1958

A Histologic Study of Regeneration in the Supporting Dental Tissues of Dogs Following Experimental Surgery

Nicholas Robert Marfino
Loyola University Chicago

A HISTOLOGIC STUDY OF REGENERATION IN THE SUPPORTING DENTAL TISSUES OF DOGS FOLLOWING EXPERIMENTAL SURGERY

by

Nicholas Robert Marfino

A Thesis Submitted to the Faculty of the Graduate School of Loyola University in Partial Fulfillment of the Requirements for the Degree of Master of Science

June

1958

APPROVAL SHEET

The thesis submitted by Dr. Nicholas R. Marfino has been read and approved by three members of the Departments of Anatomy and Oral Anatomy.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Science.

5/20/58
Date

Frank M. Zwenty
Signature of Adviser
DDS, M.S, PH.D

LIFE

Nicholas Robert Marfino was born in Buffalo, New York, August 2, 1925.

He was graduated from Canisius High School, Buffalo, New York, June 1943 and completed Pre-Dental studies at Canisius College, Buffalo, New York (1943-1945). He was graduated from the University of Buffalo, June, 1948, with the degree of Doctor of Dental Surgery.

After five years in the general practice of dentistry he served two years as Captain in the United States Air Force as head of the department of Periodontics at Ellington Air Force Base Hospital, Texas (1953-1955). Upon completion of one year post-graduate study at Loyola University School of Dentistry, Chicago, Illinois (1956) the author was awarded a research and teaching fellowship, a position held for the duration of his graduate study.

ACKNOWLEDGMENT

The author is indebted to Doctor Harry Sicher for his critical evaluation and crystallization of ideas.

Special thanks are due to Doctor Frank Wentz without whose continued guidance and unselfish cooperation this thesis would not have been possible.

Gratitude is also extended to Doctor Balint Orban for his continual advice and most excellent photo-micrographs and to Doctor Patrick Toto for his suggestions on histopathology.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

For many years past the ability of the supporting dental tissues to regenerate, once lost, has been a controversial issue. Much research on this subject has been done using both human[1-6] and animal[1-18] material under varied conditions. The preponderance of material offered in evidence of periodontal repair is based on clinical and roentgenographic evidence. Histologic evidence of periodontal reattachment in man and animals is conflicting. This investigation has for its purpose a combined histologic and clinical approach to the understanding of the mechanism of healing of surgically detached periodontal tissues to the surface of a tooth.

CHAPTER II

REVIEW OF THE LITERATURE

For many years past the ability of the supporting dental tissues to regenerate, once lost has been a controversial issue. Much research on this subject has been done using many different animals and under varied conditions.

Beckwith, Fleming and Williams (1927-1928) reported stages of regeneration of the artificially destroyed periodontal membrane, in guinea pigs and rabbits, animals with continually growing and erupting teeth. This was followed by a series of experiments on cats to see whether a like sequence of repair might be demonstrated in an experimental animal with teeth characterized by limited growth. The periodontal tissues were destroyed in an area remote from the gingival crevice. Regeneration of the periodontal membrane was again noted.

"A temporary reattachment of periodontal tissues in re-implanted dogs' teeth" was reported by Skillen and Lundquist (1934). Following this, the same authors (1937) did an experimental study of "periodontal membrane reattachment in healthy tissues of three dogs involving the gingival crevice". Pockets were produced by passing a sharp instrument under the labial gingival tissues separating them from the root. No bone was

removed. Some pockets were treated with sodium sulfide and some were left untreated. Sections were removed after one week, two weeks and two months. The authors found, "at best, 2 mm. of connective tissue reattachment on the healthy tissues of dogs. Epithelium seemed to adhere to the root surface in deeper parts of the pocket".

Beube (1934) on dogs simulated the works of Beckwith, Fleming and Williams, but in addition he used devitalized heterogenous bone powder to act as a nidus for bone formation. Such production of new bone was observed. Further experiments (1941, 1942, 1947) with boiled cow bone showed histologic evidence of formation of cementum and periodontal membrane as well as bone.

Skillen and Lundquist (1935) produced experimental gingival injuries in dogs. Various types of surgery were used to produce the injuries. These included

1. severing the gingiva to the level of bone
2. " " " " " " " " plus the use of sodium sulfide
3. typical flap operation
4. typical gingivectomy

They reported in conclusion: "In most instances there was only partial and sometimes very little periodontal membrane reattachment."

Copper bands were cemented to the teeth of dogs by Swenson (1947) to produce experimental periodontal pockets. He interpreted his histologic sections to show a resulting pocket similar to the pathologic periodontal pocket occurring in man.

In 1950 Linghorne and O'Connell began a series of experiments. The first was "a study of soft tissue reattachment following surgical destruction of bone and periodontal membrane". Notches were made on the enamel surfaces of the canine tooth of a dog to mark the position of the gingiva and to be able to record clinically the depths of the pockets. They noted repeatedly "a reattachment of connective tissue of the gingiva to the tooth by means of a deposition of new cementum". They also observed "that, when reattached, the fibers ran in a parallel direction rather than the characteristic oblique direction to the tooth".

Ranfjord (1951) took up the work started by Stone (1934) and Fish (1946) concerning surgically produced pockets on Rhesus monkeys. He demonstrated "both connective tissue and epithelial reattachment on root surfaces that had been exposed in an inflamed periodontal pocket and that removal of the epithelial lining of the pocket was necessary to obtain reattachment". He also noted that "the degree of inflammation in the area of healing appeared to determine whether the reattachment would be epithelial or connective tissue in type".

Linghorne and O'Connell (1951) in their follow-up experiment with dogs employed the same methods used previously but added autogenous bone chips to stimulate osteogenesis. Regeneration of the alveolar process in varying degrees was observed.

Butcher (1954) reported "periodontal fiber reattachment in reimplanted incisors of monkeys".

Jansen, Coppes and Verdenius (1955) reported a study on the healing of periodontal lesions in dogs under constant contamination of the wound by oral contents. The results were compared with the repair of similar lesions in which contamination and the ingrowth of oral epithelium could be excluded. In the experimental animal reattachment was found to occur, but their results suggested to them that the periodontal membrane may fail to reattach for months even without the presence of epithelium.

Linghorne and O'Connell (1955) showed regeneration in surgically created "epithelized" pockets on dogs. After reflecting a soft tissue flap and removing some alveolar bone, a pack of zinc oxide and eugenol was placed in the pocket for three weeks to assure epithelialization of the pocket. A hypothesis was advanced to explain the observed regeneration as follows: "A proliferation of cells just beneath the epithelial attachment displaces the epithelium crownwise. The tooth is now exposed to new cells and is resorbed until differentiation of cementoblasts

takes place. These lay down new cementum. After the resorptive process has progressed for some time the area of reattachment shows a continuous resorption of the tooth."

Linghorne continued this study (1957) by demonstrating regeneration in epithelized pockets following the organization of a blood clot in dogs. Periodontal packs and cements were employed to prevent reattachment of the surgical flaps to the tooth once a section of bone had been removed. The wound was allowed to heal for forty-five to ninety days. A new gingival flap was made, further prevented from reattaching by painting it with a solution of gum copal in alcohol and then collodion. As in the previous experiment autogenous bone chips were used to fill the space and after the blood clot formed it was protected by collodion applied to the oral surface of the gingiva. A new flap was made after forty-five to fifty days and the wounds examined. If the results were not satisfactory, the same procedure was repeated. If satisfactory the flap was resutured, allowed to heal for thirty more days and removed for sectioning.

He reported "reattachment and regeneration of bone and periodontal membrane without removing the epithelium from the inner aspects of the soft tissue wall of the pocket". An average of 4.50 mm. of new bone was seen plus 5.25 mm. of attachment. No distinction was made between connective tissue and epithelial attachment.

Schaffer in 1956 implanted cartilage into the periodontium of four Rhesus monkeys. Three implants were autotransplants and three homeotransplants, from the cartilage of the ear lobe. He noted "at first the cartilage was surrounded by new connective tissue; then it was invaded by fibroblasts and endothelial cells that formed capillaries. Later, presumably after differentiation from mesenchymal cells, osteoblasts formed new bone."

In 1957 Schaffer used autogenous and heterogenous cementum and dentin implants in one dog and one Rhesus monkey. The autogenous implants were placed in two extraction wounds and in one surgically created periodontal pocket in the dog. Tooth particles from human teeth were used as heterogenous implants into two surgically created periodontal pockets in the monkey. Prior to implanting, the particles from human teeth were autoclaved and kept dry for one day and for fifteen days respectively. The dog was sacrificed after sixty-four days, the monkey after twenty-eight days. The author reported "osteogenesis occurred in all of the implants, but it was much less in the periodontal pocket in the dog than in the extraction wounds or in the surgical pockets in the monkey. Small implants appeared to be more effective in stimulating osteogenic activity than larger implants".

CHAPTER III

MATERIALS AND METHODS

Ten young adult mongrel dogs with full permanent dentition approximately two to three years of age served as subject material. Surgical flap operations were performed on the maxillary canines in this investigation because of accessability and lack of muscle tension in this area. The animals were anesthetized by Nembutal administered either intra-venously or subperitoneally.

Previous to the surgery at a point approximately 1 mm. below and parallel to the gingival margin a notch was cut, by means of a power-driven abrasive disc, into the labial enamel surface extending slightly into the dentin. This notch served as a point of reference from which measurements could be calculated after the tissues had been detached surgically from their original position.

The surgical flap was then made on the labial gingiva and mucosa directly above the notch, thus exposing the periosteal side of the alveolar bone. The incisions began immediately mesial and distal of the canine and extended upward and obliquely away from the long axis of the tooth for a distance of approximately 10 mm. in each direction. The flap now had a base ranging

between 25-30 mm., thus wider at its base than at its apex.

A section of alveolar bone approximately 7x6 mm. with the attached periodontal ligament was removed.

A second notch was then made on the tooth at the base of this exposed area. This notch served as a point of reference which limited the apical extent of this surgically produced "pocket" (Plate I - Fig. 1). A soft pack of zinc oxide and eugenol was placed over the exposed area completely covering it, including the notch at the base. The pack was allowed to harden and the wound was sutured.

The pack was allowed to remain for three weeks and was then removed. Clinical estimates of the amount of atrophy and pocket depth were made.

The animals were sacrificed by an overdose of nembutal injected directly into the heart at the following intervals:

23 days

36 days

41 days

51 days

59 days

76 days

158 days

160 days

308 days

331 days

Histologic examination of the operated areas was secured by the following method:

Fixation - 10 percent neutral formalin solution

Decalcification - large quantities of 5 percent aequous nitric acid solution, observed every two days until completely decalcified.

Specimen washed in running water for twenty-four hours, then neutralized in 10 percent formalin to which an excess of calcium or magnesium carbonate has been added; again washed in running water for 24 to 48 hours.

Dehydration - 75 percent alcohol (24 hours)
95 percent alcohol (24 hours)
100 percent alcohol (24 hours)
Ether alcohol (½ and ½) (24 hours)

Embedded - celloiden (thin - 1 week)
medium - 1 week
thick - 1 week

Sectioned - serially

Stained - hematoxylin and eosin

CHAPTER IV

A. CLINICAL FINDINGS

At the time of operation the artificial periodontal pocket, created by the detachment of the gingiva, periodontal ligaments and removal of a 6x7 mm. section of alveolar bone averaged a depth of 10 mm.

