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A Histologic Study of the Tooth and Supporting Structures After Apicoectomy in Dogs

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A HISTOLOGIC STUDY OF THE TOOTH AND SUPPORTING STRUCTURES AFTER APICOECTOMY IN DOGS

by

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LIFE

Walter E. Bisch was born in St. Louis, Missouri, February 20, 1934.

He attended Christian Brothers College Military High School and was graduated in June, 1951. He received his pre-dental training at St. Louis University, and received the degree, Doctor of Dental Surgery from St. Louis University School of Dentistry in June 1959.

In July 1959, he was commissioned a full Lieutenant in the United States Navy Dental Corps. He served two years active duty at the United States Naval Training Center at San Diego, California.

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TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

There has been much written on what occurs after surgical removal of the apical end of a tooth root. While some theories have been proposed as to what eventually may develop after apicoectomy, only few studies on experimental animals have been done. The development of a granuloma and/or cyst around the apex of a tooth is well established. Many studies have been made radiographically and histologically to show the difference between a granuloma and a cyst. No one to our knowledge has shown histologically the formation of a cyst from a granuloma. There exists also no uniform histological evidence as to the nature of the tissue covering the resected root-end and filling the gap between the resected root and the surrounding bone.

A study on the histologic changes after apicoectomy was conducted by Ojha in 1961. He found granulomas in all experimental animals, except the six month specimen, a cyst had developed.

The present study was undertaken to clear the existing

confusion concerning the histological structure of the tissues following apicoectomy.

CHAPTER II

REVIEW OF THE LITERATURE

I. CONCERNING THE HISTOLOGICAL STRUCTURE OF THE TISSUES FOLLOWING APICOECTOMY

A study of healing after apicoectomy is not new to researchers in dentistry. Bauer, in 1922, did the first experimental study of the root resection on cats in Germany. Six cats were used in the experiment. Bauer resected the root apices of six maxillary canines. Animals were sacrificed one to six months. Microscopic examination showed newly formed cementum and osteoid-like tissue covering the trans-section of the root stump.

Euler, in 1923, performed root-resection on dogs, sacrificing them from six to twelve weeks. He found no instance of complete healing and observed various degrees of inflammation and abscess formation.

Bauer, in 1925, using three dogs and two cats and sacrificing one to six months, again found regeneration of bone and periodontal membrane over the newly laid cementum on the root stump, however, a few sections showed abscess formation.

In 1928, Kronfeld reported on a case one year after apicoectomy. He found on cross-section new deposition of cementum. Schachtel, in 1929, amputated the roots of ten maxillary and mandibular canines in three dogs. The animals were sacrificed from one to six months. Seven specimens showed regeneration of bone, periodontal membrane and cementum, however, three showed infection and abscess formation.

Hill, in 1932, studied 48 teeth in dogs using the second and third maxillary and mandibular incisors. Two techniques were used: 1) The pulp was removed, and with the root canals unfilled, the coronal ends were sealed. 2) After pulp removal, sterilized paper points infected with pure cultures of streptococci were inserted. All teeth developed granulomas. Hill felt that the conditions present in the development of dental granulomas in dogs, approximate but are not exactly like the conditions present in human dental granulomas. The number of foramina in dogs teeth is greater and the branching of canals occurs higher in the pulp chamber than in the average human tooth. These

anatomic features may account for the fact that dental granulomas are produced more quickly and more easily in dogs than in human beings. Hill noted resorption of root surface and said this condition is common on the roots of dogs' teeth with granulomas.

Although the employment of root resection as a treatment for dental granulomas originated around 1880, Bauer, Euler, Schachtel, Hill, and Ojha were the only investigators reporting experimental studies on laboratory animals.

The originator of apicoectomy as a procedure for treatment is not known. The removal of diseased tissue around the apex of a tooth with a bur was reported by White in 1855. The operator at that time would enter the alveolar process with a trephine and a bur in a dental engine and grind away the diseased area of tissue. The first to encourage this treatment were Farrar(1884), Rein(1890), and Dunn(1884). Dr. Rein presented three cases, which he treated in 1882, to the 13th annual meeting of the American Dental Association in 1891. C. E. Bentley reported a case of apicoectomy in the Dental Review of 1890 which was performed before the

senior class of the Chicago College of Dental Surgery by Dr. Truman Brophy.

Because of the theory of focal infection, apicoectomy received a severe blow. All infected teeth were condemned. In 1921, Dr. Hilman said, "Apicoectomy is rarely successful." Novitsky (1922) and Lucas (1922) opposed this treatment also. However, Blum (1917), Thoma (1917), and others favored apicoectomy as a form of treatment and later it became an accepted method of treating "infected teeth" and remained as such to the present day.

Nowhere in the literature can there be found any study performed on the histological appearance of an area of apicoectomy from human autopsy material. It can be easily understood that the problems involved in obtaining such material would be quite difficult. The studies done on human material are from teeth that had been treated and later extracted for some reason. Most of the reports described only the histological appearance of the dental tissue covering the resected root and not the surrounding supportive structures. Therefore, I believe they have only limited value to an

experimental study but mention is made of them in the literature.

II. CONCERNING THE MECHANISM OF GRANULOMATOUS AND CYSTIC DEVELOPMENT FOLLOWING APICOECTOMY

In reviewing the literature, much is found concerning the presence of epithelial rests in the periodontal tissues. Many theories are proposed as to how a cyst develops.

Robin and Magitot (1860) seem to have been the first to describe "epithelial debris" around a developing tooth. Malassez (1855) was the first to describe epithelial rests in the periodontal tissues. Eve (1886) stated that cystic tumors of the jaws probably originated in epithelial ingrowths invading the bone in the vicinity of teeth. Witzel (1896). Partsch, and Proell (1912), and others agreed that the origin of the squamous epithelium arose from the rests of the enamel organ as suggested by Malassez.

Henrici (1917) believed epithelial rests were left behind to fulfill a function when called upon later in life. This function he suggested to be the formation of epithelial structures in chronic periapical granulomata. He stated that once the crown of the tooth is perforated and the pulp exposed, there is no method of protecting the tissues of the

jaw from infection save by proliferation of such epithelial structures. By cyst formation there is interposed between the exposed tissues and the outside world, a layer of stratified squamous epithelium, the type of tissue that forms a barrier against bacteria invasion. The mechanism described by Henrici of cystic formation is most interesting. Within the mass of granulation tissue areas of squamous epithelium are present in isolated patches or islands. In serial section, these masses are all found to be connected. The epithelial structure so formed is arranged as a somewhat flattened mass interposed between the root tip and the granulation proper: from it numerous long finger-like projections extend in all directions into the granulation tissue. This epithelial mass increases in size and, as it does, grows down into the center of the granuloma. From this central mass, long narrow projections extend in all directions to the capsule of the lesion. The epithelial structure continues to grow, particularly as retrogressive changes occur in the granuloma; as it grows, the central cells become further and further separated from their blood supply and soon degenerate. The epithelial structure grows

in response to the same irritant which produces the granuloma and as long as the inflammatory process continues.

Dorrance (1921) reported that the concensus of opinion was that cysts developed from the epithelial sheath of Hertwig. The sequence of development is: 1) death of the pulp, 2) development of a granuloma, 3) bacterial or other toxins. Irritation of the epithelial rest cells stimulates them to overgrowth which goes on until the cyst develops.

McConnell (1921) studied over 100 specimens of granuloma and found epithelium in 35% of them. He stated that a study of granulomas of long standing would be of much value. He concluded: 1) That granulomas are specifically subacute or chronic inflammatory lesions characterized by plasma cell infiltration and connective tissue formation. 2) The term abscess should not be applied except in those cases in which the symptoms are acute and purulent infiltration is present. 3) That the capsule formation which is continuous with the peridental membrane is a protective reaction. 4) That the epithelial lining of the cysts is also a protective action. 5) That the epithelial cells

present in the above are derived from the remnants of the outer layer of the enamel organ which are so frequently found in the peridental membrane.

A radiographic and statistical survey of 1500 patients was done by Livingston (1927). He felt that chronic dental or periapical abscess is the precursor of the cyst and that histological, radiographic, and statistical findings appear to support this view.

Freeman (1931) found two types of granuloma: 1) those surrounded by a fibrous capsule without the presence of epithelium, and 2) those containing epithelium in the form of a network throughout the tissues. He said that so long as there is no irritation, the epithelial rests remain quiescent indefinitely. He believed that if an infection occurs, there is a reaction on the part of the cells to act as a protective covering. Freeman (1931) studied over 200 dental granulomas and found 45% to be devoid of any epithelial tissue.

Rywkind (1927) and Romer (1928) reported that the primary areas of cyst formation are within the epithelium

present in granuloma. They result from necrosis of the center of such epithelial masses, consequent to the avascularity and poor nutrition of this tissue. Hill (1930) confirmed the observations of Rwykind and Romer and felt that as the epithelium proliferates, it forms strands extending into surrounding tissue (similar to the finger-like projections Henrici described).

The results of apicoectomy reported by investigators vary from infection, abscess formation, cystic development to the normal repair of the root and bony wound.

The use of aseptic surgical methods, antibiotics and the selection of lower incisor teeth offering greater accessibility and minimal surgical trauma should serve to control or prevent the variation of response to apicoectomy, thus giving a clearer picture of the response.

CHAPTER III

METHODS AND MATERIALS

The material in connection with this project was collected by experimental surgery on dogs. Jaw and teeth specimens were processed for histological study. Seven, adult, healthy dogs were selected. They were anesthetized by intraperitoneal injection with 5% Nembutal, one cc. per 5 lbs of body weight, supplemented with local infiltration of the mandibular anterior segment with 2% Xylocaine containing epinephrine 1:100,000. Under aseptic conditions, an incision was made labially extending from the mid-line tothe distal of the canine (left and right). The incision was made about 2-3 mm. below the crest of the gingiva with a #15 Bard Parker blade. The mucoperisteal flap was reflected with a periosteal elevator. The bone overlying the apex of the incisors (left and right) was removed with a bur. At this time, 3-4 mm. of the root apex was resected and removed. After smoothing the rough edges and flushing with normal saline, the mucoperiosteal flap was sutured with 000 silk. The dogs were maintained on Purina dog food

and water ad libitum. Regular periodic observations were accomplished. The dogs were sacrificed after six months. The block of mandible containing the incisor teeth was removed and fixed in formalin for 24 hours, at which time the fixative was changed. The specimen blocks were dehydrated, embedded in paraffin, and sectioned at 8-10 microns. The sections were stained with hematoxylin and eosin.

