1973

The effectiveness of camphorated parachlorophenol, cresatin, eugenol and formocresol for the emergency pulpotomy prior to endodontic treatment

Boston University

School of Graduate Dentistry

Thesis

THE EFFECTIVENESS OF CAMPHORATED PARACHLOROPHENOL, CRESATIN, EUGENOL AND FORMOCRESOL FOR THE EMERGENCY PULPOTOMY PRIOR TO ENDODONTIC TREATMENT

by:

David Auerbach, D.D.S.

McGill University

Faculty of Dentistry

Submitted in partial fulfillment of the requirements

for the degree of Master of Science in Dentistry (Endodontics).

1973

First Reade

Second Read

Approved by:

First Reader [redacted]
Herbert Schilder
Professor of Endodontics

May 11, 1973
Date

Second Reader _____
Professor of

_____
Date

ACKNOWLEDGEMENTS

The author expresses, with deepest gratitude, his sincere appreciation to the following people who have so generously advised, guided, and assisted throughout the course of this investigation.

Dr. Herbert Schilder, Chairman of the Department of Endodontics who aided in formulating and initiating this project. His constant guidance, direction and encouragement made it possible for me to complete this study.

Mr. Arthur Bloom, Head of the Oral Histopathology Research Laboratory for his tireless efforts in processing the histological material and his valuable assistance in the preparation of the photomicrographs.

Ms. Eileen Lahar for her encouragement and technical assistance in the histological preparations.

Ms. Lori Satariano for her able editing and typing of this manuscript.

The author is deeply indebted to the students and staff in the Departments of Endodontics, Periodontics, Prosthodontics and Oral Surgery for their cooperation throughout the course of this investigation.

DEDICATION

This thesis is dedicated to my parents

who made my education possible.

ABSTRACT

ABSTRACT

The purpose of this study was to evaluate and compare the effectiveness of a number of widely used endodontic medicaments for the emergency pulpotomy procedure. The medicaments used were: camphorated parachlorophenol, Cresatin, eugenol and formocresol. Physiologic saline was used as a control. In some cases, the patient's saliva was used to determine the response of the pulp to contamination during the operative procedure.

The study was carried out in two parts. The first part was a clinical and radiographic evaluation of the success of the various medicaments being employed. The second part involved the histological evaluation of some of these teeth to determine the pulpal response to the various medications. The teeth were followed for periods ranging from four days to twelve weeks.

The results of this study showed Cresatin and eugenol to be the most effective medicaments for the emergency pulpotomy procedure. Good clinical results were also obtained with formocresol and physiologic saline. The success obtained with the latter group indicates that the role of medication was not as significant as the actual pulpotomy in establishing and maintaining patient comfort.

Because of the inability to establish a baseline from which deviation could be interpreted, no conclusions could be drawn from the histological portion of this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

INTRODUCTION

INTRODUCTION

The emergency treatment of the patient who arrives in pain, or the patient who is referred with an exposed vital pulp, is a common occurrance in the Endodontic Clinic. Total pulp removal can be accomplished on an emergency basis for anterior teeth. Multi-rooted posterior teeth, however, cannot be treated by pulpectomy in the limited time available for emergency treatment. Ideally, we would like to treat the emergency without having to manipulate the root canals. It would be unwise to relieve the patient's symptoms at the expense of hindering future endodontic treatment by hurriedly instrumenting the fine and often tortuous canals commonly found in posterior teeth. This is not to imply that every manipulation of canals in posterior teeth during emergency treatment necessarily leads to blockage of canals or complications, but only that such a likelihood is increased by hasty manipulation during emergency.

In the Endodontic Clinic at Boston University School of Graduate Dentistry, the emergency treatment of a pulpitis or a pulp exposure is the Cresatin pulpotomy. This procedure can be performed rapidly, relieving the patient's pain immediately and ensuring comfort for weeks or even months. The Cresatin pulpotomy is always followed by complete pulpectomy and endodontic treatment at subsequent appointments.

This study was undertaken to quantitate the clinical impression

that this technique is highly successful and also to determine the significance of the Cresatin in achieving the observed success. Because of the fact that Cresatin might no longer be available, it was decided to test other commonly used endodontic medicaments for the emergency pulpotomy procedure. As a by-product, we were able to quantify the success achieved with each of these medicaments.

OBJECTIVE

OBJECTIVE

The objective of this study was:

(1) To evaluate and compare the clinical effectiveness of camphorated parachlorophenol, Cresatin, eugenol and formocresol for the emergency pulpotomy procedure.

and

(2) To evaluate the histological response of the dental pulp to camphorated parachlorophenol, Cresatin, eugenol and formocresol following the pulpotomy procedure.

REVIEW OF THE LITERATURE

REVIEW OF THE LITERATURE

(1) The Normal Pulp

One of the objectives of this study was to determine histologically, the pulpal reaction to the medicaments. To understand this response, a thorough knowledge of the dental pulp is essential.

The pulp is a specialized loose connective tissue, almost embryonic, derived from mesenchyme of the dental papilla. It is highly vascular, rich in fluid content, pink, coherent and very dependent upon its dentin shell for protection. (1,2) The chief components are cells, intercellular ground substance, fiber elements, blood vessels, lymphatics and nerves. (1,2,3,4) The pulp has four functions: 1) formation of dentin, 2) nutrition of dentin through its tubuli, 3) innervation of the tooth, and 4) defense of the tooth and the pulp itself. (2,5)

The pulp has anatomic features which make it a peculiar type of connective tissue responding somewhat differently to irritants or to an injury than do the other connective tissues throughout the body. The pulp is the only connective tissue in the human body enclosed by walls of calcified dentin which prevents any swelling of the pulpal connective tissue that tends to accompany hyperemia and edema. Collateral circulation, which is common to all other connective tissues is not present in the dental pulp, since the blood vessels supplying the pulp must enter through

the apical foramina. There is no scientific evidence that accessory or aberrant root canals are significant in providing sufficient collateral circulation to maintain the vitality of the pulp after an injury. (6) The dental pulp presents a well integrated and organized system, within a tooth, which is limited in its ability to repair itself because of its morphological characteristics.

The histologically normal pulp has a definite structural architecture. Lining the predentin are the odontoblasts which range from tall columnar in the crown to flat or spindle shaped in the apical region. (7) The subodontoblastic layer is termed the "cell-free" zone of Weil. This layer contains very few cells but is rich in reticular fibers, capillaries and nerve fibers. (2,8) Very fine unmyelinated nerve fibers anastomose to form the parietal plexus with branches running peripherally and centrally. (8) Deep to this layer lies the "cell-rich" zone which is composed mainly of undifferentiated mesenchymal cells. (2,9,10) Fibroblasts are also found in this region in large numbers in the young pulp. (2)

The medium in which all pulpal elements are suspended is the ground substance. It is a homogeneous transparent gelatinous material; with its water content held in a colloidal state. (11) Water soluble and water insoluble phases have been documented, the relative amounts of which vary in different tissues and may vary in the same tissue under different physiologic or pathologic conditions. The relative

proportions of these two states determine the consistancy of the ground substance. (8,11) This may help to explain why the pulp tends to maintain its shape when removed from its dentinal support whereas other loose connective tissues collapse.

The ground substance is nitrogenous acidic, mucopolysaccharide and glycoprotein in composition. The acid mucopolysaccharides are amino sugars of hyaluronic acid, mucoitin sulfate and chondroitin sulfate. (1,2) They are particularly hydrophilic and form a viscous solution which imparts bulk to the pulp. The normal permeability of the pulp depends upon these polymers. They are highly resistant to fluids as well as particulate matter including bacteria. The metabolism of the cells and fibers is mediated through the ground substance. For the nutrients to reach the cells, they must first enter into solution in the ground substance. Breakdown products from the cells pass through to the venous circulation. (1) During periods of pulpal inflammation, this ground substance may be depolynerized by enzymes elaborated by microorganisms. (1,12)

The fibers of the pulp are basically the same as those of other connective tissues. (2,12) They are primarily reticular with few collagenous and no elastic components. The fibers appear to be alike chemically but differ in stages of maturity. (1) The reticular fibers are found around odontoblasts and blood vessels. The intercellular spaces contain a fine network of these fibers that can be transformed

into collagen. Between the odontoblastic cell bodies, reticular fibers which stain black with silver (argyrophil reaction) are present in coarse bundles called Korff's fibers. They originate in the "cell-free" zone and spiral upward toward predentin. They fan out into the uncalcified dentin, or predentin, in a delicate meshwork forming the fibrillar framework of the dentin. (4,8,12,13)

While few collagen fibers are found in the young pulp, as the pulp ages more and more collagen is elaborated. Regardless of age, however, the apical portion of the pulp is more fibrous than the coronal portion. (1,2,12)

The most prevalent cell in the mature pulp is the fibroblast, which is associated with collagen production. (2,12,14,15) In the young pulp there is a great preponderance of fibroblasts, spindle shaped cells which form a syncytium located in the central portion of the pulp along with undifferentiated cells. In the peripheral pulp, the fibroblasts are unevenly distributed. (4,12) The cytoplasm of the fibroblast is so faint as to be almost invisible and in routine section only the bony ovoid nucleus is visible. The cell exhibits slight metachromasia and contains phosphatase and lipid particles in the cytoplasm. (12)

The only unique pulp cell, not found in any other connective tissue, is the odontoblast. (2,5,9,12,16) The odontoblast is a highly differentiated cell with many morphologic variations. In the crown of

the tooth it is tall columnar; in the middle of the root, low columnar to cuboidal and toward the apex, it is quite flattened resembling a fibroblast. (2,12) The odontoblasts are lined up in palisade formation along the predentin border. Generally, the odontoblastic layer is about six to eight cells in depth. The cells are parallel and appear in continuous contact under the light microscope. The portion bordering the predentin gives the appearance of being an intact membrane and simulates a basement membrane. This is known as the pulpodentinal membrane. (12) Each cell sends a protoplasmic process (called Tomes' fiber) into a dentinal tubule which terminates at the dentino-enamel junction. (2,12,17) The appearance of several odontoblastic processes in one tubule has also been observed. The odontoblastic nuclei remain at the inner border of the dentin and unlike osteoblasts, do not become buried in matrix unless they are pathologically involved. (12) They are in contact with adjacent cells and cells more centrally located in the pulp through fine protoplasmic processes and, therefore, may be regarded as part of a mesenchymal syncytium. This is significant because, if an odontoblast is injured, other odontoblasts are affected. The cells on either side are affected by the breakdown products of the injured odontoblasts. Thus injury to the dentin, and therefore to the odontoblasts, creates a reaction within the pulp. (12,18,19,20)

Generally, when subjected to an irritating stimulus, loose connective tissues set up an inflammatory response. The defense cells of the pulp responsible for this process are all associated with the

reticulo-endothelial system. There are three types of cells: histiocytes, undifferentiated mesenchymal cells and ameboid or lymphoid wandering cells. They are located in close proximity to the blood vessels and therefore can act locally or travel to a distant site of inflammation by entering a capillary. (9,12) Histiocytes, or resting wandering cells, resemble fibroblasts but are somewhat smaller. They have a prominent granular cytoplasm and a nucleus densely packed with chromatin. They have long, slender, branching processes and are able to withdraw these processes and change quickly into macrophages when the need arises. As macrophages they remove foreign bodies, dead cells and bacteria from the site of inflammation. They are also believed to produce antibodies. (9,21) The undifferentiated mesenchymal cells have the ability to develop into any type of connective tissue cell: fibroblasts, macrophages, odontoblasts and osteoclasts. They constitute a reservoir of cells which the body can call upon to assume functions which are not ordinarily needed. (9,12) Before injury to the pulp, they appear elongated with faint cytoplasm and an oval nucleus; after injury they differentiate into macrophages. Like all other cellular elements of the pulp, these pluripotential cells decrease in number with age. (2,12) Thus, the defense and repair processes are slower and less effective in the older pulp. The ameboid or lymphoid wandering cells resemble small lymphocytes, having sparce cytoplasm and fine protoplasmic extensions. These cells can become macrophages or plasma cells. Plasma cells are believed to be a source of antibodies. (2,16,22)

The pulp is a highly vascular tissue but under normal circumstances, much of its rich abundant network remains dormant and collapsed. (23,24) During tooth development, there is great cellular activity coronally; hence, a large amount of blood is needed. Apically, there is not as great a need for a concentrated blood supply. In the floor of the pulp chamber there is a rich blood supply. Thus, the development of the vascular system structurally and functionally is related directly to the needs of the pulp tissue; the blood vessels and connective tissue form a single functioning system. (2) By means of perfusion with India ink, Kramer (25) was able to demonstrate the vascular network of the pulp. The main vessels, which are narrow and smooth walled, pass through the apical foramen or foramina and run directly toward the coronal portion of the tooth, giving off branches which divide and subdivide into a rich subodontoblastic capillary plexus. A small number of capillary loops penetrate the odontoblastic layer and lie among the odontoblasts near the predentin. The veins are larger, more centrally located and have walls which are more irregular than the arteries. They drain the capillary plexus and run obliquely inward toward the center and then apically where they become reduced in number and diameter.

Although it is logical that a lymphatic system, as elaborate as the capillary network, should exist in the pulp, it has not yet been demonstrated in human teeth. Recently, the presence of lymphatics in the pulps of dogs was demonstrated. (26)

The nerve fibers of the pulp enter through the apical foramen together with the blood vessels. Most of the fibers are myelinated. They mediate the sensation of pain. The unmyelinated fibers belong to the sympathetic nervous system and are the nerves of the blood vessels, reflectorily regulating their luman. (2) As the nerve trunks proceed toward the coronal portion of the pulp, they ramify and smaller groups of fibers radiate toward the predentin. The nerves often twist spirally around the blood vessels or lie embedded in loose connective tissue beside the vessels. In the coronal portion of the pulp the smaller groups of fibers break up and form a network. Small fibrils branch off from the network and proceed through the cell-rich zone, the fibrils lose their myelin sheaths and wrap around the odontoblasts as knob-like, beaded endings. (2,27) Some fibrils pass between the odontoblasts and terminate at the pulpo-dentinal junction. Others appear to enter the predentin and some loop back from the predentin and terminate more centrally in the pulp tissue. (12,30,31,32)

It is a peculiar feature that whatever stimulus reaches the pulp will always elicit only pain sensation. There is no possibility in the pulp to differentiate between heat, cold, touch, pressure or chemicals --- the result is always pain. The reason for this is that only one type of nerve ending, free nerve endings, are found in the pulp. Since there are no proprioceptive fibers in the pulp, pulpal pain is not localized to the diseased tooth. This is in contrast to the sharp localization of periodontal pain. (2,31)

PULP INFLAMMATION

Inflammation, "a disturbance of homeostasis", is a defensive chain reaction by the connective tissue elements, vascular and cellular, against an irritation. (1) The pulp, however, has anatomic features that make it a peculiar and specialized type of connective tissue, responding somewhat differently to irritants or to an injury than do the other connective tissues throughout the body. Major inflammation is not well tolerated in the pulp and the ultimate necrosis which follows is the threat to which the pulp is uniquely susceptible. (5,6) The three main factors which contribute to the vulnerability of the pulp are: (6)

1) The pulp contains a relatively large volume of tissue in relation to a small blood supply which must enter the tooth through a very narrow apical foramen.

2) Collateral circulation, which is common to all other connective tissues is not present in the pulp. There is no scientific evidence that accessory or aberrant root canals are significant in providing sufficient collateral circulation to maintain the vitality of the pulp after an injury.

3) The pulp is the only connective tissue in the body enclosed by walls of calcified dentin which prevents any swelling of the pulpal connective tissue that tends to accompany hyperemia and edema.

The degree of inflammation is related to the intensity and duration of the external influence and the successful activity of the pulpal defense cells. The resolution of this process determines the fate of the pulp. (5,9)

Because each odontoblast sends a process into dentin, exposure of dentin by caries, operative procedures or other means, invariably injures the odontoblasts. These are the first pulp cells to be affected. (12,18,32,33,34) Products liberated by the injured odontoblasts initiate the inflammation process in the rest of the pulp. Early odontoblastic changes include: (34)

1) Nuclear changes - The nuclear changes in the odontoblasts include pyknosis, karyolysis, fragmentation and formation of nuclear vacuoles.

2) Cytoplasmic changes - The cytoplasm of the odontoblasts gives indication of imminent degeneration by becoming granular.

3) Altered arrangement of the odontoblasts - The regular parallel palisaded appearance is altered so that the odontoblasts appear disoriented and are no longer parallel nor in continuous contact.

4) Reduced width of the odontoblastic layer - The odontoblastic layer becomes narrower due to the decrease in size and reduction in

number of odontoblasts.

5) Displacement of nuclei - The odontoblastic nuclei may be displaced into dentin or predentin.

6) Disruption of the pulpo-dentinal membrane - The normally continuous basement-membrane-like basophilic line becomes discontinuous.

At a later stage, the changes of the odontoblastic layer manifest themselves as an alteration of the matrix formation and calcification patterns. The quantity as well as the quality of predentin may be affected.

As a result of the odontoblastic changes, an inflammatory reaction in the deep pulp tissue usually follows. Irritation, regardless of cause, brings about two fundamental vascular changes: Namely, vasodilation and increase capillary permeability. (35) The in turn lead to a series of interrelated physiologic and morphologic changes characteristic of the inflammatory response: (1,5,18,35,36,37,38)

1) Initial vasoconstriction followed by dilation of arterioles and capillaries, and an increased rate of blood flow.

2) Increased capillary permeability and an inflammatory exudate through the capillary walls into the tissue spaces. At this time the

intrapulpal pressure rises and a "side-effect" of inflammation occurs. There is a migration of odontoblastic nuclei into the dentinal tubules. This is followed by degeneration of the odontoblasts and the breakdown products become additional irritants to the inflammatory process.

3) Marked dilitation of the blood vessels results in a decreased rate of blood flow.

4) White blood cells move toward the periphery and adhere to the vessel wall. This is called pavementing or margination of the leukocytes.

5) Migration of white blood cells through the vessel wall by ameboid movement. The polymorphonuclear leukocytes migrate first, followed by monocytes and lymphocytes later. This process is known as emigration. Diapedesis of red blood cells may also occur giving rise to hemorrhagic inflammation. This is believed to be a passive phenomenon. Soon, there is a rich infiltrate of leukocytes and also red blood cells around the dilated vessels. The polys are attracted to the site of injury by chemotaxis. Menkin ascribed chemotaxis to leukotaxine, a polypeptide elaborated by dead or injured cells. (38) Polys are also attracted by the alkaline pH. Gradually, the pH at the site of inflammation drops due to the accumulation of lactic acid. At a pH of 6.5, polys are destroyed and monocytes predominate. (12)

The defenses concerned with the inflammatory process can be

divided into two types: cellular and humoral. (9,12,37,38)

Cellular:

The principal cells are polymorphonuclear leukocytes, mononuclear cells (monocytes and macrophages) and small lymphocytes. At first the majority of the cells are polymorphs but there is an admixture of monocytes. The major function of the polys is phagocytosis of bacteria and foreign particles. They not only ingest but also digest bacteria by means of enzymes. They are only present during the acute or early stages of inflammation. In a short time these cells disintegrate, liberating a great deal of proteolytic enzymes which actually digest the tissue. The monomuclear cells then appear for "mopping-up operations". These scavengers are phagocytic for bacteria, dead cells, blood pigment, etc. digesting cellular debris and particulate matter. Small lymphocytes appear later in the reaction and, in large numbers, are indicative of chronic inflammation. Together with plasma cells, they constitute the "round cell infiltration" of chronic infection and are concerned with antibody formation. The infiltration of these cells into areas of chronic inflammation concentrates proteins to aid in regeneration and repair.

Humoral:

The blood plasma which leaks into the tissue spaces during inflammation is known as serum or intercellular fluid. This protein-rich fluid is required for the repair process.

Lymph, which is greatly increased in inflammation, accumulates in the tissue spaces. It serves three important functions: 1) It contains antibacterial substances, and anti-toxins, 2) It dilutes bacterial toxins and 3) It helps form fibrin, an interlacing network which helps confine bacteria to the inflamed area.

