Chapter 6.

THE MECHANICAL AND CHEMICAL PREPARATION OF ROOT CANALS

"The purposes of instrumentation are cleansing of the pulp chamber and root canal of tissue and its breakdown substances, removal of obstructions, enlargement of the canal so that it may receive a greater quantity of medication, and preparation of the canal to receive the filling material for complete obturation".(89)

GENERAL PREPARATIONS

a) Preparation of the Crown

It is essential that the crown of the tooth, or what remains of it is prepared for root canal treatment by the removal of all carious material and the sealing of the cavities caused by this from the oral environment. This may be done by the use of large round burs and/or excavators, and the cavities so formed are restored temporarily with a zinc oxy-phosphate cement. If the crown of the tooth is missing, or is so broken down that its integrity is jeopardised, a copper band is(90) contoured to fit and this is cemented into position. If this is not carried out, it may be difficult to place the rubber dam over the tooth, thus allowing instruments to pass through an infected field into the canal.

b) <u>The Rubber Dam</u>

It has been mentioned previously that an aseptic technique must be used in endodontic procedures, and the use of rubber dam is a pre-requisite for the establishment of an aseptic field. Sommer [91] lists the hazards involved in the use of cotton rolls as a means of obtaining a "clean" field of operation, such contaminants as air and saliva being mentioned. Grossman [92] allows the use of cotton rolls and other aids only when it is impossible to apply the rubber dam.

The danger of small instruments passing accidently into the trachea or oesophagus is another attendant feature associated with the use of some form of isolation other than rubber dam. [91][93] Only the tooth which is to be treated should be isolated with the dam, as this excludes all other sources of contamination. In some cases however, (where there is bridge work for example) a greater number of teeth may be exposed. The author sometimes finds it difficult to carry out adequate instrumentation in certain cases where the rubber dam is stretched and clamped over a single tooth, and in such cases other teeth are exposed, thus giving greater freedom for the use of reamers and files. In most cases, for irrigation of the canal and dressings to be carried out, a single clamp will suffice.

c) Periapical Radiograph

A full periapical picture of the tooth must be taken prior to root canal therapy for diagnostic purposes, and to help in the evaluation of the prognosis for successful endodontic therapy. For canal preparation, it is necessary for this picture to be taken so that a reasonable estimation may be made of the root length. Thus great care is necessary in aligning the angle of the film to the tooth, and the central ray of the machine. An impression may also be gained from this which will help the operator decide upon the angle of approach into the pulp chamber so that there is direct access to the root canals.(94)

d) Entry into the Pulp Chamber

There are three considerations(94) which are important here:

i) The size of the pulp chamber -

In the young this is large, and the opening must also be large to facilitate the passage of filling materials into the large root canals associated with young teeth.

ii) The shape of the pulp chamber -

This should be reflected in the outline form so that there is access to all portions of the chamber, and the complete roof of the chamber should be removed(95) so that there are no roof overhangs to restrict the view of the operator

or the passage of instruments. Pulp remnants which adhere to such overhangs are considered as potential crown discolourants[96] as well as possibly complicating the attempt of the operator to carry out canal sterilization.

iii) The curvature and direction of the root canal - This regulates the outline form of the approach cavity so that a root canal instrument may pass through the root canals in an unstrained condition in its approach to the apical foramen.

In anterior teeth - the opening is usually oval shaped in the adult tooth or triangular in the young tooth, the approach being made from the lingual aspect. The shape roughly conforms with the outline of the tooth when viewed in a labio-lingual direction.

In bicuspids - the opening is occlusal, being markedly oval in shape and at right-angles to the occlusal fissure.

In upper molars - the opening is occlusal and triangular in shape with the more acute apex toward the lingual. This opening is made slightly buccal to the mesial pit.

In lower molars - the opening is occlusal, the outline form of which is again triangular in shape with the more acute angle towards the distal. The preparation should be completely within the mesial half of the tooth.

INSTRUMENTS USED

1. Burs and Diamonds

The opening should be made through the enamel or an existing restoration with a small round bur or diamond, until the dentine is reached. The cavity is then enlarged with larger round burs. (85) A flame shaped bur may be used to enlarge the cavity so that a gradual taper is formed (97) leading to the root canals. On no account should fissure burs be used to outline the shape of the occlusal opening otherwise steps may be cut laterally into the side walls of the pulp chamber. (98) In posterior teeth there should be no vertical pressure exerted towards the apex when burs are used to enlarge the pulp chamber, otherwise perforation of the floor may occur.

2. Broaches

Smooth broaches are used to explore the canal prior to pulp extirpation. Barbed broaches are used to remove the major portion of the pulp by inserting the instrument, and giving a quarter turn so that the barbs are enabled to engage the pulp tissue, and this is then withdrawn from the canal. If more than a quarter turn is given to the broach, the pulp may be lacerated by the barbs, and their purpose is then defeated. Broaches are obtainable in various sizes, thus permitting the use of fine broaches for the constricted canals which are usually present in adult or posterior

teeth. Some prefer the use of holders attached to broaches, but the author considers that these instruments may be handled more effectively and with more delicacy with the fingers.

3. Reamers and Files

These instruments are available with short or long handles, the latter variety being acceptable (though preferable to some[99]) only in anterior teeth where access is satisfactory. These are also available in various sizes, numbers one to twelve, and with standard lengths although Green[100] suggests that more accuracy is required by the manufacturers in their fabrication due to the variety in the sizes of these instruments.

Grossman[101] considers that reamers should precede files and these should be used in order of size. A reamer when used should be inserted and given one quarter to one half of a turn at a time. It should be frequently removed from the canal and cleaned by twisting it in a bent sterile cotton roll. Files are used with a pull stroke in all directions laterally, thus widening the canal.[102]

Sommer[103] considers that files transmit tactile impressions more readily than reamers, and that they are less likely to break in the canal.

Grossman[104] regards reamers as being better instruments for the removal of debris from a canal because of the open spiral shape facilitating the retention of such debris within the curves of the blade. Files on the other hand are more prone to force debris ahead of the instrument and thus complicate the periapical picture.

Davis[105] advocates the use of reamers and files with rounded ends to more readily negotiate curved canals without the points binding in the outside wall of the curve.

The canal should be reamed and filed to the point at which the root filling is to terminate, and it should be enlarged so that a maximal quantity of medicament is able to come into contact with the canal walls, and so that any residual pulp remnants may be removed.

