ELECTROSURGERY: EFFECT ON DENTAL PULP AND CEMENTUM

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DECLARATION

This thesis is submitted in partial fulfilment of the requirements for the Degree of Master of Dental Surgery in the University of Adelaide. Candidature for the Degree was satisfied by a Qualifying Examination in 1981.

This thesis contains no material which, except where due mention is made, has been accepted for the award of any other degree or diploma in any University. To the best of my knowledge, this thesis contains no material previously published or written by another person, except where due reference has been made in the text.

Sithiporn Thepbanterng

ABSTRACT

THE OBJECTIVE OF THE PRESENT STUDY WAS TO INVESTIGATE THE EFFECTS OF ELECTROSURGICAL NEEDLE CONTACT WITH THE CEMENTUM, UPON THE UNDERLYING DENTAL PULP. THE ANIMAL MODEL SELECTED WAS THE DOG, AND A CONTROL SERIES OF EXPERIMENTS WAS CONDUCTED TO SATISFY THE STUDY OBJECTIVES. THE FINDINGS WERE IMPORTANT IN THAT NO PULPAL DAMAGE WAS FOUND FROM GINGIVAL RESECTIONS USING AN ELECTROSURGICAL NEEDLE. SURFACE DAMAGE TO CEMENTUM WAS ALSO FOUND TO BE MINIMAL. EXTRAPOLATION TO HUMAN TISSUE IS NOT POSSIBLE, BUT THE INDICATIONS ARE THAT ELECTROSURGERY IS SAFE FOR DENTAL PULP WHEN PRACTISED WITH A NEEDLE TO TOOTH CONTACT TIME OF APPROXIMATELY FIVE SECONDS.

Chapter I

INTRODUCTION

Electrosurgery has been a widely practiced surgical modality in dentistry for approximately twenty years. In common with many other aspects of dental surgery, the technique was introduced by equipment manufacturers before thorough clinical trials had proven the safety of the method. Research into the pulpal effect of gingival electrosurgery is still lacking despite the widespread practice of gingival resection by electrosurgical means.

The dental procedures using electrosurgery in common practice are:

1) excision of inflamed or hyperplastic gingivae, and correction of deformities resulting from periodontal disease;

2) provision of access for the manipulation of sub-gingival dental caries and restorations;

3) removal of gingival tissue coronal to crown margins to facilitate impression-taking;

4) sterilization of root canals;

5) desensitization of hypersensitive dentine;

6) frenectomies, operculectomies;

7) removal of soft tissue over an impacted tooth to assist tooth eruption;

8) biopsies;

9) incision and drainage of abscesses.

The clinical effectiveness of electrosurgery is well known, and various treatises have encouraged dental surgeons to use the method for the purposes referred to earlier (vide supra). The literature review in Chapter II of this report demonstrates the deficiencies of scientific evaluation of the electrosurgical modality for dental use. Almost all of the published data relates to clinical evaluation or histological studies of wound healing and effects upon bone.

The major objective of the present study was to determine the effect of electrosurgery, applied to dental cementum, upon the underlying connective tissue of the dental pulp. The close relationship of dentine and pulp was also considered.

A series of experiments was undertaken to examine the effect of electrosurgery upon pulp following electrosurgical needle contact with dentine. There is a dearth of similar investigations previously reported. It will be seen that of the two previous reports, one maintained needle contact for a very long time (Agnew and Kaiser, 1952), and no contact duration was mentioned in the second study (Robertson et al, 1978).

This study was required to establish an animal model to investigate the effect of electrosurgical contact with cementum upon the dental pulp. It was necessary to simulate the technique commonly used in clinical dentistry, and it further required that the effect of electrosurgery on cementum be established. The scanning electron microscope was used to observe the surface changes of cementum resulting from contact with the electrode needle.

The basic intention of the present study was to evaluate the safety of the electrosurgical technique, as commonly practiced, upon vital dental pulp. The beagle dog provided an appropriate model, and the findings and conclusions are for dog experiments and thus may not be directly extrapolated to the human. There are, however, no pressing reasons to believe that human tissue would respond in a manner substantially different from that of the dog.

Chapter II

REVIEW OF THE LITERATURE

In the late nineteenth century, d'Arsonval (1891, cited by Noyes et al 1938), a French physicist and physician, found that high frequency waves (at that time above 10,000 cycles per second) could be passed through living tissue without causing shock, muscle contraction, or pain.

These waves were found to generate heat in the tissues, and from his findings the technique of diathermy was developed. The passage of high frequency electric current through the body was directed by two large plate electrodes placed on either side of the desired location. The resistance of the tissue to the passage of current between the plates caused considerable generation of heat.

Electrosurgery was a development of diathermy (surgical diathermy), developed by Lee deForest (1907), called "cold cautery" which used one small electrode for the working side, and a large plate electrode attached to the body of the subject.

In 1923-1924, George A. Wyeth, a surgeon, helped to design the electrosurgical instrument operated with deForest's three vacuum tubes. The instrument was effective, but expensive and not widely used.

The earliest electrosurgical unit was a spark gap generator, used for the destruction of tumors or ulcerated tissue and for coagulation. This machine used a highly damped electrical waveform.

In 1928, William Cameron designed the first electrosurgical unit for dentistry in which two mercury diodes served as rectifiers to produce a full wave modulated signal (fully rectified current).

Kelly and Ward (1932) were responsible for propagating electrosurgical ideas and improving the technique. Electrosurgery was taught privately by Ogus between 1937 and 1951.

Between 1940 and 1950, a number of articles on dental electrosurgery were published separately by Saghirian, Strock, and Ogus.

Oringer (1962) was responsible for a treatise on electrosurgery applied to dentistry that asserted that the technique could be used for all aspects of dentistry mentioned in the introduction.

Many papers compared electrosurgery and traditional surgical methods on wound healing. Few articles investigated the electrosurgical effect on the pulp and cementum.

Agnew and Kaiser (1952) showed that widespread pulpal destruction occurred when they used a loop electrode in contact with the cementum for half a minute. Vascular distension and inflammatory changes occurred within the pulp as a result of using needle electrodes in gingivectomy and gingivoplasty for one minute and forty-five seconds. Finally, an extensive localized necrotic change occurred in the pulpal tissue when they used the coagulating electrode on the cervical area for one minute.

Klug (1966) studied the gingival tissue following electrical retraction and found that the electrical retraction procedure did cause a loss of gingival crest height of approximately 0.1mm. Klug concluded from his observation that the electrical method of gingival retraction is a safe and effective means of exposing the cervicular margins of prepared teeth.

Fellman (1967) described the technique of using electrosurgery in gingival retraction for fixed prosthodontics and the common causes of failure with electrosurgery.

Pope et al (1968) studied the effects of electrosurgery on healing in dogs. They found that repair was delayed for a much longer time compared with the use of a knife. They concluded that following electrosurgery there was a greater degree of bone injury, indicated by the number of osteoclasts and osteoblasts in action during the healing phase.

Malone et al (1969) compared the initial incision of the tissue and the post-operative healing. The specimens were examined by light and electron microscope. The results of the electron microscope studies illustrate that electrosurgery is a safe, efficient method of tissue retraction and removal. The healing after a seven day period failed to show any difference between the usual knife cut and electrosurgery.

Glickman and Imbert (1970) conducted a biometric and histologic study in dogs to compare the effects of resecting the gingiva with electrosurgery and periodontal knives. Shallow and deep resections were performed as close as possible to the alveolar bone. The gingiva resected using shallow incisions showed more granulation tissue and more bleeding in the first two weeks. At the end of six weeks both techniques presented a similar microscopic appearance and, the underlying bone was unaltered.

After six weeks the animal with a deep resection showed gingival inflammation, recession, and reduction in bone height in all areas treated electrosurgically. On the knife treated side there was a well-formed gingival sulcus with slight recession, and gingival inflammation in the connective tissue with a reduction in the bone height. After twelve weeks, experimental period, both scalpel and electrosurgery specimens showed a well-formed gingival sulcus with gingival inflammation and recession, with a more marked reduction in the height of alveolar bone on the electrosurgical side.

They concluded that "(e)lectrosurgery performed with sufficient competence resulted in uneventful healing following shallow resection of gingiva. Electrosurgery can produce extensive gingival recession, bone necrosis, furcation involvement, and tooth mobility when used for deep gingival resections close to bone." Such damage did not occur following similar operations with periodontal knives.

In 1970, Eisenmann et al studied with an electron microscope the effect of knife and electrosurgery on cells in the line of the initial incision. Ultrastructural examination of the cells lying along the lines of incision made either by electrosurgery or with a knife revealed a striking similarity of appearance. They concluded that electron-micrographs of the initial incision site showed no tissue destruction by electrosurgery. Healing at the cellular level showed no appreciable differences following tissue removal using either conventional scalpel or electrosurgery.

Scheida et al (1972) investigated the response of the alveolar bone crests following direct contact with the electrosurgical electrode in adult mongrel dogs. The study revealed that the electrosurgery experimental areas showed bone loss from the alveolar crest to be no greater than that found in the control areas, and the alveolar bone of the mandible was affected less than the bone of the maxilla. They concluded that the use of the electrosurgical instrument in periodontal surgery provided a safe and effective instrument, even if contact with bone occured.

Aremband and Wade (1973) studied wound healing following gingivectomy by both electrosurgery and knives in humans. Clinical, photographic, crevicular fluid measurement, cytological, and histological evaluations were made after one, two, and three weeks. Tissue specimens were prepared for histological examination. The results from this investigation suggested that there were no differences in healing between the two surgical modalities over a three week period.

In 1974, Schneider and Zaki studied wound healing following electrosurgery and conventional knives in New Zealand white rabbits. The tissue specimens were examined by light and electron microscopes. The Cameron-Miller model 26-230 provided a fully rectified current, and the sequence of events in healing wounds were observed to have a similar pattern following the two surgical modalities, Morphological differences in the connective tissue did not seem to influence the course of healing. They concluded that the electrosurgical device could be used for gingivoplasty procedures without variations in healing sequence deleterious to repair of the tissues.

Friedman et al (1974) investigated a preliminary study of the histological effects of three different types of electrosurgical currents: a highly damped current, a modulated waveform, and a filtered, unmodulated waveform. They performed the experiment on three young adult male rats. Incisions were made on the palate at a constant depth. After the operation, tissue was removed by scalpel for histological examination. They found that the smooth unmodulated current resulted in the least amount of tissue destruction.

Sozio et al (1975) developed a controlled system including mechanical control (standardization of amperage, voltage, and waveform) to evaluate histologically and electronically non-filtered full-wave modulated, and filtered current. The experiment was performed on the dorsal surface of the tongues of three inbred adult guinea pigs. They found that the scalpel wounds demonstrated more rapid healing in the early stages than wounds made by either of the two electrosurgical currents. After two weeks they found that there was little difference in healing of the three wound sites. They concluded that electrosurgery can be effectively employed in restorative dentistry.