It must be emphasized that inflammation is a very dynamic process. The inflammation may resolve if the irritant is mild, or may become chronic if the irritation occurs for a long time. There may be repair or necrosis; the inflammation can be localized or widespread. Various phases of acute and chronic inflammation can exist together. In addition, acute inflammation in the pulp can become chronic and conversely, chronic inflammation may become acute. (12)

(3) The Medicaments

The medicaments to be evaluated in this study are all non-specific antimicrobial agents, so called because they act by denaturing cell proteins and because all bacteria and yeasts are susceptible to them to some degree. (40,41,42)

Camphorated parachlorophenol (CP) was introduced into dentistry by Walkhoff in 1891. It is a light amber colored, oily liquid with a characteristic penetrating odor. CP is more antibacterial than phenol and although it is less caustic than phenol it is still irritating. The reason for its increased antibacterial activity is that it is both a phenol and also a slowly released chlorine. While the camphor is mildly antiseptic, its main purpose is as a dilutent and vehicle to reduce the caustic effect of parachlorophenol. (35,43,44,45)

Cresatin is the acetic acid ester of metacresol and represents about 70% metacresol. It is a clear, colorless, somewhat oily liquid with a characteristic spicy odor which is rather persistant. It is readily soluble in organic solvents but almost insoluble in water. Because of its low surface tension (37.7 dynes/cm.), Cresatin is able to wet surfaces readily. Cresatin has a phenol coefficient of .75. (35,40,46,47,48,49,50)

Eugenol is the principle constituent of oil of cloves. It is a colorless or pale yellow liquid with a distinctive aroma. It is almost

insoluble in water but miscible with organic solvents. Eugenol possesses antibacterial activity and is the most common anodyne used in dentistry. (51,52)

Formocresol, a combination of formaldehyde and tricresol was introduced by Buckley in 1905. The combination most frequently used consists of 19% formaldehyde and 35% tricresol in a vehicle of 15% glycerine and water. It is an oily liquid with a relatively low surface tension. It's strong pungent odor is attributable mostly to the presence of formalin. Formocresol is a very strong disinfectant with a great affinity for many organic substances and is able to fix tissue with which it comes in contact. (35,53,54,55)

A germicide is a drug that can be safely used on living tissue, destroying pathogenic organisms in the shortest period of time, without arresting the vital reactions of the tissue. The factors affecting the germicidal properties of a substance are: absolute contact, time during which contact is maintained and the sufficient concentration of the drug employed. (41)

Ostrander listed the requirements of an ideal root canal antiseptic. (56) It must be:

1. germicidal to all organisms
2. rapidly effective
3. capable of deep penetration

4. effective in the presence of organic matter
5. non-injurious to periapical tissues
6. non-staining to tooth structure
7. chemically stable
8. odorless and tasteless
9. economical

Another requirement was added after the introduction of the polyantibiotics. (10) The antiseptic must not interfere with accurate culture technique.

From this list it becomes readily apparent that the ideal root canal antiseptic does not exist.

Of utmost importance for the purpose of this study are the third and fourth requirements. The most common causes of lack of penetration are: a) too high surface tension and b) precipitation of organic matter producing a self-limiting barrier. (56)

A germicide that lowers the surface tension of the medium tends to concentrate on the surface. It thus becomes more destructive to organisms because more molecules are attracted to the surface of the organism by absorption, and there is a more rapid diffusion through the cell membrane. (47,57,58) Very few, if any, antiseptics work as effectively in the presence of organic matter as in a field free of it. Some antispetics which are highly effective in the test tube fail miserably when applied chemically in the presence of organic matter. (47)

The literature abounds with studies testing the antimicrobial effectiveness of various root canal medications. Methods of determining this have ranged from measuring the zones of inhibition produced on agar plates (59-65) to tabulating the number of treatment visits required to obtain two negative cultures when different intracanal medications were used. (43,56,66,67) The medications were tested in both their liquid and vapor phases. (65,68,69)

Wolfsohn (54) tested a number of drugs using impregnated sterile discs on innoculated brain heart infusion agar plates. Formocresol produced a 15 mm. zone of inhibition in 24 hours as compared to 5 mm. for camphorated parachlorophenol. After 72 hours, the CP zone increased to 6 mm. while there was no change around the formocresol disc.

Bartels, (60) using innoculated agar plates demonstrated the definite antibacterial effect of eugenol against a variety of micro-organisms.

Uchin and Parris (70) sealed paper points moistened with medication into root canals for periods ranging from 2 to 24 days. They then removed the points and placed them on seeded agar plates. The anti-bacterial activity of Cresatin and CP proved to be about equal. Even after 14 days in the root canal, they still produced significant zones of inhibition.

Brown, (61) using impregnated sterile discs, counted the number of significant zones of inhibition (2 mm.) produced by the different drugs in numerous trials. The results are tabulated below.

	AEROBIC				ANAEROBIC			
Conc.*:	.001	.002	.003	.004	.001	.002	.003	.004
CP	5/10**	9/10	10/10	15/15	1/10	2/10	7/10	15/15
Cresatin	0/10	0/10	8/10	15/15	0/10	0/10	4/10	14/15
Formocresol	2/10	5/10	10/10	15/15	1/10	2/10	8/10	15/15

*Concentration of medication used expressed in ml/disc.

**Expressed as number of significant zones of inhibition per number of samples.

In higher concentrations, all the drugs were relatively effective and Brown concluded that perhaps medication should be selected on factors other than antimicrobial efficiency possibly the most innocuous agent. Brown also found that Cresatin had a longer residual activity than CP or formocresol, (which were about equal) as measured by regrowth on the innoculated plates after 16 days.

From the studies cited and other studies it can be seen that the medications being tested in the present study all possess significant antibacterial activity.

The antibacterial property of a drug is of little value if it is also irritating. Especially for the purpose of the present study, it is not sufficient that the vapors of the medication be non-irritating to periapical tissues. The medication must be non-irritating even when in direct contact with vital pulp tissue. It would be unwise to apply caustic drugs to viable pulp tissue. The addition of insult to injury is not an effective method for remedying any situation. (9)

Coolidge, (71) in 1932, reported on an investigation of the reaction of the periapical tissue of dogs to drugs sealed into the root canals for 21 days after vital pulpectomy. Results showed that all drugs were irritants but some more so than others, depending largely upon their properties of penetration. The drugs that were able to precipitate protein appeared to be self-limiting in their action and did not penetrate deeply, therefore producing less tissue irritation around the root apices. Upon microscopic examination, eugenol produced extensive leukocytic infiltration with bone resorption. Formocresol produced a small localized coagulated area in the periapical tissues with little cellular infiltration. Cresatin, which does not precipitate tissue, showed a wider, but mild, periapical reaction.

In 1944, Grossman (72) placed medicaments on cotton pledgets and then placed rubber prophy cups over them on the shaved upperarm of six healthy dental students. Dressings were removed after 48 hours. The areas where camphorated parachlorophenol or Cresatin had been applied

showed no irritation or inflammation. Mild or severe necrosis was seen where formocresol had been applied. Two or three months were needed for complete healing.

In 1958, Rubbo et.al. (73) studied the reaction to root canal drugs by injecting 0.1 ml. of test solutions subcutaneously into rabbits' ears. The drug's effect on the tissues was evaluated by the degree of hyperemia, edema, necrosis and ulceration evident after a period of seven days. They found that CP and formocresol both produced severe necrosis with ulceration.

Schilder and Amsterdam, (74) in 1959, also used rabbits to conduct a well-controlled two-part study. In the first part 0.1 cc. of medicament was injected intradermally into the shaved abdomens of rabbits. After 24 hours, CP, eugenol and formocresol were observed to have produced severe inflammation, while Cresatin produced a slight inflammation. In the second part, 0.15 cc. of each drug was placed into the conjuctival sac of rabbits' eyes. Three to four hours later, the eyes with CP, eugenol and formocresol appeared to be severely inflamed. A day later the inflammations continued. Cresatin produced no inflammation and remained normal one day later. In both parts of the study, physiologic saline, used as a control, produced no inflammation.

In 1961, Torneck (75) surgically implanted punctured polyethylene carpules containing one of ten drugs into the subepidermis on the dorsum

of Syrian hamsters. Physiologic saline was used as a control and after 48 or 96 hours the tissues were excised, prepared and later examined histologically. After 48 hours, the control showed a proliferation of young fibroblasts and endothelial tissue about the periphery of the tube. Several blood vessels containing red blood cells were evident in this area, as well as a mild infiltration of polymorphs and monocytes. In the formocresol sample there was a purulent exudate at the border of the tube with an intense diffuse active inflammation after 48 hours. Necrosis of connective tissue had occurred near the puncture area of the tube. CP caused a moderate infiltation of leukocytes, monocytes and lymphocytes about the border of the tube, with no evidence of necrosis present at the area of puncture. A moderate, somewhat diffuse, active subacute inflammation was present in the surrounding connective tissue. A heavier inflammatory infiltration about the tube border was noted in the section implanted with Cresatin. The involvement of the surrounding connective tissue was less intense, however, although it was more extensive. A proliferation of fibroblasts and endothelial tissue about the periphery of the tube opposite the puncture was present in both sections. After 48 hours, the reaction to eugenol was localized to the puncture area of the tube. Suppuration and an intense inflammatory infiltration of the surrounding tissue were noted, with an attempt at regeneration seen along the opposite border of the tube. Although localized in its action, eugenol appeared to be more irritating than Cresatin or CP.

Following a test period of 96 hours, a connective tissue capsule containing mature, young and proliferating fibroblasts as well as several thin-walled capillaries was seen about the control carpule. Some inflammation was still present but this was very mild and was confined to the tissue immediately surrounding the tube. An extensive, active subacute inflammation about the tube and extending out into the surrounding adipose tissue and muscle fascia was still present after 96 hours in the formocresol section. Some coagulation necrosis of connective tissue was also noted in the area adjacent to the puncture. The reaction to eugenol observed after 96 hours was less localized than that seen at the end of the 48 hour period. A moderate, subacute inflammation was now present in the adjacent connective tissue. A moderate zone of connective tissue necrosis and an initiation of muscle tissue degeneration were evident in close proximity to the puncture area. Some proliferation of fibrous connective tissue along the sides of the tube had occurred.

The CP and Cresatin sections showed no evidence of tissue necrosis. There was an active condensation of young connective tissue about the periphery of the carpule away from the site of opening. Both sections showed a concentration of polymorphs at the puncture area and a moderate inflammatory response which extended into the tissue for some distance beyond the tube. The focal accumulation of polys appeared slightly greater in the CP specimen.

In 1962, Stewart and Gautieri tested a number of drugs including Cresatin and CP. 0.15 cc. of each drug was deposited into the conjunctival sac of rabbits in a similar manner to Schilder and Amsterdam (1959). Cresatin produced no inflammatory changes while CP produced marked inflammation.

In 1969, Attala and Calvert (77) reported on the inflammatory potential of a number of root canal medicaments using dogs' eyes and the abdominal connective tissue of guinea pigs. Camphorated parachlorophenol produced severe inflammatory reactions in the conjuctival sacs of dogs after intervals of 5 minutes, 24 hours and 5 days. Five days after injection of 0.2 ml. CP into the abdominal subcutaneous connective tissue of guinea pigs, microscopic evaluation revealed severe inflammation. A relatively extensive area of scar tissue was visible on the guinea pig abdomen.

Most recently, Vander Wall et. al. (62) tested the cytoxicity of formocresol, CP and Cresatin by placing impregnated filter paper discs on an agar overlay with either baby hamster kidney cells or diploid human embryonic lung cells. While all three drugs produced some cell death, formocresol produced the largest zones of cell death and Cresatin the smallest.

(4) The Pulpotomy

In an extensive review of the literature on pulpotomy, Berman (78) described Hoffman's three eras of vital pulp inflammation. The period before 1874 was referred to as the "Empirical Era" in which experimented science was still searching, on a trial and error basis, for a panacea to heal the injured pulp. It was in 1756 that Philip Pfaff first capped exposed pulps with gold foil and this began a series of experiments of pulp capping with opiates, silver and lead after cauterization, eugenol, creosote, tannic acid, and droppings of the English Sparrow. The latter was reportedly used by F. A. Hunter in 1883 with ninety-eight percent success. (79)

The period from 1874-1921 was called the "Antiseptic Era". The use of antiseptics to destroy bacteria and thus aid the injured pulp to recover, followed Lister's demonstration of antiseptics in general surgery. In 1874, Witzel began using weak phenol solutions to destroy bacteria and prevent decomposition and by this method hoped to maintain pulp vitality. (80) In 1904, J. P. Buckley (81) established three criteria for successful pulp treatment: "First, establish asepsis; second, prevent recurring sepsis; and third, preserve the color of the tooth, or is lost, restore it". He recommended a technique of mechanically removing the contents of the pulp chamber, making no attempt to remove the contents of the canals. He then sealed a pledget of cotton containing a mixture of formalin and tricresol into the pulp chamber.

While Buckley believed that antisepsis allowed the pulp to recover, Harker (82) in 1892 felt that antisepsis, devitalization and then pulp removal were necessary in order to retain a tooth which had experienced pulp exposure. He believed he was practicing conservative treatment of teeth by the non-conservative treatment of the diseased pulp. By 1919, the predominant treatment employed by the European school was pulp mummification followed by amputation or total extirpation.

The "Aseptic Era" can be documented from the years 1921-1937, a period which brought scientific investigation into pulp therapy to supercede empirical or "logical" procedures. Davis (83), in 1921, advocated vital pulpotomy and partial root canal filling. He emphasized that caustic antiseptics should not be used. It was preferable, he insisted, to use sterile techniques and mild medicaments which did not destroy the healing capacities of the tissues.

Sweet (84,85) pioneered the clinical usage of formocresol in pulp therapy in primary teeth. In 1930, he published a report on his pulpotomy technique. He originally described it as a four appointment procedure following the initial pulp amputation, but it has gradually been modified until today it is usually performed as a one appointment operation. (86)

The formocresol pulpotomy technique gained widespread acceptance in the decade following its introduction largely on an empirical basis.

Although advocated by many clinicians for a number of years its use was not supported by good histologic studies until the late 1950's. In 1959, Massler and Mansukhani (87) reported a histologic study of forty-three primary and permanent teeth that had been treated with the formocresol pulpotomy technique. They reported that the surface of the pulp immediately under the formocresol became fibrous and acidophilic within a few minutes after the application of formocresol. This reaction was interpreted as one of fixation of the living pulp tissue. After exposure of the pulp to formocresol for periods of 7 to 14 days, three distinct zones became evident: a broad acidophilic zone (fixation); a broad pale-staining zone, wherein the cells and fibers were greatly diminished (atrophy); and a broad zone of inflammatory cells concentrated at the junction with the pale-staining zone and diffusing deeply into the underlying tissue to the apex. No tendency to wall off the inflammatory zone by either a fribrous layer or a calcific barrier was seen. No reparative dentin formation was evident either laterally, centrally, or peripherally. Rather, a progressive fixation of the pulpal tissue with ultimate fibrosis of the entire pulp occurred.

In the same year, Emmerson and co-workers (88) reported that applications of formocresol caused a surface fixation of the pulp tissue during a time range of five minutes to three days. Calcific degeneration occurred in cases which applications remained longer than three days. They also reported that immediately below the amputated area there was a homogeneous, yellow-staining area and below that was a normal-appearing fixed zone of pulpal tissue. Below the fixed zone there was evidence of

degenerative odontoblasts and linear pulpal calcification. Throughout the pulp there was an absence of inflammatory cells, and there was no evidence of resorption or metaplastic changes.

In 1962, Doyle (89) compared the success of the formocresol pulpotomy technique to that of the calcium hydroxide pulpotomy technique on mechanically exposed, healthy primary dental pulps. Under the conditions of his study, the formocresol group proved far superior to the calcium hydroxide group. The results showed 92% histological, 93% radiographic and 100% clinical success for the formocresol group. The clinical success of the formocresol pulpotomy technique has been attributed to its germicidal properties. However, Doyle concluded that its success was due to its action on the pulp tissue. Although healing of the wound site did not occur, the inactivation of the pulp cells and the lack of stimulation or response of the apical tissue appeared to him to be desirable effects. Doyle identified vital tissue in the apical portion of root canals of primary teeth after they had been treated with formocresol pulpotomies for at least 380 days.

Berger, (90) in 1965, reporting on the pulp tissue reaction to formocresol and zinc oxide-eugenol, explained the existance of vital tissue following formocresol pulpotomy. He observed that, commencing 7 weeks following the formocresol pulpotomy, there was an ingrowth of granulation tissue through the apical foramen, replacing the necrotic tissue in the pulp canal. At later time intervals the granulation tissue appeared progressively more coronal, until at 35 weeks following treatment

it was in close proximity to and, in some instances, at the site of amputation. Osteodentin was present, repairing small areas of internal resorption and slightly narrowing the lumen of the canal. Histologically, 82% of the teeth treated with formocresol were judged to be successful while 100% were judged successful clinically. Berger attributed the clinical success to the ability of the formaldehyde to unite with tissue and to render it incapable of autolysis yet amenable to replacement by granulation tissue.

While the zinc oxide-eugenol group also showed 100% clinical success, histologically the pulp tissue of all teeth in this group presented active inflammatory reactions. These reactions varied from simple chronic to active suppurative pulpitis with internal resorption being found consistently.

In 1966, Beaver et.al. (91) reported the effects of zonc oxide-eugenol cement on the formocresolized pulp. Histologically, they observed a variety of responses that could be summarized into six main categories: 1) normal or "drug-fixed" pulp tissue; 2) fibrotic pulp; 3) fibrotic pulp with inflammatory cells; 4) coagulation necrosis; 5) cellular pulp tissue with evidence of internal resorption; and 6) amorphous debris or abscess formation. They did not find enough granulation tissue in any of the sections to presume that this tissue had become "ingrown" and would gradually replace all original radicular pulp tissue. Rather, they felt that there had been a metaplastic process induced by the original application of formocresol to the pulp stumps to stimulate the formation of fibrotic tissue.

In a clinical study, Englander et.al. (92) tested a variety of agents for pulpotomy on permanent teeth. They obtained 100 percent success with zinc oxide-eugenol in a sample of 14 cases over an averager period of 43 days. Their only criterion for success was absence of symptoms.

Cresatin as the only medicament for pulpotomy in primary teeth was first reported by Sandler (93) in 1966. He found Cresatin to be clinically and radiographically successful in 90% of treated teeth with cariously exposed pulps while histologically producing a mild irritating effect on the dental pulp. His results showed that:

1) 84% of the specimens had vital tissue in the apical third of the root.
2) Inflammation was present in 56% of the specimens.
3) 20% of the specimens demonstrated internal resorption of dentin.
4) 40% of the specimens exhibited calcification of the pulp tissue.

In a subsequent study by Robinson, (94) Cresatin was placed on the pulp for only five minutes and then a zinc oxide-eugenol base was placed followed by a permanent restoration. Results showed an inflammatory reaction adjacent to the amputation site which decreased markedly in the middle and apical thirds of the pulp. This inflammation was observed in 80 percent of the cases and was probably due not only to the Cresatin but also to the zinc oxide-eugenol base.

From the studies cited, it becomes evident that while a pulpotomy

may be successful clinically, the histological picture may show varying degrees of inflammation or even total necrosis.

MATERIALS & METHODS

MATERIALS & METHODS

Emergency pulpotomies, followed by treatment with one of four medicaments, camphorated parachlorophenol, Cresatin, eugenol or formocresol*, were performed on 138 permanent teeth. Physiologic saline was used as a control and in some cases the patients saliva was used with no other medication to determine the response of the pulp to contamination during the operative procedure.

The teeth used in this study fell into one of the following categories:

1) Clinical diagnosis of pulpitis.
2) Mechanical or traumatic pulp exposure.
3) Prior to root amputation or hemisection (but otherwise asymptomatic).
4) Due to be extracted for reasons unrelated to the pulp.

This latter group was used solely for the purpose of obtaining histologic specimens.

---

* CP - Novocol Chemical Mfg. Co., Inc., Brooklyn, N.Y.
Cresatin - Union Broach Co., Long Island City, N.Y.
Eugenol - Mynol Chemical Co., Broomall, Pa.
Formocresol - King's Specialty Co., Ft. Wayne, Indiana

In addition, all teeth met the following criteria:

1) Pulp was vital.

