Histopathological Response of the Human Tooth to an Intrapulpal Pin Implantation

Raymond W. Dolph
HISTOPATHOLOGICAL RESPONSE OF THE HUMAN TOOTH TO AN INTRAPULPAL PIN IMPLANTATION

by

Raymond W. Dolph

A Thesis in Partial Fulfillment of the Requirements for the Degree Master of Science in the Field of Endodontics

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Each person whose signature appears below certifies that he has read this thesis and that in his opinion it is adequate, in scope and quality, as a thesis for the degree Master of Science.

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CHAPTER I

INTRODUCTION

The human dental pulp traditionally has been considered a tissue which is sensitive, fragile, and unable to withstand any great change from the normal. In the history of dentistry, there has always been a fear of the "nerve" in the tooth from both the practitioner's and the patient's point of view. Both had a respect for the pulp, because of its reaction at the time of the operation, and postoperatively if inflammation and necrosis set in with resultant discomforts.

Recent studies in the cellular behavior of the pulp, as it is affected by dental caries and certain technical procedures upon the teeth, would indicate that the normal pulp can withstand and favorably respond to injuries, often of quite severe magnitude. It is now standard textbook knowledge that dental caries cause retrogressive cellular changes in the pulp, even in lesions so shallow one would not consider them worthy of clinical treatment. Dental caries of extensive destruction and long duration do not mean that the degenerative processes are irreversible. The vitality may be returned to a normal condition if properly treated.

With the above in mind it is proposed to intentionally insult the human dental pulp with a metal pin placed into the viable tissue. The reactions and results, as well as the rationale for doing this, are covered in this thesis.

The degree to which one may be able to challenge or embarrass the dental pulp and still have it remain vital is unknown. Many dental procedures have resulted in both a surprising number of successes and
failures. These have included heat generation when performing a restorative procedure on teeth, the placing of tooth structure substitutes in deep-seated lesions, the capping of vital pulpal exposures, and among others, the intentional placing of pins directly into the pulpal tissue.

There should be an effort on the part of the American dentist and society to use every avenue available for preservation of natural teeth. Among the various techniques available, one in particular, the imbedding of pins into tooth structures for added retention of restorative materials, appears to be promising. Pins are used in badly fractured teeth to help in restoring the missing hard structures, and in abraded or carious teeth that have suffered extensive loss of retentive areas. The pins can be used in direct retention for restorative material, or in the retention of a base or amalgam coping, over which a crown may be placed. In splinting of periodontally involved teeth, there are numerous methods incorporating pins.

The aim of conscientious dentists should be to save tooth structure, when it is to the patient's advantage. If retentive pins are the treatment of choice, then the possibility that the pulp may be nearly or completely perforated is always present.

Therefore, the purpose of this experimental investigation is to evaluate the histopathological changes and responses in the vital human dental tissues during intentional metal pin implantation within the pulpal core, when this procedure is carried out under as near ideal, sterile, and relatively atraumatic conditions as possible.
CHAPTER II
REVIEW OF THE LITERATURE

Until recently, relatively little attention has been given to the biologic effects of restorative materials upon the pulpo-dentinal organ and on the gingiva. For years the major emphasis was upon the physical and chemical properties of dental materials, and dental research concentrated upon improvement of these properties such as hardness, corrosion, marginal seal, ductility, color, resistance to wear, stability, solubility in saliva, setting rate, etc. The National Bureau of Standards under Paffenbarger, and dental materials research laboratories in a number of universities, (Skinner at Northwestern, Phillips at Indiana, Peyton at Michigan, and Ryge at Marquette), did a great deal to improve the quality of filling materials and to establish standards for the profession to follow.

With the appearance of reports from early workers such as Pallazzi (1923), Fasoli (1924), Helner (1927-28) in Germany, Manley of London (1936), Gurley and Van Huysen (1937) in the United States, Shroff in New Zealand (1947), and many others, the importance of the effects of filling materials upon the pulp began to be better appreciated and the emphasis shifted from purely physicochemical research to include the biologic aspects of restorative procedures. One of the reasons for the relatively late appearance of biologic research in the area of restorative dentistry and dental materials was the lack of fundamental studies in pulpal biology and dentinal responses to injury. The studies of Sir Wilfred Fish of London and Beust in the United States in 1931-33 did much to give impetus
in this direction. The reparative potential of the dentin has since that
time become better clarified, so that the effects of medicaments and fill-
ing materials upon the dentinal defenses and pulpal repair have now become
the object of serious research.\textsuperscript{31}

In recent years operative or restorative dentistry has developed,
with additional knowledge, from a purely mechanical and technical art into
a true surgical and therapeutic procedure.

Gradually a new concept of these procedures has emerged—a biological
concept—which views each tooth as a vital organ, an integral part of the
body in general and the entire mastication apparatus in particular. It
also recognizes and takes into consideration the inseparable physiological
relationship between all the soft and hard tissues of the tooth. This
relationship is of particular importance between dentin and pulp, where an
injury to one may result in injury and reactions in the other.\textsuperscript{38}

The biological considerations, that should be taken into account when
a vital tooth is being subjected to stress of dental care, are many.
Biological reactions have to do with vital function, structures, and
processes. This as one can readily see could involve vast research. With-
out going into each aspect, let it be said, it is fundamental of all dental
operations that the tooth and the patient should be left in at least as
good a state as preoperatively. The knowledge of this principle and a full
appreciation of the above concept demand that more than merely restoring
the lost tissue to the anatomical contour of the original crown be done.
It requires that the health and function of the dentin and pulp are
restored with the minimum of post-operative scarring, and that lost tissues
are restored in such a way that the normal relationships of neighboring and
opposing teeth are maintained. In the final analysis, the body should be
unaffected either physically or mentally by attempts to aid the body defenses of healing.\textsuperscript{38}