Nixon et al (1975) made an histological evaluation of the effects produced in alveolar bone following gingival incision with an electrosurgical scalpel (Coles Electrosurg TR-2 providing an undamped, fully rectified current). Twenty-five adult male guinea pigs were used in the experiment. They used an electrosurgical electrode in direct contact with the periosteum. They suggested that the use of electrosurgery in contact with alveolar bone should be avoided.

Coelho et al (1975) conducted a clinical investigation to determine the gingival recession that occurred when electrosurgery was used to expose The margins of preparations during the impression stage. The investigation was completed on 25 patients. The study used a Coles Radiosurgical Electronic Scalpel IV, which provided a coagulating current prior to making an impression. All experimental and control teeth were measured following tattooing, immediately after making impressions, after final cementation, one month, and six months after insertion. They found that an average reduction of gingival crest height of 0.23mm had occurred after six months. Only six of the twenty-five patients had complete tissue regeneration.

Noble et al (1976) studied a histological comparison of effects of electrosurgical resection using different electrodes. They operated on eleven men and women using a Cameron-Miller 26-30 fully rectified dental electrosugical unit. The dial was set at 3.5 and Cameron-Miller No. 26-1232 (a small off-set loop) and No. 26-1233 (a 90° insulated needle point) electrodes were used to retract the gingival sulcus of the interdental papilla. The tissue specimens were examined by light microscope, a wide band of coagulation necrosis resulted from the use of small loop electrodes. They suggested that to minimize tissue damage, very fine wire electrodes should be used, and deep penetration of tissue should be avoided.

Sozio et al (1976) conducted a controlled study of electrosurgical currents and wound healing. This study was made to determine the tissue healing after one and six months. They found some connective tissue response at electrosurgical sites after one month of wound healing, but there was no difference in the wounds after six months; all wounds had healed completely.

Wilhelmsen et al (1976) studied the effects of electrosurgery on the gingival attachment in monkeys. A Coles Radiosurg

Electronic Scalpel IV, a device with a fully rectified, high frequency current of undamped waveform, was employed to perform gingival resection around the teeth by using a straight, single filament electrode needle at experimental time intervals of 1 month, 3 months, 6.5 months, and 9 months. They found statistically significant recession of the free gingival margin, loss of connective tissue attachment, and apical migration of the junctional epithelium. Areas of cementum burning were found where the electrode touched the root surface. They concluded that gingival electrosurgery for crevicular troughing posed a considerable risk to periodontal tissue.

Stark et al (1978) investigated the effects of retraction cords and electrosurgery on blood pressure and tissue regeneration in Rhesus monkeys. An 8% r-epinephrine retraction cord (Racord), a non-epinephrin-type retraction cord (Pascord), a fully rectified electrosurgical device (a Coles Radiosurg Electronic Scalpel IV), and a spark gap electrosurgical device (Hyfrecator), were used for gingival retraction prior to impression-taking procedures.

They found that there was a rise in blood pressure, both systolic and diastolic, following operation by Racord, the Hyfrecator, and a Coles Radiosurg Electronic Scalpel IV. There was no effect on blood pressure following the use of Pascord. Both electrosurgical devices caused a height reduction at the gingival crest, and a marked amount of tissue loss resulted from the Hyfrecator. The authors suggested that the Hyfrecator is not a suitable instrument for tissue resection.

Robertson et al (1978) studied the pulpal and periodontal effects of electrosurgery involving cervical metallic materials in monkeys. A Strobex S-200, providing a fully rectified current, was used to make four experiments on each monkey. Class V preparations, filled with Spherical Alloy, were touched with a needle electrode. Next an electrode was placed on sound enamel. The third group, comprised of restored teeth (Class II), were not subjected to electrosurgery. Finally the control group was untouched teeth.

They found that only electrosurgery involving restored teeth showed major damage to both pulp and periodontal tissue. At 24 hours the area adjacent to the restoration was changed by disruption of pulpal tissue consistant with coagulation necrosis.

After one week the coronal portion of the pulp chamber was necrotic and had a zone of separation between vital and necrotic pulp tissue. An isolated area of necrosis and mineralized tissue resorption were noted in the furcation of multi-rooted teeth, but similar changes were not observed in single-rooted teeth.

After eight weeks the entire pulp had become necrotic and resorption of the dentine was apparent in furcation areas associated with a dense accumulation of polymorphonuclear leukocytes. Loss of periodontal ligament and osteoclastic resorption of interradicular bone was a common finding in multi-rooted teeth.

In 1978, Maness et al studied the histologic effects of electrosurgery with varying frequency and waveform. The four machines, which differed in output, waveform, and frequency, were used to perform a series of cuts on hamster tongues. Three machines were the full wave rectification type. Two machines had identical carrier frequencies of 1.7 megahertz, but different waveforms -- one was a full wave rectification type, while the other had a continuous waveform. Three hamsters were used in each machine and sacrificed immediately after each series of cuts was completed.

Histologic analysis showed that:

1. The machine with full wave rectification and the lowest frequency of operation produced significantly greater tissue alteration than did those with full wave rectification and higher frequencies of operation.
2. The continuous output waveform produced significantly less tissue alteration than the modulated type at the same frequency of

operation.

3. Histologically, the experimental defect showed a band of coagulation necrosis along the margin of the incision.

4. The experimental defect was similar in shape to the physical form of the cutting electrode.

Resection of gingival hyperplasia in mentally handicapped patients treated with the antispasmodic, dilantin sodium was suggested by Walker et al(1980). Gingivectomies were performed under general anaesthesia, using both the coagulating and cutting modalities of electrosurgery in comparison with traditional surgical methods. Bleeding time, length of procedure time, post-operative haemorrhage, and post-operative discomfort were compared. They found that electrosurgery eliminated the problems of conventional surgical excision.

Retraction of marginal gingivae in restorative techniques was performed by Ruel et al (1980). They compared the long term post-treatment effects of the use of retraction cord, copper band, and electrosurgery. The parameters of wound healing and gingival recession were observed. They found that the wounds from copper bands healed rapidly, producing the least permanent recession, and that electrosurgical incisions healed slowly and resulted in the greatest amount of permanent gingival recession. However, the electrosurgical technique they described did not use a needle held parallel to the tooth in the gingival crevice, but was angled in from the gingival crest. The comparison on that basis may be quite unfair.

Kalkwarf, et al (1981) studied early healing of electrosurgical incisions in humans. A needle electrode was used to make an incision at the facial aspect of the maxilla. The mean length and time of the incisions were 2mm. and 0.35 seconds respectively. The incisal biopsy specimens were obtained by scalpel incision at 0, 6, 12, 18, 24, 30, 36, 48, and 72 hours after electrosurgical wounding. They concluded that the clinical healing of electrosurgical wounds was complete at 72 hours. The initial wound healing exhibited the characteristics similar to the scalpel wound but it produced little haemorrhage or clot formation. Epithelial repair was not inhibited by the electrosurgical method. A denatured zone of collagen was evident adjacent to each incision for the entire 72 hours of this study. Inflammatory infiltration was minimal and consisted primarily of lymphocytes.

Chapter III

MATERIALS AND METHODS

Animal Model

The beagle dog was selected as the animal model to test the effect of a simulated clinical electrosurgical trial. The aim of the study was to reproduce the clinical conditions associated with the use of electrosurgery in restorative dentistry (exposure of crown margins). Four beagle dogs, all aged approximately two years and weighing 11.5 kg., were used to obtain the research materials recorded in the results of this report.

Equipment

The electrosurgical machine used in the experimental series was a Siemens Sirotom. The machine delivered a fully rectified current with an undamped wave form. The current flow was uniformly continuous and free from pulsating peaks of heat (Fig 1).

Fig. 1 Siemens Sirotom Electrosurgical Unit

The machine was used in a biterminal configuration with the indifferent electrode placed between the front legs of the dog. A No. 2 needle electrode angled at 45 ° was used for the gingival resection at a machine setting of 4.5 (Fig 2).

Fig. 2 A No. 2 Needle Electrode

Theraputic Agents

The dogs were starved for twenty-four hours prior to surgery and premedicated with Innovar-Vet 1ml. subcutaneously one hour before operation (each ml of Innovar-Vet contains 0.4mg. Fentanyl and 20mg Droperidol). Surgical anesthesia was obtained using 2mls. of intravenous Nembutol (60mg/ml).

Xylocain with adrenaline 1:50,000 was placed at the buccal fold in both premolar regions of the lower jaw prior to the use of the surgical modalities under test.

EXPERIMENTAL TECHNIQUE

In this study, two experiments were planned for each dog.

1) In the right mandibular premolar region the crevicular aspect of the gingiva was resected using the electrosurgical needle. The needle was used to simulate the clinical situation and remained in contact with each tooth for approximately five seconds. In the contralateral region the control teeth were treated by creating a similar internal bevel resection of the gingiva approximately 1mm from the crest using a No. 15 Bard Parker scalpel blade.

The two main purposes of this experiment were:

i) to investigate the pulpal effects of electrosurgical application to the adjacent cementum;

ii) to investigate the surface changes of cementum following electrosurgical application.

As approximately 10% of human teeth have exposed dentine between the cementum and enamel (Neyes,*et al*, 1938), clinical dental electrosurgery has the potential for contact with dentine.

No controlled experiments have been reported on the pulpal effect of electrosurgical contact with cervical dentine. Therefore, in this experiment, a model for dentinal contact was established by preparing a cervical class V cavity to expose dentine in that region.

2) Two premolar maxillary teeth had class V cavities prepared using a belt driven, low speed, right-angled handpiece and sharp steel burs. The cavity depth was approximately 1mm (Fig 3).