TECHNIQUE OF MECHANICAL INSTRUMENTATION

1. The Diagnostic Radiograph

A wire of fine gauge is inserted into the root canal and the tip is passed to a point (as estimated from the original radiograph) to which obturation of the canal is to be carried out. This may be marked by

bending the wire across the incisal or occlusal of the tooth, or a number one reamer may be used instead of the wire, set with a rubber dam marker to the estimated tooth length. A radiograph of the tooth is then taken with the wire or reamer in place, and from this the distance which the instruments are intended to pass up the canal may be computed.

2. Reaming and Filing

Reamers and files are used as previously described to enlarge the canal to the desired size, and to the predetermined distance up the canal, rubber dam markers (106)(98) or instrument stops (98) along with the diagnostic radiograph being essential aids towards the confining of these instruments within the canal. (81)

3. Biomechanical Cleaning of the Canal

Certain chemicals are used to dissolve pulpal remnants which adhere to the dentine walls of the canal, the ~~more~~ most common of these being sodium hypochlorite or chlorinated soda (double strength).

Grossman (107) states that a double strength solution of chlorinated soda will dissolve an entire pulp in from twenty minutes to two hours. Other agents are certain alkalis (sodium-potassium alloy, sodium dioxide) and acids (sulphuric and hydrochloric acids), these however demanding extreme care on behalf of the operator during manipulation and not

being as successful as chlorinated soda.

Grossman[47] states "the elimination of pulp tissue fragments or debris is extremely important for the ultimate success of the root canal operation. A pulp tissue fragment may serve as an island of refuge for a large colony of micro-organisms and prevent sterilization of the root canal". The solution may be used as an irrigant, alternately with 3 per cent hydrogen perioxide, with nascent oxygen liberated according to the following chemical equation:

$$Na\,OCl + H_2O_2 \longrightarrow Na\,Cl + H_2O + 2O\uparrow$$

It has been suggested[108] that the canal should be flooded with sodium hypochlorite and the contents stirred without vertical movement with a Kerr No. 2 file, thus ensuring the complete saturation of the canal walls with the solution, the canal then being irrigated with the remainder of the solution.

It has been claimed[109] that the use of double strength chlorinated soda and 3 per cent hydrogen perioxide as irrigants, after thorough mechanical preparation of infected root canals leads to negative culture in a majority of cases without the aid of any chemical or antibiotic sterilizing agents. Another similar claimant[110] using chlorinated soda alone

as an irrigant showed that a high percentage of negative cultures may be obtained with a combination of thorough instrumentation and irrigation with this drug. The latter attributed the high percentage of growth free cultures solely to instrumentation of the infected teeth. Grossman[111] has criticised this interpretation and he emphasises the role of the chlorinated soda as the irrigant.

The recent work of Ingle and Zeldow[89] strongly suggests an antibacterial action of the irrigating drugs as used by Stewart[109] and Auerbach.[110] Their study indicates that mechanical instrumentation does not render the root canal sterile although it may temporarily reduce the number of micro-organisms, it remains for subsequent antibacterial medication to destroy the bacteria.

4. Irrigating Solutions

These are used to wash out of the canal fragments of pulp tissue and dentinal shavings which remain after reaming and filing have been completed. They are also used at subsequent visits to remove traces of blood and exudate which may have accumulated in the canal. The solution is usually introduced via a hypodermic syringe fitted with a blunt needle bent to an obtuse angle[112], the end of which is inserted about two thirds of the length of the root canal.

The solution is then allowed to wash the canal without pressure (which would possibly force debris apically) and this is caught upon cotton rolls.[113] When there ceases to be debris showing upon the cotton roll the canal is deemed to be surgically clean.

Of the solutions in common use, chlorinated soda and hydrogen peroxide have been mentioned. Saline is a common irrigant and it is particularly useful for washing residual traces of medicament from canals before taking bacterial cultures. Sometimes the antibacterial ~~and~~ medicament which is used for the dressing is also used as an irrigant, the M.C.N. solution[86] being an example of this.

It has been suggested that an aspirator coupled with a syringe allows for more thorough irrigation than with a syringe alone.[114]

THE STERILIZATION OF ROOT CANALS

One of the major requirements for successful endodontic practice is that the root canals and periapical area in every case must be rendered free of infection before the root canals are sealed.

There are certain specific requirements for root canal medicaments, these having been summarised by Coolidge[115] as follows:

1. The germicide must be strong enough to destroy the micro-organisms with as little damage to living tissue as possible.
2. The germicide must be of such character that it will penetrate into all branches of the root canal and into the dentinal tibules i.e. the solution must have a low surface tension.
3. The germicide must be active for at least 24 hours.
4. The germicide must not cause pain.
5. The germicide must not discolour tooth structure.

There are at present three main groups of substances commonly employed in root canal medication[116] - the halogens, the phenol derivatives and the antibiotics, with a fourth group comprising combinations of these.

1. <u>The Halogens</u>

The most commonly used of the halogens are the CHLORINE compounds. IODINE has been used in a solution (mainly as zinc iodide) but the great disadvantage attendant with this drug is its potential as a discolouring agent. Of the chlorine compounds, CHLORINATED SODA (has been mentioned previously) and camphorated PARACHLOROPHENOL are currently used with a great degree of success.[62]

Stewart[116] states that parachlorophenol is relatively non-irritating. However this disagrees with the

results of injections of various drugs (intradermal and eye studies) carried out upon live rabbits by Schilder and Amsterdam.[117] They found that camphorated parachlorophenol gave a severely inflamed reaction to both the skin and the eye tests. Another interesting feature of these tests is that chlorinated soda (double strength) gave a severely inflamed reaction in the skin test and a moderately inflamed reaction in the eye test.

2. <u>The Phenols</u>

Liquified PHENOL and FORMOCRESOL have both been used in root canals, however phenol is self limiting due to its powerful caustic effects, and thus non penetrating whilst formocresol is so highly irritating that it is not recommended for use here.[116]

CRESATIN has a low surface tension, and has been recommended by Coolidge[118] as a very satisfactory drug in combination with benzine. He attributes much of its effectiveness to the fact that it has a low surface tension and it is not readily exhausted. In the tests carried out by Schilder and Amsterdam[117] the skin test gave a slight inflammatory reaction to cresatin whilst the eye test gave no reaction.

BEECHWOOD CREOSOTE is less toxic than phenol[119] and is a satisfactory root canal disinfectant, however Schilder and Amsterdam[117] found that it gave a severely inflamed reaction in their tests.

