The Restoration of the Endodontically Treated Tooth -

A review of the Literature. Supplemented by drawings and photographs of clinical cases taken by the author during operative procedures.

BY

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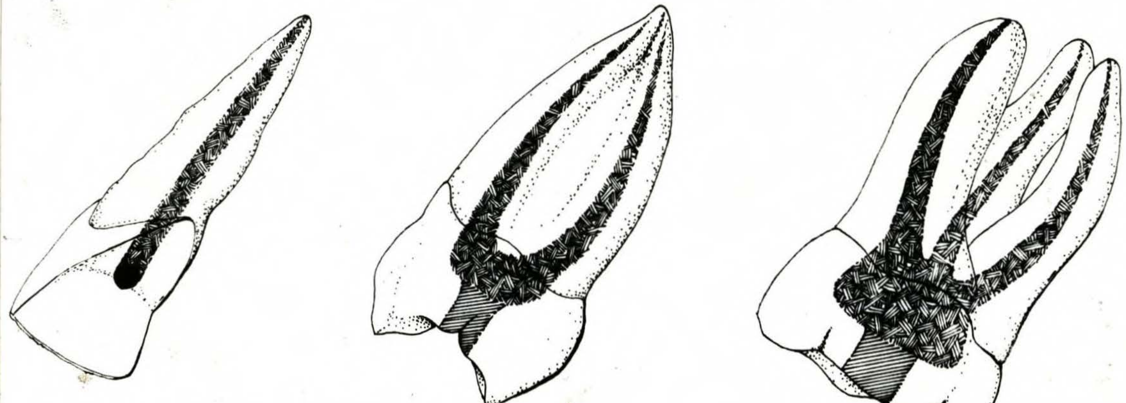

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INTRODUCTION

HISTORICAL PERSPECTIVE

Johnson, Schwartz and Blackwell[1], in a paper published in the Journal of the American Dental Association wrote :

> "Techniques that utilise the pulp chamber for retention in the restoration of teeth with badly broken-down or missing crowns have been used in dentistry for 100 years. In 1869, G.V. Black advocated the use of gold foil to fill the root canal and restore the clinical crown".
> H.W. Arthur in 1897 wrote an article describing the "when, where, and how to use Anchor Screws".

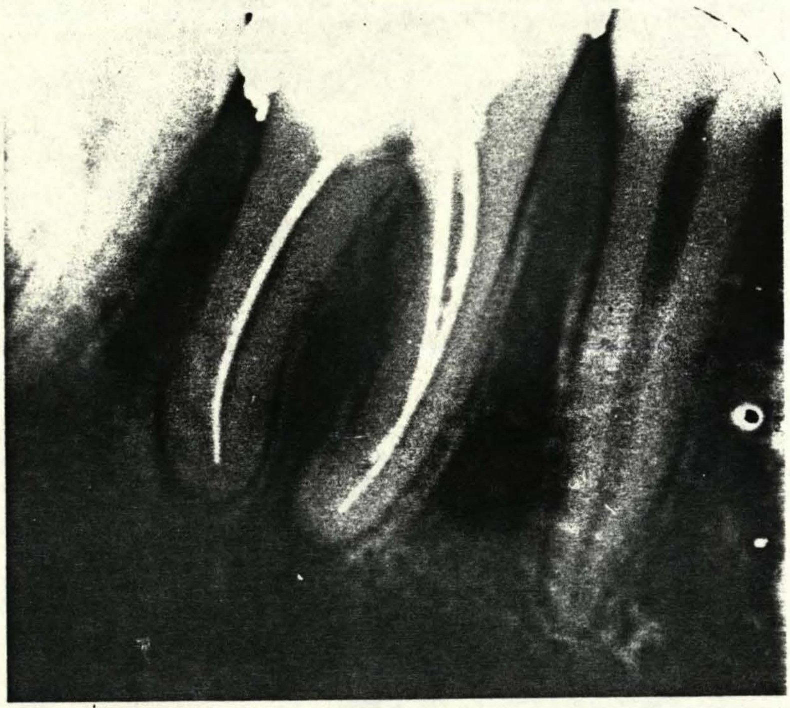
Following on the work of these great pioneers in dentistry several techniques were devised to treat the endodontically treated tooth such as the Richmond and Davis crowns. These particular crowns were used primarily on single rooted teeth.

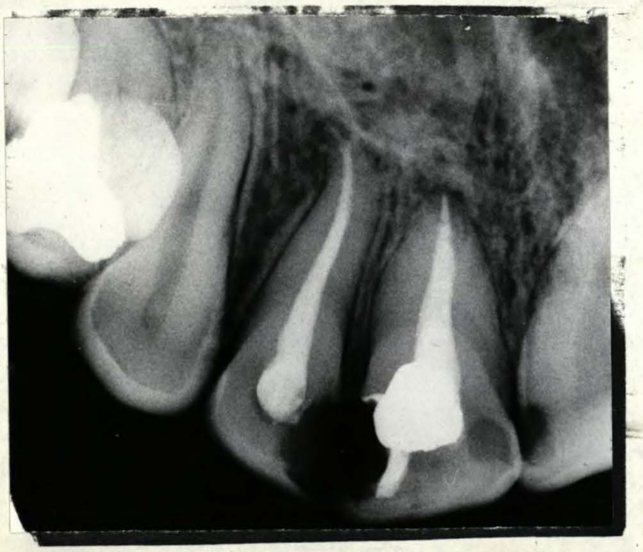
In 1920 Billings and Rosenow introduced the theory of focal infection and all non-vital teeth were condemned to extraction. For close on 30 years endodontic therapy declined but the theory of focal infection was eventually relegated to its proper perspective and since 1950 endodontic procedures, with their high degree of sophistication due to the standardisation of instrument sizes, the biomechanical preparation of the canal, and modern pharmacologic agents have not only become an accepted part of daily dental practice but have a very high success rate[2]. Ingle[2] quotes from a study presented by the University of Washington where over a five year period the success of endodontic therapy was in the region of 95%. The survey embraces both anterior and posterior teeth.