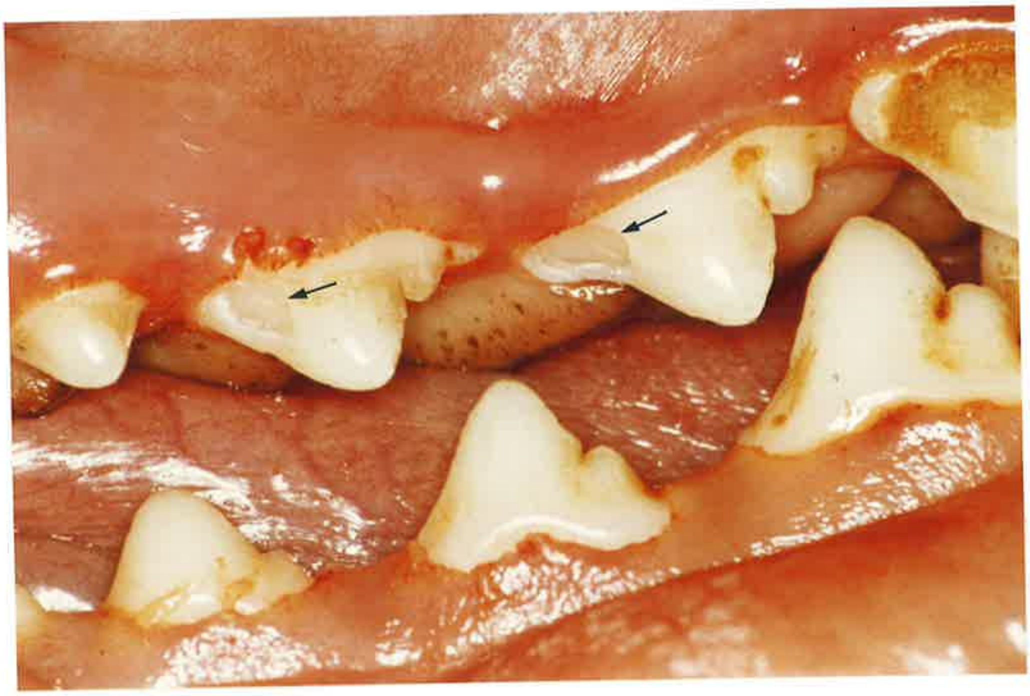

Fig. 3 Class V Cavities in Maxillary Teeth

An active electrosurgical electrode was passed across the dentinal floor of the Class V cavity on the right side. The cavity floor of the contralateral premolars, used as the control specimens, were touched by an inactive electrode. Amalgam was used to fill all cavities following the operation (Fig 4)

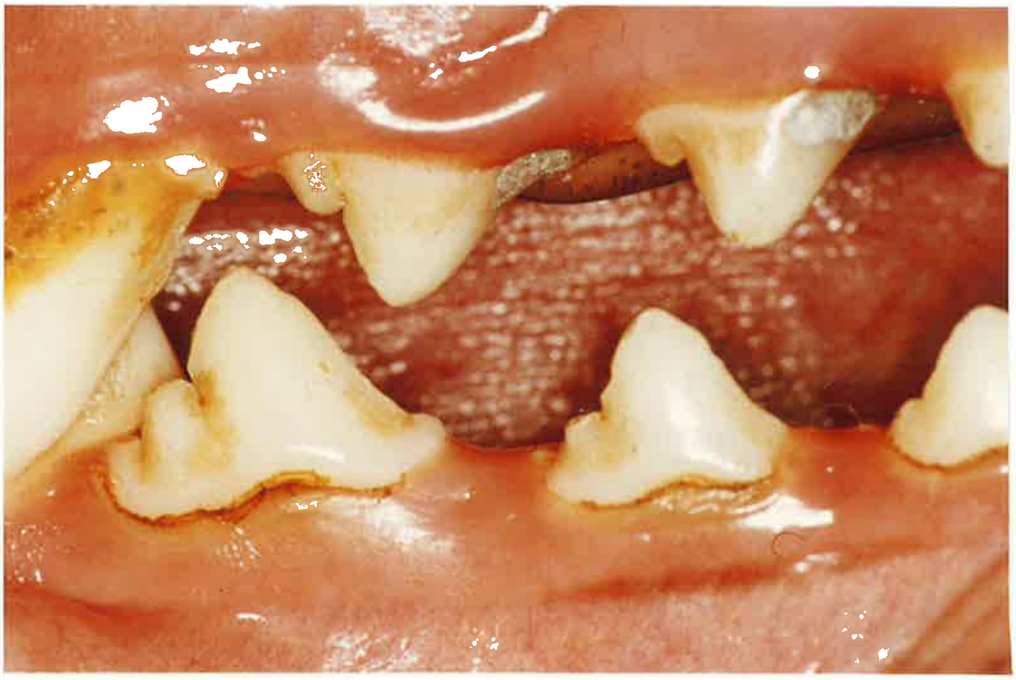

Fig. 4 Amalgam Restorations in Class V Cavities

Schedule of the Operation on the Dogs

Table 1

			Date of operation		Date of sacrifice
Dog	I	(F)	24/9/80	4 weeks	22/10/80
Dog	II	(M)	26/9/80	1 hour	26/ 9/80
Dog	III	(M)	29/9/80	24 hours	30/ 9/80
Dog	IV	(F)	30/9/80	1 week	7/10/80

Surgical Procedure

It was decided to fix the tissue in situ by perfusion of the left common carotid artery with 10 per cent buffered formal saline. The formalin was contained in a plastic tank five feet above the level of the operating table and fed via a plastic tube to a catheter inserted into the left common carotid artery. A second catheter was inserted into the right external jugular vein which providing for drainage of blood and formalin from the head. During perfusion, the head of the dog was lowered ensuring that the formalin 'pooled' in the required tissues. The formalin was allowed to flow until the solution leaving from the drainage tube was clear (approximately one hour).

Dissection

When perfusion was complete the skin and tissue were dissected from the jaws leaving a small area of gingivae in the operating sites for block sections. The block sections were separated from the jaws by using a bone chisel and mallet. The lower block sections were cut between the distal aspect of the fourth premolar and the mesial aspect of the first premolar of both quadrants. Maxillary block sections were cut mesial to the second and distal to the third premolar of both quadrants. All specimens were put in 10% formalin after separation into individual teeth with their adjacent hard and soft tissues; each specimen was kept in the individual jar.

All specimens from the maxilla were used in the light microscope for histological investigation of the effect of electrosurgery on pulp following contact of the needle with dentine (cavity floor).

One of the mandibular specimens form each dog was used in the Scanning Electron Microscope (S.E.M.) study for the investigation of the surface of cementum (Fig 5).

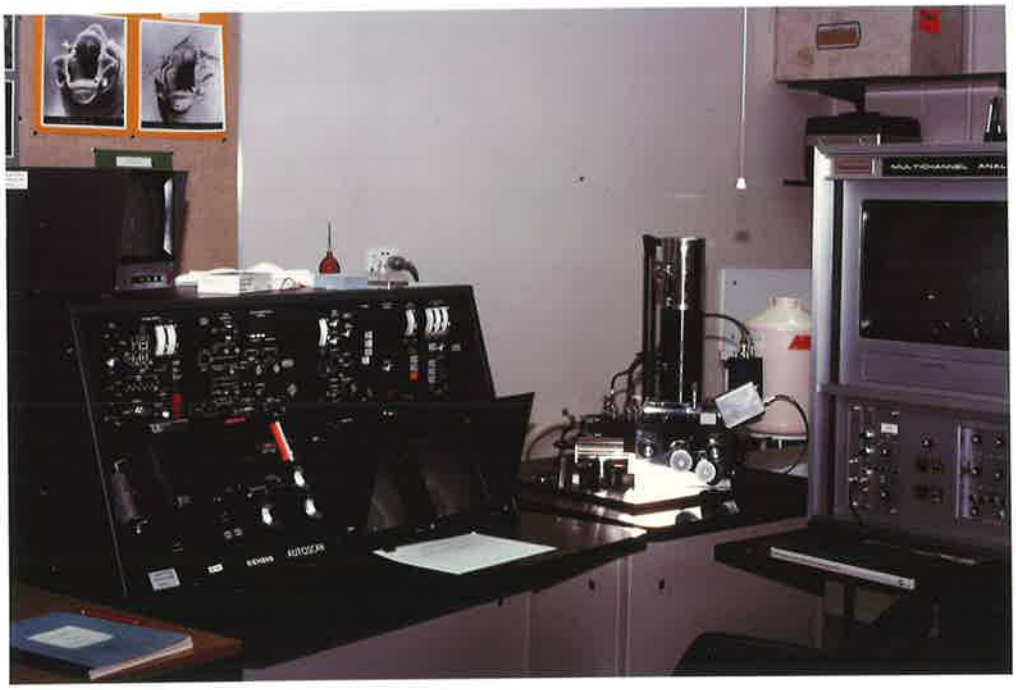

Fig. 5 Scanning Electron Microscope

The second and third premolars were used in the light microscope for investigating the histology of pulpal tissue following the application of an electrosurgical needle to the crevicular cementum.

Histological Processing (S.E.M.)

The specimens which were used for S.E.M. were deorganified in sodium hypoclorite 5% at room temperature, the solution was changed everyday until the teeth separated from their sockets. The teeth were then placed in a large beaker and washed with running water for one hour, then passed through graded alcohols as follows:

70%---12hrs
90%---12hrs
95%---12hrs
100%---24hrs
100% over anhydrous copper sulphate---24hrs

Following this, the specimens were left on filter paper in a covered glass dish to air dry and then mounted onto aluminium S.E.M. stubs and coated with gold/palladium 20nm and carbon 15nm for viewing in the S.E.M.

Histological Processing (L.M.)

The specimens used for light microscope were decalcified in formic formate solution that was changed every day until decalcification was complete (5 to 8 weeks depending on the size of the specimens). The decalcified specimens were washed in running water for one hour and dehydrated through graded alcohols for two days, cleared in celloidin for four days, and double-embedded under vacuum in paraffin wax.

A rotary microtome was used for section preparation at 6 microns after which the tissues were mounted on microscopic slides, dried and stretched on a warm plate. The slides were put in the 37°C oven for one hour for drying and changed to the 60°C oven for forty minutes. Haematoxylin and eosin solution was used to stain the tissues.

The criteria used for pulpal evaluation in this study are:

1) Inflammation -- based on the degree or density of round cell infiltration.

0	none
1	mild
2	moderate
3	severe

2) Degenerative changes -- based on changes in odontoblasts including loss of cellular details and vacuole formation.

3) Calcification -- based on demonstrable calcified materials in the pulpal tissues, e.g. secondary dentine, pulp stones, and dentinal bridges.

Chapter IV

ELECTROSURGICAL EFFECT ON PULP: LIGHT MICROSCOPE STUDY

Specimens obtained by the histological techniques described in Chapter III for the four time periods of the investigation are described herein.

Mandibular teeth were used for controls, and an inactive electrode was moved across the buccal aspect in contact with cementum. Both maxillary controls had a buccal cavity cut in the cervical region, and an inactive electrode moved across the dentine of the cavity floor.

A.

APPLICATION OF ELECTROSURGICAL ELECTRODE TO CEMENTUM

One Hour

Mandibular Control Teeth

A section of one of the mandibular control specimens is shown in Fig. 6. No changes within the pulp were detected at the base of the region touched by the electrode.

Experimental Teeth

A one hour specimen from the active electrode series also showed that no changes were apparent within the pulp tissue as a result of electrosurgery. The odontoblast and predentine appeared to be normal (Fig. 7).

Control and Experimental Specimens

Dog Mandibular Premolar Teeth

ONE HOUR

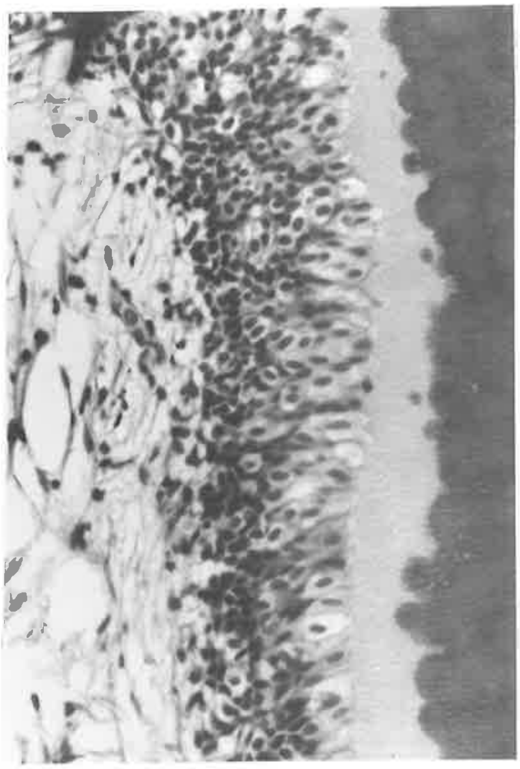

Fig. 6 x400

The normal relationship of odontoblasts is shown in a one hour control.

