixation or MMF) in the mid 1980's. Some procedures still require MMF in particular intra-oral vertical subsigmoid ramus osteotomy's. This allows the condyle to find a passive position and avoids the difficulties of applying rigid fixation in this region. As it is used almost exclusively for setbacks , good bone to bone contact occurs allowing predictable bone union.

MMF immediately post operatively has been practised for many years particularly in trauma cases with minimal problems. It must always be remembered in the initial post operative period airway control can be of concern for the anaesthetist and recovery staff. Respiratory embarrassment in an anaesthetised patient, nasal haemorrhage, and vomiting can lead to life threatening complications. In an emergency wire cutters have always been placed adjacent to the patient for rapid relief of the MMF. Studies have shown that untrained staff have great difficulty in releasing the wires in a short space of time. Goss et al. (1979) timed the various members of the management team as they released MMF. The time taken to release the jaws was an average of 35.3 seconds for experienced oral surgeons and an average of 2 minutes 9 seconds by hospital staff involved in caring for these patients. It was not a practical option for a lay person. Thus they questioned the value of releasing fixation in the initial care of obstruction or vomiting. They advocated repositioning the patient to the 'Coma position', and utilising suction.

Patients with MMF have a decrease of up to 30% of mean ventilatory volume (Williams et al 1990). This affects the patients ability to exercise and can even diminish speech clarity.

Patients may also loose weight whether desired or not . Buckley et al (1989), compared weight loss in patients with rigid fixation with those in wire MMF. He found that weight loss was less than anticipated in both groups but was substantially more in the group wired together. Weight loss generally is probably related to other factors as well as the fixation. The need for a liquid diet (vitamised or blended food often has reduced or a bland taste- taste being an important stimulant for appetite.),and reduced sensation to the lips may both play a role.

MMF also will decrease the patients ability to keep their mouth clean but this does vary between the individual patients. One suggested advantage of rigid fixation over MMF was the expected quicker return to pre surgical mouth opening. Several studies have shown little difference between the two groups (Storum et al. 1984). Limited mouth opening is more related to mandibular ramus osteotomies that involve the stripping of the insertion of the temporalis muscle. The fact that patients with rigid fixation can undergo active physiotherapy and opening exercises may enable them to return to pre surgery opening more rapidly.

Infection rates were found to be higher in Buckley's study in patients with rigid fixation. He found an increase of three fold over patients with MMF. This was probably related to bone necrosis from heat, on drilling holes for internal fixation, having a 'foreign' object in the wound, and the pumping of microorganisms into the wound during mastication.

Rigid fixation has been found to improve the stability of mandibular osteotomy's. (Van Sickels et al 1985, 1986, Will et al 1989). The question of stability in the maxilla between the two groups of fixation has been controversial. There have been several studies to examine this question.

Bone plates have been suggested to enhance stability of maxillary osteotomies. Champy (1980) reported on 40 patients with midface osteotomies stabilised by miniplates. Seven of the patients had short term relapse between 2 & 7 mm up to 10 months post operatively. Larson et al. (1989) showed an improvement in stability from Immediately post operatively, to 1 year between advancements stabilised with bone plates verses wire fixation.

Van Sickels (1996) provided an excellent review of the literature and discussion looking at the question of stability as a reflection of the fixation technique used. To compare the different types the direction of movement of the maxilla must be considered. Van Sickels (1996) did make comment that there are multiple factors at play when considering stability and there are some circumstances where the different fixation techniques made little difference. In maxillary advancement surgery, Carlotti et al (1987) found that advancements up to 11 mm. were stable if the maxilla was fixed with suspension wires, inter osseous wires and MMF with bone grafts. More complex cases or greater movements they suggest using rigid fixation. Luyk et al (1985) used rigid fixation and 6 weeks of MMF . They only had small shifts (av.. 3.7 mm). They found no significant relapse in all 9 patients . Egbert et al (1995) compared two groups of patients having advancements. All were treated by the same surgeon. One group (12 patients) had wire osteosynthesis with intermaxillary fixation for 4 weeks. The other group (13 patients) had rigid fixation. Post surgical horizontal change in both groups was in a posterior direction. Comparison of the mean values between the two groups suggested improved stability in the rigid fixation group. This result though was not statistically significant. In the vertical dimension though the wire group showed significantly more settling over a 12 month period.

Superior repositioning of the maxilla appears to be stable with whatever form of fixation is used. Proffit et al 1987, found the vertical position of the maxilla to be stable in 80% of patients having this movement when fixated with wire only. In a latter study by the same group 49 patients had a minimum of 2 mm impaction again being stabilised by wire alone. They were followed for 5 years. They were found to be very stable.

Inferior repositioning is considered very unstable again regardless of the fixation used. The lack of success has been ascribed to the instability of the fixation combined with the fact that the muscles of mastication cause a "pumping action" of the mandible against the maxilla (Wolford et al 1981) .Quejada et al (1987) found in his group of patients fixated with wires that over 50% of relapse occurred while the patient was in MMF, and the remainder of the relapse occurred in the first 6 months after release of MMF. Hedemark et al (1978) studied 12 cases fixated with wire osteosynthesis. All except 2 moved in a superior direction. Persson et al (1985) examined 16 adult patients that had inferior repositioning of the maxilla, fixated with miniplates and bone grafts. They found a mean relapse of some 20%.

Van Sickels et al (1990) found relapse when using internal rigid fixation. They also related this to an increased chance of nonunion. Ellis (1989) compared the stability between different groups in animal experiments. One group had wire fixation and bone grafting., another underwent this in conjunction with temporalis and masseter myotomies. The third group had a bite opening appliance before down grafting, and the fourth group underwent down grafting with bone grafts. All groups showed relapse. The most stable was the rigid fixation group, the least stable was the group with wire osteosynthesis alone. Wall et al (1998) recently showed in a small group of patients (10) that titanium miniplates do not prevent postoperative migration of the osteotomy segment. They found all moved in a superior direction independent of the direction of surgical repositioning.

There are no studies in the literature comparing different fixations in patients who have undergone maxillary setbacks or posterior repositioning. This is a relatively uncommon operation and as such statistically insignificant numbers are available. Technically it is difficult to remove enough bone posteriorly to allow a significant shift in this direction, and it is associated with an increased risk of avascular necrosis due to 'crimping ' of the pedicals. Van Sickels personal opinion was that this is a very stable shift when plates are used.

Stability of open bites depends more on the etiology of the open bite than on the form of fixation used. Open bites can be corrected with either maxillary and/ or mandibular surgery. Haymond et al (1991) examined 38 patients with open bite corrected with maxillary surgery and fixated with miniplates. Eighty six percent had a stable result. They found that fifty percent of the relapses were due to orthodontic relapse in transverse deficiency corrected by orthodontics alone. They suggested that internal rigid fixation did give a stable result.

Satrom et al (1991) compared the stability of rigid fixation with that of skeletal wire fixation in a sample of patients who had undergone the same procedure (maxillary impaction and mandibular advancement) to determine if stability in two jaw surgery was any different to the same operation to the jaw in isolation. They found the maxilla was just as stable in bimaxillary surgery as it was in single jaw surgery. They did suggest that rigid fixation tended to improve maxillary stability.

Most of the above mentioned studies refer generally to one piece maxillary osteotomies. The stability of segmentalised Le Fort I osteotomies fixed with miniplates was examined by Chow et al (1995) .They studied 18 patients who had correction of transverse discrepancies and differential movements between the anterior and posterior maxilla.They found there was significant relapse when there was an anterior and inferior shift of the fragments. They suggest this is due to rigid fixation being technique sensitive and requires precision. To maintain the post surgical stability of the maxillary segments the miniplates should be fixated to the bone passively because any built in strain of the miniplate can move the segments after the operation. Furthermore, they suggest their will be some osteolysis and fibrosis around the titanium screws after their insertion thus reducing their 'rigidity'. They too emphasised the possible other causes of relapse.

Internal fixation has been found to increase the incidence of nerve injuries in the mandible. Injuries can occur secondary to the placement of bicortical screws, and also when the screws are tightened compressing the nerve. A theoretical risk could apply to injuries to the infraorbital nerve and to the teeth, hence the risk would be similar to the mandible. This has not been shown in the literature. Damage to the infraorbital nerve is less likely, as in comparison to the inferior dental nerve, it is easier to visualise, shows less anatomical variation and is usually above the line of the Le Fort I osteotomy .

Rigidly Rigid fixation in the maxilla has fallen out of favour in preference for semi rigid fixation using miniplates. The main advantage of these plates is some minor positional change can be achieved with the use of post operative elastic MMF. This would be impossible to achieve with the more rigid plates particularly when the accuracy of these operations cannot be guaranteed .

5.7 Bone Grafts and Stability.

The presence of a bone graft probably adds to the initial stability of osteotomy sites. Bone grafts have been shown to be beneficial in some studies (Luyk et al 1985, Obwegeser 1969 , Welch 1989) It is proposed that bone grafting can accelerate osseous healing , act as a physical stop , and provide a matrix for bone growth (Epker et al.1980). Epker found that after a Le Fort I osteotomy wire inter-maxillary fixation was needed for eight weeks to obtain stability but if bone grafts were used this was reduced to three to six weeks.

Profitt et al (1987) indicated that bone grafts are needed in maxillary surgery if after repositioning there is little or no bony contact i.e. in movements where the maxilla is advanced and/or inferiorly repositioned. Of particular importance is obtaining bony contact around the piriform rim and the zygomatic buttress. They suggest bone grafting promotes more rapid bone healing and may improve the stability. They have found that the thin bone over the premolar region can heal with fibrous tissue leaving bony defects. This however usually has no effect on maxillary stability.

Luyk and Ward -Booth (1985) looked at the role of bone grafts in maxillary advancements stabilised with rigid fixation and felt that advancements of up to six millimetres appeared stable without the use of bone grafts. This is because the zygomatic buttress bone would still have good contact with shifts less than six millimetres.

Trimble et al (1986) found eight percent mean vertical relapse in five patients having inferior repositioning of the maxilla stabilised with bone plates and autogenous bone grafts.

Wardrop et al (1989) found that in twenty four patients who had osteotomy movements of the mid third of greater than five millimetres to forward or downward movements, with interpositional hydroxyapatite implants to be reasonably stable. All had less than one millimetre relapse. They had three patients in which the implants failed and had to be removed . These failures seemed to be related to the individuals with very thin maxillary walls for which bone plates and screws could not provide sufficient support.

There are some studies which have found bone grafts made no difference to stability or relapse. Willmar et al (1974) found no statistical difference between groups of grafted and ungrafted patients following a Le Fort I advancement osteotomy.

Arauyo et al (1978) found a large difference between grafted and ungrafted patients undergoing Le Fort I advancement. Both this and Willmar's study involved movements of less than eight millimetres and intraosseous wiring and intermaxillary fixation were used for stabilisation.

Louis et al (1993) state that in their study of stability of Le Fort I advancements it is unclear to what magnitude the maxilla can be advanced and would benefit in the reduction of post surgical relapse with the use of bone grafts. They suggest further studies would be required to answer this question.

To sum up the literature experience of bone grafts and the affects on post surgical stability Schmidts et al (1995) states understandably "The use of bone grafts to enhance maxillary stability can not be underestimated. However their contribution to clinical stability also can not be assessed." This is due to the multifactorial factors involved in stability and the difficulty of isolating these individual factors in research. Initial movement at a fracture or osteotomy site retards healing leading to non union. Bone repair requires stability and bone growth factors in order to proceed (Marx 1998). These are supplied by a bone graft when a gap greater than several millimetres exists between the bone.

5.8 Segmental versus single piece osteotomy.

The multiple piece Le Fort I has the ability to correct problems in all three planes of space at once. Segmental maxillary procedures are performed for transverse discrepancies and for the correction of differential vertical discrepancies in the maxilla. For example the closure of segmental anterior openbite. It is more complicated than a one piece maxilla and carries an increased risk of damage to the teeth and their supporting structures.

Segmental maxillary Le Fort I surgical procedures in the literature are usually included in patient groups where whole piece maxillary movements are studied and have not been formally studied for relapse as a homogeneous group. This is related more to the fact that these segmental operations are highly individualised for the patient.

Stoker and Epker (1974) , and West and Epker (1972) found maxillary superior impaction when performed segmentally is as stable as a total maxillary osteotomy impaction. Segments can be expected to act as a whole piece maxilla depending on their direction of movement. That is if in the closure of an anterior openbite caused by anterior maxillary deficiency and posterior maxillary excess the resultant three piece maxilla would involve anterior maxilla being repositioned inferiorly (a relatively unstable procedure) and the posterior maxilla being repositioned superiorly (a relatively stable procedure). Perez et al. (1997) found no difference in stability between one piece and segmental maxillae that were inferiorly repositioned.

Chow et al studied the stability of segmentalised Le Fort I osteotomies (1995). In their series of 18 patients segmentalisation was undertaken to for both correction of maxillary transverse deficiency as well as anterior and inferior repositioning of the patient's hypoplastic maxilla. Unfortunately they did not have a comparison group of non segmentalised maxillae having similar movements . Instead they compared their population with other studies. Bloomquist in his comments on this article stated that the question of segmental Le Fort I osteotomies are more or less stable than non segmented osteotomies following maxillary down grafting is yet to be satisfactory answered.

5.9 Anterior Open Bites.

Anterior open bites deserve special mention when discussing stability in Le Fort I osteotomies. Historically the results of both orthodontically and surgically treated anterior open bites have been disappointing.

Incorrect diagnosis has been identified as the main reason for treatment failure (Denison 1989, Hoppenrijis et al. 1997). Orthodontic camouflage of a skeletal problem will result in the return of the open bite once the apparatus is removed. This will also occur if the etiology of the open bite is secondary to a neuromuscular problem such as tongue thrusting or digit sucking. Rarely are open bites an isolated dental problem.

The surgical correction of anterior open bites was originally done with an anterior mandibular subapical osteotomy -Hullihen (1849) .Limberg (1925) performed an oblique osteotomy of the ramus.This was found to be very unstable (One hundred percent relapse rate). Cohn - Stock (1921) were the first to perform an anterior maxillary osteotomy for an anterior open bite. This was followed by Wassmund (1927) and later Wunderer (1963). Schuchardt (1955) was the first to address the group of patients who had excessive anterior open bite secondary to excess posterior maxillary height. He introduced his posterior maxillary osteotomy to treat this problem with good stability. The Le Fort I osteotomy (Introduced through the 1960's and 1970's) has now become the most widely accepted technique for the surgical correction of anterior open bite. There still are a large number of patients that do experience post surgical relapse.

Denison et al (1989) examined stability of maxillary surgery between openbite and non openbite malocclusions. They found 21% of patients with pre-treatment openbite suffered post treatment relapse. They suggested this wasn't due to skeletal relapse but may be related to the influences of orofacial musculature - tongue posture and hypotonic buccal musculature. Hence in obtaining stability of the openbite its etiology must be sought and controlled.

Open bite skeletal discrepancies have a number of causes. They can be corrected with maxillary procedures. It is suggested that stability of such procedures is related to the correction of transverse problems of the dentition and tongue problems.(Frolich et al.1993).

Kent et. al.(1970) states the correction of the open bite deformity is one of the most challenging problems. Open bite treated with combined orthodontics and surgery should produce stable results in certain cases; however regression is seen because of the tongue, enveloping muscles of the jaw, unusual skeletal features, or bone pathology.

Haymond et al (1991) found a fourteen percent relapse rate in a series of 38 patients his group treated with Le Fort I osteotomies. These patients were fixated with miniplates and followed from one to five years. Only one had true skeletal relapse, the others dental. Most of the relapse was attributed to transverse relapse of orthodontically expanded maxillary molars.

Hoppenreijis et al (1997 & 1998), examined a large number of patients (267) treated surgically for anterior open bite. They were followed from 20 - 210 months post surgery. Nineteen percent of the patients showed relapse post surgery. This was due to dental orthodontic relapse and/or the wrong diagnosis. Most anterior open bites are a segmental problem, so should be treated segmentally. They also thought the continued influence of the soft tissues may play a role.

Lo et al (1998) , examined the problem of orthodontic extrusion of anterior teeth prior to surgical correction of an anterior open bite. They conclude that a moderate amount of extrusion or a lack of extrusion are both stable long term and had little influence on the post treatment stability of open bite.

5.10 Muscular Interactions.

One effect of orthognathic surgery is the abrupt change in the length of the muscles and associated soft tissue of the craniofacial complex. Hence whether the process of adaption can cope with these changes will affect long term stability.

Surgical correction of vertical maxillary deformities is influenced by the resulting change in the mandible and the change in the resting position of the masticatory musculature. Surgical relapse of both superior and inferior maxillary repositioning tends to be toward a more superior position.(Proffit 1987).

The muscles of mastication and the orofacial complex have an important potential role in the etiology of some craniofacial deformities and also in the relapse of skeletal craniofacial dysplasias (Ellis and Carlson 1990).

After surgical shifts there is a period of adaptions leading to a state of homeostasis. The muscles and bones of the face are in balance. That means tension produced by the contraction of the muscles and the stretch of the soft tissues drape is effectively distributed by the associated skeletal components. This homeostatic situation is unbalanced after surgery.

The different directions the maxilla can be repositioned will obviously have a different effect on the musculature. Superior repositioning in the management of vertical maxillary excess (Long face syndrome) or in the closure of anterior open bite are included in this group. Both will result in the surgical separation of the occlusal surface of the maxillary and mandibular dentition. This allows autorotation of the mandible into its new resting position (Ellis et al 1990). It rotates around the condyle. Autorotation occurs to maintain the interocclusal dimension (freeway space). (Wessburg et al 1981 &1982). Alterations in jaw muscle morphology and muscle activity with adaptive changes by the central nervous system allow this restoration of the freeway space.

Autorotation causes the muscles to become shortened. This means there are no active or passive forces on the repositioned maxilla from the mandibular musculature. Therefore reduction of the midface results in excellent stability.

Throckmorton (1980) developed a two dimensional biomechanical model that showed superior repositioning of the maxilla should improve the biomechanical advantage of the mandibular elevator musculature.

Autorotation changes the position of the gonial angle and the coronoid process effectively modifying the temporalis and masseter movement arms - this leads to an increased mechanical advantage for the muscle. This theory was not substantiated clinically (Proffit 1989). Proffit found no patient had a change in mechanical advantage greater than 10%.

Attempts at increasing the length of the masticatory muscles creates a problem. Lengthening or stretching these muscles beyond their normal physiological rest position may significantly increase in both active and passive muscle tension.This will place undue stress on the repositioned osseous segments predisposing to relapse. Inferior repositioning of the maxilla will cause these forces by stretching the mandibular elevator muscles, making it an unstable procedure (Yellich et al, 1981). Inter positional bone grafts and newly formed woven bone may be incapable of resisting the compressive stresses generated by the muscles of mastication.

Proffit and Field et al (1989) showed that patients with vertical maxillary deficiency are capable of generating higher bite forces (up to 100 kg. molar bite force) when compared with normal individuals or those with vertical maxillary excess. Long faced individuals have bite forces in the molar region of 30 kg. , normal individuals having mean bite forces of 50 kg.

Several authors have proposed methods of reducing postsurgical relapse in vertical maxillary augmentation. These techniques being aimed at reducing the forces generated by the mandibular elevator muscles.

1.Dann et al (1980), performed coronoidectomies and pterygomassateric myotomies.

2.Wessberg and Epker (1981) placed a screw device between the zygomatic buttress of the maxilla and the mandible to alleviate distraction forces.

3.Wolford et al (1981) used bilateral threaded Steiman pins passing from the zygoma to the maxillary splint in an attempt to withstand the upward forces.

4.Rigid internal fixation has been advocated by many surgeons.

5.Use of a bite opening appliance to preadapt the elevator muscles (Proffit and White 1991).

All of these techniques have been claimed to improve stability. Proffit et al (1996) concluded that stability is greatest when soft tissues are in their relaxed position at the end of the procedure and least when they are stretched.

Johns et al (1997) examined the effect of maxillary osteotomies on the facial musculature, particularly facial movement. Surgical repositioning of the maxilla anteriorly and/or inferiorly lengthens the facial musculature resulting in an increase in facial movement while smiling. Likewise surgical repositioning of the maxilla superiorly and/or posteriorly reduces the length of the facial musculature resulting in a decrease in facial movement while smiling. These changes will likewise affect the forces created by the facial muscles.

5.11 Vascular considerations of osseous segments.

Relapse related to poor healing has not been specifically studied. As discussed in chapter 2.6 loss of vascularity of the osseous segments in maxillary surgery is a real risk. Meticulous attention must be given to the design of the pedicle flap. Segmentalising the maxilla carries the highest risk of devitalising osseous segments. Bone healing is required to obtain long term stability but actual loss of tissue due to avascular necrosis is devastating.

Bell et al (1973) examined wound healing after multi segmental Le Fort I osteotomy and transection of the descending palatine vessels. The study utilised 4 piece osteotomies in rhesus monkeys. They found the palatal mucosa or labial - buccal gingiva and mucosa were adequate pedicles to keep the osseous segments intact.

Bays (1985) found that difficulty in mobilising the maxilla and the potential for compromise of a tenuous vascular supply may complicate healing and lead to post operative instability.

Some specific categories of patients are prone to this problem. Patients with cleft palates requiring maxillary augmentation frequently have scarred palatal mucosa and a compromised blood supply (Van Sickels 1990).

Facial bone healing has been well documented from animal studies and patients with fractures (Szachowicz 1995). This information is directly applicable to the patient having orthognathic surgery. Bone is capable of complete repair (as compared to scar tissue formation). After an osteotomy the bone should heal by 'cortex to cortex' union if in contact (either directly or via a bone graft) avoiding callus formation. Otherwise a callus will bridge the gap. This is achieved by migrating cells from the adjacent bone (and bone graft) and periosteum that have osteogenic potential and lay down osteoid. This is eventually ossified forming bone. Growth factors including bone morphogenic protein (B.M.P.) play a major role in the process. Work is now being done to aid bone healing by utilising these isolated B.M.P.'s and placing them at the wound site (Lind 1998, Sakou 1998).

5.12 Growth and Stability.

Growth of the maxilla has been reviewed in section 2.4. Growth of the maxilla is generally finished after the adolescent growth spurts. In girls this is reported as between 10 and 12 years of age. Males are generally 1 to 3 years later (Savara et al, 1968). Normal maxillary growth may continue into adulthood. Anteroposterior maxillary growth is largely completed by the initiation of puberty. Any subsequent growth is in a vertical direction (Singh et al 1966).

Early surgical intervention has been reviewed by several authors. (Nanda et al 1982, 1987 & Mogavero et al 1997). Early surgery generally refers to surgical intervention undertaken prior to the completion of growth.

Several reasons have been put forward for the early correction of dentofacial abnormalities. These include:

1. Early orthognathic surgery may prevent detrimental psychosocial problems.
2. It may also prevent other physical consequences such as problems in the occlusion , masticatory function ,

temperomandibular joint and structure , speech, and the airway (Nanda et al 1982).

The main argument against early surgery is its possible ill affects on further maxillary growth. This could include:

1. The loss of favourable growth that might actually correct the malocclusion if allowed to express itself.
2. Surgical intervention could actually worsen or inhibit already abnormal growth patterns. (Schendel et al 1978).

These points have meant surgery is mainly performed after maturity has been reached.

Nanda and Topazian (1982) performed Le Fort I osteotomies on growing Macaca monkeys. All had impaction of the maxilla. They concluded that the Le Fort I osteotomy had a significant effect on the subsequent growth of the face. . In all of them there was retardation of anterior maxillary growth and vertical growth of the face . Interestingly there was a concurrent reduction in mandibular growth in such a way that a normal occlusal relationship was maintained. This is probably due to the Macaca's huge interlocking canines.

Shapiro and Kokich (1981) also examined Le Fort I osteotomies in Malaca monkeys but with advancements. They also found disturbances in maxillary growth. They suggested this was due to

1. Immature fusion of one or more circummaxillary sutures after the surgical procedures.
2. The elimination of potential growth influence of the nasal septum after antero-posterior separation of the vomer and maxilla during surgery.

3. The potential growth inhibiting influence of stretched soft palatal tissues.
4. The potential growth inhibiting influence of scar tissue which developed during the healing of the circumferential mucoperiosteal surgical incision.

Epker et al (1982) examined the effect of superior repositioning of the maxilla in growing patients (16 patients between 10 and 16 years of age.) They found that growth continued close to normal post surgically. They suggested this resulted from avoidance of the nasal septum or by transection of the septum followed by careful reapproximation. They also suggest performing a total maxillary alveolar osteotomy as it requires no septal resection. In this series of patients, in whom growth had not been completed, there was no evidence of relapse.

Mogavero et al (1997) performed similar research . They performed superior repositioning of the maxilla in growing patients. They separated the 48 patients involved into two groups. Those that received rigid internal fixation, and those that were stabilised with wire fixation. They found afterwards that growth did continue normally. They concluded that the Le Fort I osteotomy had little or no effect on vertical maxillary growth.

Growth is another factor that must be considered in the etiology of relapse in individual patients undergoing maxillary osteotomies.

5.13 Le Fort III / Syndrome Patients / Cleft Palate Patients.

Congenital maxillofacial deformities such as Crouzon's, Pfeiffer's , or Apert's syndrome present a distinct set of problems. It is more difficult to analyse these patients with standard cephalometric measures as they have no 'stable' cranial base to use as a reference point (Welch,1989). Many of the conventional landmarks move or are obliterated in the surgical procedures used to correct these deformities. Also in assessing the stability of their surgical procedures they were often operated on early, during growth due to psychosocial reasons, or neurosurgical and ophthalmic reasons.

Le Fort III osteotomies were first described in the 1950's by Tessier. Long term studies have started appearing in the literature. Bachmayer and Ross (1986) performed Le Fort III operations on growing patients (average age 7 years). They moved the maxilla forward an average 12.4 mm. and found a nine percent relapse in the horizontal plane and six percent relapse in the vertical plane. They found no correlation between the amount of surgical movement and relapse. They suggested stability wasn't related to a well interdigitated occlusion but was related to rigid stabilisation with bone grafts, intraosseous wiring, and MMF or rigid fixation during the postsurgical period.

Schmitz et. al. (1995), examined the maxillary skeletal stability after simultaneous Le Fort I/ III osteotomies in the correction of adult patients with midface and maxillary hypoplasia. All 11 patients had miniplate fixation and bone grafts. They found the maxilla relapsed vertically and suggested over correction at the time of surgery necessary to allow for this relapse. The follow up was only for one year.

Gillies et al. (1950) presented follow up on a patient who had the first reported Le Fort III procedure. They noted that the edge to edge position of the central incisors was stable after 7 years.

Epker and Wolford (1975) examined skeletal and occlusal relapse with mid-third facial osteotomies .These patients movements were stabilised with wires and bone grafts. The occlusion was over corrected in all cases.They also used I.M.F. for 6-8 weeks, followed by elastics for 2-4 more weeks. They noted a definite tendency for skeletal and occlusal relapse, but details were not provided.

Ousterhart et al. (1986) assessed the long term position of the maxilla after Le Fort III advancement for craniosynostosis syndromes utilising bone grafts. They were kept in intermaxillary fixation for 8 weeks with a bite splint. They followed patients for 9 years and found the maxilla did not significantly change in position.

Freihofer (1984) followed up 9 patients after Le fort III osteotomies. The follow up period varied. The osteotomy sites were stabilised with IMF and bone grafts. He found the maxilla to be stable in the horizontal but relapse in the vertical was in the order of 3 mm.

Kaban et al. (1986), examined patients with Crouzons or Aperts syndromes who underwent midface advancements. Bone grafts were used to stabilise the osteotomy sites. They were all placed into M.M.F. The average advancement was 14 mm. Relapse at one year was 3.4 mm at A point . He reviewed these patients at 3.5 years post surgery and found patients who were growing at the time of operation had relapsed upwards of 50%. Kaban suggested that in general Le Fort III osteotomies were stable and relapse that resulted in a class III malocclusion was secondary to postsurgical mandibular growth. He recommended that if possible Le Fort III procedures should be delayed until growth has ceased. Tulasne & Tessier found a similar relapse rate in growing patients(1986).

Ellis et al. (1989) examined different techniques of stabilising the maxilla including wire fixation, bone grafts, myotomies of the masseter and temporalis muscles. Others had bite opening devices ,and others rigid fixation. All had relapse but rigid fixation was found to be the most stable.

Cleft palate patients present another group of patients that often need maxillary osteotomies. Postoperative stability has been looked at in a number of studies.Longacre (as quoted By Welch 1989) summarised the problems these patients may present with. This includes crossbite due to collapse of the lesser segments, openbite on the collapsed side and maxillary retrusion . They also have incomplete dentitions and the presence of oronasal fistulae. Garrison et al (1987) in performing Le Fort I osteotomies on twenty patients with cleft palates, with bone grafts, found no relapse in the horizontal direction but vertical relapse occurred.This though was clinically insignificant. Araujo et al (1978) found similar relapse rates to patients treated for vertical maxillary deficiency.

5.14 Conclusion.

The etiology of relapse is a contentious issue because consensus has not been reached regarding the individual role of various aetiological factors. Many authors agree that the direction of surgical movement is the most important consideration in relapse potential after maxillary osteotomies. Other factors including pre and postsurgical orthodontics, magnitude of movement, the influence of concurrent mandibular surgery, the various methods of stabilisation (wire fixation versus rigid internal fixation) techniques used, growth and the soft tissue interactions probably play a role in individual patients. Other factors may be unrecognised.

It is most likely that in assessing an individual patient with relapse all these factors may play a role. That is relapse is most likely to be multifactorial and to a degree, individual. This does not however release the surgeon from the obligation to analyse all patients in detail over an extended period to ensure an optimal outcome for the patient.

Chapter 6 Biomechanics of fixation.

In the last 15 years there has been a tendency to move away from wire osteosynthesis techniques in combination with MMF , towards rigid internal fixation. The advantages of this include better post surgery airway control and better patient acceptance. It allows a more rapid return to normal function, and minimises potential weight loss.

Direct wiring (transosseous wiring or osteosynthesis) with or without MMF or MMF on its own, were the standard methods of treating fractured mandibles and maxillae before the advent of rigid internal fixation. Extraoral fixation was the other technique used in trauma surgery (Rowe and Williams 1994). These techniques were utilised in orthognathic surgery patients. Mostly they have been superseded but in certain they have a role eg. wiring vertical subsigmoid osteotomy mandibular setbacks (V.S.S.O.) utilising M.M.F. and wire osteosynthesis in genioplasties.

Soft stainless steel wiring has the advantage of being cheap and easy to use and is biologically well tolerated. As a fixation method it cannot be considered three dimensionally stable. This is an advantage in some situations as it allows slight postoperative occlusal adjustments. (Rowe and Williams , 1994).

Internal wire suspension is not a rigid method of fixation. It was utilised in conjunction with wire across the osteotomy site.The suspension wires are placed superiorly to the osteotomy sites. 0.5 mm diameter (pre stretched 10%) soft stainless- steel wire. Circumzygomatic suspension wires (Edwards 1965) , infraorbital wires , or piriform aperture suspension wires have been used. They do not stop displacement of the maxilla.

Monocortical semi-rigid fixation of maxillary osteotomy sites has evolved as there use in facial fractures has evolved. Miniplates and screws allows primary healing to occur.Stainless steel was the first material used in maxillofacial surgery (Roberts 1964, Battersby, 1967) Stainless steel however was found to be susceptible to corrosion (Colangelo and Green ,1969) , was difficult to bend and adapt to the bone to achieve the desired contour and may rebound after bending causing screw loosening. It also has the added disadvantage of being bulky and causing scatter on CT scans.

Titanium overcame many of these problems. When produced as a pure metal, titanium offers excellent biocompatibility. Vitallium is another material that has been used with excellent biocompatibility. It is a cobalt-chrome-molybdenum alloy (Munro 1989). Both of these materials have excellent tensile strength and are resistant to corrosion. They both produce little scatter on MRI or CT scans. They are produced in a low profile size which overcomes the problems of bulk when placed under thin overlying tissues.

Plates and screws provide three dimensional stability. When a plate is placed with two screws either side of the osteotomy site it resists both antero-posterior and rotatory movement. Loukota et al (1995) analysed the mechanical properties of miniplates. They examined the effect of compressive and tensile forces on different plate brands. Tests showed all brands of plates showed values of tensile force at failure in excess of that found in most clinical situations. Twisting through the long axis at 90 degrees had little effect. bending tests produced the most variation between brands.'Bending stiffness' showed some plates were stronger than they needed to be. Repeated bending of the plates did reduce their bend stiffness and increased their ultimate load to failure. These facts clinically mean that plates that are easier to bend and thus allow easier adaption will provide adequate strength to both tensile and compressive forces, fracture of plates in situ is a very rare event. Plates should not be reused because of work hardening, affecting their properties.

Micro plates are available for use in problem areas particularly around the infraorbital region and the nasoethmoidal region. These are less able to resist large forces so there use is confined to regions were force is minimal.

Complications of plates include exposure of plates, delayed union, palpability and infection. (Nakamaru et al. 1994) The incidence of these events is low. If patients are experiencing complications there is an obvious indication for removal. Removal of asymptomatic plates is controversial. The Strasbourg Osteosynthesis Research Group (1991) stated

"A titanium plate which is intended to assist healing of bone becomes a non-functional implant once this role is complete. It may then be regarded as a foreign body. While there is no clear evidence to date that a (titanium) plate causes any actual harm, our knowledge still remains incomplete. It is, therefore, not possible to state with certainty that an otherwise symptomless (titanium) plate left in situ in the long term is harmless. The removal of a non-functioning (titanium) plate is desirable provided that the procedure to remove the plate does not cause any undue risk to the patient."

Since this statement several studies have attempted to clarify the question of long term consequences of retained bone plates. Rosenberg et al (1993) examined 32 patients who had titanium miniplates removed and biopsies performed of the adjacent soft tissue and bone.They compared this to similar population of patients with stainless steel plates. 26% of the patients had macroscopic black pigment in the adjacent soft tissue.None of the stainless steel group had similar staining. Microscopically visible pigment was found in 72% of patients with titanium plates, and 65.3% of the stainless steel group. The material in the soft tissue around titanium plates was found to be only titanium dioxide, deposited between the collagen fibres. Around the stainless steel plates chromium, nickel, iron, and molybdenum were found, within giant cells. Schliephake et al (1993) , Torgerson et al (1995) had similar finding's. They concluded that titanium plates and stainless steel plates caused only a mild tissue reaction reflecting the fact that they are well tolerated by the host and routine removal is not indicated.

In contrast to these studies Kim et al (1997) found local macroscopic and microscopic tissue destruction was observed on bone plate removal. All plates were titanium. They suggested that if the plates were left for a long enough period of time further tissue damage would occur. They recommend the routine removal of bone plates after bone healing.

The major concern of all implants used in the human body is their carcinogenicity. Research utilising rats and retrospective studies of orthopaedic prosthesis have shown some metal implants exhibit some carcinogenicity. Takamaru et al. (1994) implanted various metals into rat muscle. They found nickel alloys showed high carcinogenic and toxic potencies. Other metals though, including titanium, showed no evidence of changes. Tumours retaining nickel alloys were malignant fibrous histiocytoma or fibrosarcoma. In some cases , lymphomata that seemed to develop spontaneously were found around the implants because lymphocytes were known to accumulate in chronic inflammatory lesions, and this phenomenon, they suggested, might also apply to lymphoma. Sunderman (1989) reviewed the orthopaedic literature regarding the carcinogenicity of metal alloys used as implants. He concluded that the occurrence of sarcoma at the implantation site constitutes a complication , albeit rare, of implanted orthopaedic prostheses.

Increasingly the general view is :

1. Remove the plate if it is symptomatic.
2. Offer removal of asymptomatic bone plates 6 months post - operatively.
3. If patient declines it is based on informed consent.

This is the current policy of the Oral Maxillofacial Surgery Unit. Less than five percent elect to have their asymptomatic plates removed.

The use of resorbable plates in osteotomies is being trialed at a number of institutes. The plates are a polymer consisting of polygalactic and polylactic acid. Edwards et al. (1998) have used the plates on twenty nine patients having Le Fort I osteotomies. These patients have been followed from two weeks to one year. There have been no problems with wound healing , fixation stability and no signs of infection. They made no comment on the stability of the relocated maxilla. The possible main advantage of these plates is no second procedure is needed to remove them. Until the issue of long term stability is resolved they should not be used except in controlled studies.

III

Materials and Method.

Materials and Method.

Chapter 7. Evaluation of Post Surgical Relapse.

7.1 Selection of Patient Records.

Patients who underwent any maxillary orthognathic surgery were identified. Their names were obtained from the theatre operating lists. Records for these patients were retrieved from the Oral and Maxillofacial Surgery Unit , The University of Adelaide South Australia, and their corresponding Royal Adelaide Hospital notes. Records dating from 1984 through to 1997 were obtained. However with the establishment of the seven year record keeping period by the South Australian Dental Service in the late 80's some records have been culled. Endeavours by different individuals have meant many records have been saved for other research studies (Hing 1989, Ching 1995). Other records have been saved by the regular, and in some cases irregular , attendance of orthognathic patients for follow up.

All patients were treated at the Royal Adelaide Hospital by any of 7 different consultant oral maxillofacial surgeons and their registrars, utilising similar operative techniques (Appendix II).

The patient population consisted of a mixed ethnic background reflecting the general population of South Australia. The majority of patients treated were Caucasian, with a steady increase in patients of Indochinese origin in more recent years. All patients treated were eligible for treatment under the guidelines of the Department of Human Services, South Australia. These patients hold a health care card (including students, secondary or tertiary, the unemployed and patients on sickness benefits.)

All patients undergoing work up for orthognathic surgery have lateral cephalograms before orthodontic treatment, before surgery, and then immediately post surgery and at intervals there after.

As this study utilised the treatment regime already established the ethics committee agreed there were no ethical implications.

Cephalometric records were accepted into the study if they met the following criteria:

1. At least one year postsurgical follow up
2. Surgery consisted of a maxillary osteotomy (Le Fort I procedure) in isolation or in conjunction with a mandibular procedure.
3. Availability of lateral head cephalometric radiographs preoperatively and at arbitrarily defined postsurgical intervals:

T0: before commencement of orthodontic treatment (Not necessary for the study).

T1: at completion of pre surgical orthodontics.

T2: within 48 hours post surgery.

T3: the most recent lateral head radiograph taken at least 12 months post surgery.

Patients who had undergone maxillary osteotomies during this period were excluded from the study if they had:

1. incomplete radiographic records necessary for detailed analysis.
2. Syndromic patients including cleft palate patients.
3. Patients treated with segmental Le Fort I osteotomies solely for transverse deficiency correction. This was due to the need for pre and post operative study casts to measure changes. Many of these were found to be missing upon instigating this research. Patients with segmental osteotomies for vertical or anteroposterior discrepancies were included.

The demographics of the patient population was recorded. This consisted of the patients gender, mean age at time of operation recorded in years and months.

Most patients received pre surgery and postsurgical orthodontics through the Department of Orthodontics , Adelaide Dental Hospital or privately . Some however did not require orthodontics and had anatomical arch bars made for surgery and post operative intermaxillary fixation as needed. Most patients had internal rigid fixation placed. This consisted of four four hole miniplates placed bilaterally at the piriform rim and zygomatic buttress.