With the success of endodontic therapy has come the development of methods of restoring these teeth to full function, after which they may be preserved for the same duration as the vital teeth. There is no doubt that a normally functioning, endodontically treated, and well-restored tooth is vastly superior to the best prosthetic replacement.

The endodontically treated tooth is today not only restored to preserve function and aesthetics in the mouth, but is also utilised as an abutment for fixed and removable bridgework and as retention for the over denture. (Fig. 1)

(Fig. 1) The Endodontically Treated Tooth.





SCOPE OF THIS STUDY

(i) Object of the Study

In view of the fact that the author has, over a number of years in private practice, restored many endodontically treated teeth and in view of the fact that this treatment is becoming more extensive it was felt that an in-depth survey of all available literature on the subject would be of interest both to the author and any clinician practising this type of restorative dentistry.

(ii) The Field of Study

All literature relevant to the subject that is available in the University of Stellenbosch's Medical and Dental School Library was reviewed, analysed and summarised and incorporated in the text. Furthermore, any methods that have been developed by the author during his practising career have been utilised where necessary. Photographs of clinical cases, taken in the author's surgery have been used to illustrate specific points, as well as illustrations and X-rays.

(iii) Summary

Many books, articles and reviews of this aspect of restorative dentistry have been published. An attempt has been made to correlate all the relevant material in order that a comprehensive review of most of the published literature could be presented under one cover. It is possible that certain aspects have been omitted, this would not have been deliberate but in a review of this nature every published article may not have been attainable.

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CHAPTER 1

THE BIOLOGY OF THE ENDODONTICALLY TREATED TOOTH

The vitality and nourishment of a tooth from which the pulp has been removed depends on the periodontal ligament[1] and therefore, with the removal of the dental pulp and its replacement with a satisfactory root canal filling, the tooth is never classified as a "dead tooth".

Experiments with radio active phosphorus injected into dogs show that mineral metabolism in the dentine of a pulpless tooth still continues, albeit at a much lower rate. However, this difference is much smaller in the root portion than in the crown, as the phosphorus intake of the cementum is not affected by removing the pulp of the tooth.

MOISTURE CONTENT

Healey[2] found that the remaining coronal portion of the treated pulpless tooth apparently is more brittle or fragile than when it contained a vital pulp. This empirical observation is often attributed to decreased moisture content.

Helfer, Melnick and Schilder[3] set up a study to determine the water content of pulpless teeth with the object of shedding some light into this area. The experimental technique involved the extirpation of pulps from dogs' teeth, followed by extraction of these teeth after predetermined time intervals. The determination of moisture loss was accomplished, and the data was plotted against time.

The moisture content in coronal tooth structure is 15,5% (enamel 2,3% and dentine 13,2%). There are two major divisions of water content in calcified tissues,[4] viz. :

(i) the water that resides outside the calcified matrix

(ii) the water within the calcified matrix.

The experiment showed that the calcified tissues of the pulpless teeth contain 9% less moisture than do the calcified tissues of teeth with vital pulps and that more moisture was lost in anterior teeth than in posterior teeth.

MASTICATORY EFFICIENCY

Grossman[1] postulates that while no accurate measurements have been made, clinical observation and experience seem to indicate that there is no difference in masticatory efficiency between a pulpless tooth and a vital tooth and that thermal sensation is reduced in a pulpless tooth or is non-existent, except through the periodontal ligament.

STRENGTH OF ENDODONTICALLY TREATED TEETH

Pulpless teeth are structurally weaker than vital teeth because of

(i) the loss of moisture content

(ii) the preparation of the access cavity, which not only reduces the amount of tooth substance but also weakens the tooth architecturally. The roof of the pulp chamber is arch-shaped, the strongest architectural form known to withstand great pressures and in gaining access to the root canals the arch is destroyed.[3] However, Perel and Muroff[5] make the point that the formation of large access cavities should not be viewed as wanton destruction of tooth structure. These cavities provide the most direct access to the apical foramen and thus facilitate cleaning, shaping, and obturation with a minimum of root perforations, tears, and broken instruments. All unsupported dentine from the roof of the pulp chamber must be removed to establish access for the desired tapered shape. (Fig. 1)