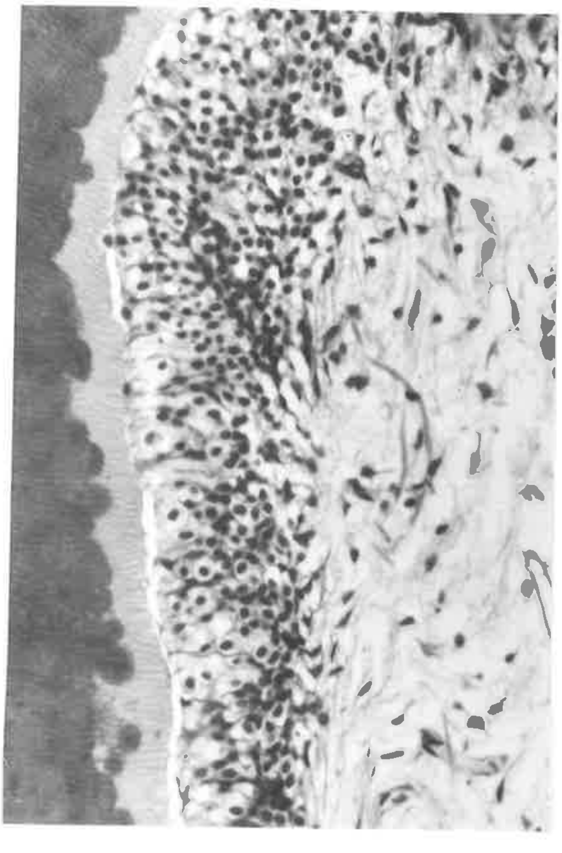

Fig. 7 x400

A one hour specimen following an active electrode contact with the adjacent cementum. No detectable pulpal change had occurred.

Twenty-four Hours

Mandibular Control Teeth

The control specimens retrieved after twenty-four hours were all normal in appearance. No disturbance of the odontoblast nuclei was detected and no inflammatory cells could be detected within the tissue (Fig. 8).

Experimental Teeth

No changes could be seen in the experimental teeth twenty-four hours after the electrosurgical contact. All pulpal histopathological parameters appeared normal (Fig. 9).

<u>Control Specimens</u>

Dog Mandibular Premolar Tooth

TWENTY-FOUR HOURS

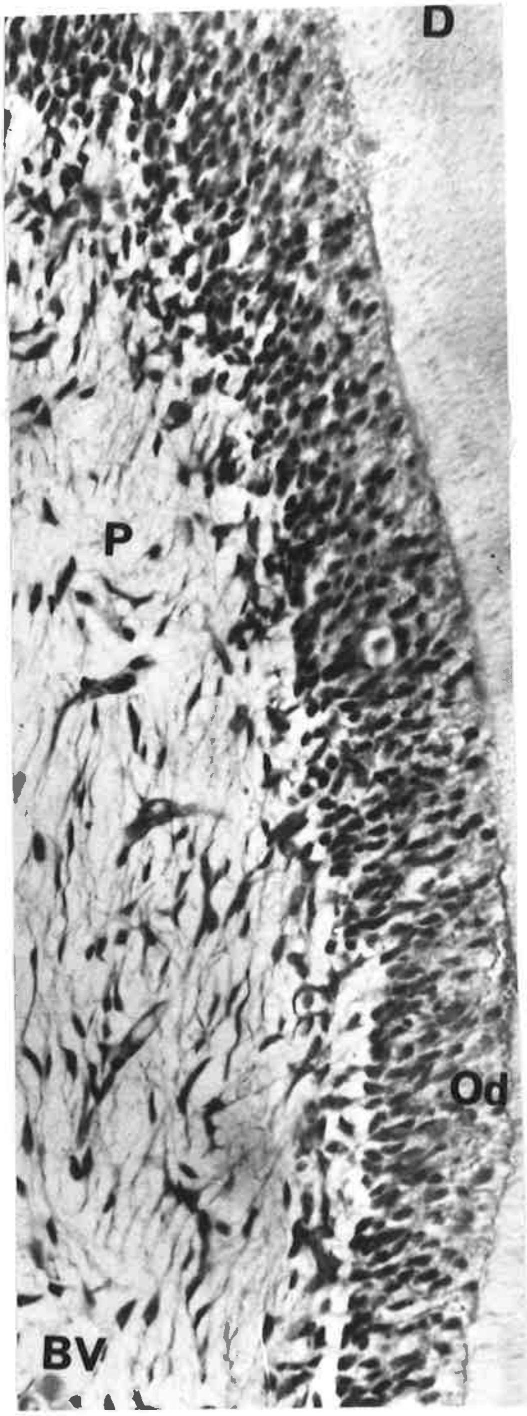

Fig. 8 x400

A high powered view of a control specimen shows a normal pulp. No damage to odontoblast and no inflammatory cells were detected.

Experimental Specimen

Dog Mandibular Premolar Tooth

TWENTY-FOUR HOURS

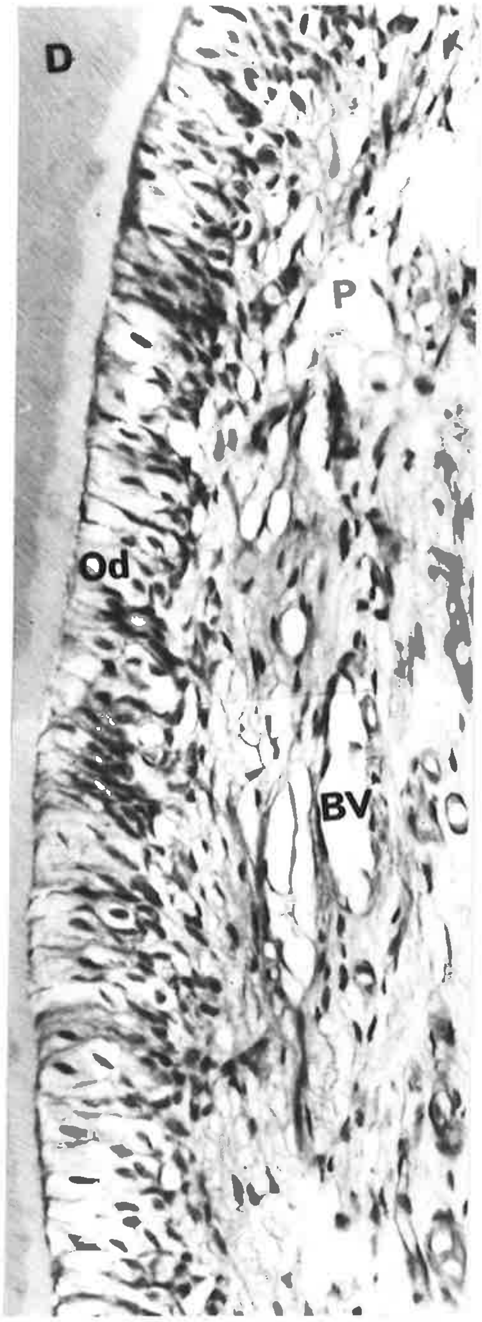

Fig. 9 x400

A high powered view of an experimental tooth shows normal pulpal histopathology. The odontoblastic nuclei are within cells, no evidence of nuclei within the dentinal tubules, and no evidence of inflammatory cells.

One Week

Mandibular Control Teeth

It may be seen from Fig. 10 that a normal predentine - odontoblast appearance was maintained at this time period. No evidence was found of odontoblast degeneration or of inflammatory cell infiltration.

Experimental Teeth

Fixation problems detracted from this series, but from Fig. 11 it is evident that no disruption of the odontoblastic layer had occurred. No nuclei could be seen within the dentinal tubules and no inflammatory cells were visible. There were no tangible signs of damage from contact with the electrosurgical electrode.

Control and Experimental Specimens

Dog Mandibular Premolar Teeth

ONE WEEK

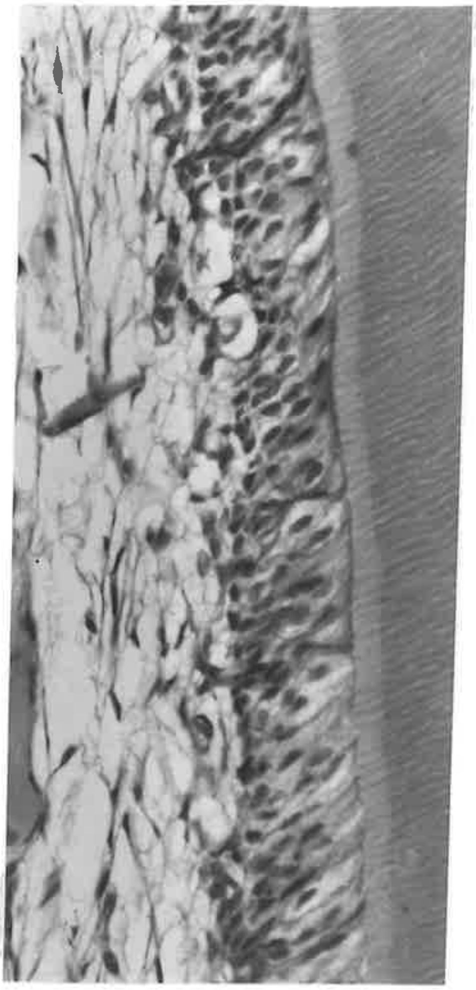

Fig. 10 x275
A one week control specimen shows a normal pulp.

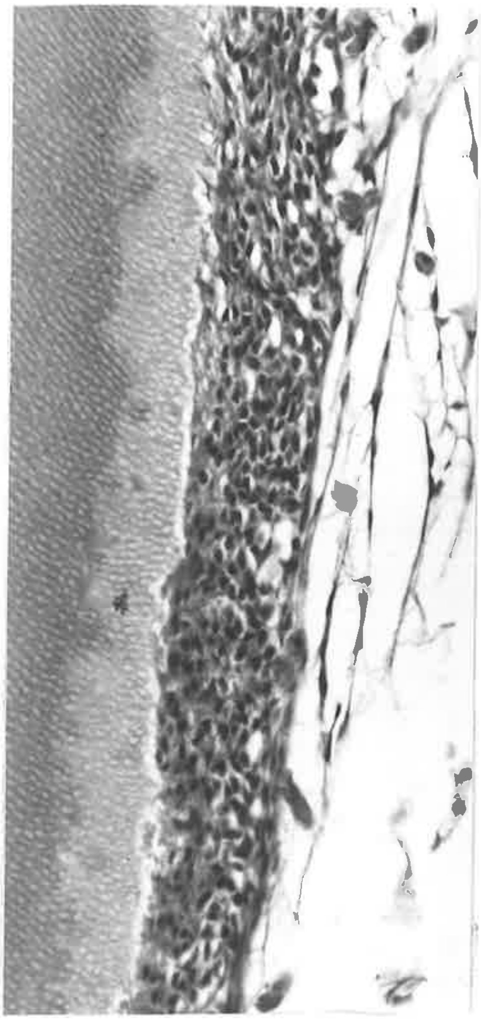

Fig. 11 x275
A one week experimental specimen shows a normal predentine -- odontoblast relationship with no loss of odontoblastic nuclei.