The patient groups were divided into groups determined by the direction of their maxillary repositioning. If two directions were undertaken the greater shift determined the group allocated. This is defined as the main direction of movement at the time of surgery. Very few osteotomies had a purely one dimensional movement . Most moved in three plains of space. In this study only two planes of space were examined - vertical and horizontal.

The groups included:

1. maxillary superior repositioning

2. maxillary inferior repositioning

3. maxillary advancement.

No patients underwent posterior repositioning .

These patient groups were then subdivided into patients who had maxillary surgery in isolation (or with a genioplasty) or in conjunction with mandibular surgery (such as a bilateral sagittal split or vertical subsigmoid osteotomy). Each group was further subdivided if additional mandibular procedures were performed. Other variables including the patients gender, the magnitude of shift of the maxilla, plating versus wire fixation, and whether segmentalising the maxilla or leaving it as a one piece had an effect on stability. Use of bone grafts and the treating Oral Maxillofacial surgeon were also examined. Each of the six surgeons involved were allocated a number from 1 - 6.

7.2 Radiographic Technique.

All radiographs were taken on standardised equipment at the Adelaide Dental Hospital radiology department.Several film types were used all being of similar quality. The film used was at the discretion of the radiographer. The three brands were *Ortho M, TMAT 6* or *Cronex Lodose* film. The film selected was placed into a *Kodak Lanex* regular cassette with *Kodak Lanex* screens. The distance of the film to the patients midsagittal plane was standardised at 160 millimetres (Farrer 1984).

A standardised technique for taking the lateral cephalograms was performed. This involved gently securing the patient by a Lumex cephalostat in the Frankfort horizontal plane. This is considered the natural head position when standing. An aluminium wedge filter was aligned with the soft tissues of the face, to allow exposure onto the film.

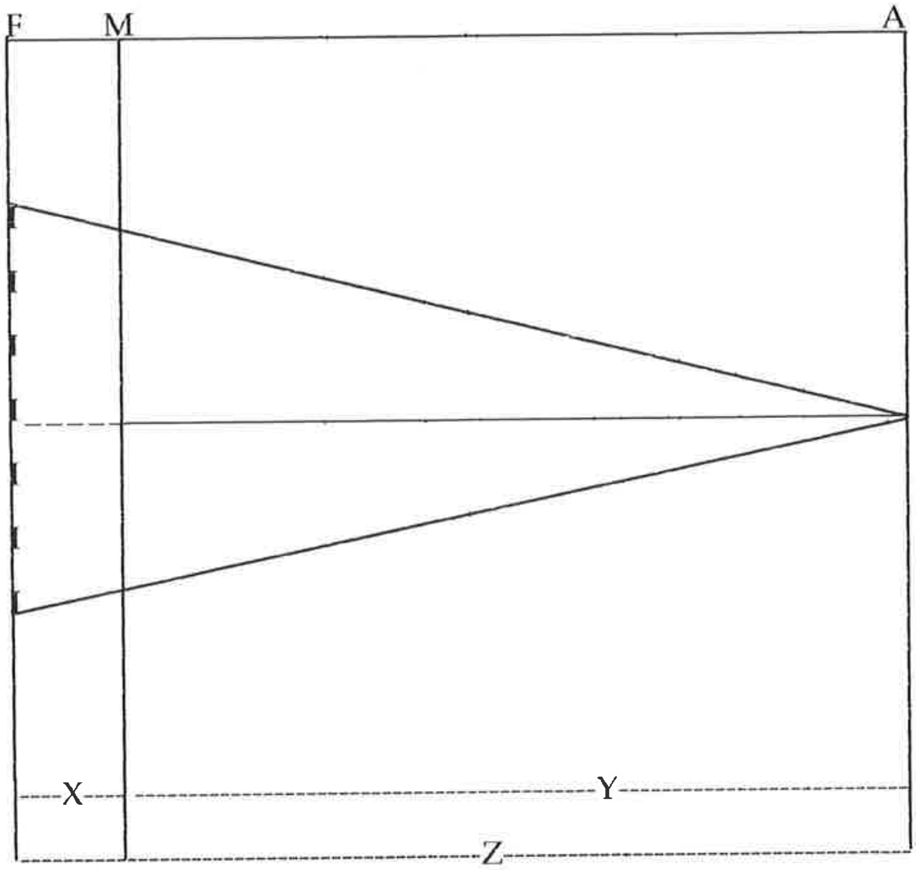
Head position is checked by using vertical and horizontal light beams projected onto mirrors from the machine. Patients bite onto their back teeth maintaining a relaxed lip posture. A Phillips Super 50 CP/80 CP microprocessor controlled unit was used to generate x-rays. The end of the cone was 1818 millimetres from the patients midsagittal plane or 1978 millimetres from the surface of the film. Knowing these distances and the knowledge that x-ray beams behave in the same fashion as light, the enlargement factor of the resultant image can be calculated (see figure 7.1). This was found to be 8.8% (Hing 1989).

Films were all processed automatically in a *Kodak RP X-OMat* film processor in the first few years of the study, but this has subsequently been updated (1991) to a Fuji FPM 2100 x-ray processor.

Films were stored in A4 brown paper envelopes, labelled with the patients details and kept within their Adelaide Dental Hospital records.

Figure 7.1 Enlargement factor : Adelaide Dental Hospital Lateral Cephalogram

Calculation of the enlargement factor for points lying on the mid-sagittal plane (Hing 1989).



F = Film plane

M= Mid-sagittal plane

A= Focus

X= 160 mm.

Y= 1818 mm.

Z = 1978 mm.

E= Enlargement factor.

E= 100 x [Z -1] / Y

= 100 x [1978/ 1818 - 1]

= <u>8.8%</u>

7.3 Tracing and digitising procedure.

Each of the lateral cephalograms were initially traced by hand and the image created digitised directly on an Apple IIe computer.

Each radiograph was placed over a fluorescent light box in a darkened room. A black cardboard frame was placed around the perimeter of the film to eliminate extraneous light. Hard and soft tissue details were recorded on Cephalometric Tracing Film Acetate (*3M Unitek* 8 " * 11") with a sharp HB pencil after the film and tracing paper were taped together . A 10 cm line was constructed on the pre surgical (T1) film seven degrees to the nasion - sella line with origin at sella. The location of each cephalometric point was determined with the film orientated to the SN - 7 line (Figure 3.1) .

A maxillary template from the pre surgical radiograph (T2) was used to transfer points anterior nasal spine (ANS) and A point (A) on each postoperative cephalogram if these points were difficult to recognise post surgery. Where an occlusal wafer was present postoperative films were corrected by rotating a mandibular template at the hinge axis until the incisal tips came into contact. (Kilpatrick 1987). This eliminated the anterosuperior mandibular rotation usually associated with occlusal wafer removal . Changes T2 or T3 were recorded with the mandible in this corrected position.

The acetate tracings created from each radiograph were digitised on a *Hewlett Packard 9874A* digitiser configured to an *Apple IIe* computer. Tracings were orientated to the SN-7 line on the digitiser tablet and secured with cellulose tape. The software programme, *Cephs Compare* developed for cephalometric research by T. Brown (Computerised Cephalometry , 1986), was programmed to record individual patient details, accept each digitised record and "transform" cartesian coordinates relative to the SN-7 line registered at sella. This gave vertical and horizontal measurements based on a X-Y coordinate system. The X axis was formed by a line rotated 7 degrees down from the SN line, parallel to Frankfort Horizontal. A perpendicular vertical reference line through sella was then drawn and used as the Y axis. Alpha numeric data relating patient details and the magnification factor were entered. The magnification of 8.8% was not corrected, but was constant.

Each nominated landmark was centrally aligned in the large window cross - hair cursor and registered by depressing a perimeter button on the cursor. Data was transformed automatically by the computer and saved to a disk for editing. All tracing and digitising procedures were carried out by the author, over many sittings.

The maximum length of a sitting was limited to 3 hours. Longer than this period fatigue would probably increase the inaccuracy of landmark identification, tracings and the digitisation .

On examination of the data for vertical change in position of the maxilla it was found that the changes between the anterior maxilla (represented by points A and ANS) and the posterior maxilla on the same patient often varied. This was found to be due to a rotational effect of the maxilla. To compensate for this movement a calculation of the maximum movement of the maxilla in the planned direction was formulated (, that is,. either A or PNS was used.) This number was termed MAXY1 or MAXY2 .

7.4 Reference points and lines.

Reference points and lines were selected from the Adelaide Oral and Maxillofacial Surgery handbook (1983) and from several other references (de Mol van Otterloo et al 1996). Definitions have been derived from several sources and referenced accordingly. Cephalometric points which relied on bilateral radiographic structures (porion, orbitale, pterygoid , condylion and gonion) were taken as the midpoint where the two images did not coincide.

7.4.1 Hard tissue points.

Sella (S): the geometric centre of the pituitary fossa of the sphenoid bone . (van der Lindon,1971; Vincent and West ,1987).

Nasion (N): the most anterior point of the frontonasal suture. (Brown, 1973).

Porion (P): (cephalometric or machine) the most superior point on the external auditory meatus Koski and Virolainen, 1956; Ricketts, 1981; Savara and Takeuchi, 1979; Pancherz and Hansen, 1984; Wolford, Hillard and Dugan,1985; Blaseio,1986; Vincent and West,1987). The external auditory meatus has three radiolucent areas which distinguish it from the internal auditory meatus: the fenestration vestibulae superiorly, the fenestrum cochlea posteriorly and the promontory anteriorly (Yen, 1960).

Orbitale(Or): the lowest point on the average of the right and left borders of bony orbit (Riolo et al. 1974).

Condylion(Co): the most superior point on the head of the condyle (Savara et al 1966; Sekiguchi and Savara, 1972; Brown, 1973; Lake et al. 1981; McNamara,1984; Smith et al ,1985). Several authors, notably Bjork (1955) have defined condylion as the most supero-posterior point on the head of the condyle. It is determined as the point of tangency to a perpendicular construction line to the anterior and posterior borders of the condylar head. Condylion, therefore is located as the most superior axial point of the condylar head rather than as the most superior point on the condyle (Riolo et al 1974).

Articulare (Ar): the point at the junction of the contour of the external cranial base and the dorsal contour of the condylar processes projected in the midsagittal plane (Wei, 1965; Brown,1973).

Gonion (Go): a point on the bony contour of the angle of the mandible located by bisecting the angle formed by the tangent to the lower border and a line through articulare and the posterior border of the ramus (Nanda,1955; Wei,1965).

Menton (Me): the inferior point on the symphyseal outline (Riolo et al 1974).

Pogonion (Po); the most anterior point on the contour of the bony chin relative to a perpendicular to SN-7 plane (Riolo et al 1974).

Down's B point or supramentale (B): the deepest point in the midsagittal plane between infradentale and pogonion, usually anterior to and slightly below the apices of the mandibular incisors (Burstone, 1978). According to Moyers point B cannot be determined if the chin profile is flat.

Lower incisal apex: the root tip of the mandibular central incisor (Riolo et al ,1974).

Lower incisal edge: the incisal tip of the mandibular central incisor (Riolo et al, 1974).

Upper incisal edge: the incisal tip of the maxillary central incisor (Riolo et al ,1974).

Upper incisal apex: the root tip of the maxillary central incisor (Riolo et al ,1974).

Down's A point or subspinale (A): the deepest point in the midsagittal plane between anterior nasal spine and supradentale, usually around the level of and anterior to the apex of the maxillary central incisors (Burstone, 1978).

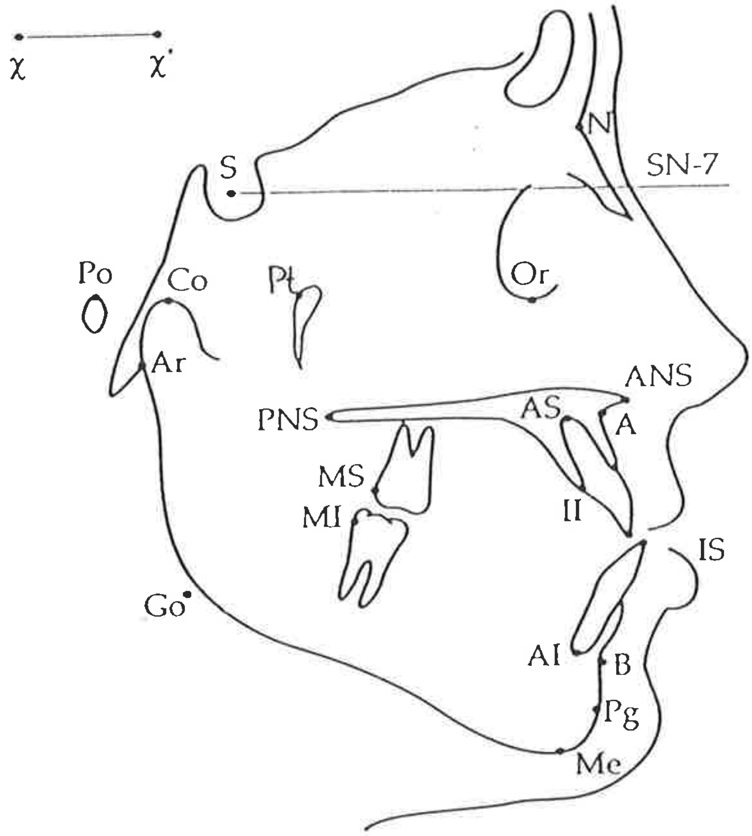
Anterior nasal spine or acanthion (ANS): the tip of the median sharp bony process of the maxilla at the lower margin of the anterior nasal opening (Riolo et al ,1974).

Posterior nasal spine(PNS): the most posterior point at the saggital plane on the bony hard palate (Riolo et al ,1974).

Upper molar crown (MS): the distal contact (height of contour) of the maxillary first molar relative to the occlusal plane (Riolo et al., 1974).

Lower molar crown(MI): the distal contact (height of contour) of the mandibular first molar relative to the occlusal plane (Riolo et al ,1974).

Figure 7.2 Hard tissue points listed in order of digitising sequence. (modified from Hing 1989).



a.	x	fudicial point 1
b.	x′	fudicial point 2
1.	S	Sella
2.	N	Nasion
3.	Or	Orbitale
4.	Po	Porion
5.	A	Down's Point A or subspinale
6.	B	Down's Point B or supramentale
7.	ANS	Anterior nasal spine
8.	PNS	Posterior nasal spine
9.	IS	Upper incisal edge
10.	AS	Upper incisal apex
11.	MS	Upper molar crown
12.	II	Lower incisal edge
13.	AI	Lower incisal apex
14.	MI	Lower molar crown
15.	Pg	Pogonion
16.	Gn	Gnathion
17.	Me	Menton
18.	Go	Gonion
19.	Ar	Articulare
20.	Co	Condylion
21.	Pt	Pterygoid
22.	Ba	Basion

7.4.2 Cephalometric Lines :

Nasion -sella line: a line passing through nasion and sella (Solow, 1975.)

Sella-nasion-7 (SN-7): a line constructed by drawing a line 7 degrees to SN plane with its origin at sella as described by Marcotte (1981). Burstone (1978) refers to SN-7 line as a surrogate Frankfort plane with its origin at nasion.

Frankfort horizontal (FH): the line passing through porion and orbitale (Scott,1967).

Mandibular line or plane: a line drawn through menton and gonion. This line has also been defined as the tangent to the lower border of the mandible or a line joining gonion and gnathion.

Functional occlusal line: a line averaging the points of posterior occlusal contact from the first permanent molars to the first premolars (Moyers et al, 1987).

7.4.3 Linear and angular variables:

These were selected from the Adelaide Oral and Maxillofacial Surgery unit handbook (1983) and from the *Quick Ceph* manual (1986).

Linear variables:

Anterior facial height (AFH): the distance between menton and nasion perpendicular to the SN-7 line.

Posterior facial height: the distance between gonion and sella perpendicular to the SN-7 line.

Point A horizontal : The distance between Down's point A and a line drawn perpendicular to nasion-sella 7 line.

Point A vertical : The distance between Down's point A and a line drawn perpendicular to nasion-sella 7 line passing through Sella turcica.

Overjet: The distance between the maxillary central incisor and the mandibular central incisor measured parallel to the occlusal plane.

Overbite : The distance between the maxillary central incisor and the mandibular central incisor measured perpendicular to the occlusal plane.

Angular Variables:

SNA: the angle formed between nasion -sella line and a line drawn through nasion and Down's A point.

SNB: the angle formed between nasion-sella line and a line drawn through nasion and Down's B point.

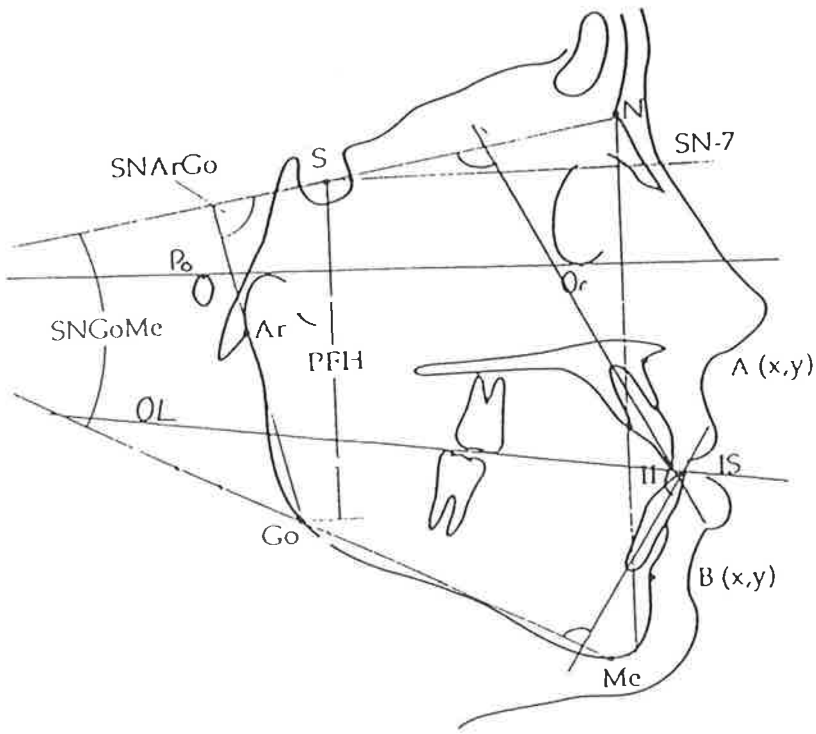
Mandibular plane angle (SNGoMe): The angle formed between nasion-sella line and the mandibular line.

Upper incisal angle: The angle between SN-7 and a line through the maxillary central incisor .

Interincisal angle: the angle between the upper and lower incisors.

Lower incisal angle: The angle between the lower incisors and the mandibular plane.

Figure 7.3 Angular and linear variables used to evaluate dentoskeletal changes following Le Fort I osteotomies (and concurrent mandibular procedures).



Cephalometric Lines

Nasion Sella line (SN)

SN - 7 line

Frankfort Horizontal (Po - Or)

Occlusal line (OL)

mandibular line (Go - Me)

Linear variables

Anterior facial height (Na - Me)

Posterior facial height (PFH)

Point A horizontal (Ax)

Point A vertical (Ay)

Overjet (II - IS horizontal)

Overbite (II - IS vertical)

Angular variables

Mandibular plane angle (SNGoMe)

SNA

SNB

Upper incisal angle

Lower incisal angle

Interincisal angle

7.5 Statistical Analysis.

The variables identified in the literature that may influence the stability of the Le Fort I maxillary osteotomy were examined. Factors implicated were analysed under the following headings:

1.Orthodontics.

2.Direction of repositioning.

3.Magnitude of shift of the maxilla.

4.Influence of bimaxillary surgery.

5.Plating versus wire fixation.

6.Segmental versus single piece osteotomy.

7.Anterior open bite.

8.Muscular interaction.

9.Vascular considerations of the osseous segments.

10.Growth of skeletal structures.

Each variable within the various groups was assessed by the mean value ,standard error and minimum and maximum value using standard statistical program. The students t-test for paired and unpaired was used to determine the significance of differences for each variable.

Figure 7.4 Summary of statistics used.

$\bar{x}$ Mean $\frac{\sum \bar{x}}{N}$

se Standard error of the mean. $\frac{s}{\sqrt{N}}$

r Correlation coefficient $\frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-x)^2(y-y)^2}$

t Students unpaired t-test

$$\frac{(\bar{x}_1-\bar{x}_2)}{\sqrt{\dfrac{\left[\sum(x_1)^2-\dfrac{\sum(x_1)^2}{N_1}\right]+\left[\sum(x_2)^2-\dfrac{\sum(x_2)^2}{N_2}\right]\times\left[\dfrac{N_1+N_2}{N_1N_2}\right]}{N_1+N_{2-2}}}}$$

where N = number of determinations

s = standard deviation

x, y = observed scores

x1 = mean of the group 1 observations

x2 = mean of the group 2 observations

Chapter 8 Errors of method.

8.1 Materials and method.

To establish the validity of results of the cephalometric assessment, an assessment of the magnitude of cephalometric errors was necessary. The magnitude of error was associated with tracing , superimposition and digitising was assessed by a series of double determinations for 10 cephalograms from 3 cases. These were randomly selected from the radiographic files of the patients involved in this study.

Repeat tracing , superimposition and digitising were separated by one month and re-recorded by one observer. Tracings were orientated to the SN-7 line on the digitiser tablet and secured with cellulose tape. Alphanumeric data relating patient details and magnification compensation were entered. Magnification of 8.8% was not corrected. Twenty two hard tissue points (Figure 8.1) and two fiducial points (x and x′) were digitised on a Hewlett Packard 9874A digitiser configured to an Apple IIe computer. Each nominated point was centrally aligned in the large window cross - hair cursor and registered by depressing a perimeter button. Data was transformed automatically by the computer and saved to the disk for editing.

The cephalometric software program developed by Professor Tasman Brown , The University of Adelaide , computes transformations of the cartesian coordinates relative to the nominated reference line. The line formed by x - x′ served as the line of reference. The computer was also programmed to perform superimpositions using the first fiducial point (x) as the point of registration.

Error associated with the digitising equipment has been critically assessed by Farrer (1984). The total error from the Hewlett Packard digitiser was $\pm$ 0.01 mm. under normal operating conditions.

Scatter grams were produced to illustrate the reproducibility of each point using the method described by Broch et al (1981). The first reading for each point was arbitrarily assigned as origin. The individual points on the scatter gram represent the difference between the first and second cephalogram indicating the dispersion of the location errors.

The differences between the first and second determination were expressed as the mean difference (M diff), the standard error of the mean difference E (M diff), the standard deviation of a single determination (S error) and the percentage of the observed variance attributable to errors following the procedure of Dahlberg (1940). The Student's t-test for paired values was used to assess whether the differences differed significantly from zero at the 5% (t = 2.262) and 1% (t = 3.250) levels for 9 degrees of freedom. Table 8.1 lists the respective formulae.

Figure 8.1 Statistical analysis of the experimental error.

M diff	Mean difference between two determinations	$\frac{\sum diff}{N}$
E (M diff)	Standard error of the mean difference	$\frac{S\ diff}{\sqrt{N}}$
S (error)	Standard deviation of a single determination	$\sqrt{\frac{\sum diff2}{2N}}$
% E var.	Error variance per cent	$\frac{S(error)^2 \times 100}{S^2}$
t value	Student's paired t - test	$\frac{M\ diff}{E(M\ diff)}$

where diff = difference between two determinations

N = number of double determinations

2N = number of single determinations

S^2 = observed variance of the measurement

IV

Results

Chapter 9 Results

9.1 Introduction:

The demographics of the patient population studied are presented first. Initial examination of the data involved identifying the various surgical groups , and then subdividing these groups into sub- categories based on the different variables.

The following groups were identified:

1. Maxillary superior repositioning.
2. Maxillary inferior repositioning.
3. Maxillary advancement.

Subgrouping was done to include concomitant surgery of the mandible (incl. bilateral sagittal split osteotomies, vertical subsigmoid osteotomies, and inverted 'L' osteotomies).

9.2 Demographics

A total of 100 patients were accepted with a total of 300 cephalograms available for analysis. The age and gender distribution of the patients is shown in table 9.1.

Table 9.1 Age and gender distribution of patients undergoing surgery.

	Number	Mean age (Yrs)	Std Dev	Min.	Max.	Range
male	23	22	5.95	15	37.7	22.7
female	77	23.1	7.81	13.8	45.3	31.5
total	100	22.8	7.41	13.8	45.3	31.5

A large number of patients (115) were excluded from the study for the following reasons.

1. Incomplete set of radiographs (n = 110).
2. Syndromal patients including cleft palate patients (n = 5).

Their age and gender distribution is shown in table 9.2 for patients with an incomplete set of radiographs and table 9.3 for the syndromal patients.

Table 9.2 Age and gender distribution of patients who underwent surgery but had incomplete records .

gender	Number	Mean age (Yrs)	Std Dev	Min.	Max.	Range
male	38	23.9	6.05	14.7	51.2	36.5
female	72	22.5	8.21	15.1	42.3	30.2
total	110	23.2	7.13	14.7	51.2	36.5

Table 9.3 Age and gender distribution of patients who underwent surgery who were syndromal patients.

gender	Number	Mean age (Yrs)	Std Dev	Min.	Max.	Range
male	3	16.2	10.05	14	19.8	5.8
female	2	25.3	15.21	14.7	36	21.3
total	5	20.8	12.6	14	36	22

The patients were divided into the major direction of movement. None of the patients underwent posterior repositioning. Table 9.4 shows the patients included in the study. Tables 9.5 and 9.6 show the patients excluded from the study.

Table 9.4 Distribution of patients involved in the study assigned by direction of maxillary movement.

Direction	Male	Female	Total
superior	8	37	45
inferior	3	10	13
advancement	12	30	42
total	23	77	100

Table 9.5 Distribution of patients assigned by direction of maxillary movement whose records were incomplete.

Direction	Male	Female	Total
superior	16	29	45
inferior	1	3	4
advancement	21	40	61
total	38	72	110

There was no significant difference between included and excluded patients when taken as a whole ($p > 0.1$). in regards to age and sex.

Table 9.6 Distribution of patients assigned by direction of maxillary movement who were syndromal patients.

Direction	Male	Female	Total
superior	1	1	2
inferior	1	0	1
advancement	1	1	2
total	3	2	5

In comparison of the above tables it can be seen that follow up was slightly less likely if the patient was male.

Table 9.7 Distribution of patients by direction of movement and concurrent mandibular surgery.

1. Le fort I in isolation.

2. Le Fort I and bilateral sagittal split osteotomy (B.S.S.O.) advancement.

3.Le Fort I and B.S.S.O. setback.

4.Le Fort I and a vertical subsigmoid setback.

5.Le Fort I osteotomy and inverted 'L' mandibular osteotomy advancement.

Direction	1	2	3	4	5
superior	19	21	3	1	1
inferior	5	5	3	0	0
advancement	6	4	24	7	1
Total	30	30	30	8	2

The number of patients undergoing vertical subsigmoid and inverted 'L' osteotomies were small and hence statistical significance was not found. When comparing the results for the two set back procedures, and the two mandibular advancement groups they were statistically similar. Thus the results were combined. As a result these were included in the bilateral sagittal split sub section. The resulting data is shown in Table 9.8.

Table 9.8 Distribution of patients by direction of movement and concurrent mandibular surgery (Combining groups 2 & 5 ; groups 3 & 4 from Table 9.7).

1. Le fort I in isolation.

2. Le Fort I and mandibular (B.S.S.O. & Inverted 'L'.) advancement.

3.Le Fort I and mandibular (B.S.S.O. & V.S.S.O) setback.

Direction	1	2	3
superior	19	22	4
inferior	5	5	3
advancement	6	5	31
total	30	32	38

Direction by surgeon is shown in table 9. 9.

Table 9.9 Distribution of patients by direction of movement and surgeon.

Direction	Surgeon 1	Surgeon 2	Surgeon 3	Surgeon 4	Surgeon 5	Surgeon 6
Superior	23	15	0	4	0	3
Inferior	4	9	0	0	0	0
Advance	33	7	1	0	1	0
Total	60	31	1	4	1	3

The number of patients that had orthodontics or were treated without orthodontics prior to or after surgery is shown in table 9.10.

Table 9.10. Patient numbers receiving pre / postsurgical or no orthodontics by direction.

Direction	Ortho.	No Ortho.	%
Superior	40	5	45
Inferior	11	2	13
Advancement	38	4	42
Total	89	11	100

Table 9.11 No. of patients having segmental / non segmental Le fort I operations by direction.

Direction	Segmental	Nonsegmental	%
Superior	16	29	45
Inferior	3	10	13
Advancement	14	28	42
Total	33	67	100

Table 9.12 Magnitude of movement by direction.

Direction	< 2 mm	2 < 4mm	4 < 6 mm	6 + mm
Superior	1	18	11	15
Inferior	1	7	4	1
Advancement	5	13	10	14
Total	7	38	25	30

Table 9.13. Patient numbers using either wire or rigid fixation by direction.

Direction	Wire	Rigid Fix.	%
Superior	7	38	45
Inferior	3	10	13
Advancement	2	40	42
Total	12	88	100

Table 9.14. Patient numbers using bone grafts or no graft by direction.

Direction	Bone	No Bone	%
Superior	7	38	45
Inferior	3	10	13
Advancement	16	26	42
Total	26	74	100

9.3 Analysis of Variables by Group.

Introduction

The results of each variable are tabulated by the direction of intended surgical movement , that is,. superior, inferior or anteriorly repositioned.

9.3.1 Superior repositioning of the Maxilla. (N =45; Table 9.1)

9.3.1.1. Points A, ANS , PNS and MAX.

45 patients underwent superior repositioning of the maxilla as the primary surgical movement. Positive numbers represent a move in the superior direction, negative numbers represent movement in an inferior direction

The mean maxillary impaction at point A (AY1), point ANS (ANSY1) ,point PNS (PNSY1) and point MAX (MAXY1). is shown in table 9.14.

Table 9.15 Mean maxillary impaction (mm). Change in mm. from T1 - T2.

	Mean	Maximum	Minimum	Standard Deviation	Standard Error
AY1	3.32	9.08	-3.16	3.234	0.482
ANSY1	3.5	10.2	-4.27	3.684	0.549
PNSY1	2.72	11.9	-2.07	2.872	0.428
MAXY1	4.93	11.9	0.77	2.557	0.381
AY2	-0.81	3.68	-7.04	2.018	0.301
ANS2	-1.08	4.5	-5.74	1.932	0.288
PNSY2	-0.58	4.73	-7.89	2.128	0.317
MAXY2	-1.13	4.73	-7.89	2.442	0.364

Table 9.16 T -Test : Superiorly repositioned maxilla.

Shows surgical movements were significant.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

	Mean Difference	t	Sig (2-tailed)	1	2
AY1	3.32	6.896	0	2.353	4.296
ANSY1	3.5	6.373	0	2.393	4.607
PNSY1	2.72	6.345	0	1.854	3.579
MAXY1	4.93	12.95	0	4.169	5.706
AY2	-0.81	-2.695	0.01	-1.417	-0.204
ANSY2	-1.08	-3.732	0.001	-1.655	-0.494
PNSY2	-0.58	-1.819	0.076	-1.216	0.062
MAXY2	-1.13	-3.106	0.003	-1.864	-0.397

Table 9.17 Correlations - superiorly repositioned maxilla (Pearsons Correlations.)

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

	AY1	ANSY1	PNSY1	MAXY1	AY2	ANSY2	PNSY2	MAXY2
AY1	1	.961**	-0.137	.597**	-.391**	-.454**	-0.108	-.325*
ANSY1	.961**	1	4	1	-.314*	-.457**	-0.033	-0.237
PNSY1	-0.137	13	1	14	0.207	0.292	-.493**	-0.208
MAXY1	7	38	25	1	-0.199	-0.275	-.376*	-.474**
AY2	-.391**	-.314*	0.207	-0.199	1	.772**	0.087	.619**
ANSY2	-.454**	-.457**	0.292	-0.275	.722**	1	-0.135	.326*
PNSY2	-0.108	-0.033	-.493**	-0.376	0.087	-0.135	1	.667**
MAXY2	-.325*	-0.237	-0.208	-0.474	.619**	.326*	.667**	1

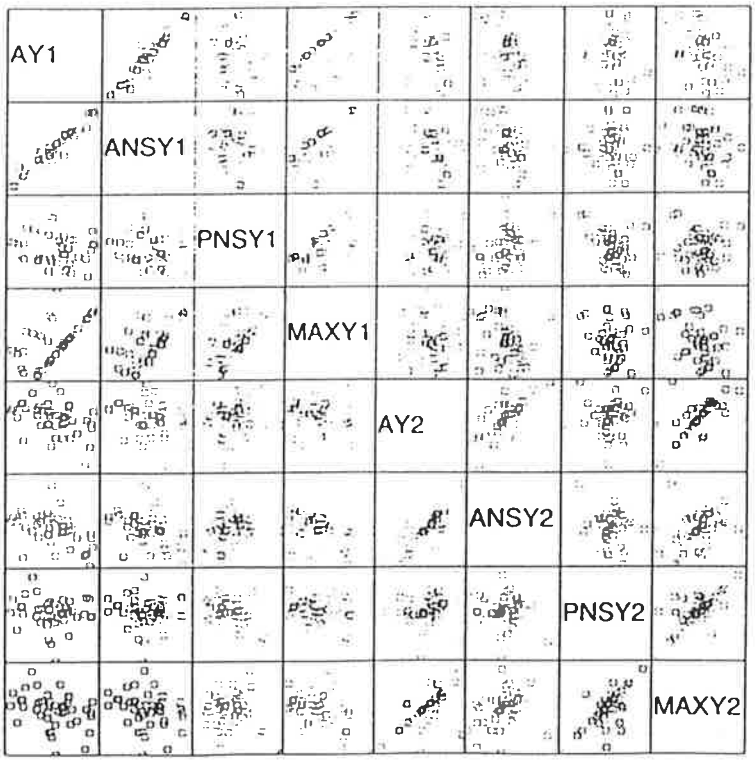


Figure 9.1 Scatter plot of maxillary landmarks for superior repositioning.

Table 9.18. Magnitude of shift in superior direction and postsurgical movement by gender.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Male	8	4.79	2.21	0.782	2.94	6.64	2.34	9.08
	Female	37	3.01	3.35	0.552	1.89	4.13	-3.16	8.85
	Total	45	3.32	3.23	0.482	2.35	4.3	-3.16	9.08
ANSY1	Male	8	4.89	2.58	0.914	2.73	7.05	2.27	9.66
	Female	37	3.2	3.84	0.632	1.92	4.48	-4.27	10.2
	Total	45	3.5	3.68	0.549	2.39	4.61	-4.27	10.2
PNSY1	Male	8	2.86	3.95	1.398	-0.45	6.16	-1.41	11.9
	Female	37	2.69	2.65	0.436	1.8	3.57	-2.07	8.46
	Total	45	2.72	2.87	0.428	1.85	3.58	-2.07	11.9
MAXY	Male	8	5.84	3.26	1.151	3.12	8.56	2.34	11.9
	Female	37	4.74	2.39	0.392	3.94	5.53	0.77	8.85
	Total	45	4.94	2.56	0.381	4.17	5.71	0.77	11.9
AY2	Male	8	-1.21	2.1	0.741	-2.97	0.054	-4.46	2.69
	Female	37	-0.72	2.02	0.331	-1.4	-2e-3	-7.04	3.68
	Total	45	-0.81	2.02	0.301	-1.42	-0.2	-7.04	3.68
ANSY2	Male	8	-1.49	1.69	0.599	-2.91	-2e-3	-3.4	2.32
	Female	37	-0.99	1.99	0.327	-1.65	-0.32	-5.74	4.5
	Total	45	-1.08	1.93	0.288	-1.66	-0.49	-5.74	4.5
PNSY2	Male	8	-1.67	2.55	0.903	-3.81	0.47	-7.89	0.21
	Female	37	-0.34	1.98	0.327	-1	0.32	-5.21	4.73
	Total	45	-0.58	2.13	0.317	-1.22	-6e-3	-7.89	4.73
MAXY	Male	8	-1.98	3.17	1.121	-4.63	0.68	-7.89	2.69
	Female	37	-0.95	2.27	0.373	-1.7	-0.19	-7.04	4.73
	Total	45	-1.13	2.44	0.364	-1.86	-0.4	-7.89	4.73

Table 9.18 and 9.19 show no significant difference in movement in the superior direction between genders.

Table 9.19. Magnitude of shift in superior direction and postsurgical movement by gender - ANOVA. (gp : 'group')

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	20.898	1	20.898	2.046	0.16
	Within gp	439.295	43	10.216		
	Total	460.193	44			
ANSY1	Between gp	18.894	1	18.894	1.405	0.242
	Within gp	578.41	43	13.451		
	Total	597.304	44			
PNSY1	Between gp	0.19	1	0.19	0.022	0.882
	Within gp	362.768	43	8.436		
	Total	362.957	44			
MAXY1	Between gp	7.954	1	7.954	1.222	0.275
	Within gp	279.847	43	6.508		
	Total	287.8	44			
AY2	Between gp	1.583	1	1.583	0.383	0.539
	Within gp	177.516	43	4.128		
	Total	179.098	44			
ANSY2	Between gp	1.697	1	1.697	0.449	0.506
	Within gp	162.562	43	3.781		
	Total	164.259	44			
PNSY2	Between gp	11.621	1	11.621	2.663	0.11
	Within gp	187.628	43	4.363		
	Total	199.249	44			
MAXY2	Between gp	6.957	1	6.957	1.172	0.285
	Within gp	255.347	43	5.938		
	Total	262.304	44			

The affect of age is shown in the following tables. Average age of the 100 patients was 23.2 years. 'Young ' patients were classified as under 23.2 years of age; 'Old' patients were classified as over 23.2 years of age. There was a significant difference in the amount of surgical shift between young and old patients but there was no difference in post surgical movement. There was greater initial movement in the younger group.