TABLE I

NO.	WEIGHT	SEX	DATE OPERATED	DATE SACRIFICED	CONDITION	APPROXIMATE AGE	SPECIMEN
1	20 lbs.	F	2/9/62	2/27/62	Poor	2 years	3 weeks
2	23 lbs.	F	6/1/62	7/3/62	Very Poor	2 years	1 month
3	33 lbs.	M	2/9/62	8/7/62	Fair	3 years	6 months
4	32 lbs.	M	3/10/62	9/10/62	Excellent	4 years	6 months
5	32 lbs.	M	3/10/62	9/10/62	Good	1 year	6 months
6	40 lbs.	F	4/10/62	10/11/62	Fair	3 years	6 months
7	20 lbs.	F	6/27/62	1/7/63	Excellent	2 years	6 months

Vital statistics of experimental animals used in study.

CHAPTER IV

FINDINGS

Of the seven experimental animals used, two died before the six month period for sacrificing. One died at three weeks, the other at one month. The other five animals lived to the six month sacrificing period.

Dog No. 1, Three Week Specimen (right side)

The mucosa and submucosa appear normal. The area formerly occupied by the apex is filled with young fibrous connective tissue (Figure 10). A few islands of bone are seen in one area of the connective tissue. Some fragments of tooth are present near the opening into the pulp chamber (Figure 7).

Many dilated capillaries are present in the connective tissue. Evidence of inflammation is apparent by the presence of polymorphonuclear leucocytes and plasma cells.

The periodontal ligament shows loose connective tissue which is continuous on both sides of the root with the connective tissue fibers in the osseous defect, immediately apical to the root.

Adjacent to the area of young connective tissue, osteoblasts are lined up and bridging of bone is seen. Deep to this, a normal bone pattern is observed.

The surface of the resected root end is free of cementum (Figure 9). Inffammation is present in the periodontal membrane adjacent to the resected surface.

The pulp tissue is necrotic. The coronal pulp has completely necrosed (Figure 8). However, the resected surface of the pulp tissue in the root is still present but highly vascular.

Dog No. 1, Three Week Specimen (left side)

The area formerly occupied by the apex contains young fibrous connective tissue. This connective tissue continues for a short distance into the pulp chamber. The root portion of the pulp tissue is highly vascular. The coronal portion of the pulp is devoid of any normal tissue, however, many polymorphonuclear leucocytes are observed.

Dog No. 2, One Month Specimen (right side)

The area of apicoectomy contains a granuloma. Infiltration of polymorphonuclear leucocytes is present and project for a short distance into pulp chamber(Figure 11). Surrounding this mass of polymorphonuclear leucocytes is a capsule of connective tissue.

Many capillaries are noted throughout the operative site (Figure 12). A layer of fibrous connective tissue over the resected end of the root is continuous with the periodontal ligament.

Except for the presence of a few areas of necrosed tissue, the pulp chamber is empty (Figure 13).

Osteoclastic resorption of the resected surface is taking place (Figures 14 & 15). Areas of osteoclastic activity are present throughout the surrounding bone. There is very little evidence of new bone apposition.

Dog No. 2, One Month Specimen (left side)

The left side also contains a granuloma in the area of defect made by apicoectomy. The connective tissue surrounding the granulomatous mass is more dense than on the

right side. The connective tissue capsule is continuous from one side to the other with the periodontal ligament.

Areas of resorption are noted on the resected surface. Present in the area of granulation tissue is a space void of any material. This apparently contained exudate.

Dog No. 3, Six Month Specimen (right side)

The area of apicoectomy is filled in with bone. This bone projects for a short distance into the pulp chamber (Figure 21).

Many capillaries are present in the area of defect and appear dilated. The bone in the area is mature.

No evidence of gross inflammation is present. Only isolated areas are noted and portions of the pulp chamber show polymorphonuclear leucocytic infiltration.

Osteo-cementum covers the resected surface (Figures 19 & 20). One side of the osteo-cementum has pulled away from the surface apparently through artefact preparation. The other side is adherent to the resected end.

The apical one-third of the pulp chamber is lined with secondary dentine (osteo-dentine)(Figure 22).

Dog No. 3, Six Month Specimen (left side)

Complete apicoectomy was not done. The lingual portion of the root is in tact.

It is interesting to note, however, that osteo-cementum covers the portion of the tooth that has been resected.

Bone has filled the defect made from the operation.

The capillaries throughout the area of defect are dilated. No areas of inflammation are noted at the operative site.

Only a small portion of the pulp chamber is noted and it shows evidence of necrosis.

Dog No. 4, Six Month Specimen (right side)

The defect is repaired by bone. Bone is observed at the opening into the pulp chamber and extends for a short distance into the pulp chamber. The bone is young and evidence of osteoblastic activity is noted. The remainder of the operative site contains bone that shows many areas of osteoblastic activity.

Secondary dentine lines the apical one-third of the pulp chamber (Figure 22). The remainder of the pulp chamber contains fibrous connective tissue and dilated capillaries.

Osteo-cementum covers one of the resected ends. The other resected end shows evidence of resorptive activity.

Between the bone and tooth on one side, fibrous connective tissue continues around the resected end from one side to the other.

Dog No. 4, Six Month Specimen (left side)

The resected surface is covered over with cementum. The pulp chamber is void of any tissue elements. There is a thin layer of secondary dentine lining the apical portion

of the pulp chamber.

Polymorphonuclear leucocytes are present at the area of apicoectomy. Connective tissue surrounds and encapsulates the inflammatory elements.

Immature bone is present between the connective tissue capsule and mature bone. The surrounding capillaries are dilated and filled with blood.

Dog No. 5, Six Month Specimen (right side)

Evidence of a granuloma is still present. There are still elements of inflammation present adjacent to the resected surface. Polymorphonuclear leucocytes are present. A connective tissue capsule lies between the area of granulation and bone.

A proliferation of bone is apparent by the osteoblastic activity present. (Figure 24)

The pulp chamber is void of any material. Some evidence of necrosis is still present.

It is interesting to note that this specimen does not contain secondary dentine as was present in the previous six month specimens.

Dog No. 5, Six Month Specimen (left side)

Repair of the defect has taken place. Bone fills the operative site. There is no evidence of inflammation present. Connective tissue continuous with the connective tissue adjacent to the periodontal ligament covers the osteo-cementum on the resected surface. This connective tissue projects into the pulp chamber.

There is osteoblastic activity present in the bone in the defect. Many dilated capillaries are present in the entire field.

Dog No. 6, Six Month Specimen (right side)

Repair of the surgical defect has taken place. The resected surface is covered over with osteo-cementum.

There are many dilated capillaries in the periodontal ligament. The connective tissue adjacent to the periodontal membrane is continuous with the connective tissue at the resected surface.

The bone in the surgical defect is coarse fibrillar bone. Trabecular reconstruction has not yet taken place. Laying down of bone is taking place by the presence of osteoblastic activity.

The major portion of the pulp has undergone necrosis. Secondary dentine is present on one side of the pulp chamber near the resected surface. The remainder of the pulp chamber is void of secondary dentine.

Dog No. 6, Six Month Specimen (left side)

There is still evidence of a granuloma at the apical foramen. The pulp is void of any tissue. However, there are small remnants of necrotic tissue present at the apical foramen, just adjacent to the granuloma. There is no

evidence of secondary dentine in the pulp chamber.

Cementum has proliferated over the resected surfaces. There is a thin connective tissue capsule between the granuloma and bone. The inflammatory elements present represent a long standing chronic inflammatory reaction.

The bone between the connective tissue and mature bone is coarse fibrillar immature bone. There are various areas of osteoblastic activity present.

Dog No. 7, Six Month Specimen (right side)

Fibrous connective tissue is present in the area of apicoectomy just adjacent to the resected surface. This connective tissue extends into the apical portion of the pulp. There is osteoblastic activity present in the bone in the defect.

Evidence of resorption is observed along the resected surface by the presence of reversal lines. A thin layer of cementum has been laid down along the resected surface. The cementum is cellular cementum.

The coronal portion of the pulp has undergone necrosis. The apical portion of the pulp contains secondary dentine.

The field is moderately vascular. There are still some inflammatory elements present but the infiltration is only slight.

Dog No. 7, Six Month Specimen (left side)

The area of defect contains a granuloma. The amount of polymorphonuclear leucocytic infiltration is quite extensive.

Along the periphery of the granuloma repair is observed.

This is evident by the osteoblastic activity taking place in the bone surrounding the surgical defect.

There is no evidence of cementum on the resected surface. Resorption of the dentine along this surface is observed by the osteoclastic activity.

The pulp has undergone necrosis. Secondary dentine is not observed in the apical portion of the pulp as was noted on the opposite side. The inflammatory elements extend for a short distance into the pulp chamber.

CHAPTER V

DISCUSSION

Gross examination of the specimens at the time of sacrifice revealed no significant changes in the oral tissues. The only edidence of the apicoectomy procedure was the presence of a scar at the site of incision. Four of the teeth showed discoloration of the clinical crown.

A definite sequence occurs after apicoectomy on a tooth with a vital pulp. The sequence of events will be discussed in conjunction with the effects on the three main areas concerned: the pulp, the resected root, and the area of the bony effect.

THE PULP

The coronal pulp is deprived of its blood supply and the resulting ischemia is prolonged which accounts for its invariable death as seen in this study. The presence of polymorphonuclear leucocytes shows that an acute suppurative pulpitis accompanies the surgical interferences to the pulp. In a recent study of apicoectomy, Ojha (1961) showed that

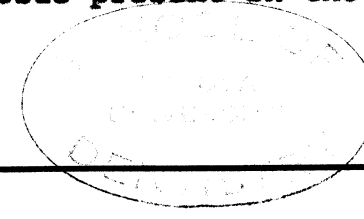
the infiltration of polymorphonuclear leucocytes occurs within twenty-four hours. This also was seen at seventy-two hours and nine day pulps. Moreover, Ojha reports complete pulpal abscess in all apicoectomies of teeth with vital pulp.

The apical portion shows a different reaction from the coronal pulp. This must be attributed to the availability of blood supply immediately following surgery. The presence of necrotic tissue in the apical portion may be due to ischemia as in the case of the coronal pulp. If the arteries entering the pulp survive, prevention of complete necrosis may occur, however. The large numbers of foramina and arteries in the canine teeth may account for variability in response. If only the very apex is removed and many of the arteries remain, complete necrosis may not occur. However, with resection high on the roots above the foramina, complete necrosis may occur. Hill (1931) believed the blood supply to the pulp in canine teeth may account for the ability of the root pulp to rapidly develop a new blood supply.