Four Weeks

Mandibular Control Teeth

As with specimens examined from the earlier time periods, no changes could be found in the control teeth (Fig. 12).

Experimental Teeth

From Fig. 13 it is evident that normal tissue was found at the base of the dentinal tubules related to the experimental area. No effect of application of the activated electrosurgical probe could be detected.

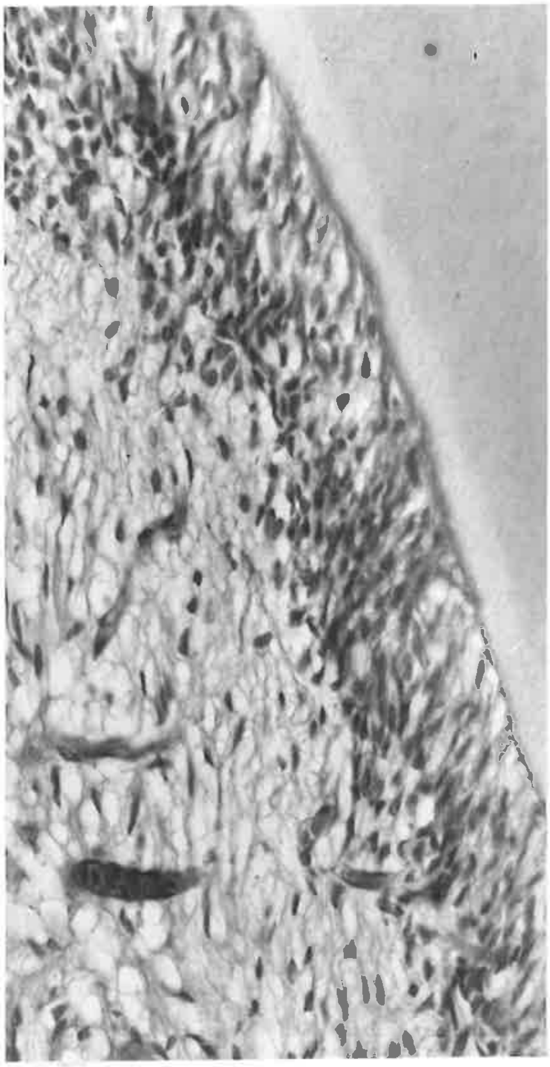

Fig. 12 x275
Normal pulp tissue was observed at the four week time period for control specimens.

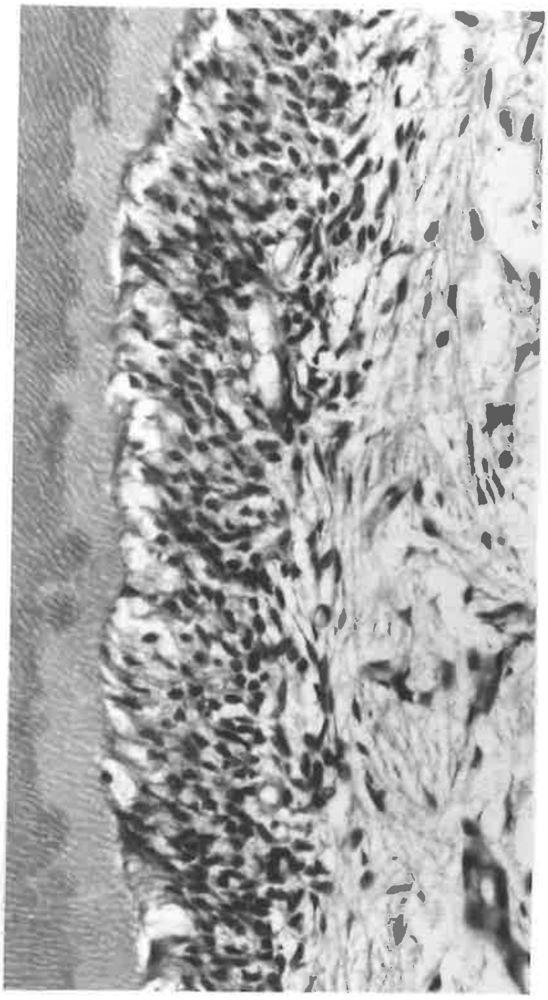

Fig. 13 x275
The experimental tooth showed that the active electrosurgical electrode had no detectable pulpal effect.

B.

APPLICATION OF ELECTROSURGICAL ELECTRODE TO DENTINE (CAVITY FLOOR)

One Hour

Maxillary Control Teeth

A section of one of the maxillary control specimens is shown in Fig. 14.

The pulpal region at the base of the control cavity that was touched by an inactive electrode appeared to be normal. Slight processing artefacts were evident, but no odontoblastic nuclei were present in the dentinal tubules or appeared to have been disrupted or reduced in number.

Experimental Teeth

No changes from the normal histopathological appearance were detected; no inflammatory cell infiltration was evident, although slight processing artefacts had resulted in separation of the odontoblasts from the predentine. No evidence of pulpal oedema was evident.

<u>Control and Experimental Teeth</u>

Dog Maxillary Premolar Teeth

ONE HOUR

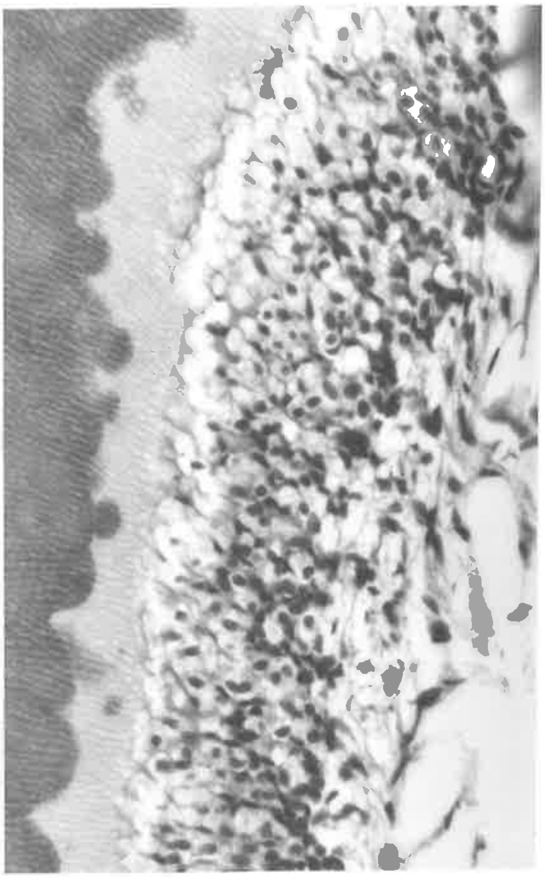

Fig. 14 x400

A one hour control shows that cavity preparation and an inactive electro-surgical probe tip had no detectable effect on the pulpal tissue.

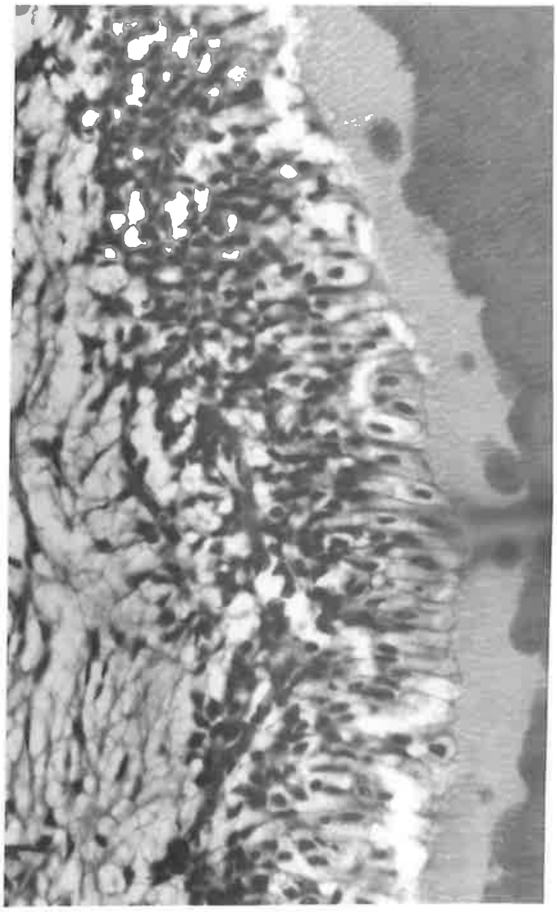

Fig. 15 x400

The experimental teeth also showed no signs of inflammation one hour after an application of an active electrosurgical tip.

Twenty-four Hours

The control specimens were completely normal (Fig. 16), but some minor histopathological changes were evident in the experimental sections. Oedema of the odontoblastic layer was evident, but no nuclei were present in the dentinal tubules. No inflammatory cells were evident in the tissue after this time period.

The distance from the floor of the cavity to the pulp in these specimens on average was 1.0mm.

Fig. 16 x400
The twenty-four hours control specimens showed a normal histological appearance.

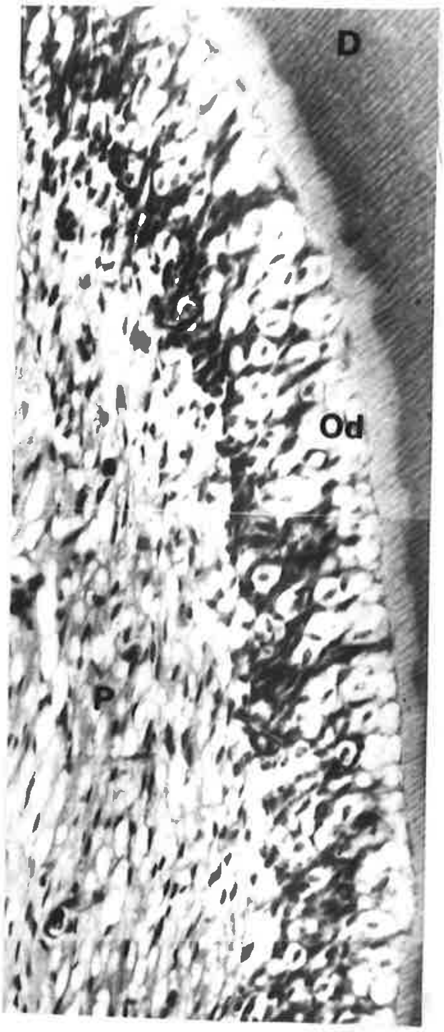

Fig. 17 x400
The experimental teeth also showed an intact odontoblastic layer, but some oedema of the odontoblast was evident.