Table 9.20. Magnitude of shift in superior direction and postsurgical movement by age.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	<23 yr	31	4.31	2.87	0.56	3.15	5.47	-1.33	9.08
	23+yr	14	1.98	3.28	0.75	0.39	3.56	-3.16	7.91
	Total	45	3.32	3.23	0.48	2.35	4.3	-3.16	9.08
ANSY1	<23 yr	31	4.66	3.34	0.65	3.32	6.01	-1.32	10.2
	23+yr	14	1.91	3.62	0.83	0.16	3.65	-4.27	7.13
	Total	45	3.5	3.68	0.55	2.39	4.61	-4.27	10.2
PNSY1	<23 yr	31	3.18	3.08	0.6	1.93	4.42	-2.07	11.9
	23+yr	14	2.09	2.5	0.58	0.88	3.29	-1.49	8.46
	Total	45	2.72	2.87	0.43	1.85	3.58	-2.07	11.9
MAXY1	<23 yr	31	5.54	2.69	0.53	4.45	6.62	0.79	11.9
	23+yr	14	4.12	2.17	0.5	3.07	5.16	0.77	8.46
	Total	45	4.94	2.56	0.38	4.17	5.71	0.77	11.9
AY2	<23 yr	31	-0.73	1.89	0.37	-1.49	3.6e-3	-4.58	3.68
	23+yr	14	-0.93	2.23	0.51	-2	0.15	-7.04	2.52
	Total	45	-0.81	2.02	0.3	-1.42	-0.2	-7.04	3.68
ANSY2	<23 yr	31	-1.11	2.2	0.43	-2	-0.22	-5.74	4.5
	23+yr	14	-1.03	1.54	0.35	-1.77	-0.29	-4.48	1.34
	Total	45	-1.08	1.93	0.29	-1.66	-0.49	-5.74	4.5
PNSY2	<23 yr	31	-1.02	2.17	0.43	-1.89	-0.14	-7.89	2.33
	23+yr	14	2.2e-3	1.98	0.45	-0.93	0.97	-4.56	4.73
	Total	45	-0.58	2.13	0.32	-1.22	6.2e-3	-7.89	4.73
MAXY2	<23 yr	31	-1.2	2.26	0.44	-2.11	-0.29	-7.89	2.69
	23+yr	14	-1.04	2.73	0.63	-2.35	0.28	-7.04	4.73
	Total	45	-1.13	2.44	0.36	-1.86	-0.4	-7.89	4.73

Table 9.21. Magnitude of shift in superior direction and postsurgical movement by age - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	59.906	1	59.906	6.435	0.015
	Within gp	400.286	43	9.309		
	Total	460.193	44			
ANSY1	Between gp	83.379	1	83.379	6.976	0.011
	Within gp	513.925	43	11.952		
	Total	597.304	44			
PNSY1	Between gp	12.979	1	12.979	1.595	0.213
	Within gp	349.978	43	8.139		
	Total	362.957	44			
MAXY1	Between gp	22.069	1	22.069	3.571	0.066
	Within gp	265.731	43	6.18		
	Total	287.8	44			
AY2	Between gp	0.442	1	0.442	0.106	0.746
	Within gp	178.657	43	4.155		
	Total	179.098	44			
ANSY2	Between gp	0.0069	1	0.0069	0.018	0.893
	Within gp	164.189	43	3.818		
	Total	164.259	44			
PNSY2	Between gp	11.808	1	11.808	2.709	0.107
	Within gp	187.442	43	4.359		
	Total	199.249	44			
MAXY2	Between gp	0.296	1	0.296	0.049	0.827
	Within gp	262.008	43	6.093		
	Total	262.304	44			

The effect of different surgeons is shown in the following tables. No statistical difference was found between surgeons 3 , 4 , 5 and 6 when compared to each other. They were thus combined. Surgeon 1 and 2 were statistically different from each other and the combined other surgeons due to the greater number of operations performed.

Table 9.22. Magnitude of shift in superior direction and postsurgical movement by surgeon.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Surg 1	23	4.11	3.53	0.74	2.58	5.64	-3.16	9.08
	Surg 2	15	2.28	2.84	0.73	0.71	3.86	-2.84	7.91
	Sur3-6	7	2.98	2.64	0.99	0.53	5.42	-1.63	5.53
ANSY1	Surg 1	23	4.68	3.88	0.81	2.99	6.36	-4.21	10.2
	Surg 2	15	2.17	3.2	0.83	0.4	3.94	-4.27	7.13
	Sur3-6	7	2.49	3.07	1.16	-0.35	5.33	-2.55	6.36
PNSY1	Surg 1	23	2.19	2.67	0.56	1.04	3.35	-2.07	8.46
	Surg 2	15	3.28	3.53	0.91	1.32	5.23	-1.49	11.9
	Sur3-6	7	3.24	1.78	0.67	1.59	4.88	0.79	5.18
MAXY1	Surg 1	23	5.32	2.45	0.51	4.26	6.38	1.07	9.08
	Surg 2	15	4.83	2.96	0.77	3.19	6.47	0.77	11.9
	Sur3-6	7	3.93	1.92	0.72	2.16	5.71	0.79	5.53
AY2	Surg 1	23	-0.89	1.53	0.32	-1.55	-0.22	-4.58	2.52
	Surg 2	15	-0.88	2.81	0.73	-2.43	0.68	-7.04	3.68
	Sur3-6	7	-0.42	1.61	0.61	-1.91	1.07	-3.4	1.14
ANSY2	Surg 1	23	-1.47	1.69	0.35	-2.21	-0.74	-5.74	1.03
	Surg 2	15	-0.83	2.47	0.64	-2.2	0.54	-4.48	4.5
	Sur3-6	7	-0.29	1.08	0.41	-1.29	0.71	-1.58	1.34
PNSY2	Surg 1	23	-0.37	1.79	0.37	-1.15	0.4	-4.56	4.73
	Surg 2	15	-0.58	2.836	0.73	-2.14	0.99	-7.89	2.66
	Sur3-6	7	-1.24	1.47	0.56	-2.61	0.12	-4.02	0.38
MAXY2	Surg 1	23	-0.96	1.91	0.4	-1.79	-0.14	-4.58	4.73
	Surg 2	15	-1.61	3.47	0.9	-3.53	0.32	-7.89	2.69
	Sur3-6	7	-0.67	1.37	0.43	-1.72	0.39	-2.34	0.98

Table 9.22 and table 9.23 showed no significant difference between the surgeons in terms of magnitude of shift in the superior direction.

Table 9.23. Magnitude of shift in superior direction and postsurgical movement by surgeon - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	31.251	2	15.625	1.53	0.228
	Within gp	428.942	42	10.213		
	Total	460.193	44			
ANSY1	Between gp	65.554	2	32.777	2.589	0.087
	Within gp	531.751	42	12.661		
	Total	597.304	44			
PNSY1	Between gp	12.886	2	6.443	0.773	0.468
	Within gp	350.072	42	8.335		
	Total	362.957	44			
MAXY1	Between gp	10.533	2	5.267	0.798	0.457
	Within gp	277.267	42	6.602		
	Total	287.8	44			
AY2	Between gp	1.246	2	0.623	0.147	0.864
	Within gp	177.852	42	4.235		
	Total	179.098	44			
ANSY2	Between gp	8.915	2	4.458	1.205	0.31
	Within gp	155.343	42	3.699		
	Total	164.259	44			
PNSY2	Between gp	4.056	2	2.028	0.436	0.649
	Within gp	195.193	42	4.647		
	Total	199.249	44			
MAXY2	Between gp	5.53	2	2.765	0.452	0.639
	Within gp	256.774	42	6.114		
	Total	262.304	44			

The affect of different operations is shown in the following tables.

Table 9.24. Magnitude of shift in superior direction and postsurgical movement by operation.

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Op. 1	19	4.13	3.02	0.69	2.67	5.58	-1.41	8.85
	Op. 2	22	2.5	3.29	0.72	1.01	4	-3.16	9.08
	Op. 3	4	3.73	3.61	1.61	-0.75	8.23	-1.63	7.91
ANSY1	Op. 1	19	4.56	3.46	0.79	2.89	6.23	-2.23	10.2
	Op. 2	22	2.58	3.8	0.83	0.85	4.31	-4.27	9.81
	Op. 3	4	3.33	3.67	1.64	-1.23	7.89	-2.55	7.13
PNSY1	Op. 1	19	3.27	2.86	0.66	1.89	4.65	-0.98	11.9
	Op. 2	22	2.13	2.84	0.62	0.84	3.43	-2.07	8.46
	Op. 3	4	3.08	3.2	1.43	-0.9	7.05	0.35	8.13
MAXY1	Op. 1	19	5.47	2.63	.6.60	4.21	6.74	1.07	11.9
	Op. 2	22	4.34	2.42	0.53	3.24	5.44	0.77	9.08
	Op. 3	4	5.42	2.85	1.27	1.89	8.96	1.59	8.13
AY2	Op. 1	19	-0.73	2.04	0.47	-1.71	0.26	-4.58	2.69
	Op. 2	22	-0.76	1.31	0.29	-1.36	-0.16	-4.46	0.73
	Op. 3	4	-1.33	4.12	1.84	-6.45	3.79	-7.04	3.68
ANSY2	Op. 1	19	-1.19	1.81	0.42	-2.07	-0.32	-5.74	2.32
	Op. 2	22	-1.02	1.5	0.33	-1.71	-0.34	-4.22	0.71
	Op. 3	4	-0.84	3.86	1.73	-5.63	3.96	-4.48	4.5
PNSY2	Op. 1	19	-0.56	2.49	0.57	-1.76	0.65	-7.89	4.73
	Op. 2	22	-0.36	1.76	0.38	-1.16	0.44	-4.56	2.66
	Op. 3	4	-1.57	2.21	0.99	-4.31	1.18	-5.21	0.38
MAXY2	Op. 1	19	-0.79	2.67	0.61	-2.08	0.5	-7.89	4.73
	Op. 2	22	-0.93	1.9	0.42	-1.8	-6e-3	-4.56	2.66
	Op. 3	4	-3.26	3.01	1.34	-6.99	0.47	-7.04	0.38

Table 9.24 and 9.25 showed no significant difference between the magnitude of shift both pre and post surgical by operation type for superior repositioning.

Table 9.25. Magnitude of shift in superior direction and postsurgical movement by operation - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	27.158	2	13.579	1.317	0.279
	Within gp	433.035	42	10.31		
	Total	460.193	44			
ANSY1	Between gp	38.947	2	19.474	1.465	0.243
	Within gp	558.357	42	13.294		
	Total	597.304	44			
PNSY1	Between gp	13.588	2	6.794	0.817	0.449
	Within gp	349.369	42	8.318		
	Total	362.957	44			
MAXY1	Between gp	14.161	2	7.08	1.087	0.347
	Within gp	273.639	42	6.515		
	Total	287.8	44			
AY2	Between gp	1.517	2	0.758	0.179	0.836
	Within gp	177.581	42	4.228		
	Total	179.098	44			
ANSY2	Between gp	0.597	2	0.299	0.077	0.926
	Within gp	163.661	42	3.897		
	Total	164.259	44			
PNSY2	Between gp	5.903	2	2.952	0.641	0.532
	Within gp	193.346	42	4.603		
	Total	199.249	44			
MAXY2	Between gp	25.661	2	12.831	2.277	0.115
	Within gp	236.643	42	5.634		
	Total	262.304	44			

Table 9.26. Movement in the superior direction and postsurgical movement by segmentalisation (Seg.) versus one piece maxilla (Nonseg.).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Seg	16	3.58	3.48	0.87	1.73	5.44	-2.84	8.85
	Nonseg	29	3.18	3.14	0.58	1.99	4.38	-3.16	9.08
ANSY1	Seg	16	3.66	4.1	1.02	1.47	5.84	-4.27	10.2
	Nonseg	29	3.41	3.51	0.65	2.08	4.75	-4.21	10.16
PNSY1	Seg	16	2.2	3.2	0.8	0.5	3.91	-2.07	8.46
	Nonseg	29	3	2.69	0.5	1.98	4.03	-1.1	11.9
MAXY1	Seg	16	5.26	2.56	0.64	3.9	6.63	1.07	8.856
	Nonseg	29	4.76	2.58	0.48	3.78	5.74	0.77	11.9
AY2	Seg	16	-1.44	2.41	0.6	-2.73	-0.15	-7.04	3.68
	Nonseg	29	-0.46	1.71	0.32	-1.11	0.19	-4.58	2.69
ANSY2	Seg	16	-1.5	2.52	0.63	-2.85	-0.16	-4.58	4.5
	Nonseg	29	-0.84	1.51	0.28	-1.41	-0.26	-5.74	2.32
PNSY2	Seg	16	-0.91	1.97	0.49	-1.96	0.14	-5.21	1.74
	Nonseg	29	-0.39	2.22	0.41	-1.24	0.45	-7.89	4.73
MAXY2	Seg	16	-2.19	2.16	0.54	-3.35	-1.04	-7.04	1.47
	Nonseg	29	-0.54	2.42	0.45	-1.47	0.38	-7.89	4.73

Table 9.26 and 9.27 show no statistical difference in magnitude of movement in the superior direction between segmentalised and one piece maxillae.

Table 9.27. Magnitude of shift in superior direction and postsurgical movement when segmentalised or one piece - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	1.661	1	1.661	0.156	0.695
	Within gp	458.531	43	10.664		
	Total	460.193	44			
ANSY1	Between gp	0.619	1	0.619	0.045	0.834
	Within gp	596.685	43	13.876		
	Total	597.304	44			
PNSY1	Between gp	6.58	1	6.58	0.794	0.378
	Within gp	356.378	43	8.288		
	Total	362.957	44			
MAXY1	Between gp	2.629	1	2.629	0.396	0.532
	Within gp	285.172	43	6.632		
	Total	287.8	44			
AY2	Between gp	9.782	1	9.782	2.484	0.122
	Within gp	169.317	43	3.938		
	Total	179.098	44			
ANSY2	Between gp	4.553	1	4.553	1.226	0.274
	Within gp	159.705	43	3.714		
	Total	164.259	44			
PNSY2	Between gp	2.72	1	2.72	0.596	0.445
	Within gp	196.529	43	4.57		
	Total	199.249	44			
MAXY2	Between gp	28.092	1	28.092	5.157	0.051
	Within gp	234.212	43	5.447		
	Total	262.304	44			

Table 9.28. Movement in the superior direction and postsurgical movement by wire or rigid fixation (R.F.).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Wire	7	1.87	3.44	1.3	-1.31	5.05	-2.84	7.91
	RF	38	3.59	3.17	0.51	2.55	4.63	-3.16	9.08
ANSY1	Wire	7	1.47	3.47	1.31	-1.74	4.68	-4.27	7.13
	RF	38	3.87	3.64	0.59	2.68	5.07	-4.21	10.2
PNSY1	Wire	7	4.44	4.04	1.53	0.7	8.18	0.76	11.9
	RF	38	2.4	2.55	0.41	1.56	3.24	-2.07	8.46
MAXY1	Wire	7	5.76	3.49	1.32	2.53	8.99	1.43	11.9
	RF	38	4.79	2.38	0.39	4	5.57	0.77	9.08
AY2	Wire	7	-1.96	2.87	1.09	-4.61	0.71	-7.04	0.57
	RF	38	-0.6	1.79	0.29	-1.19	1.0e-3	-4.58	3.68
ANSY2	Wire	7	-1.18	1.86	0.7	-2.9	0.54	-4.48	0.71
	RF	38	-1.06	1.97	0.32	-1.7	-0.41	-5.74	4.5
PNSY2	Wire	7	-1.08	3.34	1.26	-4.16	2.01	-7.89	2.33
	RF	38	-0.48	1.88	0.3	-1.1	0.13	-5.21	4.73
MAXY2	Wire	7	-2.47	4.09	1.54	-6.25	1.31	-7.89	2.33
	RF	38	-0.88	1.99	0.32	-1.53	-0.23	-5.21	4.73

Table 9.28 and 9.29 show no statistical difference between the magnitude of movement in the superior direction and post surgical movement whether the osteotomy was fixed with wires or plates.

Table 9.29. Movement in the superior direction and postsurgical movement fixated with wire or rigid fixation - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	17.536	1	17.536	1.703	0.199
	Within gp	442.657	43	10.294		
	Total	460.193	44			
ANSY1	Between gp	34.168	1	34.168	2.609	0.114
	Within gp	563.137	43	13.096		
	Total	597.304	44			
PNSY1	Between gp	24.496	1	24.496	3.112	0.085
	Within gp	338.461	43	7.871		
	Total	362.957	44			
MAXY1	Between gp	5.633	1	5.633	0.858	0.359
	Within gp	282.168	43	6.562		
	Total	287.8	44			
AY2	Between gp	10.873	1	10.873	2.779	0.103
	Within gp	168.225	43	3.912		
	Total	179.098	44			
ANSY2	Between gp	0.008	1	0.008	0.023	0.881
	Within gp	164.172	43	3.818		
	Total	164.259	44			
PNSY2	Between gp	2.084	1	2.084	0.455	0.504
	Within gp	197.165	43	4.585		
	Total	199.249	44			
MAXY2	Between gp	14.902	1	14.902	2.59	0.115
	Within gp	247.403	43	5.754		
	Total	262.304	44			

Table 9.30. Movement in the superior direction and postsurgical movement by or no orthodontics.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Ortho	40	3.47	3.27	0.52	2.42	4.51	-3.16	9.08
	No Ort	5	2.19	2.98	1.33	-1.51	5.88	-2.19	5.53
ANSY1	Ortho	40	3.57	3.81	0.6	2.35	4.79	-4.27	10.2
	No Ort	5	2.94	2.73	1.22	-0.46	6.33	-0.47	6.36
PNSY1	Ortho	40	2.78	2.99	0.47	1.82	3.74	-2.07	11.9
	No Ort	5	2.22	1.75	0.78	0.01	4.39	0.35	4.42
MAXY1	Ortho	40	5.14	2.59	0.41	4.31	5.97	0.79	11.9
	No Ort	5	3.34	1.69	0.76	1.23	5.44	0.77	5.53
AY2	Ortho	40	-0.82	2.08	0.33	-1.48	-0.15	-7.04	3.68
	No Ort	5	-0.77	1.58	0.71	-2.74	1.19	-3.35	0.98
ANSY2	Ortho	40	-1.06	1.97	0.31	-1.69	-0.43	-5.74	4.5
	No Ort	5	-1.17	1.84	0.83	-3.47	1.11	-4.45	-0.01
PNSY2	Ortho	40	-0.51	2.07	0.33	-1.17	0.15	-7.89	4.73
	No Ort	5	-1.11	2.78	1.24	-4.56	2.34	-4.02	2.66
MAXY2	Ortho	40	-1.19	2.45	0.39	-1.98	-0.41	-7.89	4.73
	No Ort	5	-0.64	2.58	1.16	-3.85	2.56	-3.35	2.66

Table 9.30 and 9.31 show no statistical difference between the magnitude of shift pre and post surgically after superior repositioning whether orthodontic treatment was performed or not.

Table 9.31. Movement in the superior direction and postsurgical movement by orthodontics or no orthodontics. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	7.29	1	7.29	0.692	0.41
	Within gp	452.902	43	10.533		
	Total	460.193	44			
ANSY1	Between gp	1.791	1	1.791	0.129	0.721
	Within gp	595.514	43	13.849		
	Total	597.304	44			
PNSY1	Between gp	1.376	1	1.376	0.164	0.688
	Within gp	361.581	43	8.409		
	Total	362.957	44			
MAXY1	Between gp	14.42	1	14.42	2.268	0.139
	Within gp	273.38	43	6.358		
	Total	287.8	44			
AY2	Between gp	0.001	1	0.001	0.002	0.965
	Within gp	179.09	43	4.165		
	Total	179.098	44			
ANSY2	Between gp	0.006	1	0.006	0.015	0.903
	Within gp	164.201	43	3.819		
	Total	164.259	44			
PNSY2	Between gp	1.597	1	1.597	0.348	0.559
	Within gp	197.652	43	4.597		
	Total	199.249	44			
MAXY2	Between gp	1.354	1	1.354	0.223	0.639
	Within gp	260.95	43	6.069		
	Total	262.304	44			

Table 9.32. Movement in the superior direction and postsurgical movement by the magnitude of movement.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	<2	1	1.43	.	.	.	.	1.43	1.43
	2 -4	18	1.26	2.46	0.58	0.003	2.49	-3.16	4.99
	4 -6	11	4.54	1.11	0.34	3.79	5.29	2.34	5.74
	>6	15	5.04	3.82	0.99	2.92	7.15	-2.19	9.08
ANSY1	<2	1	0.91	.	.	.	.	0.91	0.91
	2 -4	18	1.25	3.13	0.74	-0.3	2.81	-4.27	5..86
	4 -6	11	4.5	2.05	0.62	3.12	5.87	0.78	6.51
	>6	15	5.64	3.89	1	3.49	7.8	-0.66	10.2
PNSY1	<2	1	1.12	.	.	.	.	1.12	1.12
	2 -4	18	2.27	2.41	0.57	1.07	3.47	-0.98	8.13
	4 -6	11	1.63	2.4	0.72	0.001	3.24	-1.49	5.05
	>6	15	4.16	3.34	0.86	2.31	6.01	-2.07	11.9
MAXY1	<2	1	1.43	.	.	.	.	1.43	1.43
	2 -4	18	3.38	1.96	0.46	2.4	4.35	0.77	8.13
	4 -6	11	4.59	1.13	0.34	3.83	5.34	2.34	5.74
	>6	15	7.3	2.21	0.57	6.08	8.53	3.54	11.9
AY2	<2	1	0.22	.	.	.	.	0.22	0.22
	2 -4	18	-0.44	1.99	0.47	-1.43	0.55	-4.46	3.68
	4 -6	11	-0.59	1.82	0.55	-1.81	0.63	-3.4	2.69
	>6	15	-1.48	2.21	0.57	-2.7	-0.26	-7.04	2.52
ANSY2	<2	1	0.71	.	.	.		0.71	0.71
	2 -4	18	-0.52	2.12	0.5	-1.57	0.54	-4.58	4.5
	4 -6	11	-0.78	1.51	0.46	-1.79	0.23	-3.65	2.32
	>6	15	-2.07	1.69	0.44	-3.01	-1.14	-5.74	0.28
PNSY2	<2	1	0.14	.	.	.	.	0.14	0.14
	2 -4	18	-0.48	1.72	0.41	-1.34	0.38	-5.21	2.66
	4 -6	11	-0.61	1.43	0.43	-1.57	0.35	-4.02	1.22
	>6	15	-0.72	3.02	0.78	-2.39	0.95	-7.89	4.73
MAXY2	<2	1	0.22	.	.	.	.	0.22	0.22
	2 -4	18	-0.94	2.01	0.47	-1.94	0.006	-5.21	2.66
	4 -6	11	-0.32	1.56	0.47	-1.38	0.73	-3.33	2.69
	>6	15	--2.04	3.24	0.84	-3.84	-0.25	-7.89	4.73

Table 9.32 and 9.33 show there was no difference in post surgical movement regardless of the magnitude of the initial movement in the superior direction.

Table 9.33. Movement in the superior direction and postsurgical movement by the magnitude of that movement. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	140.241	3	46.747	5.99	0.002
	Within gp	319.952	41	7.804		
	Total	460.193	44			
ANSY1	Between gp	177.554	3	59.185	5.781	0.002
	Within gp	419.751	41	10.238		
	Total	597.304	44			
PNSY1	Between gp	50.407	3	16.802	2.204	0.102
	Within gp	312.55	41	7.623		
	Total	362.957	44			
MAXY1	Between gp	141.255	3	47.085	13.173	0
	Within gp	146.546	41	3.574		
	Total	287.8	44			
AY2	Between gp	10.738	3	3.579	0.872	0.464
	Within gp	168.36	41	4.106		
	Total	179.098	44			
ANSY2	Between gp	24.64	3	8.213	2.412	0.81
	Within gp	139.618	41	3.405		
	Total	164.259	44			
PNSY2	Between gp	0.993	3	0.331	0.068	0.976
	Within gp	198.256	41	4.836		
	Total	199.249	44			
MAXY2	Between gp	22.048	3	7.349	1.254	0.303
	Within gp	240.256	41	5.86		
	Total	262.304	44			

Table 9.34. Movement in the superior direction and postsurgical movement by bone graft or no bone graft.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

no bone = no bone graft used.

bone = bone graft used at osteotomy site.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	no bone	38	3.33	3.05	0.49	2.32	4.33	-3.16	9.08
	bone	7	3.32	4.4	1.66	-0.75	7.38	-1.63	8.85
ANSY1	no bone	38	3.47	3.58	0.58	2.29	4.65	-4.27	10.16
	bone	7	3.66	4.52	1.71	-0.52	7.84	-2.55	10.2
PNSY1	no bone	38	2.7	3.03	0.49	1.7	3.69	-2.07	11.9
	bone	7	2.83	1.94	0.73	1.04	4.62	1.01	6.17
MAXY1	no bone	38	4.93	2.51	0.41	4.1	5.75	0.77	11.9
	bone	7	5	3.04	1.15	2.19	7.81	1.07	8.85
AY2	no bone	38	-0.68	1.76	0.29	-1.26	-0.1	-4.58	3.68
	bone	7	-1.52	3.17	1.2	-4.44	1.41	-7.04	2.52
ANSY2	no bone	38	-0.94	1.89	0.31	-1.56	-0.32	-5.74	4.5
	bone	7	-1.82	2.15	0.81	-3.81	0.17	-4.58	1.34
PNSY2	no bone	38	-0.76	2.12	0.34	-1.46	-6e-3	-7.89	2.66
	bone	7	0.43	2.02	0.76	-1.43	2.3	-1.22	4.73
MAXY2	no bone	38	-1.18	2.26	0.37	-1.92	-0.43	-7.89	2.69
	bone	7	-0.88	3.48	1.32	-4.1	2.34	-7.04	4.73

Table 9.34 and 9.35 show no statistical differences in pre and post surgical movement in the superior direction whether bone grafts were used or not.

Table 9.35. Movement in the superior direction and postsurgical movement by bone graft or no bone graft - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	0.00004	1	0.0004	0	0.995
	Within gp	460.192	43	10.702		
	Total	460.193	44			
ANSY1	Between gp	0.215	1	0.215	0.016	0.901
	Within gp	597.089	43	13.886		
	Total	597.304	44			
PNSY1	Between gp	0.104	1	0.104	0.012	0.912
	Within gp	362.854	43	8.438		
	Total	362.957	44			
MAXY1	Between gp	0.00313	1	0.003	0.005	0.946
	Within gp	287.769	43	6.692		
	Total	287.8	44			
AY2	Between gp	4.173	1	4.173	1.026	0.317
	Within gp	174.925	43	4.068		
	Total	179.098	44			
ANSY2	Between gp	4.602	1	4.602	1.24	0.272
	Within gp	159.656	43	3.713		
	Total	164.259	44			
PNSY2	Between gp	8.456	1	8.456	1.906	0.175
	Within gp	190.794	43	4.437		
	Total	199.249	44			
MAXY2	Between gp	0.515	1	0.515	0.085	0.773
	Within gp	261.789	43	6.088		
	Total	262.304	44			

9.3.2 Inferior repositioning of the Maxilla. (N =13; Table 9.1)

9.3.2.1. Points A, ANS , PNS.

Table 9.36 Mean maxillary inferior repositioning (mm).

	Mean	Minimum	Maximum	Standard Deviation	Standard Error
AY1	-3.54	-6.7	-1.25	1.98	0.55
ANSY1	-4.13	-9.69	-1.49	2.43	0.67
PNSY1	-0.71	-3.86	0.92	1.38	0.38
AY2	1.4	-1.95	8.48	2.75	0.76
ANS2	1.78	-1.94	10.88	3.22	0.89
PNSY2	0.39	-2.23	2.41	1.36	0.38

Table 9.36 and 9.37 show the magnitude and range of pre and post surgical movement for each of the maxillary landmarks for the group of patients having inferior repositioning.

Table 9.37. T -Test : Inferiorly repositioned maxilla. One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean Difference	t	Sig (2-tailed)	1	2
AY1	-3.54	-6.449	0	-4.74	-2.34
ANSY1	-4.13	-6.125	0	-5.59	-2.65
PNSY1	-0.71	-1.872	0.086	-1.55	0.12
AY2	1.4	1.841	0.09	-0.26	3.07
ANSY2	1.78	1.987	0.07	-0.17	3.72
PNSY2	0.39	1.033	0.322	-0.43	1.21

Table 9.38 Correlations - inferiorly repositioned maxilla (Pearsons Correlations.)

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

	AY1	ANSY1	PNSY1	AY2	ANSY2	PNSY2
AY1	1	0.9**	0.545	-0.65*	-0.69**	0.05
ANSY1	0.9**	1	0.34	-0.82**	-0.88**	0.02
PNSY1	0.545	0.34	1	-0.3	-0.3	-0.19
AY2	-0.65*	-0.82**	-0.3	1	0.92**	-0.2
ANSY2	-0.69**	-0.88**	-0.3	-0.92	1	-0.04
PNSY2	0.05	0.02	-0.19	-0.16	-0.4	1

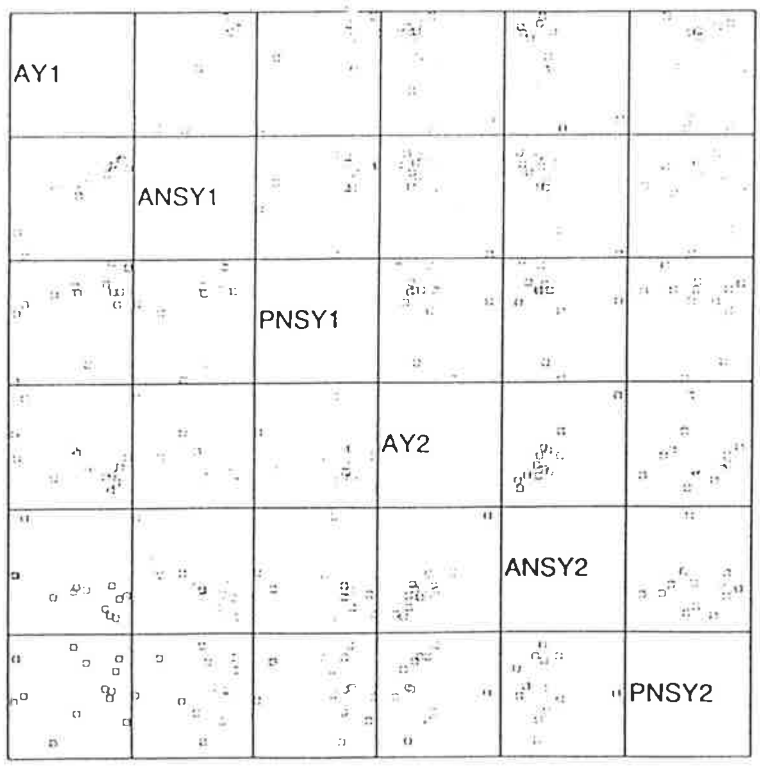


Figure 9.2 Scatter plot of maxillary landmarks for inferior repositioning.

Table 9.39. Magnitude of shift in the inferior direction and postsurgical movement by gender.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Male	4	-3.69	2.22	1.11	-7.22	-0.16	-6.62	-1.25
	Female	9	-3.47	2	0.67	-5.01	-1.93	-6.7	-1.59
	Total	13	-3.54	1.98	0.55	-4.74	-2.34	-6.7	-1.25
ANSY1	Male	4	-4.7	2.22	1.11	-8.23	-1.17	-7.74	-2.54
	Female	9	-3.87	2.6	0.87	-5.87	-1.87	-9.69	-1.49
	Total	13	-4.12	2.43	0.67	-6	-2.66	-9.69	-1.49
PNSY1	Male	4	-0.98	1.67	0.83	-3.63	1.67	-3.21	0.71
	Female	9	-0.6	1.32	0.44	-1.61	0.42	-3.86	0.92
	Total	13	-0.71	1.38	0.38	-1.55	0.12	-3.86	0.92
AY2	Male	4	1.51	0.91	0.45	-6e-3	2.95	0.22	2.36
	Female	9	1.36	3.32	1.11	-1.19	3.91	-1.95	8.48
	Total	13	1.4	2.75	0.76	-0.26	3.07	-1.95	8.48
ANSY2	Male	4	2	1.09	0.55	0.25	3.74	0.9	3.49
	Female	9	1.68	3.89	1.3	-1.31	4.67	-1.94	10.88
	Total	13	1.78	3.22	0.89	-0.17	3.72	-1.94	10.88
PNSY2	Male	4	0.36	1.6	0.8	-2.2	2.91	-1.23	1.84
	Female	9	0.41	1.35	0.45	-0.36	1.44	-2.23	2.41
	Total	13	0.39	1.36	0.38	-0.43	1.21	-2.23	2.41

Table 9.39 and 9.40 show that there was no statistical difference in the magnitude of pre and post surgical movement for inferior repositioning between genders.

Table 9.40. Magnitude of shift in the inferior direction and postsurgical movement by gender - ANOVA. (gp : 'group')

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	0.134	1	0.134	0.032	0.862
	Within gp	46.877	11	4.262		
	Total	47.011	12			
ANSY1	Between gp	1.909	1	1.909	0.305	0.592
	Within gp	68.941	11	6.267		
	Total	70.85	12			
PNSY1	Between gp	0.402	1	0.402	0.198	0.665
	Within gp	22.292	11	2.027		
	Total	22.694	12			
AY2	Between gp	0.0006	1	0.0062	0.008	0.932
	Within gp	90.65	11	8.241		
	Total	90.712	12			
ANSY2	Between gp	0.277	1	0.277	0.024	0.879
	Within gp	124.425	11	11.311		
	Total	124.701	12			
PNSY2	Between gp	0.0007	1	0.0007	0.004	0.954
	Within gp	22.208	11	2.019		
	Total	22.215	12			

Table 9.41. Magnitude of shift in the inferior direction and postsurgical movement by age.

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	<23 yr	5	-3.42	1.19	0.6	-5.32	-1.52	-4.83	-1.95
	23+yr	8	-3.59	2.31	0.77	-5.37	-1.81	-6.7	-1.25
	Total	13	-3.54	1.98	0.55	-4.74	-2.34	-6.7	-1.25
ANSY1	<23 yr	5	-3.72	1.09	0.55	-5.46	-1.98	-4.76	-2.2
	23+yr	8	-4.31	2.88	0.96	-6.52	-2.09	-9.69	-1.49
	Total	13	-4.13	2.43	0.67	-6	-2.66	-9.69	-1.49
PNSY1	<23 yr	5	-1.04	1.45	0.73	-3.34	1.27	-3.21	-0.28
	23+yr	8	-0.57	1.4	0.47	-1.65	5.0e-1	-3.86	0.92
	Total	13	-0.71	1.38	0.38	-1.54	1.1e-1	-3.86	0.92
AY2	<23 yr	5	0.49	1.29	0.64	-1.56	2.54	-0.55	2.36
	23+yr	8	1.81	3.18	1.06	-0.64	4.26	-1.95	8.48
	Total	13	1.4	2.75	0.76	-0.26	3.07	-1.95	8.48
ANSY2	<23 yr	5	1.63	0.66	0.33	0.58	2.67	0.71	2.2
	23+yr	8	1.84	3.93	1.31	-1.17	4.86	-1.94	10.88
	Total	13	1.78	3.22	0.89	-0.17	3.72	-1.94	10.88
PNSY2	<23 yr	5	-0.29	1.64	0.82	-2.89	2.32	-2.23	1.63
	23+yr	8	0.69	1.2	0.4	-0.23	1.61	-1.23	2.41
	Total	13	0.39	1.36	0.38	-0.43	1.21	-2.23	2.41

Table 9.41 and 9.42 show that there was no statistical difference in the magnitude of pre and post surgical movement for inferior repositioning between younger and older patients.

Table 9.42. Magnitude of shift in the inferior direction and postsurgical movement by age - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	0.0082	1	0.0008	0.02	0.891
	Within gp	46.928	11	4.266		
	Total	47.011	12			
ANSY1	Between gp	0.949	1	0.949	0.149	0.707
	Within gp	69.901	11	6.355		
	Total	70.85	12			
PNSY1	Between gp	0.596	1	0.596	0.297	0.597
	Within gp	22.098	11	2.009		
	Total	22.694	12			
AY2	Between gp	4.825	1	4.825	0.618	0.448
	Within gp	85.887	11	7.808		
	Total	90.712	12			
ANSY2	Between gp	0.132	1	0.132	0.012	0.916
	Within gp	124.569	11	11.324		
	Total	124.701	12			
PNSY2	Between gp	2.633	1	2.633	1.479	0.249
	Within gp	19.582	11	1.78		
	Total	22.215	12			

The affect of different surgeons is shown in the following tables. Only surgeons 1 and 2 performed this operation.

Table 9.43. Magnitude of shift in the inferior direction and postsurgical movement by surgeon.

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Surg 1	4	-2.38	0.92	0.46	-3.84	-0.92	-3.69	-1.59
	Surg 2	9	-4.05	2.14	0.71	-5.7	-2.41	-6.7	-1.25
ANSY1	Surg 1	4	-2.93	1.32	0.66	-5.04	-0.83	-4.76	-1.76
	Surg 2	9	-4.66	2.68	0.89	-6.72	-2.6	-9.69	-1.49
PNSY1	Surg 1	4	-0.2	0.16	8.1e-4	-0.45	5.4e-4	-0.29	0.04
	Surg 2	9	-0.94	1.62	0.54	-2.19	0.31	-3.86	0.92
AY2	Surg 1	4	0.64	1.25	0.62	-1.34	2.62	-0.45	2.36
	Surg 2	9	1.74	3.21	1.07	-0.73	4.22	-1.95	8.48
ANSY2	Surg 1	4	0.99	1.37	0.69	-1.19	3.17	-0.73	2.2
	Surg 2	9	2.12	3.8	1.27	-0.8	5.05	-1.94	10.88
PNSY2	Surg 1	4	0.42	1.09	0.55	-1.32	2.16	-0.82	1.84
	Surg 2	9	0.38	1.52	0.51	-0.8	1.55	-2.23	2.41

Table 9.43 and 9.44 show that there was no statistical difference in the magnitude of pre and post surgical movement for inferior repositioning between the surgeons.

Table 9.44. Magnitude of shift in the inferior direction and postsurgical movement by surgeon - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	7.741	1	7.741	2.168	0.169
	Within gp	39.27	11	3.57		
	Total	47.011	12			
ANSY1	Between gp	8.253	1	8.253	1.45	0.254
	Within gp	62.596	11	5.691		
	Total	70.85	12			
PNSY1	Between gp	1.526	1	1.526	0.793	0.392
	Within gp	21.168	11	1.924		
	Total	22.694	12			
AY2	Between gp	3.371	1	3.371	0.425	0.528
	Within gp	87.341	11	7.94		
	Total	90.712	12			
ANSY2	Between gp	3.548	1	3.548	0.322	0.582
	Within gp	121.153	11	11.014		
	Total	124.701	12			
PNSY2	Between gp	0.0005	1	0.0005	0.003	0.96
	Within gp	22.209	11	2.019		
	Total	22.215	12			

The affect of different operations is shown in the following tables.

Table 9.45. Magnitude of shift in the inferior direction and postsurgical movement by operation.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Op. 1	5	-3.91	1.91	0.86	-6.28	-1.53	-6.62	-1.95
	Op. 2	5	-3.89	2.46	1.1	-6.94	-0.84	-6.7	-1.25
	Op. 3	3	-2.35	1.17	0.67	-5.24	0.55	-3.69	-1.59
ANSY1	Op. 1	5	-4.27	2.12	0.95	-6.9	-1.65	-7.74	-2.2
	Op. 2	5	-4.86	3.05	1.36	-8.64	-1.07	-9.69	-2.37
	Op. 3	3	-2.67	1.82	1.05	-7.18	1.84	-4.76	-1.49
PNSY1	Op. 1	5	-0.35	0.46	0.21	-0.92	0.22	-1.12	0.04
	Op. 2	5	-1.24	2.21	0.99	-3.97	1.5	-3.86	0.92
	Op. 3	3	-0.44	0.28	0.16	-1.15	0.26	-0.77	-0.27
AY2	Op. 1	5	0.66	1.44	0.64	-1.12	2.44	-0.55	2.63
	Op. 2	5	2.59	4.04	1.81	-2.42	7.6	-1.95	8.48
	Op. 3	3	0.67	1.71	0.99	-3.58	4.92	-1.06	2.36
ANSY2	Op. 1	5	1.42	1.58	0.71	-0.55	3.39	-0.73	3.49
	Op. 2	5	3.09	4.74	2.12	-2.8	8.98	-1.6	10.88
	Op. 3	3	0.19	1.98	1.15	-4.74	5.12	-1.94	1.99
PNSY2	Op. 1	5	0.53	1.8	0.81	-1.7	2.77	-2.23	2.41
	Op. 2	5	2.8e-4	1.03	0.46	-1.25	1.3	-1.23	1.63
	Op. 3	3	0.75	1.39	0.8	-2.71	4.21	-0.82	1.84

Table 9.45 and 9.46 show that there was no statistical difference in the magnitude of pre and post surgical movement for inferior repositioning between the different operation types.