Pulp tissue protection is necessary both during and after an operative procedure. There are many methods used such as coolants, high speed, cement bases, medicaments, antibiotics, and a host of additional techniques. Here, however, the use of corticosteroid will be reviewed. One of the early studies was reported by Fry, Watkins, and Phatak in 1960.\textsuperscript{14} Many papers have been written since by such prominent men as Stanley, Swerdlow, and Driscoll\textsuperscript{41}, Dachi, Ross and Stigers\textsuperscript{9}, Stanley and Swerdlow\textsuperscript{42}, Sayegh and Brandt\textsuperscript{36}, Mosteller\textsuperscript{34}, and others. These writers stated that corticosteroid (Meticortelone) was useful in the relief of dentinal and pulpal hypersensitivity and for conserving the vitality of exposed dentin and pulp tissue.

Stanley\textsuperscript{41} stated that when teeth treated with the steroid formula were compared with the untreated control teeth, it was found that the intrapulpal features of inflammation, as characterized by cellular displacement, superficial and deep inflammatory responses, were decreased in the treated groups as compared to the untreated control group. This situation occurred despite the fact that the healing period was shorter, and the cavity preparations were slightly deeper in the treated teeth.

In another study, Stanley\textsuperscript{42} determined the effectiveness of a corticosteroid as compared to the vehicle consisting of camphorated parachlorophenol and metacresyl acetate. He stated that the results revealed that the prednisolone solution was more effective than the vehicle in modifying the initial response during the first twelve days, but that the prednisolone solution alone did not sustain the initial modified response. With increased postoperative time intervals, the intensity of
the inflammatory response increased in the teeth with prednisolone, only
to resemble that of the control specimens. Despite the application of
steroid medication, the phenomenon of tissue repair was not hindered, and
the deposition of reparative dentin occurred on schedule.

Laskin and Koloday, having studied exudate formation in rats,
found that prednisolone acetate was the most effective agent for the
inhibition of exudate formation, when compared with antihistamines and
aspirin. They also found prednisolone acetate (Meticortelone) to be more
effective than hydrocortisone sodium succinate (Solu-Cortef), another
corticosteroid.

There seems to be some evidence that there was not always a beneficial
reaction to the use of corticosteroid. The work of Klotz, Gerstein, and
Bahn found a systemic bacteremia in 21 per cent of patients whose pulp
exposures were experimentally treated with Streptococcus faecalis and
prednisolone. This suggested that the use of an antibiotic in addition to
the prednisolone when treating open pulps might be indicated.

The pulpal response to the stimuli produced by operative procedures
may go in an irreversible direction, resulting in necrosis and death of
the pulp. It might also go in the direction of repair and recovery.

James, Schour and Spence gave a clear and concise account of the
reaction in the connective tissue of the pulp to an inflammation causing
stimulus whenever external influences reached the dentin. The odontoblastic
processes transmitted the stimuli to the cell bodies in the odontoblastic
layer, where in turn the pulp tissue responded in a manner typical of other
connective tissues—by inflammation. Inflammation is the classical defense
mechanism of connective tissues and should be considered under its broadest
range from the vascular changes of hyperemia, diapedesis, hemorrhage, and
edema to the infiltration of macrophages and leucocytes in both acute and chronic types. The degree of inflammation is related to the intensity of the irritant and the resistance of the host. The resolution of this process determines the fate of the pulp.

Concomitant with the inflammatory response is the reaction of the odontoblasts. After the formation of the primary dentin, the odontoblasts are less active except when external stimuli initiate, in some manner, more rapid production of dentin, the so-called irritation or secondary dentin. An example of this response is seen in underlying areas of irritation and in pulpal horns where cusps have been worn down during normal occlusal function, the subjacent odontoblasts work more rapidly to lay down dentin to compensate for the attrition. This localized activity of the odontoblasts also is seen under regions of gingival erosion and under slow carious attacks. If the external stimulus is rapid and severe enough to destroy many of the underlying odontoblasts, the pulp tries to replace them by moving to the region young cells which have the potential to differentiate into cells capable of laying down dentin. The type and severity of the original irritation and subsequent inflammatory response influences the regenerative or reparative activities of the odontoblastic layer. The inflammatory and odontoblastic responses are therefore intimately interdependent and are equally important criteria for evaluating the pulpal reaction.

This research project has many correlations with restorative dentistry in regard to protection and repair of vital tooth tissues. The unique part is that the vital pulp is being directly and purposely invaded by a foreign material.

In contemporary teaching and practicing of dentistry, the use of pins
for retention is very useful and desirable. This technique will certainly have to consider the biological and physical reactions of the different tissues involved.

Many articles and much research has been devoted to this procedure in both restorative and periodontal dentistry. Baum, Kalstrom, Mosteller, Burns, and Markley, Bellavia and Ciancio, and Lloyd and Baer are but a few who have worked and written on these subjects. Now that a more broad summary has been given of pulp reactions to stimuli, a more specific reaction to metals will be presented. This is to give a background for the human pulpal reaction to the metal pins used in this research. This review will give the reactions to metals in different body tissues, before discussing dental pulp tissue and its specific response.

