THE PULPALLY INVOLVED PERMANENT TOOTH

ITS PROBLEMS AND THEIR SOLUTIONS

This review of the literature has been submitted in support of candidature for the Degree of Master of Dental Surgery.

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INTRODUCTION

A great deal of experimental work has been carried out in this field by various research workers with tests in vitro and in vivo and by the use of experimental animals, the study of such work being essential to provide the necessary background for a scientific approach towards the subject. The object of this review however is to present a concise and logical account of current methods used in the treatment of pulpally involved permanent teeth, and as a general rule only well tried and clinically acceptable techniques are presented. Thus no attempt has been made to give a complete account of the literature in the endodontic field, on the contrary this should be considered as a review of certain aspects of modern endodontic treatment which pertain to the treatment of root canals as seen through the eyes of one who has been less of a scientist and more of a private practitioner.

Chapter 1.

THE ANATOMY OF ROOT CANALS

General considerations:

A. The Pulp Chamber

This is an irregular shaped cavity which roughly conforms with the shape of the crown of the tooth. In the young tooth the chamber is large and the pulp horns are well marked, its boundaries being influenced by secondary and irregular dentine, becoming smaller with age. Sometimes however the pulp chamber increases in size[1] due to vascular changes and metaplasia of fibroblasts to cells of an osteoclastic type - this condition being called "internal resorption".

In anterior teeth the pulp chamber gradually merges into the root canal, whilst in multi-root teeth, there is a floor to the pulp chamber and separate orifices to each canal.

B. The Root Canals

1. The number of root canals generally conforms with the number of roots present. Some teeth however, have roots showing a lateral groove, and a heaping up of the dentine within the canal along the line of this groove so constricts the lumen[2] that a dentine partition is formed, thus dividing the canal into two. This division occurs mainly in the lower incisors and canines, in the mesio-buccal roots of the upper first

and second molars, in the mesial roots of the lower first and second molars, and in the upper premolars.(3)

2. The shape of the root canal usually conforms with the outer form of the root with variations according to the age of the tooth. In the young tooth, the canal is wider apically than at the dentino-enamel junction, and as time passes, the walls become more parallel and then finally converge apically, due to the formation of dentine within the canal - this being a normal physiological process.

3. The size of the root canal decreases with age due to the normal growth of dentine within the lumen of the canal.(2) Pathological disturbances may influence the activity of the odontoblasts to the extent that complete obliteration of the pulp chamber and extreme constriction of the canal may occur.

4. Accessory canals are often present, either as a connection between two canals via a dentine bridge, or as a separate canal between the main canal and the periodontal membrane.(3) Coolidge states that during tooth development, where collateral circulation enters the dental papilla at a point higher than the main source of circulation, dentine formation may be interrupted by these vessels and a lateral branch of the pulp is formed with a foramen on the side of the root.

Hess[4] has demonstrated that in the early life of the tooth there is less chance of accessory canals being present than in later life.

5. Apical ramifications[5] are present in many root canals, varying in number from 10.2 per cent (in the roots of lower third molars) to 80 per cent (in the roots of upper third molars). In young teeth, apical ramifications are few because of the incomplete development of the root apex, but the greatest number are demonstrated in the 20 to 40 age group.

C. <u>The Apical Foramen</u>

1. In the young tooth, the apical foramen is wide open because of incomplete root development, the mouth of which is filled with periodontal membrane which is later replaced by dentine and cementum.[6] As the root development becomes completed, there is a deposition of cementum upon the dentine at the apex, within the root canal, for one or two millimetres. This places the dentino-cemental junction not at the extreme end of the root, but within the canal. Thus as the apical foramen becomes smaller, a constriction develops in the canal usually one to two millimetres from what appears as the radiographic apex.[7] Kuttler[8] showed in his observations that the dentino-cemental junction is located a little more than 0.5 mm from the apical foramen in the young and 0.75 mm from the

apical foramen in older people. From observations such as these, Grove[9] maintains that it is not necessary to fill root canals to their radiographic apices but to this constriction.

2. With the knowledge that apical ramifications are present in a large number of roots, producing apical foramina rather than one apical foramen, Davis[10] suggests "partial vital pulpectomy" and claims that in 90% of cases the unremoved pulp tissue remains vital after the rest of the canal has been root filled.

A. <u>Upper Anteriors</u>

1. Central Incisor:

The pulp chamber has 2 or 3 horns, which extend well out towards the enamel in the young patient. At the base of the pulp chamber, there is often a constriction[11] which opens out again apically. Towards the crown, the canal is wide and thin, but assumes a more cylindrical shape in the middle third of the root.[12][13]

2. Lateral Incisor:

Similar in shape to the central, but smaller, and the pulp chamber usually has only 2 horns due to the small size of the crown. The canal is much wider labiolingually than mesio-distally in the coronal and middle thirds, and there is

a tendency for it to curve distally in the apical third, where it becomes more cylindrical in shape.

3. Canines:

The pulp chamber has only one horn, which is quite pointed. The root canal is usually straight, is much larger than that of the incisors, and is wider labio-lingually than mesio-distally. Sommer[14] suggests that as the average size of the root canals of the upper anteriors is that of a number 5 reamer, they should be reamed to the size of a number 5 or 6 reamer during the mechanical preparation of the canal.

B. Upper Bicuspids.

1. First Bicuspid:

The pulp chamber follows the shape of the crown, with a prominent buccal horn in the young patient.[15] These teeth generally have two roots and two canals, but may have one root and one flattened canal or two canals, or (rarely) the buccal root bifurcates to form three roots and three canals.[16] In the middle and apical thirds, the canals are fairly round, the average diameter being that of a number 3 reamer.[14]

2. Second Bicuspid:

This tooth has usually a single root, and in the

young, a simple canal. With age, a bifurcation may occur due to a build up of dentine in a mesio-distal direction, so that a buccal and a palatal canal may be formed. The two canals may be joined at intervals by transverse canals,[17] and may rejoin to form one, before branching into terminal branches at the apex. In cross section the canal is very narrow mesio-distally but broad bucco-lingually. Hess[17] found that in 56 per cent of cases examined by him, one canal was present, 42 per cent showing 2 canals and 2 per cent showing 3 canals. With the upper second bicuspid, the canal may be reamed to the size of a No.5 reamer[14] during mechanical preparation of the tooth prior to root filling.

C. Upper Molars.

The upper first and second molars usually have three roots (mesio-buccal, disto-buccal and palatal) each with one root canal. The pulp chamber tends to be somewhat mesially placed and the mesio-buccal horn is most prominent. In most adults, the chamber does not extend distal to the transverse ridge on the occlusal surface.[18]

The mesio-buccal root is wider than the disto-buccal and it often has a flattened appearance mesio-distally which may lead to a bifurcation of the canal.

Hess[19] found this so in 53 per cent of cases examined by him. Apical ramifications are more likely to occur at the tip of this root than with the other roots. The disto-buccal root is larger and the canal is usually simple in form and quite straight, apical ramifications being rare in this case.