One Week

At one week the control tooth illustrated the normal arrangement of the odontoblastic layer without disruption or reduction in the number of cells. The pulp tissue demonstrated the normal configuration (Fig. 18).

In an experimental specimen (Fig. 19), all of the observed pulpal characteristics were normal.

Control and Experimental Teeth

Dog Maxillary Premolar Teeth

ONE WEEK

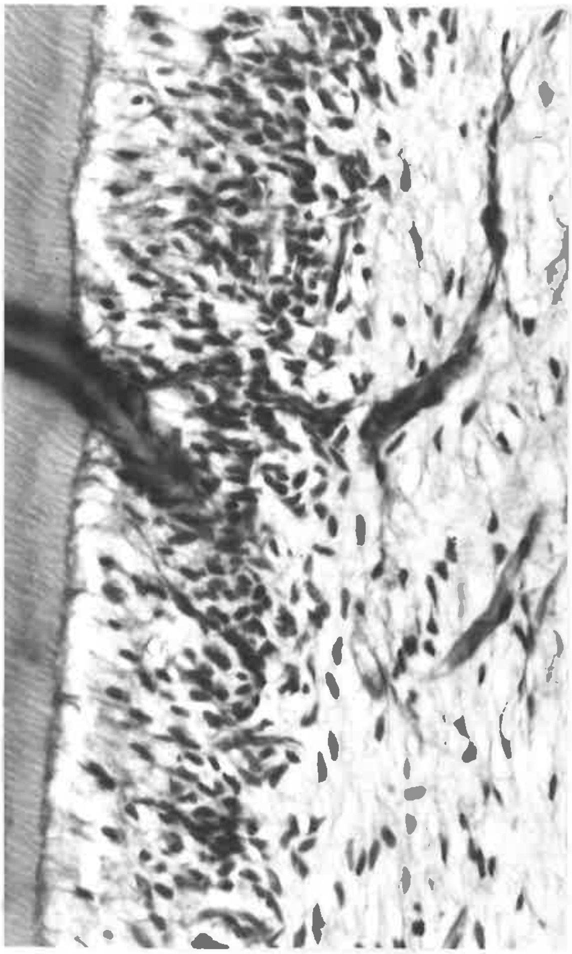

Fig. 18 x275

One week specimen. A histological configuration demonstrated the normal characteristics of pulp.

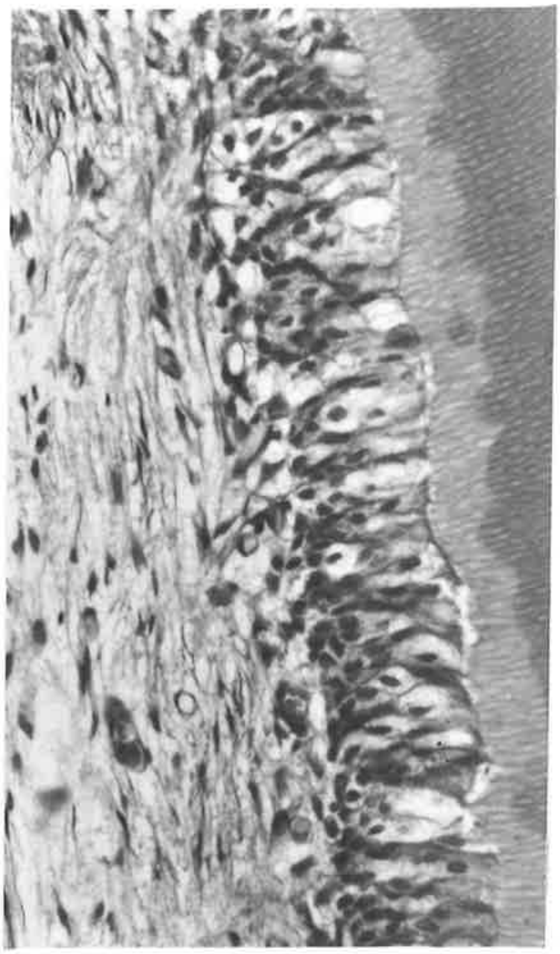

Fig. 19 x275

Experimental specimens following the contact of an active electrode on dentine showed the normal arrangement of odontoblasts and adjacent pulp tissue.

Four Weeks

Maxillary Control Teeth

The normal histological pattern of pulp in the control specimens subjected to an inactive electrosurgical tip touching the floor of the cavity is shown (Fig. 20). There was an artefact in the odontoblastic layer due to the histopathological technique. No inflammatory cells were observed in either the wider pulp tissue or the odontoblastic cells.

Experimental Teeth

At four weeks the experimental specimens in which dentine was touched by the active electrode demonstrated the normal characteristics of both the odontoblastic cells and the adjacent pulp tissue. No evidence of inflammatory reaction was observed in either region (Fig. 21).

Control and Experimental Teeth

Dog Maxillary Premolar Teeth

FOUR WEEKS

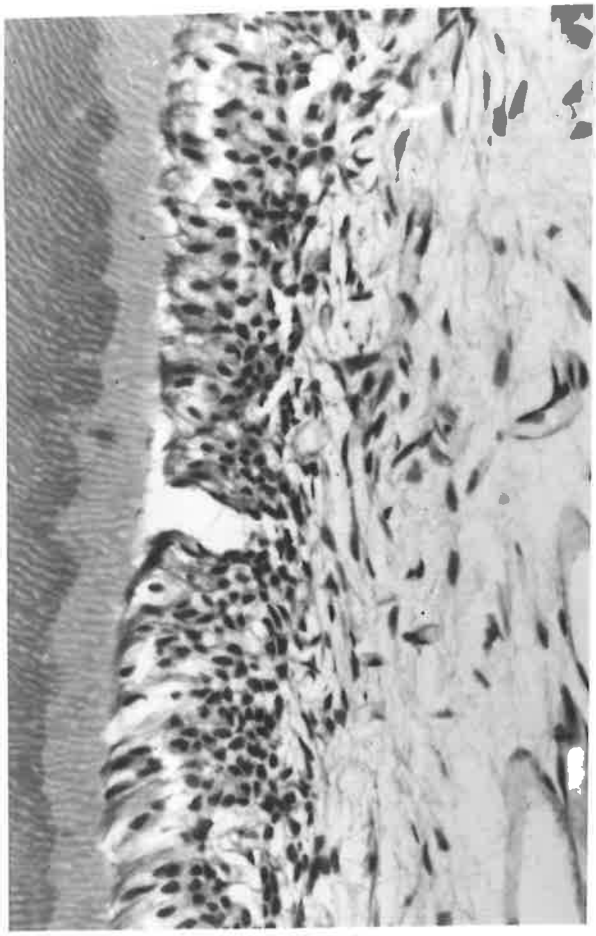

Fig. 20 x275

One specimen of a four week control tooth in which the tip of the electrode touched the cavity floor showed the normal pattern of the odontoblastic layer and pulp tissue.

Fig. 21 x275

One four week experimental specimen showed the normal layer of odontoblastic cells and adjacent pulp tissue after it was touched by an electrosurgical knife on the dentine surface.

DISCUSSION

From both series of experiments it is evident that a single shot linear contact of an active electrosurgical probe with cementum or dentine has no discernable pulpal effect. Perhaps the twenty-four hour specimen from the B group (Fig. 17) shows some minor pulpal hydropic changes to the odontoblasts. The technique of resecting gingival tissue for reasons of access to margins in restorative dentistry would appear to be efficient and safe.

On a cautionary note, however, it might be very important to reduce the time of contact of the probe with dental structures to the minimal level consistant with efficiency.

Chapter V

ELECTROSURGICAL EFFECT ON CEMENTUM: SCANNING ELECTRON MICROSCOPE STUDY

Control Specimens

The scanning electron microscope has provided the mechanism whereby the effect of touching cementum with a high-energy electrosurgical tip may be assessed. It was noted in the literature review that electrosurgery, or "cold cutting," works by the tissue adjacent to the electrode disaggregating by the sudden production of heat within the tissue, resisting the passage of high energy radiation from the electrode. From Chapter IV it was apparent that the local heating did not have significant effects only a short distance away within pulp tissue. However, the local effect on cementum was marked but localised and limited to the point of contact with the electrode. Cementum immediately adjacent to the track was not altered, as demonstrated by the 500x magnification of Fig. 26.

The composite view of a dog premolar unit (Fig. 22) demonstrates the morphology of the furcal region extending as far as the CEJ. The higher magnifications show the basic anatomical structures and the effect of the electrosurgical contact (Fig. 24, 26, 27, 28).

Control Specimen

Dog Mandibular Premolar Tooth

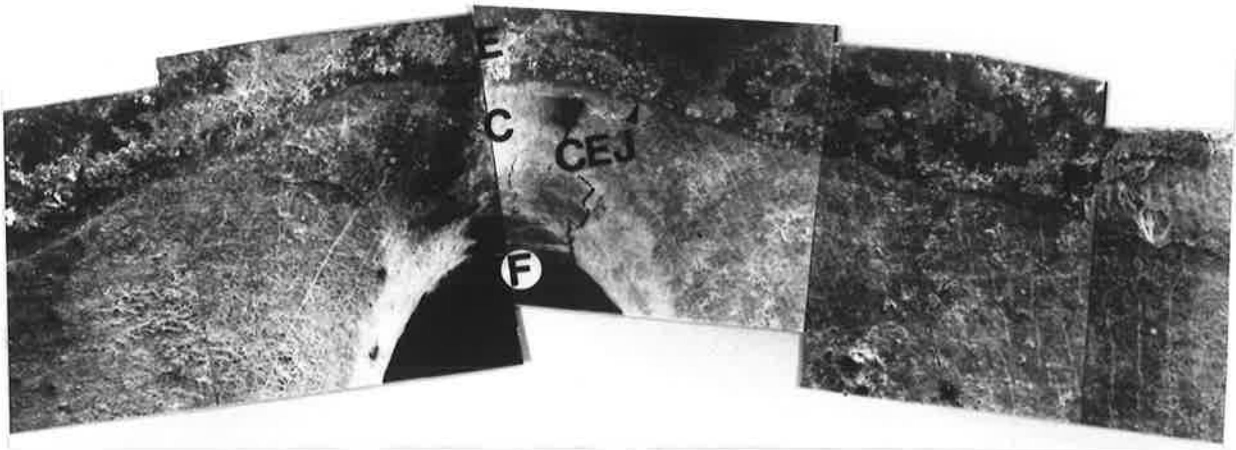

Fig. 22: Composite Photograph x 20 S.E.M.

E - enamel

C - cementum

F - furca

CEJ - cemento-enamel junction

The well-defined margin between cementum and enamel is clearly visible, although crystals of calculus may be seen crossing the junction.