1. <u>The establishment of a new dento-gingival junction</u>

This was apparent two days after the removal of the pack, and could be visualized by gently exploration and probing to identify the firm establishment of a union of the tissues to the tooth at the most apical portion of the pocket.

2. <u>Atrophy of the gingival flap</u>

Weekly clinical examination, without anesthesia, revealed an atrophy of the soft tissue wall in an apical direction. This recession progressed in the two months after the surgical detachment and then the relation of soft tissues remained fairly constant.

At the fifty-first post-operative day the shrinkage of soft tissue averaged 3 mm. or one-third of the length of the flap.

3. <u>Depth of the pocket</u>

A reduction of the depth of the pocket is dependent

on two factors:

(a) An atrophy of the soft tissue flap:

the atrophy of the gingival flap, measured from the coronal notch to the margin of the gingiva, averaged 3 mm.

(b) A coronal movement of the bottom of the pocket by reattachment of the flap to the tooth:

the pocket depth, measured from the gingival margin to the bottom of the pocket averaged 4 mm. thus a reattachment to the breadth of 3 mm. must have occurred.

B. MICROSCOPIC FINDINGS

1. Twenty-three days

Histologic examination of specimens from an animal sacrificed twenty-three days after the surgical production of a periodontal pocket and two days after the removal of the pack revealed the bottom of this pocket to be located at its original position at the apical edge of the notch in the root of the tooth. The pocket and this notch which marked the bottom of the artificial pocket were entirely free of remnants of the pack.

The wound area was epithelized, i.e. the epithelium completely lined the dental surface of the soft tissue pocket wall. The epithelial lining displayed a definite basal cell layer throughout its entire length. An adjacent layer of prickle-type cells varied in depth from two cells over the papillae at the center portion of the pocket lining to 6 - 7 cells at the most apical portion comprising the epithelial attachment. Here the cells appear swollen and there appeared to be some hydropic degeneration present. Closer to the surface these cells appeared flatter and contained flattened pyknotic nuclei. The coronal third of this lining had a keratin layer, beneath which a definite granular layer could be distinguished.

Epithelial ridges extended into the connective tissue that in this animal was free of inflammation.

Exposed cementum within the pocket area, coronal to the notch in the root of the tooth varied between four to fifteen layers in depth. These layers were separated by resting lines. The surface layers were irregular in outline and thinned out in a coronal direction. The cementum apical to the notch in the root of the tooth was fifteen layers thick and the surface layers displayed a smooth outline. In the deeper layers of the cementum both above and below the notch in the root of the tooth the lacunae were empty. While most lacunae of the superficial layers of exposed cementum were empty, some contained, surprisingly, cementocytes.

The line of resection of the alveolar bone revealed active areas of resorption indicated by the presence of osteoclasts. The periosteal side of the alveolar bone was irregular in outline while the dental side displayed one resting line in the bone.

2. Thirty-six days

At thirty-six days the bottom of the artificial pocket was located at the coronal edge of the notch in the root of the tooth. A few remnants of pack and cellular debris were present in the pocket. The wound area was incompletely epithelized, i.e. the epithelium was disrupted and did not reach to the most apical part of the pocket. Here approximately $\frac{1}{2}$ mm. of connective tissue remained exposed and the epithelium did not come into contact

with the tooth Plate II, Fig. 2.

The epithelial lining displayed a definite basal cell layer throughout its entire length. An adjacent layer of prickle cells varied in depth according to the location averaging seven cells depth in the center portion of the lining and three to four cells at both coronal and apical margins. The surface layers appeared disrupted.

Small epithelial ridges extended into the connective tissue from the coronal one-third of this pocket lining but were absent in the apical two-thirds. The connective tissue directly adjacent to the ridges showed a mild degree of chronic inflammation manifested by the presence of lymphocytes and plasma cells. In the notch in the root of the tooth proliferating connective tissue was seen Plate III, Fig. 7. This tissue was highly cellular in nature consisting of numerous fibroblasts and many young collagenous fibers with no definite pattern of arrangement. There were young patent capillaries interposed throughout, the endothelial cells of which were swollen. A side finding of secondary interest is the presence of a linear arrangement of dentin particles in the connective tissue between the tooth and alveolar bone below the notch in the root of the tooth. There, particles were embedded in layers of osteoid tissue and appeared to be acting as a nidus for bone formation Plate IV, Fig. 8.

No cementum within the pocket area, coronal to the root notch was visible. A very thin layer of cementum was present apically to the root notch adjacent to a cementoid layer and bordered by a layer of well defined cementoblasts.

The tooth surface showed areas of interrupted resorption just apical to the notch Plate V, Fig. 9.

The line of resection of the alveolar bone was covered by large amounts of trabecular bone lined by a layer of osteoblasts at its periphery. This bone had a width greater than the rest of the alveolar process Plate V, Fig. 9.

The line of resection of the alveolar bone was covered by large amount of trabecular bone lined by a layer of osteoblasts at its periphery. This bone had a width greater than the rest of the alveolar process Plate VI, Fig. 10. The large amount of new trabecular bone was observed apical to the notch in the root of the tooth which was 2.00 mm. from the cemento-enamel junction.

3. <u>Fifty-one days</u>

At fifty-one days the bottom of the artificial pocket was located 4.25 mm. coronally to its original position at the time of surgery Plate II, Fig. 3. Any measurement of the amount of reattachment is the sum of the amount of new connective tissue attachment plus new epithelial attachment.

There were no remnants of pack in the pocket. The wound area was epithelized, i.e., the epithelium lined the dental

surface of the soft tissue pocket wall and was attached, at its most apical extent, to the tooth surface for a length of 1.50 mm. Table 1.

The epithelial lining was fairly uniform in width averaging five cells in thickness. No definite basal cell layer could be distinguished. The cells comprising most of the lining were fusiform in shape. The surface layer of cells appeared flattened and gave the tissue a smooth outline. No definite epithelial ridge formation was evident except for one area of epithelial proliferation into the connective tissue where the epithelium was surrounded by a high degree of chronic inflammation as evidenced by the presence of round cell infiltration. The new connective tissue which was attached to the tooth surface in and coronal to the root notch was observed to be highly cellular in nature, most of the cells were fibroblasts although no definite collagenous fiber bundles could be distinguished. Some patent capillaries persisted although the endothelial cells were no longer swollen but instead appeared flattened Plate VII, Fig. 11.

The connective tissue comprising the periodontal ligament apical to the notch revealed collagenous fiber bundles, some of which were arranged parallel to the tooth and some at right angles which seemed to be orienting themselves.

A continuous resorption of the dentin surface in and coronally to the notch in the root of the tooth was observed to

be covered by a layer of cementoid and bordered by a definite layer of cemento-blasts.

A most striking feature of this time interval was the amount of bone added to the line of resection of the alveolar crest. The width of the bone was not quite as wide as the root of the alveolar process and extended to the coronal corner of the root notch.

The periosteal side of the alveolar process revealed a resting line and an adjacent layer of osteoid tissue bordered by a dense layer of osteoblasts. This osteoid tissue and osteoblasts were also seen on the dental side of the alveolar process.

4. Seventy-six days

At seventy-six days the bottom of the artificial pocket was located 3.75 mm. coronally to its original position at the time of surgery Plate II, Fig. 4.

There were no remnants of pack in the pocket. The wound area was epithelized, i.e., the epithelium lined the dental surface of the soft tissue pocket wall and was attached, at its most apical position, to the tooth surface for a length of 2.00 mm. Table 1. The epithelial lining had a definite basal cell layer throughout its entire length. There was a depth of eight cells thickness. The cells comprising the coronal portion were prickle shaped while those making up the apical half were flattened.

There were proliferating and anastomosing epithelial ridges in the coronal half. The adjacent connective tissue was intensely inflamed. Lymphocytes and plasma cells were seen.

The apical half of the epithelial lining was lacking in ridge formation and there was relatively no inflammation in the adjacent connective tissue.

In the area of the root notch the connective tissue was organized into definite collagenous fiber bundles. For the first time a gingival group of periodontal ligament fibers could be distinguished. These fibers extended from the bone covering the line of resection of the alveolar crest into the lamina propria of the gingiva. In the connective tissue filling the notch in the root of the tooth there was marked reduction in fibroblasts and an increase in collagenous fiber formation. There was a high degree of chronic inflammation Plate VIII, Fig. 12. Mostly lymphocytes and some plasma cells were present.

Just apical to and in the notch the dentin surface showed continuous resorption. A slight amount of interrupted resorption was seen coronal to the notch. These areas of resorbed dentin were covered by a new layer of cementum which was adjacent to a layer of cementoid. A definite layer of cementoblasts was seen at the periphery.

The bone covering the line of resection of the alveolar crest was irregular in outline and was bordered at its peripheral

margin by a seam of osteoid tissue. The highest extension of the bone was located slightly apical to the notch in the root.

A resting line was observable on the periosteal side. No such lines could be distinguished on the dental side of the alveolar bone. A layer of osteoblasts was seen on both the periosteal and dental surfaces of the alveolar bone.

5. <u>One hundred and fifty-eight days</u>

At one hundred and fifty-eight days the bottom of the artificial pocket was located 4.50 mm. coronally to its original position at the time of surgery Plate II, Fig. 5.

There were no remnants of pack in the pocket. The wound area was epithelized, i.e., the epithelium lined the dental surface of the soft tissue pocket wall and was attached at its most apical portion, to the tooth surface for a length of 2.00 mm. Table 1.

The epithelial lining displayed a definite basal cell layer throughout its entire length. An adjacent layer of prickle cells varied in depth according to the location ten cells depth in the apical half of the lining to five cells at the coronal half. The surface layers appeared smooth in outline throughout its entire length.

Extensive proliferation of epithelium into the adjacent connective tissue was seen in the coronal half of the lining, but was absent in the apical half. The connective tissue directly

adjacent to the coronal two-thirds of the epithelial lining displayed a high degree of chronic inflammation again evidenced by round cell infiltration. This type of inflammation persisted in the apical one-third but to a much lesser degree.

The connective tissue beneath the epithelial attachment and in the apical notch was differentiated into definite collagenous fiber bundles. Three types of fibers of the gingival group of the periodontal ligament were able to be distinguished. The first type, "the alveolo-gingival", extended from the alveolar bone to the gingiva. The second type is "the dento-gingival", which extended from the tooth surface to the gingiva. The third type, "the periosteal", extended from the periosteal side of the alveolar bone into the gingiva.

Filling the notch in the root of the tooth was connective tissue which was relatively free of inflammation.

Continuous resorption of the dentin surface was seen beginning at the apical edge of the notch in the root of the tooth, extending into and slightly coronal to the notch. Directly covering this resorption is a layer of very thick cellular cementum which extended coronally to the base of the epithelial attachment Plate IX, Fig. 13. This cementum appeared bone-like and extending from it are some cemental spikes. A layer of cementoblasts could also be seen.