The Palatal canal is the largest of the three, is fairly straight, but often curves back towards the buccal in the apical third even though it may appear to be straight in the X-ray picture.[18] There are sometimes accessory canals, and apical ramifications are present on some occasions. These roots may be reamed with up to a No.3 reamer (in the case of the buccal root canals) or a No.5 reamer (in the palatal canal) according to Sommer.[14]

The upper third molars may have a most complex system of roots and root canals, but sometimes these are fused to form one large canal. It is therefore considered a reasonable risk for root canal therapy only when the latter form is presented for treatment. Some authorities consider the third molar to be anatomically inoperable for root canal treatment - as is the case in an intact dental arch. However, it is not beyond the bounds

of possibility for a patient to present with only one upper posterior tooth present, and that being a third molar which has drifted mesially as far as the first molar. This tooth (if it required root canal therapy) should be treated if the operation is within the capabilities of the operator - as the tooth would at least provide anchorage for some form of prosthesis rather than resort to extraction and the subsequent replacement of the tooth with a prosthetic appliance with no distal anchorage.

D. Lower Anteriors

1. Central and Lateral Incisors:

The pulp horns are very slight, and are not much more than a mild enlargement of the pulp chamber. The root canal is very fine in a mesio-distal direction but quite broad labio-lingually, especially in the middle third. It is not uncommon for the canal to divide here and reunite apically so that a single apical foramen is formed. This occurs as a result of age allowing dentine to be heaped up on the inside of the canal, in the region opposite the lateral external groove of the root.(20) There are sometimes openings through this septum which connect both labial and lingual canals. Another common variation is that of a single canal, which bifurcates at the apex to form two apical foramina.(21)

These may be reamed to the size of a 4 or 5 reamer.(14)

2. Lower Canines:

These are similar to the lower incisors in that the root canal conforms to the shape of the root, with the labio-lingual diameter being greater than the mesio-distal. These may have a labial and a lingual canal for similar reasons to those which were discussed above, or a single canal which terminates as a bifurcation in the apical third of the root.

These may be reamed to the size of a 5 or 6 reamer.(14)

E. Lower Bicuspids

1. First Bicuspid:

The pulp chambers of both bicuspids follow the external shape of the crown, with a well marked buccal horn, especially in the first bicuspid. The canal is simple in form and corresponds with the shape of the root, being conical in young teeth and narrowing with age. It has several fine apical branches in the older tooth, and one or two accessory canals. Hess(23) could not determine a division of the root canal in his investigations, but Mulreiter(24) mentions that a division of the root can be caused by deepening of the lateral grooves, and then the simple root canal also divides. Sommer(22) states

that there is a distinct tendency for the canal of the first bicuspid to bifurcate in the apical third.

2. Second Bicuspids:

The canal is similar in shape to that of the first bicuspid but slightly larger in size. Bifurcations may appear in the lower half of the root, one of the branches of which may bifurcate again - to form 3 canals.(25) Generally however, any division in the root canal takes place in the lower part of the root, where there are several small terminal branches. The canals of both bicuspids are usually singular and simple in the young tooth - with a tendency to become complicated only with age. Sommer(14) states that these canals may be reamed to the size of a Number 5 reamer during endodontic procedures.

F. <u>Lower Molars</u>

1. The first and second molars are similar in that both have two roots (mesial and distal) and 3 canals (mesio-buccal, mesio-lingual and distal). The mesial canals are small and circular and curve distally thus increasing the difficulty of operability.(26) The distal canal is fairly straight, but wider bucco-lingually in the coronal part, narrowing to a round canal apically.

Hess[27] found that in some cases the two mesial canals unite in the apical third to form one canal, and that the dentine partition between the mesial canals often shows many delicate communications between the two canals.

Sommer[14] mentions that the mesial canals may be reamed to a size 3 reamer, and the distal canal to a size 5.

2. Lower third molars may have from three to five separate roots[28] but more often there is a fusion of these into one root. There may be from one to three root canals but as a rule two canals, one mesial and the other distal, being fairly round and uncomplicated. A significant point here is that apical ramifications are rare in this tooth.[29]

Clinical Considerations

It has been stated[30] that the purpose of a root canal filling is to obliterate the root canal as a space, so that the seeping in of body fluids which would furnish suitable pabulum for bacteria is prevented. Bearing this in mind, one is faced with the problem of completely removing non-vital pulp tissue (where present) from the accessory canals and the apical ramifications which are known to be present in many cases. It is also essential that a technique be used in filling the root canal which will ensure at least the filling of these areas with the cementing medium. It will

be noted that accessory canals may be present not only in the apical third of the root, but also in the coronal portion (notably in the upper canine).[31] Thus a well condensed root filling is essential for the whole of the root canal and not only for the apical third. Green[32] gives the following figures:

1. Approximately 20 per cent of all canals have lateral branches.
2. Apical ramifications are as follows:
   a) Upper and lower first and second molars 70%
   b) Upper and lower premolars 45%
   c) Upper and lower anteriors 25%

These points will be further developed in the sections dealing with the mechanical and chemical preparation of root canals, root canal filling techniques and repair.

Chapter 2.

PHYSIOLOGY OF THE DENTAL PULP

The dental pulp is a highly vascular connective tissue contained within the pulp cavity.[33]

A. Function

The dental pulp is FORMATIVE, in the production of primary, secondary and irregular dentine. NUTRITIVE, SENSORY and DEFENSIVE, by the production of secondary and irregular dentine due to mild stimuli. If the stimulus is great, an extreme degree of hyperaemia may result in strangulation of the pulp due to the rigidity of the surrounding tissue (i.e. dentine).

B. Anatomy

1. Pulp Chamber:

This follows the shape of the crown of the tooth, it decreases with age due to the activity of the odontoblasts, and may become completely obliterated, or may form pulp stones due to irritants.

2. Root Canals:

During root formation, the pulp canal has a wide apical foramen, limited only by the continuation of Hertwig's Sheath at the root end - the epithelial diaphragm.[34] With growth the canal becomes smaller due to dentine formation. During this phase of the development of the root end, accessory canals

may be produced due to a break in Hertwig's Sheath or the inclusion in the forming dentine of a small blood vessel.(35) (2)

3. Apical Foramen:

This varies in size, shape and location, depending upon the stage of development of the tooth. In the completely formed tooth it is usually to be found at the apex of the root, and it is round and quite small with a conical shape in vertical section.

C. Development

In the incisor region, development begins at about the fifty-fifth day of embryonic life, in the future crown of thetooth, this being a proliferation of the dental papilla. The development of the roots begins after enamel and dentine formation have reached the future cemento-enamel junction. The epithelial enamel organ plays an important part in root development, by forming Hertwig's Sheath, which initiates formation and moulds the shape of the roots. It consists of the outer and the inner enamel epithelia, the inner cells of which induce the differentiation of connective tissue cells into odontoblasts, and thus the first layer of dentine is laid down. Hertwig's Sheath then loses its continuity, and its close relation to the surface of the tooth, its remnants persisting as the epithelial rests of Malassez, these being of

special significance in the formation of a Radicular Cyst.