2) Pulp was free of spontaneous symptoms.

3) Tooth had no periapical radiolucency.

4) Tooth exhibited no sensitivity to percussion or palpation.

5) During the procedure, pulp stumps bled normally with no evidence of suppuration.

Following the emergency pulpotomy, the teeth were followed for periods from four days to twelve weeks. At the end of that time, endodontic treatment was commenced or the tooth was extracted.

Pre-operative evaluation:

1. The patient was asked to fill out a detailed medical history using the standard form which must be filled out by every new patient at the Boston University School of Graduate Dentistry Clinic.

2. Chief complaint and pertinent symptoms were recorded on both the Pulpotomy Research Form A and the BUSGD Endodontics Form B (Figures 1&2).

3. Periapical radiographs were taken, and in addition, bitewing radiographs were taken of posterior teeth.

Fig. 1

David Auerbach DDS

Pulpotomy Research Study

Patient name:_____ Student _____

Chart no. _____ Tooth no. _____

Date of pulpotomy _____

Symptoms: Sensitivity to cold: Yes No
Sensitivity to heat: Yes No
Spontaneous pain: Yes No
Sensitivity on biting: Yes No
Discoloration: Yes No
Exposure: Yes No
Asymptomatic: Yes No

Tests: Vitalometer: Pos Neg Not tested
Heat: Pos Neg Not tested
Cold: Pos Neg Not tested
Percussion: Pos Neg Not tested
Palpation: Pos Neg Not tested

Is there any periapical radiolucency? Yes No
Is there a fistula? Yes No
Is there any swelling? Yes No

Operative procedure:
Was there any evidence of suppuration? Yes No
Did stumps bleed? Yes No If yes, excessively? normally?
Was tooth taken out of occlusion? Yes No

Diagnosis: Hyperemia Pulpitis Necrosis

Medication used: _____

****

Follow up: Student: _____

Date endo treatment commenced: _____. Time elapsed since pulpotomy: _____ days.

OR

Date of extraction: _____. Time elapsed since pulpotomy: _____ days. Tooth ID No. _____

Symptoms:
Was there any pain following pulpotomy? Yes No
If yes, did the tooth require subsequent emergency Tx? Yes No
Is patient in pain now? Yes No If yes, specify _____
Is the tooth sensitive to percussion? Yes No
Is the tooth mobile? Yes No
Is there a fistula? Yes No
Is there any swelling? Yes No
Are there any radiographic changes? Yes No
If yes, specify _____

Is temporary seal intact? Yes No

Operative procedure:
Is tissue vital? Yes No
Is there any evidence of suppuration? Yes No

BOSTON UNIVERSITY SCHOOL OF GRADUATE DENTISTRY
ENDODONTICS

Card:

NAME:_____ OPD#_____ M F

ADDRESS:_____ PHONE:_____ AGE:_____

STUDENT:_____ TOOTH#(FDI)_____ #CANALS: 1 2 3 4 4+

CHIEF COMPLAINT:	Y	N
NONE		
PAIN TO HEAT		
PAIN TO COLD		
RELIEVED BY HEAT		
RELIEVED BY COLD		
PAIN TO PRESSURE		
STEADY TOOTHACHE		
TOOTHACHE AT NIGHT		
THROBBING		
TRAUMA		
SWELLING		
DRAINAGE		
DISCOLORATION		
AVULSION		

CLINICAL SIGNS:	
PERICEMENTITIS	
MOBILITY	0123
CARIES	
RESTORATION	
DISCOLORATION	
CROWN FX	
FISTULA	0
REGULAR	1
THROUGH SULCUS	2
SWELLING	
PULP TEST - VITAL	
HEAT - PROLONGED RESPONSE	
COLD - RESPONSE	
OPEN CANAL	
PULP EXPOSURE	
DISPLACEMENT	0
IMPACTION	1
EXTRUSION	2
INTACT CROWN	
NORMAL RESPONSES	

RADIOGRAPHIC SIGNS:	
NORMAL	
CARIES	
WIDE PDL	
P.A. RADIOLUCENCY	0
SIZE-AVERAGE	2 4 6 8 10
P.A. RADIO-OPACITY	
PULP CALCIFICATION	
PULP STONES	
ROOT FX	
PERFORATION	
INTERNAL RESORPTION	
EXTERNAL RESORPTION	0
APICAL	1
LATERAL	2
PREVIOUS RCT	
POST PRESENT	
OPEN APEX	
BROKEN INSTRUMENT	
ENDO - PERIO	

ETIOLOGY:	
CARIES	1
MECH. EXPOSURE	2
TRAUMA	3
EROSION, ABRAISION	4
DEEP RESTORATION	5
TRAUMATIC OCCLUSION	6
FOLLOWING C & B	7
PULP CAP	8
RE-TREATMENT	9

DIAGNOSIS:	
PULP EXPOSURE	1
PULPITIS	2
NECROSIS & GANGRENE	3

A.A.A.	4
EPITHELIATED GRANULOMA	5
HAIRLINE FRACTURE	6

PRETREATMENT:	
COPPER BAND	
ANTIBIOTICS	
I & D	
OPENED FOR DRAINAGE	
SALIVA TABLET	

Card 2 Col: 1 2 3 4 5 6 Identical

TREATMENT PLAN:	
NSRCT	
SRCT	0
CURRETAGE	1
APICOECTOMY	2
RETROGRADE AMAL.	3
HEMISECTION	4
REPLANTATION-PACKED PRIOR	5
REPLANTATION-PACKED AFTER	6
INT. REPLANT-PACKED PRIOR	7
INT. REPLANT-PACKED AFTER	8
APEXIFICATION	0
VITAL PULP	1
NECROTIC PULP-NO RAD.LUC.	2
NECROTIC PULP-RAD. LUC.	3
ENDODONTIC IMPLANT	

TREATMENT:	
NORMAL	
BROKEN INSTRUMENT	
PERFORATION	
ROOT FX	
CROWN FX	
FLARE UP	0
CULTURE POSITIVE	1
CULTURE NEGATIVE	2
POST SPACE	
PATHOLOGY REPORTS	
ACCESSORY CANALS	0
NUMBER	1 2 3 4 4+
PLACED CORONALLY	
PLACED MID-ROOT	
PLACED APICALLY	
TO LAT. RAD.-LUCENCY	
TO FURCATION	
CULTURE	P N

RECALL DATA:	
NORMAL	
RESTORATION	0
SYNTHETIC	1
AMALGAM	2
CROWN	3
ONLAY	4
CROWN FX	
RADIOGRAPHIC SIGNS	0
RESORPTION	1
P.A. AREA OR WIDENED	
PDL (NEW)	2
PREVIOUS AREA	
100% HEALING	3
90% HEALING	4
SMALLER	5
LARGER	6
NO CHANGE	7
MOBILITY	0123
FISTULA	
SWELLING	
PAIN TO PERCUSSION	
PAIN TO PALPATION	
FURTHER TX NEEDED	
TOOTH# (FDI)	____

Fig. 2

4. A careful clinical examination was carried out. The teeth were examined for caries, defective restorations, and pulp exposures. As well, they were tested for tenderness to percussion and palpation.

5. The following tests were performed:

a) Electric Pulp Test:

The Ritter Portable Pulp Tester was used after the teeth were carefully dried. The involved tooth was tested along with several neighboring teeth and a contralateral tooth if possible.

b) Heat Test:

Strips of white base plate gutta percha were heated on a plastic instrument and applied to the tooth.

c) Cold Test:

If there was any discrepancy between the electric pulp test and the heat test, this test was carried out using chips of ice wrapped in gauze.

Data from the clinical and radiographic examinations, as well as the pulp tests, were recorded on Forms A and B.

The purpose of the electric pulp test was only to determine whether the pulp was vital or not. There was no intention to differentiate among varying degrees of pulpal pathosis by means of responses to different readings on the pulp tester. A prolonged response to the heat test (that is, extreme sensitivity continuing after the heat stimulus was

removed) was interpreted as the clinical diagnosis of a pulpitis. In this state, while the pulp is still vital, the pulpal disease process is considered to be irreversible and endodontic intervention is indicated.

Operative Procedure

A sterile and uniform technique was used at all times.

A topical anaesthetic (xylocaine 5% paste) and local anaesthetic (xylocaine 2% with 1:50,000 epinephrine) were used to anaesthetize the affected tooth.

A suitable clamp was chosen and the rubber dam was placed isolating only the involved tooth. The tooth, rubber dam, and clamp were then swabbed vigorously with mercresin, followed by a second swabbing with 70% isopropyl alcohol.

The access cavity for the pulpotomy procedure was prepared in exactly the same manner as it would be for the commencement of endodontic treatment. Following penetration of the pulp chamber with a suitable size sterile round bur, the roof of the chamber was removed with a "peeling up" motion. The preparation was then funnelled so that the access cavity was narrowest at the floor of the pulp chamber and widest at the cavo-surface margin. This provided straight-line access and visibility of the whole chamber as well as a positive seat for the

temporary cement restoration.

During preparation of the access cavity, the chamber was irrigated several times with 3 percent sodium hypochlorite. Once the access cavity was completed, the remaining coronal pulp tissue was excised to the floor of the chamber with a sharp spoon excavator. The area was again irragated and inspected for any remaining pulp tissue. The chamber was then dried with several sterile #3 cotton pellets, and finally another dry pellet was placed over the cleanly excised bleeding stumps. This pellet was allowed to remain in place for a few minutes to control any hemorrhage. Once the bleeding was controlled, a #3 cotton pellet was moistened with one of the medications and then squeezed in a sterile 2 x 2 gauze sponge to expel the excess. It was then placed on the pulpal floor and a dry pellet placed over it. A temporary restoration of Cavit* was then placed and contoured with a cotton tipped applicator moistened with water to accelerate the set.

For anterior teeth this procedure was modified to a deep pulpotomy. Following preparation of the access cavity, a suitable size sterile barbed broach was inserted approximately two-thirds of the way down the canal, rotated a few revolutions and removed. Once the tissue was removed, the canal was irrigated and dried with a suitable size absorbant point. A cotton pellet, moistened with medicament and the excess expelled, was placed into the orifice and the access cavity sealed with Cavit.

---

* Cavit - Premier Dental Prod. Co., Philadelphia, Pa.

The rubber dam was then removed and the occlusion checked with articulating paper. Whenever possible, the tooth was taken out of occlusion. The patient was then instructed not to eat for one hour to allow the Cavit to set and if possible to chew on the opposite side for the next few days.

Pertinent data from the operative procedure were recorded on Form A.

Whenever possible, patients were contacted twenty-four to forty-eight hours later to determine whether they were comfortable.

Follow-up:

When the patient returned for endodontic treatment or extraction, a periapical radiograph was taken to check for any changes. The tooth was examined and the patient was questioned regarding possible symptoms experienced. Results were recorded in the "Follow-up" section of Form A.

If the tooth was treated endodontically, observations were made as to whether the radicular pulp tissue was still vital and whether there was evidence of suppuration. Since the tooth was anaesthetized, the pulp was judged to be vital if there was any evidence of bleeding during the cleaning and shaping procedure.

If the tooth was tc be extracted, the Cavit was removed immediately prior to the extraction. As soon as the tooth was extracted, the cotton pellets were removed from the pulp chamber and the tooth was immediately placed in a fixing solution.

Post-extraction procedure:

a) fixation:

Immediately following extraction teeth were placed in a solution made up of:

37-40% formaldehyde	100 ml.
80% alcohol	900 ml.
glacial acetic acid	50 ml.

The volume of the solution used was twenty times that of the tooth. Teeth remained in the fixing solution for at least forty-eight hours.

b) decalcification:

Following fixation, specimens were placed in porcelain swimming cups and immersed in 20% formic acid. The acid was changed daily and hand agitated to enhance demineralization. Specimens remained in the formic acid for six to eight days depending upon the size of the tooth. Radiographs were taken to confirm decalcification and teeth were then washed for 8 hours.

c) <u>dehydration and clearing</u>:

Dehydration and clearing was accomplished through the following steps:

80% ethyl alcohol	-	12 hours
80% ethyl alcohol	-	1 hour
95% ethyl alcohol	-	2 hours
95% ethyl alcohol	-	2 hours
absolute alcohol	-	1 hour
absolute alcohol	-	12 hours
absolute alcohol	-	1 hour
absolute alcohol with equal parts methyl-salicylate	-	1 hour
methyl salicylate	-	30 minutes
methyl salicylate	-	30 minutes

d) <u>impregnation</u>:

Impregnation was accomplished through the following steps:

methyl salicylate with equal parts paraplast-plus	-	3 hours
paraplast	-	1 hour
paraplast	-	1 hour
paraplast	-	1 hour
paraplast	-	12 hours
vacuum-oven paraplast at 25 lb./sq.in. pressure	-	1 hour

Every 15 minutes the pressure was dropped and then immediately raised to enhance removal of all bubbles of air.

e) embedding and sectioning:

Specimens were then placed in a form filled with melted paraffin and quickly cooled. The block was trimmed, mounted, and sectioned using an international rotary microtome. Sections were cut parallel to the long axis of the tooth to a thickness of six to eight microns. During sectioning, the angulation of the block was frequently adjusted to compensate for curvatures in the root canals.

f) staining:

Sections were arranged on glass slides and placed in an oven (56-58° C) for twelve hours. This procedure removed excess paraffin and allowed the sections to adhere to the slides. The slides were then stained through the following sequence:

first clearing:	
xylol	2½ minutes
xylol	2½ minutes
absolute alcohol	2½ minutes
absolute alcohol	2½ minutes
95% alcohol	2½ minutes
95% alcohol	2½ minutes
80% alcohol	2½ minutes
wash	2½ minutes
staining:	
Harris haematoxylin	3 minutes
rinse	12 dips

1% HCL in 70% alcohol	1 dip
rinse	12 dips
Lithium Carbonate (for blueing)	1 minute
wash	15 minutes
alcoholic eosin	15 dips

second clearing:

95% alcohol	12 dips
95% alcohol	12 dips
absolute alcohol	12 dips
absolute alcohol	12 dips
xylol	2½ minutes
xylol	2½ minutes
xylol	2½ minutes

Slides were now mounted with coverslips and piermont.

RESULTS

In order to determine the approximate amount of medication used on a clinical level, groups of ten #3 cotton pellets were weighed before and after application of each of the medications. The results are listed on Table 1.

Table 1: Weight of medicament on #3 cotton pellet expressed in mg..

	Weight of Medicament			
Sample No.	CP	Cresatin	Eugenol	Formocresol
1	4.4	7.3	6.5	9.0
2	8.3	4.5	8.1	7.3
3	8.7	4.4	4.1	6.7
4	5.0	6.9	6.3	8.4
5	6.3	5.5	5.8	5.7
6	4.9	8.1	5.5	5.3
7	7.8	7.4	7.8	7.3
8	6.7	6.9	8.0	4.8
9	5.9	5.3	8.1	6.3
10	8.1	5.9	6.0	6.9
Average:	6.6	6.2	6.6	6.8

Pulpotomies were performed on one hundred thirty-eight teeth. The number of teeth treated with each of the medicaments is listed in Table 2.

Table 2: Number of teeth treated with each of the medicaments.

	Number of Teeth		
Medicament	Posterior	Anterior	Total
CP	14	3	17
Cresatin	22	6	28
Eugenol	21	7	28
Formocresol	23	5	28
Saline	23	3	26
Saliva	9	2	11
Total	122	26	138

Teeth were considered clinically successful on the basis of the following criteria: no pain or discomfort, no tenderness to percussion, no swelling and no evidence of a fistula.

Radiographic success was based on an intact lamina dura and periodontal ligament space, no periapical radialucency and no evidence of internal resorption.

(1) Clinical Evaluation

CAMPHORATED PARACHLOROPHENOL

A total of seventeen teeth were treated with CP. The distribution of these teeth according to diagnosis and duration of treatment is listed in Tables 3 and 4 respectively.

Table 3: Distribution of CP treated teeth according to diagnosis.

Diagnosis	No. of Teeth
Pulpitis	14
Exposure	3
Elective**	0

**Teeth in this category were treated prior to root amputation, hemisection or extraction.

Table 4: Distribution of teeth according to duration of treatment with CP.

Duration	No. of Teeth
1-14 days	9
15-28 days	3
29-56 days	2
57+ days	3

Of the fourteen pulpitic teeth treated with CP, nine were judged to be clinically successful. Five teeth required emergency treatment for pain. Three of these occurred within four days of the pulpotomy. The others occurred at eight and eleven days. A suppurative exudate with a strong odor of the medicament was present in two of the cases.

Two of the three exposed teeth were clinically successful. One patient complained of intermittant pain for a period of one week but did not require emergency treatment for this.

No radiographic changes were seen in any of the teeth treated with CP.

On the basis of this study, CP was 64.7% successful clinically and 100% successful radiographically.

CRESATIN

Twenty-eight teeth were treated with Cresatin. They were distributed in the following manner, according to diagnosis (Table 5) and duration of treatment (Table 6).

Table 5: Distribution of Cresatin treated teeth according to diagnosis.

Diagnosis	No. of Teeth
Pulpitis	18
Exposure	2
Elective	8

Table 6: Distribution of teeth according to duration of treatment with Cresatin.

Duration	No. of Teeth
1-14 days	7
15-28 days	10
29-56 days	3
57+ days	8

Seventeen of the eighteen teeth in the pulpitis category were judged clinically successful. One tooth required emergency treatment for pain after three days. There was no evidence of exudate upon removal of the Cavit and cotton pellet.

The two exposed teeth as well as the eight treated electively were all clinical successes.

No radiographic changes were observed in the teeth treated with Cresatin.

From the results of this study, Cresatin was 96.4% successful clinically and 100% successful radiographically.

EUGENOL

The twenty-eight teeth treated with eugenol were distributed according to diagnosis (Table 7) and duration of treatment (Table 8) as follows.

Table 7: Distribution of eugenol treated teeth according to diagnosis.

Diagnosis	No. of Teeth
Pulpitis	15
Exposure	4
Elective	9

Table 8: Distribution of teeth according to duration of treatment with eugenol.

Duration	No. of Teeth
1-14 days	5
15-28 days	9
29-56 days	8
57+ days	6

Of the fifteen teeth in the pulpitis category, fourteen were clinically successful. One tooth had to be treated on an emergency basis for pain seventeen days postpulpotomy.

All exposed teeth and those treated electively were asymptomatic.

Radiographically, no changes were observed in any of the teeth treated with eugenol.

Eugenol was 96.4% successful clinically and 100% successful radiographically on the basis of this study.

FORMOCRESOL

Twenty-eight teeth were treated with formocresol following pulpotomy. The distribution of these teeth according to diagnosis and duration of treatment is listed in Tables 9 and 10 respectively.

Table 9: Distribution of formocresol treated teeth according to diagnosis.

Diagnosis	No. of Teeth
Pulpitis	16
Exposure	2
Elective	10

Table 10: Distribution of teeth according to duration of treatment with formocresol.

Duration	No. of Teeth
1-14 days	7
15-28 days	7
29-56 days	9
57+ days	5

Of the sixteen pulpitic teeth, fifteen were considered clinically successful. One patient complained of sensitivity upon chewing after 33 days but experienced no spontaneous pain.

Both exposed teeth and nine of the ten teeth treated electively remained asymptomatic. Upon clinical examination after 45 days, one tooth was extremely tender to percussion. This tooth displayed a thickening of the periodontal ligament in the periapical area when examined radiographically. All other teeth treated with formocresol appeared radiographically normal.

Based on the results of this study, formocresol was 92.9% successful clinically and 96.4% radiographically.

SALINE

Twenty-six teeth treated with physiologic saline served as controls for this study. Their distribution according to diagnosis and duration of treatment is listed in Tables 11 and 12.

Table 11: Distribution of saline treated teeth according to diagnosis.

Diagnosis	No. of Teeth
Pulpitis	15
Exposure	4
Elective	7

Table 12: Distribution of teeth according to duration of treatment with saline.

Duration	No. of Teeth
1-14 days	8
15-28 days	4
29-56 days	7
57+ days	7

Thirteen of the fifteen pulpitic teeth were successful clinically. One tooth had to be treated for pain after seven days. Another tooth developed a fistula which was discovered upon clinical examination

seventy-five days postpulpotomy. This tooth was otherwise comfortable.