Control Specimen

Dog Mandibular Premolar Tooth

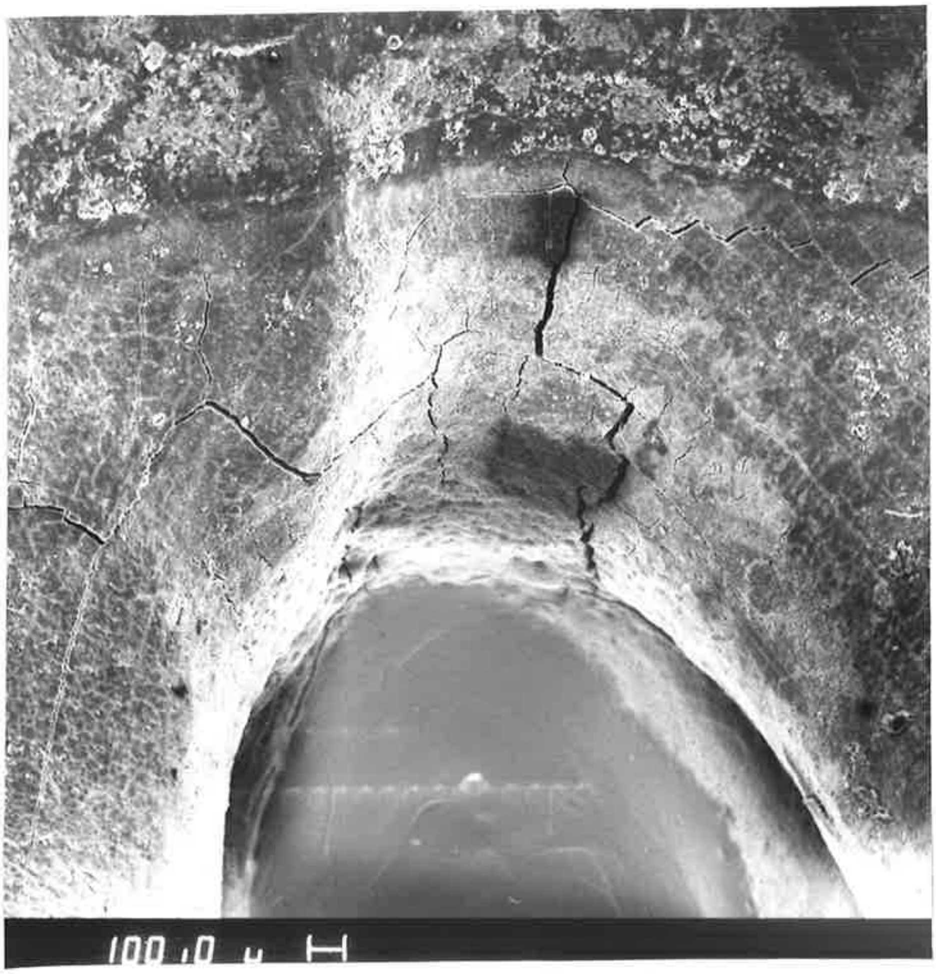

Fig. 23   x 20 S.E.M.

The furcal region between the two roots is shown, along with the cemento-enamel junction, cementum, and enamel. The cemental surface provides the comparison for the cemental damage produced by the electrosurgical needle shown in Fig. 25.

Control Specimen

Dog Mandibular Premolar Tooth

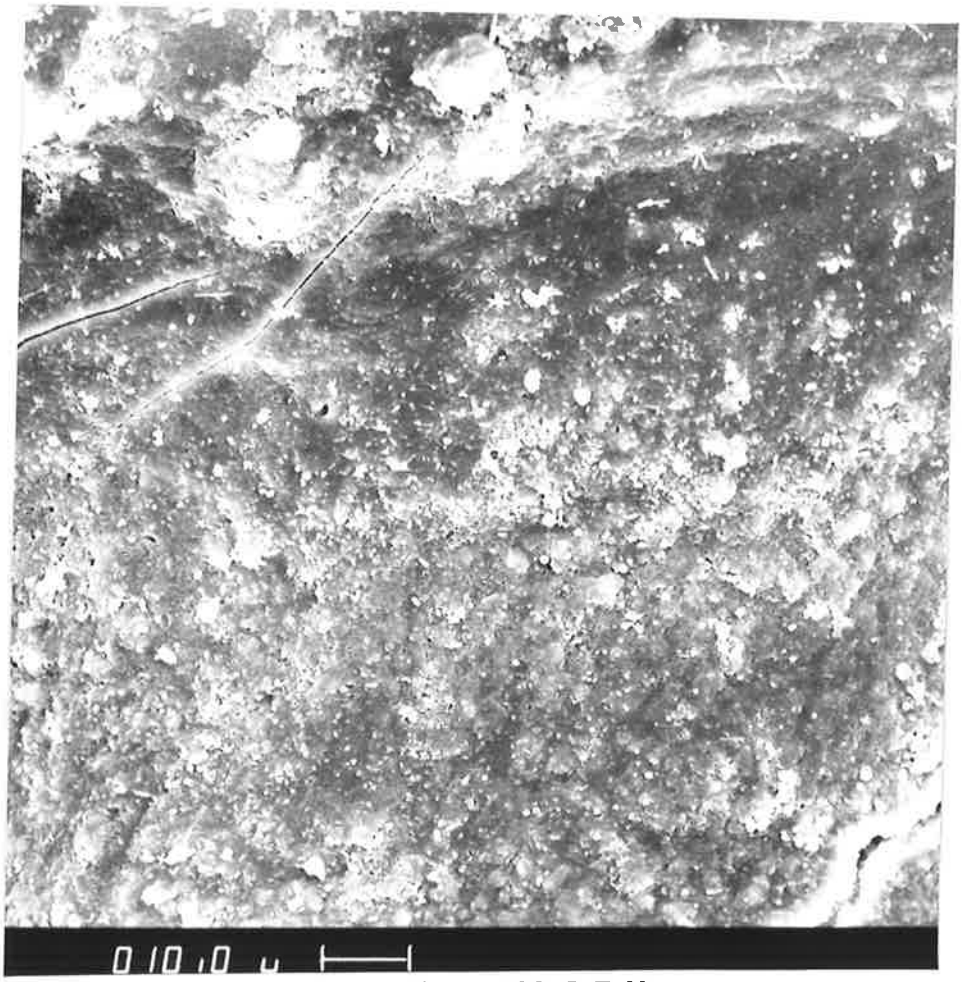

Fig. 24 x 500 S.E.M.

The normal appearance of the cemento-enamel junction is demonstrated. Crystals of cementum merge into the smoother and flatter regions of enamel prisms.

<u>Experimental Specimen</u>

Dog Mandibular Premolar Tooth

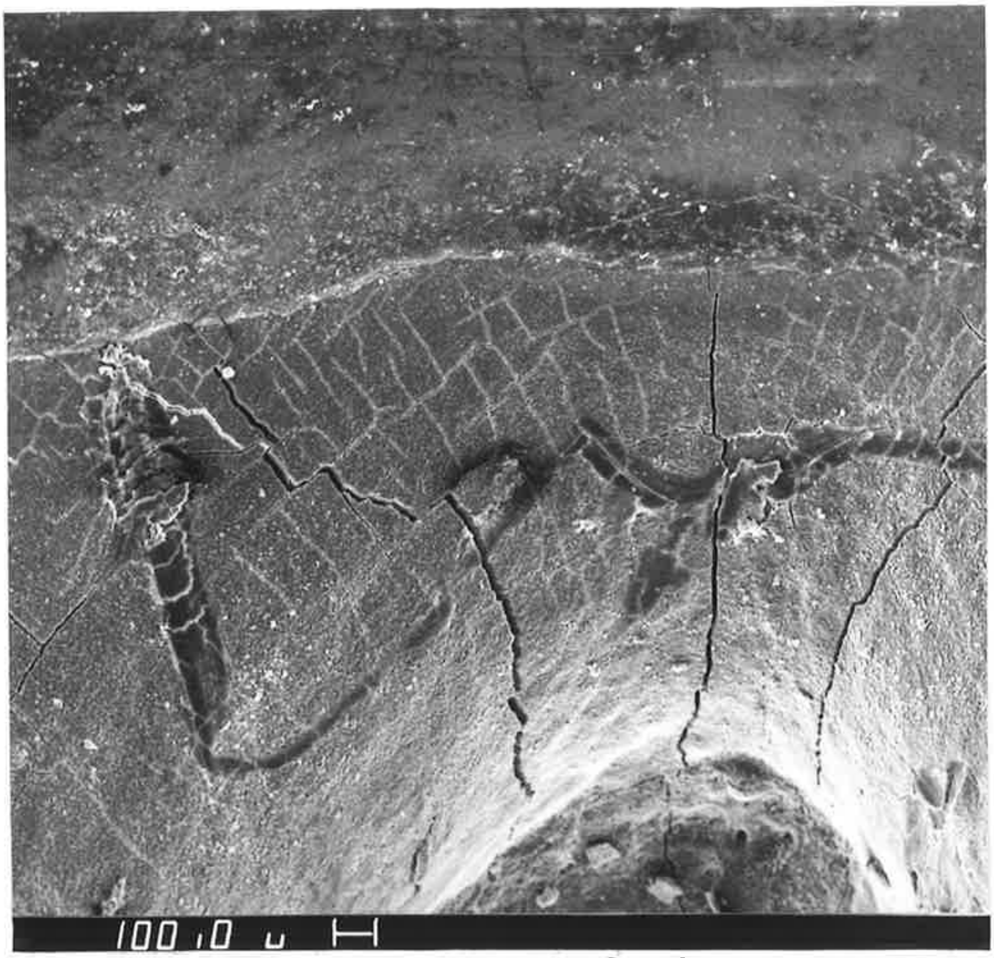

Fig. 25 x 20 S.E.M.

The cemento-enamel junction is clearly visible, as is the track of the electrosurgical needle. The starting point is demarcated by severe disruption of the cementum, with patches of light and heavy contact visible in the pathway.