The alveolar bone at the line of resection, at the

periosteal and dental sides was irregular in outline. Resting lines and a definite layer of osteoblasts were seen on all surfaces. The furthest extent of this bone was located slightly apical to the apical notch in the root of the tooth.

6. Three hundred and thirty-one days

At three hundred and thirty-one days, the bottom of the artificial pocket was located 2.50 mm. coronally to its original position at the time of surgery Plate II, Fig. 5. There were no remnants of pack in the pocket. The wound area was epithelized, i.e., the epithelium lined the dental surface of the soft tissue pocket wall and was attached, at its most apical extent to the tooth surface for a length of 1.75 mm. Table 2, Plate X, Fig. 14. In all other respects sections from this time interval closely resembled the sections from the one hundred and fifty-eight day specimen.

CHAPTER V

DISCUSSION

A. The Regeneration of the Dento-Gingival Junction

The timing, the degree, and the proportional amount of new connective tissue attachment and new epithelial attachment is a significant finding of this experiment. However, the problem of reattachment of the soft tissues to the hard tissues of a tooth must be considered from these two individual aspects before the mechanisms of regeneration may be clarified.

1. The attachment of the connective tissue elements to the tooth surface and alveolar margin
2. The attachment of the epithelium to the tooth surface

These two attachments then comprise the "dento-gingival junction". The connective tissue provides the mechanical resistance needed in such a junction of hard and soft tissues while the biological sealing of underlying structures against bacterial and chemical irritation is provided by the attachment of the epithelium to the surface of a tooth.

The two functions are somewhat overlapping in these tissues but serve for the greatest part as stated above.

Plate XI, Fig. 15 and Plate XII, Fig. 16 show that

there is a relatively constant proportion of new connective tissue and new epithelial attachment.

1. The connective tissue had a range of attachment which measured from 1.25 mm. to 2.50 mm. from the apical portion of the notch in the root to the apical end of the epithelial attachment.

2. The epithelial attachment was observed to be a cuff measuring in a majority of the specimens 1.50 mm. to 2.50 mm. in length.

In this study the connective tissue was formed and attached to the tooth surface in the earliest stages, but it organized slowly and could not be distinguished as definite collagenous fiber bundles until the seventy-sixth post-operative day. On the other hand, a definite epithelial attachment also may be observed as early as the twenty-third day after the surgical production of the artificial pocket.

It is interesting to note that definite orderly progressive stages of development could not be observed time-wise.

It appears that the variation in the pattern of healing exhibited is due to the early behavior of the pack in the pocket. If this pack were displaced from the notch in the root of the tooth early, this would allow a blood clot to form and organize into connective tissue before the epithelium had a chance to migrate down the pocket wall and prevent its organization. If

the pack was held in place for a longer period of time the epithelium then had more time to migrate down the pocket wall and attach itself to the tooth surface before the connective tissue could be formed.

Also observed in sections from the twenty-third day specimens was a definite keratin layer on the surface of the coronal one-third of the epithelial lining. This was possibly due to an irritation, both chemical and physical, on direct contact with the zinc oxide and eugenol pack.

The large amount of new bone found apical to the notch in the root of the tooth Plate VI, Fig. 10 in the thirty-six day specimens is explained as follows. This notch was the point to which the seven millimeters of bone was removed to. Since this new bone is found apical to this notch it must be the consequence of eruption of a tooth that was not completely erupted at the time of surgery Plate XIII, Figs. 17, 18, 19, 20.

In most of the specimens a proliferation of cells of the epithelial lining into the adjacent connective tissue was seen in varying degrees. Since a prominent infiltration of chronic inflammatory cells was always observed in the areas of connective tissue surrounding these epithelial proliferations, it is felt that they are the result of irritation (possibly from toxins originating in the pocket area) and not a normal structure of this part.

B. Comparison of Findings with Previous Experiments

It has been pointed out in the review of the literature that a similar experiment was performed by Linghorne and O'Connell (1955). The findings in this study appear to be contradictory to theirs. However, certain procedures in this experiment differed from theirs. The variations in procedure, must be stated here, since the basis of explanation of the contradictory findings is dependent upon this comparison.

1. When the artificial pocket was made, Linghorne and O'Connell used only one notch (in the enamel) as a point of reference. To denote the most apical extent of the newly created pocket the cementum was scraped from the root surface of the tooth. The most apical point of denudment of the cementum indicated the bottom of the pocket. This seemed highly inadequate since resorption which is constantly seen to take place in such a process of repair will easily destroy this point of reference.

Therefore in the present experiment in order to have an unmistakable point of reference marking the bottom of the surgically created pocket a notch was also placed in the root in addition to the crown as the second point of reference Plate I, Fig.1.

2. The figures recorded at the various time intervals by Linghorne and O'Connell were taken from the living animal by means of a probe calibrated in millimeters.

In the present experiment in addition to gross clinical measurements, microscopic measurements were made on histologic sections obtained from the animals sacrificed at the various time intervals. Realizing that a pocket does not always heal uniformly around a tooth, serial sections were made of the teeth and histologic measurements were taken Plate XV, Fig. 1. This was done by means of an eye-piece disc micrometer which was calibrated with a slide micrometer, measured in units of .01 mm.

3. No histologic sections before the nineteenth post-operative month were secured by Linghorne and O'Connell, nor were any microscopic measurements computed on the histologic specimens. However, a hypothesis of what transpired during these post-operative nineteen months was offered by the authors.

In the present experiment histologic sections were secured as early as 23 days post-operatively (2 days after removal of the pack) and at periods of 36, 41, 51, 59, 76, 158, 160, 331 days.

The hypothesis advanced by Linghorne and O'Connell suggests that during the healing process a progressive displacement of the epithelial attachment occurs in a coronal direction. Linghorne and O'Connell illustrated diagramatically these progressive stages of healing according to their hypothesis Plate XIV, Figs. 21(A), 22(B), 23(C), 24(D), 25(E). This hypothesis therefore indicates that the epithelial attachment must be closest

to the apical notch in the earliest specimens and furthest from this notch in the oldest spécimens. These conclusions cannot be substantiated by the results of the present experiment. To the contrary, the epithelium was observed to be attached at its maximal coronal position from the apical notch in the younger specimens and progressively closer to the apical notch in the older specimens until at 331 days the epithelial attachment had encroached upon the notch itself. This phenomena might be interpreted by the fact that the epithelial attachment was once attached at a more coronal point and then in time migrated apically.

Comparable stages to those shown in their illustration was seen in the present study, except they did not follow the same progressive order of occurrance. This is best shown by the following table of comparison.

Progressive stages represented by Linghorne and O'Connell in order of occurrance Plate XIV	Fig.	21(A)	22(B)	23(C)	24(D)	25(E)
Comparable stages in present study in order of occurrance	Fig.	2	4	4	4	3

The implications of these findings are as follows:

1. There was a definite regenerative capacity of the dento-gingival junction, limited only in extent.

2. Good morphological and functional re-establishment of a new dento-gingival junction was observed.
3. The epithelium lining the inner surface of the pocket attached itself to the tooth surface in most experiments. This attachment was observed in the earliest stages of the healing process.
4. A new formation and attachment of connective tissue elements was also observed early in the healing process but organized slowly.
5. An attachment of epithelium and connective tissue to the surface of the tooth in a coronal position could be seen in the early stages of healing. In the later stages these attachments assumed a more apical position.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This investigation represents a histologic and clinical evaluation of the healing mechanism which occurred following the surgical creation of periodontal pockets.

Ten young adult mongrel dogs with full permanent dentition served as subject material. The pockets, ten millameters in depth, were produced by surgical flap operations on the maxillary canines. Notches were made in the crown and root of the tooth to serve as reference points. The animals were sacrificed at the following time intervals: 23, 41, 51, 59, 76, 158, 160, 308, and 331 days.

The following were the major results obtained:
The regeneration of the dento-gingival junction after the production of a 10 mm. artificially produced periodontal pocket is complete and consists of:

1. New attachment of connective tissue averaging 1.50 mm.
2. New attachment of epithelium averaging 1.75 mm.

These attachments occur at a point in the apical third of the distance between the two notches in the tooth. The depth of the remaining pocket however, diminishes but this is due to atrophy of the soft tissue flap. After the initial atrophy the

depth of the pocket is more or less constant for the rest of the experiment. Microscopically no progressive coronal shift of the connective tissue and epithelial attachment ever occurred. These microscopic findings indicate, therefore, that healing of the dento-gingival junction is complete and functionally acceptable after surgery but without a total regeneration of the original morphology.

CHAPTER VII

BIBLIOGRAPHY

A. References Cited

1. Beckwith, T. D., W. C. Fleming and A. Williams, 1927, The Regeneration of the Rodent Periodontal Membrane. Proc. Soc. Exp. Biol. & Med., 24:562.

2. _ _ _ _ _. 1928, Regeneration of the Periodontal Membrane in the Cat. Proc. Soc. Exp. Biol. & Med., 25:713.

3. _ _ _ _ _. 1943, Repair of the Tooth and Parodontium in the Guinea Pig, Rabbit and Cat. U. of Cal. (Publ. in Micro-biol.), 1, No. 1.

4. Beube, F. E. and H. F. Silvers, 1934, Influence of Devitalized Heterogenous Bone Powder on Regeneration of Alveolar and Maxillary Bone of Dogs. J. D. Res., 14:15.

5. Beube, F. E., 1941, Further Observations on the Formation of Cementum, Periodontal Membrane and Bone with the Use of Boiled Cow-bone Powder. J. D. Res., 20:239.

6. _ _ _ _ _. 1942, Observations on the Formation of Cementum, Periodontal Membrane and Bone Twenty Months, Post-Operatively, with the Use of Boiled Cow-bone Powder. J. D. Res., 21:298.

7. Beube, F. E., 1947, A Study of Reattachment of the Supporting Structures of the Teeth. J. of Perio., 18:55.

8. Butcher, E. O., 1954, Periodontal Fiber Reattachment in Re-implanted Incisors of the Monkey. J. D. Res., Oct., abst., 33:703.

9. Jansen, M. T., L. Coppes and H. H. Verdenius, 1955, Healing of Periodontal Wounds in Dogs. J. of Perio., 26:292.

10. Linghorne, W. J. and D. C. O'Connell, 1950, Soft Tissue Reattachment. J. D. Res., 29:419.

11. _ _ _ _ _. 1951, Regeneration of Alveolar Process. J. D. Res., 30:604.

12. _ _ _ _ _. 1955, Regeneration in Epithelized Pockets. J. D. Res., 34:164.

13. Linghorne, W. J., 1957, Regeneration in Epithelized Pockets Following the Organization of a Blood Clot. J. D. Res. 36:4.

14. Lundquist, G. A., 1935, Experimental Gingival Injury in Dogs. J. D. Res., 15:165.

15. Ramfjord, S., 1951, Experimental Periodontal Reattachment in Rhesus Monkeys. J. of Perio., 22:67.

16. Skillen, W. G. and G. A. Lundquist, 1934, Re-implanting Dogs Teeth. J. D. Res., abstr. 35., 14:177.

17. Skillen, W. G. and G. A. Lundquist, 1937, An Experimental Study of Periodontal Membrane Reattachment in Healthy and Pathologic Tissues. J.A.D.A., 24:175.