3. The Antibiotics

These are selective in their actions, and they act by their power to inhibit the growth and metabolic activity of micro-organisms. It has been shown[120] that there is a wide variety in the species of organisms in infected pulpless teeth, such a variety in fact that no known antibiotic is effective against all of those which may be encountered. Because of this, a combination of antibiotic agents have been evolved by Grossman[121] and others.[122][123] The most commonly used of these is the polyantibiotic mixture of Grossman[124] which is known as P.B.S.C. and contains the following:

1,000,000 units potassium penicillin

10,000 units bacitracin

1 gm. streptomycin calcium chloride

1 gm. sodium caprylate

D.C. 200 silicone fluid

It has been calculated by Stewart[125] that the average volume of the root canal of an upper central incisor is 0.0163 cc. It would thus seem possible to insert into such a canal 5433 units of pencillin, 54 units of bacitracin, 5.4 gmg of streptomycin and 5.4 mg of

sodium caprylate.

Grossman maintains that this presents a tremendous concentration of antibiotic in such a small volume, but he omits to mention that a certain quantity (the major portion) is extruded from the canal when the paper point which he recommends is inserted to force the antibiotic mixture into "close contact with the canal wall". [127][128] Various authors have attributed the success in obtaining negative cultures from canals which have been medicated with antibiotics to the effects of residual antibiotic material in the root canal at the time that the culture is taken. [129] Grossman agrees with this but contends that with the use of penicillinase to inactivate the penicillin, cysteine to inactiviate the streptomycin, and due to the rather short activation period of sodium caprylate, the only compound in P.B.S.C. which requires consideration is bacitracin. He maintains that if the root canal is dried three times before cultures are taken the likelihood of transferring any of the polyantibiotic paste on the fourth absorbent point to the culture medium is negligible.

In their studies of the effects of certain root canal medicaments upon the skin and eyes of rabbits, [117] Schilder and Amsterdam found that P.B.S.C. exhibited a very high irritant potential.

FREQUENCY OF MEDICATION AND ROTATION OF DRUGS

It is considered necessary to change root canal dressings at least once but preferably twice per week. This is because the medicament will loose its effectiveness by diffusing into periapical tissues, becoming diluted with exudate, and by becoming decomposed by interaction with bacteria in the root canal.

It is also considered good practice to rotate the drugs used in the medication of root canals to prevent the establishment of resistant mutants. Dietz[130], however maintains that drug rotation is now obsolete because of the synergistic action of the components of the combination of drugs known as XP-7, the composition of which is as follows:

Parachlorophenol.....25gm.

Metacresylacetate.....25gm.

Camphor (U.S.P.).....50gm.

Where drug rotation is contemplated, a record should be kept of each drug used to facilitate this procedure.

THE SEALING OF MEDICAMENTS WITHIN THE CANAL

The commonest form of introducing the medicament to the canal is by applying it to a paper point and inserting this into the canal. This however does not ensure a maximum quantity of the medicament within the canal, but seems the safest way of applying strong drugs which would irritate periapical tissue if direct contact is established between

the drug and this tissue. In such cases, the paper point should be cut so that the tip does not extend further apically than three quarters of the way along the root canal. Jasper[81] says "Sometimes potent drugs are used without due regard to their effects upon the periapical structures. Such damage has brought about severe pain and has sometimes resulted in the loss of teeth".

Mild medicaments however, may be inserted by the use of an irrigation syringe, or a capillary pipette[131] and the canal is flooded with the drug and a paper point is then inserted into the canal before sealing. Root canals must be sealed with a quick setting and impermeable cement to exclude saliva and food from the canal between visits. The drug however must be protected from the cement seal because in most cases there is an adverse effect upon the action of the medicament due to the contents of the cementing medium. Thus an inner seal of gutta-percha and an outer seal of zinc oxide and eugenol cement provides the best solution to this problem.

CRITERIA WHICH INDICATE THE READINESS OF THE CANAL FOR OBTURATION

Nearly all responsible authorities[89][132][133][134] advocate the use of bacterial cultures in assessing the readiness of the canal for root filling. Negative cultures however must not be considered alone as the sole criterion. It has been pointed out that negative cultures may be obtained with infected canals, and Sommer[133] gives other conditions

which must be satisfied before root filling should be considered:

1. There should be two sequential negative cultures.
2. The tooth must feel comfortable.
3. There should be little or no serous exudate from the canal.
4. Any previous fistula may have disappeared completely.

Whether the negative bacteriologic culture is an essential part of the endodontic ritual is a matter which is open to some doubt. The culture technique most certainly tells the operator when <u>not</u> to fill the canal but it must be used in conjunction with the latter three points (mentioned above) when assessing the time at which a canal should be filled. One must take cognizance of the fact that in this country, about the only places where cultures are used in this way are the Dental Schools and associated clinics. It would be therefore interesting to note the percentage of failures of endodontic treatments which have been carried out without bacteriologic control. If a canal is mechanically cleansed of necrotic tissue, and after acute symptoms (if present) have subsided, thus satisfying the latter three requirements listed above, and the canal has been completely obliterated by the root canal filling

material what becomes of any bacteria which may have been present in the canal but in such small quantities or of such low virulence that a tissue response was not noticeable before obturation? It is reasonable to assume that some are trapped in the lateral canals (if present) and in the dentinal tubules whilst others are foreed apically ahead of the root filling material. In such cases if the lateral canals contain vital tissue a mild reaction would ensue which may terminate in either resolution or in failure of the root filling. The same may be said of bacteria forced apically, except that there would be some form of periapical periodontitis present immediately after root filling has been completed. If necrotic tissue is in any lateral canals which may be present, one may assume that eventual failure of the filling would be inevitable whether bacteriologic cultures were used to determine the readiness of the canal to be filled - or not. It seems, however that bacteriologic culture techniques associated with root canal therapy, whether totally or only partially satisfactory as a means of determining whether a canal should be filled, are desirable. They provide so far the only scientific aid to the answer of this question, and they also instil into the minds of students and dentists that absolutely strict aseptic techniques are essential throughout endodontic procedures, thus leading to a scientific approach and consequently more predictable results for treatment.

Chapter 7.

THE ROOT CANAL FILLING

The root filling should be such that the root canal is completely obliterated in all dimensions, with an inert insoluble and non-irritating material. This is difficult to accomplish, as all root filling materials are irritants in some form[135] as they constitute foreign bodies when in contact with body tissues. The ultimate result which the endodontist hopes to achieve is not only to maintain healthy periapical tissues, but for new cementum to be deposited over the apical end of the root filling.[136] Thus the root end becomes completely covered with cementum.

Root canals may be underfilled, overfilled, or filled exactly to the apical foramen. The latter is considered a rare occurrence[8] or even impossible[137] due to the difficulties involved in ascertaining the exact position of the foramen radiographically, and because of the funnel shaped cemental canal.

Overfilling is considered undesirable because the foreign body reaction of the periapical tissues interferes with the repair process which attempts to deposit new cementum at the root apex. Gross overfilling of course should be avoided at all costs as apart from severe acute reactions which may accompany such a procedure, there would always

be a foreign body reaction occurring at the root apex.