Experimental Specimen

Dog Premolar Tooth

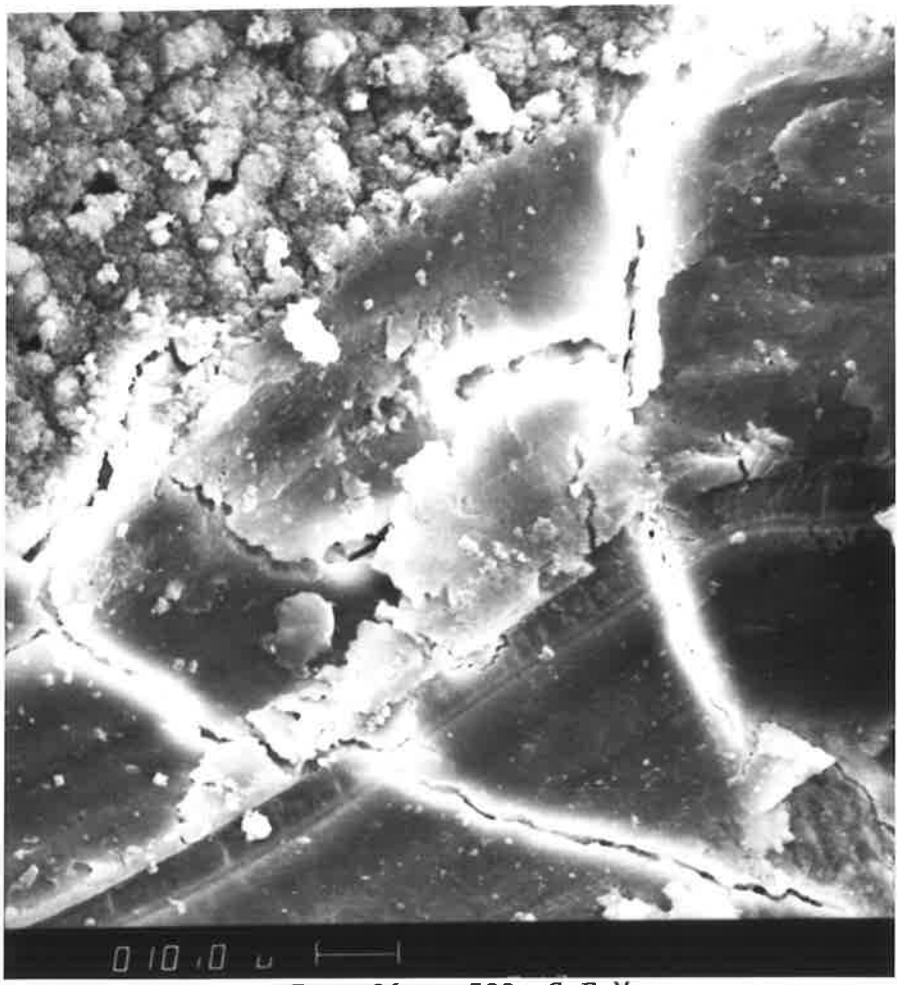

Fig. 26 x 500 S.E.M.

The high power view shows the disaggregation of the cementum from the passage of the active electrode across the surface. The appearance suggests that the energy of the electrode tip was sufficient to fuse the crystals of cementum.

Control Specimen

Dog Mandibular Premolar Tooth

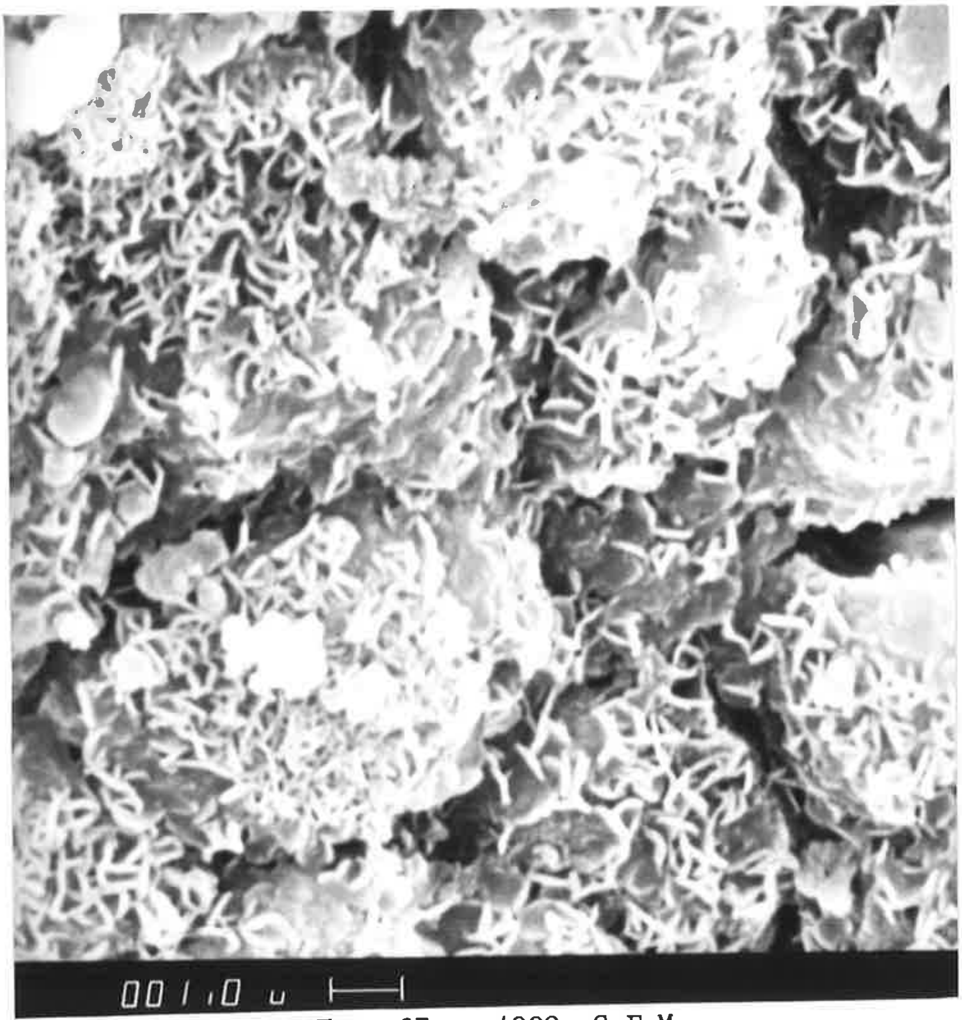

Fig. 27 x 4000 S.E.M.

High magnification of normal characteristics of the crystals of cementum.

<u>Experimental Specimen</u>

Dog Mandibular Premolar Tooth

Fig. 28 x 4000 S.E.M.

Under high magnification, cementum burned by the tip of the electrosurgical electrode was clearly discriminated from the normal cementum in the top part of the picture.

DISCUSSION

The effect of electrosurgical contact with cementum appears to be the production of a strictly localised lesion. The trauma would appear to result in a burn of the cementum in contact with the electrode tip. Electrode contact across the surface appeared to be "scratchy" at the time of surgery, and regions of heavier and lighter contact of the tip with cementum are evident. The appearance is consistent with the slight flicking of the electrode across the surface as orchestrated by roughness of the surface and its contact with a very light wire electrode.

Damage to the cementum following electrosurgical contact was minimal. The width of the burned track in cementum was limited to the diameter of the electrode tip. Therefore it is probable that the larger the needle, loop, or ball electrode used, the greater the potential for cemental damage. Periodontal problems could result from plaque accumulation in the depth of the electrode tracks.

Chapter VI

DISCUSSION

The electrosurgery instrument is in widespread use in dental practice as a means of recontouring gingival tissue and exposing crown margins in the impression stage of prosthodontic practice. The technique is simple, time-efficient, and has the added advantage of sealing blood vessels on the wound surface, thereby reducing the complication of blood-spoiled impressions.

Known disadvantages include the risk of bone necrosis should the alveolus be touched by the electrosurgical scalpel. In prosthodontic uses of electrosurgery this complication should not occur, but there exists the potential for pulp tissue damage from contact of the electrosurgical electrode with cementum (or dentine). The effects of electrosurgical gingival resection upon the underlying dental pulp have not been properly assessed. Agnew and Kaiser (1952) used a loop electrode in contact with cementum for 30 secs., and found vasuclar widespread pulpal destruction within the underlying pulp tissue. Needle electrodes used for gingivectomy for 105 secs. resulted in vascular distension and inflammatory changes within the pulp.

The contact times of the electrodes with the dental structure appear to be unrealistically great. In the present study the estimated contact time of needle electrode and tooth was approximately five secs. per dental unit. This time allowed adequate manipulation of the soft tissue to expose the cementum apical to the CEJ on the aspect of the premolar teeth.

Robertson _et al_ (1978) investigated the effect of electrosurgery on the pulpal tissue of monkeys. They found that when the needle contacted the metallic restoration in Class V cavities, pulpal damage resulted. No estimation of contact time of electrosurgical needle and amalgam was given. It is not possible, therefore, to know whether it was a realistic or unrealistic set of experiments.

The lack of adequate data relating to electrosurgery and the pulp prompted the present investigation. The technique closely simulated that of the usual clinical situation, but was performed on an animal model. The dog has been widely used for pulp studies, and is the animal of choice after the monkey. The response of dog pulps to dental techniques have been shown to closely mimic human tissue (Clarke 1968, 1971). The findings of the present study cannot be directly extrapolated to the human situation, but probably provide a reasonable guide.

The principle finding of the present study was that no pulpal deviation from normal could be found in any of the time periods in the series of experiments where the electrosurgical needle contacted cementum. This finding was in accord with Robertson _et al_ (1978) for their studies involving electrosurgery and cementum. The present study did not investigate the effect of electrosurgery on metallic restorations that Robertson _et al_ (1978) found to be damaging. Therefore the findings of no pulpal changes resulting from electrosurgical contact with cementum strongly support the concept that the procedure, as commonly practiced in the clinic, is safe.

In the second series of experiments where the electrode was passed across freshly cut dentinal tubules of a Class V cavity the results were similar. The distance separating pulp from the electrode was reduced by the depth of the cavity. Further, dentine composed of tubules filled with odentoblastic processes has to be considered a continuation of the pulpal tissue. Cementum, on the other hand, has no affinity or connection with the pulp and is of different morphological derivation.

If electrosurgery were to have a pulpal effect, it would seem that contact with dentine would be the most vulnerable site. However, apart from an unconvincing swelling of odontoblast in a 24 hour specimen, no signs of inflammation or damage were seen in the series. These findings strongly support the earlier contention that electrosurgery conservatively used is a safe procedure in the field of gingival resection.

The S.E.M. study revealed cemental changes that were unmistakenly due to contact with the electrosurgical needle. The crystals of cementum in the electrode pathway appeared to have melted, leaving a track across the cemental surface. The track was irregular in width and in depth, probably representing the absence of constant pressure and time of electrode contact per unit of surface length. Roughness of the cementum caused a "catching" and "flicking" effect on the needle during its travel across the cementum.

The experiments overall appear to indicate that the electrosurgical technique, when used as described, is an efficient and safe modality for resecting gingival tissue. However there are certain to be hard tissue changes in cementum following contact with an electrosurgical needle. These are of minor significance and probably can be disregarded in terms of clinical significance.

CONCLUSIONS

The principle findings of the present study were:

1) Electrosurgical techniques for resecting gingiva involving contact of a needle electrode with cementum appear safe for the underlying dental pulp;

2) Contact with dentine at the neck of a tooth by a needle electrode would also appear to have no significant pulpal consequences. This finding was perhaps more surprising in view of the intimate relationship between pulp and dentine;

3) The local contact of a needle electrode with cementum resulted in a "burn" of the crystals of cementum in contact with the electrode. The damage was limited in width to the electrode width and appeared to be very shallow;

4) Overall, it would appear that electrosurgery is a safe and efficient technique for gingival resection where that objective is a rational one.

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