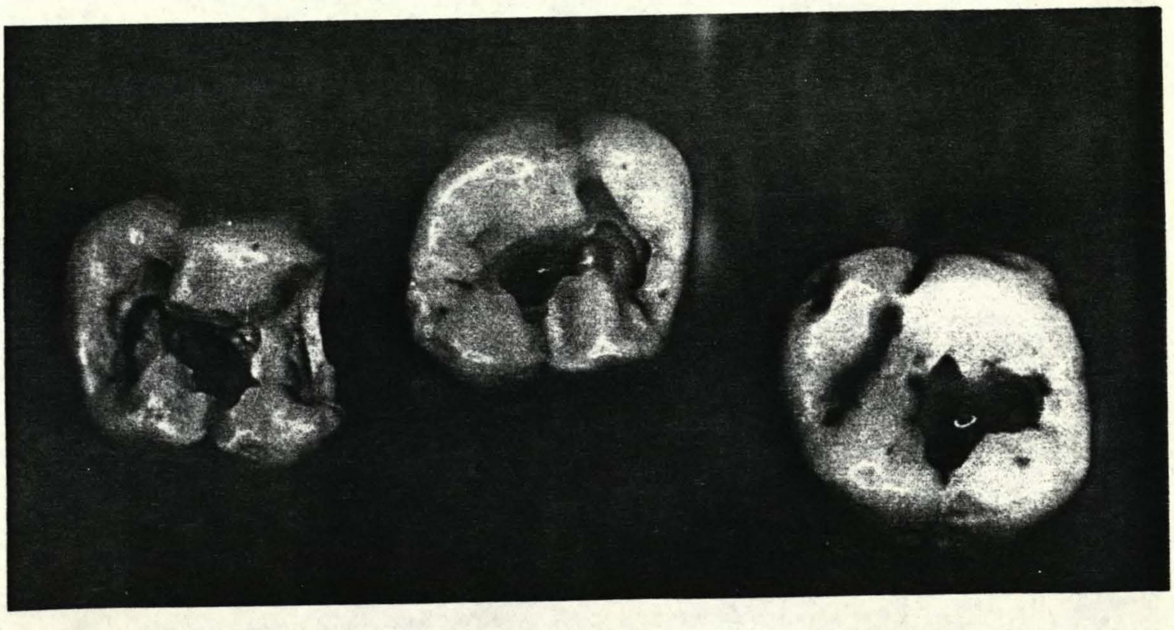
(iii) the use of chelating agents, e.g. ethylenediemine tetra acetic acid (R.C. Prep.)to decalcify dentine where the pulp chambers have become calcified and obliterated. The decalcification decreases tooth strength.

(iv) flaring of the coronal third of the root canal in the gutta perca technique leading to the removal of more dentine and a further weakening of the tooth.

CONCLUSION

Taking all these factors into consideration it is recommended that both anterior and posterior teeth that have been endodontically treated be strengthened prior to restoration in order that they fulfil the functional and aesthetic demands to which they will be subjected.[6]

(Figure 1 : 1)



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CHAPTER 2

PRE-TREATMENT CONSIDERATIONS

Baraban[1] wrote in 1967 that "the basic objective in dealing with an endodontically treated tooth is to restore the tooth to fulfil the functional and aesthetic demands to which it will be subjected". The root canal therapy has saved the tooth and a well chosen restoration reinstates the tooth as a member of the masticatory apparatus. If it is impossible to adequately restore a devitalised tooth to a functioning state after endodontic treatment, there is no reason for such therapy in the first place. However, with the many techniques of restoration available, it is rare that the restoration of such a tooth is found to be impossible if its determined value justifies the effort[2].

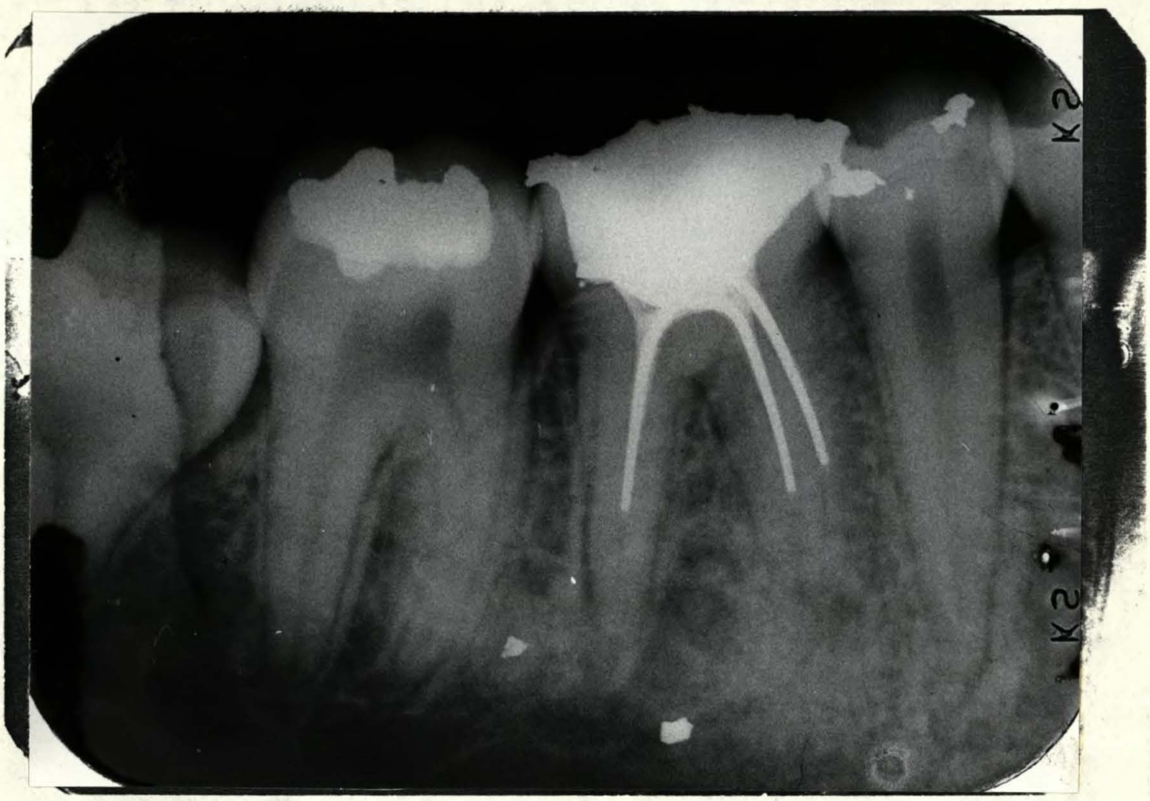
Writing in Dental Clinics of North America, Virgil Lau[3] suggests that a visual and tactile examination must be conducted to evaluate the functional and parafunctional stresses present, the alignment and position of the tooth relative to adjacent teeth, the potential abutment for a prosthesis, and the support of the periodontium.