If cells of the epithelial root sheat remain adherent to the dentine, they may differentiate into functioning ameloblasts and produce enamel - such droplets of enamel being called enamel pearls.

D. Structural Elements

1. Fibroblasts and Fibres:

The principle cells of the pulp are spindle or stellate cells of the fibroblast/ type - these being embryonic in character.(33) With advancing years in the course of development, the relative number of cellular elements in the pulp decreases whilst the intercellular substance increases. There is a progressive reduction in the number of fibroblasts accompanied by an increase in number of fibres.(36)

2. Odontoblasts:

These are highly differentiated connective tissue cells, columnar in shape with an oval nucleus, which line the periphery of the pulp. From each cell a cytoplasmic process extends into a tubule in the dentine matrix (which subsequently becomes dentine); these are the Tome's fibres. Just beneath the odonboblastic layer is an area termed the "zone of Weill", which is a cell free layer containing abundant nerve fibres - the so called subodontoblastic plexus.

3. Defence Cells:

These are histiocytes, undifferentiated mesenchyme cells (which may become transformed into phagocytic wandering cells or into fibrocytes during or following inflammation), and lymphocytes.

4. Blood Vessels:

There are usually one artery and two veins (possibly only one vein) which enter andleave via the apical foramen. The artery branches into a rich network of vessels soon after entering the pulp canal, the veins drawing the blood from the capillary network and leaving via the apical foramen.

5. Lymph Vessels:

These are difficult to show histologically but it has been shown conclusively that they are present.[37] Grossman[38] states that there are no endothelial lined lymph vessels but intercellular spaces into which the lymph drains.

6. Nerves:

Thick nerve bundles enter via the apical foramen and pass into the coronal portion of the pulp where they split into numerous groups of fibres and ultimately into single fibres. Usually the nerve fibres follow the blood vessels, the large with the large vessels and the small with the capillaries. As the nerve fibres approach the odontoblastic layer

they lose their myelin sheaths and become amylenitic, the finer fibres forming the subodontoblastic plexus, or "plexus of Raschkow". An occasional nerve fibre may pass directly into the dentinal tubules.(38)

E. Regressive Changes

a) Pulp Stones:

These have been found in normally functioning teeth and also in unerupted teeth.

A "True Denticle" is a pulp stone which shows traces of dentinal tubuli and odontoblasts. These are comparatively rare and are found close to the apical foramen. They may be formed from remnants of Hertwig's Sheath which have become enclosed in the development.

A "False Denticle" is a calcified formation in the pulp which does not show the structure of true dentine. It consists of concentric layers of calcified tissue, in the centre of which are usually remnants of necrotic and calcified cells. They may sometimes achieve such large size that they may completely fill the pulp chamber.

b) Calcifications:

There are diffuse calcifications in the form of irregular calcific deposits in the pulp tissue, usually following collagenous fibre bundles, or

blood vessels. They are amorphous, have no specific structure, and are usually the outcome of hyaline degeneration of the pulp tissue. These diffuse calcifications are usually located in the root canal, with the pulp chamber being quite normal.

c) Secondary Dentine:

With advancing age the pulp chamber and root canals become narrower due to secondary dentine formation. This dentine usually has less tubules per unit area than primary dentine, and they are arranged in a less regular fashion. The formation of secondary dentine does not proceed at an even rate in all areas, being best observed in bicuspids and molars, where more secondary dentine is produced on the floor and the roof of the pulp chamber than on the side walls.[39]

d) Irregular Dentine:

The pulp reacts to more severe stimuli by forming a type of dentine which shows a still greater difference from primary dentine than the secondary dentine. It forms in restricted areas of the pulpal wall as a reaction to wear, erosion, and caries, which by the exposure of odontoblastic processes causes pulpal irritation. It is termed "irregular dentine". In some cases calcium salts are deposited in or around degenerating odontoblast processes and may obliterate the

tubules. In such cases, the blocking of the tubules may be considered as a defensive reaction of the dentine. Tests have shown that such areas are denser and harder than normal dentine.

e) Fibrosis:

It has been mentioned that with advancing age, the cellular elements decrease in number whereas the fibrous components increase in the pulp. In older individuals, this shift in tissue elements can be considerable and fibrosis may occur. Thereby the vitality of the pulp may be lowered without any consequence to the function of the tooth.

F. Clinical Considerations

a) In some cases of deep caries, the radical removal of all discoloured dentine should be avoided. Disinfectants should be used in an attempt to control bacteria which may remain, and a temporary filling material should be inserted, to stimulate the formation of irregular dentine. At the time of placing a permanent restoration (after final cavity preparation), there is then a strong bridge of irregular dentine covering the unexposed pulp. Whilst excavating carious dentine it is as well to bear in mind the work of two research groups. One group [40] found that superficial layers of caries were always infected, intermediate layers were

sometimes infected, and deep layers were almost always sterile. The other group[41] found that the deep layers of carious dentine were acid (pH 4.6-5.5) owing to the presence of lactobacilli, and they propounded that the high acidity prevented the ingress of pathogenic organisms from carious dentine into the pulp.

It therefore appears prudent in certain cases to respect the continuity of the odontoblastic layer of the pulp, and rather than excavate caries until an exposure has been produced, attempt to control the carious process until a sound layer of irregular dentine has been deposited at the site of the potential exposure - thus preserving the integrity of the pulp.

b) Whenever dentine is cut, or heat or drugs are applied, a reaction occurs as a result of irritation of the odontoblasts through the Tome's processes. The exposed dentine should not suffer from strong drugs, undue operative trauma, unnecessary thermal changes or irritating restorative materials.

c) It should be noted that in exposing one square millimetre of dentine, about thirty thousand tubules are exposed.[42] The surface may be treated with astringent drugs such as phenol or silver nitrate to coagulate the protoplasm of the exposed odontoblastic processes. It is advisable to cover the dentine surface with a non-irritating, insulating substance.

d) One may encounter difficulties in opening into a pulp for root canal work where extensive secondary dentine formation has taken place, due to near obliteration of the chamber or canal. Pulp stones may complicate the position even more.

e) The position of the apical foramen may be a problem if it is not directly at the apex of the root, also the presence of secondary or accessory canals may make root canal therapy fail in cases where these are infected and left unfilled.

f) Due to the repair mechanism of the young pulp, capping or pulpotomy is sometimes a satisfactory solution to the problems presented by a vital exposed pulp.

HYPERAEMIA OF THE PULP

This is a reversible reaction which occurs as the result of a stimulus, and which usually subsides upon its removal. It may quite easily extend to pulpitis if the stimulus is allowed to remain or to become great enough. It is an excessive accumulation of blood in the pulp resulting in vascular congestion,[43] and it may be arterial (active), or venous (passive), it being impossible to distinguish between the two types clinically. The cause may be any of the causes of pulpal injury, or may sometimes be associated with local vascular congestion (e.g. sinus infection) or circulatory disturbances (e.g. menstruation or pregnancy).[43] Hyperaemia is usually characterised by a short, sharp pain associated with a stimulus e.g.[44] thermal or osmotic changes, due to hot or cold, sweet or sour foodstuffs. The pain generally disappears when the stimulus is removed.