The remaining twelve teeth treated with saline were asymptomatic.

The fistulated tooth displayed a periapical radiolucency. All other treated teeth appeared normal radiographically.

Therefore saline was 92.3% successful clinically and 96.2% radiographically in this investigation.

SALIVA

Eleven teeth were treated with cotton pellets moistened with the patient's saliva under the rubber dam. No medication was used in these cases. The teeth were distributed in the following manner, according to diagnosis (Table 13) and duration of treatment (Table 14).

Table 13: Distribution of saliva treated teeth according to diagnosis.

Diagnosis	No. of Teeth
Pulpitis	5
Exposure	4
Elective	2

Table 14: Distribution of teeth according to duration of treatment with saliva.

Duration	No. of Teeth
1-14 days	6
15-28 days	3
29-56 days	1
57+ days	1

Two of the five pulpitic teeth were judged clinically successful. Two failures had to be treated on an emergency basis after 3 days and the other after six days.

Of the four teeth with exposed pulps, one tooth required treatment for pain after 2 days. Another tooth developed a swelling in the mucco-buccal fold after 21 days with tenderness to percussion. Radiographically, a thickening of the periodontal ligament was evident. The other two teeth remained asymptomatic.

One tooth treated electively presented with pain after four days. This tooth was extracted for histologic examination. The other tooth treated electively remained asymptomatic but developed a periapical radiolucency.

On the basis of this investigation, saliva was clinically 45.5% successful and 81.8% successful radiographically.

(2) Histological evaluation:

Thirty-three teeth were treated on an elective basis in order to evaluate histologically, the pulpal response to the medicaments. Twenty-four of these teeth were recovered for microscopic examination. They were distributed as follows: (Table 15)

Table 15: Distribution of teeth recovered for microscopic examination.

Duration of Treatment	MEDICAMENT					
	CP	Cresatin	Eugenol	Formo-cresol	Saline	Saliva
1-10 days	0	2	1	1	1	1
11-20 days	0	2	1	0	1	0
21-30 days	0	4	3	2	3	0
31-45 days	0	0	0	0	0	0
45+ days	0	0	0	1	1	0
TOTAL	0	8	5	4	6	1

No conclusions could be drawn from the histological portion of this study. Several variables made it impossible to attribute the results to the medicaments alone. Since this study was concerned with permanent teeth, their availability was limited. Samples were obtained from patients whose periodontally involved teeth were destined for root amputation, hemisection or extraction. Because of their age, a number of non-inflammatory changes were in progress in these teeth. These changes include: loss of the odontoblastic layer, fibrosis of the pulp

tissue and linear calcification. In a number of cases, it was extremely difficult to obtain longitudinal sections through the fine, tortuous canals. In addition, several specimens showed evidence of inadequate fixation. Because of these variations, it was not possible to establish a baseline from which deviation could be interpreted.

Inflammatory changes observed in the various specimens did not follow a general pattern which could be attributed to any specific medicament.

The Appendix contains histological descriptions of all teeth recovered, along with representative photomicrographs.

DISCUSSION

DISCUSSION:

A problem which plagues many clinicians is the emergency treatment of vital cases requiring endodontic therapy. The results of this investigation have shown the pulpotomy to be an effective emergency treatment for teeth with exposed vital pulps and those with a clinical diagnosis of pulpitis. This treatment was effective for periods ranging from four days to twelve weeks. These limits were imposed by the structure of this study. Emergency pulpotomy treatment is effective for much longer periods but were not part of this study. Four days to twelve weeks were chosen as the most likely intervals between emergency treatment and the start of root canal therapy even under most unusual circumstances.

The role of medication in the pulpotomy procedure was not found to be as significant as the amputation of the coronal pulp tissue in establishing and maintaining patient comfort. While three medicaments, Cresatin, eugenol and formocresol all yeilded greater than 92% clinical success, comparable results were obtained in the control group where no medicament was used. The higher success rates obtained with Cresatin and eugenol may then be attributed to the medicaments themselves.

Camphorated parachlorophenol was less successful than the other medicaments. The application of CP to the freshly excised pulp stumps appears to have an irritating rather than sedative effect clinically. Originally it was the author's intention to obtain at least twenty-five

cases with each of the medicaments in this study. Because of the relatively low clinical success obtained with CP on patients in the Endodontic clinic, it was decided to terminate its use after seventeen cases. This is not to be taken as a judgement on CP for other endodontic uses but only for this particular procedure.

The effect of contamination, as measured by the results of the saliva group, was to reduce the success rate considerably. This serves to confirm, what is known by every clinician, that strict asepsis must be maintained at all times.

While some authors recommend partial or total pulp extirpation for the emergency treatment of a pulpitis, (95) this procedure appears to be unnecessary. Not only can a pulpotomy be performed more rapidly, but it eliminates the necessity of having to place instruments into the canals. During an emergency procedure when time is of utmost importance, the chances of displacing a pulp stone or creating a ledge are increased greatly.

The success of the pulpotomy depends upon a number of factors, the most important of which is an accurate diagnosis. The clinical diagnosis of pulpitis used in this study was a prolonged paroxysmal pain response following application of heat to the affected tooth. Spontaneous, throbbing pain is indicative of an inflammatory process which has proceeded beyond the coronal portion of the pulp. This tooth will not respond to a pulpotomy.

Although this study gave no indication as to whether relieving the occlusion had any effect on the success of the emergency treatment, it appears that this is a desirable measure.

SUMMARY

SUMMARY:

In the Endodontic Clinic at Boston University School of Graduate Dentistry, the emergency treatment of a clinical pulpitis or a pulp exposure is the Cresatin pulpotomy. The purpose of this study was to quantitate the clinical impression that this technique is highly successful and also to determine the significance of the Cresatin in obtaining the observed success. Because of the fact that Cresatin might no longer be available, other commonly used endodontic medicaments were also tested for the emergency pulpotomy procedure.

Emergency pulpotomies were performed on one hundred thirty-eight teeth using one of the following medicaments: camphorated parachlorophenol, Cresatin, eugenol or formocresol. Physiologic saline was used as a control. In some cases, the patient's saliva was used to determine the response of the pulp to contamination during the operative procedure. The teeth were followed for periods ranging from four days to twelve weeks.

The study was carried out in two parts. The first part was a clinical and radiographic evaluation of the success obtained with each of the medicaments. The results are summarized in Table 16.

Table 16: Summary of clinical and radiographic success rates obtained with each medicament for the emergency pulpotomy procedure.

Medicament	Success Rate	
	Clinical	Radiographic
Camphorated parachlorophenol	64.7%	100%
Cresatin	96.4%	100%
Eugenol	96.4%	100%
Formocresol	92.9%	96.4%
Saline	92.3%	96.2%
Saliva	45.5%	81.8%

The second part of this study involved the histological evaluation of some of these teeth to determine the pulpal response to the various medications. Because of the inability to establish a baseline from which deviation could be interpreted, no conclusions could be drawn from the histological portion of this study.

CONCLUSIONS

CONCLUSIONS:

(1) The emergency pulpotomy procedure is successful in alleviating the symptoms of clinical pulpitis and maintaining patient comfort. This procedure is also effective for the emergency treatment of exposed vital pulps.

(2) The role of medication is not as significant as the actual pulpotomy procedure in achieving clinical success.

(3) Cresatin and eugenol are the most effective medicaments for this procedure.

(4) Camphorated parachlorophenol is not recommended for the emergency pulpotomy procedure.

(5) Contamination with saliva results in a significant reduction in the success rate of the pulpotomy.

(6) No conclusions could be drawn from the histological data.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Snyder, D.E. and Kaufman, I.F.: A review of the dynamics of inflammation as applied to the dental pulp. Oral Surg., Oral Med., and Oral Path. 14: 997, 1961.

2. Orban, B.J.: Oral Histology and Embryology. Edited by H. Sicher, 5th edition, C.V. Mosby Co., St. Louis, 1962.

3. Hartsook, J.T.: Pulp therapy in primary and young permanent teeth. Dental Clinics of North America. 1966: 377-389.

4. Weatherford, T.W.: Some of the histological, physiological and pharmacological aspects of pulpal therapy in pedodontics. Alabama Dental Review. 10: 11-23, 1961-1962.

5. Ogilvie, A.L.: Histology of the Dental Pulp. in Ingle, J.I. Endodontics. Lea and Febiger, Philadelphia, 1965.

6. Gardner, Alvin F.: Pathology of the dental pulp with clinical correlations. Practical Dental Monographs, May 1963.

7. James, V.E., Schour, I., and Spence, J.M.: Response of the human pulp to gutta percha and cavity preparation. J.A.D.A. 49: 639, 1954.

8. James, V.E., Schour, I., and Spence, J.M.: Biology of the pulp and its defense. J.A.D.A. 59: 903, 1959.

9. Stanley, H.R.: The cells of the dental pulp. Oral Surg., Oral Med., and Oral Path. 15: 849-858, 1962.

10. Stewart, J.M.: Replacement of odontoblasts. Odont. Tidsk. 73: 424, 1965.

11. Engel, M.B.: The structure and reactivity of connective tissues, Symposium by the Am. Assoc. of Endodontists entitled Biology of the Pulp, Chicago, Ill.. 1961.

12. Seltzer, S. and Bender, I.B.: The Dental Pulp, Phila. J.B. Lippincott Co., 1965.

13. Bevelander, G.: The development and structure of the fiber systems of dentin. Anat. Rec. 81: 79, 1941.

14. Hadfield, J.: The tissue of origin of fibroblasts of granulation tissue. Brit. Dent. J. 50: 870, 1963.

15. Avery, J.K. and Han, S.S.: The formation of collagen fibrils in the dental pulp. J. Dent. Res. 6: 1248, 1961.

16. Bloom, W. and Fawcett, D.: A Textbook of Histology. 8th edition, W.B. Saunders Co., Philadelphia, 1962.

17. Kaye, H. and Harold, R.C.: The structure of human dentin. Arch. Oral Biol. 11: 255, 1966.

18. Langland, K.: Tissue Changes in the Dental Pulp. Oslo University Press, Oslo, 1957.

19. Brannstrom, M. and Lind P.O.: Pulpal response to early dental caries. J. Dent. Res. 44: 1045, 1965.

20. Langland, K.: Pulpal response to caries and operative procedures. J. Dent. Assoc. S. Aftrica. 18: 101, 1963.

21. Zander, H.A.: Phagocytes in the dental pulp. J. Endo, 1: 26, 1946.

22. Coolidge, E.D. and Kesel, R.G.: A Textbook of Endodontology. 2nd edition, Lea and Febiger, Philadelphia, 1956.

23. Boyle, B.E.: Kronfeld's Histopathology of the Teeth and Their Surrounding Structures. 3rd edition, Lea and Febiger, Phil., 1949.

24. Scheinen, A.: Flow characteristics of the pulpal vessels. J. Dent. Res. 42: 438, 1963.

25. Kramer, I.H.R.: The vascular architecture of the human dental pulp. Arch. Oral Biol. 2: 177, 1960.

26. Bernick, S. and Patek, P.R.: Lymphatic vessels of the dental pulp in dogs. J. Dent. Res. 48: 959, 1969.

27. Engstrom, H. and Ohman, A.: Studies on the innervation of human teeth. J. Dent. Res. 39: 799, 1957.

28. Rapp, R., Avery, J.K., and Rector, R.A.: A study of the distribution of the nerves in human teeth. J. Canad. Dent. Assoc. 23: 477, 1957.

29. Bernick, S.: Differences in nerve distribution between erupted and non-erupted human teeth. J. Dent. Res. 43: 406, 1964.

30. Wasserman, F.: The innervation of teeth. J.A.D.A. 26: 1097, 1939.

31. Sicher, H.: Problems of pain in dentistry. Oral Surg., Oral Med., and Oral Path. 7: 149, 1954.

32. Seltzer, S., Bender, I.B., and Ziontz, M.: The dynamics of pulpal inflammation; correlations between diagnostic data and actual histologic findings. Oral Surg., Oral Med., and Oral Path. 16: 846, 969, 1963.

33. Ostrom, C.A.: Pulp damage by induced inflammation. Dent. Prog. 3: 207, 1963.

34. Seltzer, S., Bender, I.B., and Kaufman, I.J.: Histological changes in the dental pulp of dogs and monkeys following application of pressure, drugs and micro-organisms on prepared cavities. Oral Surg., Oral Med., and Oral Path. 14: 328 - 348, 1961.

35. Grossman, L.I.: Endodontic Practice, 7th edition, Philadelphia, Lea and Febiger, 1970.

36. Stanley, H.R.: Design for a human pulp study. Oral Surg., Oral Med, and Oral Path. 25: 633-647, 1968. 25: 756-764, 1968.

37. Robbins, S.L.: Pathology, 3rd edition, W.B. Saunders Co., Philadelphia, 1967.

38. Robbins, S.L. and Angell, M.: Basic Pathology, W.B. Saunders Co., Philadelphia, 1971.

39. Menkin, V.: Modern views of inflammation. Inter. Arch. Allerg., 4: 131, 1953.

40. Schilder, H.: Intracanal Medication, in Ingle, J.I.: Endodontics, Philadelphia, Lea and Febiger, 1965, pp. 486-493.

41. Luebke, R.G.: Pulp cavity debridgement and disinfection. Dent. Clin. of No. Amer., P. 603, Nov. 1967.

42. Penick, E.C., Osetek, E.W.: Intracanal drugs and chemicals in endodontic therapy. Dent. Clin. of No. Amer., P. 743, Oct. 1970.

43. Sommer, R.F., Ostrander, F.D., and Crowley, M.C.: Clinical Endodontics: A Manual of Scientific Endodontics, 3rd edition, Philadelphia, W.B. Saunders Co., pp. 182-185, 1966.

44. Grossman, L.I., Prinz, H.: A comparative study of root canal therapy with (I) camphorated chlorophenol (LL) Electrosterilization. Dental Cosmos, 74: 324, 1932.

45. Manufacturer's Product Information, CMC, Novocol Chemical Mfg. Co., Brooklyn, N.Y..

46. McGhee, W.H.C. and Green, M.W.: Pharmacology and Pharmacotherapeutics for Dentists, New York, The Blakiston Co., 4th edition, 1952.

47. Coolidge, E.D.: Studies of germicides for the treatment of root canals. Jour. of Amer. Dent. Assoc., 16: 698-714, 1929.

48. Stewart, G.G.: Rational root canal medication. Dent. Clin. of No. Amer., W.B. Saunders, Philadelphia, P. 823-834, Nov. 1957.

49. Lederman, M.D.: Cresatin in laryngology and otology. Laryngoscope, 50: 784, 1940.

50. Manufacturer's Product Information, Cresatin, Merck, Sharpe and Dohme, West Point, Pennsylvania.

51. Clarke, E.G.C.(ed.): Isolation and Identification of Drugs. The Pharmaceutical Press, London, 1969.

52. Stecher, P.G.: The Merck Index, 8th edition, Merck & Co., Rahway, New Jersey, 1968.

53. Grossman, L.I.: Sterilization of infected root canals. J.A.D.A., 85: 900, 1972.

54. Redig, D.F.: A comparison and evaluation of two formocresol pulpotomy technics utilizing 'Buckleys' formocresol. Dent. Child., 35: 22-29, 1968.

55. Manufacturer's Product Information, Cresol & Formalin, J, Bird Moyer Co., Philadelphia, Pennsylvania.

56. Ostrander, F.D.: The development of antiseptics and antibiotics for use in endodontics., Transactions of the Second International Conference on Endodontics, 1968.

57. Feirer, W. and Leonard, V.: Hexylresorcinol in oral antisepsis with special reference to solution S.T. 37, Dental Cosmos, 69: 882-92, 1927.

58. Frobisher, M.: Studies upon the relationship between surface tension and the action of disinfectants, with special reference to hexylresorcinol., J. Bacteriology, 13: 163-82, 1927.

59. Wolfsohn, B.L.: Effectiveness of a group of endodontic therapeutic agents, Oral Surg., 11: 1394-1403, 1958.

60. Bartels, H.A.: The effect of eugenol and oil of cloves on the growth of micro-organisms. Am. J. Ortho. and Oral Surg. 33: 458, 1959.

61. Brown, J.I.: An evaluation of the antimicrobial effectiveness of of root canal medicaments., Master of Science Thesis, Boston University School of Graduate Dentistry, 1970.

62. Vander Wall, G.L., Dowson, J. and Shipman, C. Jr.: Antibacterial efficacy and cytotoxicity of three endodontic drugs, Oral Surg., Oral Med., and Oral Path. 33: 230 - 241, 1972.

63. Wantulok, J.C. and Brown, J.I.: An in vitro study of the diffusibility of camphorated parachlorophenol and metacresylacetate in the root canal. Oral Surg., Oral Med., and Oral Path. 34: 653-660, 1972.

64. Bartels, H.A.: A bacteriologic appraisal of some materials used in root canal therapy. J.A.D.A. 28: 1108-1112, 1941.

65. Pear, J.R.: Bactericidal effects of some drugs used in pulp canal therapy. J.A.D.A. 29: 244-48, 1942.

66. Ostrander, F.D. and Crowley, M.C.: The effectiveness of clinical treatment of pulp involved teeth as determined by bacteriological methods. Jour. Endodontics, 3: 6-12, 1948.

67. Ostrander, F.D., Crowley, M.C., and Dowson, J.: A clinical study of the treatment of root canal and periapical infections with penicillin. Jour. Dent. Res., 26: 403, 1947.

68. Treanor, H.F. Jr. and Goldman, M.: Bactericidal efficiency of intracanal medications. Oral Surg., Oral Med., and Oral Path., 33: 791-796, 1972.

69. Cwikla, J.R.: The vaporization and capillarity effect of endodontic medicaments. Oral Surg., Oral Med., and Oral Path., 34: 117-121, 1972.

70. Uchin, R.A. and Parriss, L.: Antibacterial activity of endodontic medications after varying time intervals within the root canal. Oral Surg., Oral Med., and Oral Path., 16: 608, 1963.

71. Coolidge, Edgar: Reaction of dog tissue to drugs used in root canal treatment. J.A.D.A., 19: 747, 1932.

72. Grossman, L.I.: Irritating potentialities of root canal medicaments. Am. J. Orth. and Oral Surg., 30: 564, 1944.

73. Rubbo, S.O., Reich, J., and Dixson, S.: The use of a combination of neomycin, bacitracin and polymyxin in endodontia, Oral Surg., Oral Med., and Oral Path., 8: 878-896, 1958.

74. Schilder, H., and Amsterdam, M.: Inflammatory potential of root canal medicaments. Oral Surg., Oral Med., and Oral Path., 12: 211, 1959.

75. Torneck, Calvin: Reaction of hamster tissue to drugs used in sterilization of the root canal. Oral Surg., Oral Med., and Oral Path. 14: 730, 1961.

76. Stewart, G., and Gautieri, R.: Reduced inflammatory root canal medication, Oral Surg., Oral Med., Oral Path. 15: 715, 1962.

77. Attalla, M.N., and Calvert, J.M.: Irritation properties of root canal medicaments. J. Canad. Dent. Ass. 35: 76, 1969.

78. Berman, D.: Pulp amputation and healing. J. Dent. Child. 25: 184, 1958.

79. Hunter, F.A.: Saving pulps, a queer process. Dental Items of Interest, 5: 532, 1883.

80. Witzel, A.: The covering of exposed pulps. The Dental Register, 35: 1, 1881.

81. Buckley, J.P.: A rational treatment for putrescent pulps. The Dental Review, 18: 1193-97, 1904.

82. Harker, Charles: Anti-conservative treatment of the exposed dental pulp. Dental Cosmos, 34: 893-900, 1892.

83. Davis, C.: Pulpotomy and partial pulp-canal filling. Dent. Summary, 41: 311, 653, 787, 1921.

84. Sweet, C., Sr.: Procedures for treatment of exposed and pulpless deciduous teeth. J.A.D.A., 17: 1150, 1930.

85. Sweet, C.A., Jr.: Treatment for deciduous teeth with exposed pulps. U. of Wash. Dent. J., 3: 78, 1936.

86. Finn, S.B.: Clinical Pedodontics, 3rd edition, W.B. Saunders Co., Philadelphia, P. 228 - 233., 1967.

87. Massler, M. and Mansukhani, N.: Effects of formocresol on the dental pulp. J. Dent. Child., 26: 277, 1959.

88. Emmerson, C.C., Miyamoto, Osamu, Sweet, C.A., and Bhatia, H.L.: Pulpal changes following formoleresol applications on rat molars and human primary teeth., South. Calif. S. Dent. A.J., 27: 309-23, 1959.