PRECAUTIONS

It would not be advisable to undertake extensive restorative procedures

(i) where there is any doubt about the success of the root canal treatment. (Figure 2 : 1)

(Figure 2 : 1)



Bender, Seltzer and Saltanoff[4] established criteria for judging the success of endodontic treatment viz :-

(a) an absence of pain or swelling

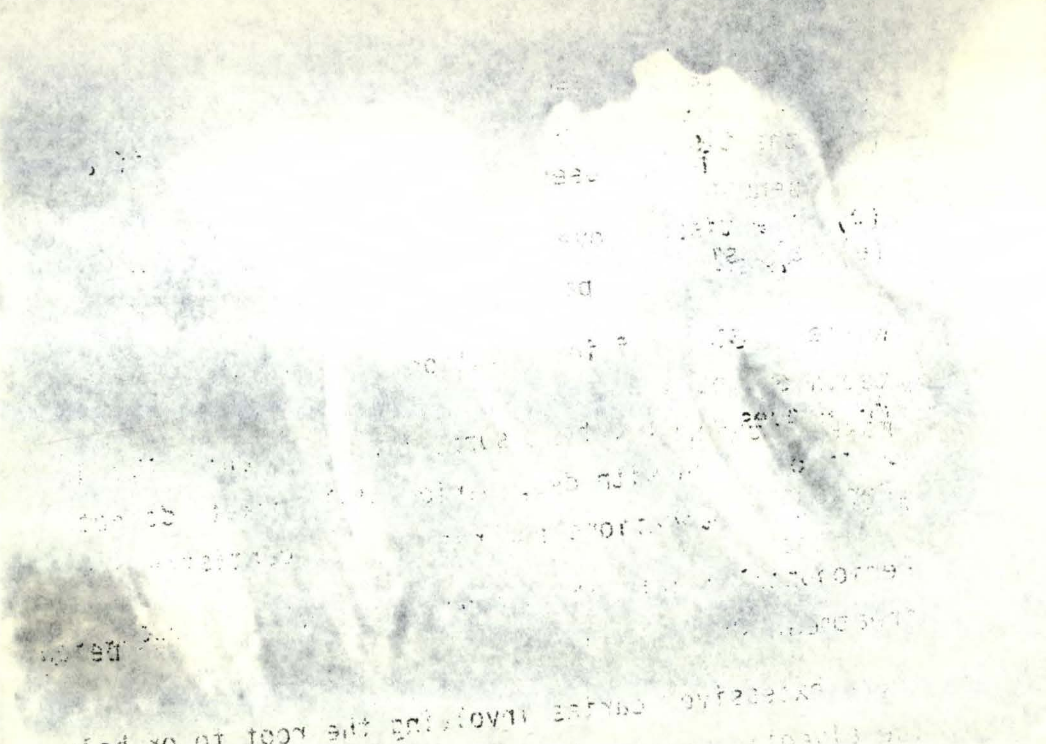
(b) disappearance of a fistula

(c) no evidence of further tissue destruction

(d) radiographic evidence of the eliminated or arrested area of rarefaction after an interval of six months to two years.

In a review of the subject Johnson et al.[5] found that opinions as when to restore the endodontically treated tooth varied from immediately to a waiting period of two years. The criteria as set out by Ingle[6] would seem to be a sound evaluation. He states that the endodontically treated tooth can be restored when

(a) the radiographic evidence shows healing of the periapical area



(b) the tooth is not sensitive to pressure applied from any direction

(c) there is absence of drainage or exudate if a fistula had been present

(d) the tissues over the apical region are not sensitive to palpation

(e) all signs of inflammation are absent.

(ii) where questionable bone support was present. Mobile teeth or teeth with deep periodontal pockets do not make good foundations for restorative dentistry.

Periodontal treatment in conjunction with endodontic treatment should first be carried out

(iii) where excessive caries involving the root to or below the alveolar crest existed

(iv) where the root exhibited a fracture or fractures both vertically or horizontally that would make long term prognosis doubtful.

(v) where occlusal disharmonies exist. These have been directly implicated in the failure of many post crowns and should be corrected prior to restorative treatment.

(vi) where tension and parafunctional habits exist.

TENSION AND PARAFUNCTIONAL HABITS

Hamish Thomson[8] defines parafunction as the contact that exists between the teeth in the empty mouth during the habits of clenching, tapping, grinding or sliding the teeth together. Parafunction as defined by Stallard[8] is any conscious or subconscious act performed by an individual which overrides the protective neurologic mechanisms of the masticatory system.