The apical portion of the pulp shows evidence of survival. The apposition of dentine is seen on the apical one-third of the pulpal surface. This suggests that the reduction in blood supply and acute suppurative inflammation did not seriously effect the root pulp.

The nature of the connective tissue in the apical pulp is identical with the granulation tissue seen at the root apex. In some specimens, the apical pulp contained fibrous connective tissue continuous with the reformed periodontal ligament. In other cases, new bone tissue extended from the periapical cancellous bone into the apical pulp canal. Thus, the apical pulp behaves exactly as the periapical connective tissue and may be considered as a singular tissue. In this regard, the presence of granulation tissue in the pulp canal may be called an intra-dental granuloma.

Although there is pulpal necrosis, a state of equilibrium apparently is reached and a repairative process is initiated. Evidence of this repair is bbserved by the inflammatory elements and connective tissue present in the



apical one-third of the canal and the periapex.

THE RESECTED ROOT

Cementum is laid down over the resected end after apicoectomy. This was also observed by Bauer, Euler, Hill, and others. This process occurs in two phases: a resorption phase and a apposition phase.

After surgical removal of the tooth apex, the surface of the remaining tissue shows differentiation of osteoclasts which resorbs the dentine. While the extend of the resorption is of only a few microns in thickness, the regulation of the extent of resorption is not known. Aging of bone tissue contributes to the formation of osteoclasts and bone resorption. However, any effect induced by the age of the dentine must be modified by the covering of predentine and odontoblasts on the inner surface and the covering of the last layer of cementum on the periodontium surface. However, injury to the pulp or periodontium may cause proliferation and differentiation of connective tissue cells to form osteoclasts.

The surgical injury, the subsequent pulpitis, and the

formation of periapical granulation tissue occur concurrently with the resorption of the dentine. It is significant that resorption, a so-called destructive process is part of the proliferative activity of granulation tissue.

The small, scalloped resorptive defects on the dentine are covered by newly apposed cementum. The process of apposition of cementum on the resected surface is a necessary biologic phenomenon. Cementum is necessary for the attachment of the cementum group of fibers of the periodontal ligament. Cementum is also essential to the continued growth and eruption of the teeth. Sicher points out that the functional age of the tooth is only that of the last layer of cementum.

The cementum covering the resected dentine of the teeth studied in the present investigation was both cellular and acellular, however, for the most part, cellular cementum was observed. The incremental lines observed indicate a normal periodic apposition of cementum.

THE AREA OF THE BONY DEFECT

It is evident that repair in the periodontium and

alveolar bone follows apicoectomy on a tooth with a vital pulp.

The first response to the trauma made by surgery is the formation of a blood clot at the operative site. Next, inflammation occurs, characterized by the infiltration of polymorphonuclear leucocytes which takes place during the first 24 hours post operative.

Following the above changes, organization of the clot takes place. Loose connective tissue cells proliferate and endothelial budding occurs. This young connective tissue forms granulation tissue between the bone and the resected root end.

The formation of granulation tissue in the periapical region resolves by the formation of a new periodontal ligament and the formation of alveolar bone. The differentiation from granulation tissue of both osteoblasts and fibroblasts are responsible for the new bone formation and new fibers of the periodontal ligament. It must be pointed out that as cementum is apposed on the resected root, new collagenous fibers are embedded, forming the cementum group of periapical

alveolar group of fibers. The intermediate zone remains vascular and contains the irregularly arranged intermediate plexus of fibers. Thus, what is a complete resolution by repair and reconstruction occurs in the periapical tissue. However, this type of resolution is dependent upon a healthy apical canal. It has been noted that when only coronal necrosis is observed, the apical pulp resolves by forming granulation tissue, apposition of dentine and bone formation.

The apical tissue resolves by the formation of a chronic inflammatory process when the apical pulp is necrotic. In such a case, the apical granulation tissue extends over the resected root end. The face of granulation tissue in contact with cancellous bone may form new bone and a fibrous capsule. The face of the granulation tissue in contact with the resected root retains indefinitely the elements of granulation tissue, e.g. capillaries and indifferent connective tissue cells. However, in addition, macrophage, plasma cells and polymorphonuclear leucocytes infiltrate the periapex. In such cases, a residual periapical granuloma remains.

CHAPTER VI

SUMMARY AND CONCLUSION

This investigation was undertaken to study the histologic changes that follow apicoectomy on a vital pulp. Seven dogs were used as experimental animals. The 2nd lateral incisor bilaterally was used as the operative site. The animals were sacrificed at three weeks to six months. The section of the jaws containing the tooth was fixed, embedded in paraffin and stained with H & E. The pulp resected root and area of bony defect were examined in detail.

CONCLUSION

I. a) The coronal pulp deprived of its blood supply dies.

b) The apical pulp may resist necrosis and repair by formation of secondary dentine, connective tissue, and bone.

II. The resected surface repairs by being covered with cementum.

III. a) In the presence of a healthy apical canal

repair in the peridontium and alveolar bone follows apicoectomy on a tooth with a vital pulp. The apposition of new bone is accompanied by the formation and embedding of the periapical group of fibers.

b) In the presence of a necrotic apical pulp, the apical granulation tissue extends over the resected root end and a residual periapical granuloma remains.

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FIGURE 1

Photograph showing the area of apicoectomy prior to surgery.

FIGURE 2

Photograph of the defect after apicoectomy.

FIGURE 3

Photograph showing the closure of the mucosa over the operative site. Interrupted sutures were placed, using 000 black silk.

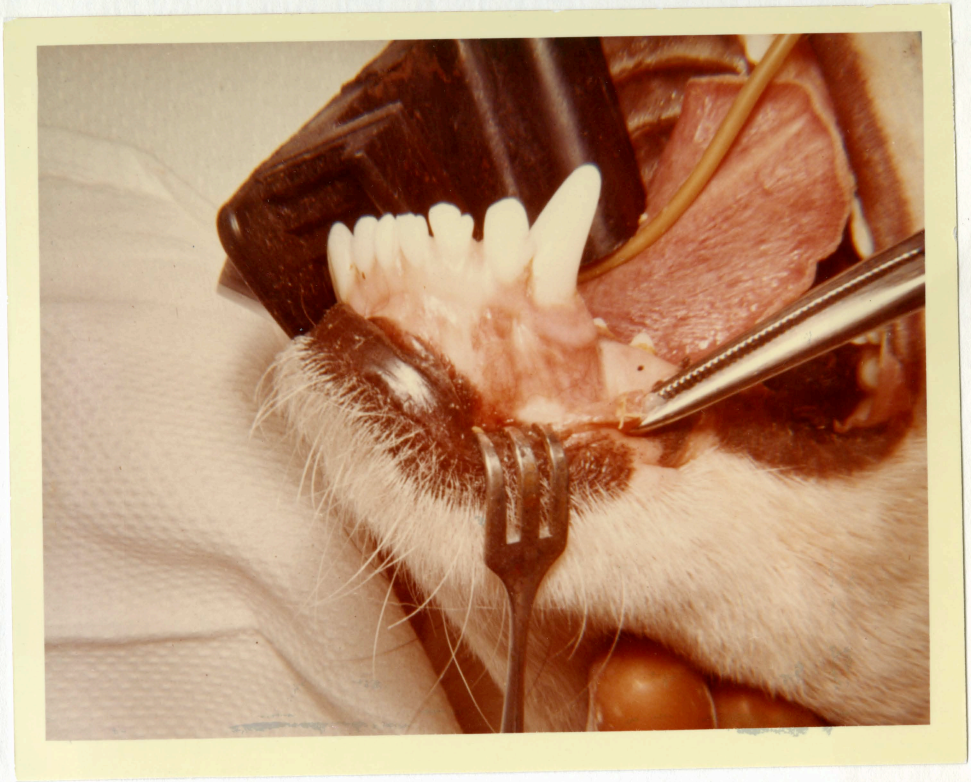


FIGURE 4

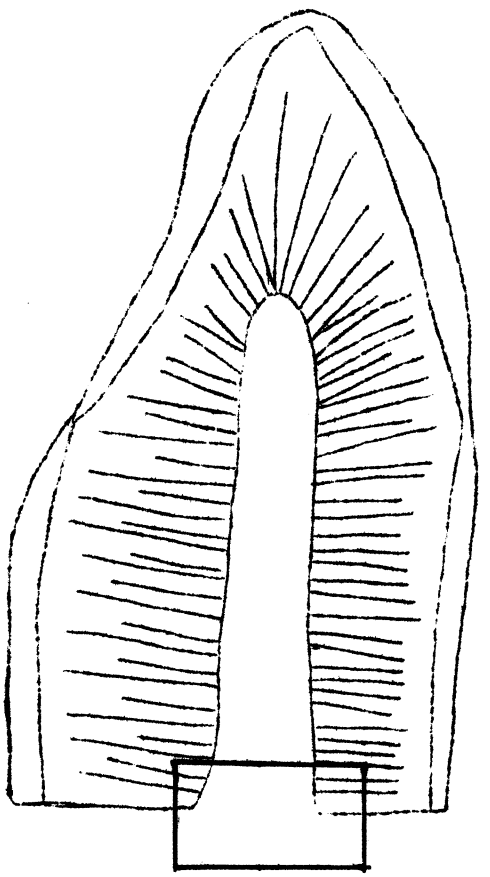
Photograph of the operative site three months post-operative. The specimen pictured above is dog number 7.

FIGURE 5

Radiograph of the one month specimen at the time of sacrifice. The specimen has been cut down to shorten the time of decalcification.

FIGURE 6

Radiograph of six month specimen at the time of sacrifice. The notch observed in the cuspid tooth was made for identification purposes. Note the trabeculation in the area of apicoectomy.



Area of photomicrograph figure 7.