18. Swenson, H. M., 1947, Experimental Pockets in Dogs. J. D. Res., 26:273.

B. Secondary Sources

1. Beube, F. E., 1952, A Radiographic and Histologic Study on Reattachment. J. of Perio., 23:158.

2. Morris, M. L., 1949, Reattachment of Periodontal Tissue. O.S., O.M., O.P., 2:1194.

3. _ _ _ _ _. 1953, The Reattachment of Human Periodontal Tissues Following Surgical Detachment: A Clinical and Histologic Study. J. of Perio., 24:220.

4. _ _ _ _ _. 1955, Healing of Naturally Occurring Periodontal Pockets about Vital Human Teeth. J. of Perio., 26:285.

5. Orban, B., 1948, Pocket Elimination or Reattachment. N.Y.S.D.J. 14:227.

6. Schaffer, E. M. and H. A. Zander, 1953, Histologic Evidence of Periodontal Reattachment of Pockets. Paradentologie, 3:101.

CHAPTER VIII

TABULATION

A. CLINICAL MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Distance from the Coronal Notch to the Bottom of the Pocket (Att.)

and from the Coronal Notch to the Gingival Margin (G.M.)

36 days (Dog #55)

Operation: December 15, 1956 Sacrificed: January 19, 1956

	Before Surgery		After Surgery		At Time of Sacrifice	
	Att.	G.M.	Att.	G.M.	Att.	G.M.
Left Canine	4	1	10	2	9	6
Right Canine	4	1	8	2	9	6

Left canine - 4 mm. atrophy plus 1 mm. new attachment

Right canine - 4 mm. atrophy plus no new attachment

41 days (Dog #11B)

Operation: March 1, 1957 Sacrificed: April 10, 1957

	Before Surgery		After Surgery		At Time of Sacrifice	
	Att.	G.M.	Att.	G.M.	Att.	G.M.
Left Canine	3	2	10	2	8	2
Right Canine	3	2	10	2	8	2

Left canine - No atrophy plus 2 mm. new attachment

Right canine - No atrophy plus 2 mm. new attachment

CLINICAL MEASUREMENTS OF THE MAXILLARY CANINE TOOTH (Continued)

51 days (Dog #49A)

Operation: March 19, 1956 Sacrificed: May 8, 1956

	Before Surgery		After Surgery		At Time of Sacrifice	
	Att.	G.M.	Att.	G.M.	Att.	G.M.
Left Canine	4	2	10	2	7	4
Right Canine	4	2	10	2	6	2

Left canine - 2 mm. atrophy plus 3 mm. new attachment

Right canine - No atrophy plus 4 mm. new attachment

59 days (Dog #50)

Operation: December 14, 1955 Sacrificed: February 14, 1956

	Before Surgery		After Surgery		At Time of Sacrifice	
	Att.	G.M.	Att.	G.M.	Att.	G.M.
Left Canine	5	2	13	3	(Pack)	4
Right Canine	6	2	14	2	(Pack)	4

Left canine - 1 mm. atrophy

Right canine - 2 mm. atrophy

CLINICAL MEASUREMENTS OF THE MAXILLARY CANINE TOOTH (Continued)

76 days (Dog #35B)

Operation: February 1, 1956 Sacrificed: May 16, 1956

	Before Surgery		After Surgery		At Time of Sacrifice	
	Att.	G.M.	Att.	G.M.	Att.	G.M.
Left Canine	4	2	13	2	11	5
Right Canine	4	2	11	2	7	5

Left canine - 3 mm. atrophy plus 2 mm. new attachment

Right canine - 3 mm. atrophy plus 4 mm. new attachment

158 days (Dog #44)

Operation: November 2, 1956 Sacrificed: April 10, 1957

	Before Surgery		After Surgery		At Time of Sacrifice	
	Att.	G.M.	Att.	G.M.	Att.	G.M.
Left Canine	4	3	14	3	12	8
Right Canine	4	3	10	3	10	6

Left canine - 5 mm. atrophy plus 2 mm. atrophy

Right canine - 3 mm. atrophy plus no new atrophy

CLINICAL MEASUREMENTS OF THE MAXILLARY CANINE TOOTH (Continued)

160 days (Dog #35A)

Operation: January 18, 1956   Sacrificed: June 25, 1956

	Before Surgery		After Surgery		At Time of Sacrifice	
	Att.	G.M.	Att.	G.M.	Att.	G.M.
Left Canine	5	2	11	3	8	3
Right Canine	4	2	12	2	9	4

Left canine - No atrophy plus 3 mm. new attachment

Right canine - 2 mm. atrophy plus 3 mm. new attachment

308 days (Dog #36)

Operation: June 27, 1956   Sacrificed: April 10, 1957

	Before Surgery		After Surgery		At Time of Sacrifice	
	Att.	G.M.	Att.	G.M.	Att.	G.M.
Left Canine	5	2	14	4	11	7
Right Canine	5	2	14	4	11	4

Left canine - 3 mm. atrophy plus 3 mm. new attachment

Right canine - No atrophy plus 3 mm. new attachment

CLINICAL MEASUREMENTS OF THE MAXILLARY CANINE TOOTH (Continued)

331 days (Dog #11A)

Operation: December 7, 1955 Sacrificed: November 2, 1956

	Before Surgery		After Surgery		At Time of Sacrifice	
	Att.	G.M.	Att.	G.M.	Att.	G.M.
Left Canine	3	1	11	2	9	4
Right Canine	3	1	10	2	7	4

Left canine - 2 mm. atrophy plus 2 mm. new attachment

Right canine - 2 mm. atrophy plus 3 mm. new attachment

B. MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table 1. Measurements of landmarks illustrated in Plate XV, Fig. 26

36 days (Dog #55) Left Canine

	1	2	3	4	6	7	8	Av.
A	9.75	9.75	10.00	10.25	9.75	10.25	9.75	10.00
B	4.25	4.25	4.75	4.75	4.25	4.75	4.25	4.50
B^1	.75	.75	.25	.25	.75	.25	.75	.50
B^2								
B^3	3.50	3.50	4.50	4.50	3.50	4.50	3.50	4.00
C	5.50	5.50	5.25	5.50	5.50	5.50	5.50	5.50
D			.25	.25		.25		
E	3.00	3.00	2.75	2.75	3.00	2.75	2.75	2.75

36 days (Dog #55) Right Canine (No Apical Notch)

	2	3	4	5	6	7	8	9	10	11	Av.
A	9.00						9.50	9.75			
B	2.85						3.25	3.25			
B^1	.75						.50				
B^2	.75	1.25	.75	1.25	1.00	1.50			.75	.75	
B^3	1.25	.50	1.00	.50	1.75	.50	2.75	3.25	1.75	1.50	1.50
C	6.25	6.25	6.25	6.25	6.50	6.25	6.35	1.50	6.50	6.50	6.25
D	.75						1.50	1.50			
E	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table I (Continued)

41 days (Dog #11B) Left Canine (No Apical Notch)

	1	3	4	5	6	7	8	9	10	Av.
A										
B										
B^1										
B^2	.50	.25	.25			.50	.75	.75	.75	.50
B^3	5.25	6.25	6.00	6.00	6.00	5.50	5.50	5.50	5.50	5.75
C	1.50	1.50	1.50	1.50	1.50	1.50	1.75	1.75	1.50	1.50
D										
E										

41 days (Dog #11B) Right Canine

	2	3	4	5	6	7	8	9	10	Av.
A										
B										
B^1										
B^2	1.50	1.25	1.50	1.50	1.50	1.25	1.00	1.50	1.50	1.50
B^3	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
C	2.25	2.25	2.25	2.50	2.25	2.25	2.25	2.25	2.25	2.25
D										
E										

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table I (Continued)

51 days (Dog #49A) Left Canine

	1	2	4	5	6	7	8	9	10	Av.
A	10.75	10.50	10.75	10.50	10.75	10.75	10.75	10.75	10.75	10.75
B	6.25	6.25	6.25	6.00	6.25	6.25	6.25	6.25	6.25	6.25
B^1	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.75	2.00	2.00
B^2	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
B^3	2.50	2.50	2.25	2.00	2.25	2.50	2.50	2.75	2.50	2.50
C	4.50	4.25	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50
D	.50	.75	1.00	1.50	1.50	1.00	.25	.50	.25	.75
E	2.50	2.50	1.75	2.50	2.50	1.50	1.25	1.50	1.25	2.00

51 days (Dog #49A) Right Canine

	1	2	3	4	6	7	8	9	10	Av.
A	10.00	10.00	10.00	10.25	9.75	9.50	10.00	10.00	10.00	10.00
B	7.75	7.75	7.75	8.00	7.75	7.50	7.75	7.75	7.75	7.75
B^1	2.75	2.75	3.00	3.00	2.75	2.75	3.00	2.75	2.75	2.75
B^2	1.50	1.50	1.25	1.50	1.50	1.50	1.50	1.50	1.50	1.50
B^3	3.50	3.50	3.50	3.50	3.50	3.25	3.25	3.50	3.50	3.50
C	2.25	2.25	2.25	2.25	2.00	2.00	2.25	2.25	2.25	2.25
D	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75
E	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table I (Continued)

59 days (Dog #50) Left Canine (Pack Still in Place)

	1	3	4	5	6	7	Av.
A	12.50	12.75	13.00	13.00	12.50	12.75	12.75
B	8.00	8.25	8.75	8.75	8.00	8.25	8.25
B^1							
B^2							
B^3							
C	4.50	4.50	4.25	4.25	4.50	4.50	4.50
D	2.00	2.00	2.25	2.25	1.75	2.00	2.00
E	.50	.50	.25	.25	.00	.50	.25

59 days (Dog #50) Right Canine (Pack Still in Place)

	1	2	3	5	6	7	8	9	Av.
A	13.50	14.50	13.50	13.75	13.75	15.25	13.75	13.50	14.00
B	10.00	10.25	10.00	9.50	9.50	10.00	9.75	9.25	9.75
B^1	2.25	2.25	2.00	2.25	2.25	2.00	2.00	2.00	2.25
B^2	.75	.75	.75	.75	.75	.75	.75	.75	.75
B^3	7.00	7.25	7.25	6.50	6.50	7.25	7.00	6.50	7.00
C	3.50	4.25	3.50	4.25	4.25	5.25	4.00	4.25	4.25
D	.25	.25	.25	.25	.25	.00	.25	.50	.25
E									

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table I (Continued)

76 days (Dog #35B) Left Canine

	1	2	3	4	5	6	8	9	10	11	Av.
A	13.25	13.25	13.25	13.25	13.25	13.25	13.25	13.00	13.25	13.25	13.25
B	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.50	8.75	8.75	8.75
B^1	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
B^2											
B^3	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
C	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50
D	.25	.25	.25	.25	.25	.50	.50	.50	.50	.50	.50
E											

76 days (Dog #35B) Right Canine

	1	2	3	4	6	7	8	9	Av.
A	10.75	10.75	10.75	11.00	11.00	11.00	11.00	11.00	11.00
B	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
B^1	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
B^2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
B^3	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
C	4.25	4.25	4.25	4.50	4.50	4.50	4.50	4.50	4.50
D	.25	.25	.25	.25	.25	.25	.25	.25	.25
E	1.50	1.50	1.50	1.50	.75	1.50	1.50	1.50	1.50