Underfilling predisposes to periapical infection, or reinfection because the residual space in the apical end of the canal will allow tissue exudate to accumulate and stagnate. Protein decomposition products act as toxins to the tissues adjacent to the periapical tissues and thus prevent healing. The periapical lesion will be maintained by the continuous presence of toxins and may be subjected to subsequent secondary infection by way of haematogenous[137] or periodontal[55] routes.

ROOT FILLING MATERIALS

Materials which have been used for filling root canals are many in number[138] and according to Grossman "it would seem as if every conceivable article which might be safely stowed away in a root canal, has been used at one time or another". The materials which are in present day use are two in type, one being a solid or semi-solid which supplies the bulk of the filling and the other being a plastic material which acts as a cementing medium, thus filling the remainder of the space. Of the former, cones made from gutter percha are commonly used for filling the root canals of anterior teeth, and posterior teeth with wide canals,

whilst silver cones are usually confined for use in posterior teeth with fine canals, although they may also be used in anterior teeth. An objection to the use of silver cones for filling the canals of anterior teeth is that difficulties may be encountered in removing the coronal end of the cone if some form of post retention is required for the restoration of the tooth.

Root filling pastes are used to seal the solid portion of the filling within the canal, thereby completing the hermetic seal of the root canal. There is a variety of pastes in use at present, the properties of each conforming with the individual operators technique of filling the canal. There is, however one common property associated with the root canal sealers used by all responsible authorities, that being that the paste is non resorbable. This of course places certain demands upon the skill of the operator in his being able to confine the paste within the root canal during filling procedures. Certain manufacturers of dental materials who advocate the use of resorbable pastes eulogise upon the beneficial results associated with the use of such pastes, but give no definite evidence of their results. Furthermore, there appears to be a significant lack of scientific literature pertaining to the use of these materials. Therefore one must assume that at this stage at least, they must not be considered as root canal sealers as there are doubts associated with the nature of the contents

of the radiolucent areas which show radiographically around the solid filling material within canals in which these materials have been used. Resorbable pastes may however offer a solution to the problem of carrying out root therapy for a pulpally involved deciduous tooth.

Recent work[139] indicates that the most efficient root canal filling consists of a fitted gutta percha point and sealer, the next most efficient being a silver point and sealer. In each case the sealer is the important aid to complete obturation, and of the sealers in common use there are only slight variations in efficieney, these being of little clinical significance.

METHODS EMPLOYED IN FILLING ROOT CANALS

Methods Using Gutta Percha Points

1. Single Cone Technique:

In this technique, a preformed cone of gutta percha is selected which will fill the canal to the desired distance by comparing it with the radiograph and the known length of the root canal. If a cone is not available which fulfils the size requirements of the canal, one may be rolled to the correct size by taking several points and gently flaming their ends before rolling between thumb and finger.[140] The selected cone is then carried into the root canal

the desired distance and the butt end is cut off level with the incisal or occlusal surface of the tooth, and a roentgenogram is taken.

If the cone fits correctly it is placed aside into a sterilizing solution for later use, whereas if the cone is too short, the operator must estimate whether it can be forced apically with pluggers when filling the canal, or whether a finer cone should be selected.

After selection of the cone, the root sealer should be mixed to a stringy consistency and after drying the canal, it is applied to its walls with a smooth broach so that all of the canal walls are covered with a layer of the paste. The selected point is then washed in alcohol, dried, and placed into the canal and firmly seated so that the butt end is level with the incisal or occlusal of the tooth and a roentgenogram is taken. If the result is satisfactory the coronal portion is removed with a warmed instrument, level with the floor of the pulp chamber.

2. Sectional Technique:

A root canal plugger is selected which will bind within the cone shaped canal about three or four millimetres from the apex[141] (this is determined by radiographs) and a gutta percha point is selected

which fits the canal. This is cut into three or four sections, and after drying the canal and coating its walls with sealer, the apical section is picked up by the warmed previously selected plugger, and gently placed into the apical portion of the canal. The plugger is then rocked back and forth to dislodge the gutta percha and the next sections are packed against each other until the canal has been filled to the floor of the pulp chamber.

3. Lateral Condensation Technique:

This method is particularly useful when obturating a wide, ovoid, elliptical or ribbon shaped canal.(141)
A gutta percha cone is selected which will fill the canal apically and after the butt end has been trimmed level with the incisal or occlusal of the tooth a roentgenogram is taken.
If satisfactory the canal walls are dried and coated with sealer and the point which has also been coated with sealer is inserted for the desired distance into the canal. A Kerr No. 3 spreader is then used to condense the cone against one of the side walls of the canal. Upon its withdrawal a cone of approximately the size of the spreader is inserted into the space beside the first cone and this is then condensed against the first cone by insertion of the

spreader. This procedure is repeated until there is no more space within the canal for the spreader. The butt ends of the cones are then cut off with a warmed plastic and they are trimmed to the level of the floor of the pulp chamber. Sommer[142] maintains that such a technique will enable the average operater to achieve a well condensed filling which will hermetically seal the canal and completely eliminate all points of possible leakage. As a result of studies using radio-isotopes to determine the efficiency of root canal filling seals, Marshall[139] points out that the skill of the operator is perhaps more important to successful obturation than the materials used. Therefore the simpler the technique and/or the more experienced the operator - the better the result.

An interesting variation upon this method has been advocated by Kuttler[8] where the initial cone is softened at its tip with chloroform, and dentinal shavings (which have been collected by filing the sterile canal) are added to this before seating the cone within the canal. Further cones are then packed around the original. Thus dentinal shavings cover the apical seal of the root filling which may

lead to a deposition of cementum over the end of the gutta percha - the result being a perfect apical seal of cementum.

4. Inverted Cone Technique:

In certain cases where it is essential to carry out root canal therapy upon children's teeth with wide open canals, they can be filled by the single cone method, where a number of cones are rolled to form one which measures up to the size of the canal. Another satisfactory way of achieving success is to insert the first cone in the inverted position and to pack subsequent cones in the normal way against this by the lateral condensation method.

5. Chloropercha Method:

Instead of a cement being used to coat the walls of the canal before the insertion of the pre-selected point, the canal walls are covered with a solution of chloropercha. To make this, gutta percha is dissolved in chloroform until a creamy consistency is obtained and this mix is applied to the inside of the canal by the use of a smooth broach. Another way of doing this is to soften a gutta percha point in chloroform and apply this to the canal walls by inserting it into the canal and removing it. A fresh previously selected point is then packed into the canal.