89. Doyle, W.A., McDonald, R.E., and Mitchell, D.F.: Formocresol versus calcium hydroxide in pulpotomy. J. Dent. Child., 29: 86, 1962.

90. Berger, J.E.: Pulp tissue reaction to fromocresol and zinc oxide-eugenol. J. Dent. Child., 32: 13, 1965.

91. Beaver, H.A., Kopel, H.M., and Sabes, W.R.: The effect of zinc oxide-eugenol cement on a formocresolized pulp. J. Dent. Child., 33: 381, 1966.

92. Englander, H.R., Massler, M., and Carter, W.J.: Clinical evaluation of pulpotomy in young adults. J. Dent. Child. 23: 48, 1956.

93. Sandler, E.: The histological response of the dental pulp to Cresatin. Master of Science Thesis, Boston University School of Graduate Dentistry, 1966.

94. Robinson, B.: The histological response of the cariously exposed dental pulp to Cresatin and formocresol. Master of Science Thesis, Boston University School of Graduate Dentistry, 1967.

95. Lance, J.R. and Marshall, F.J.: Emergency endodontic therapy. J.A.D.A. 85: 1119, 1972.

APPENDIX

This section contains representative photomicrographs of the histological specimens obtained in this study. All are stained with hematoxylin and eosin.

NUMBER: S-1

AGE: 23 years

SEX: Female

TOOTH IDENTIFICATION: Upper left cuspid

DATE OF PULPOTOMY: November 16, 1972

MEDICAMENT EMPLOYED: Saline

DATE OF EXTRACTION: November 16, 1972

DURATION OF TREATMENT: 2 hours

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. At the amputation site there is an accumulation of extravasated red blood cells. (Fig. 3)

2. Beneath this there are a number of dilated blood vessels.

3. The remainder of the pulp appears normal.

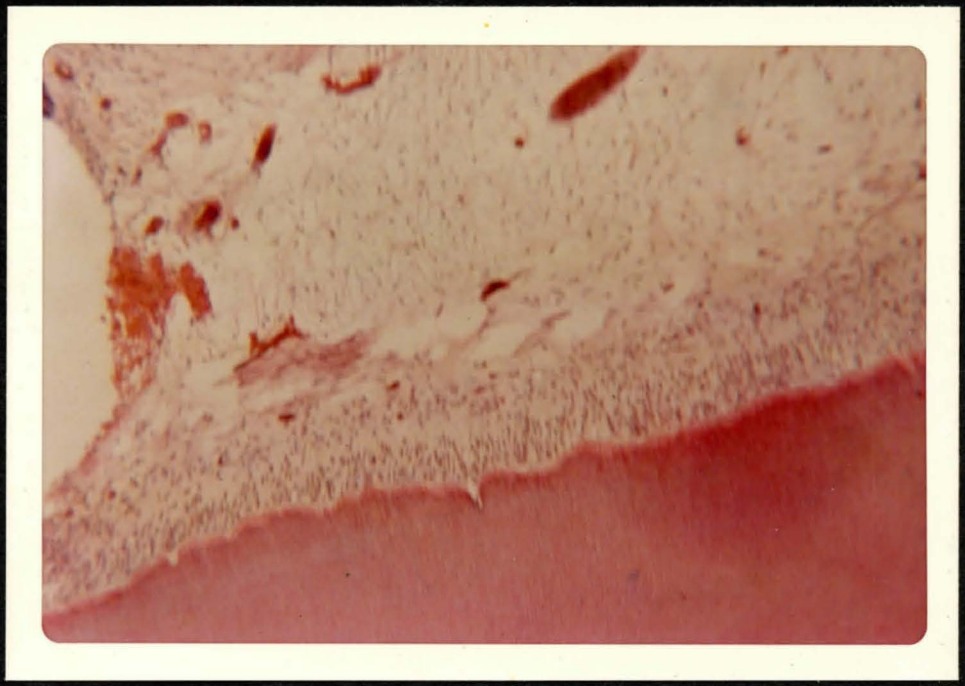

Fig. 3

H&E 100X

NUMBER: S-2

AGE: 47 years

SEX: Male

TOOTH IDENTIFICATION: Upper right first molar

DATE OF PULPOTOMY: November 8, 1972

MEDICAMENT EMPLOYED: Saline

DATE OF EXTRACTION: November 22, 1972

DURATION OF TREATMENT: 14 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. The cervical portion of the pulp is fibrotic with some linear calcification. (Fig. 4)

2. In the middle third there is extensive linear calcification with osteodentin formation along the walls of the canal. There is a projection of osteodentin into the pulp tissue. (Fig. 5)

3. Odontoblasts are visible apical to this projection.

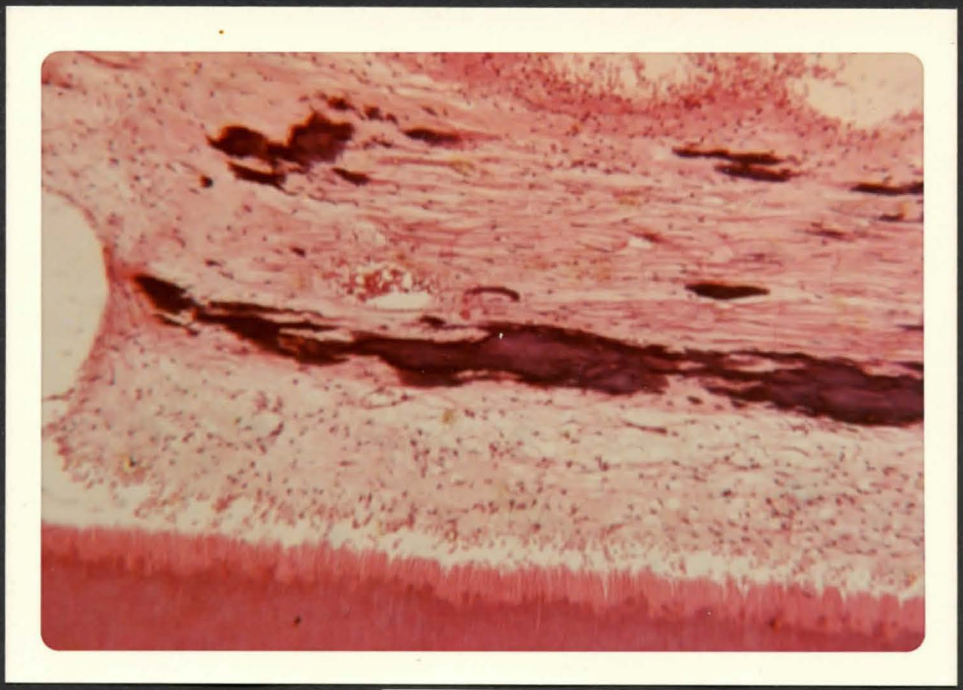

Fig. 4

H&E 100X

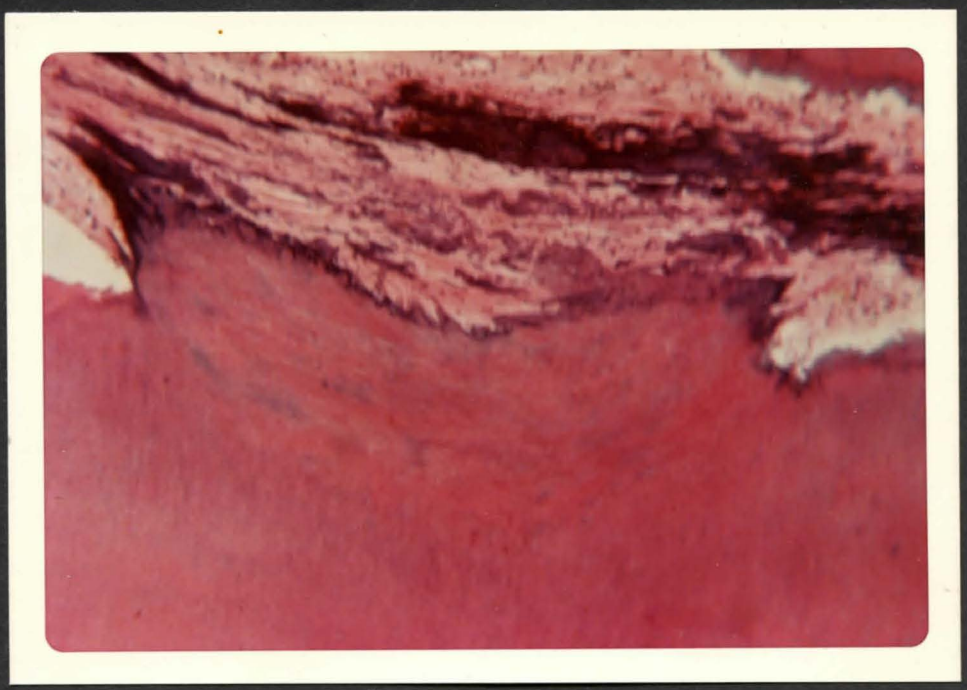

Fig. 5

H&E 100X

NUMBER: S-3

AGE: 47 years

SEX: Male

TOOTH IDENTIFICATION: Upper right second molar

DATE OF PULPOTOMY: November 8, 1972

MEDICAMENT EMPLOYED: Saline

DATE OF EXTRACTION: December 6, 1972

DURATION OF TREATMENT: 28 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Adjacent to the cotton pellet there is a mass of necrotic tissue which extends through the middle third of the root. (Fig. 6)

2. In the apical third there is viable tissue which is markedly inflamed. (Fig. 7)

3. There is no evidence of odontoblasts.

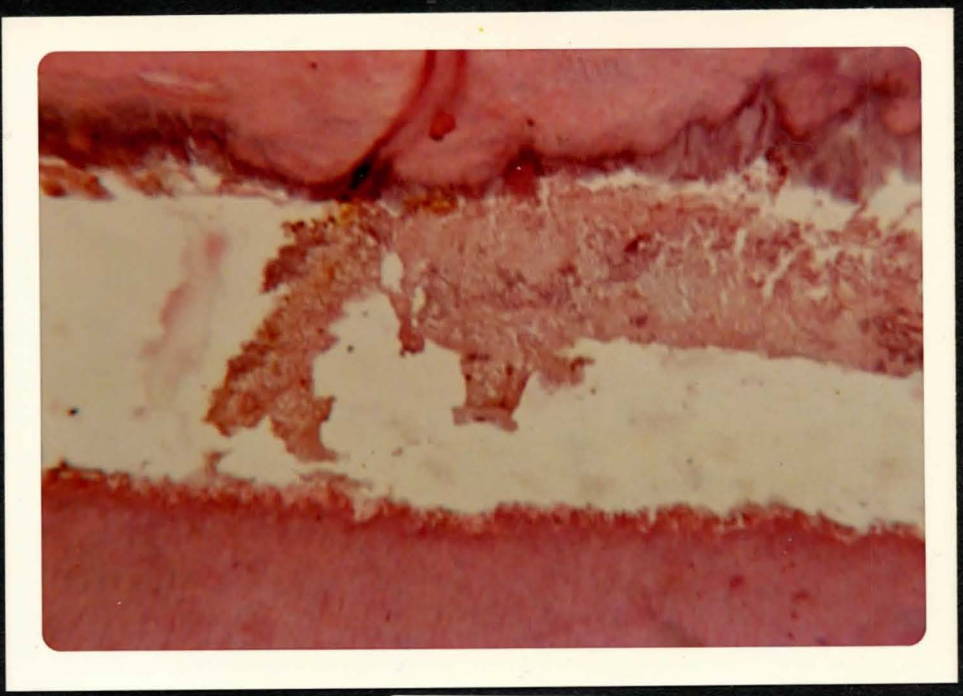

Fig. 6

H&E 35X

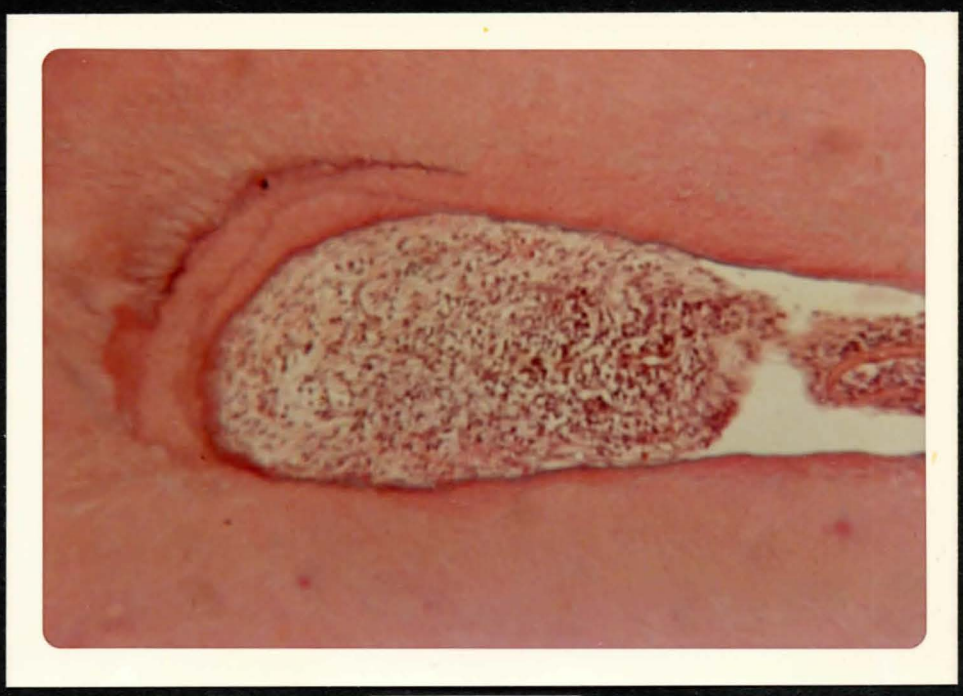

Fig. 7

H&E 35X

NUMBER: S-4

AGE: 45 years

SEX: Female

TOOTH IDENTIFICATION: Upper right first molar

DATE OF PULPOTOMY: November 9, 1972

MEDICAMENT EMPLOYED: Saline

DATE OF EXTRACTION: December 7, 1972

DURATION OF TREATMENT: 28 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Adjacent of the medication the pulp is fibrotic with marked linear calcification which extends apically. (Fig. 8)

2. In the middle third, the pulp appears more cellular.

3. There is osteodentin deposition and internal resorption along the walls.

4. No odontoblasts are seen.

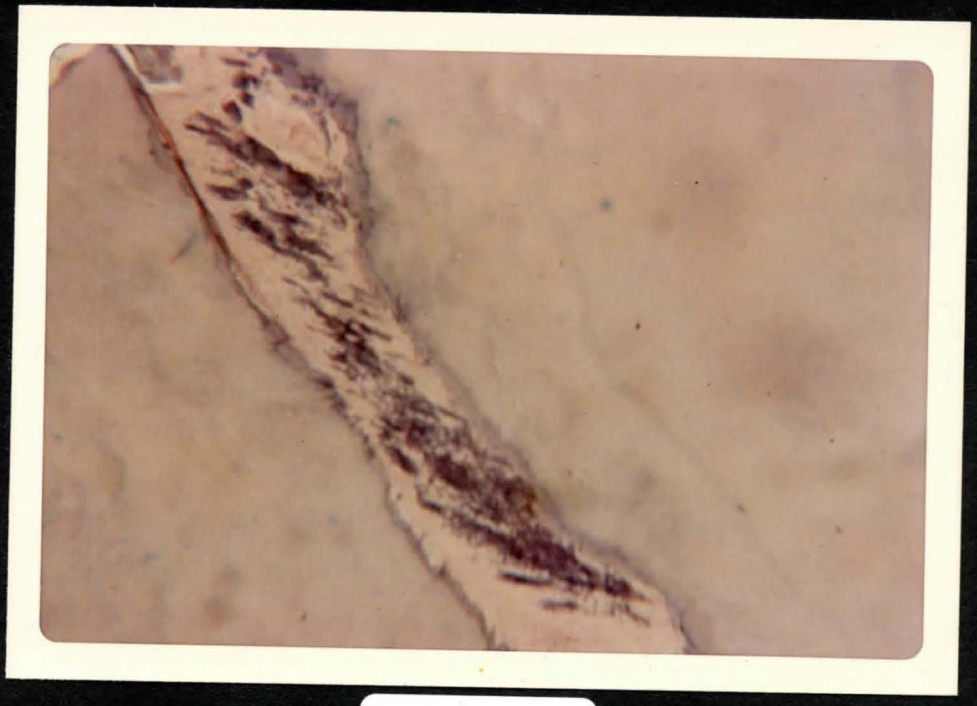

Fig. 8

H&E 35X

NUMBER: S-5

AGE: 45 years

SEX: Male

TOOTH IDENTIFICATION: Upper right cuspid

DATE OF PULPOTOMY: December 6, 1972

MEDICAMENT EMPLOYED: Saline

DATE OF EXTRACTION: January 3, 1973

DURATION OF TREATMENT: 29 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. The coronal portion of the pulp appears fibrotic. (Fig. 9)

2. There is a marked increase in vascularity with a slight inflammatory exudate.

3. There is evidence of linear calcification in the middle third of the root.

4. Apically the pulp appears essentially normal with a few dilated vessels.

Fig. 9

H&E 100X

NUMBER: S-6

AGE: 37 years

SEX: Male

TOOTH IDENTIFICATION: Upper right first premolar

DATE OF PULPOTOMY: December 7, 1972

MEDICAMENT EMPLOYED: Saline

DATE OF EXTRACTION: February 1, 1973

DURATION OF TREATMENT: 56 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Near the amputation site there is a mass of necrotic tissue with degenerating inflammatory cells.

2. Beneath this layer there is a dense inflammatory infiltration which becomes more moderate toward the apical third. (Fig. 10)

3. There is no evidence of odontoblasts.

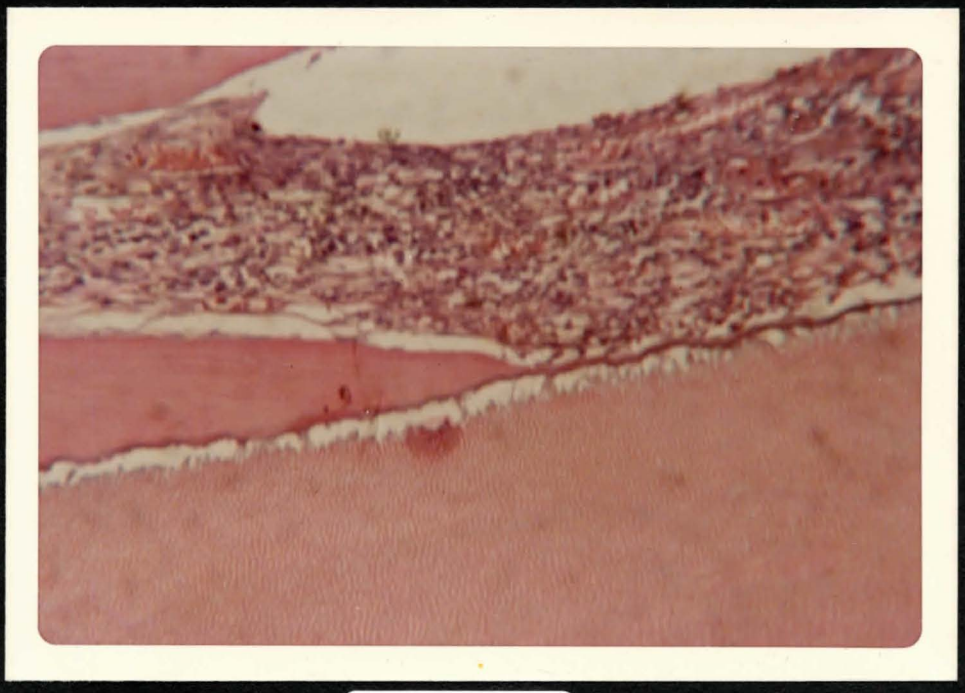

Fig. 10

H&E 35X

NUMBER: CR-1

AGE: 29 years

SEX: Female

TOOTH IDENTIFICATION: Upper right second molar

DATE OF PULPOTOMY: January 4, 1973

MEDICAMENT EMPLOYED: Cresatin

DATE OF EXTRACTION: January 11, 1973

DURATION OF TREATMENT: 7 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. The area near the medicament was lost in histological preparation.