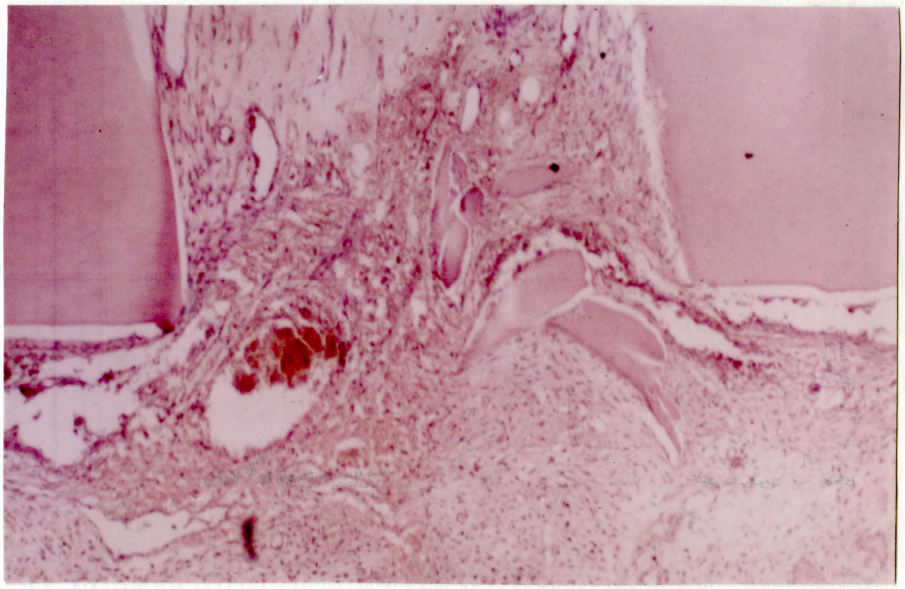
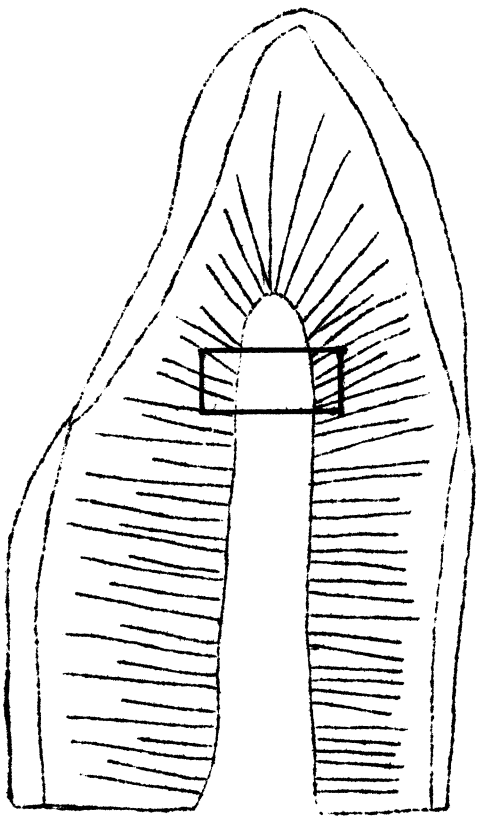


FIGURE 7

Photomicrograph of three week specimen showing the area formerly occupied by the apex. Note the young fibrous connective tissue present. Some fragments of tooth are present near the opening into the pulp chamber. (All specimens stained with Hematoxylin and eosin). (X25).



Area of photomicrograph of figure 8.

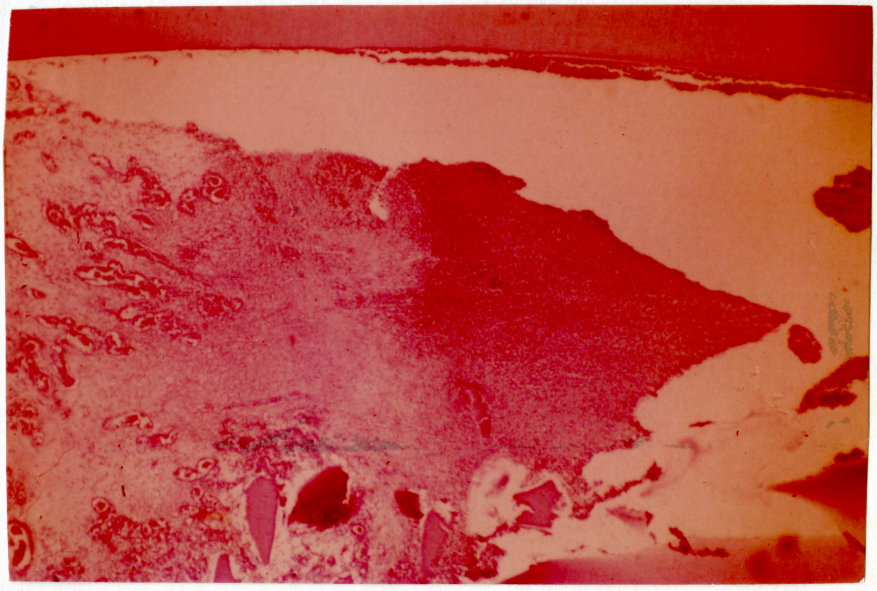
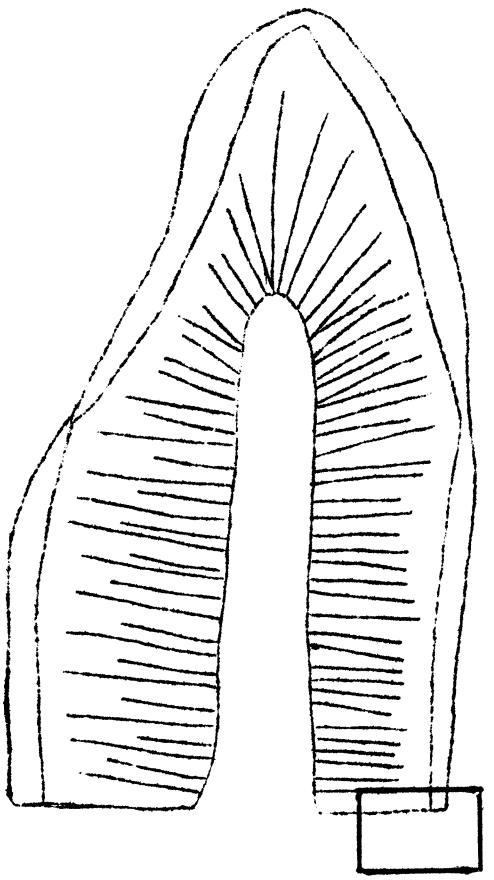


FIGURE 8

Photomicrograph X10 of three week specimen showing the coronal portion of the pulp. Observe that the coronal pulp is completely necrosed. (X10).



Area of photomicrograph of figure 9.

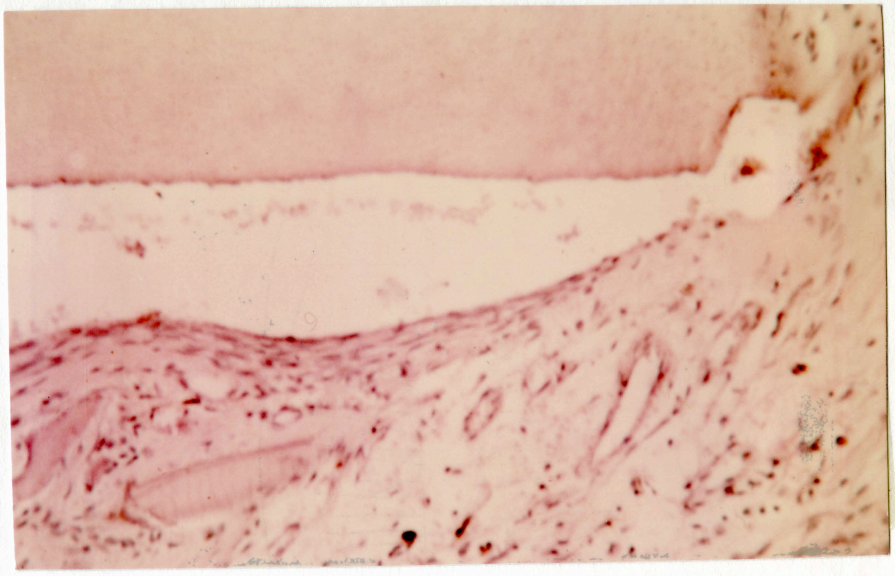
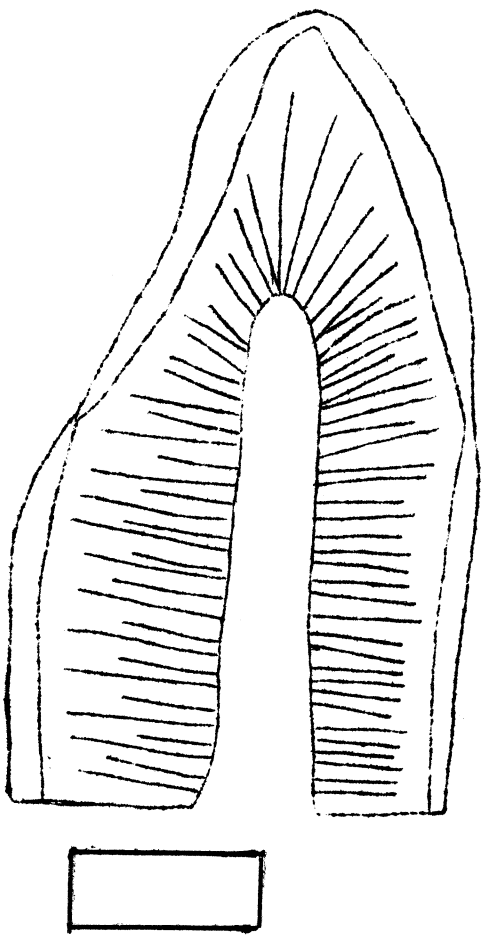


FIGURE 9

Photomicrograph of three week specimen showing the resected surface. Note the resected root end is free of cementum. The space between the soft tissue and resected surface is artefact. (X100).



Area of photomicrograph of figure 10.