Table 9.46. Magnitude of shift in the inferior direction and postsurgical movement by operation. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	5.555	2	2.777	0.67	0.533
	Within gp	41.456	10	4.146		
	Total	47.011	12			
ANSY1	Between gp	9.134	2	4.567	0.74	0.502
	Within gp	61.716	10	6.172		
	Total	70.85	12			
PNSY1	Between gp	2.23	2	1.115	0.545	0.596
	Within gp	20.464	10	2.046		
	Total	22.694	12			
AY2	Between gp	11.432	2	5.716	0.721	0.51
	Within gp	79.28	10	7.928		
	Total	90.712	12			
ANSY2	Between gp	16.792	2	8.396	0.778	0.85
	Within gp	107.909	10	10.791		
	Total	124.701	12			
PNSY2	Between gp	1.151	2	0.575	0.273	0.766
	Within gp	21.064	10	2.106		
	Total	22.215	12			

Table 9.47. Movement in the inferior direction and postsurgical movement by segmentalisation (Seg.) versus one piece maxilla (Nonseg.).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Seg	3	-3.31	2.9	1.67	-1.05	3.88	-6.62	-1.25
	Nonseg	10	-3.61	1.83	0.58	-4.92	-2.3	-6.7	-1.59
ANSY1	Seg	3	-4.22	3.05	1.76	-11.8	3.37	-7.74	-2.37
	Nonseg	10	-4.1	2.41	0.76	-5.82	-2.38	-9.69	-1.49
PNSY1	Seg	3	0.17	1.12	0.65	-2.62	2.96	-1.12	0.92
	Nonseg	10	-0.98	1.38	0.44	-1.97	7.8e-4	-3.86	0.04
AY2	Seg	3	0.5	2.12	1.23	-4.77	5.77	-1.95	1.73
	Nonseg	10	1.67	2.95	0.93	-0.44	3.79	-1.06	8.48
ANSY2	Seg	3	0.93	2.54	1.47	-5.39	7.25	-1.6	3.49
	Nonseg	10	2.03	3.48	1.1	-0.46	4.52	-1.94	10.88
PNSY2	Seg	3	0.18	1.55	0.9	-3.68	4.03	-1.23	1.84
	Nonseg	10	0.45	1.38	0.44	-0.54	1.44	-2.23	2.41

Table 9.47 and 9.48 show that there was no statistical difference in the magnitude of pre and post surgical movement for inferior repositioning whether the maxillae was segmentalised or was left in one piece.

Table 9.48. Magnitude of shift in inferior direction and postsurgical movement when segmentalised or one piece - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	0.206	1	0.206	0.048	0.83
	Within gp	46.805	11	4.255		
	Total	47.011	12			
ANSY1	Between gp	0.003	1	0.003	0.005	0.946
	Within gp	70.819	11	6.438		
	Total	70.85	12			
PNSY1	Between gp	3.047	1	3.047	1.706	0.218
	Within gp	19.647	11	1.786		
	Total	22.694	12			
AY2	Between gp	3.186	1	3.186	0.4	0.54
	Within gp	87.526	11	7.957		
	Total	90.712	12			
ANSY2	Between gp	2.792	1	2.792	0.252	0.626
	Within gp	121.909	11	11.083		
	Total	124.701	12			
PNSY2	Between gp	0.177	1	0.177	0.089	0.772
	Within gp	22.037	11	2.003		
	Total	22.215	12			

Table 9.49. Movement in the inferior direction and postsurgical movement by wire or rigid fixation (R.F.).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Wire	3	-3.77	2.49	1.44	-9.94	2.41	-6.22	-1.25
	RF	10	-3.47	1.96	0.62	-4.87	-2.07	-6.7	-1.59
ANSY1	Wire	3	-5.5	3.73	2.16	-14.77	3.77	-9.69	-2.54
	RF	10	-3.72	1.99	0.63	-5.14	-2.29	-7.74	-1.49
PNSY1	Wire	3	-2e-3	0.73	0.42	-1.83	1.78	-0.74	0.71
	RF	10	-0.92	1.48	0.47	-1.98	0.14	-3.86	0.92
AY2	Wire	3	4.28	3.67	2.12	-4.83	13.38	1.73	8.48
	RF	10	0.54	1.87	0.59	-0.8	1.88	-1.95	4.47
ANSY2	Wire	3	4.4	5.62	3.24	-9.54	18.35	0.9	10.88
	RF	10	0.99	1.96	0.62	-0.42	2.39	-1.94	3.65
PNSY2	Wire	3	0.41	1.85	1.07	-4.18	5	-1.23	2.41
	RF	10	0.38	1.31	0.41	-0.55	1.32	-2.23	1.84

Table 9.49 and 9.50 show that there was no statistical difference in the magnitude of pre surgical movement for inferior repositioning whether the maxillae was fixated with wire or plates and screws. There was however greater surgical movement of the wire fixated group post surgically at point A.

Table 9.50. Movement in the inferior direction and postsurgical movement fixated with wire or rigid fixation - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	0.206	1	0.206	0.048	0.83
	Within gp	46.805	11	4.255		
	Total	47.011	12			
ANSY1	Between gp	7.309	1	7.309	1.265	0.285
	Within gp	63.541	11	5.776		
	Total	70.85	12			
PNSY1	Between gp	1.842	1	1.842	0.972	0.345
	Within gp	20.852	11	1.896		
	Total	22.694	12			
AY2	Between gp	32.262	1	32.262	6.072	0.031
	Within gp	58.54	11	5.314		
	Total	90.712	12			
ANSY2	Between gp	26.918	1	26.918	3.028	0.11
	Within gp	97.783	11	8.889		
	Total	124.701	12			
PNSY2	Between gp	0.0001	1	0.0001	0.001	0.978
	Within gp	22.213	11	2.019		
	Total	22.215	12			

Table 9.51. Movement in the inferior direction and postsurgical movement by orthodontics or no orthodontics.

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Ortho	11	-3.84	2.02	0.61	-5.19	-2.48	-6.7	-1.25
	No Ort	2	-1.91	0.21	0.15	-3.82	-4e-4	-2.06	-1.76
ANSY1	Ortho	11	-4.53	2.43	0.73	-6.16	-2.89	-9.69	-1.76
	No Ort	2	-1.93	0.62	0.44	-7.52	3.66	-2.37	-1.49
PNSY1	Ortho	11	-0.86	1.41	0.42	-1.8	8.7e-4	-3.86	0.71
	No Ort	2	0.0075	1.2	0.85	-10.66	10.81	-0.77	0.92
AY2	Ortho	11	1.93	2.65	0.8	0.15	3.71	-0.55	8.48
	No Ort	2	-1.51	0.63	0.45	-7.16	4.15	-1.95	-1.06
ANSY2	Ortho	11	2.42	3.08	0.93	0.35	4.5	-0.73	10.88
	No Ort	2	-1.77	0.24	0.17	-3.93	0.39	-1.94	-1.6
PNSY2	Ortho	11	0.36	1.46	0.44	-0.62	1.34	-2.23	2.41
	No Ort	2	0.58	0.93	0.66	-7.75	8.9	-0.08	1.23

Table 9.51 and 9.52 show that there was no statistical difference in the magnitude of pre and post surgical movement for inferior repositioning whether the patient received orthodontic treatment or not.

Table 9.52. Movement in the superior direction and postsurgical movement by orthodontics or no orthodontics. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	6.28	1	6.28	1.696	0.219
	Within gp	40.731	11	3.703		
	Total	47.011	12			
ANSY1	Between gp	11.416	1	11.416	2.113	0.174
	Within gp	59.434	11	5.403		
	Total	70.85	12			
PNSY1	Between gp	1.471	1	1.471	0.762	0.401
	Within gp	21.223	11	1.929		
	Total	22.694	12			
AY2	Between gp	20	1	20	3.111	0.105
	Within gp	70.712	11	6.428		
	Total	90.712	12			
ANSY2	Between gp	29.723	1	29.723	3.442	0.091
	Within gp	94.978	11	8.634		
	Total	124.701	12			
PNSY2	Between gp	0.008	1	0.008	0.04	0.845
	Within gp	22.134	11	2.012		
	Total	22.215	12			

Table 9.53. Movement in the inferior direction and postsurgical movement by the magnitude of movement.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	<2	1	-1.95	.	.	.	.	-1.95	-1.95
	2 -4	7	-3	1.83	0.69	-4.69	-1.3	-6.7	-1.25
	4 -6	4	-4.12	1.95	0.97	-7.22	-1.01	-6.22	-1.59
	>6	1	-6.62	.	.	.	.	-6.62	-6.62
ANSY1	<2	1	-2.2	.	.	.	.	-2.2	-2.2
	2 -4	7	-3.4	1.52	0.58	-4.81	-2	-5.91	-1.49
	4 -6	4	-4.97	3.35	1.68	-10.3	0.37	-9.69	-1.76
	>6	1	-7.74	.	.	.	.	-7.74	-7.74
PNSY1	<2	1	-0.28	.	.	.	.	-0.28	-0.28
	2 -4	7	-0.92	1.88	0.71	-2.66	0.82	-3.86	0.92
	4 -6	4	-0.36	0.29	0.14	-0.81	0.1	-0.74	-0.05
	>6	1	-1.12	.	.	.	.	-1.12	-1.12
AY2	<2	1	-0.007	.	.	.	.	-0.07	-0.07
	2 -4	7	0.76	2.22	0.84	-1.3	2.82	-1.95	4.47
	4 -6	4	2.82	3.99	2	-3.53	9.17	-0.55	8.48
	>6	1	1.72	.	.	.	.	1.72	1.72
ANSY2	<2	1	2.2	.	.	.	.	2.2	2.2
	2 -4	7	0.55	2.06	0.78	-1.35	2.45	-1.94	3.65
	4 -6	4	3.38	5.01	2.51	-4.6	11.36	0.51	10.88
	>6	1	3.49	.	.	.	.	3.49	3.49
PNSY2	<2	1	0.28	.	.	.	.	0.28	0.28
	2 -4	7	0.13	1.04	0.39	-0.83	1.08	-1.23	1.63
	4 -6	4	0.52	2.09	1.04	-2.81	3.84	-2.23	2.41
	>6	1	1.84	.	.	.	.	1.84	1.84

Table 9.53 and 9.54 show that there was no statistical difference in the magnitude of pre and post surgical movement for inferior repositioning regardless of the magnitude of the original movement.

Table 9.54. Movement in the inferior direction and postsurgical movement by the magnitude of that movement. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	15.434	3	5.145	1.466	0.288
	Within gp	31.577	9	3.509		
	Total	47.011	12			
ANSY1	Between gp	23.22	3	7.74	1.463	0.289
	Within gp	47.63	9	5.292		
	Total	70.85	12			
PNSY1	Between gp	1.174	3	0.391	0.164	0.918
	Within gp	21.52	9	2.391		
	Total	22.694	12			
AY2	Between gp	13.196	3	4.399	0.511	0.685
	Within gp	77.516	9	8.613		
	Total	90.712	12			
ANSY2	Between gp	23.913	3	7.971	0.712	0.569
	Within gp	100.788	9	11.199		
	Total	124.701	12			
PNSY2	Between gp	2.669	3	0.89	0.41	0.75
	Within gp	19.546	9	2.172		
	Total	22.215	12			

Table 9.55. Movement in the inferior direction and postsurgical movement by bone graft or no bone graft.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	no bone	10	-3.38	2.06	0.65	-4.85	-1.91	-6.7	-1.25
	bone	3	-4.07	1.99	1.15	-9.01	0.87	-6.22	-2.3
ANSY1	no bone	10	-3.62	1.99	0.63	-5.04	-2.2	-7.74	-1.49
	bone	3	-5.82	3.46	2	-14.42	2.78	-9.69	-3.01
PNSY1	no bone	10	-0.83	1.57	0.49	-1.94	0.28	-3.86	0.92
	bone	3	-0.33	0.39	0.23	-1.3	0.64	-0.74	0.04
AY2	no bone	10	0.79	1.9	0.6	-0.57	2.15	-1.95	4.47
	bone	3	3.46	4.57	2.63	-7.88	14.81	-0.45	8.48
ANSY2	no bone	10	1.09	1.85	0.59	-0.23	2.42	-1.94	3.65
	bone	3	4.05	6.07	3.51	-11.04	19.13	-0.73	10.88
PNSY2	no bone	10	0.55	1.51	0.48	-0.53	1.62	-2.23	2.41
	bone	3	-0.13	0.62	0.38	-1.67	1.41	-0.82	0.38

Table 9.55 and 9.56 show that there was no statistical difference in the magnitude of pre and post surgical movement for inferior repositioning whether bone grafts were used or not.

Table 9.56. Movement in the superior direction and postsurgical movement by bone graft or no bone graft. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	1.096	1	1.096	0.262	0.619
	Within gp	45.915	11	4.174		
	Total	47.011	12			
ANSY1	Between gp	11.169	1	11.169	2.059	0.179
	Within gp	59.681	11	5.426		
	Total	70.85	12			
PNSY1	Between gp	0.575	1	0.575	0.286	0.604
	Within gp	22.119	11	2.011		
	Total	22.694	12			
AY2	Between gp	16.542	1	16.542	2.453	0.146
	Within gp	74.17	11	6.743		
	Total	90.712	12			
ANSY2	Between gp	20.105	1	20.105	2.114	0.174
	Within gp	104.596	11	9.509		
	Total	124.701	12			
PNSY2	Between gp	1.055	1	1.055	0.548	0.475
	Within gp	21.16	11	1.924		
	Total	22.215	12			

9.3.3 Anterior repositioning of the Maxilla. (N =42; Table 9.1)

9.3.3.1. Points A, ANS , PNS .

Table 9.57. Mean maxillary advancement (mm).

	Mean	Minimum	Maximum	Standard Deviation	Standard Error
AX1	3.91	0.64	8.96	2.26	0.35
ANSX1	4.19	0.35	9.75	2.23	0.34
PNSX1	4.23	0.19	10.23	2.36	0.36
AX2	-0.9	-4.01	1.87	1.35	0.21
ANSX2	-1.06	-4.45	2.33	1.5	0.23
PNSX2	-1.02	-4	3.22	1.56	0.24

Table 9.57 and 9.58 show the magnitude of pre and post surgical movement for the advancement group.

Table 9.58 T -Test : Anteriorly repositioned maxilla.

One - sample test (df =41).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean Difference	t	Sig (2-tailed)	1	2
AX1	3.91	11.213	0	3.21	4.62
ANSX1	4.19	12.15	0	3.5	4.88
PNSX1	4.23	11.633	0	3.5	4.97
AX2	-0.9	-4.316	0	-1.32	-0.48
ANSX2	-1.06	-4.61	0	-1.53	-0.6
PNSX2	-1.02	-4.228	0	-1.5	-0.53

Table 9.59 Correlations - anteriorly repositioned maxilla (Pearsons Correlations.)

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

	AX1	ANSX1	PNSX1	AX2	ANSX2	PNSX2
AX1	1	.922**	.920**	-0.129	-0.184	-0.275
ANSX1	.922**	1	.971**	-0.064	-0.16	-0.26
PNSX1	.92**	.971**	1	-0.082	-0.124	-0.259
AX2	-0.129	-0.064	-0.082	1	.749**	.686**
ANSX2	-0.184	-0.16	-0.124	.749**	1	.888**
PNSX2	-0.275	-0.26	-0.259	.686**	.888**	1

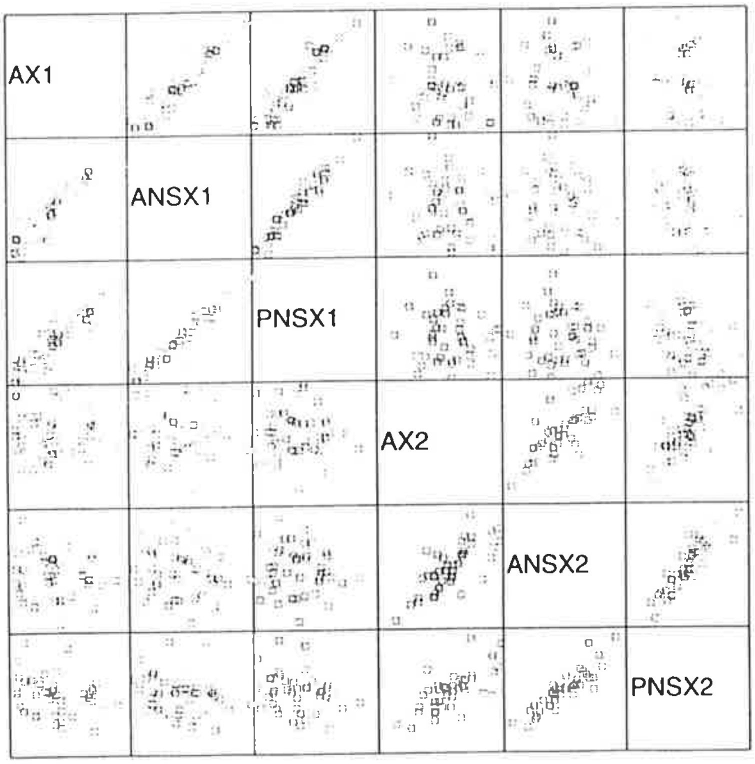


Figure 9.3 Scatter plot of maxillary landmarks for anterior repositioning.

Table 9.60. Magnitude of shift in the anterior direction and postsurgical movement by gender.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	Male	11	3.53	2.01	0.61	2.18	4.88	0.64	6.85
	Female	31	4.04	2.36	0.42	3.18	4.91	0.65	8.96
	Total	42	3.91	2.26	0.35	3.21	4.61	0.64	8.96
ANSX1	Male	11	3.9	2.36	0.71	2.32	5.48	0.35	7.24
	Female	31	4.29	2.22	0.4	3.47	5.1	0.66	9.75
	Total	42	4.19	2.23	0.35	3.49	4.88	0.35	9.75
PNSX1	Male	11	3.96	2.41	0.73	2.34	5.58	0.19	7.44
	Female	31	4.33	2.37	0.43	3.46	5.2	0.34	10.23
	Total	42	4.23	2.36	0.36	3.5	4.97	0.19	10.23
AX2	Male	11	-0.52	0.92	0.28	-1.14	9.9e-3	-1.44	1.87
	Female	31	-1.03	1.5	0.26	-1.57	-0.5	-4.01	1.67
	Total	42	-0.9	1.35	0.21	-1.32	-0.48	-4.01	1.87
ANSX2	Male	11	-1.03	1.09	0.33	-1.76	-0.3	-2.81	0.9
	Female	31	-1.07	1.63	0.29	-1.67	-0.48	-4.45	2.33
	Total	42	-1.06	1.49	0.23	-1.53	-0.6	-4.45	2.33
PNSX2	Male	11	-0.8	1.52	0.46	-1.82	0.22	-3.19	2.75
	Female	31	-1.09	1.59	0.29	-1.67	-0.51	-4	3.22
	Total	42	-1.02	1.56	0.24	-1.5	-0.53	-4	3.22

Table 9.60 and 9.61 show that there was no statistical difference in the magnitude of pre and post surgical movement for advancements between genders.

Table 9.61. Magnitude of shift in the anterior direction and postsurgical movement by gender - ANOVA. (gp : 'group')

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	2.132	1	2.132	0.411	0.525
	Within gp	207.335	40	5.183		
	Total	209.467	41			
ANSX1	Between gp	1.205	1	1.205	0.237	0.629
	Within gp	203.136	40	5.078		
	Total	204.341	41			
PNSX1	Between gp	1.117	1	1.117	0.197	0.66
	Within gp	226.881	40	5.672		
	Total	227.998	41			
AX2	Between gp	2.132	1	2.132	1.182	0.283
	Within gp	72.146	40	1.804		
	Total	74.278	41			
ANSX2	Between gp	0.002	1	0.002	0.007	0.936
	Within gp	91.316	40	2.283		
	Total	91.331	41			
PNSX2	Between gp	0.662	1	0.662	0.268	0.607
	Within gp	98.617	40	2.465		
	Total	99.279	41			

Table 9.62. Magnitude of shift in the anterior direction and postsurgical movement by age.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	<23 yr	24	3.48	1.85	0.44	2.56	4.4	0.76	7.2
	23+yr	18	4.24	2.52	0.51	3.17	5.3	0.64	8.96
	Total	42	3.91	2.26	0.35	3.2	4.61	0.64	8.96
ANSX1	<23 yr	24	3.89	1.74	0.41	3.02	4.75	0.35	6.9
	23+yr	18	4.41	2.56	0.52	3.33	5.49	0.74	9.75
	Total	42	4.19	2.23	0.35	3.48	4.88	0.35	9.75
PNSX1	<23 yr	24	3.99	1.78	0.42	3.1	4.87	0.34	7.18
	23+yr	18	4.42	2.74	0.56	3.26	5.57	0.19	10.23
	Total	42	4.23	2.36	0.36	3.5	4.97	0.19	10.23
AX2	<23 yr	24	-0.62	1.46	0.34	-1.34	0.11	-3.16	1.67
	23+yr	18	-1.11	1.24	0.25	-1.63	-0.58	-4.01	1.87
	Total	42	-0.9	1.35	0.21	-1.31	-0.48	-4.01	1.87
ANSX2	<23 yr	24	-0.78	1.75	0.41	-1.65	0.008	-3.44	2.33
	23+yr	18	-1.27	1.27	0.26	-1.81	-0.73	-4.45	0.92
	Total	42	-1.06	1.49	0.23	-1.53	-0.6	-4.45	2.33
PNSX2	<23 yr	24	-0.94	1.93	0.45	-1.89	0.002	-4	3.22
	23+yr	18	-1.07	1.25	0.26	-1.6	-0.55	-3.69	2.75
	Total	42	-1.01	1.56	0.24	-1.5	-0.53	-4	3.22

Table 9.62 and 9.63 show that there was no statistical difference in the magnitude of pre and post surgical movement for advancements between young and old patients.

Table 9.63. Magnitude of shift in the anterior direction and postsurgical movement by age - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	5.865	1	5.865	1.152	0.29
	Within gp	203.602	40	5.09		
	Total	209.467	41			
ANSX1	Between gp	2.84	1	2.84	0.564	0.457
	Within gp	201.502	40	5.038		
	Total	204.341	41			
PNSX1	Between gp	1.926	1	1.926	0.341	0.563
	Within gp	226.071	40	5.652		
	Total	227.998	41			
AX2	Between gp	2.495	1	2.495	1.39	0.245
	Within gp	71.783	40	1.795		
	Total	74.278	41			
ANSX2	Between gp	2.431	1	2.431	1.094	0.302
	Within gp	88.9	40	2.223		
	Total	91.331	41			
PNSX2	Between gp	0.197	1	0.197	0.08	0.779
	Within gp	99.082	40	2.477		
	Total	99.297	41			

Table 9.64. Magnitude of shift in the anterior direction and postsurgical movement by surgeon.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	Surg 1	33	3.77	2.1	0.37	3.02	4.51	0.64	7.79
	Surg 2	7	3.72	2.86	1.08	1.07	6.37	1.18	8.96
	Sur3-6	2	6.94	0.37	0.26	3.64	10.24	6.68	7.2
ANSX1	Surg 1	33	4.16	2.08	0.36	3.42	4.89	0.35	7.96
	Surg 2	7	3.81	3.11	1.18	0.94	6.69	1.31	9.75
	Sur3-6	2	6	0.91	0.65	-2.2	14.19	5.35	6.64
PNSX1	Surg 1	33	4.2	2.15	0.38	3.43	4.96	0.19	8.53
	Surg 2	7	3.9	3.47	1.31	0.69	7.12	0.59	10.23
	Sur3-6	2	5.96	0.52	0.37	1.26	10.66	5.59	6.33
AX2	Surg 1	33	-0.7	1.39	0.24	-1.19	-0.21	-4.01	1.87
	Surg 2	7	-1.72	0.89	0.36	-2.54	-0.9	-2.71	-0.15
	Sur3-6	2	-1.27	1.33	0.94	-13.2	10.67	-2.21	-0.33
ANSX2	Surg 1	33	-1.06	1.56	0.27	-1.61	-0.51	-4.45	2.33
	Surg 2	7	-1.24	1.31	0.5	-2.45	-2e-3	-3.01	0.92
	Sur3-6	2	-0.48	1.56	1.11	-14.5	13.56	-1.58	0.63
PNSX2	Surg 1	33	-0.97	1.69	0.29	-1.57	-0.38	-4	3.22
	Surg 2	7	-1.35	1.03	0.39	-2.31	-0.4	-2.31	0.68
	Sur3-6	2	-0.52	0.61	0.43	-5.98	4.94	-0.95	-0.09

Table 9.64 and 9.65 show that there was no statistical difference in the magnitude of pre and post surgical movement for advancements between the different surgeons.

Table 9.65. Magnitude of shift in the anterior direction and postsurgical movement by surgeon - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	19.298	2	9.641	1.977	0.152
	Within gp	190.185	39	4.877		
	Total	209.467	41			
ANSX1	Between gp	7.552	2	3.776	0.748	0.48
	Within gp	196.789	39	5.046		
	Total	204.341	41			
PNSX1	Between gp	6.762	2	3.381	0.596	0.556
	Within gp	221.236	39	5.673		
	Total	227.998	41			
AX2	Between gp	6.353	2	3.176	1.824	0.175
	Within gp	67.925	39	1.742		
	Total	74.278	41			
ANSX2	Between gp	0.9	2	0.45	0.194	0.824
	Within gp	90.431	39	2.319		
	Total	91.331	41			
PNSX2	Between gp	1.346	2	0.673	0.268	0.766
	Within gp	97.933	39	2.511		
	Total	99.279	41			

The affect of different operations is shown in the following tables.

Table 9.66. Magnitude of shift in the anterior direction and postsurgical movement by operation.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	Op. 1	6	3.59	2.81	1.15	0.64	6.54	1.2	8.96
	Op. 2	4	3.24	2.2	1.1	-0.26	6.74	0.88	6.15
	Op. 3	32	4.06	2.22	0.39	3.26	4.85	0.64	7.79
ANSX1	Op. 1	6	3.62	3.17	1.3	0.28	6.95	1.29	9.75
	Op. 2	4	2.86	1.65	0.82	0.23	5.48	1.67	5.22
	Op. 3	32	4.46	2.08	0.37	3.71	5.21	0.35	7.96
PNSX1	Op. 1	6	3.51	3.53	1.44	-0.2	7.21	0.59	10.23
	Op. 2	4	3.18	2.35	1.17	-0.55	6.91	1.39	6.55
	Op. 3	32	4.5	2.12	0.37	3.74	5.26	0.19	8.53
AX2	Op. 1	6	-1.63	1.15	0.47	-2.84	-0.42	-2.75	0.23
	Op. 2	4	-1.36	1.15	0.58	-3.19	0.47	-2.48	0.25
	Op. 3	32	-0.7	1.37	0.24	-1.19	-0.21	-4.01	1.87
ANSX2	Op. 1	6	-1.73	1.34	0.55	-3.18	-0.32	-3.29	0.44
	Op. 2	4	-1.15	1.44	0.72	-3.43	1.13	-2.41	0.9
	Op. 3	32	-0.93	1.53	0.27	-1.48	-0.37	-4.45	2.33
PNSX2	Op. 1	6	-1.72	1.14	0.47	-2.93	-0.52	-2.7	0.24
	Op. 2	4	-1.04	0.78	0.39	-2.27	0.2	-1.87	-0.03
	Op. 3	32	-0.88	1.68	0.3	-1.48	-0.27	-4	3.22

Table 9.66 and 9.67 show that there was no statistical difference in the magnitude of pre and post surgical movement for advancements by operation type.

Table 9.67. Movement in the anterior direction and postsurgical movement by operation - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	3.085	2	1.543	0.292	0.749
	Within gp	206.382	39	5.292		
	Total	209.467	41			
ANSX1	Between gp	11.418	2	5.709	1.154	0.326
	Within gp	193.924	39	4.947		
	Total	204.341	41			
PNSX1	Between gp	9.886	2	4.943	0.884	0.421
	Within gp	218.112	39	5.593		
	Total	227.998	41			
AX2	Between gp	5.325	2	2.662	1.506	0.234
	Within gp	68.953	39	1.768		
	Total	74.278	41			
ANSX2	Between gp	3.286	2	1.643	0.728	0.489
	Within gp	88.045	39	2.258		
	Total	91.331	41			
PNSX2	Between gp	3.615	2	1.808	0.737	0.485
	Within gp	95.664	39	2.453		
	Total	99.279	41			

Table 9.68. Movement in the anterior direction and postsurgical movement by segmentalisation (Seg.) versus one piece maxilla (Nonseg.).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	Seg	14	4.25	2.54	0.68	2.79	5.72	0.65	8.96
	Nonseg	28	3.74	2.14	0.4	2.91	4.57	0.64	7.79
ANSX1	Seg	14	4.54	2.33	0.62	3.2	5.89	1.67	9.75
	Nonseg	28	4.01	2.2	0.42	3.15	4.86	0.35	7.96
PNSX1	Seg	14	4.62	2.5	0.66	3.19	6.05	1.39	10.23
	Nonseg	28	4.04	2.32	0.44	3.14	4.94	0.19	8.53
AX2	Seg	14	-0.78	1.26	0.34	-1.51	-0.01	-2.75	1.67
	Nonseg	28	-0.96	1.4	0.7	-1.5	-0.41	-4.01	1.87
ANSX2	Seg	14	-0.89	1.5	0.4	-1.76	-0.01	-3.29	1.46
	Nonseg	28	-1.15	1.51	0.28	-1.73	-0.56	-4.45	2.33
PNSX2	Seg	14	-1.09	1.07	0.29	-1.71	-0.47	-3.19	0.85
	Nonseg	28	-0.98	1.77	0.33	-1.66	-0.29	- 4	3.22

Table 9.68 and 9.69 show that there was no statistical difference in the magnitude of pre and post surgical movement for advancements whether the maxillae were segmentalised or one piece.

Table 9.69. Magnitude of shift in the anterior direction and postsurgical movement when segmentalised or one piece - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	2.445	1	2.445	0.472	0.496
	Within gp	207.023	40	5.176		
	Total	209.467	41			
ANSX1	Between gp	2.696	1	2.696	0.535	0.469
	Within gp	201.645	40	5.041		
	Total	204.341	41			
PNSX1	Between gp	3.124	1	3.124	0.556	0.46
	Within gp	224.874	40	5.622		
	Total	227.998	41			
AX2	Between gp	0.288	1	0.288	0.156	0.695
	Within gp	73.99	40	1.85		
	Total	74.278	41			
ANSX2	Between gp	0.619	1	0.619	0.273	0.604
	Within gp	90.712	40	2.268		
	Total	91.331	41			
PNSX2	Between gp	0.111	1	0.111	0.045	0.834
	Within gp	99.168	40	2.479		
	Total	99.279	41			

Table 9.70. Movement in the anterior direction and postsurgical movement by wire or rigid fixation (R.F.).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	Wire	2	2.05	1.22	0.87	-8.95	13.04	1.18	2.91
	RF	40	4	2.27	0.36	3.28	4.73	0.64	8.96
ANSX1	Wire	2	2.06	0.23	0.17	-0.004	4.15	1.89	2.22
	RF	40	4.29	2.23	0.35	3.58	5.01	0.35	9.75
PNSX1	Wire	2	2.26	0.13	0.001	1.05	3.46	2.16	2.35
	RF	40	4.33	2.37	0.38	3.57	5.09	0.19	10.23
AX2	Wire	2	-1.86	0.59	0.42	-7.13	3.42	-2.27	-1.44
	RF	40	-0.85	1.36	0.22	-1.28	-0.41	-4.01	1.87
ANSX2	Wire	2	-0.96	1.39	0.98	-13.41	11.49	-1.94	0.02
	RF	40	-1.07	1.51	0.24	-1.55	-0.58	-4.45	2.33
PNSX2	Wire	2	-0.81	2.11	1.5	-19.81	18.18	-2.31	0.68
	RF	40	-1.03	1.56	0.25	-1.52	-0.53	-4	3.22

Table 9.70 and 9.71 show that there was no statistical difference in the magnitude of pre and post surgical movement for advancements between wire or rigid fixation.

Table 9.71. Movement in the anterior direction and postsurgical movement fixated with wire or rigid fixation - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	7.312	1	7.312	1.447	0.236
	Within gp	202.156	40	5.045		
	Total	209.467	41			
ANSX1	Between gp	9.53	1	9.53	1.957	0.17
	Within gp	194.812	40	4.87		
	Total	204.341	41			
PNSX1	Between gp	8.215	1	8.215	1.495	0.229
	Within gp	219.783	40	5.495		
	Total	227.998	41			
AX2	Between gp	1.93	1	1.93	1.067	0.308
	Within gp	72.348	40	1.809		
	Total	74.278	41			
ANSX2	Between gp	0.002	1	0.002	0.01	0.923
	Within gp	91.309	40	2.283		
	Total	91.331	41			
PNSX2	Between gp	0.0084	1	0.0084	0.34	0.855
	Within gp	99.195	40	2.48		
	Total	99.279	41			

Table 9.72. Movement in the anterior direction and postsurgical movement by orthodontics or no orthodontics.

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	Ortho	38	4.05	2.23	0.36	3.32	4.78	0.64	8.96
	No Ort	4	2.6	2.44	1.22	-1.29	6.49	0.82	6.15
ANSX1	Ortho	38	4.29	2.28	0.37	3.53	5.04	0.35	9.75
	No Ort	4	3.23	1.55	0.78	0.76	5.7	1.8	5.22
PNSX1	Ortho	38	4.29	2.41	0.39	3.5	5.08	0.19	10.23
	No Ort	4	3.71	1.99	1	0.54	6.87	2.16	6.55
AX2	Ortho	38	-0.95	1.35	0.22	-1.39	-0.5	-4.01	1.87
	No Ort	4	-0.44	1.42	0.71	-2.69	1.82	-1.61	1.45
ANSX2	Ortho	38	-1.123	1.51	0.25	-1.61	-0.62	-4.45	2.33
	No Ort	4	-0.54	1.33	0.66	-2.64	1.58	-1.94	0.92
PNSX2	Ortho	38	-1.03	1.6	0.26	-1.55	-0.5	-4	3.22
	No Ort	4	-0.92	1.15	0.57	-2.75	0.9	-2.31	0.5

Table 9.72 and 9.73 show that there was no statistical difference in the magnitude of pre and post surgical movement for advancements whether or not orthodontic treatment was undertaken.

Table 9.73. Movement in the anterior direction and postsurgical movement by orthodontics or no orthodontics. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	7.627	1	7.627	1.511	0.226
	Within gp	201.84	40	5.046		
	Total	209.467	41			
ANSX1	Between gp	4.055	1	4.055	0.81	0.374
	Within gp	200.286	40	5.007		
	Total	204.341	41			
PNSX1	Between gp	1.209	1	1.209	0.213	0.647
	Within gp	226.789	40	5.67		
	Total	227.998	41			
AX2	Between gp	0.931	1	0.931	0.508	0.48
	Within gp	73.347	40	1.834		
	Total	74.278	41			
ANSX2	Between gp	1.226	1	1.226	0.544	0.465
	Within gp	90.105	40	2.253		
	Total	91.331	41			
PNSX2	Between gp	0.0038	1	0.0038	0.015	0.902
	Within gp	99.241	40	2.481		
	Total	99.279	41			

Table 9.74. Movement in the anterior direction and postsurgical movement by the magnitude of movement.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	<2	5	2.32	2.42	1.08	-0.68	5.33	0.76	6.59
	2 -4	13	2.87	1.25	0.35	2.12	3.62	0.64	3.92
	4 -6	10	3.26	1.47	0.46	2.21	4.31	0.82	5.15
	>6	4	5.91	2.17	0.58	4.65	7.16	0.88	8.96
ANSX1	<2	5	2.47	2.52	1.13	-0.66	5.6	0.66	6.86
	2 -4	13	3.3	1.56	0.43	2.36	4.24	0.35	5.48
	4 -6	10	4.01	1.28	0.41	3.09	4.92	1.8	5.93
	>6	4	5.74	2.42	0.65	4.35	7.14	1.67	9.75
PNSX1	<2	5	2.19	2.4	1.07	-0.79	5.17	0.34	6.28
	2 -4	13	3.51	1.75	0.48	2.46	4.57	0.19	6.46
	4 -6	10	3.78	1.18	0.37	2.93	4.62	2.34	5.9
	>6	4	5.95	2.55	0.68	4.48	7.43	1.39	10.23
AX2	<2	5	-0.34	1.7	0.76	-2.45	1.77	-2.71	1.38
	2 -4	13	-0.83	0.94	0.26	-1.4	-0.26	-1.88	1.67
	4 -6	10	-0.8	1.78	0.56	-2.07	0.48	-4.01	1.45
	>6	4	-1.23	1.25	0.33	-1.96	-0.51	-3.16	1.87
ANSX2	<2	5	-1.02	1.79	0.8	-3.24	1.2	-3.01	1.26
	2 -4	13	-0.77	1.14	0.32	-1.46	-8e-3	-2.94	1.46
	4 -6	10	-1.35	2.18	0.69	-2.91	0.21	-4.45	2.33
	>6	4	-1.14	1.19	0.32	-1.83	-0.45	-3.44	0.63
PNSX2	<2	5	-0.77	1.76	0.79	-2.96	1.42	-2.31	1.77
	2 -4	13	-0.91	1.1	0.31	-1.57	-0.24	-3.42	0.85
	4 -6	10	-1.31	2.11	0.67	-2.82	0.2	-3.69	3.22
	>6	4	-1	1.54	0.41	-1.89	-0.11	-4	2.75

Table 9.74 and 9.75 show that there was no statistical difference in the magnitude of post surgical movement for advancements regardless of the magnitude of the original surgical movement.