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table I (Continued)

158 days (Dog #35A) Left Canine

	1	2	3	4	5	6	7	Av.
A	10.75	10.75	10.75	11.00	11.00	12.50	11.00	11.25
B	7.00	7.00	7.00	7.25	7.00	9.75	7.50	7.50
B^1	1.50	1.25	1.50	1.25	1.50	1.25	1.00	1.25
B^2	3.75	3.50	4.00	3.75	4.00	1.00	2.00	3.25
B^3	1.75	2.25	1.50	2.50	1.50	7.50	4.50	3.00
C	3.75	3.75	3.75	3.75	4.00	2.75	3.50	3.75
D	.50	.50	.50	.50	.50	.00	.75	.50
E								

158 days (Dog #35A) Right Canine

	1	2	3	4	5	6	Av.
A	11.00	10.75	11.00	11.25	11.00	10.75	11.00
B	6.50	6.25	6.50	6.75	6.50	6.25	6.50
B^1	1.50	1.25	1.50	1.25	1.50	1.25	1.50
B^2	1.25	1.25	1.25	1.25	1.25	1.25	1.25
B^3	3.75	3.75	3.75	4.25	3.75	3.75	3.75
C	4.50	4.50	4.50	4.50	4.50	4.50	4.50
D	.50	.25	.50	.50	.25	.50	.50
E							

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table I (Continued)

160 days (Dog #44) Left Canine

	1	2	3	4	5	6	7	8	Av.
A	13.00	13.00	12.75	13.00	12.75	13.25	13.25	12.75	13.00
B	4.50	4.25	4.50	4.50	4.25	4.50	4.50	4.25	4.50
B^1	1.00	1.00	1.50	1.50	1.25	1.50	1.50	1.75	1.50
B^2									
B^3	3.50	3.25	3.00	3.00	3.00	3.00	3.00	2.50	3.00
C	8.50	8.75	8.50	8.50	8.50	8.50	8.50	8.50	8.50
D									
E									

160 days (Dog #44) Right Canine

	1	2	3	4	5	6	7	Av.
A	11.25	11.25	10.75	10.75	10.75	13.00	11.00	11.25
B	5.50	4.50	3.75	3.75	3.75	4.00	5.50	4.50
B^1	.25	.25	.50	.50	.50	.50	.25	.50
B^2								
B^3	5.25	4.25	3.25	3.25	3.25	3.50	5.25	4.00
C	5.75	6.75	7.00	7.00	7.00	9.00	5.50	6.75
D	.50	.50	.75	.75	.75	.75	.50	.75
E								

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table I (Continued)

308 days (Dog #36) Left Canine

	1	2	3	4	5	6	7	8	9	Av.
A	13.50	13.50	12.75	13.25	13.25	13.50	13.25	13.25	12.50	13.25
B	7.00	7.00	6.75	6.75	7.00	6.75	7.00	7.00	6.75	7.00
B^1	1.25	1.25	1.25	1.25	1.50	1.25	2.00	2.25	1.25	1.50
B^2	2.50	2.50	1.75	2.00	2.75	2.25	2.00	2.00	2.00	2.25
B^3	3.25	3.25	4.00	3.50	2.75	3.25	3.00	2.75	3.50	3.25
C	6.50	6.50	6.00	6.50	6.25	6.75	6.25	6.25	5.75	6.25
D	1.00	1.00	.25	1.00	.50	.00	1.00	.25	.25	.50
E										

308 days (Dog #36) Right Canine

	1	2	3	4	5	6	7	8	Av.
A	14.00	13.75	13.75	14.50	14.75	15.00	13.75	14.50	14.25
B	10.25	10.25	10.25	11.50	11.75	12.00	10.75	11.25	11.00
B^1	1.50	1.50	1.25	2.00	2.00	2.00	1.50	1.50	1.75
B^2	2.75	2.75	2.75	2.75	2.75	2.75	2.50	2.75	2.75
B^3	6.00	6.00	6.25	6.75	7.00	7.25	6.75	7.00	6.75
C	3.75	3.50	3.50	3.00	3.00	3.00	3.00	3.25	3.25
D	.25	.25							
E									

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table I (Continued)

331 days (Dog #11A) Left Canine

	1	2	3	4	Av.
A	10.25	10.00	10.00	10.00	10.00
B	7.00	6.75	6.75	6.75	6.75
B^1	.75	.75	.75	.75	.75
B^2	1.75	1.75	1.75	1.75	1.75
B^3	4.50	4.25	4.25	4.25	4.25
C	3.25	3.25	3.25	3.25	3.25
D	1.25	1.25	1.25	1.25	1.25
E					

331 days (Dog #11A) Right Canine

	1	2	3	4	5	Av.
A	10.25	10.00	10.00	10.00	9.75	10.00
B	8.00	7.75	8.00	7.75	7.00	7.75
B^1	2.00	2.00	2.00	2.00	2.00	2.00
B^2	2.25	2.25	2.25	2.25	2.50	2.25
B^3	3.75	3.50	3.75	3.50	2.50	3.50
C	2.25	2.25	2.00	2.25	2.25	2.25
D	1.00	1.00	1.00	.75	.75	1.00
E						

B. MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table 2. Distribution of the original pocket depth following healing

Time Interval of Healing	Original Pocket Depth (After surgery in mm.)	Attachment (in mm.)		Atrophy (in mm.)	Remaining Pocket Depth (in mm.)
		Fibrous	Epithelial		
<u>36 days</u>					
Left Canine	8.00	.50		3.50	4.00
Right Canine	6.00			4.25	1.50
<u>41 days</u>					
Left Canine			.50		5.75
Right Canine			1.50		5.00
<u>51 days</u>					
Left Canine	8.75	2.00	1.75	2.50	2.50
Right Canine	8.00	2.75	1.50	.25	3.50

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table 2 (Continued)

Time Interval of Healing	Original Pocket Depth (After surgery in mm.)	Attachment (in mm.) Fibrous	Epithelial	Atrophy (in mm.)	Remaining Pocket Depth (in mm.)
59 days					
Left Canine	9.75			1.50	
Right Canine	12.00	2.25	.75	2.25	7.00
76 days					
Left Canine	11.25	1.25		2.50	7.50
Right Canine	9.00	1.75	2.00	2.50	2.75
158 days					
Left Canine	8.00	1.25	3.25	.75	3.00
Right Canine	9.00	1.50	1.25	2.50	3.75

MICROSCOPIC MEASUREMENTS OF THE MAXILLARY CANINE TOOTH

Table 2 (Continued)

Time Interval of Healing	Original Pocket Depth (After surgery in mm.)	Attachment (in mm.)		Atrophy (in mm.)	Remaining Pocket Depth (in mm.)
		Fibrous	Epithelial		
160 days					
Left Canine	10.00	1.50		5.50	3.00
Right Canine	8.25	.50		3.75	4.00
308 days					
Left Canine	9.25	1.50	2.25	2.25	3.25
Right Canine	10.25	1.75	2.75		6.75
331 days					
Left Canine	8.00	.75	1.75	1.25	4.25
Right Canine	8.00	2.00	2.25	.25	3.50

PLATE I

Figure 1:

Clinical photograph of left maxillary canine with surgical flap retracted. Section of alveolar bone removed. Coronal and apical notches are seen.

CHAPTER IX

APPENDIX

A. Photomicrographs

PLATE I

Figure 1

PLATE II

Figure 2: 36 day specimen

3: 51 day specimen

4: 76 day specimen

5: 158 day specimen

6: 331 day specimen

Composite photomicrograph showing the relationship of soft tissues to the tooth at various time intervals. (X10)

PLATE II

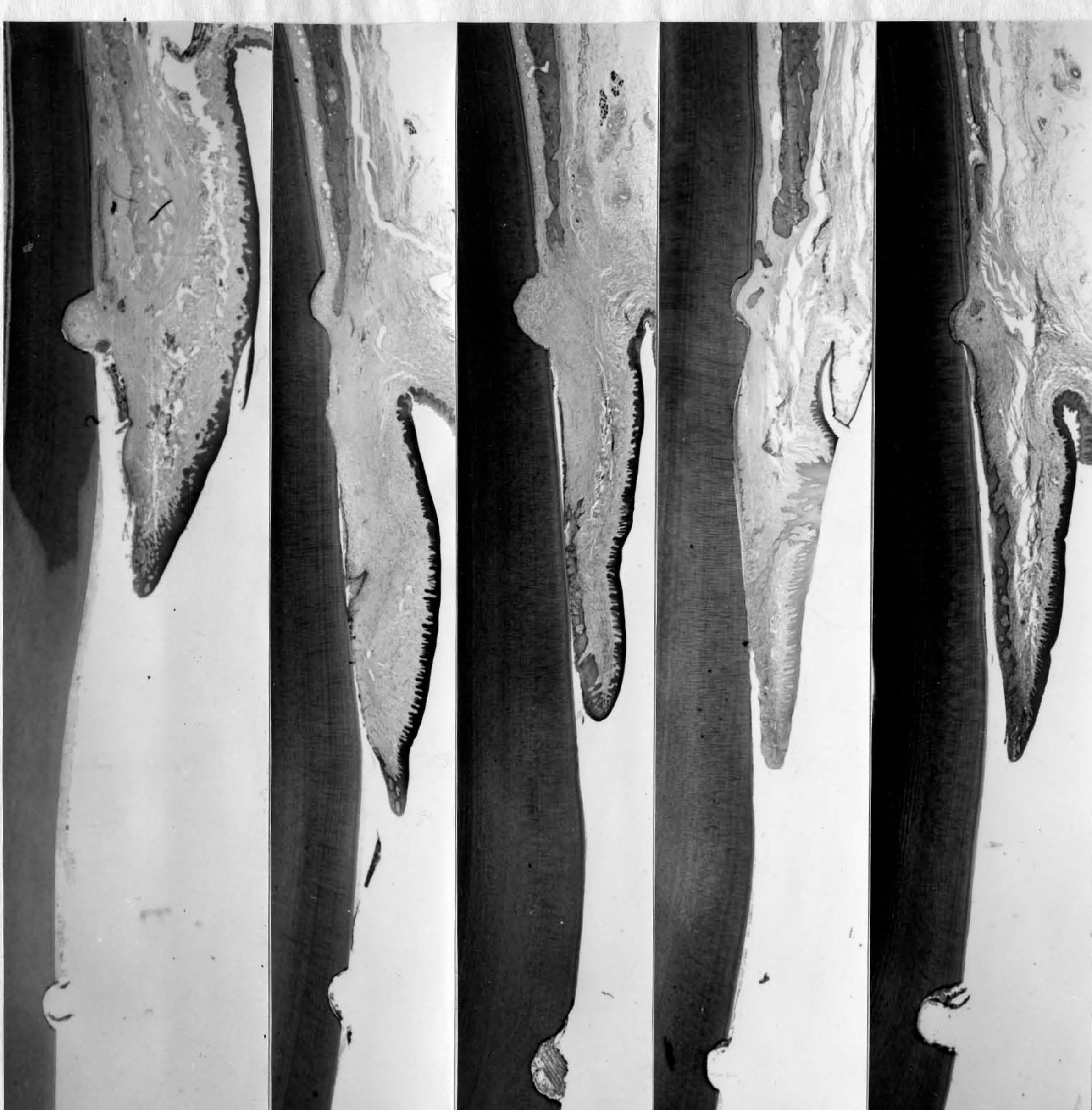

Figure 2 3 4 5 6

PLATE III

Figure 7:

Photomicrograph of 36 day specimen - right maxillary canine (X107)

Note:

a) numerous fibroblasts

b) numerous patent capillaries

PLATE III

Figure 7

PLATE IV

Figure 8:

Photomicrograph of 36 day specimen - left maxillary canine (X107)

Note:

a) highly cellular granulation tissue

b) particles of dentin surrounded by osteoid tissue

PLATE IV

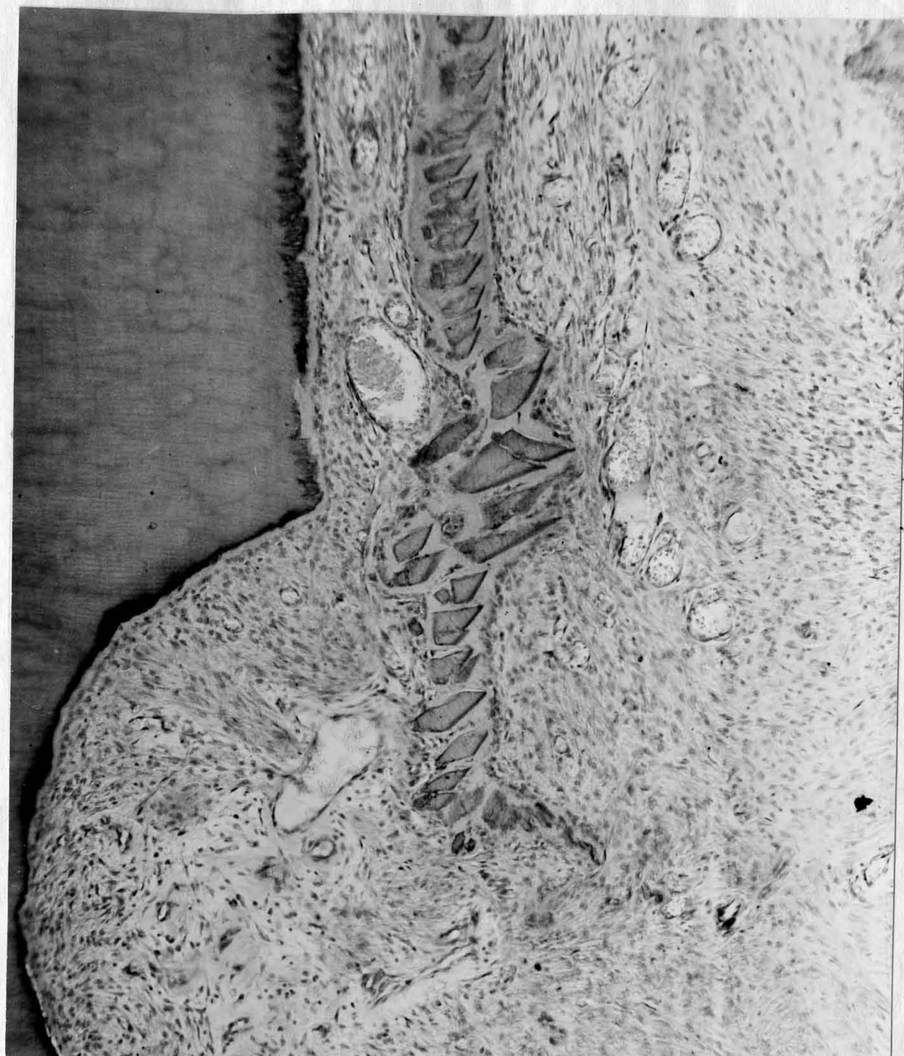

Figure 8

PLATE V

Figure 9:

Photomicrograph of 36 day specimen - left maxillary canine (X107)

Note:

a) interrupted resorption on tooth surface by osteoclasts

b) presence of immature trabecular bone

PLATE V

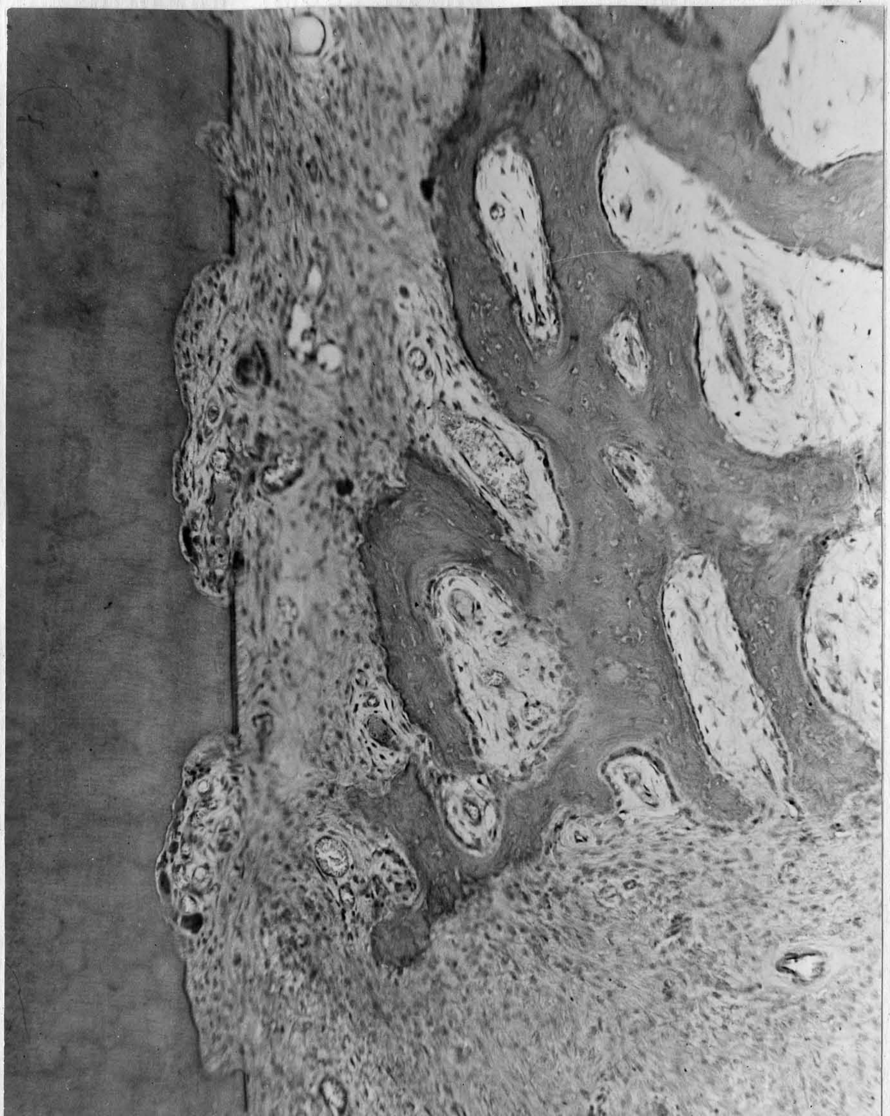

Figure 9

PLATE VI

Figure 10:

Photomicrograph of 36 day specimen - left maxillary canine (X42)

Note:

a) large amount of immature trabecular bone added to alveolar crest

b) dentin particles surrounded by osteoid tissue

c) highly cellular granulation tissue

d) fragments of pack adjacent to and in granulation tissue

PLATE VI

Figure 10

PLATE VII

Figure 11:

Photomicrograph of 51 day specimen - left maxillary canine (X107)

Note:

a) immature cellular bone spicules extending coronally beyond the apical notch

b) resorption of tooth surface and lined by new cementum

c) connective tissue attachment

PLATE VII

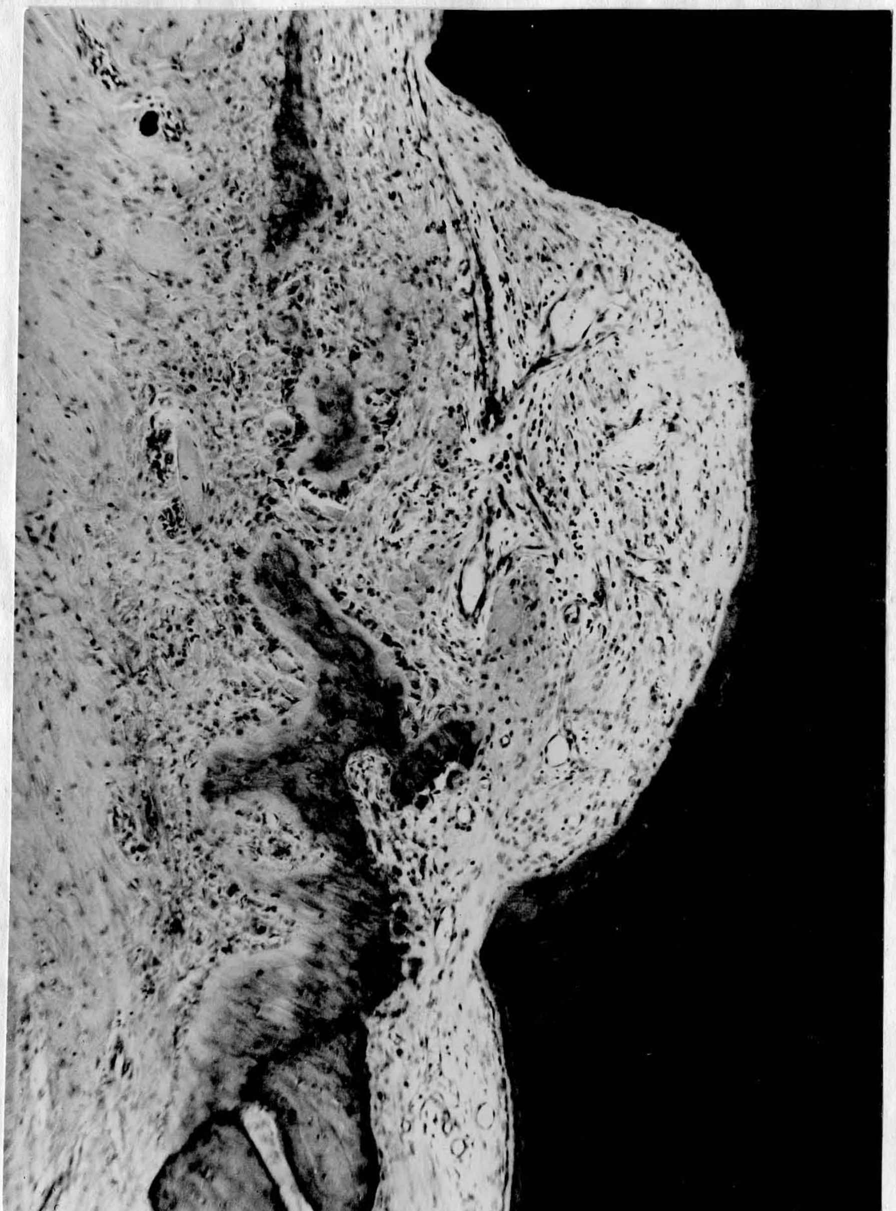

Figure 11

PLATE VIII

Figure 12:

Photomicrograph of 76 day specimen - right maxillary canine (X107)

Note:

a) interrupted resorption on tooth surface coronally to apical notch

b) continuous resorption in notch

c) connective tissue attachment and inflammation

d) epithelial attachment

PLATE VIII

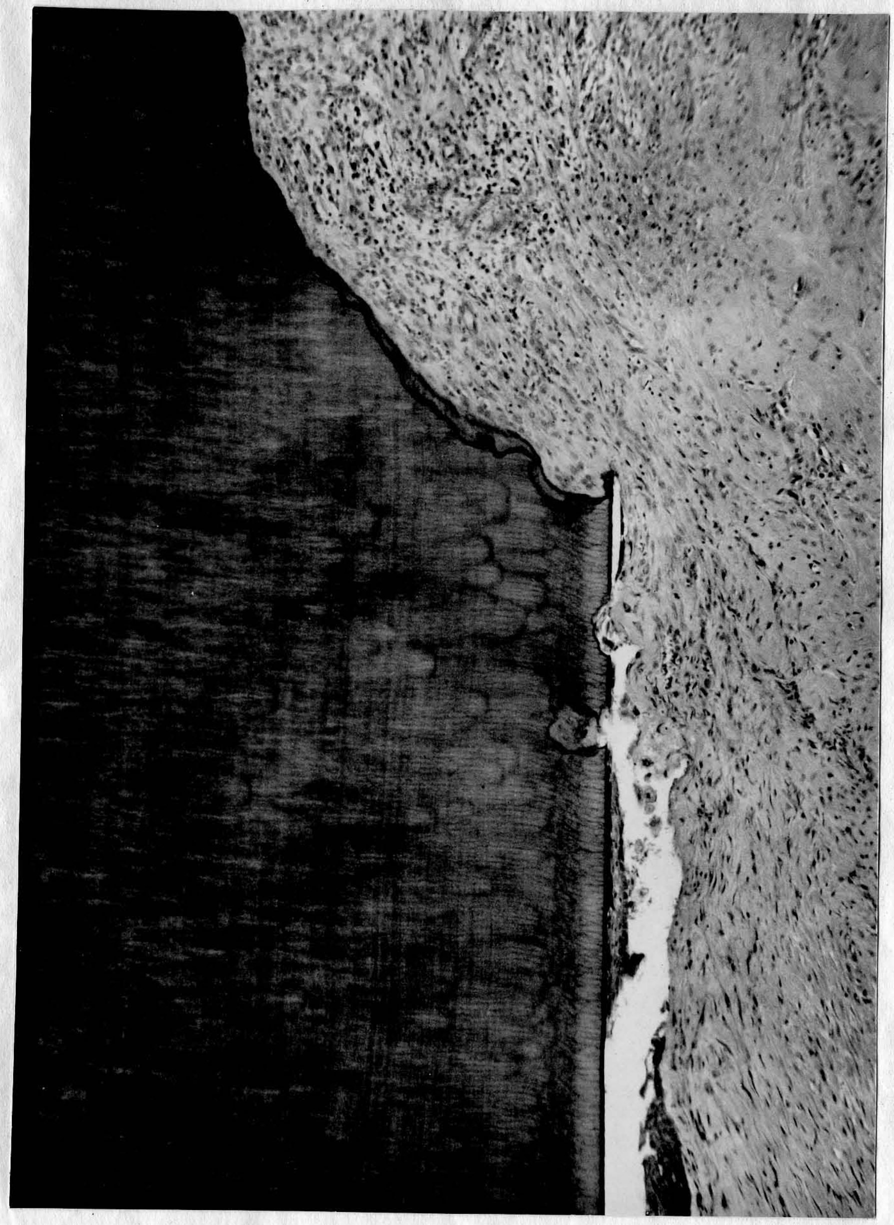

Figure 12

PLATE IX

Figure 13:

Photomicrograph of 158 day specimen - left maxillary canine (X42)

Note:

a) thick layer of cellular cementum in apical notch with cemental spike

b) island of cementum (possibly bone) in apical notch

c) hair embedded in connective tissue

d) presence of epithelial attachment

PLATE IX

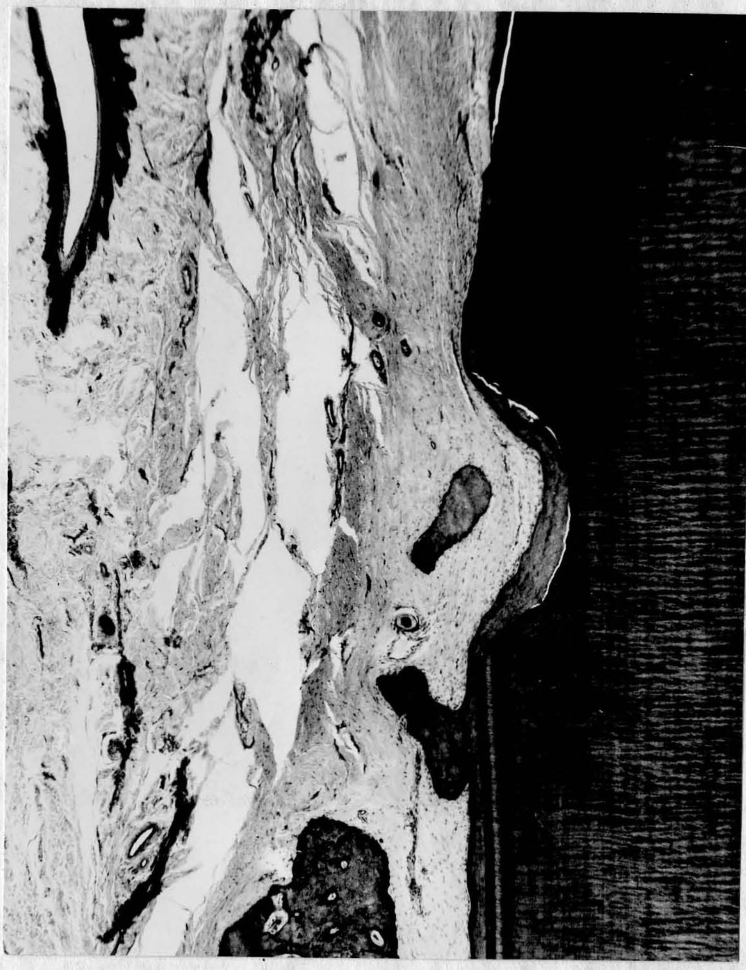

Figure 13

PLATE X

Figure 14:

Photomicrograph of 331 day specimen - right maxillary canine (X107)

Note:

a) epithelial attachment

b) resorption of dentin and thick cellular cementum in the apical notch

c) projection of alveolar crest bone into the apical notch

d) presence of inflammation in connective tissue in apical notch

PLATE X

Figure 14

PLATE XI

Figure 15:

Graph illustrating repair of new connective tissue attachment

B. Graphs

PLATE XI

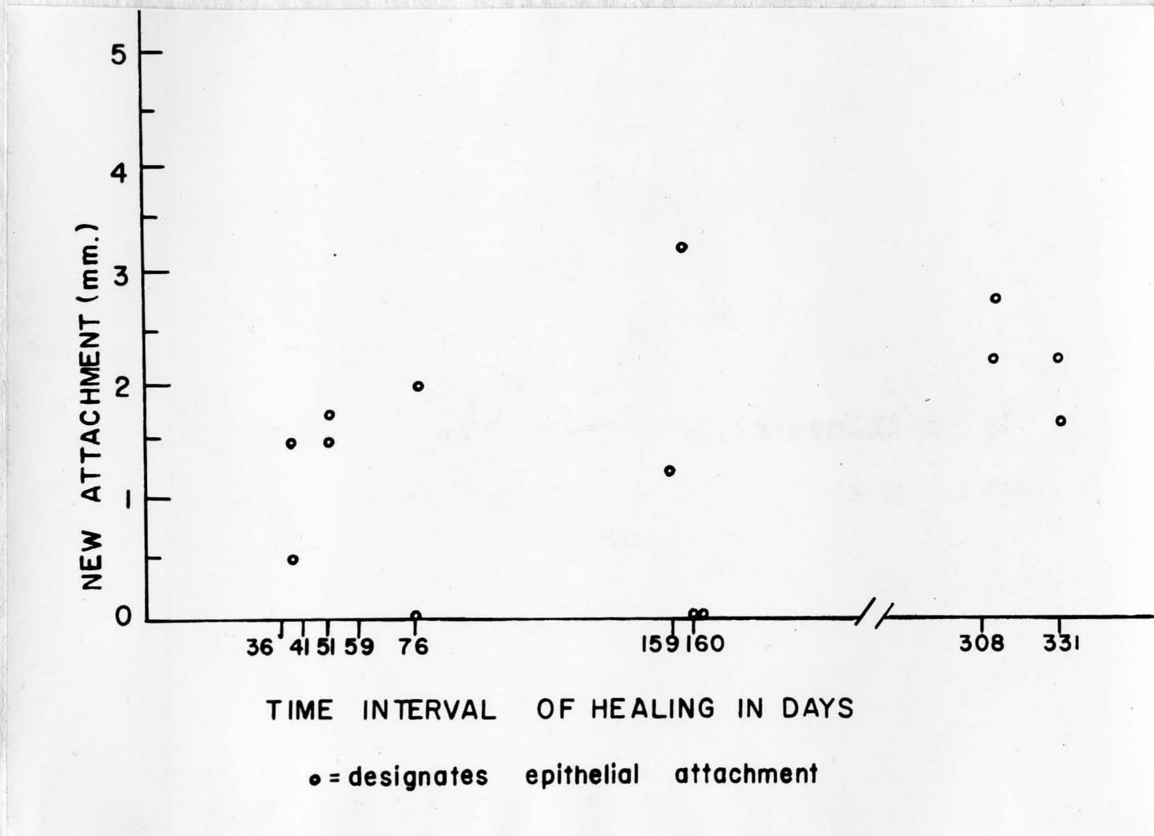

Figure 15

PLATE XII

Figure 16:

Graph illustrating repair of new epithelial attachment.