In orthopedic surgery this has been called the "metallurgic age." There are many uses for metals in repairing broken or diseased human bodies. Metal pins and wires have been used in many bones and tendons to help repair tissues and to maintain function. Dentistry has long used metal to restore teeth. As stated earlier in this article, metal pins are the contemporary method used in restoring badly broken down teeth.

In dentistry both gold and tantalum plates have been used to facilitate healing in chronic oroantral fistulas. The metal acted as a surface on which epithelization can take place. There is also hope that osteoid or soft connective tissue can be stimulated to grow beneath the outer tissue covering.

Roydhouse and Weiss reported research in which different dental materials were placed in the fascial layers of the belly wall of rats. Stainless steel pins (0.08 inches by 0.04 inches) were used in one
experiment. Fibrogenic activity about the stainless steel pins was observed in five days, and in fifteen days the implants were encapsulated by fibrous tissue.

Zander stated that gold was completely inert as far as the dental pulp was concerned; however, temperature changes should be kept in mind. Thermal conductivity applies the same to gold, if not more than to amalgam, and might produce an adverse reaction.

In this research project, gold plated stainless steel pins were used. These were then covered with temporary cement and thus insulated from thermal change and the possible resultant tissue shock. It would appear from the above statements that if metal is to be introduced into viable connective tissue that this is the method of choice.

When considering the biological approach to repair in human tissue, the correlation between tissue of the body and pulp tissue may be challenged. However, pulp tissue is a connective tissue similar in all respects to other body connective tissue, except for the absence of elastic fibers and the pulp is also characterized by its specialized peripheral odontoblasts, which maintain their long cytoplasmic processes within the tubules of dentin that they help form. The difference between these connective tissues is the fact that the pulpal tissue is almost completely encased in a hard unyielding structure. This, of course, can cause great tissue embarrassment in case of edema, hyperemia, and other inflammatory reactions. The purpose of this investigation is to determine if the human dental pulp tissue can be insulted, although as gently as possible under the circumstances, proceed through the inflammatory reactions, the reparative stages, and finally recover to be part of a serviceable vital tooth.
CHAPTER III
METHODS AND MATERIALS

The object of this research project is to take healthy, vital human teeth and implant a metal pin into the pulp chamber, and after a variable period of time to extract these teeth. Following fixation and decalcification, the teeth are prepared for histologic examination. The histology of the pulp is then studied to determine what effect these pins have had upon it. From the data gathered it should be possible to arrive at a preliminary conclusion, as to whether or not this operative procedure holds merit. This will be a consecutive and chronological description of the manner in which this research was carried out.

After selecting the patient and obtaining a brief medical history, the teeth were selected in pairs in the same arch. If previous radiographs of the teeth were not available, new ones were taken at this time.

At the time of pin implantation a local anesthetic was administered, the rubber dam placed and a clamp positioned on the tooth to retract the gingival tissue. Then tooth and surrounding area was wiped with Metaphen tincture by Abbott Laboratories, North Chicago, Illinois.

Using a high speed (Midwest) handpiece and a No. 35 inverted cone burr, an oval cavity preparation about 2 x 3 millimeters was made on the labial or buccal surface near the cementoenamel line at right angles to the long axis of the tooth. Copious quantities of water, along with intermittent cutting, were used as a coolant. The cavity depth was established at about 1.5 mm. This was not considered too significant, since a pulpal entrance was to be made. However, in view of the fact that
a deeper cavity might cause more pulpal inflammation, it was considered wise to keep the cavity shallow. It must be kept in mind that it is impossible to differentiate between inflammation caused by cavity preparation and that caused by the pin in the pulp. Therefore, anything to lessen the noxious stimuli of cavity preparation will cause the inflammation to be more significant, in that it is more likely to be from the trauma of pin penetration and subsequent foreign body reaction.

Immediately following the cavity preparation, the slow speed hand-piece was used with a size .027 bibevel spirec twist drill to establish the opening into the pulp chamber. As soon as no resistance to the drill was felt, it was assumed that the pulp chamber had been entered and further cutting was immediately terminated.

In some cases there was pulpal hemorrhage and in others none. The reason there was no hemorrhage in some cases may be attributed partially to the small size of the hole, and the fact that the drill did not penetrate into the pulp tissue. Another factor is that the dentin debris, forced ahead of the drill, entered the pulp chamber and acted as a hemostatic agent.

As soon as the pin hole was drilled, the cavity was flooded with fresh Meticortelone acetate (aqueous suspension) by Schering Corporation, Bloomfield, New Jersey, from a recently filled sterile plastic disposable syringe. Cotton pliers were used to dip the pin into a Meticortelone solution in a dappen dish. Then the pin was carried to the cavity preparation and placed in the prepared hole. The special wrench for the pin was attached and the pin screwed into the hole until resistance caused it to break off at the shear line. All instruments used here were sterile.
Again, using the high speed handpiece, a 35 burr, and water coolant, the pin was cut off flush with the axial wall of the cavity preparation.

The pins that have been used in this study are stainless steel, gold plated, and threaded with O.D. of .030 inch. They are manufactured by Whaledent, Inc., 304 Ashland Place, Brooklyn, New York 11217, and known as T.M.S. pins.

An attempt was made to place these pins into the coronal portion of the pulp and in the case of bicuspids below the pulp horns. Mesial-distally the pin was placed as near as possible in the center of the pulp chamber. In other words, the aim was to place the pin in the center of the largest anatomical part of the pulp.