The chief requirements of healthy muscles are to respond effectively to impulses and to return smoothly to their starting length or resting posture.

Impulses from the higher centres of the brain are the result of interaction between the various centres involved and sometimes the intensity of impulse exceeds the direction. The result may take the form of irrelevant muscle activity and provide an explanation for the parafunctional movements of the mandible in both the waking and sleeping states with clenching or grinding of the teeth.

Five categories of parafunctional activity have been identified.[9]

(i) Psychically motivated, meaning that the parafunctions are of a neurotic nature e.g. bruxism

(ii) Stress motivated, representing exaggerated response to stress, of a concentration often seen during athletic activities or some types of work

(iii) Habitual, associated with ones trade or profession

(iv) Endogenous, arising from systemic diseases such as epilepsy, tetanus, meningitis and other infections.

(v) Excessively compensatory and involuntary and unconsciously exaggerated, representing reactions to occlusal interferences and to disturbances of various kinds.

In function i.e. mastication, deglutition and speech there are no abnormal stresses or forces on the teeth but in parafunction the forces are of much greater intensity and longer duration and often exerted in a non-axial direction. They can, therefore, result in failure of the restorative procedures and must be corrected prior to restorative treatment.

ORAL HYGIENE

The patient's oral hygiene is of the utmost importance but it is assumed that this is well taken care of as otherwise endodontic treatment would not have been undertaken. A patient must have an adequate dental intelligence quotient in order to undergo restorative treatment.[10] Patients with a high caries rate, who do not improve their oral hygiene with education during preliminary treatment, should not be considered for extensive restorative treatment and/or endodontic treatment.

Once it has been decided that the tooth is functionally stable the decision is then taken on how best to restore the tooth.

FACTORS DETERMINING TYPE OF RESTORATION

(i) The amount of remaining crown standing

(ii) The position of the tooth in the arch

(iii) The forces that the tooth will be subjected to

(iv) The requirements of the tooth, i.e. is it to be a single unit or to be used as an abutment tooth in a fixed prosthesis or for a partial removable prosthesis.

(v) The aesthetic factors in the mouth will determine the type of restoration to be placed.

At this stage it must be stated that it will not be possible to elaborate on every available method used to restore an endodontically treated tooth but to give coverage to the most common methods used and described in the literature from 1958 to the present day. The wide variations encountered in the restoration of pulpless teeth indicate that a single restorative technique cannot be applied in all cases. A variety of methods may be utilised, depending on the situation that exists.

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CHAPTER 3

PERIODONTAL CONSIDERATIONS

Soft Tissues - Prior to the restoration of any tooth in the mouth, not only in the case of the endodontically treated tooth, the periodontium must be in a good condition. Ramfjord[1] states that the preparation of a tooth and the impression techniques are greatly facilitated by the absence of haemorrhage following careful manipulation of healthy gingival tissues. The unpredictable gingival recession which often follows preparation and impression techniques applied to teeth with periodontal disease can be completely avoided in a healthy gingiva.

Pockets - Bower and Henry[2] note that where gingival architectural abnormalities exist which hinder the patient in plaque control, elimination of these abnormalities must be carried out prior to the final restoration being constructed. This is particularly necessary where pockets of more than 3mm exist and these must be eliminated by either conservative methods such as curretage or by surgery.

Fractures - Where a tooth has fractured subgingivally prior to construction of the post and core, surgical treatment may salvage the remaining root. Bower and Henry[2] recommend the apically repositioned flap procedure which allows excellent access to the margins of both fracture and bone. If the fracture has extended apically to the margin of the alveolar process the bone may be remodelled[3].

PLACEMENT OF PERIPHERAL MARGINS

During the initial treatment of the tooth for the fitting of the post and core the peripheral margin of the tooth or remaining root need not really be considered. However, once the preparation for the superstructure is planned, it is of importance to decide as to whether the margin is to be subgingival or supragingival. Kornfeld[4] states that whenever possible the peripheral margins of the restoration should rest on sound enamel with a definite abrupt bevel and slightly above the gingival margin. These steps prevent gingival irritation and also facilitate accurate marginal adaptation of the restorative material.

Silness[5] presents evidence that the supragingival position of a crown margin is more favourable than a subgingival position but Macphee and Cowley[6] state that there is no general rule with regard to margin placement and that each case has to be treated on its individual merits.

As aesthetics is a most important consideration in restorative dentistry, especially in the anterior section of the mouth, subgingival placement of margins may be necessary. In such instances Ramfjord[7] feels that the margin should be placed in the gingival sulcus $\frac{1}{2}$ - $\frac{3}{4}$ mm under the gingival margin, rather than involving the epithelial attachment which may extend 2 - 3 mm under the gingival margin in a healthy gingiva.

SOFT TISSUE INJURY

During the placement of a bevel or a chamfer on subgingival preparations, the soft tissue may be traumatised. However, as long as these injuries involve only the soft tissues healing without any permanent ill effect will take place. If the preparation is extended apically to the bottom of the epithelial attachment, the injured cementum may become covered by epithelium instead of a regrowth of connective tissue attachment, and the result is likely to be loss of periodontal support.[7] Partial or full separation of the epithelial attachment from the tooth is unavoidable during subgingival preparation, but this is of no periodontal significance if the gingiva is healthy prior to the procedure as the junctional epithelium will reattach to the tooth surface within one week.

Periodontal considerations with regard to retraction methods and materials used in post, core and superstructure and their effect on the periodontium are discussed in the appropriate chapters.