Table 9.75. Movement in the anterior direction and postsurgical movement by the magnitude of that movement. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	86.693	3	28.898	8.944	0
	Within gp	122.774	38	3.231		
	Total	209.467	41			
ANSX1	Between gp	59.149	3	19.716	5.16	0.004
	Within gp	145.192	38	3.821		
	Total	204.341	41			
PNSX1	Between gp	71.053	3	23.684	5.735	0.002
	Within gp	156.945	38	4.13		
	Total	227.998	41			
AX2	Between gp	3.303	3	1.101	0.589	0.626
	Within gp	70.975	38	1.868		
	Total	74.278	41			
ANSX2	Between gp	2.012	3	0.671	0.285	0.836
	Within gp	89.319	38	2.35		
	Total	91.331	41			
PNSX2	Between gp	1.316	3	0.439	0.17	0.916
	Within gp	97.963	38	2.578		
	Total	99.279	41			

Table 9.76. Movement in the anterior direction and postsurgical movement by bone graft or no bone graft.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	no bone	26	4.05	2.02	0.4	3.24	4.87	0.76	7.2
	bone	16	3.68	2.66	0.67	2.26	5.1	0.64	8.96
ANSX1	no bone	26	4.19	1.92	0.38	3.41	4.96	0.66	7.27
	bone	16	4.18	2.74	0.68	2.72	5.64	0.35	9.75
PNSX1	no bone	26	4.15	2.07	0.41	3.32	4.98	0.34	7.18
	bone	16	4.37	2.84	0.71	2.86	5.88	0.19	10.23
AX2	no bone	26	-0.71	1.3	0.25	-1.23	-0.19	-3.16	1.67
	bone	16	-1.2	1.41	0.35	-1.96	-0.45	-4.01	1.87
ANSX2	no bone	26	-0.8	1.55	0.3	-1.43	-0.18	-3.44	2.33
	bone	16	-1.48	1.34	0.34	-2.2	-0.77	-4.45	0.6
PNSX2	no bone	26	-0.97	1.54	0.3	-1.59	-0.35	-4	3.22
	bone	16	-1.09	1.63	0.41	-1.96	-0.22	-3.69	2.75

Table 9.76 and 9.77 show that there was no statistical difference in the magnitude of pre and post surgical movement for advancements whether bone grafts were used or not.

Table 9.77. Movement in the anterior direction and postsurgical movement by bone graft or no bone graft. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	1.334	1	1.334	0.256	0.615
	Within gp	208.133	40	5.203		
	Total	209.467	41			
ANSX1	Between gp	0.0008	1	0.0008	0	0.99
	Within gp	204.34	40	5.109		
	Total	204.341	41			
PNSX1	Between gp	0.482	1	0.482	0.085	0.773
	Within gp	227.516	40	5.688		
	Total	227.998	41			
AX2	Between gp	2.353	1	2.353	1.308	0.259
	Within gp	71.925	40	1.798		
	Total	74.278	41			
ANSX2	Between gp	4.605	1	4.605	2.124	0.153
	Within gp	86.726	40	2.168		
	Total	91.331	41			
PNSX2	Between gp	0.133	1	0.133	0.054	0.818
	Within gp	99.146	40	2.479		
	Total	99.279	41			

9.3.4 Points UMC and LMC (In the vertical and Horizontal).

Points upper molar crown (UMC) and lower molar crown (LMC) are shown in the following tables by the three different directions of movement. Changes at surgery at post surgery are shown in both the vertical and horizontal.

Table 9.78. Mean movement of points LMC and UMC in the horizontal (X) and vertical (Y) planes for superior repositioning n = 45 (mm). Includes at surgery (1) and post surgery (2).

	Mean	Standard Deviation	Standard Error
UMCX1	2.88	3.34	0.5
UMCX2	-0.007	2.66	0.4
UMCY1	2.96	2.12	0.32
UMCY2	-0.88	1.57	0.23
LMCX1	5.37	5.68	0.85
LMCX2	-0.1	3.4	0.51
LMCY1	1.14	2.21	0.33
LMCY2	0.33	1.83	0.27

Table 9.78 and 9.79 show the magnitude of movement of the upper and lower first molars pre and post surgically in both the vertical and horizontal planes for the superior repositioned group.

Table 9.79 T -Test for points UMC and LMC for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean Difference	t	Sig (2-tailed)	1	2
UMCX1	2.88	5.787	0	1.87	3.88
UMCX2	-0.007	-0.184	0.855	-0.87	0.73
UMCY1	2.96	9.377	0	2.32	3.59
UMCY2	-0.88	-3.767	0	-1.35	-0.41
LMCX1	5.37	6.346	0	3.67	7.08
LMCX2	-0.1	-0.199	0.843	-1.12	0.92
LMCY1	1.14	3.462	0.001	0.48	1.8
LMCY2	0.33	1.202	0.236	-0.22	0.88

Table 9.80. Mean movement of points LMC and UMC in the horizontal (X) and vertical (Y) planes for inferior repositioning n = 13 (mm). Includes at surgery (1) and post surgery (2).

	Mean	Standard Deviation	Standard Error
UMCX1	1.59	3	0.83
UMCX2	-0.38	1.91	0.53
UMCY1	-1.25	2.67	0.74
UMCY2	0.54	1.7	0.47
LMCX1	2.74	5.22	1.45
LMCX2	0.41	2.85	0.79
LMCY1	-2.3	3.52	0.98
LMCY2	1.7	1.85	0.51

Table 9.80 and 9.81 show the magnitude of movement of the upper and lower first molars pre and post surgically in both the vertical and horizontal planes for the inferior repositioned group.

Table 9.81 T -Test for points UMC and LMC for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

	Mean Difference	t	Sig (2-tailed)	1	2
UMCX1	1.59	1.908	0.081	-0.225	3.4
UMCX2	-0.38	-0.723	0.484	-1.53	0.77
UMCY1	-1.25	-1.69	0.117	-2.87	0.36
UMCY2	0.54	1.156	0.27	-0.48	1.57
LMCX1	2.74	1.896	0.082	-0.41	5.89
LMCX2	0.41	0.523	0.61	-1.31	2.13
LMCY1	-2.3	-2.356	0.036	-4.4	-0.17
LMCY2	1.7	3.311	0.006	0.58	2.82

Table 9.82. Mean movement of points LMC and UMC in the horizontal (X) and vertical (Y) planes for anterior repositioning n = 42. Includes at surgery (1) and post surgery (2).

	Mean	Standard Deviation	Standard Error
UMCX1	3.63	2.9	0.45
UMCX2	0.55	1.64	0.25
UMCY1	-0.18	2.67	0.41
UMCY2	0.006	1.39	0.21
LMCX1	-0.81	5.69	0.88
LMCX2	1.35	2.16	0.33
LMCY1	-1.12	2.89	0.45
LMCY2	1.26	1.87	0.29

Table 9.82 and 9.83 show the magnitude of movement of the upper and lower first molars pre and post surgically in both the vertical and horizontal planes for the anterior repositioned group.

Table 9.83 T -Test for points UMC and LMC for advancement.

One - sample test (df =41).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

	Mean Difference	t	Sig (2-tailed)	1	2
UMCX1	3.63	8.139	0	2.73	4.54
UMCX2	0.55	2.158	0.037	0.004	1.06
UMCY1	-0.18	-0.442	0.661	-1.01	0.65
UMCY2	0.006	0.268	0.79	-0.37	0.49
LMCX1	-0.81	-0.926	0.36	-2.58	0.96
LMCX2	1.35	4.06	0	0.68	2.03
LMCY1	-1.12	-2.511	0.016	-2.02	-0.22
LMCY2	1.26	4.371	0	0.68	1.85

Table 9.84. Movement in each direction and postsurgical movement at points UMC, LMC in both the vertical (Y) and horizontal (X) - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
UMCX1	Between gp	43.585	2	21.792	2.245	0.111
	Within gp	941.429	97	9.705		
	Total	985.013	99			
UMCX2	Between gp	12.495	2	6.247	1.303	0.276
	Within gp	464.984	97	4.794		
	Total	477.479	99			
UMCY1	Between gp	296.334	2	148.167	24.961	0
	Within gp	575.787	97	5.936		
	Total	872.12	99			
UMCY2	Between gp	29.794	2	14.897	6.521	0.02
	Within gp	221.582	97	2.284		
	Total	251.376	99			
LMCX1	Between gp	833.213	2	416.606	13.149	0
	Within gp	3073.241	97	31.683		
	Total	3906.454	99			
LMCX2	Between gp	46.448	2	23.224	2.819	0.065
	Within gp	799.049	97	8.238		
	Total	845.497	99			
LMCY1	Between gp	173.271	2	86.635	11.899	0
	Within gp	706.261	97	7.281		
	Total	879.531	99			
LMCY2	Between gp	28.591	2	14.296	4.166	0.018
	Within gp	332.888	97	3.432		
	Total	361.479	99			

9.3.5.SNA and Frankfort horizontal (For each direction of movement).

Table 9.85. Mean angle SNA and mean Frankfort horizontal (NA - FH) for superior repositioning.

Includes at surgery (SNA1 or NAFH1), immediately post surgery (SNA2 or NAFH2), change between the two (SNA12 or NAFH12) , final angles (SNA3 or NAFH3) and the change in angle since surgery (SNA23 or NAFH23).

	Mean	Standard Deviation	Standard Error
SNA1	80.53	4.24	0.63
SNA 2	82.93	4.75	0.71
SNA 12	2.41	3.23	0.48
SNA 3	82.54	4.71	0.7
SNA 23	-0.39	2.47	0.37
NA-FH 1	82.51	5.04	0.75
NA-FH 2	85.05	4.94	0.74
NA-FH 12	2.54	3.58	0.53
NA-FH 3	84.3	4.38	0.65
NA-FH 23	-0.75	2.41	0.36

Table 9.85 and 9.86 show the pre and post surgical angles SNA and NA - FH and greater than twelve months post surgery for superior repositioning. There was no statistical significant relapse.

Table 9.86 T -Test for angles SNA and NA-FH for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
SNA1	80.53	127.428	0	79.27	81.8
SNA 2	82.93	117.109	0	81.51	84.36
SNA 12	2.41	4.999	0	1.44	3.37
SNA 3	82.54	147.648	0	82.53	83.95
SNA 23	-0.39	-1.1	0.288	-1.14	0.35
NA-FH 1	82.51	109.751	0	80.99	84.02
NA-FH 2	85.05	115.3	0	83.56	86.53
NA-FH 12	2.54	4.765	0	1.47	3.61
NA-FH 3	84.3	129.062	0	82.98	85.62
NA-FH 23	-0.75	-2.085	0.051	-1.47	-0.0025

Table 9.87. Mean angle SNA and mean Frankfort horizontal (NA - FH) for inferior repositioning.

Includes at surgery (SNA1 or NAFH1), immediately post surgery (SNA2 or NAFH2), change between the two (SNA12 or NAFH12) , final angles (SNA3 or NAFH3) and the change in angle since surgery (SNA23 or NAFH23).

	Mean	Standard Deviation	Standard Error
SNA1	78.04	4.35	1.21
SNA 2	80.61	4.18	1.16
SNA 12	2.2	2.73	0.76
SNA 3	80.12	3.38	0.94
SNA 23	-0.48	1.15	0.32
NA-FH 1	79.5	5.81	1.61
NA-FH 2	81.82	4.89	1.35
NA-FH 12	2.32	2.79	0.77
NA-FH 3	81	3.71	1.03
NA-FH 23	-0.82	2.06	0.57

Table 9.87 and 9.88 show the pre and post surgical angles SNA and NA - FH and greater than twelve months post surgery for inferior repositioning. There was no statistical significant relapse.

Table 9.88. T -Test for angles SNA and NA-FH for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
SNA1	78.04	65.037	0	75.78	81.03
SNA 2	80.61	69.483	0	78.07	83.13
SNA 12	2.2	2.905	0.13	0.55	3.85
SNA 3	80.12	85.379	0	78.08	82.17
SNA 23	-0.48	-1.518	0.155	-1.17	0.21
NA-FH 1	79.5	49.265	0	75.98	83.02
NA-FH 2	81.82	60.392	0	78.87	84.78
NA-FH 12	2.32	3.003	0.011	0.64	4.01
NA-FH 3	81	78.635	0	78.76	83.25
NA-FH 23	-0.82	-1.437	0.176	-2.06	0.42

Table 9.89. Mean angle SNA and mean Frankfort horizontal (NA - FH) for anterior repositioning.

Includes at surgery (SNA1 or NAFH1), immediately post surgery (SNA2 or NAFH2), change between the two (SNA12 or NAFH12) , final angles (SNA3 or NAFH3) and the change in angle since surgery (SNA23 or NAFH23).

	Mean	Standard Deviation	Standard Error
SNA1	81.11	4.65	0.72
SNA 2	85.41	5.47	0.84
SNA 12	4.3	3.13	0.48
SNA 3	84.25	5.42	0.84
SNA 23	-1.16	2.79	0.43
NA-FH 1	81.82	5.19	0.8
NA-FH 2	85.77	5.48	0.85
NA-FH 12	3.96	4.13	0.64
NA-FH 3	84.36	5.18	0.8
NA-FH 23	-1.42	2.95	0.46

Table 9.89 and 9.90 show the pre and post surgical angles SNA and NA - FH and greater than twelve months post surgery for anterior repositioning. There was statistical significant relapse long term for angle NA -FH (NA -FH 23).

Table 9.90 T -Test for angles SNA and NA-FH for anterior repositioning.

One - sample test (df =41).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
SNA1	81.11	113.167	0	79.66	82.56
SNA 2	85.41	101.249	0	83.7	87.11
SNA 12	4.3	8.894	0	3.32	5.27
SNA 3	84.25	100.699	0	82.56	85.94
SNA 23	-1.16	-2.691	0	-2.02	-0.29
NA-FH 1	81.82	102.268	0	80.21	83.44
NA-FH 2	85.77	101.512	0	84.07	87.49
NA-FH 12	3.96	6.215	0	2.67	5.24
NA-FH 3	84.36	105.465	0	82.75	85.98
NA-FH 23	-1.42	-3.111	0.003	-2.34	-0.5

9.3.6. Anterior facial height : Nasion to Menton (Na - Me) for each direction of movement.

Table 9.91.Anterior facial height (Na - Me) for superior repositioning (mm.) n = 45. Includes height at surgery (Na-Me 1), immediately post surgery (Na-Me 2), change between the two (Na-Me 12) , final height (Na-Me 3) and the change in height since surgery (Na-Me 23).

	Mean	Standard Deviation	Standard Error
Na-Me 1	126.42	8.06	1.2
Na-Me 2	121.88	6.81	1.01
Na-Me 12	-4.54	5.23	0.78
Na-Me 3	123.37	7	1.04
Na-Me 23	1.49	3.48	0.52

Table 9.91 and 9.92 show the pre and post surgical anterior facial height and and the change in height greater than twelve months post surgery for superior repositioning. There was statistically significant relapse long term post surgery (Na -Me 23).

Table 9.92 T -Test for anterior facial height for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Na-Me 1	126.42	105.186	0	124	128.84
Na-Me 2	121.88	120.085	0	119.83	123.92
Na-Me 12	-4.54	-5.822	0	-6.11	-2.97
Na-Me 3	123.37	118.294	0	121.26	125.47
Na-Me 23	1.49	2.862	0.006	0.44	2.53

Table 9.93. Anterior facial height (Na - Me) for inferior repositioning (mm.) n = 13. Includes height at surgery (Na-Me 1), immediately post surgery (Na-Me 2), change between the two (Na-Me 12) , final height (Na-Me 3) and the change in height since surgery (Na-Me 23).

	Mean	Standard Deviation	Standard Error
Na-Me 1	123.05	12.57	3.49
Na-Me 2	123.08	11.69	3.24
Na-Me 12	0.0034	5.6	1.55
Na-Me 3	123.64	11.17	3.1
Na-Me 23	0.56	2.12	0.59

Table 9.93 and 9.94 show the pre and post surgical anterior facial heights and the change in height greater than twelve months post surgery for inferior repositioning. There was no statistically significant relapse

Table 9.94 T -Test for anterior facial height for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Na-Me 1	123.05	35.293	0	115.45	130.65
Na-Me 2	123.08	37.971	0	116.02	130.15
Na-Me 12	0.0034	0.22	0.983	-3.35	3.417
Na-Me 3	123.64	39.914	0	116.89	130.39
Na-Me 23	0.56	0.95	0.361	-0.72	1.84

Table 9.95.Anterior facial height (Na - Me) for anterior repositioning (mm.) n = 42. Includes height at surgery (Na-Me 1), immediately post surgery (Na-Me 2), change between the two (Na-Me 12) , final height (Na-Me 3) and the change in height since surgery (Na-Me 23).

	Mean	Standard Deviation	Standard Error
Na-Me 1	122.76	11.16	1.72
Na-Me 2	121.57	8.45	1.3
Na-Me 12	-1.18	5.18	0.8
Na-Me 3	121.54	9.41	1.45
Na-Me 23	-0.003	2.93	0.45

Table 9.95 and 9.96 show the pre and post surgical anterior facial heights and the change in height greater than twelve months post surgery for anterior repositioning. There was no statistically significant relapse

Table 9.96 T -Test for anterior facial height for anterior repositioning.

One - sample test (df =41).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Na-Me 1	122.76	71.266	0	119.28	126.23
Na-Me 2	121.57	93.282	0	118.94	124.2
Na-Me 12	-1.18	-1.487	0.145	-2.81	0.43
Na-Me 3	121.54	83.667	0	118.61	124.47
Na-Me 23	-0.003	-0.07	0.945	-0.95	0.88

9.3.7. Posterior facial height (S - Go) for each direction of movement.

Table 9.97. Mean facial height (S - Go) for superior repositioning (mm.) n = 45. Includes height at surgery (S - Go 1), immediately post surgery (S - Go 2), change between the two (S - Go 12) , final height (S - Go 3) and the change in height since surgery (S - Go 23).

	Mean	Standard Deviation	Standard Error
S -Go 1	79.97	7.13	1.06
S - Go 2	79.76	7.73	1.15
S - Go12	-0.2	2.92	0.44
S - Go 3	78.09	7.21	1.08
S - Go 23	-1.67	2.83	0.42

Table 9.97 and 9.98 show the pre and post surgical posterior facial heights and the change in height greater than twelve months post surgery for superior repositioning. There was no statistically significant relapse.

Table 9.98. T -Test for posterior facial height for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
S -Go 1	79.97	75.157	0	77.82	82.11
S - Go 2	79.76	69.189	0	77.44	82.09
S - Go12	-0.2	-0.462	0.646	-1.08	0.68
S - Go 3	78.09	72.628	0	75.93	80.26
S - Go 23	-1.67	-3.965	0	-2.53	-0.82

Table 9.99. Posterior facial height (Na - Me) for inferior repositioning (mm.) n = 13. Includes height at surgery (S - Go 1), immediately post surgery (S - Go 2), change between the two (S - Go 12) , final height (S - Go 3) and the change in height since surgery (S - Go 23).

	Mean	Standard Deviation	Standard Error
S -Go 1	80.8	9	2.5
S - Go 2	81.42	7.87	2.18
S - Go12	0.62	4.51	1.25
S - Go 3	79.53	9.7	2.69
S - Go 23	-1.89	3.78	1.05

Table 9.99 and 9.100 show the pre and post surgical posterior facial heights and the change in height greater than twelve months post surgery for inferior repositioning. There was no statistically significant relapse

Table 9.100. T -Test for posterior facial height for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
S -Go 1	80.8	32.372	0	75.36	86.24
S - Go 2	81.42	37.282	0	76.66	86.18
S - Go12	0.62	0.498	0.627	-2.1	3.35
S - Go 3	79.53	29.56	0	73.67	85.39
S - Go 23	-1.89	-1.804	0.096	-4.18	0.39

Table 9.101. Posterior facial height (S - Go) for anterior repositioning (mm.) n = 42. Includes height at surgery (S - Go 1), immediately post surgery (S - Go 2), change between the two (S - Go 12) , final height (S - Go 3) and the change in height since surgery (S - Go 23).

	Mean	Standard Deviation	Standard Error
S -Go 1	82.58	5.65	0.87
S - Go 2	81.89	5.68	0.87
S - Go12	-0.69	3.43	0.53
S - Go 3	81.57	5.46	0.84
S - Go 23	-0.31	4.22	0.65

Table 9.101 and 9.102 show the pre and post surgical posterior facial heights and the change in height greater than twelve months post surgery for anterior repositioning. There was no statistically significant relapse

Table 9.102. T -Test for posterior facial height for anterior repositioning.

One - sample test (df =41).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
S -Go 1	82.58	94.751	0	80.82	84.34
S - Go 2	81.89	93.514	0	80.12	83.65
S - Go12	-0.69	-1.305	0.199	-1.76	0.38
S - Go 3	81.57	96.884	0	79.87	83.27
S - Go 23	-0.31	-0.479	0.635	-1.63	1

9.4. Dentoskeletal changes

9.4.1. Maxillary incisal angle. (SNA - Max).

Table 9.103. Mean maxillary incisal angle (SN - Max) for superior repositioning n = 42. Includes angle at surgery (SN - Max 1), immediately post surgery (SN - Max 2), change between the two (SN - Max 12) , final angle (SN - Max 3) and the change in angle since surgery (SN - Max 23).

	Mean	Standard Deviation	Standard Error
SN -Max 1	110.67	9.2	1.37
SN - Max 2	109.45	8.13	1.21
SN - Max12	-1.22	7.48	1.11
SN - Max 3	108.76	8.32	1.24
SN - Max 23	-0.69	6.31	0.94

Table 9.103 and 9.104 show the pre and post surgical maxillary incisal angle and the change in angle greater than twelve months post surgery for superior repositioning. There was no statistically significant relapse

Table 9.104. T -Test for maxillary incisal angle for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
SN -Max 1	110.67	80.62	0	107.91	113.44
SN - Max 2	109.45	90.29	0	107.01	111.89
SN - Max12	-1.22	-1.097	0.279	-3.47	1.02
SN - Max 3	108.76	87.64	0	106.26	111.26
SN - Max 23	-0.69	-0.738	0.465	-2.59	1.21

Table 9.105. Mean maxillary incisal angle (SN - Max) for inferior repositioning n = 13. Includes angle at surgery (SN - Max 1), immediately post surgery (SN - Max 2), change between the two (SN - Max 12) , final angle (SN - Max 3) and the change in angle since surgery (SN - Max 23).

	Mean	Standard Deviation	Standard Error
SN -Max 1	110.31	7.45	2.07
SN - Max 2	106.15	8.75	2.43
SN - Max12	-4.15	6.56	1.82
SN - Max 3	107.25	8.62	2.39
SN - Max 23	1.09	6.22	1.73

Table 9.103 and 9.104 show the pre and post surgical maxillary incisal angle and the change in angle greater than twelve months post surgery for inferior repositioning. There was no statistically significant relapse.

Table 9.106. T -Test for maxillary incisal angle for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
SN -Max 1	110.31	53.412	0	105.81	114.81
SN - Max 2	106.15	43.75	0	100.87	111.44
SN - Max12	-4.15	-2.279	0.042	-8.12	-0.18
SN - Max 3	107.25	44.87	0	102.04	112.46
SN - Max 23	1.09	0.632	0.539	-2.67	4.85

Table 9.107. Mean maxillary incisal angle (SN - Max) for advancement n = 45. Includes angle at surgery (SN - Max 1), immediately post surgery (SN - Max 2), change between the two (SN - Max 12) , final angle (SN - Max 3) and the change in angle since surgery (SN - Max 23).

	Mean	Standard Deviation	Standard Error
SN -Max 1	112.12	8.79	1.36
SN - Max 2	110.55	8.8	1.36
SN - Max12	-1.57	5.78	0.89
SN - Max 3	113.11	9.66	1.49
SN - Max 23	2.56	6.64	1.02

Table 9.107 and 9.108 show the pre and post surgical maxillary incisal angle and the change in angle greater than twelve months post surgery for superior repositioning. There was statistically significant relapse long term (Sn Max 23).

Table 9.108. T -Test for maxillary incisal angle for advancement .

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
SN -Max 1	112.12	82.643	0	109.38	114.86
SN - Max 2	110.55	81.395	0	107.81	113.29
SN - Max12	-1.57	-1.763	0.085	-3.37	0.23
SN - Max 3	113.11	75.855	0	110.1	116.12
SN - Max 23	2.56	2.5	0.017	0.49	4.63

9.4.2.Interincisal angle.

Table 9.109. Mean interincisal angle for superior repositioning

n = 42. Includes angle at surgery (INCI 1), immediately post surgery (INCI 2), change between the two (INCI 12), final angle (INCI 3) and the change in angle since surgery (INCI 23).

	Mean	Standard Deviation	Standard Error
INCI 1	124.38	10.88	1.62
INCI 2	128.81	10.23	1.53
INCI 12	4.42	9.56	1.42
INCI 3	128.63	6.07	1.23
INCI 23	-0.18	8.21	1.22

Table 9.109 and 9.110 show the pre and post surgical interincisal angle and the change in angle greater than twelve months post surgery for superior repositioning. There was no statistically significant relapse.

Table 9.110. T -Test for interincisal angle for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
INCI 1	124.38	76.652	0	121.11	127.65
INCI 2	128.81	84.08	0	125.72	131.89
INCI 12	4.42	3.1	0.003	1.58	7.3
INCI 3	128.63	83.93	0	123.07	134.17
INCI 23	-0.18	-0.149	0.882	-2.65	2.28

Table 9.111. Mean interincisal angle for inferior repositioning n = 13. Includes angle at surgery (INCI 1), immediately post surgery (INCI 2), change between the two (INCI 12) , final angle (INCI 3) and the change in angle since surgery (INCI 23).

	Mean	Standard Deviation	Standard Error
INCI 1	132.48	10.66	2.95
INCI 2	135.71	9.37	2.6
INCI 12	3.23	9.26	2.57
INCI 3	137.04	8.54	2.34
INCI 23	1.34	7.83	2.17

Table 9.111 and 9.112 show the pre and post surgical interincisal angle and the change in angle greater than twelve months post surgery for inferior repositioning. There was no statistically significant relapse.

Table 9.112. T -Test for interincisal angle for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
INCI 1	132.48	44.77	0	126.03	138.93
INCI 2	135.71	52.19	0	130.04	141.37
INCI 12	3.23	1.26	0.233	-2.37	8.82
INCI 3	137.04	47.22	0	126.6	147.55
INCI 23	1.34	0.615	0.55	-3.4	6.07

Table 9.113. Mean interincisal angle for advancement n = 45.

Includes angle at surgery (INCI 1), immediately post surgery (INCI 2), change between the two (INCI 12) , final angle (INCI 3) and the change in angle since surgery (INCI 23).

	Mean	Standard Deviation	Standard Error
INCI 1	134.11	11.88	1.83
INCI 2	134.44	10.83	1.67
INCI 12	0.32	7.59	1.17
INCI 3	133.61	8.32	1.22
INCI 23	-0.83	10.01	1.54

Table 9.113 and 9.114 show the pre and post surgical interincisal angle and the change in angle greater than twelve months post surgery for anterior repositioning. There was no statistically significant relapse.

Table 9.114 T -Test for interincisal angle for advancement .

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
INCI 1	134.11	73.13	0	130.41	137.82
INCI 2	134.44	80.416	0	131.06	137.81
INCI 12	0.32	0.276	0.784	-2.04	2.69
INCI 3	133.61	75.22	0	128.55	140.11
INCI 23	-0.83	-0.538	0.594	-3.32	2.29

9.4.3. Overjet.

Table 9.115. Mean overjet (mm.) for superior repositioning

n = 42. Includes overjet before surgery (Jet 1), immediately post surgery (Jet 2), change between the two (Jet 12) , final overjet (Jet 3) and the change in overjet since surgery (Jet 23).

	Mean	Standard Deviation	Standard Error
Jet 1	6.19	4.77	0.71
Jet 2	3.54	1.78	0.27
Jet 12	-2.63	4.69	0.7
Jet 3	4.15	1.89	0.28
Jet 23	0.61	1.95	0.29

Table 9.115 and 9.116 show the pre and post surgical overjet and the change in overjet greater than twelve months post surgery for superior repositioning. There was statistically significant relapse in overjet long term.

Table 9.116. T -Test for overjet for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Jet 1	6.19	8.7	0	4.75	7.62
Jet 2	3.54	13.35	0	3.01	4.08
Jet 12	-2.63	-3.76	0	-4.05	-1.22
Jet 3	4.15	14.73	0	3.59	4.73
Jet 23	0.61	2.09	0.043	0.002	1.19

Table 9.117. Mean overjet for inferior repositioning

n = 13. Includes overjet before surgery (Jet 1), immediately post surgery (Jet 2), change between the two (Jet 12) , final overjet (Jet 3) and the change in overjet since surgery (Jet 23).

	Mean	Standard Deviation	Standard Error
Jet 1	5.94	5.31	1.47
Jet 2	3.33	2.23	0.62
Jet 12	-2.61	4.63	1.29
Jet 3	3.06	1.94	0.54
Jet 23	-0.27	1.73	0.48

Table 9.117 and 9.118 show the pre and post surgical overjet and the change in overjet greater than twelve months post surgery for inferior repositioning. There was no statistically significant relapse.

Table 9.118. T -Test for overjet for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Jet 1	5.94	4.03	0.02	2.73	9.15
Jet 2	3.33	5.38	0	1.98	4.68
Jet 12	-2.61	-2.03	0.065	-5.41	0.19
Jet 3	3.06	5.69	0	1.89	4.23
Jet 23	-0.27	-0.56	0.584	-1.31	0.77

Table 9.119. Mean overjet for advancement n = 45.

Includes overjet before surgery (Jet 1), immediately post surgery (Jet 2), change between the two (Jet 12) , final overjet (Jet 3) and the change in overjet since surgery (Jet 23).

	Mean	Standard Deviation	Standard Error
Jet 1	-1.35	6.3	0.97
Jet 2	3.56	1.93	0.3
Jet 12	4.91	6.46	1
Jet 3	3.32	1.15	0.18
Jet 23	-0.24	2.09	0.32

Table 9.119 and 9.120 show the pre and post surgical overjet and the change in overjet greater than twelve months post surgery for anterior repositioning. There was no statistically significant relapse.

Table 9.120. T -Test for overjet for advancement .

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Jet 1	-1.35	-1.39	0.172	-3.31	0.61
Jet 2	3.56	11.969	0	2.96	4.16
Jet 12	4.91	4.922	0	2.9	6.93
Jet 3	3.32	18.754	0	2.96	3.67
Jet 23	-0.24	-0.755	0.455	-0.9	0.41

9.4.4. Overbite.

Table 9.121. Mean overbite (mm.) for superior repositioning n = 42.

Includes overbite before surgery (Bite 1), immediately post surgery (Bite 2), change between the two (Bite 12) , final overbite (Bite 3) and the change in overbite since surgery (Bite 23).

	Mean	Standard Deviation	Standard Error
Bite 1	1.87	3.27	0.49
Bite 2	1.94	1.51	0.22
Bite12	-0.18	2.9	0.43
Bite 3	2.1	1.63	0.24
Bite 23	0.16	1.64	0.24

Table 9.121 and 9.122 show the pre and post surgical overbite and the change in overbite greater than twelve months post surgery for superior repositioning. There was no statistically significant relapse.

Table 9.122 T -Test for overbite for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Bite 1	1.87	3.842	0	0.89	2.85
Bite 2	1.94	8.638	0	1.49	2.39
Bite12	-0.18	-0.41	0.684	-1.05	0.69
Bite 3	2.1	8.645	0	1.61	2.59
Bite 23	0.16	0.65	0.519	-0.33	0.65

Table 9.123. Mean overbite (mm.) for inferior repositioning n = 13. Includes overbite before surgery (Bite 1), immediately post surgery (Bite 2), change between the two (Bite 12) , final overbite (Bite 3) and the change in overbite since surgery (Bite 23).

	Mean	Standard Deviation	Standard Error
Bite 1	0.83	3.17	0.88
Bite 2	1.78	1.49	0.41
Bite12	0.95	3.05	0.84
Bite 3	2.83	1.81	0.5
Bite 23	1.05	1.5	0.42

Table 9.123 and 9.124 show the pre and post surgical overbite and the change in overbite greater than twelve months post surgery for inferior repositioning. There was statistically significant relapse long term (Bite 23).

Table 9.124. T -Test for overbite for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Bite 1	0.83	0.948	0.362	-1.08	2.75
Bite 2	1.78	4.293	0.001	0.87	2.68
Bite12	0.95	1.116	0.286	-0.9	2.79
Bite 3	2.83	5.642	0	1.74	3.92
Bite 23	1.05	2.513	0.027	0.14	1.96

Table 9.125. Mean overbite (mm.) for advancement n = 45.

Includes overbite before surgery (Bite 1), immediately post surgery (Bite 2), change between the two (Bite 12) , final overbite (Bite 3) and the change in overbite since surgery (Bite 23).

	Mean	Standard Deviation	Standard Error
Bite 1	1.1	3.44	0.53
Bite 2	1.24	1.19	0.18
Bite12	0.14	3.64	0.56
Bite 3	1.96	1.7	0.26
Bite 23	0.73	1.96	0.3

Table 9.125 and 9.126 show the pre and post surgical overbite and the change in overbite greater than twelve months post surgery for anterior repositioning. There was statistically significant relapse long term (Bite 23).

Table 9.126. T -Test for overbite for advancement .

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Bite 1	1.1	2.074	0.044	0.003	2.17
Bite 2	1.24	6.698	0	0.86	1.61
Bite12	0.14	0.241	0.811	- 1	1.27
Bite 3	1.96	7.488	0	1.43	2.49
Bite 23	0.73	2.41	0.021	0.18	1.34

9.5. Influence of mandibular surgery.

9.5.1. Angle SNB

Table 9.127. Mean SNB angle for superior repositioning n = 42.

Includes angle at surgery (SNB 1), immediately post surgery (SNB 2), change between the two (SNB 12) , final angle (SNB 3) and the change in angle since surgery (SNB 23).

	Mean	Standard Deviation	Standard Error
SNB 1	79.04	5.03	0.75
SNB 2	82.73	4.43	0.66
SNB12	3.69	3.49	0.52
SNB 3	81.96	5.22	0.78
SNB 23	-0.77	2.91	0.43

Table 9.127 and 9.128 show the pre and post surgical SNB angle and the change in SNB greater than twelve months post surgery for superior repositioning. There was no statistically significant relapse.

Table 9.128 T -Test for SNB angle for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
SNB 1	79.04	105.512	0	77.53	80.55
SNB 2	82.73	125.393	0	81.4	84.06
SNB12	3.69	7.097	0	2.64	4.74
SNB 3	81.96	105.31	0	80.39	83.53
SNB 23	-0.77	-1.769	0.84	-1.64	0.11

Table 9.129. Mean SNB for inferior repositioning n = 13.

Includes angle at surgery (SNB 1), immediately post surgery (SNB 2), change between the two (SNB 12) , final angle (SNB 3) and the change in angle since surgery (SNB 23).

	Mean	Standard Deviation	Standard Error
SNB 1	78.42	4.45	1.23
SNB 2	80.53	4.24	1.18
SNB12	2.11	3.11	0.86
SNB 3	80.41	4.29	1.19
SNB 23	-0.13	1.32	0.37

Table 9.129 and 9.130 show the pre and post surgical SNB angle and the change in SNB greater than twelve months post surgery for inferior repositioning. There was no statistically significant relapse.

Table 9.130. T -Test for angle SNB for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
SNB 1	78.42	63.532	0	75.73	81.11
SNB 2	80.53	68.472	0	77.97	83.1
SNB12	2.11	2.45	0.031	0.23	3.99
SNB 3	80.41	67.619	0	77.82	83
SNB 23	-0.13	-0.351	0.732	-0.93	0.67

Table 9.131. Mean angle SNB for advancement n = 45.

Includes angle at surgery (SNB 1), immediately post surgery (SNB 2), change between the two (SNB 12) , final angle (SNB 3) and the change in angle since surgery (SNB 23).

	Mean	Standard Deviation	Standard Error
SNB 1	86.21	6.86	1.06
SNB 2	85.58	4.61	0.71
SNB12	-0.64	4.09	0.63
SNB 3	85.89	4.93	0.76
SNB 23	0.32	1.66	0.26

Table 9.131 and 9.132 show the pre and post surgical SNB angle and the change in SNB greater than twelve months post surgery for anterior repositioning. There was no statistically significant relapse.

Table 9.132 T -Test for angle SNB for advancement .

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
SNB 1	86.21	81.361	0	84.07	88.35
SNB 2	85.58	120.25	0	84.14	87.01
SNB12	-0.64	-1.007	0.32	-1.91	0.64
SNB 3	85.89	112.882	0	84.36	87.43
SNB 23	0.32	1.242	0.221	-0.2	0.84

9.5.2. Mandibular plane angle (SN - Go - Me).

Table 9.133. Mean mandibular plane angle (MPA) for superior repositioning n = 42. Includes angle at surgery (MPA 1), immediately post surgery (MPA 2), change between the two (MPA 12) , final angle (MPA 3) and the change in angle since surgery (MPA 23).

	Mean	Standard Deviation	Standard Error
MPA 1	33.2	8.18	1.22
MPA 2	29.89	7.08	1.06
MPA 12	-3.3	5.4	0.8
MPA 3	31.69	7.36	1.1
MPA 23	1.79	3.57	0.53

Table 9.133 and 9.134 show the pre and post surgical mandibular plane angles and the change in the angle greater than twelve months post surgery for superior repositioning. There was statistically significant relapse long term (MPA 23).

Table 9.134 T -Test for mandibular plane angle for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
MPA 1	33.2	27.223	0	30.74	35.66
MPA 2	29.89	28.337	0	27.77	32.02
MPA 12	-3.3	-4.107	0	-4.92	-1.68
MPA 3	31.69	28.87	0	29.45	33.9
MPA 23	1.79	3.374	0.002	0.72	2.87

Table 9.135. Mean mandibular plane angle for inferior repositioning n = 13. Includes angle at surgery (MPA 1), immediately post surgery (MPA 2), change between the two (MPA 12) , final angle (MPA 3) and the change in angle since surgery (MPA 23).

	Mean	Standard Deviation	Standard Error
MPA 1	32.7	11.62	3.22
MPA 2	32.54	9.29	2.58
MPA 12	-0.15	6.68	1.85
MPA 3	33.08	9.19	2.55
MPA 23	0.54	2.63	0.72

Table 9.135 and 9.136 show the pre and post surgical mandibular plane angles and the change in the angle greater than twelve months post surgery for inferior repositioning. There was no statistically significant relapse.

Table 9.136 T -Test for mandibular plane angle for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
MPA 1	32.7	10.147	0	25.67	39.72
MPA 2	32.54	12.635	0	26.92	38.15
MPA 12	-0.15	-0.083	0.935	-4.19	3.88
MPA 3	33.08	12.979	0	27.53	38.64
MPA 23	0.54	0.744	0.471	-1.05	2.13

Table 9.137. Mean mandibular plane angle for advancement n = 45. Includes angle at surgery (MPA 1), immediately post surgery (MPA 2), change between the two (MPA 12) , final angle (MPA 3) and the change in angle since surgery (MPA 23).

	Mean	Standard Deviation	Standard Error
MPA 1	27.56	7.13	1.1
MPA 2	27.64	4.72	0.73
MPA 12	0.008	4.73	0.73
MPA 3	27.67	6.14	0.95
MPA 23	0.0033	3.69	0.57

Table 9.137 and 9.138 show the pre and post surgical mandibular plane angles and the change in the angle greater than twelve months post surgery for anterior repositioning. There was no statistically significant relapse.

Table 9.138 T -Test for mandibular plane angle for advancement .

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
MPA 1	27.56	25.041	0	25.34	29.78
MPA 2	27.64	37.93	0	26.17	29.11
MPA 12	0.008	0.109	0.914	-1.4	1.56
MPA 3	27.67	29.186	0	25.76	29.59
MPA 23	0.0033	0.059	0.954	-1.12	1.19

9.6. Influence of occlusal plane.

(Occlusal plane to Frankfort horizontal).

Table 9.139. Mean occlusal plane angle for superior repositioning n = 42. Includes angle at surgery (Occ 1), immediately post surgery (Occ 2), change between the two (Occ 12) , final angle (Occ 3) and the change in angle since surgery (Occ 23).