2. In one canal there is a marked increase in vascularity. A large pulp is visible. (Fig. 11)

3. The pulp appears essentially normal in the other canal. (Fig. 12)

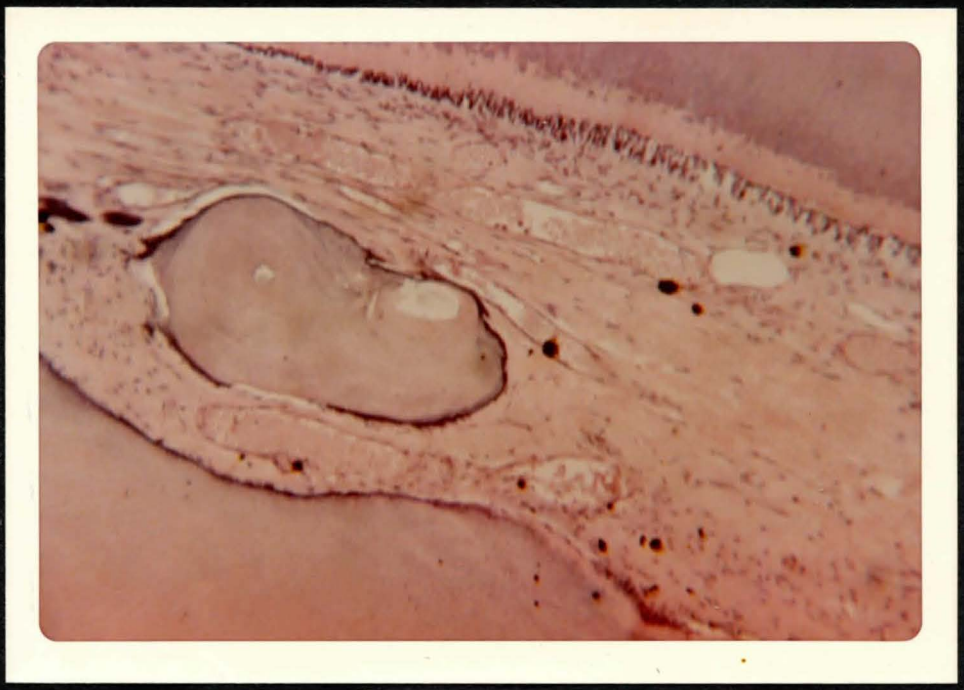

Fig. 11

H&E 35X

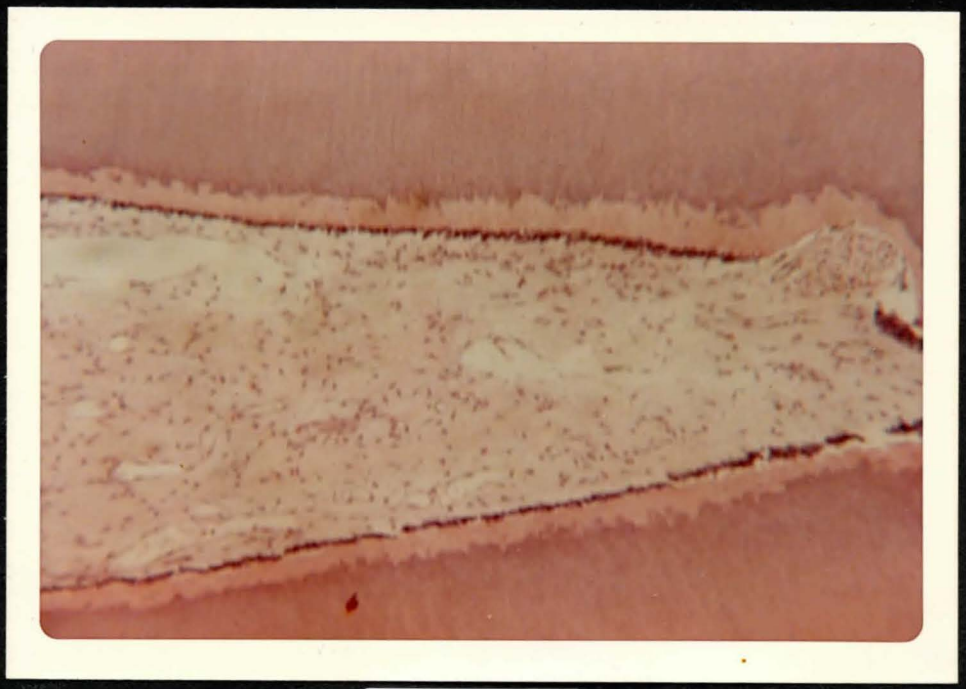

Fig. 12

H&E 35X

NUMBER: CR-2

AGE: 41 years

SEX: Female

TOOTH IDENTIFICATION: Upper right first molar.

DATE OF PULPOTOMY: November 6, 1972

MEDICAMENT EMPLOYED: Cresatin

DATE OF EXTRACTION: November 14, 1972

DURATION OF TREATMENT: 8 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. There is a pink-staining homogeneous layer adjacent to the site of amputation. (Fig. 13)

2. Beneath this layer there is marked vasodilatation.

3. The remaining pulp elements appear essentially normal. (Fig. 14)

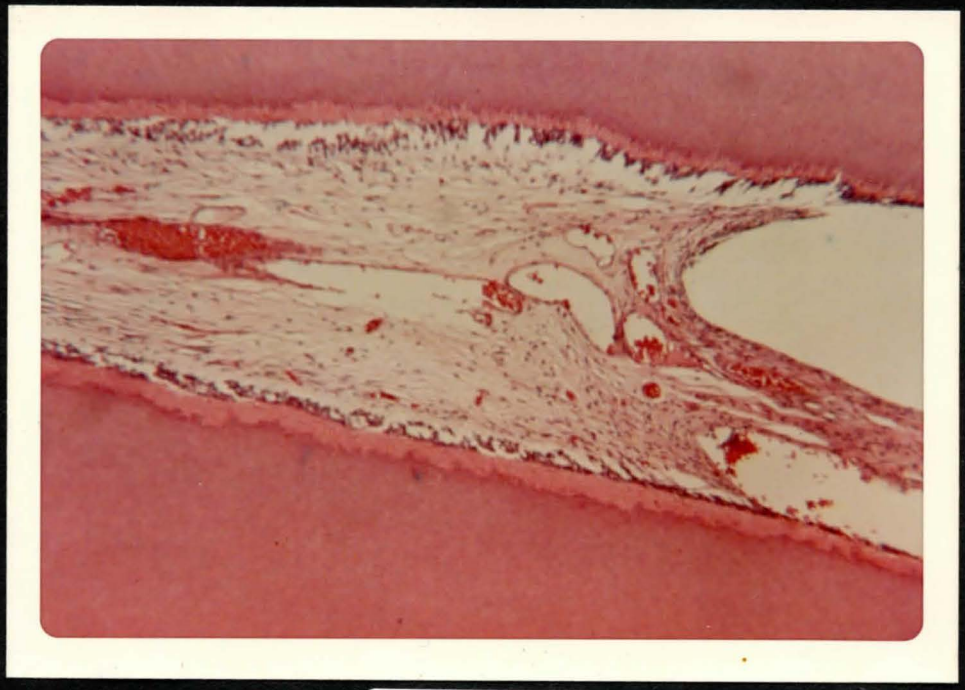

Fig. 13

H&E 35X

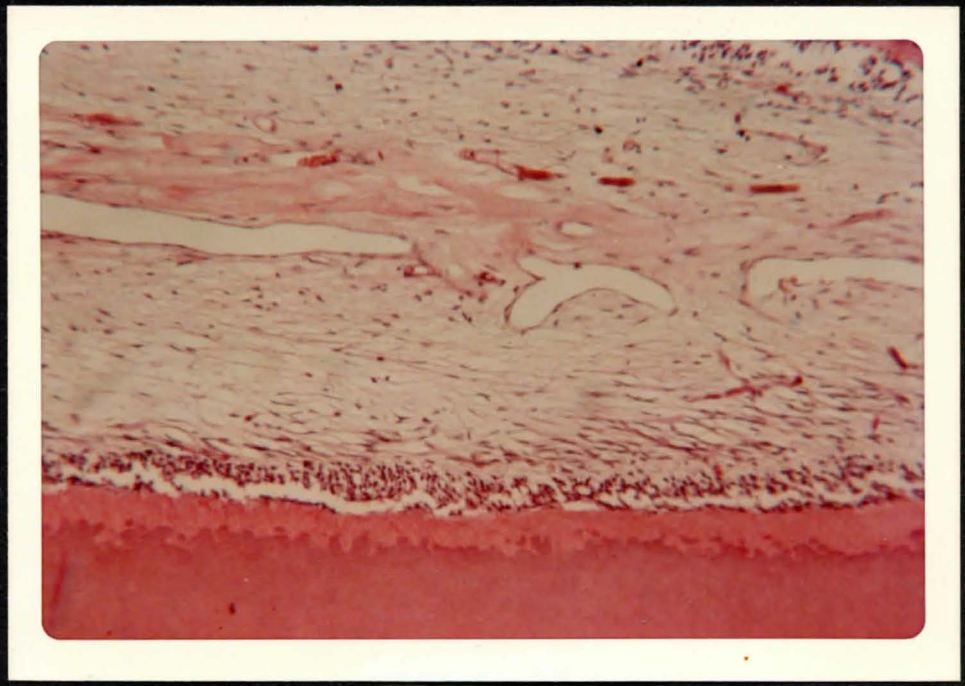

Fig. 14

H&E 100X

NUMBER: CR-3

AGE: 4½ years

SEX: Female

TOOTH IDENTIFICATION: Lower left third molar

DATE OF PULPOTOMY: January 8, 1973

MEDICAMENT EMPLOYED: Cresatin

DATE OF EXTRACTION: January 22, 1973

DURATION OF TREATMENT: 14 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. There is a pink staining tissue layer adjacent to the medicament.
2. Below this there are numerous blood vessels. (Fig. 15)
3. The odontoblasts layer appears intact. (Fig. 15)
4. A large pulp stone is present just below the amputation site.

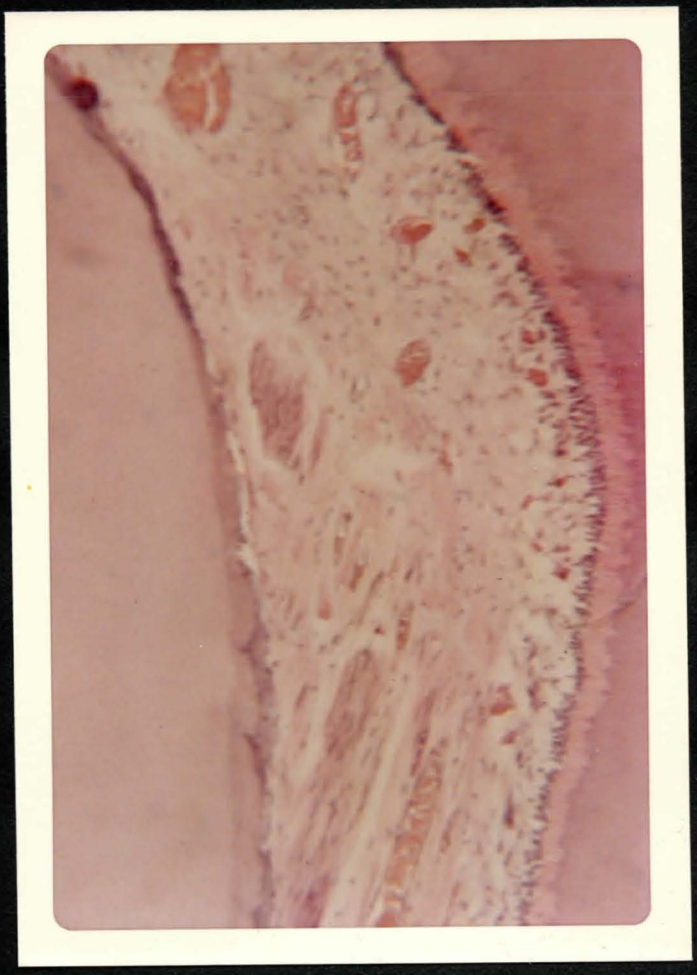

Fig. 15

H&E 100X

NUMBER: CR-4

AGE: 52 years

SEX: Male

TOOTH IDENTIFICATION: Lower right first molar

DATE OF PULPOTOMY: November 15, 1972

MEDICAMENT EMPLOYED: Cresatin

DATE OF EXTRACTION: November 29, 1972

DURATION OF TREATMENT: 14 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Near to the medication there is a homogeneous layer with loss of cellular detail.

2. Beneath this layer there is an increase in vascularity.

3. Fibrosis and calcification of the pulp tissue continues into the apical third. (Fig. 16)

4. There is no evidence of odontoblasts.

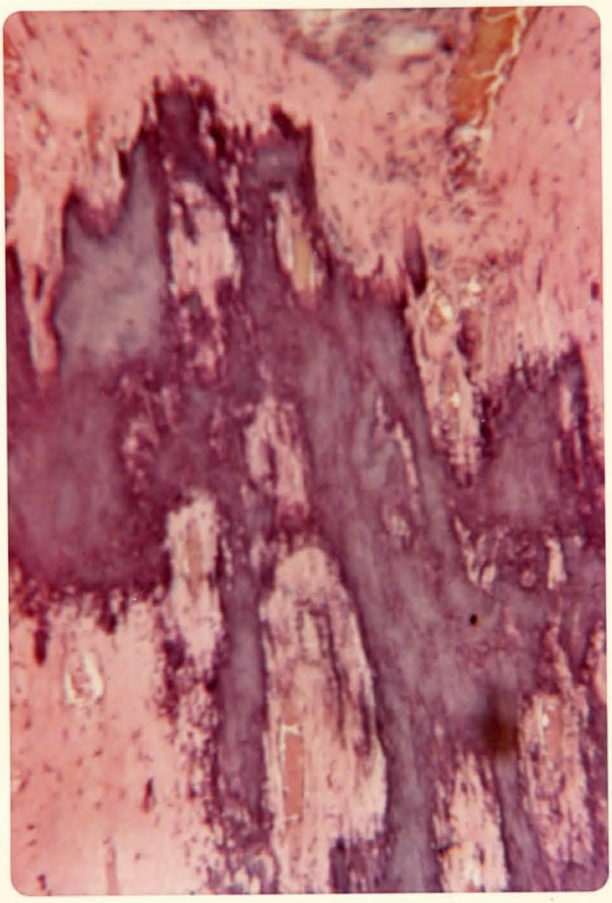

Fig. 16

H&E 100X

NUMBER: CR-5

AGE: 39 years

SEX: Female

TOOTH IDENTIFICATION: Upper left lateral incisor

DATE OF PULPOTOMY: December 11, 1972

MEDICAMENT EMPLOYED: Cresatin

DATE OF EXTRACTION: January 4, 1973

DURATION OF TREATMENT: 24 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Adjacent to the medication there is a mass of necrotic partially calcified tissue mixed with degenerating inflammatory cells which continued apically. (Fig. 17)

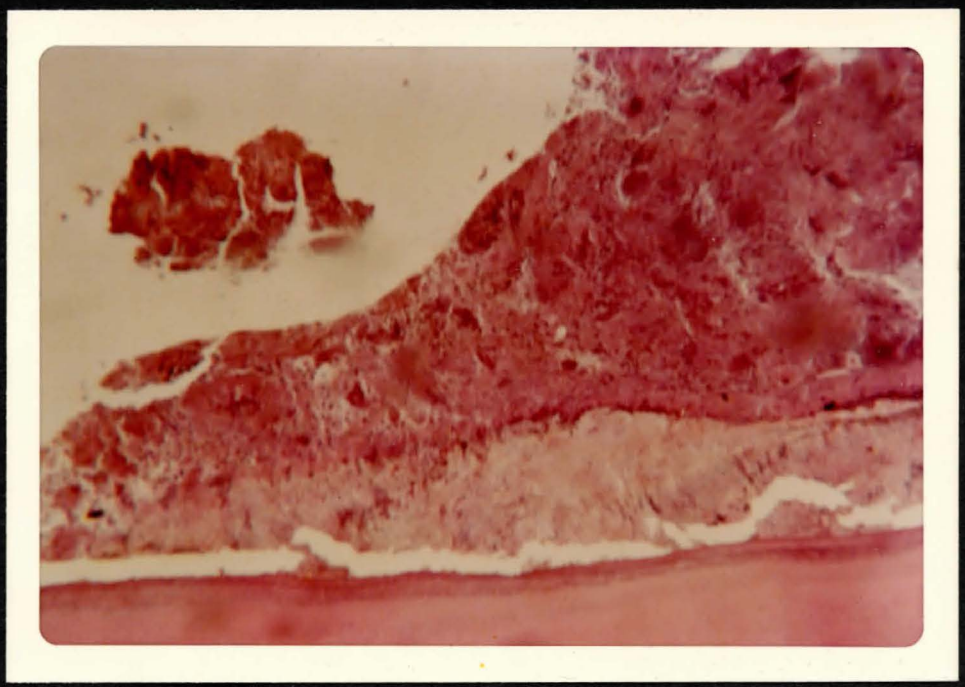

Fig. 17

H&E 100X

NUMBER: CR-6

AGE: 47 years

SEX: Male

TOOTH IDENTIFICATION: Upper left first molar

DATE OF PULPOTOMY: November 8, 1972

MEDICAMENT EMPLOYED: Cresatin

DATE OF EXTRACTION: December 6, 1972

DURATION OF TREATMENT: 28 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. There is a thin pink-staining homogeneous layer near the medicament.

2. The pulp is fibrotic with heavy linear calcification.

3. There is evidence of osteodentin formation and some internal resorption in the middle third.

4. No odontoblasts are visible.

NUMBER: CR-7

AGE: 45 years

SEX: Male

TOOTH IDENTIFICATION: Upper right first premolar

DATE OF PULPOTOMY: December 5, 1972

MEDICAMENT EMPLOYED: Cresatin

DATE OF EXTRACTION: January 3, 1973

DURATION OF TREATMENT: 29 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Adjacent to the site of amputation there is a homogeneous layer of tissue.

2. Below this layer dilated blood vessels are visible with a slight inflammatory exudate.

3. The remainder of the pulp appears slightly fibrous.

4. An odontoblastic layer can be seen.

NUMBER: CR-8

AGE: 45 years

SEX: Male

TOOTH IDENTIFICATION: Upper left cuspid

DATE OF PULPOTOMY: December 5, 1972

MEDICAMENT EMPLOYED: Cresatin

DATE OF EXTRACTION: January 3, 1973

DURATION OF TREATMENT: 29 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. There is a homogeneous layer at the site of amputation. (Fig.18)
2. Beneath this there are numerous dilated vessels with a slight inflammatory exudate. (Fig. 18)
3. Some internal resorption is visible in the middle third of the root. (Fig.19)
4. There is fibrosis of the central portion of the pulp.