The treatment of hyperaemia is, firstly to remove the cause so that the congestion may be reduced to normal limits within the pulp. It may be necessary to seal a sedative dressing of zinc oxide and eugenol within the tooth if the hyperaemia is due to a cavity. The use of caustics upon exposed dentine where the necks of teeth have been eroded or abraded, according to the formulae presented by Hill[45] is another common form of treatment.

Where pain continues to persist despite the above measures the condition should be regarded as inflammatory rather than hyperaemic and in the adult tooth, the pulp should then be extirpated and root canal therapy instituted.

Chapter 3.

PATHOLOGY OF THE DENTAL PULP

Inflammation of the pulp may be due to any of the causes of pulpal injury as listed by Grossman[46], and it may be acute or chronic, total or partial, infected or sterile. The only differentiation from a clinical viewpoint however, is whether the inflammation is acute or chronic, as the other stages of pulpal inflammation are only demonstrable histologically.

Acute Inflammation may be divided into two clinically recognisable types:

Acute Serous Pulpitis

Acute Suppurative Pulpitis

and Chronic Inflammation may also be shown clinically as either

Chronic Ulcerative Pulpitis or

Chronic Hyperplastic Pulpitis.

A. Acute Serous Pulpitis

This is a mild form of acute inflammation, usually in a portion of an unexposed pulp.[47] If left to progress it will develop into suppurative or chronic pulpitis, and ultimately lead to death of the pulp.

Symptoms:

Pain is usually brought on by sudden temperature changes, particularly cold, or by lying down -

thus increasing the vascular congestion in the pulp.

Diagnosis:

Oral examination may show a deep cavity, or recurrent caries under an existing restoration, X-rays being particularly helpful in this respect. There is no radiographic evidence of any other pathology, the picture being otherwise quite normal.

The differential diagnosis between serous pulpitis and hyperaemia is usually very difficult. In a hyperaemic pulp, the pain is not considered to be so severe, and it usually disappears rapidly after the stimulus is removed. The condition of the pulp may approach that of a suppurative pulpitis where the pain would be dull rather than sharp, and a response to heat would be given.

Histopathology:

The vessels are dilated, with increased numbers of leucocytes present, some of which are seen in the surrounding tissue. The odontoblasts in the neighbourhood of the involved area are often destroyed.

Treatment:

The immediate treatment is the relief of pain, (48)(49) (50) followed by pulp extirpation. Some operators prefer to remove the pulp immediately if no pain

relief is afforded by sedatives such as eugenol.

If caries is present, this is removed and a dressing of cotton wool soaked with eugenol is sealed without pressure into the cavity by means of a zinc oxide/eugenol cement. After 48 hours, when vascular congestion has subsided, pulp extirpation is carried out.

B. Acute Suppurative Pulpitis

This is an acute condition where there is great pain due to the build up of pressure upon the surface of an unexposed or slightly exposed pulp, characterised by abscess formation in that region.

Symptoms:

Pain is always severe and is usually described as "throbbing". It is increased by heat, sometimes relieved by cold, and periodontal disturbances may become manifest in the latter stages due to an extension of the inflammatory processes apically.

Diagnosis:

The radiographic picture may show a deep cavity, extensive caries under a restoration, impingement of filling material upon a pulp horn, or a near exposure of the pulp.(51) Thermal tests are useful, as cold will often give relief to the patient but heat intensifies the pain. The tooth may be slightly tender to percussion.

Histopathology:

Blood vessels are dilated, with enclosed thrombi, the connective tissue elements are infiltrated with pus cells and there is destruction of the odontoblasts near the source of infection. The tissue adjacent to where thrombi are present in the vessels, is broken down, and becomes liquified. The abscess may be localised to the coronal pulp, or in advanced cases, extend to the radicular portion.

Treatment:

The pulp chamber should be well opened to allow free drainage of purulent material, and the exposed pulp irrigated with warm saline. A dressing such as a beechwood creosote impregnated cotton wool pledget is then inserted into the pulp chamber for 48 hours. The pulp may then be extirpated and routine endodontic procedures instituted.

C. <u>Chronic Ulcerative Pulpitis</u>

This is usually observed in young vigorous pulps which have been exposed; however, it may be seen in unexposed pulps[52] when the resistance of the pulp is sufficient to withstand a progressive inflammation for a long time, without much accumulation of pus and exudate.

Symptoms:

Pain may be slight or absent, usually being only a dull consciousness; however, it is moderate with extremes of temperature, and direct pressure effects of food packing into the cavity.

Diagnosis:

The pulp surface at the site of the exposure has a greyish superficial layer which is composed of dead leucocytes and decomposed food debris. This area is non sensitive to the explorer point, but pain and haemorrhage occur when the point passes deeper into vital and inflamed pulp tissue. The X-ray picture shows a deep cavity with exposure of the pulp, caries under a restoration, or a very deep restoration. Sommer[53] states that the roentgenogram is of little value diagnostically as it cannot show anything which is not known clinically.

Histopathology:

There is a necrotic surface which has granulation tissue beneath, this being markedly infiltrated by round cells, and showing enlarged capillaries. Where the chronic pulpitis is of long standing, the granulation tissue may extend towards the root apices, and the tissue immediately beneath the ulcer

tends to become calcified, such calcifications as denticles and pulp stones are then likely to be present.

Treatment:

Superficial caries should be removed, along with the necrotic pulp tissue, until vital tissue is reached. The pulp stump is then washed with warm saline, the cavity dried, and a dressing of beechwood creosote applied. After 48 hours the pulp is extirpated.

D. Chronic Hyperplastic Pulpitis

A carious exposure in a young resistant pulp may allow the formation of granulation tissue which is sometimes covered by a stratified squamous epithelial layer.

Symptoms:

This condition is usually symptomless, although there may be pain due to the pressureof a food bolus upon the polypoid mass of tissue.

Diagnosis:

The condition is usually seen in the young. A wide open cavity which is overfilled with a red mass of tissue is present, this tissue being less sensitive than normal pulp tissue, but more sensitive than the oral epithelium. It will often appear as

if the oral mucosa and the pulp polypus are one. This tissue will bleed most freely due to the rich network of blood vessels which are present.

Hisopathology:

The microscopic picture is usually one of coronal pulp appearing as granulation tissue, proliferating pulp cells, polyblasts and dilated blood vessels being seen, the whole usually being covered by stratified squamous epithelium. The apical pulp tissue may be normal.

Treatment:

The polyp is eliminated by a sharp scalpel, and the coronal pulp is removed. After haemorrhage has been controlled a dressing of beechwood creosote is applied and the pulp is extirpated at a subsequent visit.