As soon as the pin was made flush, a fresh mix of zinc oxide and eugenol cement was placed over it and contoured to fill the cavity. The patient was cautioned not to pick at or disturb the cement, because if the cement were dislodged, possible cold sensitivity and bacterial invasion through the dentinal tubules could occur. The patient was then dismissed.

After a time lapse of several days, the patient returned for the extraction of both experimental and control teeth. In all cases these were extracted at the same appointment.

As soon as the teeth were extracted, a pair of rhonquers was used to clip off about a third of the apical end of each root. This was for the ready penetration of the ten per cent formalin into which the teeth were immediately placed. A quantity of fixing solution, at least ten times the tooth bulk, was used.

The teeth were then delivered to the tissue laboratory where they were decalcified, processed, and microscope slides made. The solution used for decalcification is a commercial rapid bone decalcifier for the
preparation of histological material. It is manufactured by Du Page Kinetic (Downers) Laboratories, Inc., Downers Grove, Illinois 60515. The trade name is RDO. In the decalcifying process, the metal pins were loosened and then removed before the teeth were imbedded in paraffin. The usual hematoxylin and eosin stain (H and E) was used for all slides.

All teeth used for this experiment or as controls were considered healthy. This was determined by x-ray, vitality test in all the older patients, clinical examination, and case history. Any fillings or caries were minimal and were noted on the data charts, pages 19-22.

The teeth were all anteriors or bicuspid paired with the mate in the same arch as the control. There were no molar teeth available for this research. This would be a likely source for another study, due to the multirooted aspect as well as the fact that pins are used extensively in molars.

In this research there were 27 experimental and 27 control teeth used. These teeth were in the mouth for periods of three to 170 days from pin placement to extraction. The patients varied in age from eleven to 67 years, and all were considered normal and healthy. There were no great variations except that the older patients tended to have more periodontal problems, which is to be expected, since they were losing the teeth for prosthetic appliance replacement.

As to the sex of the patients, there was no attempt made to control whether male or female. The teeth were selected at random whether it was right or left to be used as controls.

In the absence of the investigator, the clinical symptoms were gathered as near as possible from a third party. If done by the investigator, in the absence of the patient, a third party should be
questioned. In other words, the third party was interrogated by the investigator or his assistant about possible symptoms away from the patient so that there could be no communication between the patient and the third party regarding the results.

This last precaution was taken because of the usual tendency of the subject person to unconsciously help the investigator by reporting the data that he thought was desired. Of course, a third party is liable to react the same way to questions, but if the inquiry is worded in a neutral way a less biased evaluation can be made.

In the histopathological study of the microscope slides, the pathologist was given the slides without any information regarding the tooth section other than whether it was a control or not. This last was obvious, since the pin penetration of dentin was very much in evidence.

A blind study could not be attempted here due to the lack of serial sections of the involved teeth. Serial sections would have helped eliminate the evidence of the pin and made the observations more unbiased.

Any deviations from the expected normal in either clinical symptoms or histological study are indicated on the data charts, pages 19-22.
CHAPTER IV
RESULTS

The results are differentiated into statistical, clinical, and histopathological findings.

Statistical Results

The resultant data on the patients and teeth used in this research study are listed as follows:

Patients. There were eleven patients involving 26 experimental teeth and 24 control teeth in the final data.

Teeth. There were 27 experimental teeth and 27 paired control teeth used in this research. One experimental and three control teeth were lost because of breakage, unexpected pathology, or laboratory failure. All were apparently normal anterior or bicuspid teeth.

Time period. This varied from three to 170 days that the pins were in the pulp chambers. The average length of time for one person was 42.4 days. The weighted mean for all teeth was 47.5 days.

Age. The persons varied from eleven to 67 years in age, the mean was 22.5 and the median was thirteen.

Sex. There were six males and five females involved. There was no attempt made to control the numbers of male versus number of female participants.

There was difficulty determining just what the average or median might be because of the weighted factor that some patients had more teeth involved, and one patient had teeth extracted at two different time periods.
Clinical Results

The clinical signs and symptoms were virtually nonexistent. In other words, there were almost no adverse conditions relating to pain, discomfort or impairment of mastication. As noted in the data, after placement of the pin, one older man complained of slight discomfort in the lower right cuspid area. He, however, of his own accord quickly stated that he had had a severe cold, and this discomfort was present during his illness. One girl, age twelve, said that her teeth were somewhat sensitive to cold, but this was not considered of any significance as she could not detect which teeth, in her case, were affected. Cold was the only condition that elicited any discomfort, and this was very transient.

This lack of clinical symptoms was in accord with the earlier data collected by Dr. Baum. In this study only one person, a teenage boy, stated that he had experienced some discomfort in the experimental tooth.

Histological Results

The histopathological results are listed under different time periods for pin in pulp.

Three and four day period. Free hemorrhage, hydropic degeneration, and inflammation seen.

Seven to ten day period. Beginning organization of infarcted pulp areas, reticular atrophy about vacuoles, calcification commencing, pin seems to be well accepted.

Twenty-three day period. Presence of giant and plasma cells, odontoblasts aligned on predentin. In these cases there was tendency toward diffuse calcification.
Fifty and 82 day periods. Early dentinoid formation, extensive diffuse calcification.

One hundred twenty-one and 170 day periods. The most significant finding here was the extensive predentin or dentinoid material coalescing the dentinal tubules of debris. Repair processes were well advanced.

In no case did the pulp become necrotic. In cases where there was localized necrosis, the surrounding tissue seemed to have accepted it by encapsulating the area.