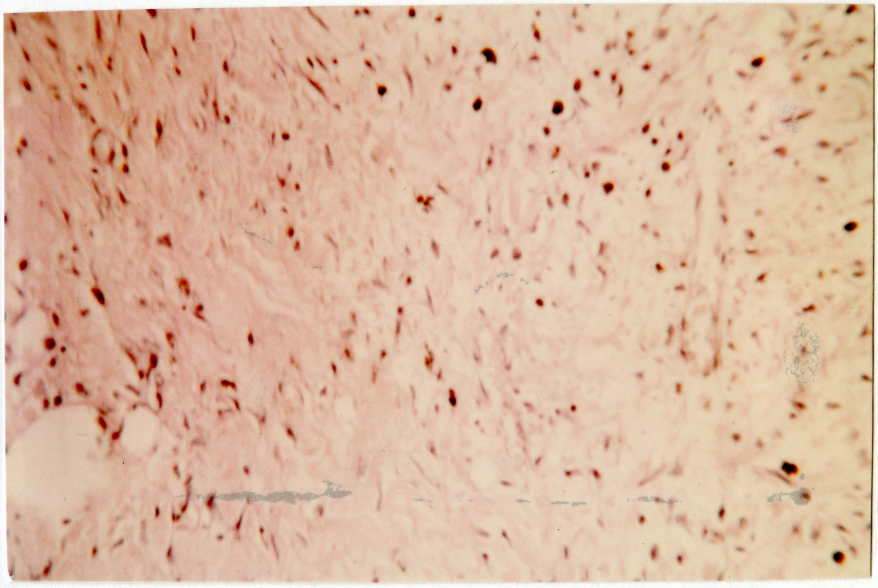
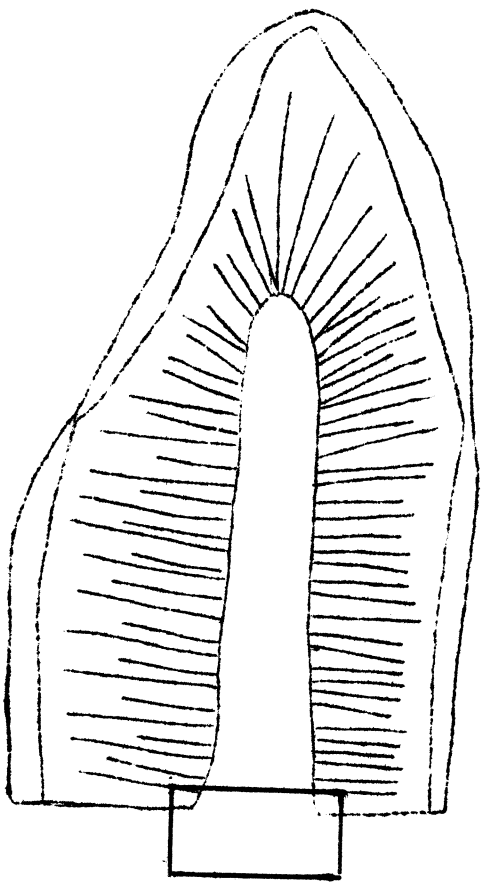


FIGURE 10

Photomicrograph of the three week specimen showing the young connective tissue in the surgical defect. The tissue is highly vascular(X100).



Area of photomicrograph figure 11.

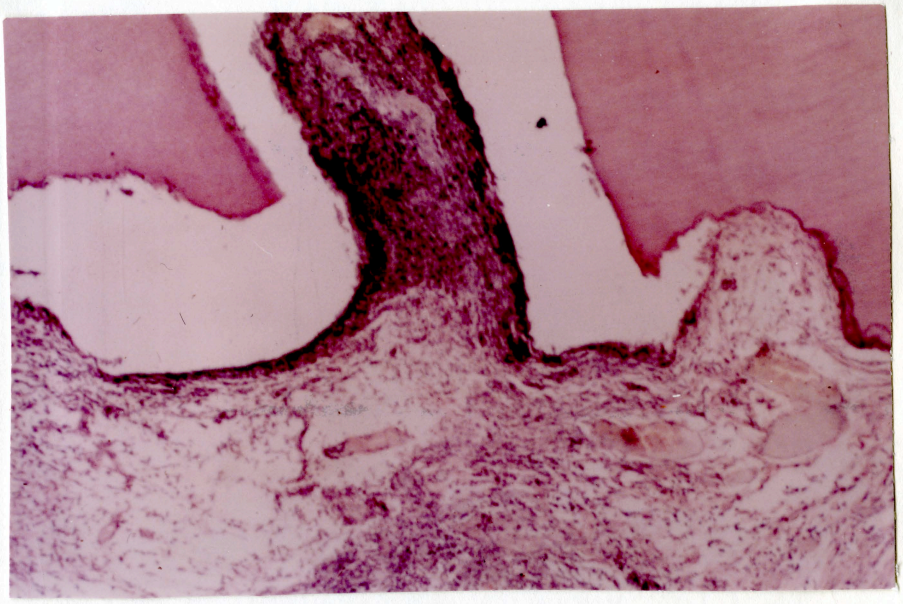
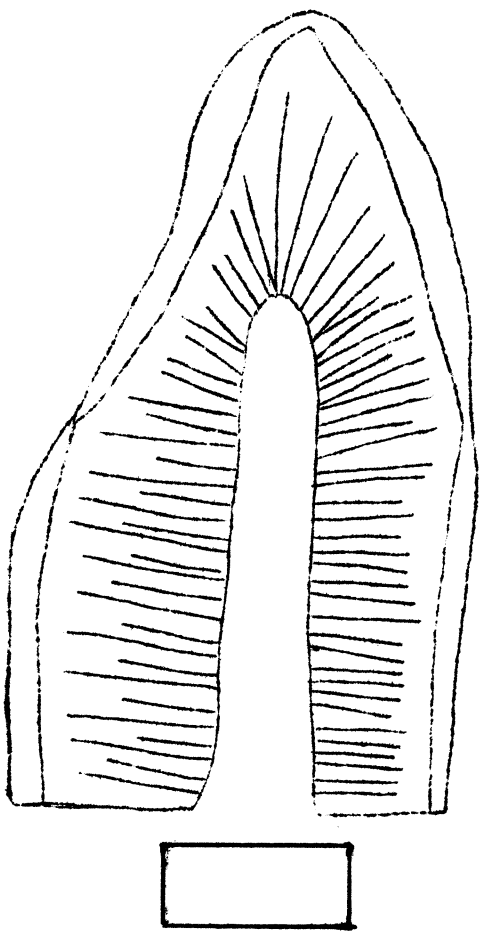


FIGURE 11

Photomicrograph of the one month specimen showing the infiltration of polymorphonuclear leucocytes at the apical portion of the degenerating pulp (X25).



Area of photomicrograph figure 12.

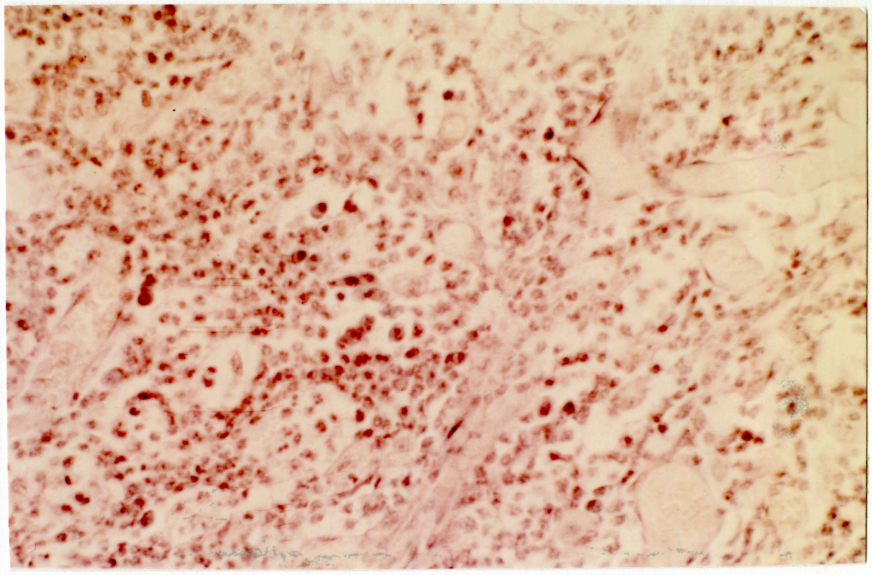
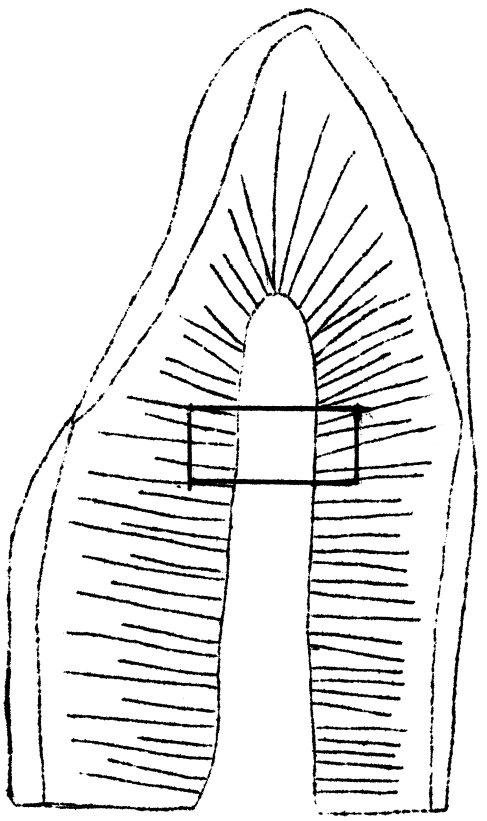


FIGURE 12

Photomicrograph of the one month specimen showing the tissue in the area of the defect made by apicoectomy. Note heavy infiltration of polymorphonuclear leucocytes and increased vascularity(X100).



Area of photomicrograph figure 13.

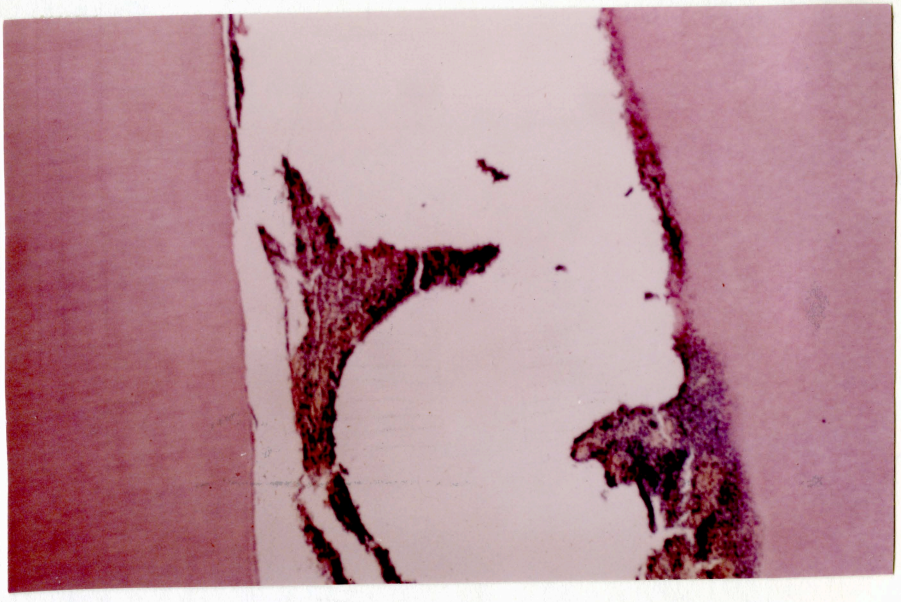
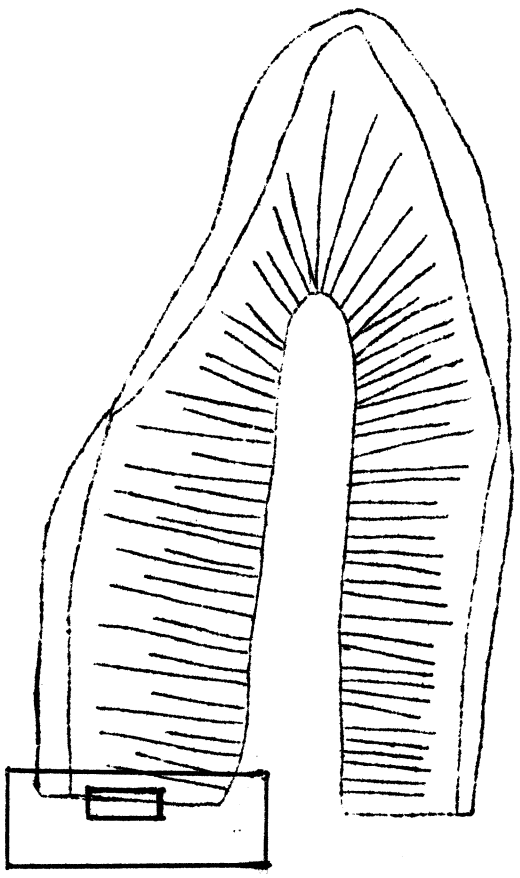


FIGURE 13

Photomicrograph of the one month specimen showing the complete necrosis that has taken place in the coronal portion of the pulp(X10).