Grossman[54] allows that in selected cases, pulpotomy may be tried before resorting to pulp extirpation.

E. Pulp Degeneration

The pulp may undergo a variety of processes which are collectively titled "pulp degenerations", these however differing from the previously described conditions in that they are not directly related

to caries or infection. They are of little significance clinically, except that they must be differentiated from a necrotic pulp, to prevent the potential loss of a vital even though "degenerated" pulp.

The necrotic pulp generally alters the colour of the tooth whereas a degenerated pulp has no effect in this way, excepting in the case of internal resorption or "pink spot". The lack of sensation to cavity preparation will sometimes make the operator suspicious of whether a pulp is necrotic or undergoing one of the degenerations. The age of the individual is often a help in this, young people usually being free of the degenerative changes. The presence or absence of a deep cavity or large restoration may also help in the differential diagnosis.

The degenerations are:

Atrophic degeneration - where there are fewer stellate cells present and an increase in intercellular fluid.

Fibrous degeneration - where there is replacement of cellular elements by fibrous connective tissue.

Vacuolization of the odontoblasts - where the odontoblasts degenerate and are replaced by spaces.

Fatty degeneration - where fatty deposits are seen in the odontoblasts and with the other cells of the pulp.

Internal Resorption - where resorption of the dentine takes place from the pulpal surface as a result of osteoclastic activity. This is usually seen during routine X-ray examination and the treatment is pulp exirpation and root canal therapy if this is feasible. Where the root of the tooth has been perforated, extraction appears to be the only solution.

F. Necrosis and Gangrene

Whilst necrosis simply refers to the death of the pulp, gangrene is the state where a dead pulp is invaded by saprophytic organisms.

The common form of necrosis is that which is termed coagulation necrosis, where the soluble portion of the tissue is converted into a solid material. Caseation is a form of coagulation necrosis where the solid appearance of the necrotic tissue is likened to a "cheesy mass". Also common is liquifaction necrosis, where proteolytic enzymes convert the tissue into a liquid form, as in the liquifaction of the pulp associated with an acute alveolar abscess.

Gangrene may be moist or dry, depending upon the type of necrosis which is present. The end products of

protein decomposition contain gases such as hydrogen sulphide and ammonia, and certain other gases are given off as intermediate products. These (indole, skatole, putrescin and cadaverin) may account for the unpleasant odours associated with root canals containing putrescent pulps.

Symptoms:

The tooth may present no painful symptoms; however bacteria may gain access via the blood stream or from neighbouring tissues[55] which may lead to acute alveolar abscess and the painful sequelae associated with this condition. The first indication that the pulp is nonvital may be a lack of translucency of the crown, or a definite darkening of the crown to a brown or grey. There may be no pain upon cavity preparation without anaesthetic or the tooth may be painful when hot liquids are consumed, due to expansion of gases within the pulp canal and subsequent pressure upon sensory nerve endings in the periapical tissues.

Diagnosis:

Roentgen ray examination generally shows a large cavity or restoration (possibly not if the necrosis was due to a blow) and a thickening of the apical periodontal membrane. Heat may elicit a painful response as mentioned above.

Histopathology:

Necrotic tissue is seen in the root canal, along with cellular debris and micro-organisms. The periapical tissue may be normal, or may show signs of inflammatory response. One group of research workers were able to demonstrate the presence of bacteria (both aerobic and anaerobic types), in the pulp chambers of intact teeth which were found to be non-vital due to impact injury. They postulated that most of these organisms reached the pulp from the oral cavity via the lymphatics and blood vessels of the periodontal structures.

Treatment:

This consists of the mechanical and chemical preparation of the root canal followed by routine endodontic procedures.

Chapter 4.

PATHOLOGY OF THE PERIAPICAL TISSUES

The various pathological disturbances of the periapical tissues according to Grossman[56] are:

A. Acute Apical Periodontitis

This is an acute inflammation of the apical periodontal membrane, which may be due to mechanical, chemical or bacterial irritation associated with endodontic procedures, or from occlusal trauma.

Symptoms:

There is pain and tenderness to percussion, the tooth often being extruded slightly so that the patient experiences pain when establishing occlusal contact.

Diagnosis:

One must first establish whether the tooth is vital (by heat, cold and electrical tests) thereby determining whether the tooth is pulpally involved or not. The tooth is tender to percussion and the mucosa overlying the periapical tissues may be tender upon palpation. The radiographic picture will show a normal periodontal membrane if a vital tooth is present, or periapical thickening of the membrane or rarefaction if a pulpless tooth is involved.

Histopathology:

The apical periodontal membrane shows the presence of polymorphs around dilated vessels, with an accumulation of serous exudate tending to extrude the tooth. Bacteria may be present if the condition is of bacterial origin, although these may be confined to the root canal the inflammation sometimes being due to the irritating effect of their toxins. If the irritation is severe, there may be bone breakdown due to osteoclastic action - thus progressing to the next stage, that of acute alveolar abscess.

Treatment:

This is entirely dependent upon establishing the correct cause, and the immediate removal of the irritation. If the tooth is vital and the condition is caused by occlusal trauma, the tooth should be disoccluded. If the cause is due to root canal medicaments or instrumental trauma, the dressing should be removed, and the canal left open for 5 minutes to allow accumulated exudate to pass into the canal. This is removed by absorbent points, the canal is dried and the opening sealed with a pledget of cotton wool, and a zinc oxide and eugenol cement. When the periodontitis follows root filling procedures, a counter-irritant may be applied to the mucosa overlying the periapical tissues and the tooth is

disoccluded by grinding.

B. Acute Alveolar Abscess

An acute inflammation of the periodontal tissue around the apical foramen attended by an increasing amount of inflammatory exudate and suppuration.(57) This condition may be the result of trauma, chemical or mechanical irritation, but the immediate cause is always bacterial invasion of necrotic pulp tissue.(58)

Symptoms:

Initially it may be difficult to differentiate from acute apical periodontitis, but as the condition progresses, there is a severe and throbbing pain with swelling of the overlying tissues. With time, if the condition is untreated, the swelling of adjacent tissues becomes obvious, and there may be an osteitis, a periostitis, a cellulitis or an osteomyelitis. The tooth and the adjacent teeth become markedly loose and extruded due to the contained pus attempting to obtain release, and this may happen within the mouth, upon the skin surface of the face or neck into the antrum or the nasal cavity.

Before fistula formation, body temperature is raised, and fever develops, the tongue is covered with a heavy coating and the patient complains of loss of

appetite and pain in regional lymph nodes.(59) As soon as the pus escapes, the swelling rapidly subsides and, as long as drainage is not obstructed, no further acute symptoms occur.