The use of Meticortelone does not seem to be significant. In the three cases (see data chart) where it was left out there was no detectible difference. After the first few days, steroid seemed to have limited usefulness and in this study a long period of experiment appeared to be indicated. The steroid, therefore, was of doubtful benefit, unless possibly it could be used in conjunction with another medication to reduce sensitivity, inflammation, and infection.

Taking age, time, and all factors into consideration the following conclusion was made. There was pulpal acceptance of the pin as placed, and although there was reactions, as is to be expected, the final result was healing. This healing was in the form of coalescence of the dentinal spicules from debris and the existing predentin of the pulpal chamber. The odontoblasts seemed to form and start repair in a very acceptable manner. Granulation tissue forms, repair, and regeneration progressed in the pulpal tissue itself.

The longer this healing went on the more improved the histological picture of the healing pulp became. After 100 days there was evidence that repair was much greater and more organized than previously. This was to be expected, if the tissue survived which it most certainly had done.
LEGEND OF CODE USED IN DATA CHART

Clinical symptoms

IF = Itchy feeling in tooth area
NS = No symptoms
SC = Sensitive to cold
SP = Slight pain

Deviations

AP = Amalgam filling present
AT = Abraded tooth
CP = Caries present
DB = Drill broken in tooth
IR = Internal resorption
LH = Lingual hole in crown for formalin penetration
NH = No hemorrhage at time pin placed
NM = No Meticortelone
RT = Root apices not amputated on teeth for 24 hours

Remarks

CA = Chronic microabscess present
CB = Coagulation at end of bur cut
DC = Diffuse calcification
DP = Denticles present
DS = Dentinoid well formed around dentinal debris
EC = Extensive diffuse calcification
ED = Early dentinoid formation
ET = Well formed odontoblasts attached to tubules
FH = Free hemorrhage
GC = Giant cells present
HD = Hydropic degeneration
ID = Islands of diffuse calcification
IP = Infarction distal to pin
OI = Organization of infarcted pulp horn
PC = Plasma cells present
PS = Pulpstones
RA = Reticular atrophy about vacuoles
WA = Well accepted pin

Columns

a = Intensity of inflammatory response
b = Intensity of cell displacement in dentinal tubules
c = Degree of hyperemic change
d = Displacement of dentin into pulp tissue
0 to ++++ Indicate degree of change for each variable
<table>
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Data Chart 5
Fig. 1. Photomicrograph x63 of slide 39A. Patient 12 year old female: 8 day old experimental pulp showing where threaded gold plated stainless steel pin has penetrated dentin (arrow) and completely transversed pulp chamber. Scallopung of pulp tissue edges is due to threads on pin.
Fig. 2. Photomicrograph x25 of slide 132C. Patient 12 year old female: 121 day old experimental pulp showing coalescence of dentin spicules and tertiary dentin by the activity of odontoblasts. (See Fig. 3 for enlargement of area marked)
Fig. 3. Photomicrograph x400 of slide 132C. Showing enlargement of area marked in Fig. 2. Shows odontoblasts (O) aligned on dentinoid or tertiary dentin (TD). The space between odontoblasts and fiberous elements of pulp (P) is artifact in slide preparation.
Fig. 4. Photomicrograph x40 of slide 132A. Patient 12 year old female: 121 day experimental tooth showing the pin penetration across pulphorn of pulp (arrow) with almost complete obliteration of area by tertiary dentin (TD). (See Fig. 5 for enlargement of area marked)
Fig. 5. Photomicrograph x400 of slide 132A. This is an enlargement of area marked in Fig. 4. It shows tertiary dentin (TD) adjacent to original dentin and coalescing of dentinal spicules (DS). Note odontoblasts (O) aligned on new dentin.
Fig. 6. Photomicrograph x100 of slide 12A. Patient 47 year old male: 50 day experimental pulp showing dentin debris forced ahead of pin. The surrounding pulp is normal appearing except for inflammatory reaction.
CHAPTER V
DISCUSSION

Now that a procedural presentation has been given for the current research, a discussion of its history and reasons for certain techniques are listed.

History of This Investigation

What will be the human dental pulpal reaction, if it is intentionally invaded so as to gain added retention? This was the problem that raised the query in the thinking of Dr. Lloyd Baum at the Dental School of Loma Linda University in 1967. He observed many times the so-called "unfortunate experience" of seeing dental pulps exposed during pin retention operations in the dental clinic. Many times there were no adverse clinical reactions. After some consideration, Dr. Baum decided to intentionally implant some pins in vital human dental pulps and assay the reaction. For two years, he and selected dental students did this on a more or less informal research basis. After this initial research, it was decided that this project warranted further study. At this time, the present research thesis idea was born.

Presented here is the data chart (see Chart 6) for the initial work done on the pin implantations by the dental students in 1967-68. This was on teeth to be extracted in relation to a planned treatment program.

The average age of these patients was 35.4 years. The fact that some ages were weighted, because the patient had more than one tooth treated, was not taken into consideration here. There were seven patients and
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DATA CHART FOR ORIGINAL STUDY

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sixteen teeth involved. Of the sixteen teeth, nine were eventually useful in this study. Of the remaining seven teeth, three were not sectioned so as to involve the pulp chamber; three teeth were lost or ruined in the laboratory processing; and one tooth had the pulp tissue completely displaced from the pulp chamber.

The mean was 65.5 days for the length of time the pins were in the teeth. The pins used were threaded stainless steel, except for two pins in one patient that were the friction type by Unitek.

Because of the nature of this study there were no complete records kept as to all materials and methods used. The above represents the significant data, except for the following clinical and histological report.