Area of photomicrograph figures 14 & 15.

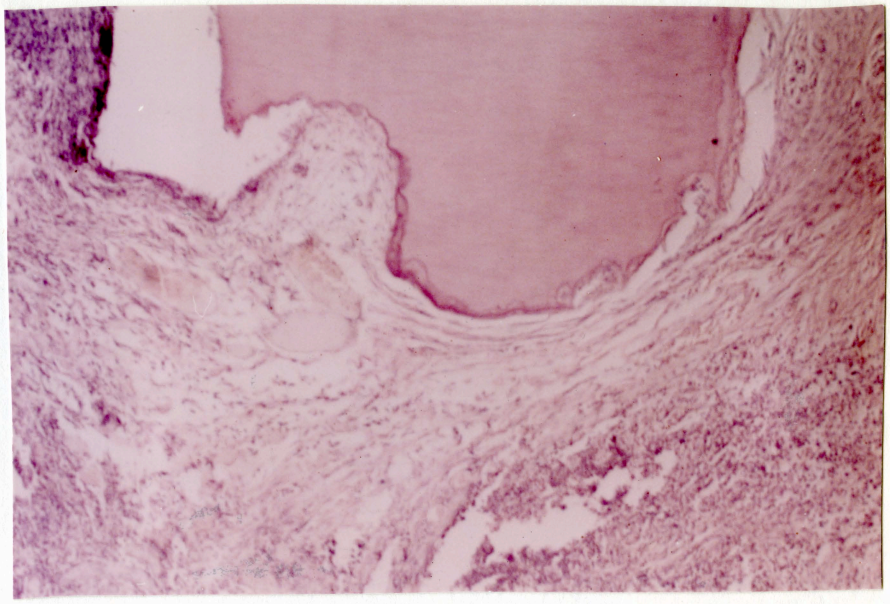


FIGURE 14

Photomicrograph of the one month specimen showing the osteoclastic resorption of the resected surface (X25).

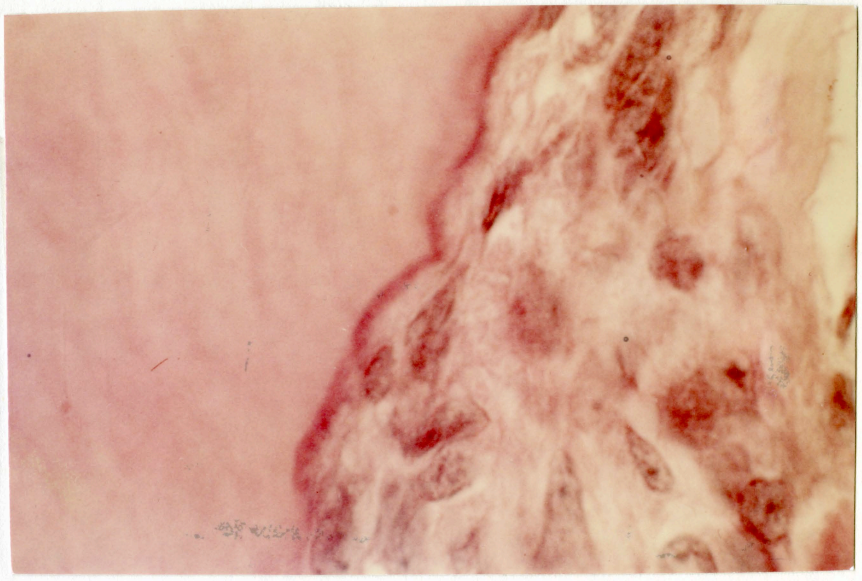
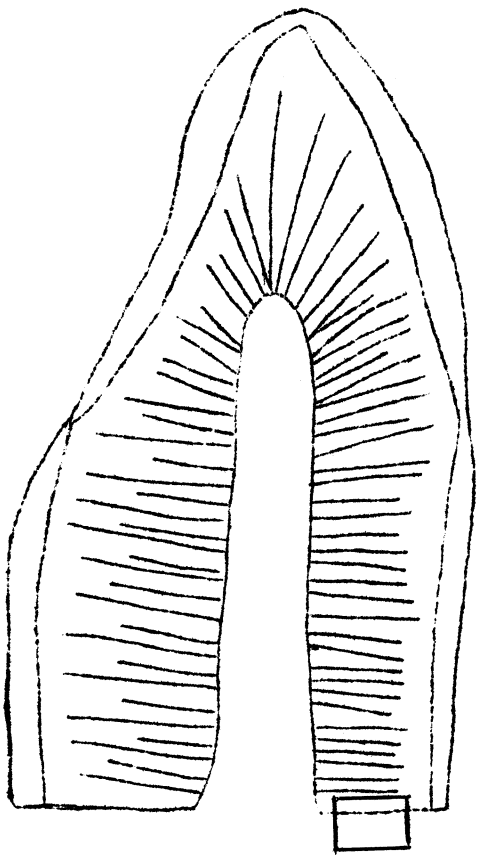


FIGURE 15

Photomicrograph of FIGURE 14 showing the osteoclastic resorption of the resected surface(X400).



Area of photomicrograph figure 16.

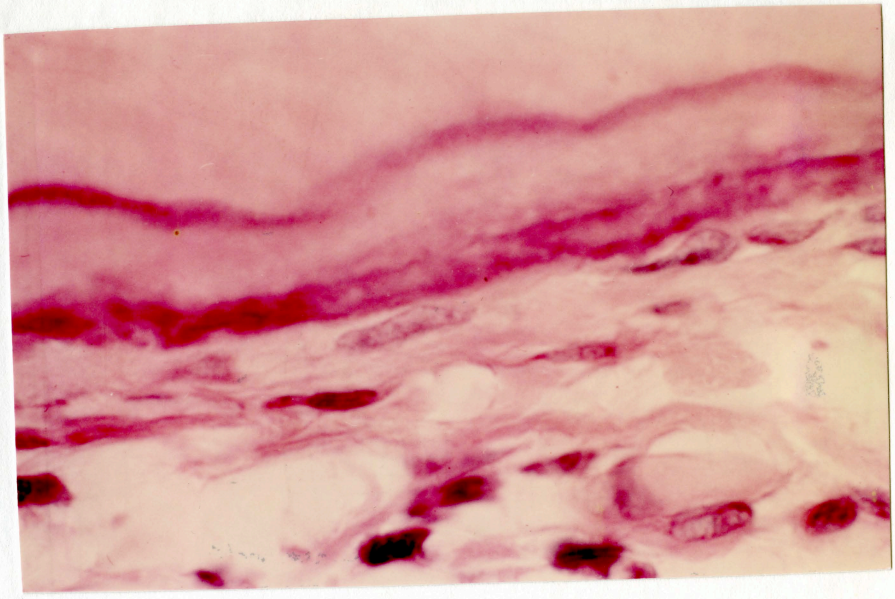
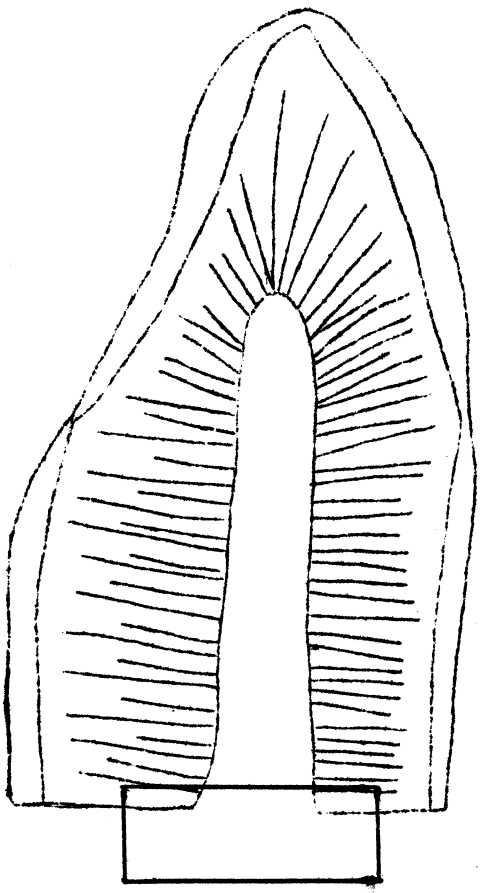


FIGURE 16

Photomicrograph showing fibroblasts adjacent to the resected surface(X400).



Area of photomicrograph figure 17.