EXTRUSION OF ENDODONTICALLY TREATED TEETH

Horizontal or oblique root fractures extending below the alveolar crest preclude the restoration of the root. They may be overcome by the extrusion of the root with the use of elastic bands attached to a labial arch wire on adjacent teeth. A method is described for anterior teeth using orthodontic wire in the root canal from which an elastic band is attached to the round orthodontic wire etched to the adjacent teeth, creating vertical movement[8].

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CHAPTER 4

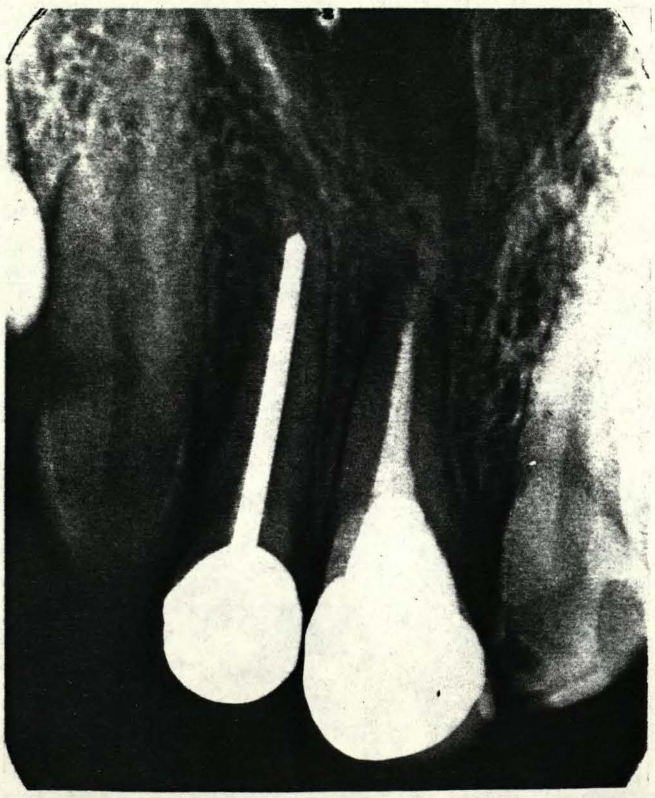
POSTS (DOWELS) AND CORES

- A Discussion and description of their uses.

Once the minimum requirements for the restoration of the tooth have been met (see chapter 2), the method by which the tooth will be restored must now be decided.

If the only defect in the crown of an anterior tooth is the access cavity for the endodontic treatment, a simple filling is all that may be needed. However, a pulpless tooth is very prone to fracture, usually at the cervical part of the tooth[1]. Baraban[2] finds that a post in the canal after endodontic treatment is good policy to prevent the possibility of a shearing of the tooth at the gingival line. A post, either cast in gold or a non-precious metal or a prefabricated post should be cemented into the prepared root canal, extending a minimum of one half the length of the root to be effective[2].

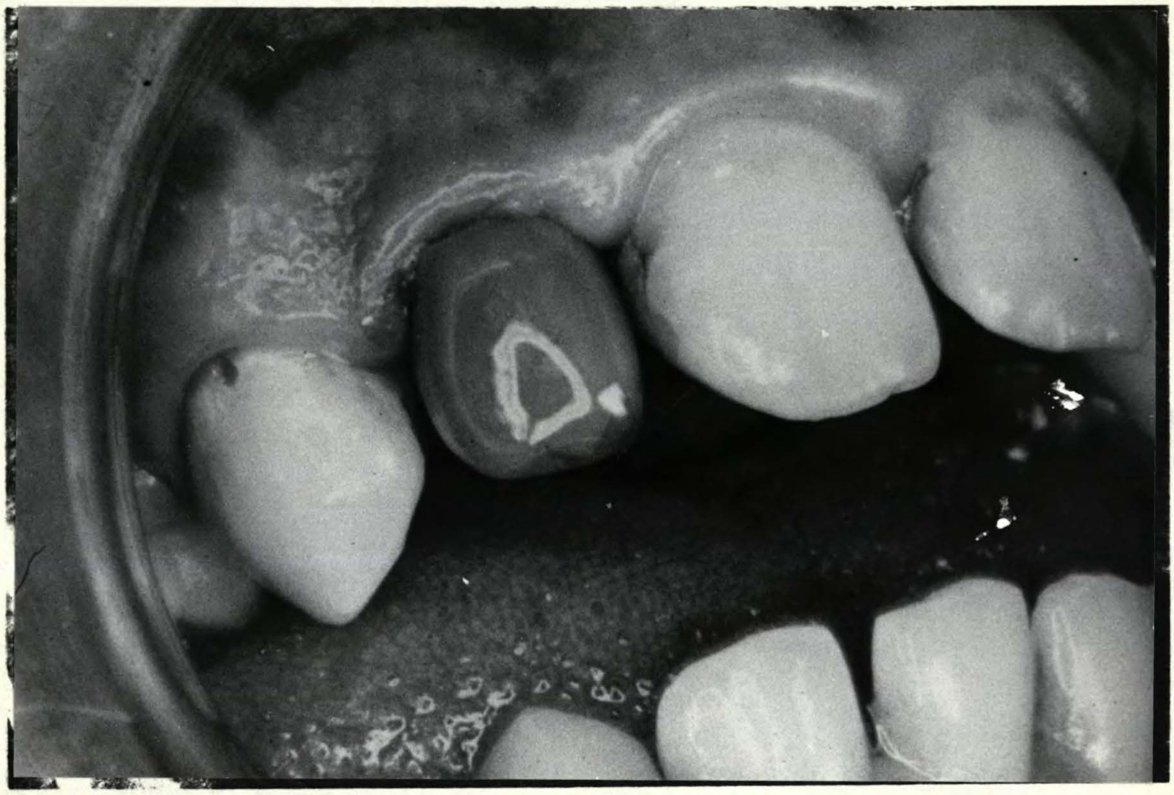
(Figure 4 : 1) Upper lateral incisor with a full-length post.