Diagnosis:

In the early stages, it may be difficult to locate the offending tooth, clinical tests may help by establishing the vitality of the tooth, X-ray examination may show recurrent caries or an open cavity but may show a normal apical picture because of the lack of time involved in the periapical bone destruction. The affected tooth responds to neither the electric test nor cold, but may be painfully responsive to heat. Transillumination will show an apical shadow, the apical mucosa is tender to palpation, and the tooth is tender to percussion. If a pledget of cotton wool soaked with hydrogen perioxide is held in contact with the mucous membrane overlying the apex of the affected tooth the tissue will turn white.(58) This indicates that the tissue in this region is beginning to show signs of breakdown associated with fistula formation.

Histopathology:

There is a marked infiltration of polymorphs, and distention of the apical periodontal membrane due

to the rapid accumulation of inflammatory exudate. Microscopically empty spaces are seen where suppuration has occurred, surrounded by polymorphs and some mononuclear cells. The root canal may be devoid of tissue and clumps of micro-organisms and debris may be observed.(60)

Treatment:

In the early stage, drainage through the root canal may be sufficient to eliminate accumulated pus and exudate. This may be accomplished by making an opening into the pulp chamber (stabilising the tooth if necessary by means of impression compound or dental floss) with a diamond stone or a sharp bur. Any pulpal remnants are removed with a barbed broach and a loosely rolled pledget of cotton wool is packed into the pulp chamber to prevent the ingress of food debris. The patient is then dismissed for a few days to allow free drainage and the acute symptoms to subside. Sommer et al(61) advocate the flooding of the pulp chamber with sodium hypochlorite and the filling of the canal with a Kerr number two file to be sure of a free pathway for drainage to take place.

The tooth should be disoccluded by grinding when elongation is present.

When the canal is narrow and insufficient drainage is available via the canal, if the soft tissues overlying the root apex are soft and fluctuant, an incision may be made (under regional, general or surface anaesthesia) to the bone, to allow free drainage. In extreme cases of malaise, the patient should be confined to bed, and the use of a mild aperient and a mouthwash together with a light but well balanced diet is indicated. After the acute symptoms have subsided chemical and mechanical preparation of the root canal may be carried out as a step towards the ultimate goal, root canal filling.

In cases where the tooth is anatomically inoperable or where the patient has rampant caries or where extensive periodontal disease is present, it may be more prudent and a more commonsense approach to extract the tooth (62) and thus establish drainage via the socket.

C. Chronic Alveolar Abscess

This is a low grade infection of the periapical bone, which may be a result of pulpal death with an extension of the infection periapically, or it may

result from a pre-existing acute abscess or from an incomplete or over-extended root filling.

Symptoms:

A chronic alveolar abscess is generally symptomless unless an acute exacerbation has occurred. In such cases, pain and swelling will be present, along with all of the other symptoms of the acute condition until drainage is established by nature or by the dentist. When a fistula is present, pus may be detected when pressure is applied above the opening. The fistula may be located opposite the root apex of the abscessed tooth, but may sometimes be near an adjoining tooth - the pus taking the line of least resistance during the formation of the fistula.

Diagnosis:

Clinical examination may reveal a tooth which is heavily filled or has a large cavity. The usual tell-tale sign of a chronic abscess is the presence of an enlarged spherical mass of gum tissue usually lying in the region of the root tip.(63) This usually shows a small opening on the surface, a fine blunt explorer being passed through this can be made to follow the fistulous tract. Sometimes the first knowledge that there is a chronic alveolar abscess is given by the roentgenogram, which shows a diffuse area of bone rarefaction which may fade indistinctly

into normal bone, or show only a slight demarcation from normal bone. The periodontal membrane is thickened.

Histopathology:

There is detachment or loss of some of the periodontal fibres at the root apex due to bacteria or their toxins and eventually destruction of the apical periodontal membrane. The root canal may be empty or contain cellular debris, the centre of the abscessed area containing polymorphs and sometimes mononuclears, with lymhocytes and plasma cells at the periphery. Fibroblasts may be seen at the periphery beginning to form a capsule.

Treatment:

Chemo-mechanical preparation of the root canal followed by complete obturation is the line of treatment which should be carried out. Grossman[64] prefers to reseet the root end and curette the surrounding bone if the radiolucent area is greater than 5 mm. in diameter - although recent work by Sommer et al[65] and Wais[66] indicates that this is an unnecessary step provided negative cultures are obtainable prior to filling the root canal.

D. <u>Subacute Alveolar Abscess</u>

This classification is one which covers most cases of chronic alveolar abscess which flare up into an

acute condition and present symptoms pertaining to both the acute and chronic states. The clinical signs and symptoms are generally those of an acute alveolar abscess, but X-ray examination will disclose an area of apical rarefaction. Treatment is as for an acute alveolar abscess.

E. Granuloma

A granuloma may be looked upon as a chronic, low-grade productive reaction to apical irritation, occurring at the expense of alveolar bone, in the form of a growth of granulation tissue, continuous with the periodontal membrane. A requisite condition for the development of a granuloma is a continued mild irritation which is not severe enough to produce an abscess.

Symptoms:

Mostly it is symptomless, but in rare cases the granulation tissue breaks down and undergoes suppuration.

Diagnosis:

Roentgenograms have been considered as showing fairly conclusive evidence of either granuloma or chronic alveolar abscess. Grossman[67] states that with a granuloma, the area of rarefaction is well defined, being bounded by a fine, not always continuous white line which is indicative of dense bone, in

contra-distinction to a chronic abscess, where the rarefied area is diffuse and fades into the surrounding bone.

The tooth is not sensitive to percussion or palpation, and it gives a negative response to both thermal and electric tests.

Transillumination almost always reveals a shadow.

Histopathology:

Periapical granulation tissue is present consisting of a rich capillary network, fibroblasts, lymphocytes and plasma cells. Macrophages and foreign body giant cells may also be present. Irritation from bacteria or their toxins allows exudate to accumulate at the expense of alveolar bone which is cleared by macrophages and foreign body giant cells. The fibroblasts at the periphery build a fibrous wall which is continuous with the periodontal membrane.

Treatment:

It was once considered necessary to carry out root resection and apical curettage following a root canal filling in teeth where granulomas were present. The tendency in latter years is to consider a granuloma as a defensive and sterile (or at least potentially sterile) tissue. Boyd[68] says that "on account of its

cellularity, a granulating surface has a remarkable power of resisting bacterial infection. It presents so powerful a barrier that septicaemia cannot occur once an intact wall of granulation tissue has been formed". Sommer et al[69] says that "since a granuloma is largely made up of granulation tissue which is a tissue of repair, it would seem that once the source of irritation had been removed, there would be no further need for the defensive cells contained in the granuloma, and that tissue repair would take place. This is exactly what does happen".

Grossman[70] prefers to carry out resection where a large area of rarefaction is disclosed by the roentgenogram, as epithelium is likely to be present in the granulation tissue, and this could persist and lead to cyst formation. A presentation of further data relating to the question of whether or not to carry out root resection is given later in this work.

F. <u>Radicular Cyst.</u>

This is a slow growing epithelial lined sac at the apex of a tooth. It may contain a glairy fluid characterised by the presence of cholesterin crystals.