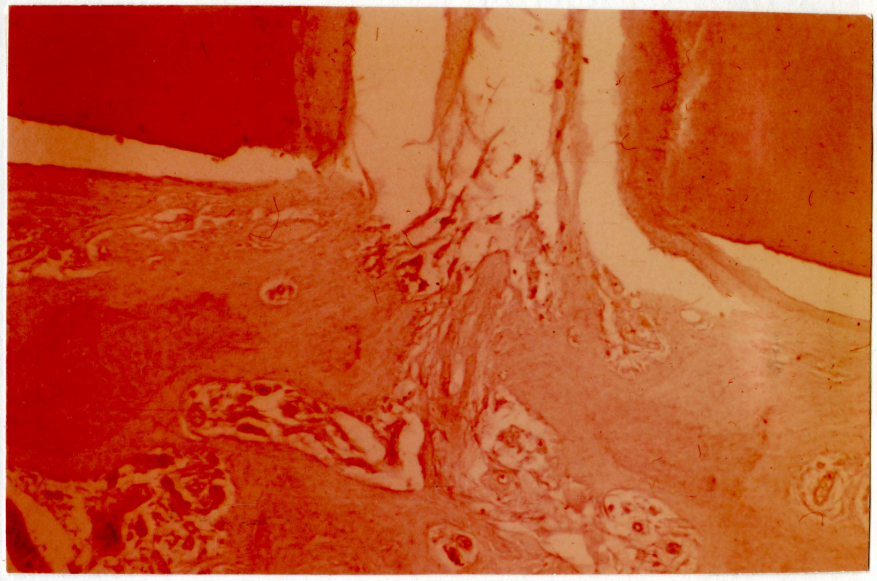
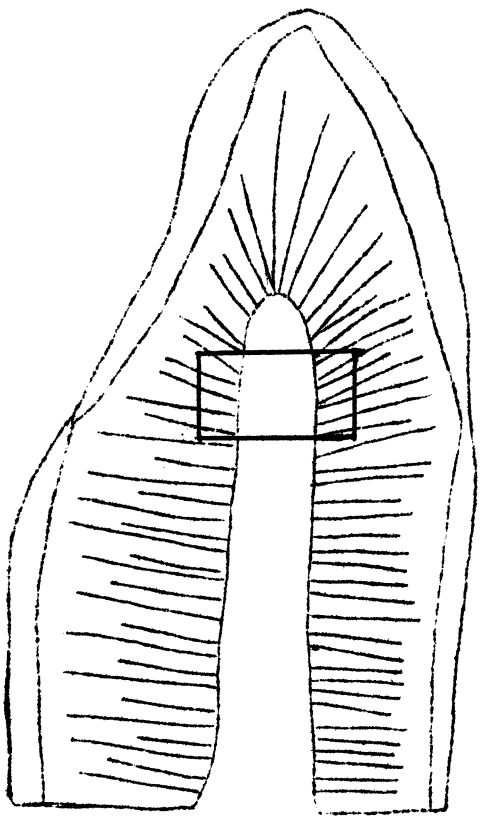


FIGURE 17

Photomicrograph of six month specimen showing the presence of young trabecular bone in a field of fibrous connective tissue at the resected surface. The field is moderately vascular. The pulp has degenerated. Artefacts present at resected surface (X25).



Area of photomicrograph figure 18.

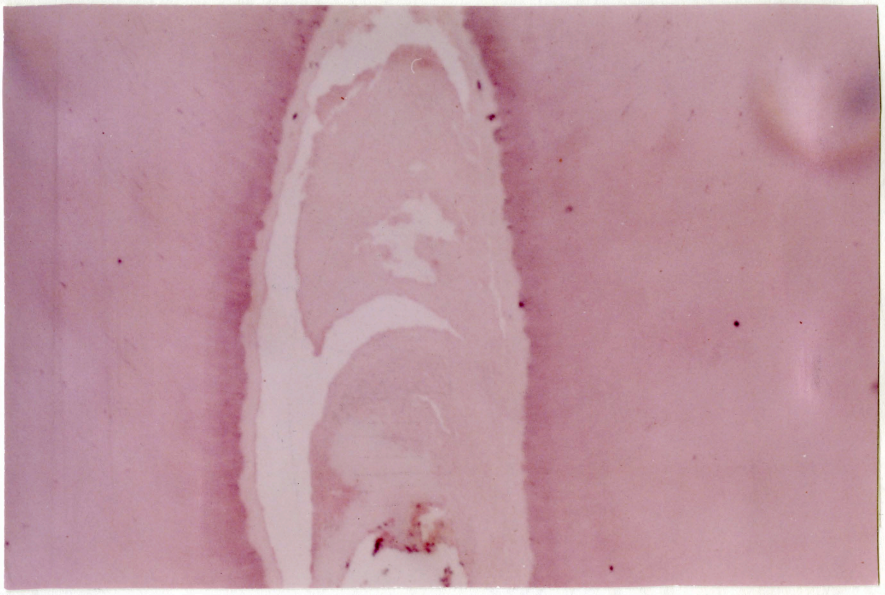
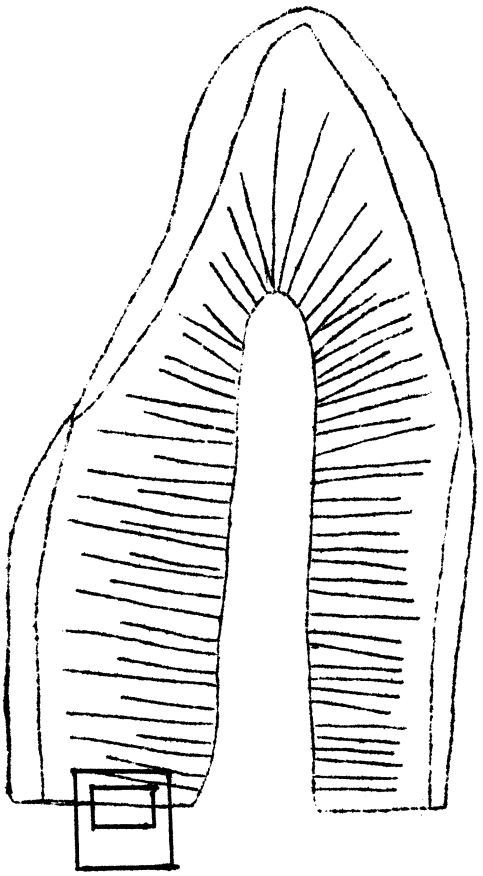


FIGURE 18

Photomicrograph of six month specimen showing necrosis of the coronal portion of the pulp(X25).



Area of photomicrograph figures 19 & 20.

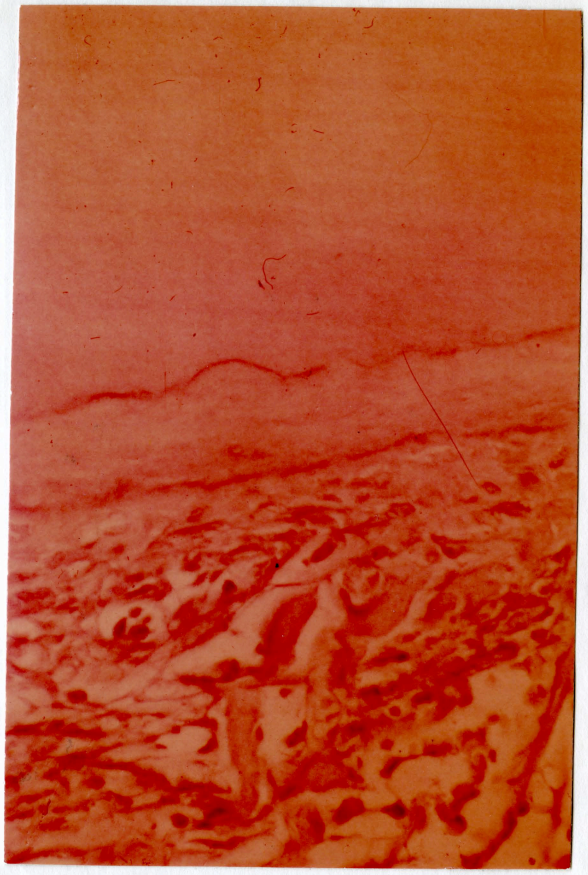


FIGURE 19

Photomicrograph of six month specimen showing a zone of cementum covering the dentine of the resected surface. Well organized connective tissue with abundant vascular supply is observed(X100).

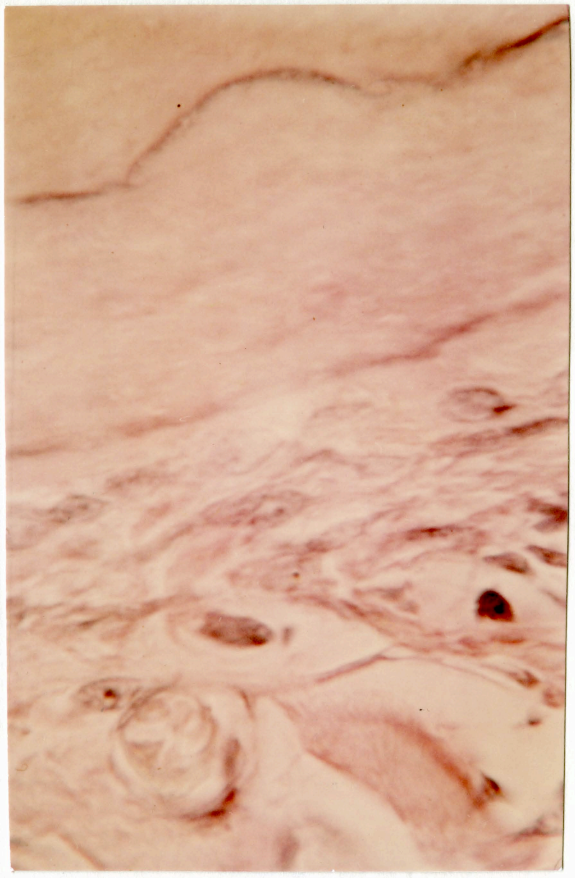
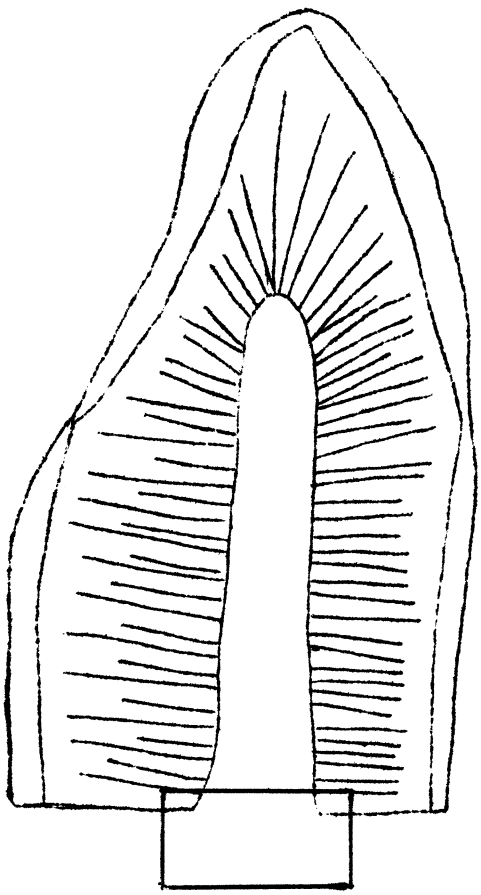


FIGURE 20

Photomicrograph of FIGURE 19. Cementoblasts laying down cementum along resected surface(X400).