REMOVAL OF THE CROWN OF THE TOOTH

The crown of a tooth has to be removed, most times up to the gingival level, when it is no longer able to withstand the pressures being exerted on it or when, after endodontic treatment, it has undergone a definite change in appearance because of an altered light refraction due to a more opalescent dentine.

(Figure 4 : 2)



Once removed the tooth is restored with a dowel and core and a crown superstructure[3]. As much sound dentine as possible should be retained at all times.
There are other reasons for removing the remaining crown and rebuilding with a post and core viz :-

(i) where the tooth is subjected to excessive occlusal forces e.g. in bruxism

(ii) where previous restorations or caries leave insufficient dentine to support simple restorations.

(iii) where malaligned teeth may require elective devitalisation followed by post and core preparation to realign the tooth to receive a crown to be placed in the most ideal position for aesthetics and function[4]

(iv) where the non-vital tooth is to be used as an abutment for either a fixed or removable prosthesis and leaving weakened enamel and dentine could lead to failure of the prosthesis at a later date.

(Before the removal of the crown an alginate impression could be taken to assist the laboratory technician and the dentist in the waxing of the full crown[5]).

POST (DOWEL) AND CORE - A Definition

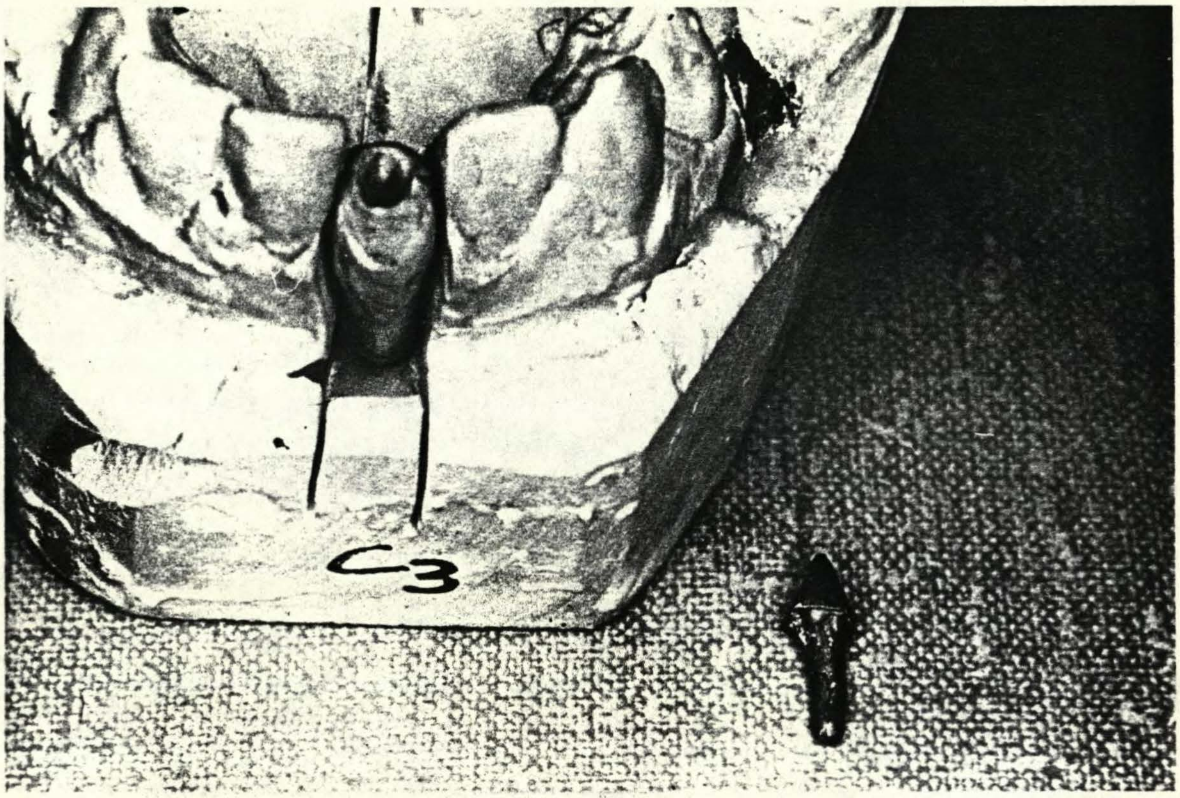
The most common method used for restoring an endodontically treated anterior (single rooted) tooth is by means of a post and core cemented into position and over which the coronal restoration is fitted[6].

The Post (Dowel) is a reinforcement and retention pin that is inserted into the root canal after the mechanical preparation of the canal[3]. See Fig. 4 : 3.

The core is the coronal extension of the dowel over which will be placed the final crown. The core can also take the form of a pin-retained gold casting, a pin-retained amalgam structure, or a pin-retained composite restoration[3]. Amalgam and composites without pins, retained within the remaining walls of posterior teeth may also be utilised as the cores. See fig. 4:3.