6. Eucapercha Method:

A solution of gutta percha in oil of eucalyptus may be substituted for chloropercha and the canal is filled with a gutta percha cone as in the chloropercha method.

METHODS USING SILVER CONES

It is a known fact that silver is capable of exerting an in-vitro antibacterial effect, along with certain other metals. This has been utilised by the advocates of the silver cone technique, however Grossman[143] is more reserved in his outlook, maintaining that whilst in-vitro evidence is definite regarding the "oligodynamic effect" of silver there is so far no in-vivo evidence of such. Whether this is so or not, is of no consequence in modern endodontic practice, as if the canal has been made devoid of all bacteria or active strains, before obturation, there should be no necessity for any antibacterial action on behalf of the root filling material.

Silver cones are available in sizes which are machined to conform with the Kerr root canal instruments and these are recommended by Grossman.[143] They are particularly useful as a filling material where fine and tortuous canals present, as they will easily bend to conform with the canal shape and they are able to be removed and replaced a number of times without fear of distortion or fracture.

The cone really only serves as a core for filling the bulk of the canal[143] but it should fit the canal as accurately as possible as if it fits the canal loosely or makes contact only where irregularities exist, too much reliance is placed upon the sealing compound.[81]

The root canal cements for silver points may also be used for gutta percha, several of which are available commercially. The formula for two cements which may be easily made up by a pharmacist are given:

1. Suggested by Rickert and Dixon[144]

Powder:	Zinc Oxide	41.2	parts by weight
	Precipitated Silver	30.0	" " "
	White Rosin	16.0	" " "
	Thymol Iodide	12.8	" " "
Liquid:	Oil of Cloves	78.0	parts by weight
	Canada Balsam	22.0	" " "

2. Suggested by Hill[145]

Powder:	Zinc Oxide	60.0	parts by weight
	Precipitated Silver	40.0	" " "
Liquid:	Oil of Cloves	60.0	parts by weight
	Canada Balsam	30.0	" " "
	Rosin	10.0	" " "

Grossman[146] gives a third formula but maintains that the precipitated silver should be extremely fine, at least 60 mesh and preferably 100 mesh.

Technique:

The silver cone is selected according to the size of the file last used in the mechanical preparation of the canal. The cone is then inserted into the canal and the end cut off so that it is level with the incisal or occlusal of the tooth. The tooth is then X-rayed and from this the degree of fit of the cone in the canal is determined and any adjustments are carried out.

The cone is then placed into a sterilizing agent, whilst the canal walls are dried and covered with cementing medium, using a fine smooth broach. The cone may be cut so that the coronal end does not protude beyond the floor of the pulp chamber and after washing in alcohol and drying it is coated with cement and carried in a pair of tweezers and inserted into the canal, being seated with a root canal plugger so that the blunt end is level with the floor of the pulp chamber. A check radiograph is taken and if satisfactory, the crown of the tooth is filled with a temporary cement. Another technique is to insert the cone without trimming the blunt end, and after the operator is satisfied that the filling is completed to his requirements the pulp chamber is filled with cement.

After this has set the protruding portion of the silver cone, and the cement is trimmed to the cervical line.(141)

There are occasions where a combination of gutta percha and silver cones are used, the canal being firstly filled with a silver point and this is wedged with gutta percha points at the coronal end of the canal.(81)

Chapter 8.

ROOT RESECTION

This operation which was first performed over a century ago[147] implies the removal of some portion of the root and along with what is presumed to be pathological tissue associated with the apex. For a successful prognosis the root canal should be free from infection before it is filled[148] and the root canal must be hermetically sealed with an impervious material at the resected level.

Grossman[149] lists the indications and contra-indications for the operation as follows:

Indications for Root Resection

1. Extensive destruction of the periapical tissues, bone, or periodontal membrane, involving more than one third of the root apex.
2. Where there is a crater shaped erosion at the root apex indicating destruction of apical cementum.
3. Where previous root canal therapy has not been successful and an area of rarefaction is still present.
4. Where a negative culture, following root canal therapy, cannot be obtained.
5. Where there is fracture of the root apex with death of the pulp.
6. Where an instrument has broken in the apical third of the canal.

7. Where a peroration has occurred in the apical third of the canal.
8. Where a root canal filling has broken off, is lying free in the periapical region and is acting as an irritant.
9. Where the root apex is involved in a cystic condition.
10. Where the root apex in a young tooth is incompletely formed and where hermetic filling of the canal near the apical foramen is extremely difficult because the canal is widest at this point.

One further indication as mentioned by Wais[66] is "where only one sitting is possible". In such a case root filling and immediate root resection are carried out during the one appointment.

Contraindications to Root Resection

1. If more than one third of the apical end of the root is involved.
2. Molar teeth, because the roots of these are generally too near the antrum in the upper jaw and too near the mandibular canal in the lower jaw.
3. Where access to the field of operation is difficult.
4. Where periodontal absorption is so extensive as to leave too little support for the tooth.

5. In the presence of a parietal abscess.

6. Where a general systemic disease, such as active diabetes, tuberculosis, syphilis, nephritis or anaemia is present, or where, for other reasons the health of the patient does not warrant it.

7. In a person over fifty years of age.

These lists should not however be considered as fully comprehensive and all embracing entities, rather they should be used as a guide to treatment planning. The author fails to see why a healthy individual of over fifty years should not present a good risk for root resection if surgery is warranted, there being more demands made upon the repair process of the body in filling the resultant crater from extraction than from root resection if the quantity of bone repair is considered. It is also difficult to ascertain what happens to a root which shows evidence of an eroded apex if resection is not carried out. If root canal therapy has been completed after the cause of the erosion has been removed (either bacterial or chemical) it is reasonable to assume that repair takes place by the recovering of the root end with cementum and periodontal membrane as one hopes to achieve following root resection.

Kronfeld[150] reports upon a case where "the dentine surface at the root end shows evidence of previous resorptions that were repaired by deposition of cementum".

It was once considered essential to carry out root resection, or at least apical curettage upon all teeth which showed radiolucent areas. Modern practice however has been to carry out conservative treatment whenever possible unless the radiographic apprearance of the lesion conformed with the concept of a cyst. Coolidge[151] states that "the microscopic evidence of healing of pathological areas surrounding the apical foramina of infected root canals obtained many years following canal filling, reveals many healed areas of granulation and fibrous tissue: which were observed in roentgenographic evidence as translucent areas at the time the root canal was treated. These areas have been entirely regenerated in normal bone".