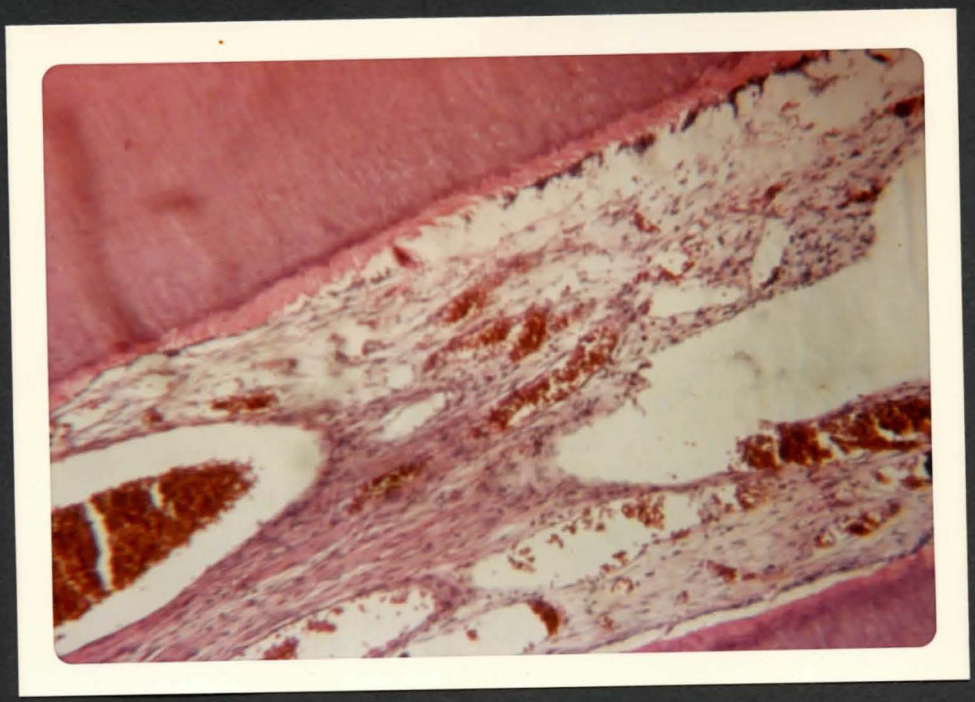

Fig. 18

H&E 35X

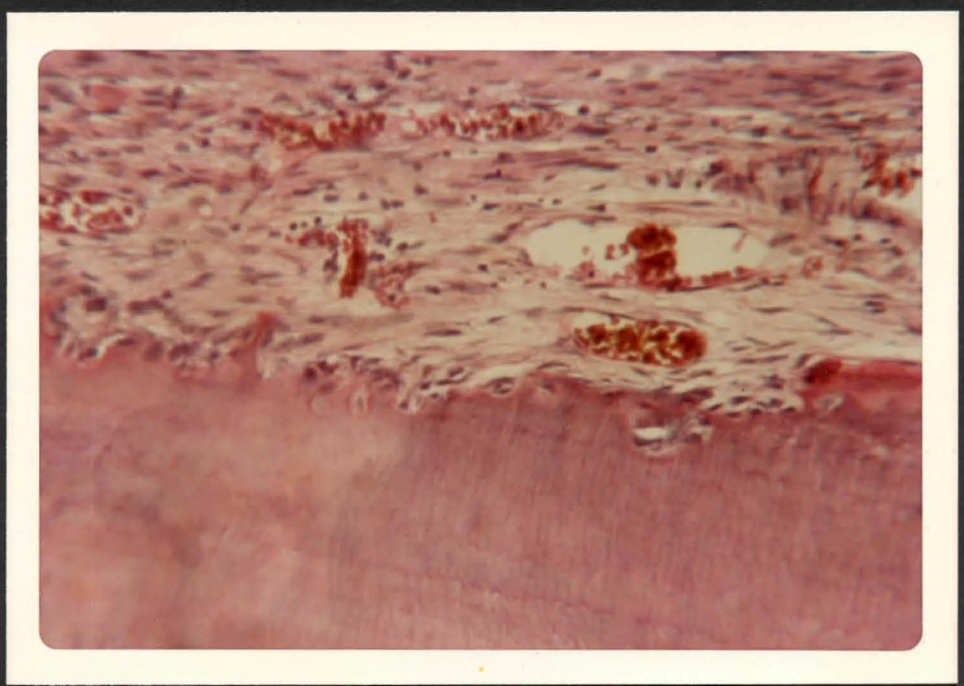

Fig. 19

H&E 100X

NUMBER: E-1

AGE: 42 years

SEX: Female

TOOTH IDENTIFICATION: Lower left first molar

DATE OF PULPOTOMY: October 24, 1972

MEDICAMENT EMPLOYED: Eugenol

DATE OF EXTRACTION: October 31, 1972

DURATION OF TREATMENT: 7 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. There is a homogeneous fixed layer near the site of amputation.

2. Beneath this there is marked vasodilation with a slight inflammatory exudate. (Fig. 20)

3. There is fibrosis and linear calcification in the body of the pulp as well as osteodentin deposition along the walls. (Fig. 20)

4. There is no evidence of odontoblasts.

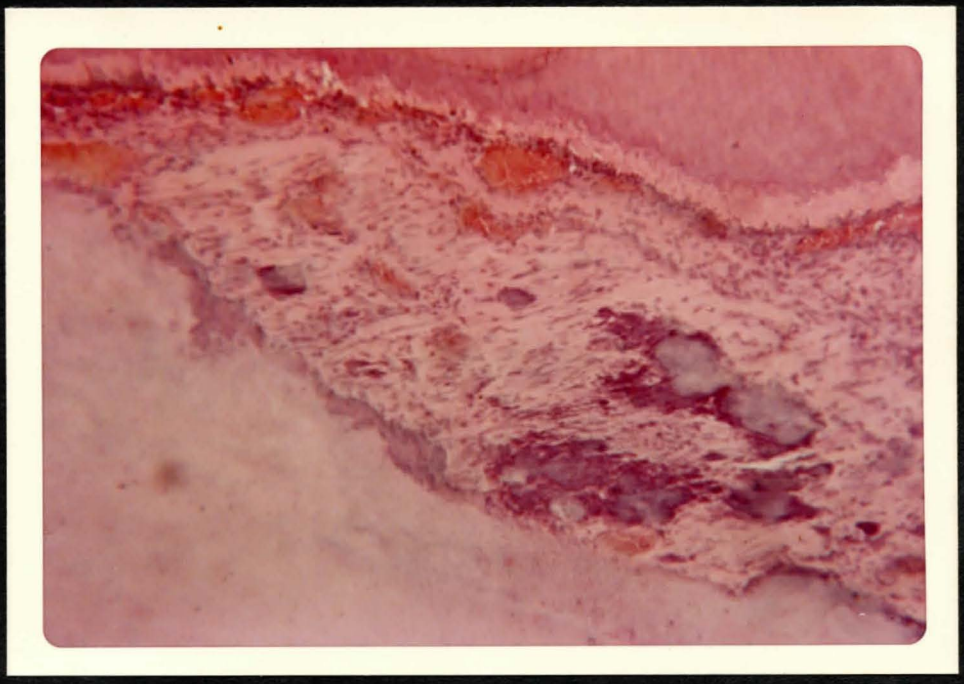

Fig. 20

H&E 35X

NUMBER: E-2

AGE: 49 years

SEX: Male

TOOTH IDENTIFICATION: Upper right second molar

DATE OF PULPOTOMY: November 6, 1972

MEDICAMENT EMPLOYED: Eugenol

DATE OF EXTRACTION: November 21, 1972

DURATION OF TREATMENT: 15 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Adjacent to the medication there is a thick fixed layer with loss of cellular detail.

2. There are numerous small centers of calcification within the pulp as well as irregular osteodentin deposition along the walls. (Fig. 21)

3. There is linear calcification in the middle third of the root. (Fig. 21)

4. No odontoblasts are visible.

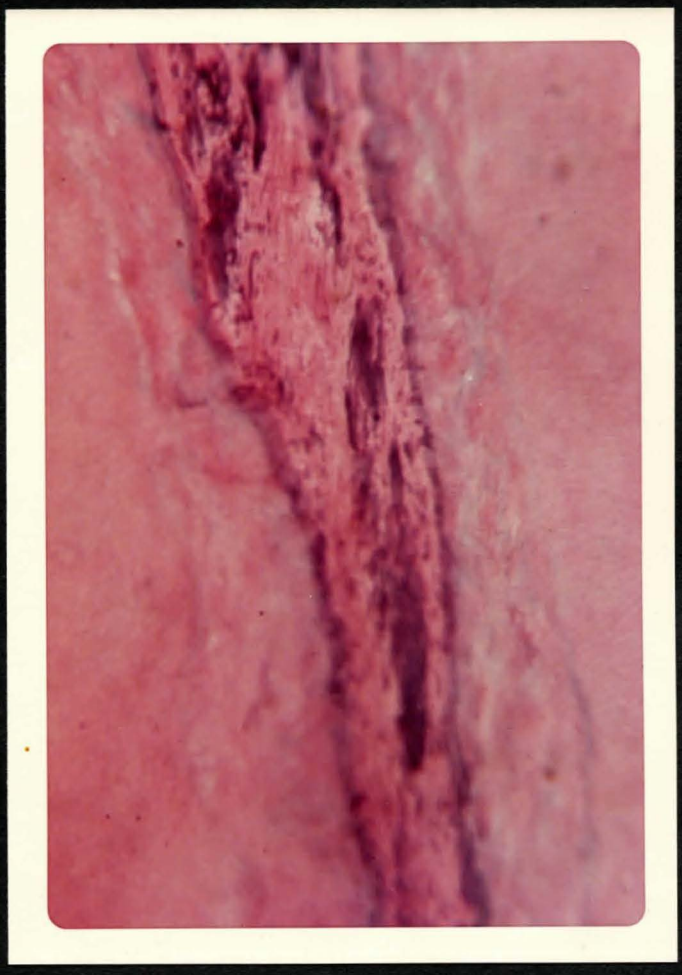

Fig. 21

H&E 35X

NUMBER: E-3

AGE: 39 years

SEX: Female

TOOTH IDENTIFICATION: Upper right lateral incisor

DATE OF PULPOTOMY: December 11, 1972

MEDICAMENT EMPLOYED: Eugenol

DATE OF EXTRACTION: January 4, 1973

DURATION OF TREATMENT: 24 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS: (Fig. 22)

1. Adjacent to the medicament there is a "fixed" homogeneous layer.
2. Immediately beneath this, there is a large pulp stone.
3. There is a marked increase in vascularity.
4. The pulp lacks cellular detail.

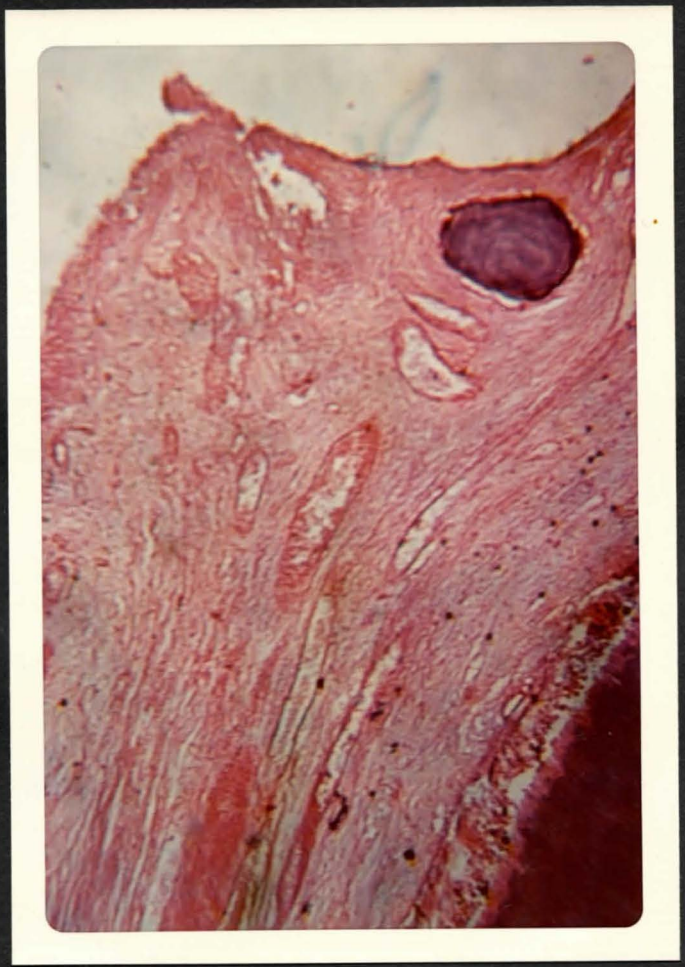

Fig. 22

H&E 100X

NUMBER: E-4

AGE: 35 years

SEX: Female

TOOTH IDENTIFICATION: Upper right first molar

DATE OF PULPOTOMY: November 9, 1972

MEDICAMENT EMPLOYED: Eugenol

DATE OF EXTRACTION: December 1, 1972

DURATION OF TREATMENT: 22 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Adjacent to the medication there is a necrotic mass of tissue.

2. Beneath this layer there is a dense inflammatory exudate. (Fig. 23)

3. In the apical portion, there are a few inflammatory cells but the underlying pulp tissue can be identfified. (Fig. 24)

4. No odontoblasts are visible.

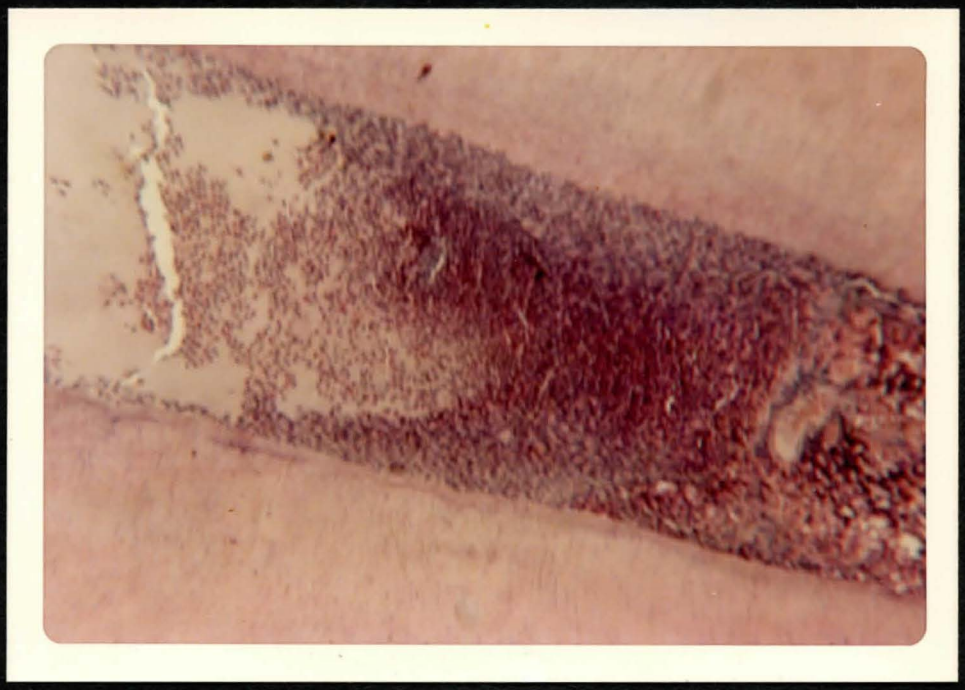

Fig. 23

H&E 35X

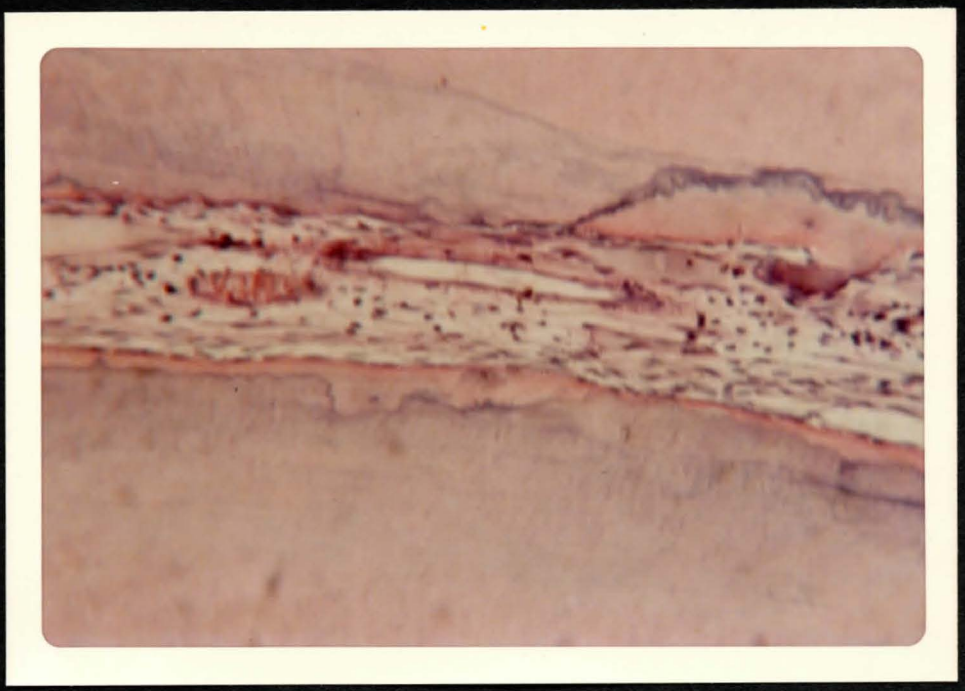

Fig. 24

H&E 35X

NUMBER: E-5

AGE: 45 years

SEX: Male

TOOTH IDENTIFICATION: Upper left central incisor

DATE OF PULPOTOMY: December 5, 1972

MEDICAMENT EMPLOYED: Eugenol

DATE OF EXTRACTION: January 3, 1973

DURATION OF TREATMENT: 29 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS: (Fig. 25)

1. Near the medication there is a thin layer of homogeneous tissue.
2. Beneath this layer there are a few dilated blood vessels.
3. The pulp is fibrotic with heavy, diffuse linear calcification.
4. There is no evidence of odontoblasts.