Area of photomicrograph figure 21.

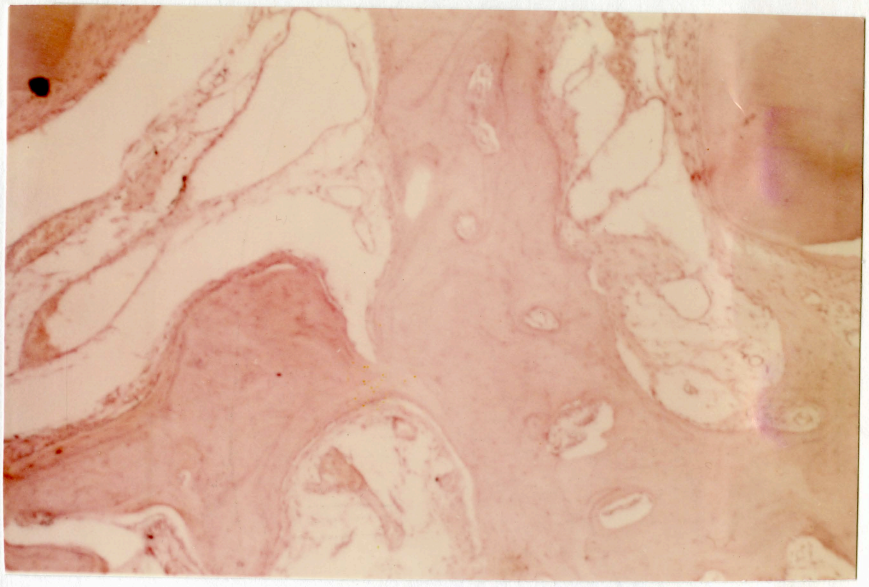
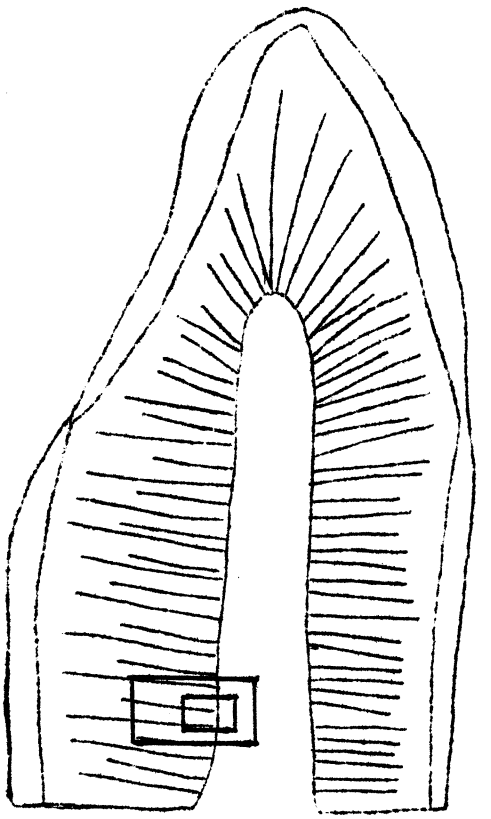


FIGURE 21

Photomicrograph of six month specimen showing mature bone in the defect and the apical portion of the pulp chamber. Secondary dentine is evident lining the apical portion of the pulp chamber(X10).



Area of photomicrograph figures 22 & 23.

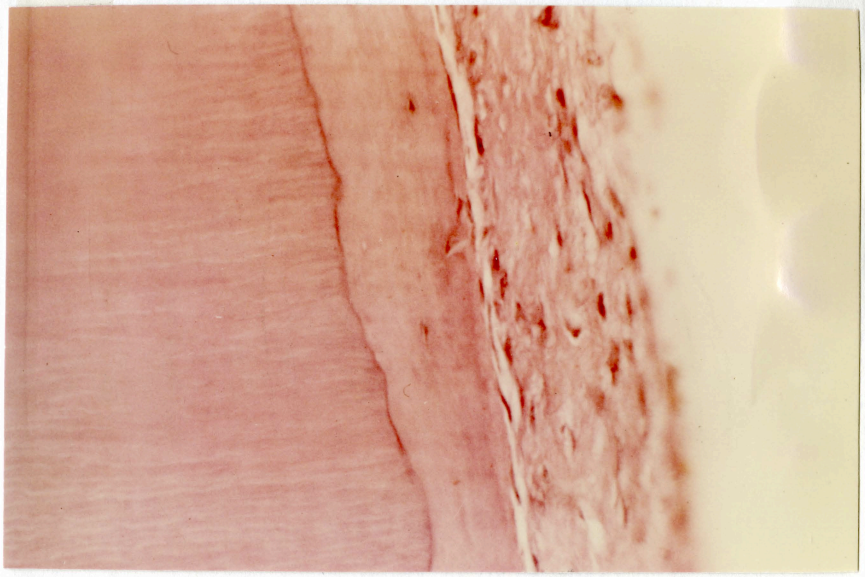


FIGURE 22

Photomicrograph of six month specimen showing secondary dentine present near the apical one-third(X100).

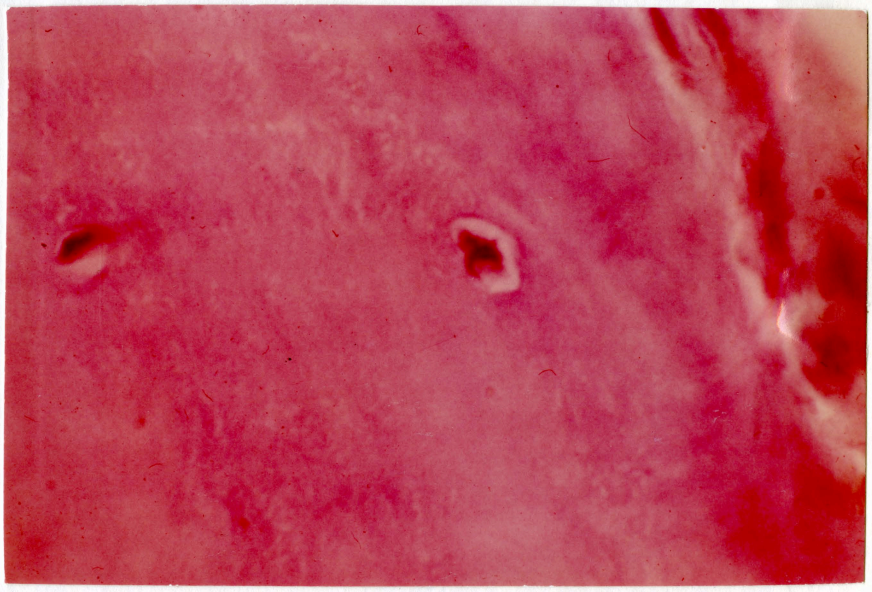
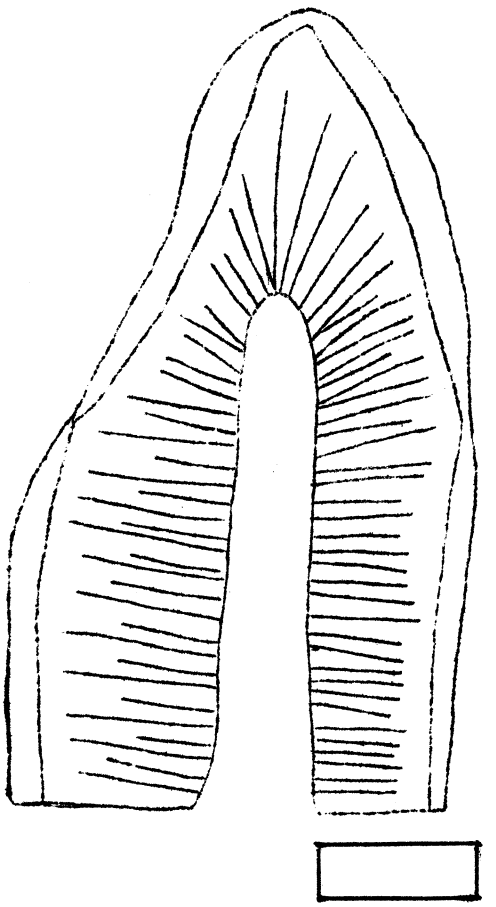


FIGURE 23

Photomicrograph of secondary dentine. Dentinocyte encased in secondary dentine(X400).



Area of photomicrograph figure 24.

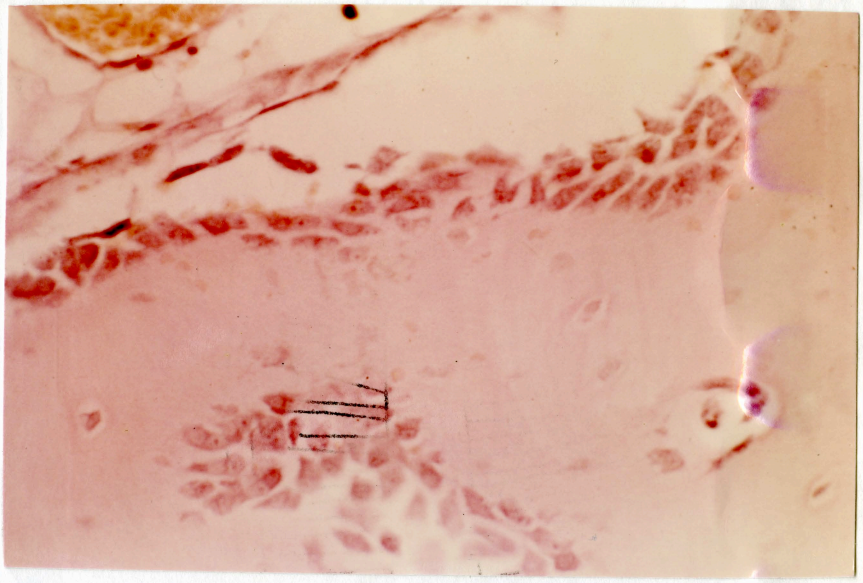


FIGURE 24

Photomicrograph of six month specimen showing osteoblastic activity taking place near the resected surface(X100).

APPROVAL SHEET

The thesis submitted by Walter E. Bisch has been read and approved by four members of the faculty of the Graduate School.

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.

Date 5/20/63

Nicholas C. Choukas, D.D.S., M.S.

Nicholas C. Choukas
Signature of Advisor