Clinically there were virtually no subjective symptoms. Only one patient in this group expressed any discomfort.

Histological findings, after preparation of the pulpal tissues, were reported by the pathologist. Of the nine specimens that were usable, all were vital. The inflammatory response varied from none to that which was rated two plus on a scale of four. Hyperemia (congestion) was observed from none to extensive.

Some fibrosis, sclerotic dentin, displacement of dentinal spicules, denticles, displacement of odontoblasts in tubules, and calcification were noted; but because of the lack of controls and adequate information this was not recorded with the data.

The significant results from this experiment was that the teeth, after an average of over two months, remained clinically asymptomatic and histologically vital and comparatively normal.
Techniques

In keeping with the before mentioned biological considerations for the teeth, the following methods have been adhered to in this research project. Since each of these variables, both in material used and method, might effect the data and the final results, they are here listed and discussed.

Local Anesthetic

Since the local anesthetic may cause disturbance in the pulp vascularity, it was used with caution and in minimal amounts. All teeth used in this research for operative purposes were anesthetized locally. In one case the patient was extremely hypertensive and an intravenous pre-medication of pentobarbital sodium U.S.P. (Nembutal Sodium) by Abbott Laboratories and meperidine hydrochloride (Demerol Hydrochloride) by Winthrop Laboratories was used.

Masella stated that earlier literature maintained that local injection of anesthesia influenced the circulation in the vessels of the dental pulp in such a way as to cause hemorrhage by diapedesis or rhexis. The work of Langeland, however, indicated that there was no difference in pulpal response to any dental procedure, whether local anesthesia, general anesthesia, or no anesthesia was utilized.

Isolation

In all cases a single tooth rubber dam was used to isolate the area to be operated. As near as possible, an aseptic field was established by the use of Metaphen as a germicidal agent on the tooth and the surrounding field on the rubber dam.
Sterile Technique

All burrs, instruments, drills, pins, dappen dishes, and armamentarium were autoclaved before use, with the exception of the dental handpieces which were wiped with alcohol.

Operative Technique

A high speed handpiece (Midwest) was used with light touch and with short intermittent cutting to prepare the class V box forms to receive the pin. By using light touch and intermittent cuts, the hole for the pin itself was prepared with a slow speed handpiece and drill.

Coolant

Water was used during cavity preparation and pin hole drilling, because it was considered to be a better coolant. Air alone can cause desiccation of dentinal tubules and odontoblasts. A basic fact is that no biologic system can exist in the absence of water.

Corticosteroid

The one chosen was an aqueous suspension of Meticortelone acetate. This was flooded into the cavity preparation, as soon as the hole for the pin was established. The pin was placed in a sterile dappen dish and flooded with Meticortelone. From the dappen dish the medicated pin was removed with sterile cotton pliers, placed into the prepared hole, and screwed into place with the sterile wrench made for this purpose. After the pin was in place, the high speed handpiece with copious quantities of water was used to remove the part of the pin extending labially or buccally from the floor of the cavity. By this time the excess Meticortelone had been removed.
Other Medicaments Used

The only drugs used in this research were the local anesthetics, Metaphen for topical germicidal effect on teeth and immediate surrounding field, corticosteroid (Meticortelone), and the eugenol in the temporary cement.

Cavity Seal

The cavity and the exposed end of the pin were sealed with a fresh mix of zinc oxide and eugenol cement. This cement was spatulated fairly thick, and after being placed in the preparation was smoothed and patted into position with a cotton pledget.

An important ideal requirements of any dental filling material is that it have no adverse effect upon the dental pulp. The filling material used should not only be non-irritating in itself, but it should also be capable of mollifying the injury caused by the cavity preparation, thus restoring the pulp to normal. Zinc oxide and eugenol is such a material and, though unsatisfactory physically, is ideal biologically. It is the least harmful and most palliative material to the pulp. It has a marked anodyne action and reduces inflammation in connective tissue. The active ingredient is probably the eugenol.\textsuperscript{29}

Stanley\textsuperscript{43} also stated that zinc oxide and eugenol usually are considered the least irritating following a stimulus and may actually possess the ability to meliorate a pulpal response. Zander\textsuperscript{46} and Shroff\textsuperscript{38} agreed that the above material caused very little irritation.

Operative Time

There was no attempt made to keep track of the time lapse in these operations. A calculated guess would be that it took about two minutes
to prepare the cavity, drill the hole, and place the pin. This was done with dispatch, so as to keep at a minimum the trauma to dentin and pulp tissue. In no case was there much deviation from this time factor.

Desiccation

At no time, after the enamel was penetrated, was drying of the tooth structure permitted beyond what was considered good prudent operative dental procedure.

Excessive drying or desiccation of the dentin prior to cementation has been found to cause large numbers of odontoblasts to enter the dentinal tubules. A customary cavity drying agent is alcohol. There is disagreement as to whether or not the use of alcohol will elicit a pulpal response. Alcohol was not applied to living tissue at any time in this research.

Age

The age of the patients had a range of eleven to 67, with a mean of 22.5 and a median of thirteen. It was purposely desired that the age would range over what might be considered the average life span period of a tooth when there is the greatest probability of having to restore the tooth with pins. This is usually the case in the teenager when an anterior tooth is broken in an accident, or in the middle-aged person when tooth structure is lost due to caries or broken cusps.