Recent work[66] indicates that the majority of periapical lesions associated with pulpless teeth are not cystic, and that most of the endodontic surgery involving periapical radiolucent areas is unnecessary. Further to this Baumann and Rossman,[71] basing their assumptions upon the work carried out at Philadelphia and by Priebe and his associates[152] together with the successful results following conservative root canal therapy reported by various investigators, concluded that a certain percentage of cysts are successfully treated by the conservative method. This is contrary to the accepted concept[149][153] of the required clinical approach to

epithelial lined cysts. They further conclude that:

1. Clinical and roentgenologic observations are of doubtful value in distinguishing cysts from non-cystic lesions in periapical disease.
2. A re-evaluation of the roentgenologic interpretation of periapical radiolucent areas and the clinical approach to periapical lesions must be made.
3. The differential diagnosis between cysts and non-cystic lesions in periapical disease can be made with certainty only by means of microscopic study of histopathologic sections.

In the light of recent work, a rational approach to the question of whether or not one should carry out root resection, may be along the lines suggested by Wais:(66)

1. The dentist who employs accepted scientific endodontic procedures and then routinely performs curettage or root resection on pulpless teeth presenting periapical areas is performing root surgery unnecessarily in most cases.
2. The conservative treatment of these teeth in such cases where the patient can be routinely recalled for examination is warranted in most instances.

THE TECHNIQUE OF ROOT RESECTION

Preparation of the Canal

The root canal should be in a state which is ready to receive the root filling. This in most instances requires that pulp extirpation, reaming and filing and the general preparations of the canal have been carried out during previous visits. The rubber dam is applied and after a gutta percha cone is selected in the normal way the canal is filled so that it becomes overfilled - thus ensuring the lateral fit of the root filling material against the walls of the canal. The root filling is sealed off within the crown of the tooth, and the rubber dam is removed.

The patient is premedicated if necessary and prepared for oral surgery with the aid of sterile headcap and towels.

The area is anaesthetised by infiltration or conduction and the mucosa is painted with a sterilizing agent. The field within the mouth is isolated with sterile gauze swabs and the operation is commenced.

A semilunar incision is made and a mucoperiosteal flap is raised so that the bone overlying the root apex is revealed. This is cut away with the aid of a fissure bur and a bone chisel thus exposing the root apex which lies immediately beneath the labial plate.(154) The root tip is cut through with the aid of a fissure bur, so that access is gained to

the whole of the radiolucent area as it appears radiographically. This ensures that all necrotic or cystic-material may be then curetted from the periapical tissue. Some operators prefer the use of a chisel for removing the root apex, however Sommer[155] maintains that a fissure bur affords less trauma and less danger of splitting the root. The root end should be then filed to smoothness and the wound irrigated with sterile saline or anaesthetic solution.[156] To ensure that there is an hermetic apical seal, Ostby[157] suggests that a pledget of cotton wool soaked in chloroform should be used to smooth the gutta percha at the resected apex towards the dentine surrounding the canal. The flap is then replaced and the wound is sutured. The patient is instructed to use an ice pack to reduce post operative swelling, and to restrict muscular movements for a few days, although attendant post operative pain and swelling are often satisfactory reminders in this regard. The normal post operative treatments should be given the patient as with other forms of oral surgery, and the sutures are removed in five to seven days.

There are several variations of the technique given above most of which are minor and the reasons for such variations in most instances being that they satisfy the individual requirements of the operator. There are however a few techniques which vary markedly from the normal, and a short description of each is given.

1. Post-Resection Filling Technique

This method involves the cutting off of the root end and then filling the canal. The root apex is removed, the bone is curetted and the wound is packed with gauze. The root canal is then enlarged, irrigated and dried with absorbent points. The canal is then filled by means of a root canal cement introduced by a syringe, and a gutta percha cone is inserted into the canal, the excess being trimmed flush with the resected root end with a warm instrument. Grossman[158] gives certain objections to this technique which does not compare favourably with the conventional method.

2. Immediate Root Resection

This method involves the operator in the preparation, sterilization and filling of the canal followed immediately by the surgical operation, at one sitting. It has certain advantages over the conventional method as regards time saved, but where ~~where~~ acute conditions prevail there should be previously established drainage so that the operation may be carried out without danger of spreading the infection. Grossman[159] prefers to attempt to sterilize the canal after mechanical preparation by electrolytic medication. The canal preparation and root filling are done under rubber dam and the root is resected as previously described.

3. Indirect Resection

Occasionally a case presents where there is a periapical lesion on a tooth which carries a post restoration. If this restoration is satisfactory it is possible to carry out root resection and filling without disturbing it. Sommer[160] gives an interesting report of such a case. After exposing the root end, it is removed with a fissure bur at an angle so that the root canal opening is able to be viewed by the operator. The apical portion is enlarged with Kerr files having a right angle bend ½ inch from the end. A silver point is cut to fit the apical end of the canal - virtually as a "plug" and this is cemented into place, the excess being made smooth with the resected root end.

4. Periapical Curettage

The advantage of this operation is that the root retains its original length. The disadvantage is that it is sometimes very difficult to be sure that all of the pathological tissue has been removed from the periapical area, there are certain regions which are not exposed to the view of the operator if the root end is not removed.
The root canal is prepared and filled in the normal manner, and the treatment is similar to that for root resection until the labial plate is removed

and the root end is exposed. The necrotic material is removed with a curette and with Black's No. 69 and No. 70 excavators.(161) The root end is then filed to remove any superficial necrotic cementum so that sound healthy cementum is exposed and after thorough debridement, the wound is closed with sutures.

Chapter 9.

REPAIR

The repair processes which are brought about following root canal therapy are dependant upon the condition of the pulp and the periapical tissues prior to the operation. Where a vital pulp has been extirpated within the canal and there is no periapical pathology, the wound is small and the repair process is quite simple. Where there is a large periapical area involved the process is more complicated and takes a much longer time to become completed. Whatever the case may be, the ultimate end result is for the apical foramen to become obliterated with cementum which is continuous with that which covers the root of the tooth. When preparing the tooth for root filling there are certain points to be borne in mind by the operator, which predispose towards a minimum of trauma to the pulp wound or periapical tissues. Such aids as a diagnostic wire[81] and instrument stops[162] during mechanical instrumentation are essential if the wound is to be protected from repeated injury due to the pointed ends of reamers and files. The methods in which these instruments are used must also be considered[163] to prevent debris being forced apically.

The drugs which are used in medicating the root canal should be non-injurious to the pulp stump or to the

periapical structures.[81][164] "Any disinfectant that destroys the cellular elements or lowers the resistance of the tissue locally by impairing nutrition will interfere with subsequent repair".[166]

The repair processes which are brought about following endodontic procedures may now be considered.