Symptoms:

There are no symptoms unless the cyst has expanded to such an extent that intra-oral swelling occurs.

There may be spontaneous fracture of the mandible due to the lack of bone beneath a tooth as a result of cystic expansion.

Diagnosis:

These are usually discovered by radiographic examination of a suspected non-vital or pulpless tooth, other clinical tests (except transillumination) being negative. A well defined area of rarefaction is present, which is well circumscribed and is limited by a radiopaque line. Pressure from a developing cyst may force apart the root apices of teeth. Although the recognised texts give a definite radiographic picture for a cyst, the study carried out by Baumann and Rossman (71) indicates that -

a) clinical and roentgenologic observations are of doubtful value in distinguishing cystic from non-cystic lesions in periapical disease, and
b) the differential diagnosis between cystic and non-cystic lesions in periapical disease can be made with certainty only by means of microscopic study of histopathologic sections.

Histopathology:

A cyst is formed when the epithelial rests of Malassez which are normally present in the apical periodontal membrane proliferate as a result of

irritation of long standing. Stratified squamous epithelium is found lining the inner surface of the fibrous capsule. Within the lumen there may be cholesterin crystals.

Treatment:

Where the diagnosis is certain, the root should be resected after root canal filling has been carried out, and the periapical tissue should be curetted so that no epithelial remnants which would allow the cyst to recur are permitted to remain. If this is not feasible due to the close proximity of the root apex to important structures such as the maxillary sinus, the mandibular canal, and the mental foramen, or due to anatomical difficulties associated with the root canal, the tooth should be extracted and a thorough curettage of the socket should be carried out.

Chapter 5.

THE TREATMENT OF TEETH WITH PULPAL OR PERIAPICAL INVOLVEMENT

This question will be discussed under the following headings:

A. Pulpal Involvement

1. In the Young Tooth

a) Pulp Capping

b) Pulpotomy

c) Pulpectomy

d) Extraction

2. In the Mature Tooth

a) Pulpectomy

b) Extraction

B. Periapical Involvement

1. Pulp Extirpation where

a) Acute conditions prevail

b) Chronic conditions prevail

2. Extraction.

A. PULP INVOLVEMENT

1. The Young Tooth

a) Pulp Capping:

Pulp capping is the protection of a slightly exposed, healthy pulp by means of an antiseptic or sedative in order to allow the pulp to recover and maintain its

normal vitality and function.[72] The ultimate aim in pulp capping is to obtain a bridge of dentine between the pulp and the capping material at the site of the exposure. This is not always maintained, even in cases where there is no after pain and the tooth appears normal from a clinical viewpoint.[73]

The indications for capping an exposed pulp are that the exposure should be mechanical and the roots of the teeth must not be fully developed. The author considers that when the X-ray shows the root canal walls have narrowed to a convergance just beyond parallelism the risk which is associated with successful pulp capping is increased.

Coolidge[74] considers that the pulps of adults which are accidentally exposed by excavating sound dentine are satisfactory pulps for capping. It would seem however, to be a more satisfactory procedure in such a case to carry out vital pulpectomy and root canal therapy if there are no anatomical difficulties associated with the operation, rather than possibly run the risk of having to perform the operation later upon a non-vital and infected organ.

Technique of Pulp Capping:

The rubber dam should be applied immediately if not already in position and as much caries as possible is carefully removed, the dentine being treated with

a sterilizing agent. Care must be taken to keep the pulp surface free from any caustic drugs. The cavity is dried with a pledget of sterile cotton wool, and a thin layer of calcium hydroxide and distilled water (mixed into a paste) is applied without pressure to the exposed pulp tissue. The excess is removed, and the cavity is partly filled with a zinc oxide and eugenol cement and the remainder with a zinc oxy-phosphate cement. The placing of a final restoration should be no sooner than twelve weeks following this operation.(75)

b) Pulpotomy:

Pulpotomy is the removal of the coronal portion of an uninfected, vital pulp.(76) It should be attempted only in cases of healthy, hyperaemic or slightly inflamed pulps and in selected cases of slight serous pulpitis or chronic hyperplastic pulpitis, where only the surface of the pulp is involved.

It should be confined to young teeth - as in pulp capping - and should be carried out under rubber dam. Pulpotomy is the operation of choice when the root canal is divergent and thus presents a difficulty when root canal filling is attempted. This circumstance prevails in the young, whose anterior teeth are particularly vulnerable to

accidents associated with sports and games.(77)

Grossman(78) says "during development of the root, before the apices have been completely formed, every effort should be made to preserve the vitality of the apical portion of the pulp. Even if only the apical 3 mm or 4 mm of pulp tissue is still vital, the root will go on to complete calcification". When the roots have fully formed, if it appeared that pulpotomy was not successful due to clinical or radiographic evidence - it would seem that root canal therapy would then be a feasible operation.

The ultimate aim in pulpotomy is to remove the bulky coronal pulp tissue which may be infected and to cover the amputated stump with a material which once again will stimulate the formation of dentine - thus forming a dentine bridge between the junction of capping material and pulp tissue.

Technique of pulpotomy:

The tooth is anaesthetised by infiltration or conduction, and the rubber dam is applied, swabbed with an antiseptic agent and the carious dentine is removed with an excavator or a slowly revolving large round bur. The cavity is swabbed with a pledget

of cotton wool impregnated with phenol, dried, and enlarged so that all of the roof of the pulp chamber is removed, thus exposing the complete occlusal (posterior tooth) or linguo-incisal (anterior tooth) portion of the pulp.

Sommer[79] advocates that the amputation of the pulp at the level of the floor of the pulp chamber should be carried out in posterior teeth by the use of a large sterile round bur, (as large as will comfortably fit into the curvature of the pulp chamber) and in anterior teeth the level of the amputation should be approximately one third down the root canal of the developed root, again, using a sterile round bur.

Grossman[80] considers a spoon excavator is preferable to a bur for removing the soft pulp tissue because it allows more accurate control in severing the coronal from the radicular pulp tissue. The auther agrees with this in prineiple but believes that the close confines of the pulp chamber and root canal in anterior teeth precludes the use of anything but a bur in most cases.

After amputation, the pulp chamber is washed with warm, sterile water and dried with cotton wool and any remnants of pulp tissue adhering to the walls

of the chamber are removed with excavators. Haemorrhage is controlled by cotton wool pellets, if necessary, moistened with adrenalin hydrochloride.

A mixture of calcium hydroxide and distilled water is made into a paste and applied as a layer across the amputated surface of the pulp, and a layer of zinc oxide and eugenol cement followed by zinc oxy-phosphate cement to fill the cavity as a temporary restorstion completes the operation.