A controversy as to the response of dental pulps in different age groups was evident in dental research. Langeland said this biologic variability was one of the reasons why one pulp might succumb to the irritants, while another would remain vital. This particularly could be seen in the comparison of response in teeth of young and old individuals.
Large areas of irritation dentin might be present, but the pulp could still "blow up" after what one might consider a rather inert procedure when taking the remaining dentin thickness into consideration. The explanation was that such a pulp might be exposed to previous harmful operations or to caries, and not have much recuperative power left. On the other hand, in young teeth a cavity might be much nearer the pulp, despite the same distance from the surface of the tooth. There would be wider dentinal tubules in the young tooth but still the pulp might resist the same kind of irritants as the older tooth was exposed to because better circulation and recuperative power existed. Massler stated very nearly the same thing, in that the older teeth might have more sclerosis of the dentin and thus be more resistant to irritants.

Stanley said, except possibly for a slight increase in the number of more severe lesions in the larger teeth, neither age nor tooth size appeared to influence the type of reaction obtained. In this study under consideration, no account was taken of tooth size, although they all appeared to be very normal, average teeth in size and morphology.

James, Schour, and Spence had this to say about age. The inflammatory response of the older person was slightly more extensive, and the secondary dentin formation was slightly less than in younger persons. This was due to the intensity of the inflammation which tended to be in direct relationship to the depth of the cavity. The deeper the cavity, the greater was the extension of the inflammation. The stimulus for dentin formation tended to be dependent on the inflammatory picture. When the inflammation was mild there was a tendency for a limited amount or none of secondary dentin formation. If inflammation was extensive, secondary dentin formation was retarded or minimal.
Antibiotics

No antibiotics were used either locally or systemically in any case.

Status of Teeth Used

The teeth were selected to be used in contralateral pairs, one tooth to receive the pin and the other left untouched as a control. The pairs were chosen as nearly as possible to be non-carious virgin teeth. Any deviation from this was noted on the data chart.

In selecting human experimental material, great care should be exercised in selection of both teeth and subjects. The response of the human pulp to injury may be influenced by a great many variables and it is best to eliminate as many of these as possible.

Sayegh and Brandt in their work recommended that in determining the status of the teeth to be used, that they be selected on a basis of being asymptomatic or having previous existing amalgam restorations, but non-carious. Also the teeth should be evaluated by means of clinical history, radiographs, percussion, and vitality test. These criterion have been adhered to in this research, except for the percussion which was not used in any case, and the vitality test was used in the older patients only to determine that the teeth were within a normal range of vitality. A Burton Vitalometer instrument was used and a reading of three to five considered normal for the involved teeth. It was felt that an electric vitality test was of doubtful value in newly erupted teeth.

Human Teeth

All teeth used were vital human teeth destined for extraction in orthodontic or prosthetic treatment plans. Since human teeth were available, animal teeth were not considered. It was felt that the data
collected would be more significant, if the subjective response available was from persons. There might be some good arguments why animal subjects were not used before human teeth were employed in this research.

Length of Time Pins in Position

The time from the placement of the pin in the pulp until the tooth was extracted in this research took from three days to 170 days. Having different time spans is in agreement with good research technique.

In two studies written up by Stanley, he used various time periods in the treatment of teeth. In one case it was from one to four days, in another from one hour to 114 days.

Sayegh and Brandt, in their work on young teeth to be extracted for orthodontic purposes, used a time period of three to 24 days. Zander, in his work testing pulps and their reaction to restorative materials, used time periods up to three months. The reason, he said, for the three months was that the pulp usually could recover from injury in this time period. The adverse of this would probably be that degeneration would set in, if the pulp was not going to recover in this period. Stanley also felt that the three month period was usually sufficient to give the investigator a good enough microscopic picture so he could surmise the prognosis of the specimen.

Cavity Preparation Location

It was not felt that the location of the cavity preparation on the coronal part of the tooth had any bearing in this work. To standardize the procedure and to work in the easiest area, in all cases, the buccal or labial Class V locale near the cementoenamel line was used. No significance was placed on the location, since the coronal pulp chamber-
was to be directly invaded. This would cause irritation and would not correlate to other experiments done on different surfaces of the teeth where the purpose is to preserve a definite amount of dentin between filling and pulp.

**Extraction Methods**

All teeth were extracted in the dental school clinic by dental students. In all cases a local anesthetic was used, although in several cases nitrous oxide was used as a supplement. Shroff felt that there was a difference of the pulpal reactions in different extractions. This might be due to the method used or the trauma necessary to remove the tooth from the alveolar socket. He also felt there was a difference whether a local vasoconstrictor or general anesthetic was used. This last was not taken into consideration in this specific research.
CHAPTER VI
SUMMARY

This research project was undertaken to determine the human dental pulpal reaction to intentionally implanted metal pins.

The rationale for this is that in many cases it may be necessary to use pins in reconstructing fractured or badly decayed teeth. At times the pulp may be intentionally penetrated or it may even be wise to encroach upon the vital pulp tissue for added retention.

Human teeth destined to be extracted for orthodontic or prosthetic reasons were used. The teeth selected were as free of caries or filling material, as it was possible to find. The teeth were selected in contralateral pairs in the same arch, one for experimental purpose and the other as a natural control.

The ages of the eleven patients varied from eleven to 67 years. Six male and five female patients were used.

Of the original 27 pairs of teeth, 26 experimental and 24 control teeth were used in the final analysis.

By using rubber dam, autoclaved instruments, and a reasonably aseptic technique, the gold plated stainless steel pins were placed into the pulp chambers of the teeth. This was accomplished as atraumatically as possible with the use of high speed burrs, water coolant, zinc oxide eugenol cement as a cavity sealer, and other factors calculated to cause a minimal pulpal response.