VITAL PULPS

Tissue Changes Following Pulp Extirpation

Pulp extirpation may be partial or total although it appears doubtful if a total removal of pulp tissue is often accomplished because of anatomical irregularities, and the prevalence of funnel-shaped foramina[8] and of pulp ramifications.[32][166] Whatever the level of amputation may be, the tissue reaction remains basically the same. The extirpation wound is usually placed as near to the foramen as possible,[167] modern trends indicating that the apical constriction[8][9] is a satisfactory level. The pulp is thus severed at its weakest point[168] and because of the operative difficulties encountered it may be rather badly lacerated. Haemorrhage ensues which is profuse, but soon subsides, a clot of fibrin later being formed over the surface of the wound.

The tissue immediately below the wound surface is then involved in an inflammatory reaction whilst the wound continues to discharge a serous exudate for a day or so. There is a white cell infiltration near the wound surface,

these forming a protective wall between the wound and the adjacent tissues, by destroying any bacteria which may be present and by phagocytosis they dispose of any cell debris. The exudation and round cell infiltration is responsible for the slight soreness following this operation.[169] After discharge from the wound has ceased a clot of fibrin is formed, and beneath this, fibroblasts begin to proliferate, and initiate scar formation; a connective tissue scar finally being formed at the point where the pulp was severed.

Tissue Changes Following Root Filling

a) In the Main Canal:

Kronfeld[170] reports upon findings in human teeth in which root canal operations have been performed. From these it appears that only in a small percentage of cases does the root filling material extend to the apex even though this may appear to be so radiographically. Most roots are underfilled, the distance of the filling from the apex being 0.5mm to 2.0mm, and the space between the root filling and the apical foramen is filled with a fibrous connective tissue which has a tendency to form cementum. The cementum if formed appears as lamellae on the walls of the pulp canal,[171] and it may eventually completely obliterate the apical foramen.[172]

If the root filling material reaches the apical foramen and ends level with the root surface, a fibrous capsule is formed and new cementum may be deposited on the root surface, and sometimes across the root filling material.(173)

If the root filling material protrudes slightly beyond the apical foramen it is covered with a dense fibrous connective tissue capsule which is attached all round the apical foramen to a newly deposited layer of cementum, foreign body giant cells being present in the capsule.(174)

b) In the Accessory and Apical Branches:

It has been demonstrated(175) that although apical ramifications and accessory canals are present in a large number of human teeth it is not necessary to fill these completely when a vital pulp is extirpated. These fine canals contain living tissue which is impossible to remove in most cases (although Davis(105) suggests a round ended broach to negotiate the angles encountered at root apices) and the removal of which is unnecessary. These canals usually become obliterated by the deposition of cementum within the lumen of each canal.(176)

TISSUE CHANGES IN THE APICAL REGION FOLLOWING THE TREATMENT OF INFECTED PULPLESS TEETH

It has been shown that the repair process for root therapy following vital pulp removal is both understood and almost always predictable from a scientific viewpoint. This is not the case where necrotic pulps are involved, although evidence of healing and repair indicates that results may be predictable when the operator has carried out successful drainage complete disinfection and obliteration of the canal.[177][178][179] The case reports of various authors bear testimony to the fact that periapical repair will take place around the root apices of infected pulpless teeth after conservative endodontic treatment.[180][181][182]

"The periodontal tissue surrounding the apex of such a tooth is in a state of chronic inflammation with granulation tissue and many inflammatory blood cells present, sometimes surrounded by a fibrous capsule of connective tissue, or epithelium forming a cystic membrane".[183]
There may be apical resorption as a result of granulation tissue penetrating through the cementum into dentine. It is possible however for the connective tissue to restore this with secondary cementum when the environment is made favourable. Once this phase of repair has commenced, new connective tissue fibres are arranged in their correct relation for attachment to the secondary cementum and alveolar bone. Eventually a new line of dense alveolar bone is formed, thus the root is covered by a continuous

layer of cementum which is attached by periodontal fibres to the lamina dura.

It is difficult to find in the available literature an author who will commit himself upon the fate of the necrotic tissue within the accessory canals and apical ramifications if these are present. These are sometimes partially cleaned by the use of chemicals as irriganta, so that they appear to be filled in post operative radiographs. Whether these canals still contain necrotic tissue, or even residual spaces for lymph and tissue exudates to collect thus paving the way for further periapical tissue irritation appears to be a matter for further investigation. Until more is known along these lines there will always be doubts associated with the pulpless tooth as either a possible source of infection or a localised tissue irritation.

Where an area of rarefaction has been present prior to insertion of the root filling, a time of six months (in the young patient; to five years in older people) may elapse before there is radiographic evidence of bone repair. Roentgenograms taken at regular intervals will reveal the progress of repair, and when bone density in the previously rarefied area equals that in the adjacent tissue it may be assumed that healing is completed.

TISSUE CHANGES FOLLOWING ROOT RESECTION

After this operation has been carried out, the cavity within the bone is filled with blood clot, which becomes organised into a type of granulation tissue, which is pervaded with many new capillaries, and osteoblasts (arising from the periosteum).[184] Within a short time osteoid tissue is formed around the resected root end, this being later calcified. The root apex is eventually covered with secondary cementum and a normal periodontal membrane.[185]

Chapter 10.

FOCAL INFECTION

It is sixty years since Hunter first introduced the idea that a number of diseased states were due to infection in the mouth[186], and almost fifty years since the monumental address given by him at McGill University.[187] Although it appears now that his premises were based upon case reports rather than scientific evidence they were widely accepted at the time, and the medical and dental professions were virtually stampeded into a wave of surgical removal of teeth. This however did not always conform with Hunter's ideas as he did not necessarily demand that the teeth should be extracted, but that in many cases the teeth should be "cleansed and dressed" - thus indicating that he regarded the principle source of infection as the gum margin.[186]

Since then there have been many papers written which relate to this subject, some with experimental evidence to support the remarks of the authors[188][189][190], others based upon case reports[191], and others in the form of a critical review.[192] It appears that although certain diseased states have been removed from the list of diseases which may arise from specific foci of infection, there are many others which to date have been neither proven nor disproved as being associated with "septic foci".

To evaluate the arguments for and against focal infection one must firstly establish what is meant by the terms "focus of infection" and "focal infection".

Definition

(193)
A focus of infection is a circumscribed area of tissue which is infected with exogenous pathogenic micro-organisms and which is usually located near a mucous or cutaneous surface.

Focal infection refers to the metastasis from the focus of infection of organisms or their toxins, that are capable of injuring tissue.

The Mechanism of Focal Infection

(193)
There are two ways in which focal infection may arise (as generally accepted) -

a) There may be a metastasis of micro-organisms from an infected focus by haematogenous or lymphogenous spread.

b) Toxins or toxic products may be carried via blood or lymphatic channels from a focus to a distant site where they may incite a hypersensitive reaction in the tissues.