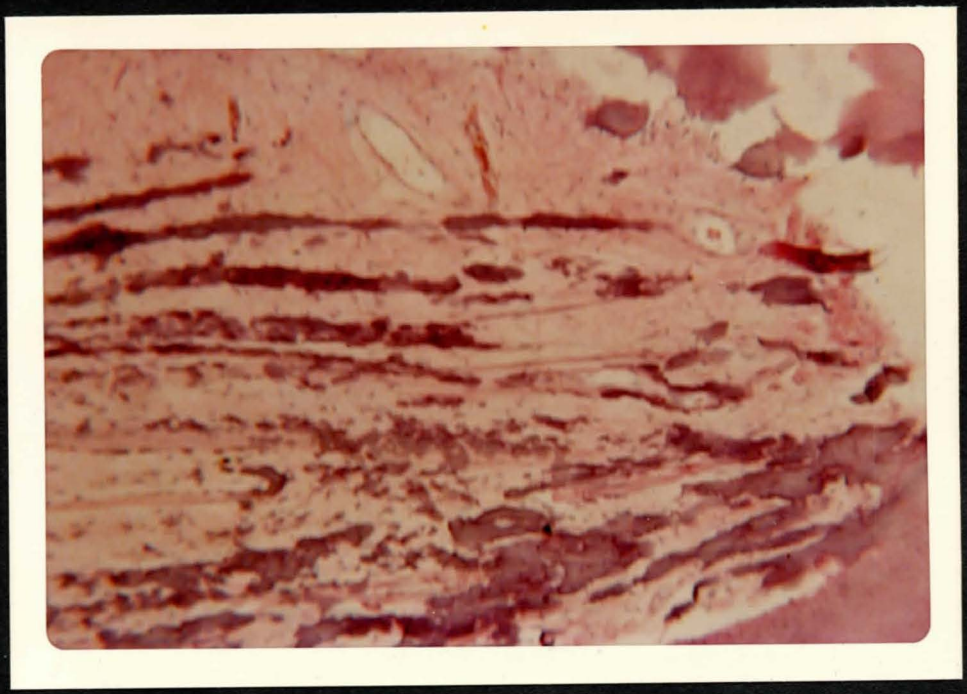

Fig. 25

H&E 100X

NUMBER: F-1

AGE: 40 years

SEX: Male

TOOTH IDENTIFICATION: Lower left second premolar

DATE OF PULPOTOMY: February 7, 1973

MEDICAMENT EMPLOYED: Formocresol

DATE OF EXTRACTION: February 14, 1973

DURATION OF TREATMENT: 7 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS: (Fig. 26)

1. There is a homogeneous layer of tissue at the site of amputation.

2. There is a loss of cellular detail. The pulp appears to have a fibrinoid degeneration.

3. There is no evidence of odontoblasts.

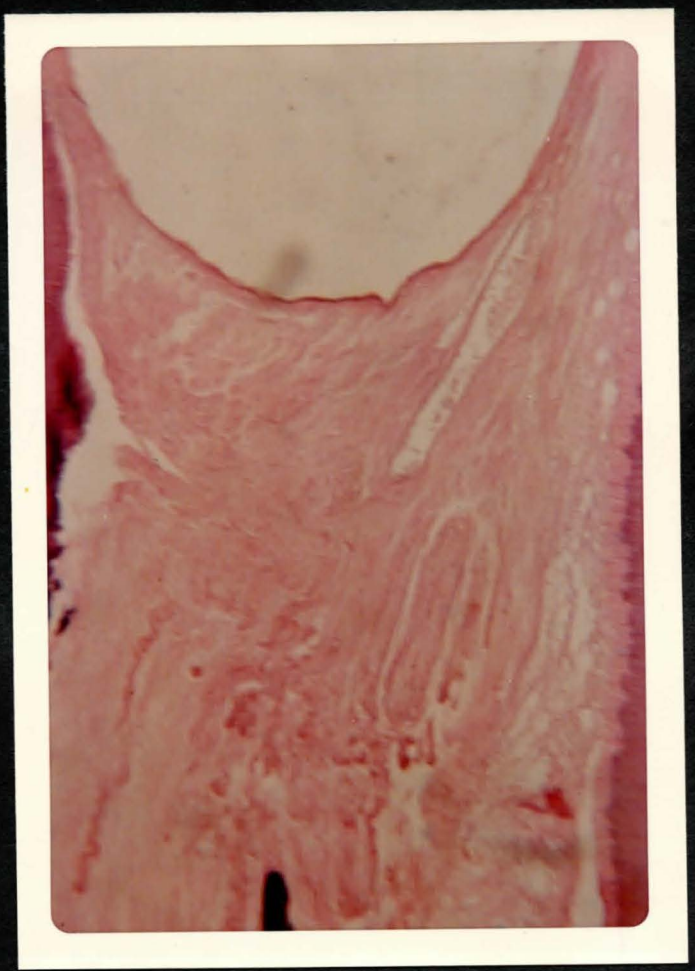

Fig. 26

H&E 100X

NUMBER: F-2

AGE: 39 years

SEX: Female

TOOTH IDENTIFICATION: Upper right central incisor

DATE OF PULPOTOMY: December 11, 1972

MEDICAMENT EMPLOYED: Formocresol

DATE OF EXTRACTION: January 4, 1973

DURATION OF TREATMENT: 24 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS: (Fig. 27)

1. There is a homogeneous pink-staining zone with loss of cellular detail at the amputation site.

2. Beneath this the pulp shows increased vascularity.

3. There is fibrosis of the central portion of the pulp with some evidence of calcification which continues into the middle third of the root.

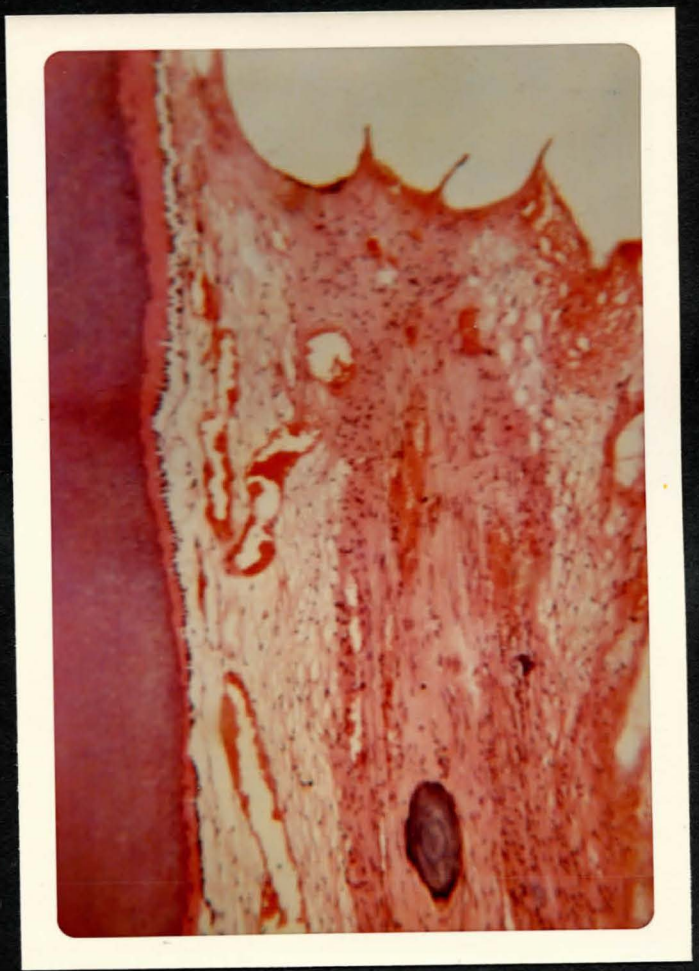

Fig. 27

H&E 100X

NUMBER: F-3

AGE: 45 years

SEX: Male

TOOTH IDENTIFICATION: Upper right lateral incisor

DATE OF PULPOTOMY: December 5, 1972

MEDICAMENT EMPLOYED: Formocresol

DATE OF EXTRACTION: January 2, 1973

DURATION OF TREATMENT: 29 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Adjacent to the medication there is a thick "fixed" homogeneous layer with loss of cellular detail. (Fig. 28)

2. Below this area, a few inflammatory cells are visible. (Fig. 28)

3. The middle third of the pulp shows marked vascularity. (Fig. 29)

4. Fibrosis and some calcification are visible centrally. (Fig. 29)

5. The odontoblastic layer appears intact. (Fig. 29)

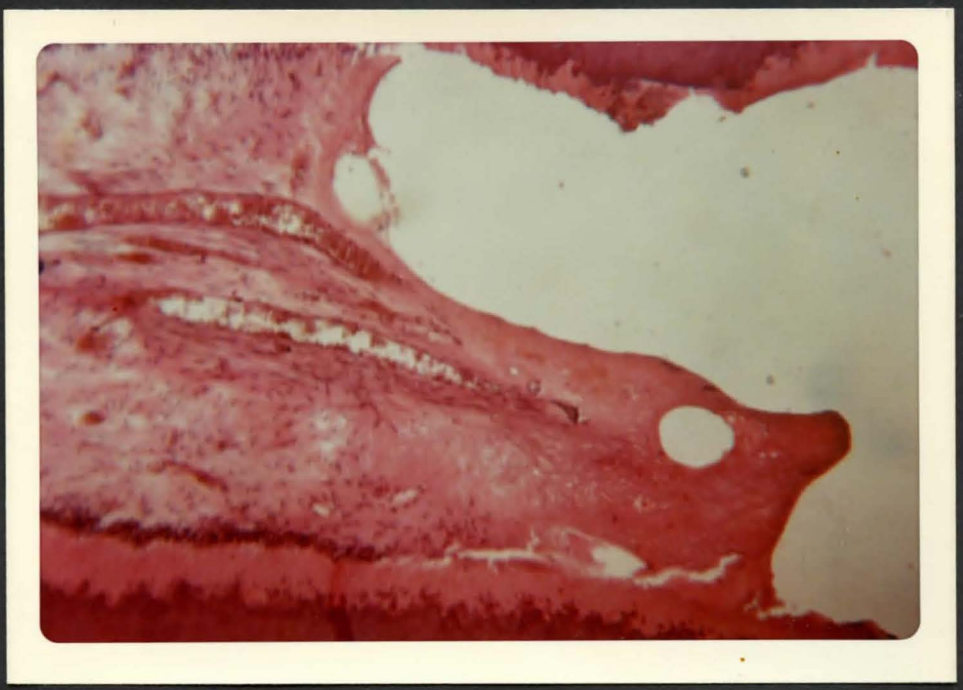

Fig. 28 H&E 100X

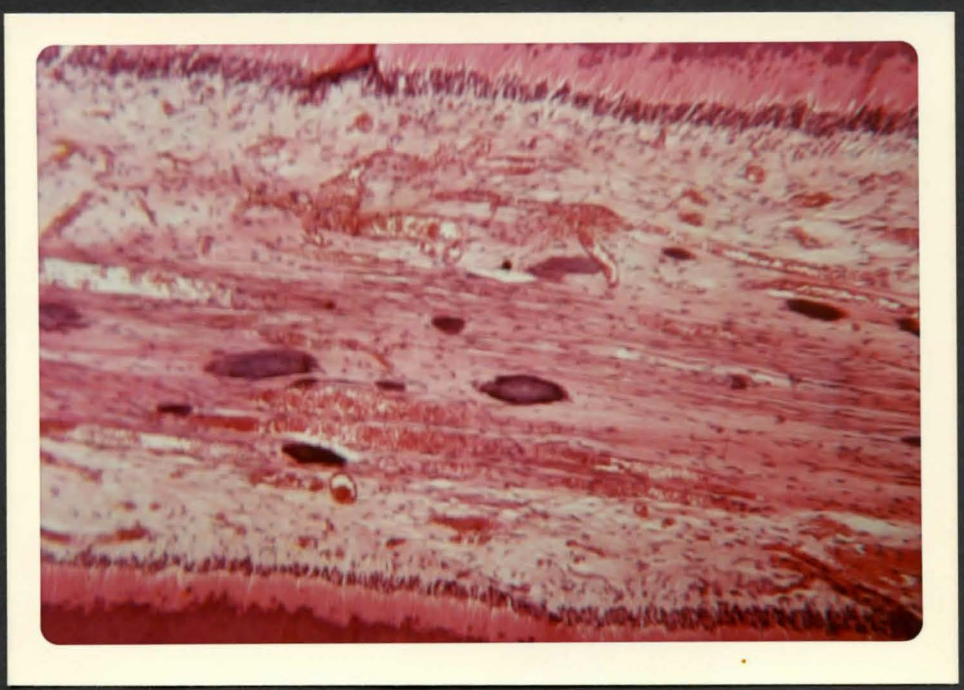

Fig. 29 H&E 100X

NUMBER: F-4

AGE: 31 years

SEX: Male

TOOTH IDENTIFICATION: Lower left first molar

DATE OF PULPOTOMY: September 20, 1972

MEDICAMENT EMPLOYED: Formocresol

DATE OF EXTRACTION: November 15, 1972

DURATION OF TREATMENT: 56 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Normal

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Near the site of amputation a thin layer of fixed tissue is visible.
2. Below this layer there are numerous dilated blood vessels. (Fig. 30)
3. The pulp is very fibrous with areas of linear calcification extending into the middle third. (Fig. 31)
4. Osteodentin deposition can be seen along the dentinal walls together with some evidence of internal resorption. (Fig. 31)

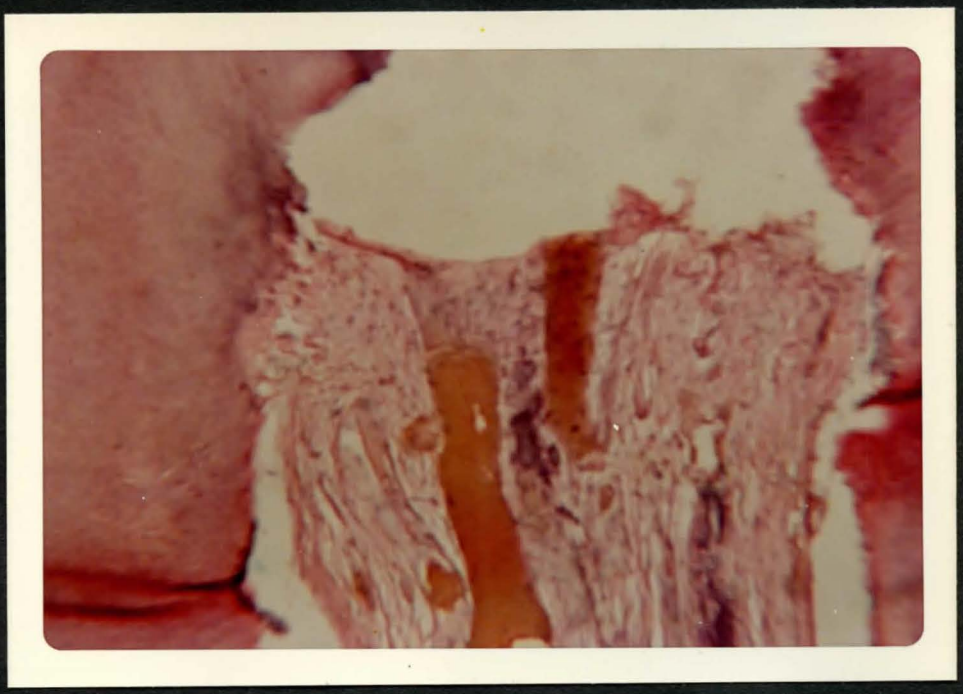

Fig. 30 H&E 100X

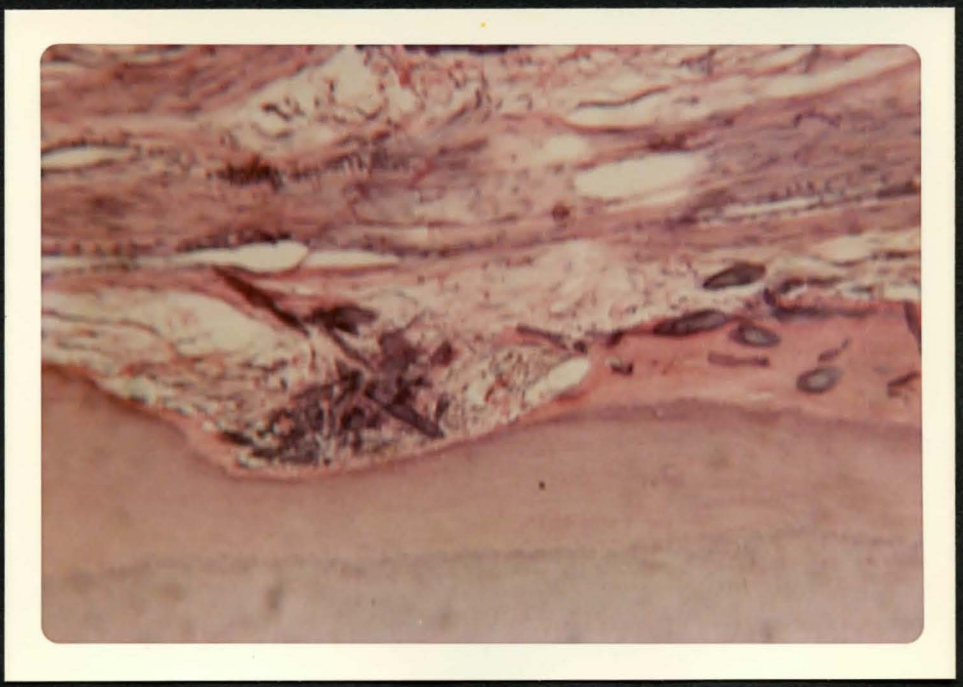

Fig. 31 H&E 100X

NUMBER: SA-1

AGE: 41 years

SEX: Female

TOOTH IDENTIFICATION: Upper left third molar

DATE OF PULPOTOMY: January 8, 1973

MEDICAMENT EMPLOYED: Saliva

DATE OF EXTRACTION: January 12, 1973

DURATION OF TREATMENT: 4 days

EXAMINATION PRIOR TO EXTRACTION:

1) CLINICAL: Patient complained of throbbing pain.

2) RADIOGRAPHIC: Normal

HISTOLOGIC FINDINGS:

1. Adjacent to the cotton pellet there is a dense inflammatory exudate. (Fig. 32)

2. Odontoblastic nuclei are visible in the dentinal tubules adjacent to the inflammation. (Fig. 33)

3. Apically the pulp appears normal. (Fig. 33)

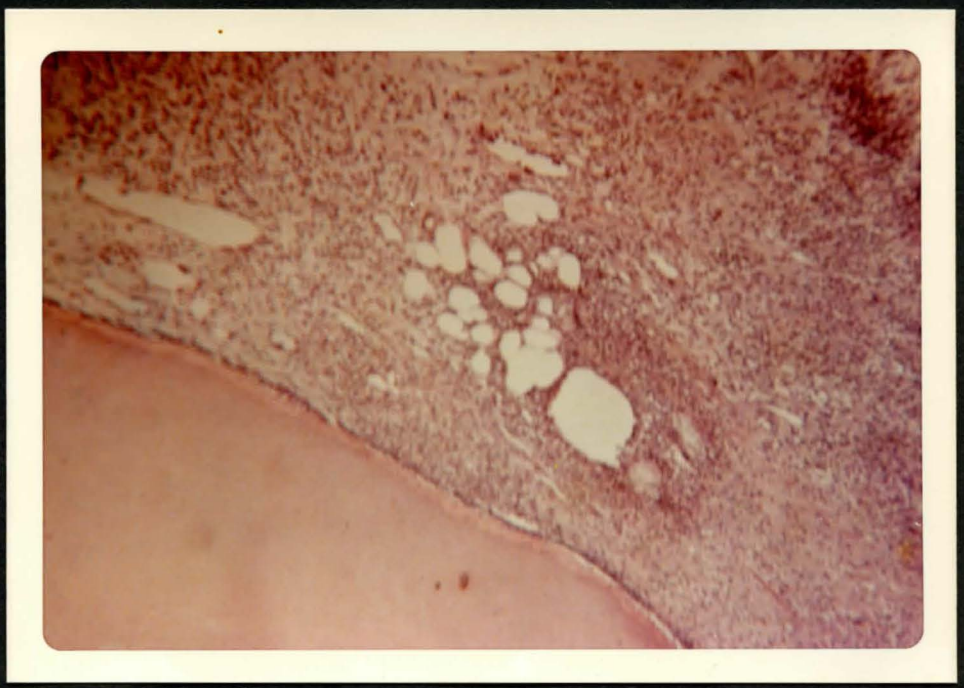

Fig. 32

H&E 100X

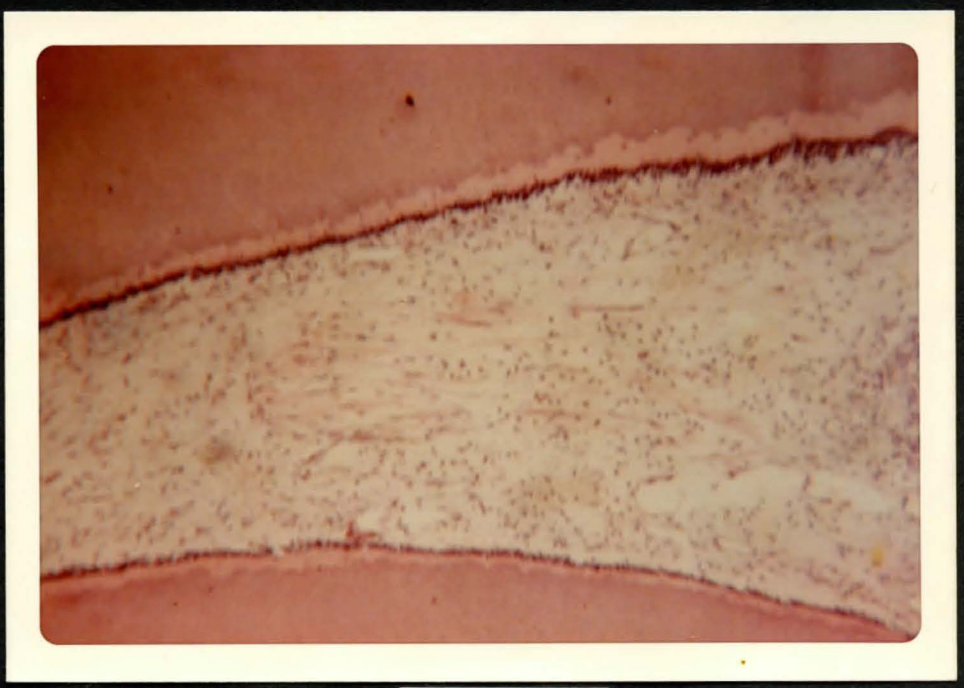

Fig. 33

H&E 100X