	Mean	Standard Deviation	Standard Error
Occ 1	12.7	4.93	0.74
Occ 2	12.5	5.94	0.89
Occ 12	-0.23	5.96	0.89
Occ 3	13.36	6.07	0.9
Occ 23	0.89	2.82	0.42

Table 9.139 and 9.140 show the pre and post surgical occlusal plane angles and the change in the angle greater than twelve months post surgery for superior repositioning. There was statistically significant relapse long term (Occ 23).

Table 9.140 T -Test for occlusal plane angle for superior repositioning.

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Occ 1	12.7	17.625	0	11.22	14.18
Occ 2	12.5	14.075	0	10.68	14.26
Occ 12	-0.23	-0.257	0.798	-2.02	1.56
Occ 3	13.36	14.766	0	11.54	15.19
Occ 23	0.89	2.125	0.039	0.005	1.74

Table 9.141. Mean occlusal plane angle for inferior repositioning n = 13. Includes angle at surgery (Occ 1), immediately post surgery (Occ 2), change between the two (Occ 12) , final angle (Occ 3) and the change in angle since surgery (Occ 23).

	Mean	Standard Deviation	Standard Error
Occ 1	12.22	5.46	1.51
Occ 2	15.17	8.23	2.28
Occ 12	2.95	4.99	1.38
Occ 3	15.38	7.32	2.03
Occ 23	0.21	4.46	1.24

Table 9.141 and 9.142 show the pre and post surgical occlusal plane angles and the change in the angle greater than twelve months post surgery for inferior repositioning. There was no statistically significant relapse.

Table 9.142 T -Test for occlusal plane angle for inferior repositioning.

One - sample test (df =12).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Occ 1	12.22	8.07	0	8.92	15.52
Occ 2	15.17	6.644	0	10.2	20.15
Occ 12	2.95	2.134	0.054	-0.006	5.97
Occ 3	15.38	7.578	0	10.96	19.8
Occ 23	0.21	0.166	0.871	-2.49	2.9

Table 9.143. Mean occlusal plane angle for advancement n = 45. Includes angle at surgery (Occ 1), immediately post surgery (Occ 2), change between the two (Occ 12) , final angle (Occ 3) and the change in angle since surgery (Occ 23).

	Mean	Standard Deviation	Standard Error
Occ 1	12.84	4.51	0.7
Occ 2	13.85	5.08	0.78
Occ 12	1	2.96	0.46
Occ 3	13.81	5.27	0.81
Occ 23	-0.003	2.89	0.45

Table 9.143 and 9.144 show the pre and post surgical occlusal plane angles and the change in the angle greater than twelve months post surgery for anterior repositioning. There was no statistically significant relapse.

Table 9.144 T -Test for occlusal plane angle for advancement .

One - sample test (df =44).

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

	Mean difference	t	Sig (2-tailed)	1	2
Occ 1	12.84	18.438	0	11.44	14.25
Occ 2	13.85	17.667	0	12.26	15.43
Occ 12	1	2.194	0.034	0.008	1.92
Occ 3	13.81	16.999	0	12.17	15.45
Occ 23	-0.003	-0.077	0.939	-0.93	0.87

9.7. Other factors

9.7.1. Single jaw surgery (Maxilla only) vs Bimaxillary surgery.

Table 9.145. Single jaw surgery (Le fort only) versus two jaw surgery (Others) for superiorly repositioned maxillae before (1) and after surgery (2) utilising points A, ANS, PNS and MAX.

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Lefort	19	4.12	3.02	0.69	2.67	5.58	-1.41	8.85
	Others	26	2.74	3.32	0.65	1.4	4.08	-3.16	9.08
	Total	45	3.32	3.23	0.48	2.35	4.3	-3.16	9.08
ANSY1	Lefort	19	4.56	3.46	0.79	2.89	6.22	-2.23	10.2
	Others	26	2.73	3.71	0.73	1.29	4.23	-4.27	9.81
	Total	45	3.5	3.68	0.55	2.39	4.61	-4.27	10.2
PNSY1	Lefort	19	3.27	2.86	0.66	1.89	4.65	-0.98	11.9
	Others	26	2.31	2.87	0.56	1.15	3.47	-2.07	8.46
	Total	45	2.72	2.87	0.43	1.85	3.58	-2.07	11.9
MAXY1	Lefort	19	5.47	2.63	0.6	4.21	6.74	1.07	11.9
	Others	26	4.55	2.48	0.49	3.54	5.55	0.77	9.08
	Total	45	4.94	2.56	0.38	4.17	5.71	0.77	11.9
AY2	Lefort	19	-0.73	2.04	0.47	-1.71	0.26	-4.58	2.69
	Others	26	-0.87	2.04	0.4	-1.69	-0.005	-7.04	3.68
	Total	45	-0.81	2.02	0.3	-1.41	-0.2	-7.04	3.68
ANSY2	Lefort	19	-1.19	1.81	0.42	-2.06	-0.32	-5.74	2.32
	Others	26	-0.99	2.05	0.4	-1.81	-0.16	-4.48	4.5
	Total	45	-1.07	1.93	0.29	-1.66	-0.49	-5.74	4.5
PNSY2	Lefort	19	-0.56	2.5	0.57	-1.75	0.65	-7.89	4.73
	Others	26	-0.59	1.87	0.37	-1.34	0.16	-5.21	2.66
	Total	45	-0.58	2.13	0.32	-1.21	0.006	-7.879	4.73
MAXY2	Lefort	19	-0.79	2.67	0.61	-2.07	0.49	-7.89	4.73
	Others	26	-1.38	2.28	0.45	-2.3	-0.46	-7.04	2.66
	Total	45	-1.13	2.44	0.36	-1.86	-0.4	-7.89	4.73

Table 9.145 and 9.146 compare magnitude of shift at surgery and post surgery between single jaw procedures and two jaw procedures for superior repositioning. There was no statistically significant difference in relapse between the two groups.

Table 9.146. Single jaw surgery (Le fort only) versus two jaw surgery (Others) for superiorly repositioned maxillae before (1) and after surgery (2) utilising points A, ANS , PNS and MAX. - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	21.062	1	21.062	2.062	0.158
	Within gp	439.131	43	10.212		
	Total	460.193	44			
ANSY1	Between gp	36.677	1	36.677	2.813	0.101
	Within gp	560.627	43	13.038		
	Total	597.304	44			
PNSY1	Between gp	9.992	1	9.992	1.217	0.276
	Within gp	352.965	43	8.208		
	Total	362.957	44			
MAXY1	Between gp	9.412	1	9.412	1.454	0.235
	Within gp	278.388	43	6.474		
	Total	287.8	44			
AY2	Between gp	0.218	1	0.218	0.053	0.82
	Within gp	178.88	43	4.16		
	Total	179.098	44			
ANSY2	Between gp	0.452	1	0.4562	0.119	0.732
	Within gp	163.807	43	3.809		
	Total	164.259	44			
PNSY2	Between gp	0.002	1	0.0014	0.003	0.955
	Within gp	199.234	43	4.633		
	Total	199..249	44			
MAXY2	Between gp	3.828	1	3.828	0.637	0.429
	Within gp	258.476	43	6.011		
	Total	262.304	44			

Table 9.147. Single jaw surgery (Le fort only) versus two jaw surgery (Others) for inferiorly repositioned maxillae before (1) and after surgery (2) utilising points A, ANS and PNS.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	Lefort	5	-3.91	1.91	0.86	-6.28	-1.53	-6.62	-1.95
	Others	8	-3.31	2.11	0.75	-5.08	-1.54	-6.7	-1.25
	Total	13	-3.54	1.98	0.55	-4.74	-2.34	-6.7	-1.25
ANSY1	Lefort	5	-4.27	2.12	0.95	-6.9	-1.64	-7.74	-2.2
	Others	8	-4.04	2.74	0.97	-6.33	-1.74	-9.69	-1.49
	Total	13	-4.13	2.43	0.67	-5.6	-2.66	-9.69	-1.49
PNSY1	Lefort	5	-0.35	0.46	0.2	-0.92	0.21	-1.123	0.04
	Others	8	-0.94	1.72	0.61	-2.38	0.5	-3.86	0.92
	Total	13	-0.71	1.38	0.38	-1.54	0.12	-3.86	0.92
AY2	Lefort	5	0.66	1.43	0.64	-1.13	2.44	-0.55	2.63
	Others	8	1.87	3.34	1.18	-0.92	4.66	-1.95	8.48
	Total	13	1.4	2.75	0.76	-0.26	3.07	-1.95	8.48
ANSY2	Lefort	5	1.42	1.58	0.71	-0.54	3.39	-0.73	3.49
	Others	8	2	4.03	1.42	-1.37	5.37	-1.94	10.88
	Total	13	1.78	3.22	0.89	-0.17	3.72	-1.94	10.88
PNSY2	Lefort	5	0.54	1.8	0.81	-1.7	2.77	-2.23	2.41
	Others	8	0.3	1.14	0.4	-0.65	1.25	-1.23	1.84
	Total	13	0.39	1.36	0.38	-0.43	1.21	-2.23	2.41

Table 9.147 and 9.148 compare magnitude of shift at surgery and post surgery between single jaw procedures and two jaw procedures for inferior repositioning. There was no statistically significant difference in relapse between the two groups.

Table 9.148. Single jaw surgery (Le fort only) versus two jaw surgery (Others) for inferiorly repositioned maxillae before (1) and after surgery (2) utilising points A, ANS and PNS . - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	1.1	1	1.1	0.264	0.618
	Within gp	45.911	11	4.174		
	Total	47.011	12			
ANSY1	Between gp	0.174	1	0.174	0.027	0.872
	Within gp	70.676	11	6.425		
	Total	70.85	12			
PNSY1	Between gp	1.052	1	1.052	0.535	0.48
	Within gp	21.642	11	1.967		
	Total	22.694	12			
AY2	Between gp	4.544	1	4.544	0.58	0.462
	Within gp	86.168	11	7.833		
	Total	90.712	12			
ANSY2	Between gp	1.031	1	1.031	0.092	0.768
	Within gp	123.671	11	11.243		
	Total	124.701	12			
PNSY2	Between gp	0.173	1	0.173	0.086	0.774
	Within gp	22.041	11	2.004		
	Total	22.215	12			

Table 9.149. Single jaw surgery (Le fort only) versus two jaw surgery (Others) for anteriorly repositioned maxillae before (1) and after surgery (2) utilising points A, ANS and PNS.

1. 95 % Confidence Interval of the Difference - lower.
2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	Lefort	6	3.59	2.81	1.15	0.64	6.54	1.2	8.96
	Others	36	3.97	2.2	0.37	3.22	4.71	0.64	7.79
	Total	42	3.91	2.26	0.35	3.21	4.62	0.64	8.96
ANSX1	Lefort	6	3.61	3.17	1.3	0.28	6.95	1.29	9.75
	Others	36	4.28	2.08	0.35	3.58	4.98	0.35	7.96
	Total	42	4.19	2.23	0.35	3.49	4.88	0.35	9.75
PNSX1	Lefort	6	3.51	3.53	1.44	-0.2	7.21	0.59	10.23
	Others	36	4.35	2.15	0.36	3.63	5.08	0.19	8.53
	Total	42	4.23	2.36	0.36	3.5	4.97	0.19	10.23
AX2	Lefort	6	-1.63	1.15	0.47	-2.84	-0.42	-2.75	0.23
	Others	36	-0.77	1.35	0.23	-1.23	-0.32	-4.01	1.87
	Total	42	-0.9	1.35	0.21	-1.32	-0.48	-4.01	1.87
ANSX2	Lefort	6	-1.73	1.34	0.55	-3.14	-0.32	-3.29	0.44
	Others	36	-0.95	1.5	0.25	-1.5	-0.44	-4.45	2.33
	Total	42	-1.06	1.49	0.23	-1.53	-0.6	-4.45	2.33
PNSX2	Lefort	6	-1.73	1.14	0.47	-2.93	-0.52	-2.7	0.24
	Others	36	-0.9	1.6	0.27	-1.44	-0.36	- 4	3.22
	Total	42	-1.02	1.56	0.24	-1.5	-0.53	- 4	3.22

Table 9.149 and 9.150 compare magnitude of shift at surgery and post surgery between single jaw procedures and two jaw procedures for anterior repositioning. There was no statistically significant difference in relapse between the two groups.

Table 9.150. Single jaw surgery (Le fort only) versus two jaw surgery (Others) for anteriorly repositioned maxillae before (1) and after surgery (2) utilising points A, ANS and PNS . - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	0.736	1	0.736	0.141	0.709
	Within gp	208.731	40	5.218		
	Total	209.467	41			
ANSX1	Between gp	2.276	1	2.276	0.451	0.506
	Within gp	202.065	40	5.052		
	Total	204.341	41			
PNSX1	Between gp	3.708	1	3.708	0.661	0.421
	Within gp	224.289	40	5.607		
	Total	227.998	41			
AX2	Between gp	3.767	1	3.767	2.137	0.152
	Within gp	70.511	40	1.763		
	Total	74.278	41			
ANSX2	Between gp	3.111	1	3.111	1.411	0.242
	Within gp	88.22	40	2.205		
	Total	91.331	41			
PNSX2	Between gp	3.526	1	3.526	1.473	0.232
	Within gp	95.753	40	2.394		
	Total	99.279	41			

9.7.2. Early relapse vs late relapse.

Table 9.151. Comparison of patients followed up for less than average time (2.6 years) and those followed up longer . Examines patients before (1) and after surgery (2) utilising points A, ANS, PNS and MAX. Superior repositioning.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	<=2.6	31	3.39	3.08	0.55	2.26	4.52	-2.84	9.08
	>2.6	14	3.17	3.66	0.98	1.06	5.29	-3.16	8.85
	Total	45	3.32	3.23	0.48	2.35	4.3	-3.16	9.08
ANSY1	<=2.6	31	3.64	3.36	0.6	2.41	4.88	-4.27	10.16
	>2.6	14	3.18	4.44	1.19	0.61	5.74	-4.21	10.2
	Total	45	3.5	3.68	0.55	2.39	4.61	-4.27	10.2
PNSY1	<=2.6	31	2.98	3.05	0.55	1.87	4.1	-2.07	11.9
	>2.6	14	2.12	2.42	0.65	0.72	3.52	-1.49	8.13
	Total	45	2.72	2.87	0.43	1.85	3.58	-2.07	11.9
MAXY1	<=2.6	31	5.06	2.58	0.46	4.11	6.01	0.77	11.9
	>2.6	14	4.66	2.59	0.69	3.17	6.16	1.43	8.85
	Total	45	4.93	2.56	0.38	4.17	5.71	0.77	11.9
AY2	<=2.6	31	-0.89	2	0.36	-1.63	-0.16	-7.04	2.69
	>2.6	14	-0.62	2.11	0.56	-1.84	0.6	-4.58	3.68
	Total	45	-0.81	2.02	0.3	-1.42	-0.2	-7.04	3.68
ANSY2	<=2.6	31	-1.27	1.66	0.3	-1.88	-0.67	-4.58	2.32
	>2.6	14	-0.63	2.45	0.65	-2.05	0.78	-5.74	4.5
	Total	45	-1.07	1.93	0.89	-1.66	-0.49	-5.74	4.5
PNSY2	<=2.6	31	-0.7	2.31	0.42	-1.55	0.14	-7.89	4.73
	>2.6	14	-0.29	1.68	0.45	-1.26	0.68	-5.21	1.5
	Total	45	-0.58	2.19	0.32	-1.21	0.006	-7.89	4.73
MAXY2	<=2.6	31	-1	2.67	0.48	-1.98	-0.002	-7.89	4.73
	>2.6	14	-1.41	1.89	0.51	-2.51	-0.32	-5.21	0.51
	Total	45	-1.13	2.44	0.36	-1.86	-0.4	-7.89	4.73

Table 9.151 and 9.152 compare magnitude of shift at surgery and post surgery between patients followed for less than 2.6 years (early relapse) and those followed for longer than 2.6 years (late relapse) for superior repositioning. There was no statistically significant difference in relapse between the two groups.

Table 9.152. Comparison of patients followed up for less than average time (2.6 years) and those followed up longer. Superior repositioning - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	0.471	1	0.471	0.044	0.835
	Within gp	459.721	43	10.691		
	Total	460.193	44			
ANSY1	Between gp	2.112	1	2.112	0.153	0.698
	Within gp	595.192	43	13.842		
	Total	597.304	44			
PNSY1	Between gp	7.166	1	7.166	0.866	0.357
	Within gp	355.791	43	8.274		
	Total	362.957	44			
MAXY1	Between gp	1.545	1	1.545	0.232	0.632
	Within gp	286.256	43	6.657		
	Total	287.8	44			
AY2	Between gp	0.759	1	0.759	0.183	0.671
	Within gp	178.339	43	4.147		
	Total	179.098	44			
ANSY2	Between gp	3.997	1	3.997	1.072	0.306
	Within gp	160.262	43	3.727		
	Total	164.259	44			
PNSY2	Between gp	1.626	1	1.626	0.354	0.555
	Within gp	197.624	43	4.596		
	Total	199.249	44			
MAXY2	Between gp	1.61	1	1.61	0.266	0.609
	Within gp	260.694	43	6.063		
	Total	262.304	44			

Table 9.153. Comparison of patients followed up for less than average time (2.6 years) and those followed up longer . Examines patients before (1) and after surgery (2) utilising points A, ANS, and PNS . Inferior repositioning.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AY1	<=2.6	9	-3.64	2.01	0.67	-5.19	-2.1	-6.7	-1.59
	>2.6	4	-3.51	2.19	1.1	-6.79	0.18	-6.22	-1.25
	Total	13	-3.54	1.98	0.55	-4.74	-2.34	-6.7	-1.25
ANSY1	<=2.6	9	-3.81	2.03	0.68	-5.37	-2.25	-7.74	-1.49
	>2.6	4	-4.84	3.41	1.71	-10.27	0.59	-9.69	-2.37
	Total	13	-4.13	2.43	0.67	-5.59	-2.66	-9.69	-1.49
PNSY1	<=2.6	9	-1.1	1.44	0.48	-2.2	0.005	-3.86	0.04
	>2.6	4	0.15	0.79	0.4	-1.11	1.41	-0.74	0.92
	Total	13	-0.71	1.38	0.38	-1.54	0.12	-3.86	0.92
AY2	<=2.6	9	0.85	1.79	0.6	-0.53	2.22	-1.06	4.47
	>2.6	4	2.66	4.32	2.16	-4.22	9.53	-1.95	8.48
	Total	13	1.4	2.75	0.76	-0.26	3.07	-1.95	8.48
ANSY2	<=2.6	9	1.21	1.83	0.61	-0.19	2.62	-1.94	3.65
	>2.6	4	3.04	5.44	2.72	-5.61	11.69	-1.6	10.88
	Total	13	1.78	3.22	0.89	-0.17	3.72	-1.94	10.88
PNSY2	<=2.6	9	0.79	1.43	0.48	-0.3	1.89	-2.23	2.41
	>2.6	4	-0.52	0.61	0.3	-1.49	0.45	-1.23	0.05
	Total	13	0.39	1.36	0.38	-0.43	1.21	-2.23	2.41

Table 9.151 and 9.152 compare magnitude of shift at surgery and post surgery between patients followed for less than 2.6 years (early relapse) and those followed for longer than 2.6 years (late relapse) for inferior repositioning. There was no statistically significant difference in relapse between the two groups.

Table 9.154. Comparison of patients followed up for less than average time (2.6 years) and those followed up longer. Inferior repositioning - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AY1	Between gp	0.319	1	0.319	0.075	0.789
	Within gp	46.692	11	4.245		
	Total	47.011	12			
ANSY1	Between gp	2.932	1	2.932	0.475	0.505
	Within gp	67.918	11	6.174		
	Total	70.85	12			
PNSY1	Between gp	4.312	1	4.312	2.58	0.137
	Within gp	18.382	11	1.671		
	Total	22.694	12			
AY2	Between gp	9.044	1	9.044	1.218	0.293
	Within gp	81.667	11	7.424		
	Total	90.712	12			
ANSY2	Between gp	9.265	1	9.265	0.883	0.368
	Within gp	115.436	11	10.494		
	Total	124.701	12			
PNSY2	Between gp	4.785	1	4.785	3.02	0.11
	Within gp	17.43	11	1.585		
	Total	22.215	12			

Table 9.155. Comparison of patients followed up for less than average time (2.6 years) and those followed up longer . Examines patients before (1) and after surgery (2) utilising points A, ANS, and PNS .Anterior repositioning.

1. 95 % Confidence Interval of the Difference - lower.

2. 95 % Confidence Interval of the Difference - upper.

		N	Mean	Std dev.	Std Er	1	2	Min	Max
AX1	<=2.6	27	3.7	2.31	0.45	2.78	4.61	0.64	8.96
	>2.6	15	4.3	2.19	0.56	3.09	5.51	0.65	7.79
	Total	42	3.91	2.26	0.35	3.21	4.62	0.64	8.96
ANSX1	<=2.6	27	3.89	2.23	0.43	3	4.77	0.66	9.75
	>2.6	15	4.72	2.21	0.57	3.5	5.95	0.35	7.96
	Total	42	4.19	2.23	0.34	3.5	4.88	0.35	9.75
PNSX1	<=2.6	27	3.89	2.44	0.47	2.93	4.86	0.19	10.23
	>2.6	15	4.84	2.14	0.55	3.66	6.03	1.54	8.53
	Total	42	4.23	2.36	0.36	3.5	4.97	0.19	10.23
AX2	<=2.6	27	-1.1	1.42	0.27	-1.66	-0.54	-4.01	1.67
	>2.6	15	-0.53	1.15	0.3	-1.16	0.1	-2.27	1.87
	Total	42	-0.9	1.35	0.21	-1.31	-0.48	-4.01	1.87
ANSX2	<=2.6	27	-1.22	1.7	0.33	-1.89	-0.55	-4.45	2.33
	>2.6	15	-0.77	1.01	0.26	-1.33	-0.21	-2.94	0.92
	Total	42	-1.06	1.49	0.23	-1.53	-0.59	-4.45	2.33
PNSX2	<=2.6	27	-1.15	1.66	0.32	-1.81	-0.49	-4	3.22
	>2.6	15	-0.77	1.36	0.35	-1.53	-0.002	-3.42	2.75
	Total	42	-1.02	1.56	0.24	-1.5	-0.53	-4	3.22

Table 9.151 and 9.152 compare magnitude of shift at surgery and post surgery between patients followed for less than 2.6 years (early relapse) and those followed for longer than 2.6 years (late relapse) for anterior repositioning. There was no statistically significant difference in relapse between the two groups.

Table 9.156. Comparison of patients followed up for less than average time (2.6 years) and those followed up longer. Anterior repositioning - ANOVA.

		Sum Of Sq	df	Mean Sq	F	Sig
AX1	Between gp	3.508	1	3.508	0.681	0.414
	Within gp	205.96	40	5.149		
	Total	209.467	41			
ANSX1	Between gp	6.756	1	6.756	1.368	0.249
	Within gp	197.585	40	4.94		
	Total	204.341	41			
PNSX1	Between gp	8.753	1	8.753	1.597	0.214
	Within gp	219.245	40	5.481		
	Total	227.998	41			
AX2	Between gp	3.122	1	3.122	1.755	0.193
	Within gp	71.156	40	1.779		
	Total	74.278	41			
ANSX2	Between gp	1.949	1	1.949	0.872	0.356
	Within gp	89.382	40	2.235		
	Total	91.331	41			
PNSX2	Between gp	1.373	1	1.373	0.561	0.458
	Within gp	97.906	40	2.448		
	Total	99.279	41			

9.8 Complications following Surgery.

Table 9.157. Complication rates for the 100 patients undergoing Le Fort I osteotomies.

Complication	Incidence
Haemorrhage	1%
Parathesia	2%
Infection	5%
Plate removal	6%
T.M.J. Disorder	2%
Dental Complication	0%

9.8.1 Intraoperative haemorrhage.

Average blood loss in this series of patients was estimated as:

1. Le Fort I osteotomy : 350 (200 -550) mls .
2. Le Fort I and a mandibular procedures: 600 (250 -1200) mls.
3. Le Fort I/ mandible/ and iliac bone graft: 820 (600 - 1200) mls.

As would be expected the more complex the surgical procedure the greater the expected blood loss. The maxillary osteotomy, due to its greater vascularity had greater blood loss than isolated mandibular osteotomies. Based on these findings and the age and health of the patient undergoing surgery use of autologous pre donated blood is indicated only in the more complex cases.

Only one of the hundred patients had a brisk, general haemorrhage during a Le Fort I osteotomy. It was characterised by a generalised ooze from all surgically treated tissues rather than from specific vessels. The operation was expeditiously performed and completed in around one hour. Two units of the patients pre donated autologous blood were returned on closing. Bleeding studies were undertaken (INR, APTT, platelets) and no abnormalities seen.

The patient was transferred to the intensive care unit for close monitoring. The bleeding slowed dramatically on closing. An estimated 2,900 cc of blood was lost. His 24 hour post operative haemoglobin was 7.6 g/dL. (A substantial amount of haemodilution would still be expected.) The patient , apart from being tachycardic, maintained an adequate blood pressure without any other clinical signs.

A transfusion of homologous blood was discussed but refused by the patient. His post operative recovery was otherwise uneventful with a stay in hospital of only one day longer than the average.

He was subsequently investigated by the haematological unit of the Royal Adelaide Hospital. Only a slightly extended bleeding time was noted secondary to a probable platelet function disorder. No other abnormalities were found.

9.8.2 Immediate post operative complications.

Only one patient experienced immediate post operative bleeding. On day one post surgery bleeding commenced that could not be controlled with nasal packing. She was returned to theatre and the maxilla remobilised. The bleeding was identified from the descending palatine artery. This was ligated and she experienced no further problems.

One other patient sustained a fracture of the anterior superior iliac spine post an anterior iliac bone graft. On mobilising at day one he heard a 'crack' and experienced severe pain and parathesia of the lateral cutaneous nerve of the thigh. After an orthopaedic consult rest was arranged and no active management initiated. The gait disturbances and altered sensation dissipated over the next 6 weeks.

9.8.3 Delayed post operative complications.

9.8.3.1. Parathesia of the infraorbital nerve.

Two patients experienced infraorbital parathesia greater than 12 months post surgery . They had unilateral (both right sided) change in sensation (light touch, and two point discrimination, not pain) associated with the distribution of the infraorbital nerve. This was of no functional concern for them.

9.8.3.2. Infections.

Five patients from this series experienced post surgical infections. All developed them greater than 4 weeks post surgery. All appeared to be related to the bone plates used. One of these patients developed an infection in a cyst associated with a retained bone plate 12 months after her surgery. This required enucleation of the cyst and removal of the plate under general anaesthesia as an inpatient.

The other 4 patients had their infections treated with simple incision and drainage under local anaesthetic, followed by a course of oral antibiotics. Two subsequently went on to have their plates removed.

9.8.3.3 Plate Removal.

Six patients in all have had their bone plates removed including the three mentioned above secondary to infections. The other three elected to have theirs removed due to the ability to palpate them and the occasional dull ache associated with them.

9.8.3.4 TMJ disorders.

Two patients developed TMJ pain post surgery. Both had bimaxillary procedures. Both responded to non surgical measures (including exercises , NSAID's and bite splints).

Two other patients had TMJ disorders prior to surgery which continued post surgery. No case had TMJ disorders which resolved with orthognathic surgery.

9.8.3.5 Dental Complications.

No patients in this series had dental complications that could be related to the maxillary surgery. It was noted in two patients that the apices if the upper canines were damaged during the maxillary osteotomy but no long term post operative sequelae occurred . The teeth remained non responsive to vitality testing in both patients over twelve months post surgery, but so did their other anterior teeth. None of the teeth became discoloured.

Chapter 10 Results : Errors of the Method.

10.1 Errors of Method.

The magnitude of errors in the horizontal and vertical axes for ten sets of double determinations were calculated and summarised in Tables 10.1 and 10.2. The maximum mean difference measured in both the vertical and horizontal axes was 1.10 mm.The mean differences in the vertical dimension showed greater error when compared to the mean differences in the horizontal dimension. The errors for the mean differences varied from 0.09 to 0.75 in the horizontal axis and from 0.19 to 1.10 in the vertical. The standard errors of the mean differences varied from 0.08 to 0.28 in the horizontal axis and from 0.08 to 0.22 in the vertical axis.

The most variable point in identification in the horizontal plane was the point posterior nasal spine with a standard error of the mean being measured at 0.28 mm. Discrepancies in the location of this point ranged from - 0.55 to 2.44 mm. in horizontal. In the vertical direction , the most variable point was condylion with a standard error of the mean being measured at 0.22 mm. Discrepancies in the location of this point ranged from -2.26 to -0.33 mm. in the vertical plane. The most reliable point in the horizontal plane was the point sella with a standard error of 0.08 mm. In the vertical plane , the most reliable point was pogonion with a standard error of 0.12 mm.

The two tailed Student's *t*- test for paired values showed that the point gonion in the horizontal plane was significant at the 1% (T= 3.250) level for 9 degrees of freedom. In the vertical plane, a number of points also showed significance at the 1% level. These included pogonion, menton, anterior nasal spine, mandibular incisal root tip, pterygoid, orbitale, and articulare. This reflects the lower accuracy of identifying these points.

Scatter grams for each of the hard tissue points are illustrated showing errors in the horizontal and vertical axes.

Table 10.1 Error for 20 hard tissue points (Horizontal axis) by double determination.

Variable	M diff	E (M diff)	Min.	Max.	S (error)	Rank	% E
S x	0.09	0.08	-0.33	0.53	0.2	2	0.07
N x	0.12	0.12	-0.58	0.8	0.27	3	0.09
Po x	0.24	0.11	-0.27	0.88	0.35	8	0.18
Or x	0.35	0.17	-0.73	1.08	0.46	13	0.25
Ba x	0.42	0.18	-0.65	1.24	0.94	14	1.02
Co x	-0.21	0.27	-1.55	0.92	0.47	7	0.37
Ar x	0.19	0.13	-0.38	0.61	0.42	6	0.25
Gn x	0.75	0.17	-0.13	1.55	1.68	18	1.89
Go x	0.09	0.26	-1.8	0.85	0.2	2	0.08
Me x	0.25	0.2	-0.83	0.96	0.56	9	0.27
Pg x	0.45	0.16	-0.45	1.4	1.01	15	1.2
B x	0.28	0.18	-0.74	0.85	0.63	10	0.29
A x	0.24	0.13	-0.33	0.95	0.54	8	0.41
ANS x	-0.05	0.15	-1.17	0.6	0.11	1	0.04
PNS x	0.5	0.28	-0.55	2.44	1.12	16	1.32
MIT x	0.13	0.19	-0.66	0.83	0.29	4	0.14
UMC x	0.18	0.17	-0.72	0.92	0.4	5	0.22
MRT x	0.34	0.18	-0.55	1.01	0.76	12	0.34
MAIT x	0.24	0.17	-0.63	0.94	0.54	8	0.38
MART x	0.52	0.22	-0.48	1.67	1.16	17	1.02
LMC x	0.32	0.2	-0.84	1.34	0.72	11	0.32

Table 10.2 Error for 20 hard tissue points (Vertical axis) by double determination.

Variable	M diff	E (M diff)	Min.	Max.	S (error)	Rank	% E
S y	-0.19	0.16	-0.86	0.45	0.42	1	0.37
N y	-0.4	0.2	-1.27	0.87	0.89	3	0.46
Po y	-0.25	0.08	-0.58	0.34	0.56	2	0.4
Or y	-0.56	0.11	-1.09	-0.08	1.25	11	0.6
Ba y	-0.48	0.16	-1.83	-0.09	1.07	6	0.45
Co y	-1.1	0.22	-2.26	-0.33	2.46	21	1.85
Ar y	-0.65	0.16	-1.67	-0.08	1.45	15	1.02
Gn y	-0.66	0.19	-1.9	-0.01	1.48	16	1.05
Go y	-0.42	0.14	-1.17	-0.06	0.94	4	0.84
Me y	-0.82	0.2	-2.12	-0.16	1.83	20	1.55
Pg y	-0.78	0.17	-1.6	-0.13	1.74	19	1.44
B y	-0.62	0.16	-1.32	0.06	1.39	12	1.02
A y	-0.54	0.17	-1.33	-0.05	1.21	10	1.11
ANS y	-0.64	0.12	-1.17	0.6	1.43	14	1.2
PNS y	-0.47	0.13	-1.2	-0.01	1.05	5	0.84
MIT y	-0.5	0.13	-1.13	-0.02	1.12	8	0.87
UMC y	-0.63	0.17	-1.53	-0.06	1.41	13	0.88
MRT y	-0.75	0.21	-1.64	-0.04	1.68	17	1.55
MAIT y	-0.77	0.18	-2.1	-0.08	1.72	18	1.42
MART y	-0.51	0.18	-1.63	0.58	1.14	9	0.87
LMC y	-0.49	0.14	-1.24	-0.01	1.09	7	0.78

Figure 10.1 Differences between digitised double determinations for sella (S).

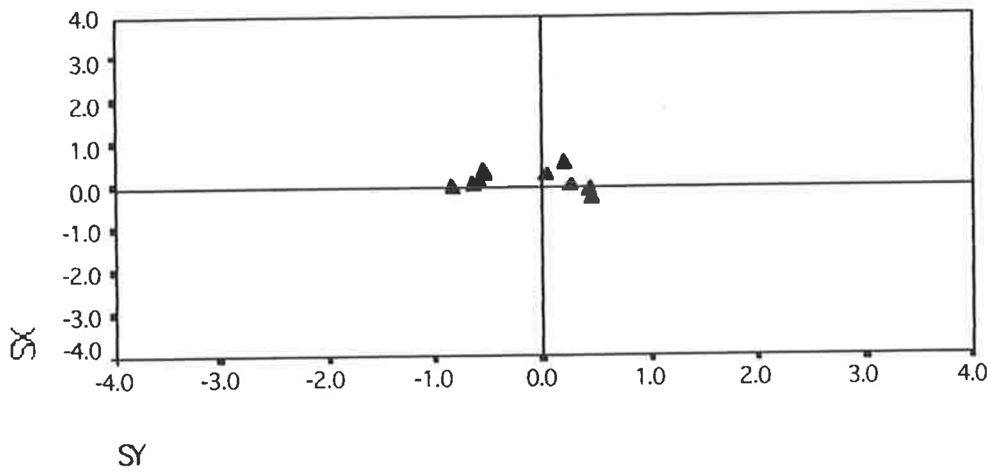


Figure 10.2 Differences between digitised double determinations for nasion (Na).

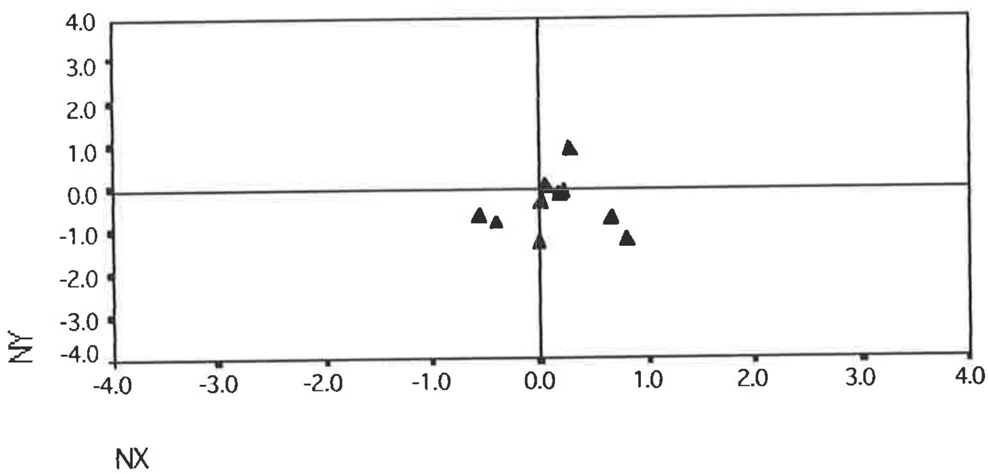


Figure 10.3 Differences between digitised double determinations for orbitale (Or).

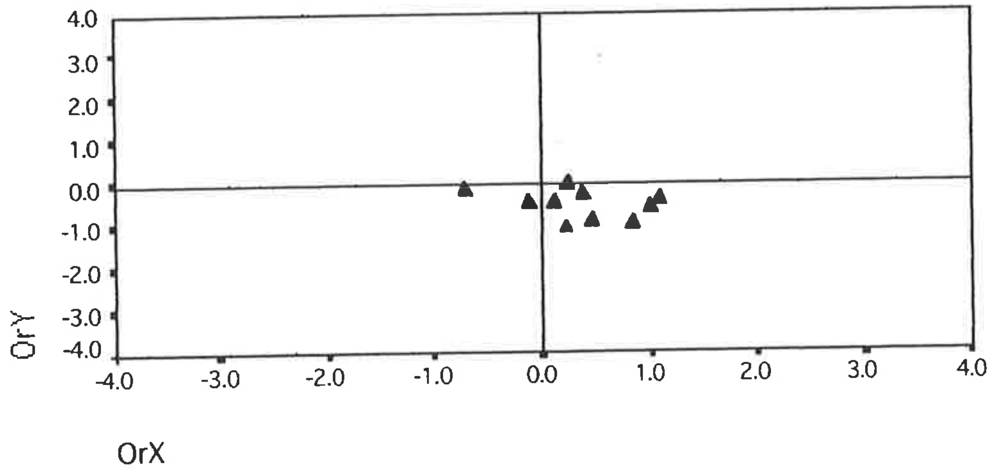


Figure 10.4 Differences between digitised double determinations for porion (Po).

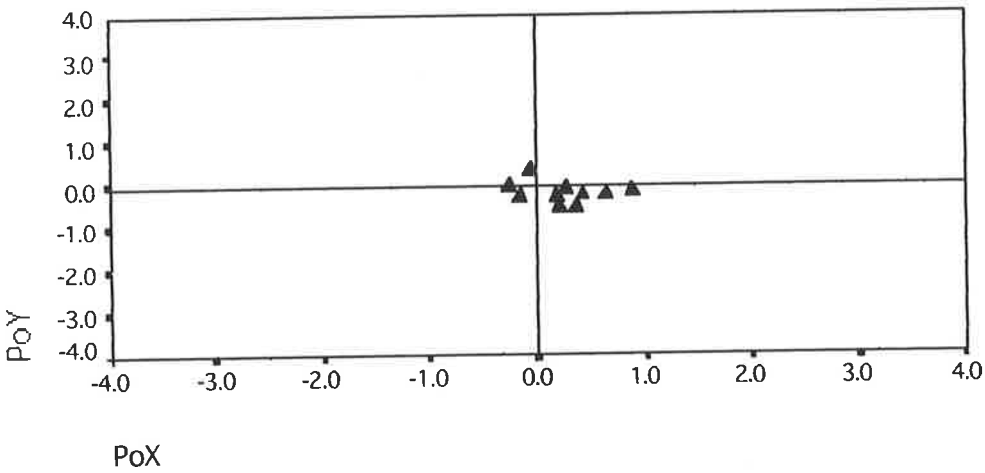


Figure 10.5 Differences between digitised double determinations for A point (A).