Regarding these two points, the first - haematogenous spread of bacteria, is a well established fact, the term "transient bacteraemia" being used frequently in medical and dental literature. The spread of toxins is also

well known - the cutaneous features of scarlet fever being due to a toxin which is liberated by the infecting streptococci.(194) It has been proposed that in certain diseases the lesions result from an antibody antigen reaction to bacteria or toxins in specific tissues, an example of this being rheumatic fever, although Boyd(195) maintains that the cause of this disease is still uncertain.

Possible Sources of Infection

Apart from possible "medical" sources such as the kidneys, tonsils,(196) appendix and sinuses(191) there are two possible "dental" sources namely:

1. Periapical Disease:
   a) Infected periapical lesions - granuloma, cyst, abscess.
   b) Infected root canals.
2. Periodontal Disease:

1. Periapical Disease:

These lesions when of a chronic nature are usually surrounded by a fibrous capsule which separates the area of infection from the adjacent tissue, but does not prevent the absorption of bacteria or their toxins. However, the fact that a root canal is infected, or a periapical area of rarefaction shows radiographically does not necessarily indicate that there is infection in the periapical

tissue. Findings by Grossman,[197] Ostrander and Crowley[198] show that quite often cultures are unable to be obtained from periapical tissue in such cases.

2. Periodontal Disease:

It is known that a transient bacteraemia follows in most instances when teeth which are affected by periodontal disease are extracted.[199][200] "The evidence overwhelmingly indicates that the extraction of teeth and sometimes even more minor oral procedures, may produce a transient bacteraemia. This bacteraemia seldom persists for over 30 minutes in the majority of patients".[201]

THE DISEASES INVOLVED

The diseases which may be aggravated or caused by oral foci have been set out by Shafer, Hine and Levy[201] as follows:

a) Arthritis - chiefly of the rheumatoid type.

b) Valvular Heart Disease - particularly subacute bacterial endocarditis.

c) Gastro - intestinal diseases.

d) Ocular diseases.

e) Skin diseases.

f) Renal diseases.

Of these diseases, the first two gain more prominence in the available literature than the remainder. The

evidence which has been offered to confirm dental implication in gastro-intestinal, ocular, skin and renal diseases is rather meagre and in some cases highly questionable.[202]

Arthritis:

In assessing the relation of infection to arthritis, the remarks of Freyberg[203] are significant:

"First, then, one needs to know whether the patient has arthritis, second, if he has arthritis, what kind of arthritis is it? Third can infection reasonably be the cause of that type of arthritis?"

He carries on -

"The infectious basis for rheumatoid arthritis has not been proved, and no infectious organisms have been found in articular structures. The theory that localised infection may be an important etiologic factor, acting as a "trigger mechanism" in many cases, seems reasonable. Once rheumatoid arthritis is established it seems to have capabilities of continuing, independent of localised infection. Theoretically it seems doubtful whether removal of foci or infection would be helpful in cases of rheumatoid arthritis of long duration".

Kersley[204] states "I would suggest that one looks upon dental sepsis as the occasional trigger in firing off some biochemical mechanism we do not as yet understand .

alternatively gross sepsis may help to sensitise the mechanism to the pull of other triggers e.g. a specific food, trauma or a shock".

Thus it seems that eminent medical authorities, although accepting the fact that there may be no direct bacterial link between rheumatoid arthritic conditions and oral bacterial sources do consider that there may be some "other" relationship between the two. Perhaps the answer at this stage is to treat patients with rheumatic disease as outlined by Bulleid.(205)

"There is no infallible way of assessing the importance of dental sepsis and its relationship to rheumatic diseases, and each case must be studied separately and judged on its merits. Personally I think the logical way is to treat the dental sepsis if present, on general lines if no general lesion were present, and render the patient dentally fit to the best of one's ability".

Freyberg(203) states "If foci of infection are attacked, this should be only one part of a broad program of treatment. The removal of infected parts should not be relied upon to cure arthritis".

Subacute Bacterial Endocarditis:

This form of endocarditis is due to demonstrable bacteria which, as a rule, occurs in previously damaged heart valves, an active or healed rheumatic lesion being present in from 75 per cent to 90 per cent of cases.(206) In about 95 per cent of cases the infecting organism is strep. Viridans(206) which is a common inhabitant of the mouth and is often found in the blood following tooth extraction. The advent of the antibiotics however has resulted in drug resistant organisms assuming a more important role of late.(207)

Apart from the definite relation between bacteria and certain types of endocarditis, nothing of a positive nature has as yet been issued regarding the other diseases which have been ascribed to focal infection. In many cases it seems that whenever an obscure complaint is presented to certain members of the medical profession, the patient is referred hopefully to the dentist to remove "oral foci". This in the author's opinion should be done routinely, to reduce the demands upon a patient's general resistance, which may in some cases lead to an increase in standard of the health of that patient. However, the role of the dentist in effecting a cure of the diseases which have at times been thought to arise from focal infection must be viewed at present with caution. After

an exhausting review of the literature carried out by Mitchell and Helman,[92] they summarise thus:

"Since so much confusion exists, there is no doubt that further clinical and experimental research, scientifically controlled, is necessary before the theory of focal infection can be accepted, modified, or rejected".

SUMMARY

1. A description of the anatomical configurations of the pulp chambers and the root canals of the various permanent teeth has been given. These features are to be treated with some discretion clinically, because of variations due to age, physiological and pathological stimuli.

2. An outline of the structure and function of the pulp together with the physiological changes which may take place within the pulp are given.

3. The various inflammatory responses of the dental pulp are discussed, along with certain forms of pulp degeneration.

4. The inflammatory reactions in the periapical tissues and their accepted forms of immediate treatment are presented.

5. The question of whether to carry out pulp capping, pulp amputation, pulp extirpation or extraction is discussed. Such points as the health of the patient, caries susceptibility, oral hygiene, accessibility of the tooth, skill of the operator and the condition of the tooth prior to treatment are considered.

6. In the chemo-mechanical preparation of root canals, the opening into the canal must be such that instruments are allowed an unrestricted pathway towards the root apex. The importance of an aseptic technique and adequate debridement are stressed.

7. The purpose of the root filling, some notes on the materials used to achieve the complete obliteration of the canal, and the various methods employed in doing so are given.

8. The most common techniques of root resection are given, along with a discussion of the need or otherwise for this operation.

9. From a limited supply of information upon human subjects, the repair processes following root canal therapy are discussed.

10. A short survey of current thoughts upon the origins of certain systemic diseased states relating to dental foci is presented.

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