Meticortelone was used in the pulp chamber and on the implanted pin. After varying lengths of time, from three to 170 days, the experimental
and control teeth were extracted at the same appointment and prepared for histologic examination.

During the time the implant pins were in the pulps, little clinical reaction was noted, such as pain or hypersensitivity. Histological findings showed that the dentin particles carried into the pulp chamber during pin placement were well tolerated. After the initial inflammatory response there was a walling off of implant materials by encapsulation, followed by fibrous regeneration, and the coalescing of the spicules by the formation of a dentinoid or predentin material by odontoblasts.

The teeth in all cases remained vital and showed considerable tissue repair and regeneration. The time factor indicated that about 100 days were necessary for the tissue to recover in a significant manner.

The project was born out of observation from dental patients who had had unintentional pulpal pin implants and had not experienced any untoward clinical reactions or any significant histological changes microscopically.
CHAPTER VII
OBSERVATIONS AND CONCLUSIONS

Previous literature on the intentional implanting of pins was very scarce, in fact it was almost nil, especially for human subjects. Although the writer had made quite an exhaustive review of the literature for the past ten years, and in many cases longer, there was no reference uncovered that dealt with the subject of intentionally implanting a metal into the human pulp.

It was really very surprising that of all the thousands of articles written concerning animal or human dentally related methods, materials, and reactions, that none touched upon this subject. The number of articles were legion about methods and materials to protect tooth structures before and during operative procedures, medication, and the postoperative phase.

For anyone in the future that may care to pursue related research the following suggestions are made:

I. Keep a thorough record of all the teeth as to pre-existing condition. This would include history, radiographs, vitality test, and symptoms.

II. Because of the lack of any significant findings for Meticortelone, that its use be considered in conjunction with an antibiotic.

III. In the case of young orthodontic patients, that the pins be left in place for a period of at least 90 days. In older patients the longer the pins is in place the more significant the results.

IV. Have a subjective questionnaire prepared that could be filled in by the patient, after his or her part of the experiment was completed.
This would ask questions as to the sensation of the teeth to cold, hot, mastication, percussion, or any other sensory factors in or around the involved area. This form could also contain blanks for information regarding any illness, pregnancy, or surgical operations the patient might have undergone during the pin implantation period. Any remarks as to their psychological reaction to the experiment might also be solicited.

V. At the beginning of the experiment it would be helpful, if the patient were not given any more information than necessary as to the expected results. This would give more of an unbiased reaction to the results, whether negative or positive. The researcher would be helped, if he had a list of instructions for each patient, so that some would not be given more information than another and be lead to unnecessary pre-conceived ideas of expectations.

This last item may be hard to accomplish, for as soon as a person feels that the "nerve" in his tooth is to be tampered with, he immediately has visions of torture and pain. It would not be fair to withhold all information and yet some may be dangerous. By whatever method the researcher chooses to accumulate his subjective clinical symptoms, it should be gathered as nearly as possible on a uniform basis.

The following conclusions are made. First, the human pulp tissue has a very wonderful defense mechanism. In this case, the pulp tissue has been demonstrated to recover from a very severe intrapulpal insult of a foreign body, and apparently to be well on the way to complete repair. Second, the use of intrapulpal metal pins seems to have a great potential
in helping to restore teeth that are so badly broken or decayed that a
pulpal implant is virtually impossible.

It is hoped that this research, while limited in scope, may serve
as a guide in further investigation of this aspect of modern dentistry.
Future work may answer some of the questions that have been raised
concerning this research, especially what will be the long term results
and what might be expected if this were done under more routine dental
office procedure.
BIBLIOGRAPHY


HISTOPATHOLOGICAL RESPONSE OF THE HUMAN TOOTH TO AN INTRAPULPAL PIN IMPLANTATION

by

Raymond W. Dolph

An Abstract of a Thesis in Partial Fulfillment of the Requirements for the Degree Master of Science in the Field of Endodontics

June 1969
This investigation was designed to serve as a research project
directed toward the study of the histopathological response of human teeth
to the intentional implantation of threaded, stainless steel, gold plated
pins into the vital pulp.

Pins of several types are currently used in several aspects of
restorative and periodontal dentistry. In some cases there may be unin-
tentional perforation of the dental pulp. In other cases it may be
advantageous to purposely perforate the pulp for added retention. The
purpose of this research is to help determine the reaction, possibilities,
and prognosis of such a technique.

Human teeth selected for experimental and control groups were those
recommended for extraction in the treatment plans for orthodontics or
prosthodontics. The teeth, being relatively free of fillings and caries,
were as near normal as possible. The patients whose teeth were to be
utilized were reasonably healthy, psychologically adjusted individuals.

A clinical and x-ray examination of the teeth followed. A local
anesthetic was administered at the time of pin implantation. The pin was
placed into a hole established in the axial wall of a class V preparation,
then the cavity was sealed with dental cement.

After varying periods of time, both experimental and control teeth
were extracted. All teeth were decalcified and microscope slides prepared
so that the histology of the pulp could be studied and compared.

Clinical, as well as histopathological data, was recorded and compiled
in this thesis along with microphotographs of the results.

In all cases, the human teeth did not unfavorably react to the over-
all treatment. Clinically the response was one of little discomfort or
inconvenience. Histologically the pulpal response was one of repair and
regeneration, especially after a period of about 100 days.

This method of pin retention has very desirable possibilities, and the results of this study show that the pulpal response can be most encouraging.