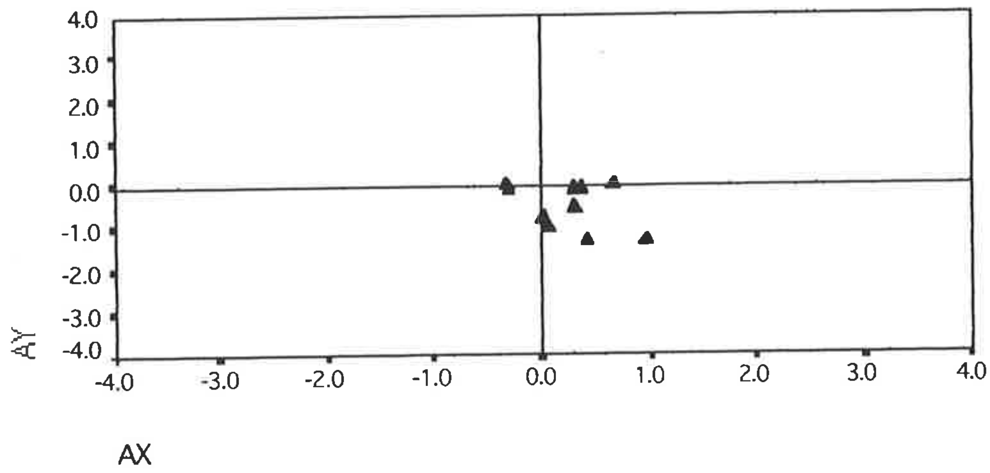


Figure 10.6 Differences between digitised double determinations for B point (B).

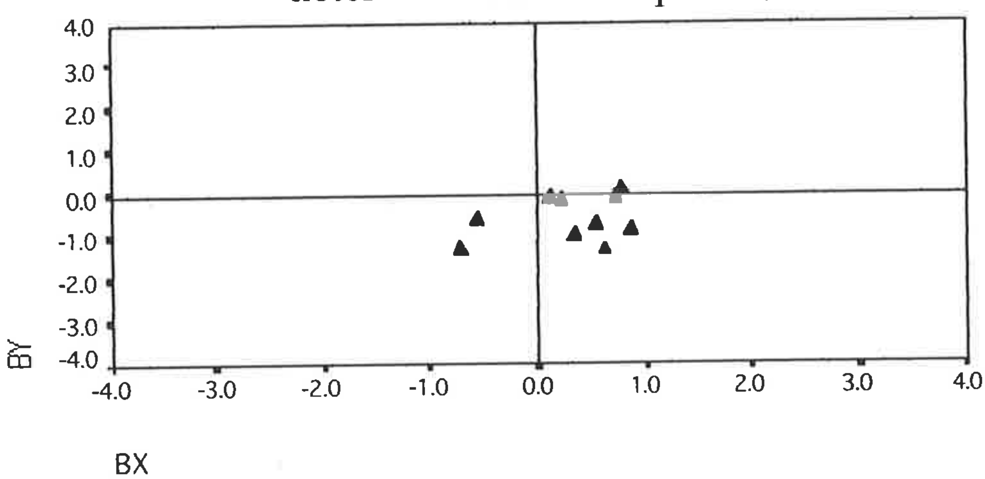


Figure 10.7 Differences between digitised double determinations for anterior nasal spine (ANS).

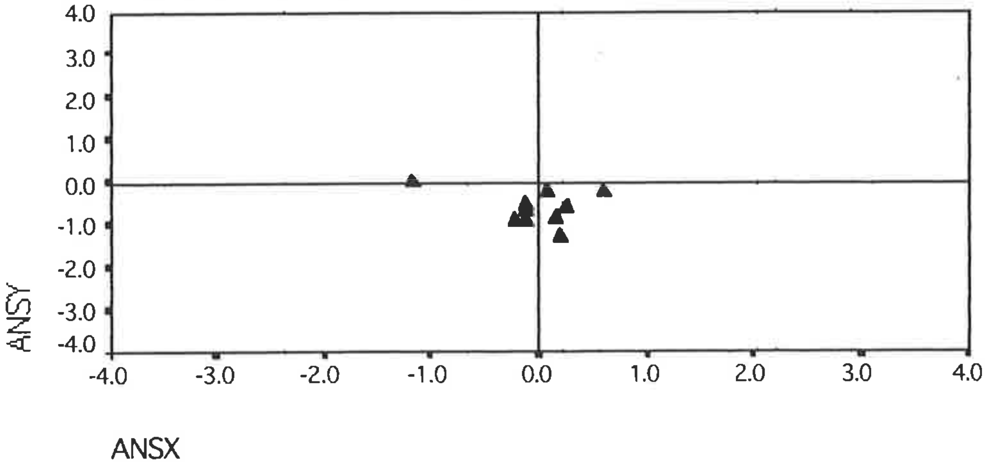


Figure 10.8 Differences between digitised double determinations for posterior nasal spine (PNS).

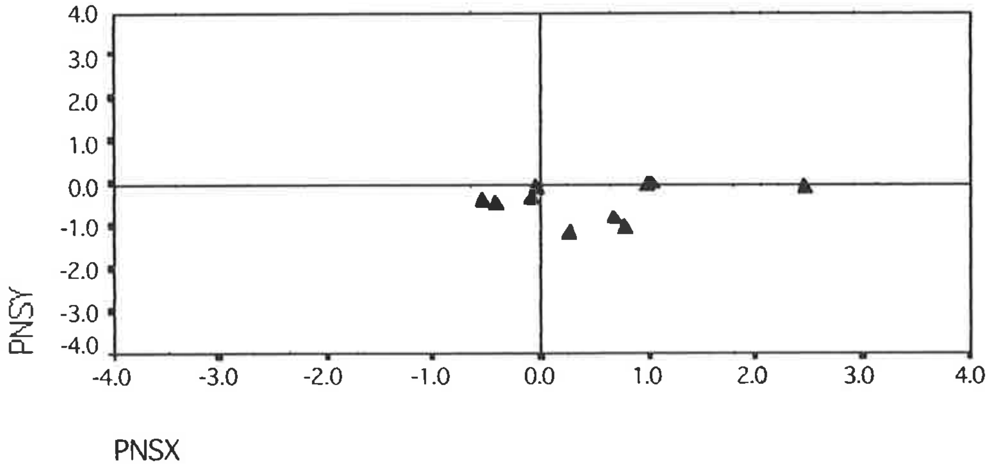


Figure 10.9 Differences between digitised double determinations for max. incisal tip (MIT).

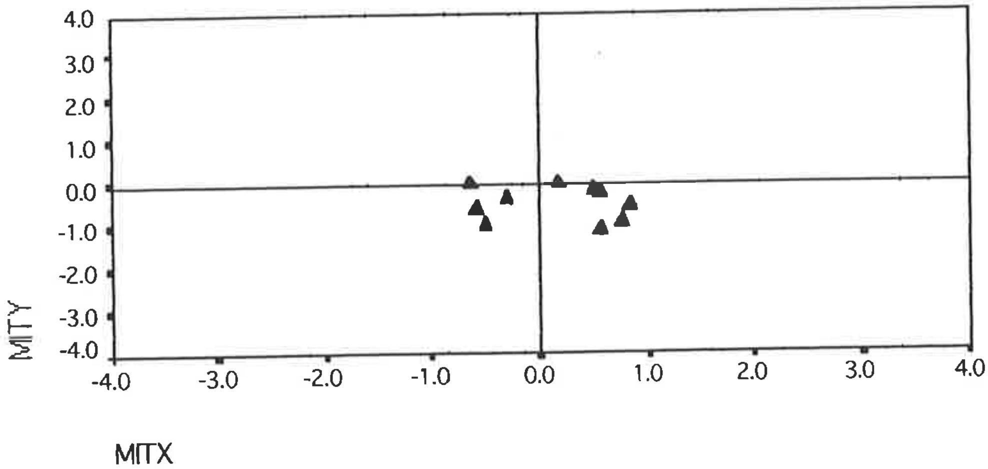


Figure 10.10 Differences between digitised double determinations for max. root tip (MRT).

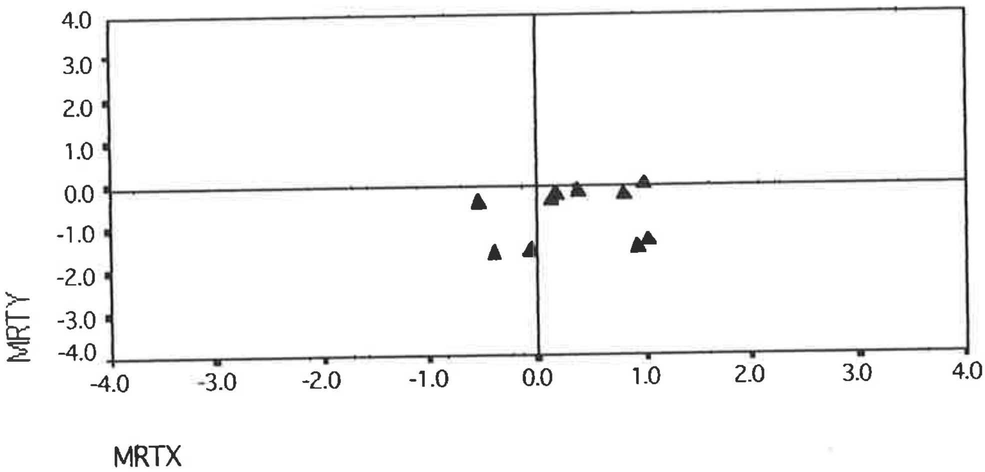


Figure 10.11 Differences between digitised double determinations for upper molar crown (UMC).

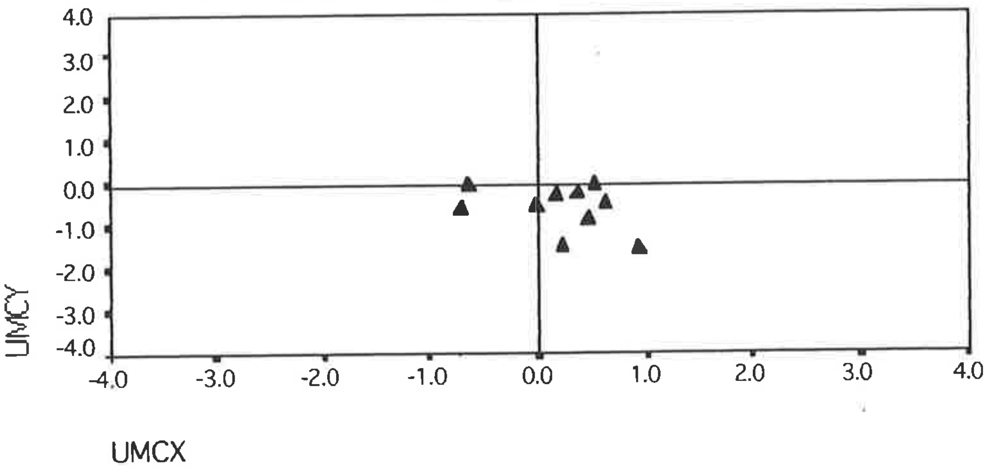


Figure 10.12 Differences between digitised double determinations for mand. incisal tooth (MAIT).

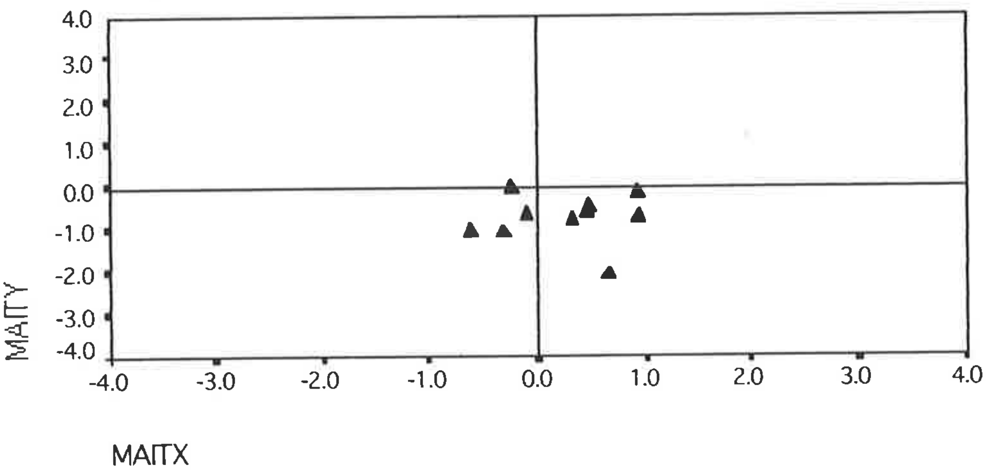


Figure 10.13 Differences between digitised double determinations for mand. incisor root tip (MART).

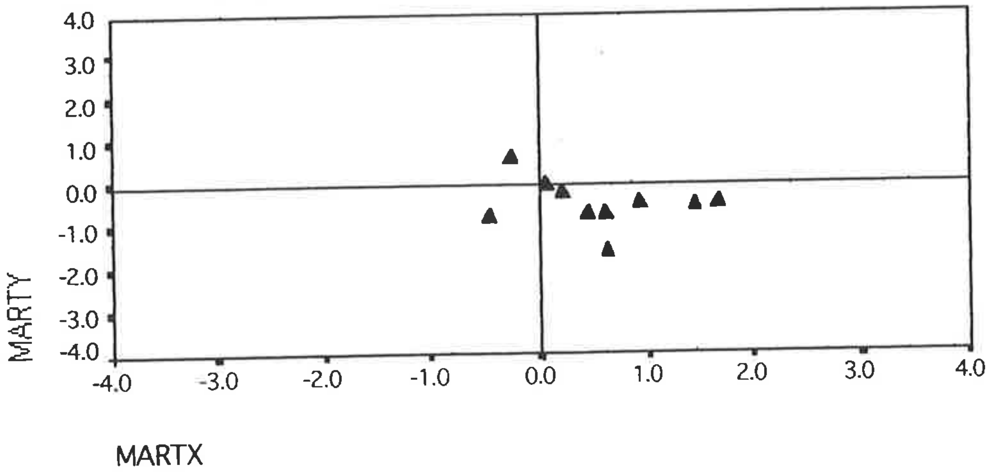


Figure 10.14 Differences between digitised double determinations for lower molar crown (LMC).

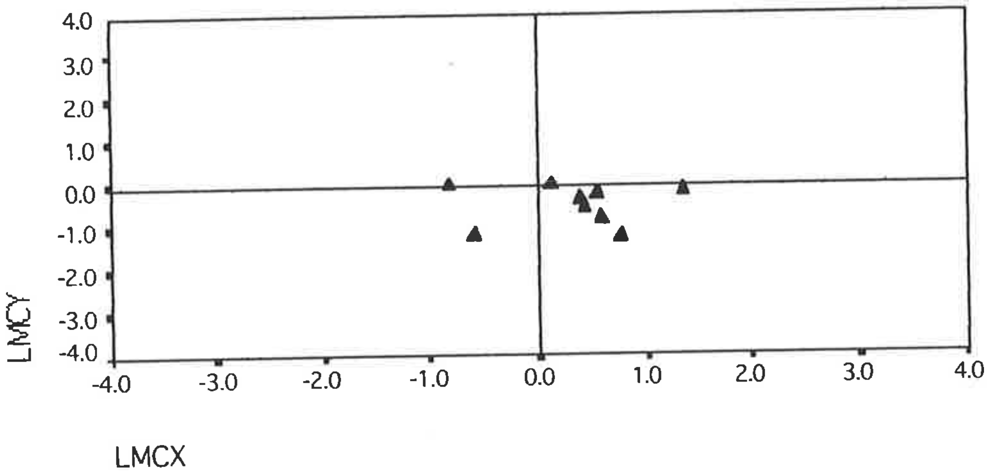


Figure 10.15 Differences between digitised double determinations for pogonion (Pg).

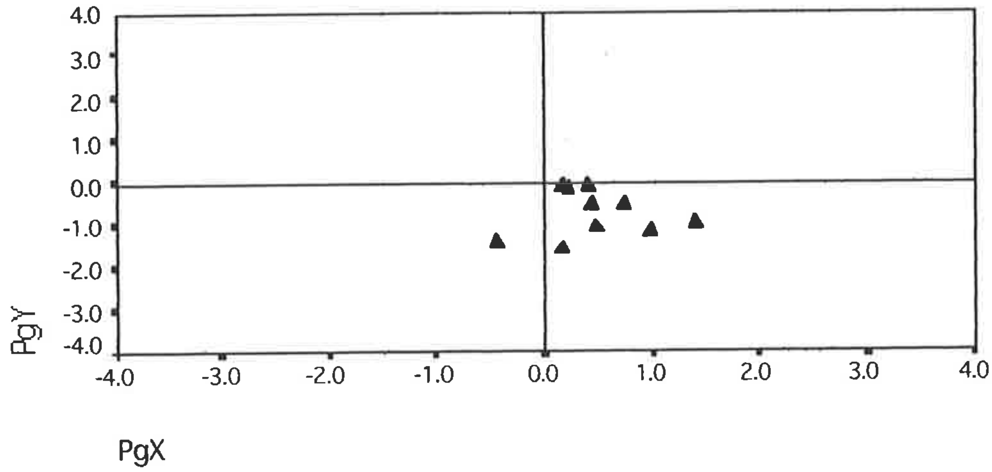


Figure 10.16 Differences between digitised double determinations for gonion (Gn).

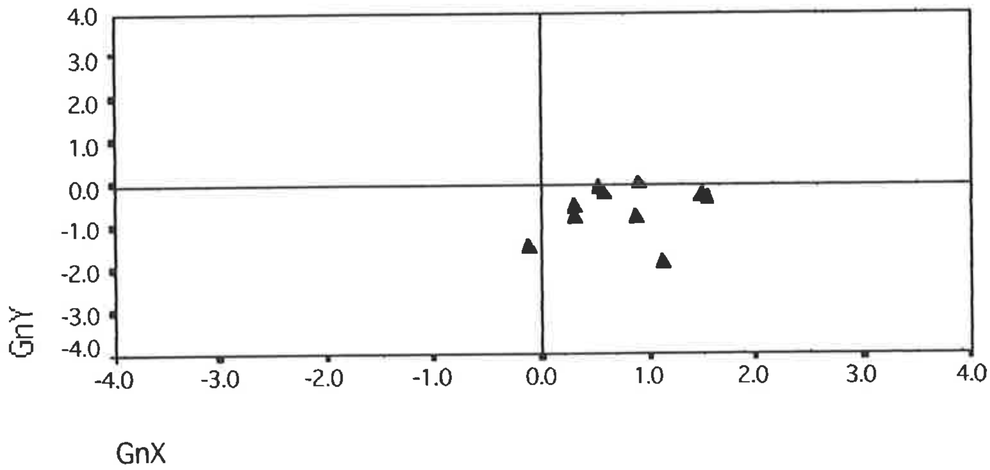


Figure 10.17 Differences between digitised double determinations for menton (Me).

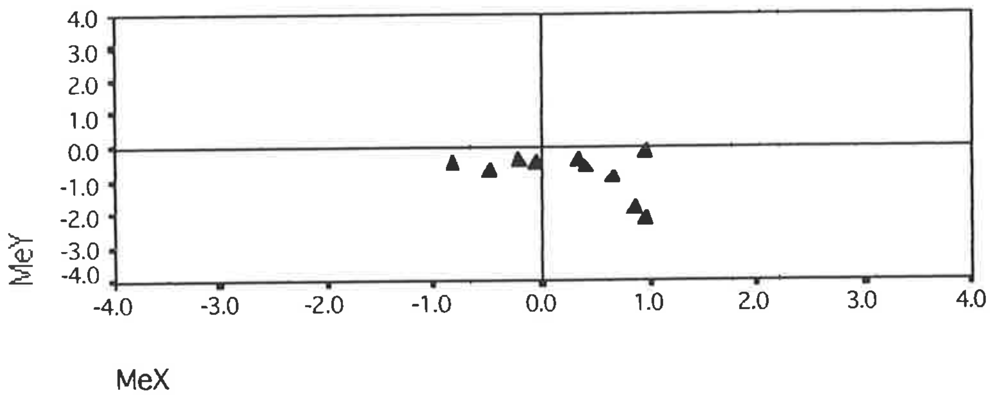


Figure 10.18 Differences between digitised double determinations for gonion (Gn).

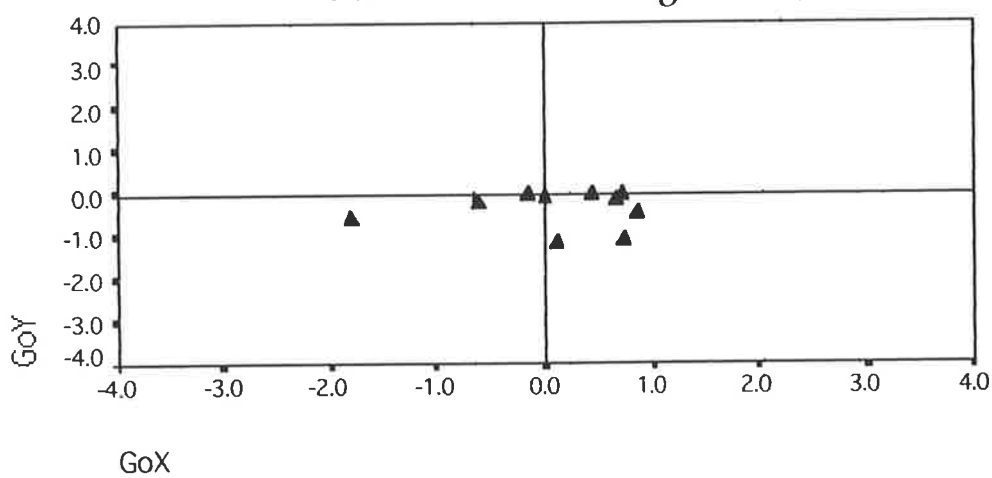


Figure 10.19 Differences between digitised double determinations for articular (Ar).

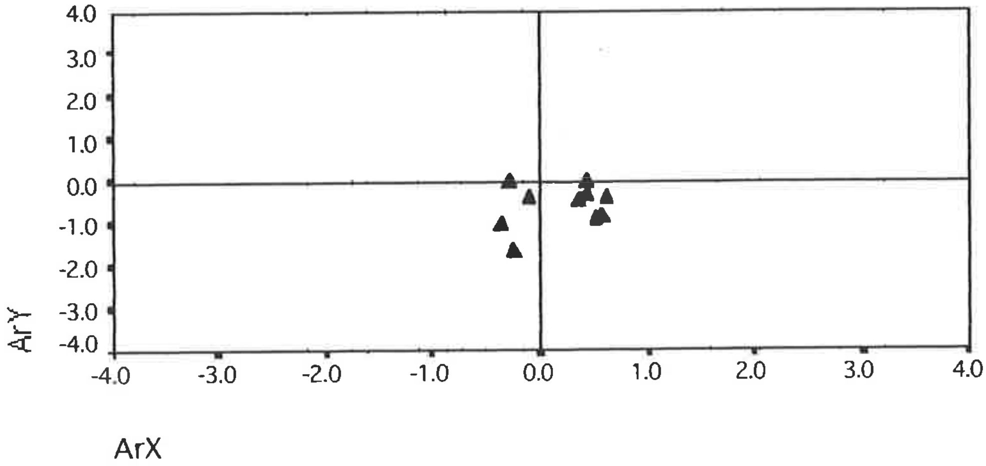


Figure 10.20 Differences between digitised double determinations for condylion (Co).

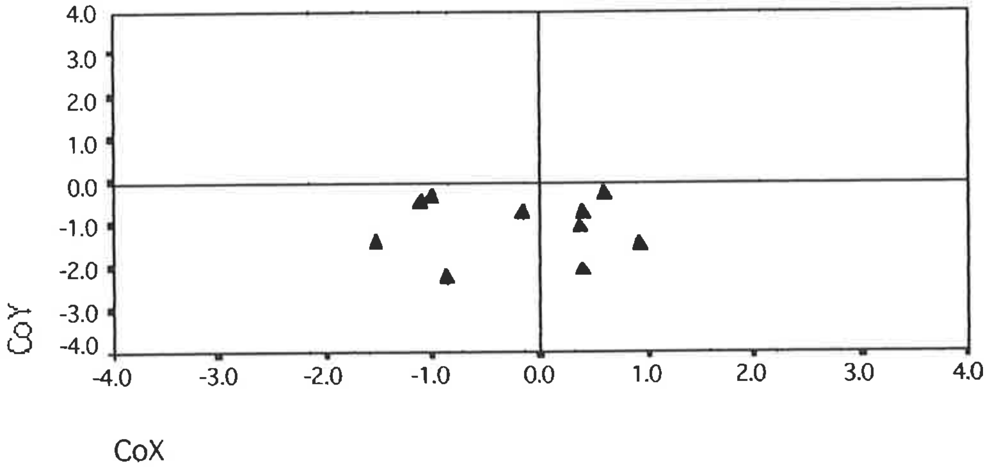


Figure 10.21 Differences between digitised double determinations for pterygoid (Pt).

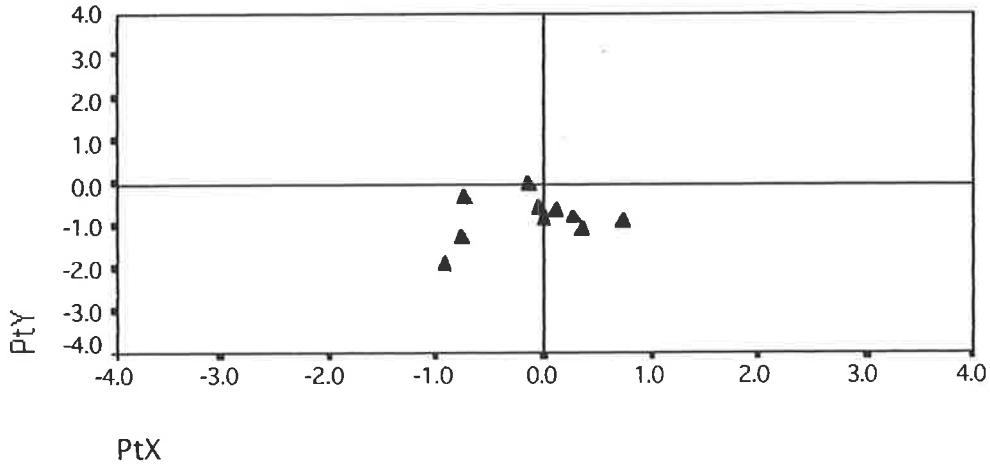
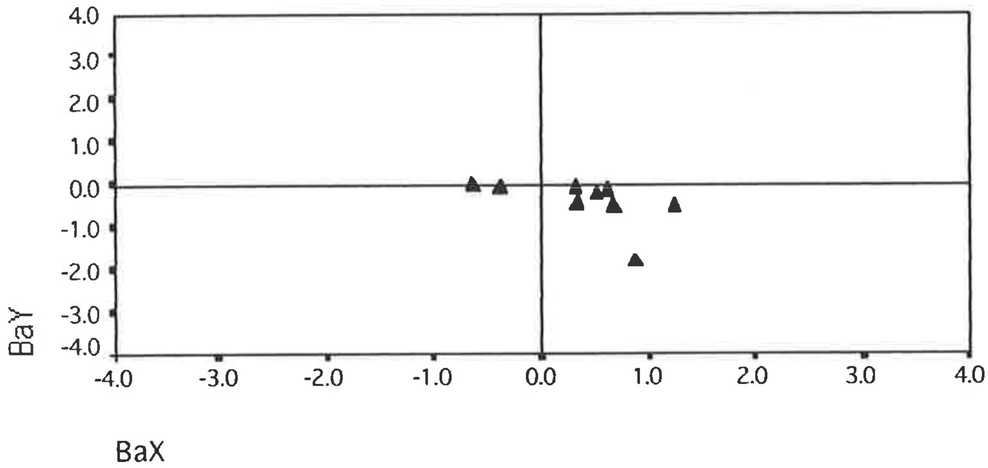


Figure 10.22 Differences between digitised double determinations for basion (Ba).



V

Discussion.

Chapter 11 Discussion of Experimental Design.

11.1 Patient Selection.

Two hundred and fifteen case records were retrieved from the surgical files of the Oral and Maxillofacial Surgery unit , The University of Adelaide. Of the two hundred and fifteen patients who underwent Le Fort I level maxillary surgery , a total of one hundred patients were accepted into the study. The remainder of the patients records were excluded for reasons of:

1. incomplete radiographic records necessary for detailed analysis (n = 110, or 51%);
2. syndromic patients with physical disabilities (n = 5 or 2.3%).

Even though an established protocol exists in the O.M.F.S. unit, numerous cases were found to have incomplete radiographic data. This was due to a number of reasons. The records were frequently misplaced; radiographs not being requested post surgically by the surgeon or the orthodontist, the radiographs were ordered but not taken (radiographic department closed or staff unavailable) or the patient was lost to follow up

The reason for lack of radiographic collection may have stemmed from the underlying socioeconomic factors influencing the patient population examined. Patient commitment was often low once the major steps in treatment were completed. Many of the patients were school students or unemployed. Many on recall had moved interstate, or were travelling 'indefinitely' overseas. Many more were country patients from areas up to 600 km's away that were reluctant or unable to make the trip to the city for long term follow up.

Demographically the selected group studied and the group that was excluded were similar. The average age for the group studied being 22.8 years (Range: 13.9 - 45.3 years) and the excluded groups age was 23.2 years (Range: 14.7 - 51.2 years). In the syndromal group of patients the average age was slightly younger at 20.8 years (Range 14 - 36 years).

The selected sample ranged in age from 13.9 years to 45.3 years with a mean age of 23 years. Bone age in this study could not be confirmed in this retrospective study as hand - wrist films were not taken at the time of surgery. Although some hand- wrist radiographs were taken at the initial presentation and consultation with the orthodontist to assess the degree of deformity and the timing of treatment, the decision to undertake surgery was based primarily on the post pubertal changes as well as the chronological age. Hand - wrist radiographs would have provided a more reliable guide to developmental status than clinical assessment but on a number of occasions the technique of superimposition of serial radiographs was performed for those deemed to be still undergoing active growth.

A comparison with untreated patients matched for skeletal maturation, gender and dentoskeletal pattern may have provided a better indication of the effects of growth. However , this would present logistical problems since the number of patients who present for surgery is only a small proportion of the general population. Matching untreated patients with treated patients could prove difficult given the limited pool of patients who are eligible for treatment at the Adelaide Dental Hospital.

The number of females to males was similar to other studies. In the group studied the percentage of females was 72%, and males 28%. In the group excluded due to lack of radiographs etc. the number of males was higher at 38 individuals compared to 72 females. This reflects the overall better attendance records of females in regards to health care (Australian Bureau of Statistics - personal enquiry). Hence they were more likely to show up for recalls /reviews. Most orthognathic studies show a higher proportion of females undergoing surgery (Franco et al 1989, Pepersack and Chausse, 1978, Proffit et al 1991, Perez et al 1997). This finding appears to be associated with greater aesthetic and functional concerns.

The results of this study showed that there were no statistical difference between genders for any of the variables (see section 12.9) hence these were combined for each of the variables.

11.2 Materials and Methods.

In this cephalometric study several points or landmarks were used to describe the changes in the maxilla. These included points A, ANS, and PNS. All of these points have advantages and disadvantages as discussed in Chapter 3. These points were used to help identify the magnitude of surgical movement of the maxilla , and the amount of post surgical movement that may have occurred.

The technique of the Le Fort I osteotomy surgically affects some of the routine landmarks used in cephalometric analysis. The main points used in this study included A point (Down's A point or subspinale (A): the deepest point in the midsagittal plane between anterior nasal spine and supradentale, usually around the level of and anterior to the apex of the maxillary central incisors (Burstone, 1978)), anterior nasal spine or acanthion (ANS, the tip of the median sharp bony process of the maxilla at the lower margin of the anterior nasal opening (Riolo et al ,1974)), and posterior nasal spine (PNS, the most posterior point at the saggital plane on the bony hard palate (Riolo et al ,1974)).

Point A may be changed post surgically to a minor degree secondary to stripping of the mucosa over the area and subsequent remodelling. The point was found to be reproduciblely identifiable in the double determination technique in Chapter 10.

Point ANS was more vulnerable to change secondary to the direct effects of the surgery. The anterior nasal spine is often removed at surgery , especially when anterior repositioning is being undertaken as some surgeons believe it turns the nasal tip up causing excessive nasal projection (the 'snobs nose') (Bell 1986).

Point PNS is not directly affected by surgery but can be obscured by soft tissue swelling.

Movement of the maxilla at the planing stage is often in a specific direction with minor movements in other directions. As an example when the maxilla is to be impacted (superior repositioning) it is common practice to advance it 2 mm. This permits telescoping of the posterior maxilla upwards over the posterior maxilla or pterygoid plates (Depending upon the site of disjunction) without the need to remove bone in this difficult to access region. For the sake of this study the patients were divided up into groups depending upon the main desired direction of movement as stated in the surgical plan. (ie. superior, inferior and anterior repositioning).

With superior repositioning the maxilla rarely was impacted evenly. The posterior and anterior regions were often impacted different degrees leading to a rotational effect of the maxilla. In some situations the maxilla's movements would result in either the anterior or posterior maxilla moving inferiorly while the rest went superiorly. For effective statistical comparison an overall average impaction was calculated for each superiorly repositioned case. This calculated number was called MAX. This was calculated from the average change in position of both point ANS and A point.

Six surgeons treated the patients in this study with variable registrar involvement. There were two surgeons who performed ninety one percent of the operations. The remaining four surgeons were found to have no statistical difference in the relapse rate of the patients they treated. As such they were combined and compared to the other two surgeons to examine if there was any difference in stability influenced by the surgeon performing the operation.

Chapter 12 Discussion of factors in the relapse of Le Fort I osteotomy.

There was a statistical difference between the three directions of shift (ie. superior, inferior, and anteriorly), as such these were analysed individually for each variable.

12.1 Definition of Relapse.

Reitzak (1988) provides the best definition of relapse defining it as ' a return to the preoperative state'. The advantage of this definition is it takes into account relapse associated with any cause. Of importance in orthognathic surgery is the occurrence of true skeletal relapse plus co-existing orthodontic relapse, or whether each can cause relapse on its own. Dental relapse should be distinguished from surgical relapse but in the clinical setting this is extremely hard to do. In all cases there is probably a component of both dental and skeletal instability. It is possible that one may 'compensate' or even hide the other.

The use of the term stability is probably preferred to relapse as relapse suggests movement in the opposite direction to the original surgical movement whereas stability or instability reflects the movement of the skeletal unit away from its desired surgical position. The main example of this occurrence is the continued upward 'drift ' of superiorly repositioned maxillae. This may or may not move with time back to the surgical position or 'relapse' further towards the maxillae original pre surgical position.

12.2 Orthodontics and occlusion.

Pre surgical orthodontic treatment is aimed at the elimination of dental compensations and alignment of the individual dental arches to the underlying bone.

12.2.1 Orthodontics versus no orthodontics.

Pre surgical orthodontics has been suggested by several authors (Welch, 1989, Wardrop and Wolford ,1989) to be one of the factors affecting stability of orthognathic surgery. Orthodontic preparation can affect both horizontal and vertical dimensions (Vasir et al 1991), due to the creation of various intermediate occlusal interferences. There is the suggestion that a lack of occlusal intercuspation could predispose to relapse.

The difficulty in studies involving orthognathic surgery is to separate orthodontic instability from surgical instability , and to identify the interaction between the two. That is does one lead to the other? More overlap between orthodontics and surgery's influence on the position of the maxillary anterior teeth occurs due to re-angulation of the maxilla. The surgical movements would consequently alter the angles used to measure incisor position in the same direction as if dental relapse had occurred. In this study a minority of patients received no orthodontic treatment (n = 11) whereas the majority had pre and post surgical orthodontic treatment (n = 89) , hence a comparison between the two was made depending upon the direction of surgery.

Forty patients of the 45 patients having superior repositioning of the maxilla had pre surgical orthodontics to align and decompensate the dentition prior to surgery. The remaining 5 patients had surgery utilising arch bars ligated to the dentition to enable maxillo-mandibular fixation. Comparisons were made between these two groups for both the surgical movement (T1 -T2) and the degree of instability post surgery (T2 -T3). Analysis by student t- test and ANOVA , showed no statistical significance ($p < 0.05$) being evident between the two groups that is those treated orthodontically and those that received no pre or post surgical orthodontics (Table 9.30 and 9.31). The wide range in both the postsurgical groups reflects a subgroup of patients who after having superior repositioning of their maxillae continued to drift in an upwards direction (see discussion 12.3).

Eleven patients of the thirteen patients having inferior repositioning of the maxilla had pre surgical orthodontics to align and decompensate the dentition prior to surgery. Two had no orthodontics. Comparisons were made between these two groups for both the surgical movement (T1 -T2) and the degree of instability post surgery (T2 -T3). Analysis by student t- test and ANOVA , showed no statistical significance ($p < 0.05$) being evident between the two groups (Table 9.51 and 9.52).

Thirty eight patients of the forty two patients having maxillary advancement had pre surgical orthodontics to align and decompensate the dentition prior to surgery. Four had no orthodontics. Comparisons were made between these two groups for both the surgical movement (T1 -T2) and the degree of instability post surgery (T2 -T3). Analysis by student t- test and ANOVA , showed no statistical significance ($p < 0.05$) being evident between the two groups (Table 9.72 and 9.73).

Some of the studies on stability in patients receiving orthodontic correction of their malocclusions have also shown no identifiable cause of instability suggesting it is multi factorial in nature. In another review of orthodontic relapse El -Mangoury (1979) examined 50 patients with orthodontic treatment alone. They examined variables such as class I and class II dental malocclusions. There was no significant difference between the two groups. Extraction and non extraction cases and the gender of the patient were also examined and again no difference in stability or relapse was found. Other dental indices examined in this study included the changes in overbite and overjet, maxillary incisal angles, interincisal angle, occlusal plane angle, and upper molar crown.

12.2.2 Orthodontics - overjet and overbite.

Changes in overjet and overbite were also examined for each of the subjects and divided up by direction of maxillary movement at surgery. For the group undergoing superior repositioning the average change in overjet (Table 9.115 & 9.116) post surgery was posteriorly 2.6 mm. On long term review it moved anteriorly 0.61 mm . A change of 23%. This relapse was statistically significant ($p < 0.05$). The change at surgery may reflect rotation of the maxilla on impaction in a clockwise fashion. This would have the effect of moving the maxillary incisal tips posteriorly. The 'relapse ' may indicate either skeletal anti- clockwise relapse, post surgical orthodontic treatment, dental relapse or a combination of both dental and skeletal relapse.

The overbite (Table 9.121 & 9.122) in the superior repositioned maxillae was increased from an average of 1.87 +/- 3.27 mm. by a very small amount at surgery. Some relapse occurred post-surgery but this was statistically insignificant. The change in this vertical dimension by the maxilla is compensated for by autorotation of the mandible.

Patients undergoing inferior repositioning of the maxilla had a decrease in overjet (Table 9.117 & 9.118) initially at surgery. This move remained relatively stable long term. Overbite (Table 9.123 & 9.124) in this group increased about 1 mm post surgery which increased again by another 1 mm. on long term review. This was found to be statistically significant ($p < 0.05$). This change is more likely to reflect dental changes eg. retroclination of the lower incisors creating a deeper overbite.