PLATE XII

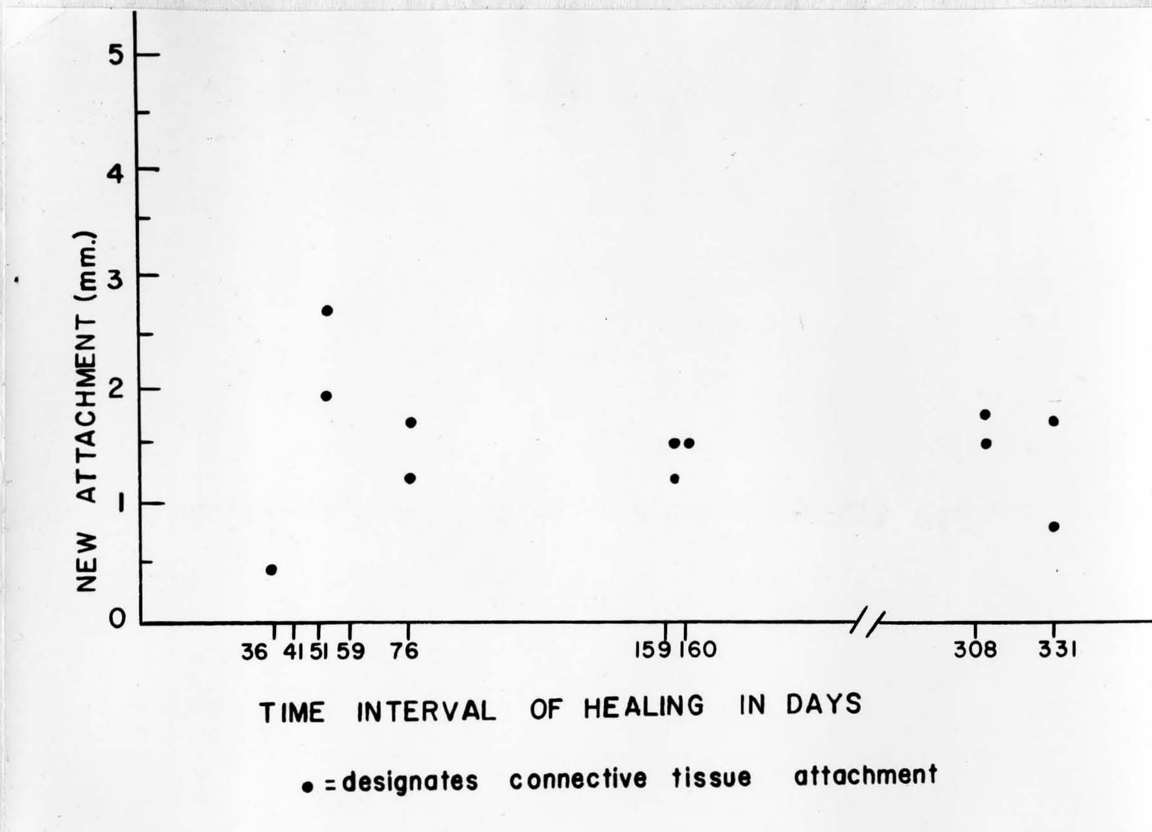

Figure 16

PLATE XIII

Figure 17: Incompletely erupted

18: Distance between the bone crest and cemento-enamel junction immediately after surgery

19: A slight labial movement of tooth

20: Upward eruption with addition of new bone at the crest apical to the notch

Diagrammatic illustration explaining presence of new immature trabecular bone apical to the notch in the root of the tooth (illustrated on lower tooth)

C. Diagrammatic Illustrations

PLATE XIII

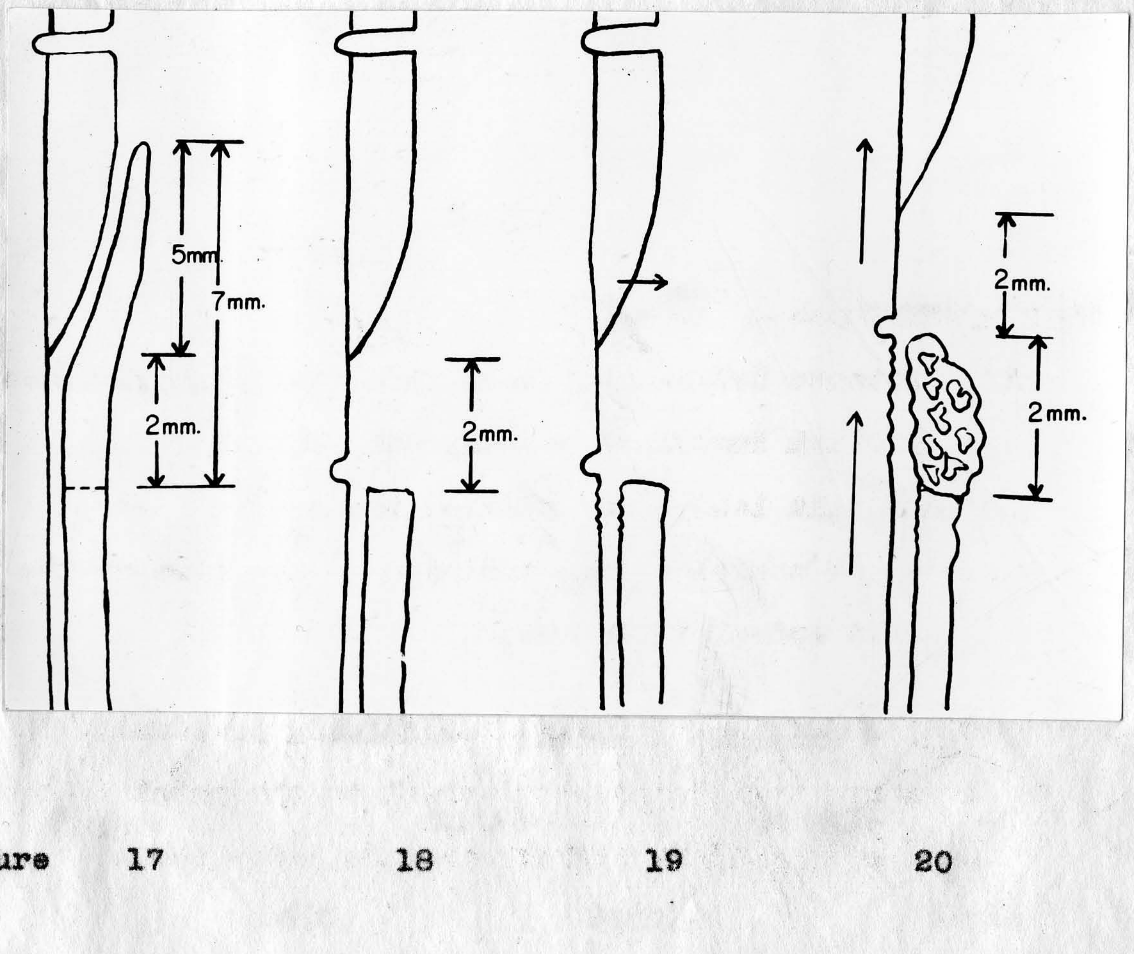

Figure 17 18 19 20

PLATE XIV

Figures: 21(A), 22(B), 23(C), 24(D), 25(E)

Diagrammatic illustration explaining hypothesis advanced by Linghorne and O'Connell (1955) showing reduction of pocket by coronal movement of epithelial attachment ahead of connective tissue attachment

PLATE XIV

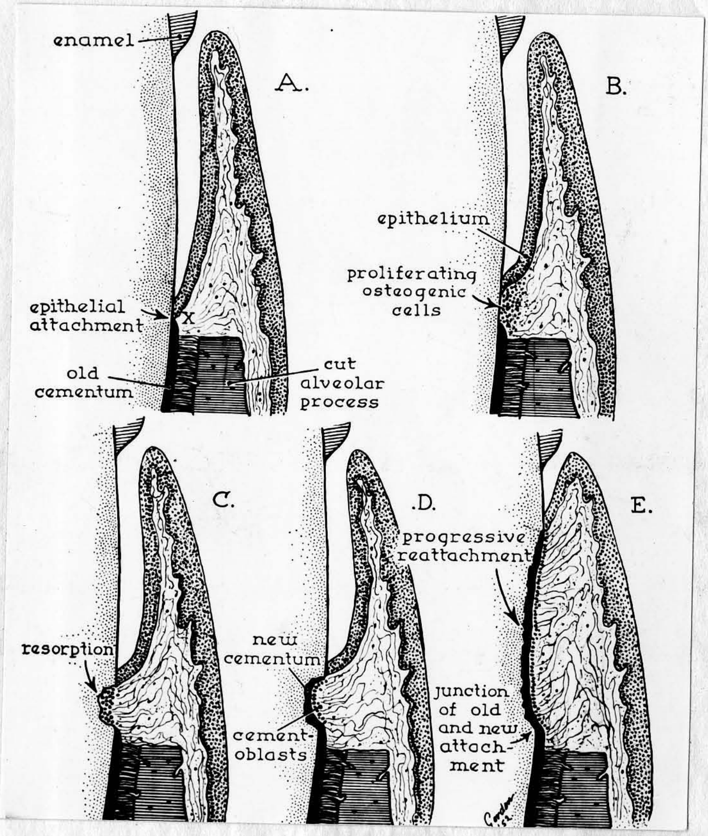

Figure 21(A) 22(B)

23(C) 24(D) 25(E)

PLATE XV

Figure 26:

Diagrammatic illustration - Key to microscopic measurements in present study

A - Total distance between coronal and apical notches

B - Total distance between apical notch and gingival margin

B^1- Amount of new connective tissue attachment

B^2- Amount of new epithelial attachment

B^3- Depth of remaining pocket

C - Amount of atrophy

D - Distance between alveolar margin and apical notch

E - Amount of new bone added to alveolar crest

Insert:

A - Notch in the root of the tooth (apical notch)

B - Notch in the crown of the tooth (coronal notch)

PLATE XV

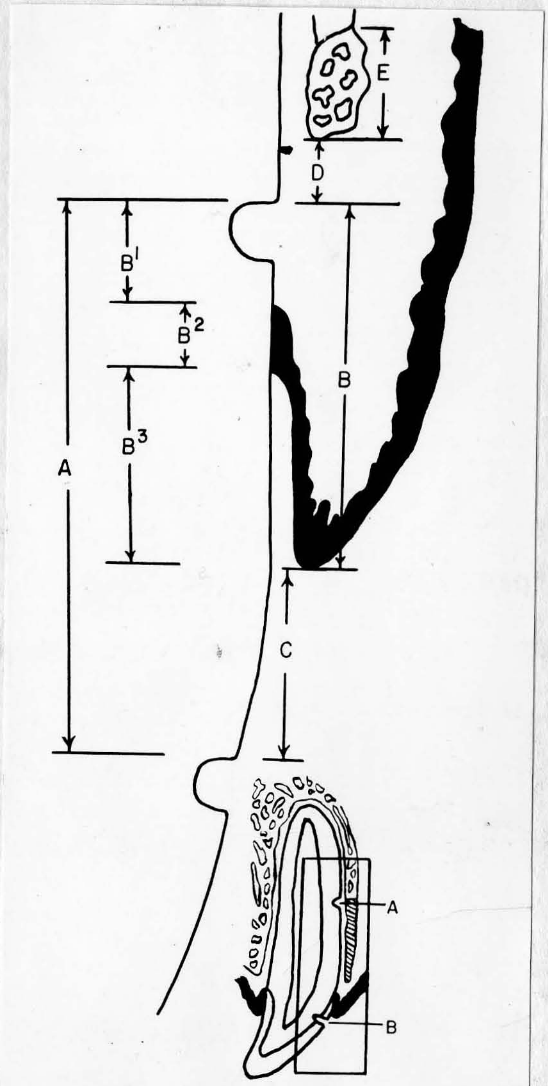

Figure 26