It is essential that pre-and post-operative radiographs are taken along with further clinical tests and radiographs for a period of two years following pulpotomy. If after one month to six weeks clinical tests are satisfactory, a permanent filling may be placed.

e) Pulpectomy:

This procedure is similar to that which is described in the following discussion relating to the removal of a mature pulp. In the tooth which has a wide, funnel shaped root canal due to incomplete root formation it is always better to carry out one of the previous operations to allow completion of the root formation, and subsequently follow this in

later years by pulp removal if it is then necessary. This of course presupposes the existence of a vital pulp. If necrosis has taken place, the remnants of the pulp are removed with barbed broaches, root canal files and chemical irrigants as discussed later in this review.

d) Extraction:

There are occasions which present where there is no alternative but to extract the tooth, whether it be due to anatomical considerations which contra-indicate root canal therapy, or whether the patient suffers from some debilitating disease which would lower the patient's resistance to extensive and prolonged treatment.(62)(81) The tooth may be the recipient of a blow, with other complications such as oblique root fracture which precludes the satisfactory restoration of the crown even were root therapy possible. In such cases, where extraction is necessary, if the condition of the remainder of the mouth warrants such action, the dentist should restore the gap with a temporary appliance as suggested by Ellis(82) until such time as a permanent restoration such as a fixed bridge may be considered.

2. The Mature Tooth

a) Pulpectomy:

Pulp extirpation and subsequent treatments are operations which must be carried out under strict surgical conditions, thus a strong chain of asepsis must be maintained at all times. Where there is no evidence of periapical involvement the pulp is usually vital although it is reasonable to assume that non vital pulps will be noted with no radiographic evidence of periapical disease. The technique for vital pulpectomy is hereby given:

It is assumed that a periapical X-ray of the tooth is available and the tooth has been prepared for pulp extirpation, all caries having been removed, anaesthesia carried out (infiltration or conduction are the most common[83] and usually the best for pulp removal), and the rubber dam applied. The rubber dam is first scrubbed with alcohol followed by (untinted) tincture of metaphen.[30] The pulp is exposed and the cavity swabbed with beechwood creosote, then adequate access to the root canal is obtained[84] by the use of a flame shaped bur[85] so that a smooth funnel shaped opening is available for the direct passage of instruments into the root canal.

A smooth broach is passed about two thirds of the length of the root canal to examine for any

obstructions, followed by a barbed broach, which is inserted for the same distance, and given a quarter turn so that the barbs may engage the vital pulp tissue and this is then withdrawn from the canal.

In certain conditions where the pulp is known to be infected it is as well to remove only the coronal third of the pulp at the first visit and remove the remainder at subsequent visits.

In such cases, after the coronal third is removed, a dressing of beechwood creosote is sealed into the pulp chamber for 48 hours to control the infection. This prevents the risk of forcing any infected material towards the root apex.

A Kerr number one reamer is measured against the radiograph, and a rubber dam marker is attached to record the approximate tooth length. This is then inserted into the tooth until either the apical constriction is reached or the marker abuts against the incisal or occlusal extremity of the tooth. A periapical radiograph is then taken (this can be done without removing the rubber dam by only releasing the frame) and the "diagnostic wire" is checked against the tooth length.

The canal is then reamed and filled to size and is prepared as discussed in the next chapter.

b) Extraction:

It is unfortunately often necessary to extract a tooth which is endodontically involved. Ostrander[62] states that although a large percentage of teeth can be saved by root canal therapy, by no means 100 per cent of pulpally involved teeth are candidates for endodontic procedures.

The strategic importance of the tooth must be balanced against the patient's willingness to comply with involved and extensive therapy, and this in turn must be weighed against the anatomical operability of the tooth, the condition of the remainder of the oral structures, and the condition of the patient as a whole. It must be said however, that the chances of success with the pulpally involved tooth are much higher than those of the periapically involved tooth. It is regrettable though, that so many patients are willing to bear the pain associated with pulpitis and allow the pulp to become necrotic, thus leading to periapical involvement and the sequelae associated therewith.

B. PERIAPICAL INVOLVEMENT

1. Pulp Extirpation

In cases where the periapical tissues are involved and there is bone rarefaction showing in the roentgenogram, one may assume the presence of a non-vital pulp. Thus the remnants may be removed without anaesthesia.

a) Acute Conditions:

When an acute alveolar abscess is present, the tooth may be stabilised during the mechanical opening into the pulp chamber by a matrix of impression compound positioned labially, or by the use of a loop around the tooth of dental floss, supported by the patient's finger. The lingual or occlusal opening is then made and the accumulated purulent exudate is allowed to discharge. The pulpal remnants if any are removed with a barbed broach, and a loosely rolled pledget of cotton wool is packed into the pulp chamber to prevent the ingress of food debris. The patient is dismissed for a few days to allow the drainage to continue and for the acute symptoms to subside. At the next visit, the rubber dam is applied, and the field is prepared as in the case of a vital pulp, for the reaming and filing of the root canal, and the

subsequent preparation for it to receive a root filling.

b) Chronic Conditions:

The rubber dam is applied as before, and prepared by the use of sterilizing agents, access to the root canal is obtained as in the case of a vital pulpectomy, and the pulp remnants are then able to be removed with a barbed broach. Some (86) prefer to remove only the coronal and middle thirds of the necrotic pulp at the first visit, to prevent forcing infected debris apically, by instrumentation. A dressing is sealed into the canal, and at the second visit, the remainder of the pulp is extirpated.

With the aid of a diagnostic radiograph, the canal is then prepared by mechanical or chemical means for the root canal filling.

2. Extraction

Once again one is faced with the problem of whether the tooth is worth endodontic procedures, and if so whether it is anatomically operable. In teeth with periapical involvement (excepting certain cases of acute apical periodontitis when the pulp is vital, or was vital prior to endodontic procedures being instituted) one presupposes a necrotic pulp. This leads to the question of whether the accessory canals and apical ramifications which are known to be

present in many cases[32] contain necrotic tissue and if so is it possible to remove this by chemical means during the preparation of the root canal? In some instances this is possible, the use of pulp solvents[87] such as chlorinated soda (double strength) being particularly helpful in such cases.

If such lateral and apical branches are cleansed of necrotic tissue is it possible to sterilize these, and later fill them with a sealer? The author has had personal experience of the latter, by the use of the lateral condensation technique of filling root canals as advocated by Sommer.[88] However, there appears to be little control associated with the filling of lateral canals, the successful cases possibly being rather fortunate ones where the root sealing paste was forced into the canal, against the periodontal tissues, by the lateral pressure exerted in the filling technique.

However, if all such canals cannot be cleansed of necrotic tissue, and made sterile, they must form a residual space where tissue fluids may stagnate, and bacteria may survive thus paving the way for tissue damage and thus a failure of the root filling.[62] Thus it would seem that when non-vital teeth present for root canal treatment, a certain degree of skill and experience is necessary to provide the operator

with the ability to decide whether root canal therapy is possible or whether extraction and the replacement of the tooth with a fixed or removable appliance would be a better solution.

There is no doubt however, that endodontic procedures which are carried out where the pulp has been vital prior to the operation, have a better prognosis in the majority of cases than those which follow the removal of a necrotic pulp. This fact must be considered if regard is given to the previously mentioned lateral canals and apical ramifications, and their contents.