Patients undergoing advancement maxillary procedures had an average change in overjet (Table 9.119 & 9.120) of 4.91 mm. after surgery. It relapsed only 0.24 mm. long term. This was statistically insignificant. The overbite (Table 9.125 & 9.126) changed only slightly after surgery by 0.14 mm but continued to deepen with time a further 0.73 mm which was statistically significant ($p<0.05$). These changes reflect only dental changes and do not reflect the underlying stability of the skeletal bases.

In non surgical orthodontically treated patients followed over several years post treatment , Sadowsky et al (1994) found there was a general increase in both overjet and overbite , regardless of the original malocclusion and treatment regime. This was found in this study involving surgical patients with the only exceptions being the overbite in the superior repositioned group and the overjet in the inferior repositioned group. These were relatively stable in the long term.

12.2.3 Orthodontics - Maxillary incisal angle and interincisal angle.

The maxillary incisal angle relates the angle of the maxillary incisors long axis to the cranial base (ie. SN - Max). This may be altered both in pre and post operative surgical orthodontics or by rotational effects of the maxilla at surgery. The average angle prior to surgery in this study was greater than the average found in angle class I occlusions ie 100 -104 degrees. With the superior repositioned group the average pre surgical angle was 111 +/-9 degrees. This was reduced only 1.2 degrees post surgery and remained relatively stable over the long time. None of these changes were statistically significant (Table 9.103 & 9.104).

Those undergoing inferior repositioning also had a starting angle around 110 +/- 7.5 degrees which was reduced a significant amount post surgery ($p<0.05$) by an average of 4.2 degrees. Over time post surgery the teeth further proclined a statistically insignificant amount (Table 9.105 & 9.106).

With advancement surgery the average starting angles were reduced only 1.5 degrees. Long term post surgery they became more proclined by 2.6 degrees. This was statistically significant ($p<0.05$).(Table 9.107 & 9.108).

The maxillary incisal angle was stable in both the groups having primarily vertical changes in the maxilla , post surgery. In the advancement group it did relapse. This was primarily a dental problem, either in post surgery orthodontic treatment or relapse. It is more likely secondary to further orthodontic treatment as advancement of the maxilla will put the upper incisors under more pressure from the upper lip - this would more likely cause further retroclination of the teeth.

The interincisal angle was examined but is obviously influenced by the position of the mandible and mandibular incisal angulation. The interincisal angle has a normal mean of 135 degrees with a range of 130 - 150 degrees.

In the superior repositioned group the average pre-surgical angle was 124 +/-

10.9 degrees which reflects the most common Angle class II skeletal relationship having superior repositioning and mandibular advancement (either surgically or by autorotation). Post surgery this angle increased by an average of 4.4 degrees which was statistically significant, as the skeletal relationship approached a more class I relationship. Long term this change remained very stable.

For patients having inferior repositioning the interincisal angle was 132.5 +/- 10.7 degrees. It was increased by 3 degrees with surgery and long term moved another degree. Both of these shifts were statistically insignificant.

In the advancement group they started with an angle of 134 degrees .This was not changed significantly with surgery and only relapsed slightly. Again these changes were not statistically significant.

The interincisal angle was maintained long term post surgery.

12.2.4 Orthodontics - Occlusal plane angle (Table 9.139 - 144).

The occlusal plane is the line from the occlusal surface of the first molar to a point midway between the tips of the upper and lower central incisors. It is of interest in this study in helping assess rotational movements of the maxilla during and post surgically. It is an important measure in the planning of the final position of the maxillary and mandibular segments in cases of anterior open bite.

In this study the average overall occlusal plane angle was higher than the mean but within the normal range (ie. mean is 9 degrees with a range of 1 -14 degrees).

Patients who underwent superior repositioning and advancement surgery had little change in the angle both after surgery and at long term review. This suggests that very little rotational movement of the maxilla occurred. In the group who underwent inferior repositioning the angle was increased by 3 degrees. This stayed relatively stable post surgery. These changes were not statistically significant but may reflect tipping of the maxilla downwards, anteriorly causing autorotation of the mandible.

12.2.5 Orthodontics - Upper molar and lower molar crown position.

The position of the molar teeth was also examined both pre and post surgery. Any changes may reflect the underlying skeletal changes or orthodontic movements or both. Movements at surgery and long term post surgery were examined in both the horizontal and vertical direction.

Taken overall (Table 9.82) there was statistically significant instability ($p<0.05$) or movement of the upper molar crown post surgery (UMCY2). When examining UMCY2 by direction of surgery both superior repositioning and advancing the maxilla were stable (ie after the surgical movement and with post surgical orthodontic movements the upper crown did not move in the vertical dimension). Inferior repositioning was less stable. Also when taken overall LMCY2 showed statistically significant instability ($p<0.05$). Again by direction only inferior repositioning was unstable. The other directions being relatively stable.

Movement in the horizontal direction of both the upper and lower molars was stable long term post surgery.

The instability of the molar teeth in the inferior repositioned maxillae most likely represents skeletal relapse. Extrusion of the molars was not evident in this group of 13 patients. If this had occurred in the pre-surgical orthodontic phase dental relapse would occur under occlusal forces. Hence in this series relapse was probably secondary to skeletal relapse.

Orthodontic treatment in the surgical patient involves close cooperation between the orthodontist and surgeon. The key is in the pre - treatment work up , leading to a diagnosis and treatment plan. At the University of Adelaide Dental School, the OMFS Unit and Orthodontic unit discuss cases on both an informal and formal basis regularly. This helps reduce the possibility of building in potential instability . This is borne out in this study with fairly stable occlusions overall post treatment.

Open bite deserves special mention in regards to the possibility of incorrect pre-surgical treatment. Fourteen patients in this study had treatment for open bite in conjunction with other skeletal excesses and deficiencies. Two of the patients (14%) had evidence of a partial relapse of their openbites on long term follow up. In both of these patients the skeletal bases remained stable post surgery , but their was dental relapse. Most studies of anterior open bite have found that incorrect pre surgical orthodontic treatment and incorrect diagnosis of the open bites etiology (Denison 1989, Hoppenrijis et al. 1997) , to be the main causes leading to relapse. Orthodontic camouflage of a skeletal problem will result in the return of the open bite once the orthodontic apparatus is removed. Denison et al (1989) examined stability of maxillary surgery between openbite and non-openbite malocclusions. They found 21% of patients with pre-treatment openbite suffered post treatment relapse. They suggested this wasn't due to skeletal relapse but may be related to the influences of orofacial musculature - tongue posture and hypotonic buccal musculature. Hence to obtain stability of the openbite corrections it is mandatory that the etiology must be identified and removed.

Haymond et al (1991) found a fourteen percent relapse rate in a series of 38 patients his group treated with Le Fort I osteotomies. These patients were fixated with miniplates and followed from one to five years. Only one had true skeletal relapse, the others dental. Most of the relapse was attributed to transverse relapse of orthodontically expanded maxillary molars.

Hoppenreijis et al (1997 & 1998), examined a large number of patients (267) treated surgically for anterior open bite. They were followed from 20 - 210 months post surgery. 19% of the patients showed relapse post surgery. This was due partly to dental relapse (orthodontic relapse) and the wrong skeletal diagnosis. Most anterior open bites are a segmental problem, so should be treated segmentally. They also thought the continued influence of the soft tissues may play a role.

Lo et al (1998) , examined the problem of orthodontic extrusion of anterior teeth prior to surgical correction of an anterior open bite. They conclude that a moderate amount of extrusion or a lack of extrusion are both stable long term and had little influence on the post treatment stability of open bite.
Relapse in the two patients in this study probably was secondary to orthodontic extrusion of both the upper and lower incisors. Although not studied specifically in this series of patients, many minor to moderate transverse deficiencies in the maxilla, were treated by orthodontic expansion. This being inherently unstable may have also played a role in the relapse of these two patients.

In summary the role of pre and post surgical orthodontics cannot be under estimated in the etiology of relapse in orthognathic surgical patients. Although there was no statistical difference between patients who had orthognathic surgery and those that did not in relapse rates , when individual cases of relapse were examined some of the clinically observable relapses could be related to incorrect diagnosis and thus treatment planning or inappropriate treatment even when in essence the diagnosis may have been correct (eg the two anterior open bite cases that relapsed).

12.3 Direction and magnitude of movement.

The direction of movement is probably the single most important determinate of post surgical stability (Schendel et al 1976, Epker 1981, Rondahl et al 1988, Bailey et al 1993, Proffit et al 1987, 1996.). In this study the maxilla was moved in three main directions. These included the vertical directions (superiorly and inferiorly) and horizontally (anteriorly only).

In vertical shifts of the maxilla it was rare to have pure movements ie. there was usually a concurrent shift in the horizontal plane , and also some degree of rotation. The 'main ' direction was thus based on both the surgical diagnosis and the actual main direction of movement. The two were usually the same but there were exceptions. These exceptions generally showed less relapse.

When taken as a whole superior repositioned maxillae (Table 9.15 & 9.16) moved inferiorly 26% of the original surgical movement. Care must be taken in interpreting this result as a subgroup of these patients continued to move in a superior direction post surgery. Of the 42 patients having this procedure 15 continued to move upwards an average of 1.8 mm. The other 30 patients were found to relapse in the inferior direction an average of 1.1 mm. There were no correlations to any of the other variables examined to identify which group would move which direction.

Inferiorly repositioned maxillae (Table 9.36 & 9.37) had a relapse on average of 38 % of the original surgical movement. All in a superior direction making it the most unstable of procedures. The probable cause of this inherent instability of inferior repositioning results from force against the displaced maxilla during dental occlusion (Proffit 1996).

In broad terms the group undergoing anterior repositioning (Table 9.57 & 9.58) had an average post surgical movement in the posterior direction of 16%.

These findings are not exactly the same as Proffits 'Hierarchy of Stability' published in 1996.They have found that superior repositioning of the maxilla is the most stable procedure. This is followed , in order ,by anterior shift of the maxilla, a combination of maxillary impaction and mandibular advancement, maxilla forward with the mandible being setback. Inferior repositioning of the maxilla and increasing its transverse dimension were found to be the most unstable, which is in agreement with this study.

The magnitude of the original surgical movement has been found in some studies to be directly correlated to relapse potential .The maxilla is more restricted in its range of movements in three dimensions , when compared to the mandible, due to biological constraints - particularly vascular supply.

No correlation was made in the amount of superior repositioning and post surgery relapse in Proffit's 1987 study. Bailey et al (1993) in their 5 year follow up of surgical repositioning found no correlation with the magnitude of impaction and postsurgical relapse. This was confirmed in this study.

Little is mentioned on correlations with relapse and the magnitude of inferior repositioning of the maxilla. Quejada et al (1987) examined relapse in this surgical group. They found a lack of correlation between the amount of surgical change and the amount of relapse . The reason for this finding they stated as unclear. They suggested that the magnitudes of inferior repositioning achieved in their series (av. 4.4 mm.) were insufficient to surpass the adaptive capability of the masticatory muscles. In this study four patients had inferior repositioning between 4 - 6 mm's. In these patients the relapse average of 2.8 mm was affected by one individual having almost complete relapse. One patient with a shift greater than 6 mm. had minimal relapse. Overall there was no statistical difference in instability between patients in this group.

Maxillary advancement has been suggested to be more unstable with extremely large shifts. Studies have shown (Freihofer 1977, Kaminishi et al 1983) that shifts up to 7 mm are very stable. Araujo et al (1978), showed stability of shifts up to 6 mm but suggested shifts greater than this needed bone grafts to make them stable. In this study the magnitude of shift was not statistically correlated to the degree of post surgery instability irrespective of whether bone grafts were used or not.

Other variables apart from specific landmarks were examined to try and identify variations between the different directions of movement and instability. Two angles were used to relate the maxilla to the cranium - S.N.A. and N.A. to F.H. or Frankfort horizontal (Tables 9.85 - 9.90). S.N.A. giving an indication of the antero-posterior relationship of the maxilla to the bony cranial base, at the midline and N.A. to F.H being a surface landmark of the same relationship. Changes in S.N.A. by each direction post surgery were statistically insignificant.

N.A. to F.H. was statistically significant ($p<0.01$) in the anterior repositioned group indicating some post surgical change. The angle returned back slightly towards its pre surgical angle. This was not confirmed by the S.N.A. or points A, and ANS (although there was some relapse at these points it was statistically insignificant). There was no statistically significant change in the inferior and superior groups.

Vertical changes were also assessed by changes in the anterior facial height (Nasion to menton or Na- Me.)(Tables 9.91 - 9.96) and posterior facial height (sella to gonion or S -Go) (9.97 - 9.102). In the superiorly repositioned group there was a statistically significant ($p<0.01$) change in post surgical dimension. Since the surgical decrease in this dimension at surgery it had a tendency, on average, to move inferiorly increasing the height. When examining the two subgroups previously mentioned this increase was made more obvious in the group that relapsed in the inferior direction once the superiorly drifting group was excluded. No other changes were statistically significant in the inferior or anterior repositioned groups.

Changes in posterior facial height by each direction post surgery were statistically insignificant.

12.4 Type of fixation and use of bone grafts.

12.4.1 Fixation.

Two types of fixation were used in this study. In 1984 - 1987 wire osteosynthesis was used (Usually a combination of intraosseous wires , zygomatic suspension wires and intermaxillary fixation) and from 1988 - 1997 internal fixation with bone plates and screws was used. These two groups were compared statistically.

The initial stability of the repositioned bones is dependent on the ability of these appliances to resist internal and external forces. They probably have little or no bearing on long term stability at the osteotomy sites and become a non functioning implant.

Rigid fixation was initially thought to be the solution to post surgical instability. Plates and/ or screws have been found to improve the stability of mandibular osteotomy's. (Van Sickels et al 1985, 1986, Will et al 1989). The question of stability in the maxilla between the two groups of fixation has been controversial.

Van Sickels (1996) did make comment that there are multiple factors at play when considering stability and there are some circumstances where the different fixation techniques made little difference.

Most of the literature on fixation and stability compares the two types of fixation used in this study. All find either no difference between the two (Luyk et al 1985, Proffit 1987, Wolford et al 1981, Ellis 1989) or that internal fixation with bone plates and screws to be superior , improving stability (Egbert et al 1995, Larson et al 1989, Satrom et al 1991). None found wire fixation to be superior. Some authors suggested relapse occurred earlier with wire fixation revealing itself when the MMF was removed at six weeks.

In this study rigid fixation was slightly more stable in patients having inferior repositioning but in the other directions of movement there was no significant statistical difference between the two forms of fixation used.

12.4.2 Bone grafts.

Bone grafts have also been recommended to enhance stability, particularly if the bony segments are moved away from each other creating a gap. The presence of a bone graft probably adds to the initial stability of osteotomy sites. It is proposed that bone grafting can accelerate osseous healing , act as a physical stop , and provide a matrix for bone growth (Epker et al.1980). Obviously this is more important in inferior and advancement osteotomies where the greater the movement the bigger the gap, than with superior repositioning.

Luyk and Ward -Booth (1985) looked at the role of bone grafts in maxillary advancements stabilised with rigid fixation and felt that advancements of up to six millimetres appeared stable without the use of bone grafts. This is because the zygomatic buttress bone would still have good contact with shifts less than six millimetres. This study showed no statistical difference between the two forms of fixation when the maxilla was advanced. Of interest though is the advances of greater than 5 mm. undertaken in this study (n =9) three that suffered substantial long term relapse did not have bone grafts in place , which would support Luyk et al's findings.

Louis et al (1993) state that in their study of stability of Le Fort I advancements it is unclear to what magnitude the maxilla can be advanced and would benefit in the reduction of post surgical relapse with the use of bone grafts.

Trimble et al (1986) found greater stability in patients having inferior repositioning of the maxilla when a combination of bone grafts and rigid fixation were used. Surprisingly only 3 out of 13 patients having this procedure had bone grafts placed. Relapse was found to be high in both situations.

To sum up the literature experience of bone grafts and the affects on post surgical stability Schmidts et al (1995) states "The use of bone grafts to enhance maxillary stability can not be underestimated. However their contribution to clinical stability also can not be assessed."

Initial movement at a fracture or osteotomy site retards healing leading to non union. Bone repair requires stability and bone growth factors in order to proceed (Marx 1998). These are supplied by a bone graft when a gap greater than several millimetres exists between the bone. Hence although not proven convincingly in this study or others, most surgeons consider bone grafts necessary particularly in the early phase of bone healing and stability at the osteotomy site.

12.5 Growth.

Little has been shown in the literature of the effects of growth on the maxilla after orthognathic surgery, especially when compared to the research on the mandible. Research into the result of growth on long term relapse in maxillary procedures has been more in tune with the effect that surgery can have on growth. Many authors have explored this question in particular reference to performing surgery earlier during growth. Timing of orthognathic surgery in the cleft palate patient remains controversial because of its potential to limit anterior growth of the maxilla.

The facial skeleton grows downward and forwards from the anterior cranial base and increases in size sagittally, vertically and transversely. This is partly as a result of sutural growth and partly as a result of periosteal remodelling. Sutural growth is important initially , but continues at a fairly slow rate until after puberty. Subsequently all changes are secondary to periosteal remodelling. Males tended to grow more in all directions , commencing and finishing later in life (13 - 18 years). Most female growth occurs between 8 - 13 years and stops by 15 years. Normal maxillary growth may continue into adulthood (Enlow 1968). Chronological age is used as an indicator to determine potential growth.

Some authors consider that early surgery restricts potential growth of the malformed maxilla condemning the patient to further surgery or a deficient middle third. For the non cleft patient completion of the dentition or concurrent mandibular surgical needs generally have dictated when surgery is undertaken.

Early correction of dentofacial abnormalities has the advantage of preventing detrimental psychosocial problems and may also prevent other physical consequences such as problems in the occlusion , masticatory function , temperomandibular joint and structure , speech, and airway (Nanda et al 1982).

The main argument against early surgery is its possible ill affects on further maxillary growth (Schendel et al 1978).

Utilising a definition of early surgery as surgery undertaken before growth is completed this would mean surgery before the age of 18 years in males and 15 years in females. Six male patients had their surgery before the age of 18 years, only two females had their surgery prior to 15 years in this study. No significant statistical difference between these patients and the remainder of the group was found. This agrees with Epker et al (1982) and Mogavero et al (1997) who both found no influence on post surgical stability of Le Fort osteotomies when the surgery was performed before the predicted completion of growth.

When examining the influence of age on instability potential patients in this study were divided up into those having surgery before 23 years of age, this was the mean age for the whole group, and those after it. This was performed by direction of movement.

A comparison was performed to assess age as a factor for instability.The superior repositioned group of 45 patients was divided into two groups. A comparison was also made between patients younger than 20 years of age and those older. Analysis by student T- tests and ANOVA found point A(Y1) and ANS (Y1) was significantly different ($P< 0.05$) with the original surgical shift (the younger group had a larger surgical shift) but there was no significant difference in stability between the two groups post surgery (Table 9.20 and 9.21).

For both the inferior and advancement groups there was no significant statistical difference in surgical stability post surgery.

The studies that have suggested maxillary osteotomies affect subsequent growth have been primate studies. Nanda et al (1982) and Shapiro and Kokich (1981 & 1982) found maxillary growth was affected by surgery. They felt vertical and anterior growth was retarded due to the surgery affecting the vomer 'growth centre'. No human studies have been able to substantiate these studies in non syndromal , non cleft patients.

Timing of surgery should probably be dictated by concurrent mandibular problems, orthodontic requirements and the individual patients psychosocial situation.

12.6 Surgeon.

Diagnosis of dentofacial skeletal discrepancies and their surgical correction, is under the influence of the surgeon and his expertise. Six surgeons were identified in this study. Two surgeons performed the vast majority of the operations (Surgeon 1, 60 operations, Surgeon 2, 31 operations.) The remainder of the operations being performed by the other four surgeons (Surgeons 3 -6 , 9 operations). To allow meaningful statistical comparison these four surgeons were placed into the same group.These surgeons were the least experience in years of practice and as well as the numbers of operations performed (Table 9.9). It must be noted that all six surgeons were assisted by registrars. The extent to which the registrar performed the operation is not defined.

Analysis by t-test and ANOVA showed no statistically significant between the two experienced surgeons and the least experienced. Whichever direction the maxilla was moved the stability was the same between the groups. (Table 9.22, 9.23, 9.43, 9.44, 9.64, & 9.65).

No other studies have identified the surgeon and his level of experience to be significant as a cause of instability post maxillary orthognathic surgery.

12.7 Effect of segmentalising the maxilla versus 'one piece' osteotomies.

The multiple piece Le Fort I has the ability to correct problems in all three planes of space at once. Segmental maxillary procedures are performed for transverse discrepancies and for the correction of differential vertical discrepancies in the maxilla.

In this series of 100 patients 33 patients had segmentalisation of the maxilla. The remainder had 'one piece' procedures (Table 9.11). Segmentalisation was done for transverse maxillary discrepancies (n = 21) and also for vertical differences between the posterior and anterior maxilla such as for the correction of anterior openbite (n =12). The influence of segmentalising the maxilla was examined to determine its effect on long term stability.

The segmental groups were subclassified to examine any difference in stability between segmentalising for vertical discrepancies and transverse discrepancies. No patient had both of these procedures performed simultaneously. No difference in stability was identified.

In the superior repositioned group there was no statistically significant difference between the amount of post surgical movement of the segmented maxillae and the one piece unit. The 9 subjects in this group who underwent segmentalisation of their maxillae to enable differential impactions of the posterior and anterior maxilla. In this group of patients movement of ANS was examined for anterior maxillary stability, and PNS for posterior maxillary stability. No statistically significant relapse occurred at either of these points.

Stoker and Epker (1974) , and West and Epker (1972) found maxillary superior impaction when performed segmentally is as stable as a total maxillary osteotomy impaction. Segments can be expected to act as a whole piece maxilla depending on their direction of movement.These were similar findings to this study.

A similar finding occurred in the inferior repositioned group with no difference in stability between segmental and non segmental maxillae. Perez et al. (1997) also found no difference in stability between one piece and segmental maxillae that were inferiorly repositioned.

Of the advancement group, 14 patients out of the 42 had segmentalisation, many for transverse deficiencies. Again there was no statistical difference between the two groups.

Segmentalising the maxilla carries the highest risk of devitalising osseous segments. Bone healing is required to obtain long term stability . This appeared not to be a great influence on long term stability in this series.

12.8 Influence of concurrent mandibular surgery (Bimaxillary surgery).

Stability of the maxilla may be influenced by concomitant surgery of the mandible. This may be due to the decreased masticatory forces found after two jaw surgery, or reflects the extensive surgery performed.

Concurrent mandibular surgery was undertaken in 70 patients in this study. The groups were categorised as:

1. Maxillary surgery alone.
2. Maxillary surgery and B.S.S.O./ Inverted L mandibular advancement.
3. Maxillary surgery and B.S.S.O./ V.S.S.O. setback.

(The original groups 3, 4, and 5 collectively only had a total of 5 subjects. As such these were placed together for statistical analysis - Tables 9.7 and 9.8).

Student t-tests and ANOVA showed no significant differences between the groups in regards to post surgical stability . This was determined by comparing the different operations to each other (Tables 9.24, 9.25, 9.45, 9.46, 9.66, & 9.67). and also comparing single jaw surgery with two jaw surgery (Tables 9.145 - 9.150). Other studies vary in their findings. Most agree that two jaw surgery is as stable as one jaw surgery (Hoffman et al 1994, Law et al 1989, Hennes 1988, and Bothur et al 1998). Other researchers consider two jaw surgery to be more stable (Brammer et al 1980, Maser and Freihofer 1980, Kahnberg and Ridell 1988, and Proffit 1991). It is suggested by some that this enhanced stability is due to spreading the discrepancies between the two jaws rather than one large movement in one jaw. It is also thought to be due to decreased biting forces that occur when two jaws are operated on simultaneously.

Skoczylos et al 1988,and La Banc et al 1982 found a decreased stability between when two jaws were operated upon.

The angle SNB, reflecting the anteroposterior position of the mandible, was also evaluated to examine the influence of mandibular instability on the maxilla. No statistical correlation could be found for any of the directions of maxillary movement (Tables 9.127 - 9.132).

The mandibular plane angle (M.P.A.), which relates the mandible to the cranium in the vertical plane was also evaluated (Tables 9.133 - 9.138). It increased post surgery a statistically significant amount ($p<0.01$) for the superior repositioned group . This may reflect the overall average inferior instability of the superiorly repositioned maxilla causing clockwise rotation of the mandible. No other statistically significant changes occurred in the inferior and anterior repositioned groups.

12.9 Patient Gender.

The results of surgical movement and subsequent stability of the 100 patients undergoing maxillary surgery were grouped by gender to determine if there were any differences in stability between the genders. Twenty three males had surgical repositioning of the maxilla compared to 77 females. No statistical significance was found as analysed with ANOVA for each of the points A, ANS, PNS (and MAXY in the superior group). (Tables 9.18, 9.19, 9.39, 9.40, 9.60 & 9.61.).

12.10 Timing of Relapse.

Most osteotomies experience some relapse. Most of this is clinically insignificant. When this relapse occurs remains unclear. In this study the average time of follow up over the 100 patients was 2.6 years. All patients were reviewed longer than one year. Patients that were followed up longer (ie. greater than 2.6 years) were compared for stability by direction of movement with those patients followed up for shorter periods (ie less than 2.6 years).

(Tables 9.151 - 9.156) There was no statistical difference between the two groups suggesting that relapse occurs early in the post operative period and once this has occurred the maxilla will remain stable.

VI

Conclusions.

Chapter 13 Conclusions.

This study showed that

1. All Le Fort I osteotomies have a degree of post surgical instability.

2. The direction of maxillary movement altered the amount of instability post surgery. Advancement osteotomies are more stable than the superior repositioned maxilla, which in turn are more stable than the inferior repositioned maxilla.

3. The timing of the instability was within the first twelve months after the operation was performed. After minor early instability the Le Fort I osteotomy can be considered stable in the long term.

4. Instability with superior repositioning can occur either in a further superior direction or relapse in an inferior direction. Identification of etiological factors that may aid the recognition of the patients in each of these groups prior to surgery was not achieved.

5. No significant difference in stability could be assigned to age or gender.

6. Whether orthodontic treatment was used or not had no influence on the stability of the Le Fort I osteotomy.

7. The type of fixation used at surgery generally had no bearing on the amount of post-surgical instability. In the inferiorly repositioned group there was a slight improvement in stability when bone plates were used rather than intra-osseous wiring.

8. Bone graft use had no effect on the amount of instability long term.

9. Growth had no influence on long term stability.

10. The experience of the surgeon performing the Le Fort I osteotomy had no influence on the long term stability of the osteotomy.

11. Segmentalised maxillae, either for transverse or vertical discrepancies in the maxilla, had similar relapse rates as one piece maxillary osteotomies.

12. Concurrent mandibular osteotomies performed with the maxillary osteotomy had no influence on the long term stability of the Le Fort I procedure.

13. This study confirms that the Le Fort I osteotomy is versatile, robust, and stable.

VII
Appendix

Appendix I: Bone grafts.

Anterior Iliac Crest.

If a bone graft is required then then this is harvested prior to orthognathic surgery.

1. Pre Surgery:

(a) Prophylaxis against D.V.T. starts with advice preoperatively. Females on oral contraceptive pills (depending on the type) are advised to cease their use 4 weeks prior and use alternative methods of birth control.

2. Patient positioning:

(a) The selected hip is exposed. A sand bag is placed beneath the hip.

3. Surgery.

(a) Skin is prepared and draped with or without a steridrape.

(b) The skin incision 3 cm's below the iliac crest and 2 cm posterior to the anterior superior iliac spine is marked with a surgical pen. Local anaesthetic can be placed now or at the end of the procedure.

(c) To make the incision the skin is pulled medially and the incision made sharply down onto the ridge. This allows the wound and resulting scar to be lateral to the crest (less visible and more comfortable for the patient).

(d) The length of incision reflects amount of bone needed (usually 4 cm will be sufficient in jaw osteotomy surgery).

(e) The incision is continued through the fascia lata , iliac muscle , and the periosteum.

(f) Periosteum is reflected medially and a large bowel retractor used to protect the intra-abdominal contents.

(g) Bone in the form of a corticocancellous block is taken from the medial aspect utilising saws and osteotomes. The crest is either partially preserved or completely by creating a hinge of bone to gain access. Cancellous bone can also be obtained.

(h) On completion of bone harvesting, bleeding is controlled (+/- bone wax) and a drain inserted.

(i) The wound is closed in layers with sutures.

4. Postoperative management.

(a) Remove drain at 24 hours if non productive.

(b) Mobilise with assistance early, consider ongoing deep venous thrombosis risk. Intraoperatively intermitten calf compressors can be used or T.E.D. stockings. The T.E.D. stockings are used into the post operative period until the patient is mobilising. Subcutaneous heparin or the low molecular weight heparins are used in conjunction with the above if the patient is deemed high risk of a D.V.T. Early mobilisation is encouraged actively.

(c) Subcutaneous or intramuscular narcotic analgesic to commence with, then switched to oral analgesics when tolerating fluids. Patient controlled analgesia or P.C.A. used as required.

(d) Determine bowel function by presence / absence of bowel sounds day 1 post surgery.

Appendix II: Le Fort I Osteotomy.

1. Indications.

(a) Maxillary deficiency in the anterior posterior plane. (Advancement osteotomy).

(b) Maxillary excess in the vertical plane (Superior or impaction osteotomy).

(c) Maxillary deficiency in the vertical plane (Inferior repositioning)

(d) Anterior open bite (segmental : posterior segments repositioned superiorly, +/- inferior repositioning of the anterior segment ; if one piece : differential movement posteriorly to anteriorly).

or one piece osteotomy. (e) Other less common procedures incl. correction of maxillary excess in the anterior posterior plane, correction of asymmetries, and in cleft palate patients. Includes segmental and one piece Le Fort I maxillary osteotomies.

(f) Access for removal of pathology in maxilla, paranasal sinuses, base of skull and intracranial pathologies.

2. Contraindications. (Relative only)

(a) Bleeding disorders.

(b) Body Dysmorphic Syndrome.

(c) Systemic contraindications to elective surgery.

3. Preoperative work up.

3.1 Before admission.

(a) Orthognathic Surgery work up as per major surgery protocol, Oral and Maxillofacial Surgery Unit, University of Adelaide. This involves the following:

(i) Clinical and medical assessment.

(ii) Anaesthetic assessment.

(iii) Autologous blood donation (No longer indicated in simple Le Fort osteotomies. Recommended in high level, complicated mid facial osteotomies and also if iliac crest bone harvest planned).

(iv) Radiographs - lateral head cephalogram, orthopantogram, posteroanterior cephalogram. Others as indicated including periapical films (segmental osteotomies).

(v) Photographs of face (extraoral) and dentition (intraoral).

(vi) Cephalometric analysis.

(vii) Study models.

(viii) Body image and Illness behaviour questionnaire; and

(ix) Oral And Maxillofacial surgery Unit clinical work up sheets. (attached).

(b) Model surgery to indicate movements and for construction of occlusal wafer.

(c) Determine means of intermaxillary fixation intraoperatively (and post operatively if required):

(i) arch bars.

(ii) Orthodontic bands - 'high hats' or soldered cleats.

(iii) Placed in 'passive' orthodontic retention prior to final model surgery.

3.2 On admission.

(a) Full pre surgical work up.

(b) Confirmation of treatment plan supported by model surgery. Check accuracy of occlusal wafer.

(c) Theatre notified of procedure, osteotomy instrument required.

(d) Consideration to use of high dependency use.

4. Operative Procedure.

4.1 Anaesthesia.

(a) Advise anaesthetist expected time of operation , intraoperative need for maxillo-mandibular fixation and if needed post operative intermaxillary fixation.

(b) Nasoendotracheal intubation.Throat pack placed in position out of operative field.

(c) Standard anaesthetic medications - hypotensive anaesthetic utilised to minimise blood loss. Consideration to use of haemodilution techniques.

(d) Standard anaesthetic monitoring which routinely involved:

(i) pulse oximetry.

(ii) CO_2

(iii) blood pressure.

(iv) pulse rate.

(v) tidal volume.

(vi) ECG (3 lead).

(e) patient placed in anti- trendelenburg position to reduce blood pressure in head and neck region.

4.2 Instruments.

(a) Osteotomy tray

(i) 2 stripping periosteal elevators (small and large);

(ii) Sagittal saw with bread knife.

(iii) Osteotomes - 6 mm straight, nasal septum osteotome, large curved osteotome.

(iv) Rowes disimpaction forceps.

(v) Acrylic bur and small round burs.

(vi) Wire - 26 & 28 gauge.

(vii) Bone plates and screws.

4.3 Preparation.

(a) Intravenous dexamethasone (8 mg.) and cephalothin (1 g.)

(b) *Sigmacort* 1% ointment applied to lips;

(c) prepared and draped (head drape) in the conventional way for in intraoral procedure.

4.4 Access.

(a) Cheek retractors are positioned (assistant number 2).

(b) Arch bars are ligated to teeth (circumdental wires) if necessary.

(c) Haemostasis: infiltrate oral mucosa from first molar to first molar with Xylocaine 2% and adrenaline 1:80,000. 4 mls is usually adequate.

4.5 Incision.

(a) Above the attached mucosa , a mucosal incision is made from the area above the first molar on the right side around to the first molar on the left. the incision is tapered superior at each end, slightly out into the upper lip. Diathermy switching pencil (unipolar) or scalpel.

(b) an incision through the periosteum is then completed avoiding the soft tissues of the nose.

(c) any teeth other than the third molars that need extraction can be removed now.

4.6 Mucoperiosteal Reflection.

(a) Stripping is carried out in a superior direction to expose the lateral nasal wall, and anterior maxillary wall on each side. The infraorbital nerve defines the upper limit of this dissection.

(b)No reflection is carried out in the inferior direction maintaining the

integrity of the soft tissues (and their blood supply) over the alveolus.
(c) Tunnelling under the mucoperiosteum is performed back to the pterygomaxillary junction. Care of the created soft tissue pedicle is required to protect blood supply to the maxilla from the lateral tissues (ie the facial artery).
(d) Lateral nasal mucosa is reflected back gently towards the posterior nasal cavity underneath the inferior nasal conchae. The attachment of the cartilaginous nasal septum and the anterior nasal spine at the junction of the two maxilla is severed with a scalpel and the nasal mucosa on the floor of the nose reflected back.
(f) Retractors are now placed on one side of the maxilla. A bone hook is used to protect the region of the infraorbital nerve (care is needed to prevent a traction injury). A small malleable retractor is placed between the bone and the lateral nasal mucosa, and another is used to reflect and protect the lateral mucosa of the maxilla back to the pterygomaxillary junction.

4.7 Osteotomies.

(a)Using the sagittal saw a cut is made above the roots of the maxillary teeth commencing posterior through the zygomatic buttress and proceeding in an upper sloping fashion to the lateral nasal wall.
(b) A second cut can now be performed parallel and above the first to remove any bone for superior repositioning as determined by the model surgery.
(c) The saw is turned around and the cut continued posteriorly to the pterygomaxillary junction.
(d) A small straight osteotome is used to check these cuts and to continue the lateral nasal wall cut.
(e) The above four steps are performed on the contra lateral side.
(f) A nasal osteotome is then used to separate the nasal septum from the maxillae.

(g) Finally a large curved osteotome (12 mm) is placed between the posterior maxilla and the pterygoid plates. (Some surgeons perform this manoeuvre through the maxillary tuberosity) In a downward (45 degrees) , inwards (45 degrees) and forward direction the osteotome is struck with a mallet until it is palpated by the assistants finger placed at the junction of the hard and soft palates.

(h) All osteotomy cuts are reviewed for their completeness.

(i) if the maxilla is to be segmented the periosteum between the teeth is tunnelled under with a fine periosteal elevator. A combination of the saw and small osteotomes complete the alveolus cut. The palate is cut from the superior access once the maxilla is down-fractured.

4.8 Separation.

(a) With finger pressure whilst standing behind the patient the maxilla is down fractured. Whilst down fracturing the nasal mucosa along the floor of the nose is lifted in a posterior direction.

(b) Down fracture and subsequent manipulation of the maxilla can be enhanced by placing a wire through a hole created in the anterior nasal spine.

(c) If the maxilla can not be mobilised , the osteotomy cuts are reviewed. The Rowes disimpaction forceps may be used to assist with down fracturing .

(d) Bony interferences are removed as required.

(e) If damaged the descending palatine vessels can be isolated and ligated. (f) Maxillary sinus pathology can be removed (polyps are common).

(g) Third molars can be left in situ, extracted by conventional means at the commencement of the operation if erupted or partially erupted or they can be extracted if unerupted and high from the superior aspect whilst the maxilla is down fractured.

(h) Nasal mucosa is repaired with resorbable sutures as required.

4.9 Fixation.

(a) Check occlusion with wafer.

(b) Wire the maxilla , wafer and mandible together with 28 gauge wire - maxillo-mandibular fixation.

(c) With the condyles seated in the glenoid fossa (The complex being in its most posterior position) the complex is rotated up into its final position.

(d) With the assistant holding the complex units final position four four hole plates are adapted and placed over the osteotomy site with 5 or 6 mm screws. A range of plates and screws have been used . The preference now is for low profile plates (1.5 mm thickness) . Generally 'L' shaped or straight plates are used. Two on each side over the anterior maxilla.

Before the routine use of bone plates and screws circumzygomatic wires were placed with a trocar and stab incision over the zygomatic arch. Maxillo-mandibular fixation was also left in place for 6 weeks.

(e) Bone grafts if required are shaped and placed in the osteotomy sites.

(f) Maxillo-mandibular fixation is removed. The occlusion is checked with the wafer in and with it out.

(g) mandibular osteotomies if to be performed are then commenced.

4.10 Soft tissue closure.

(a) Alar cinching to prevent flaring of the nostrils is performed (Nylon suture).

(b) 'V- Y' closure (single or double) is performed to lengthen the soft tissue of the upper lip.

(c) The remaining soft tissue is closed with 3/0 chromic cat gut or 3/0 monoacryl sutures.

(d) The throat pack is removed.

5 Postoperative Management.

5.1 Immediate.

(a) High dependency recovery considered for 24 hours if patient in MMF.

(b)Intravenous dexamethasone 8 milligrammes 12 hourly and cephalothin 1 gram 6 hourly for 48 hours postoperatively.

(c) Narcotic analgesia intramuscularly or subcutaneously 4 hourly prn is gradually replaced with paracetamol - codeine preparations ;

(d) Clear fluids are given in the first 24 hours.

5.2 Postoperative recovery.

(a) Oral intake and ambulation are encouraged; and

(b) postoperative lateral head cephalogram, PA mandible and OPG are taken as early as possible to confirm the accuracy of surgery.

Appendix III: Bone Plate Removal.

One ongoing controversy with internal rigid fixation is the question of bone plate removal after healing is complete. The current philosophy of our unit is to remove symptomatic plates only. Patients are advised that if they wish asymptomatic plates can be removed at 6 months post surgery. In this study no patients elected to have asymptomatic plates removed. The answer lies between weighing up the morbidity of a further operation versus possible long term consequences of retained plates. Worldwide there is a trend towards removing all non functioning implants. Titanium plates are used in our unit over stainless steel and aluminium plates . They have excellent biocompatibility coupled with minimal disruptive effects on CT or MRI images make them the material of choice.

VIII

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