A coping is a band of metal that surrounds the root with a ferrule effect. It may be incorporated in the core or formed by the final restoration[3].

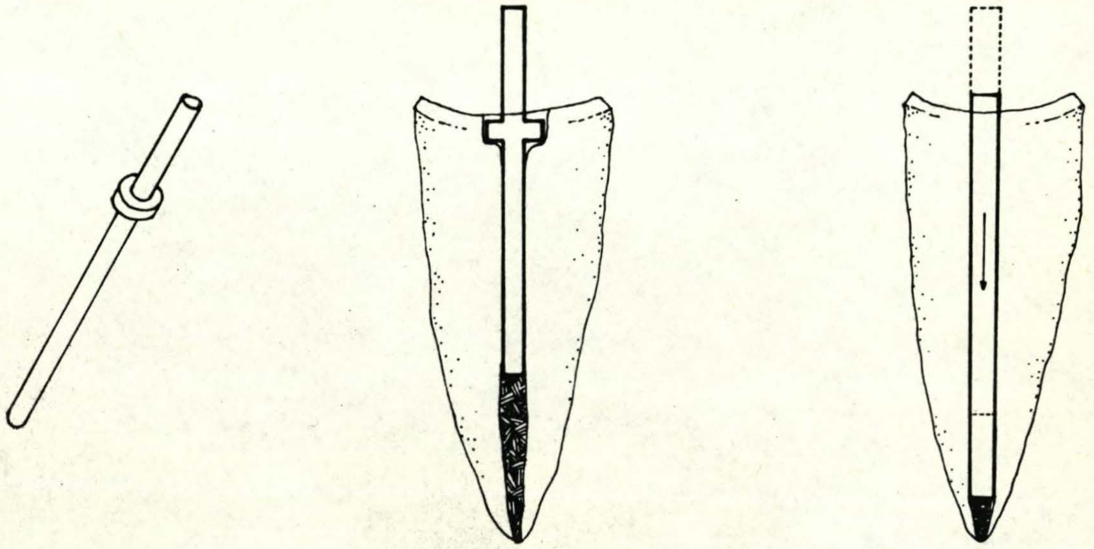
(Figure 4 : 3) Post and core on stone model.



THE POST (DOWEL) - Properties

The post must be long enough to prevent excessive internal stress on the root and of sufficient length and width to provide adequate force transmission from the occlusal surface to the bone and the periodontal tissues supporting the tooth. Posts provide protection from horizontal as well as vertical fractures. Because their insertion and retention in the prepared canal is independent of dentine elasticity, they produce no lateral stress that can crack or fracture the root if they have a positive seat and cannot move apically beyond this seat[7]. See Fig. 4 : 4.

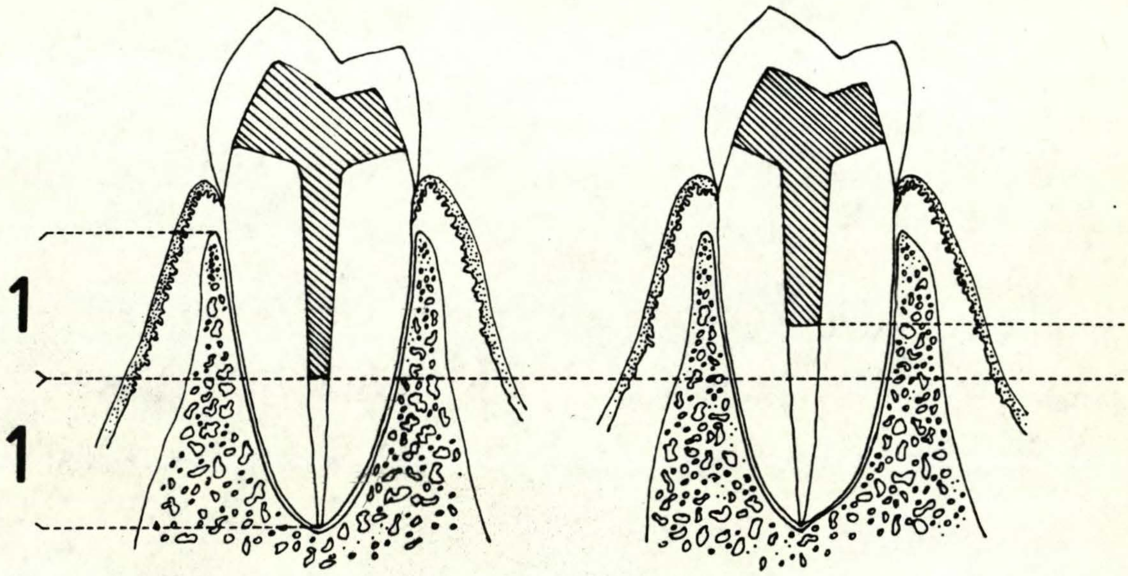
(Figure 4 : 4) Positive occlusal seat.



(i) Position in Relation to Alveolar Bone

The apical extension of the biomechanically prepared dowel should reach a point which lies at least half-way between the apex of the root and the alveolar crest of bone[8]. This compensates for the possibility of the tooth fracturing, as is prone to happen, diagonally from the coronal level to the margin of the supporting bone. See Fig. 4 : 5.

(Figure 4 : 5) Position of post in relation to alveolar bone.

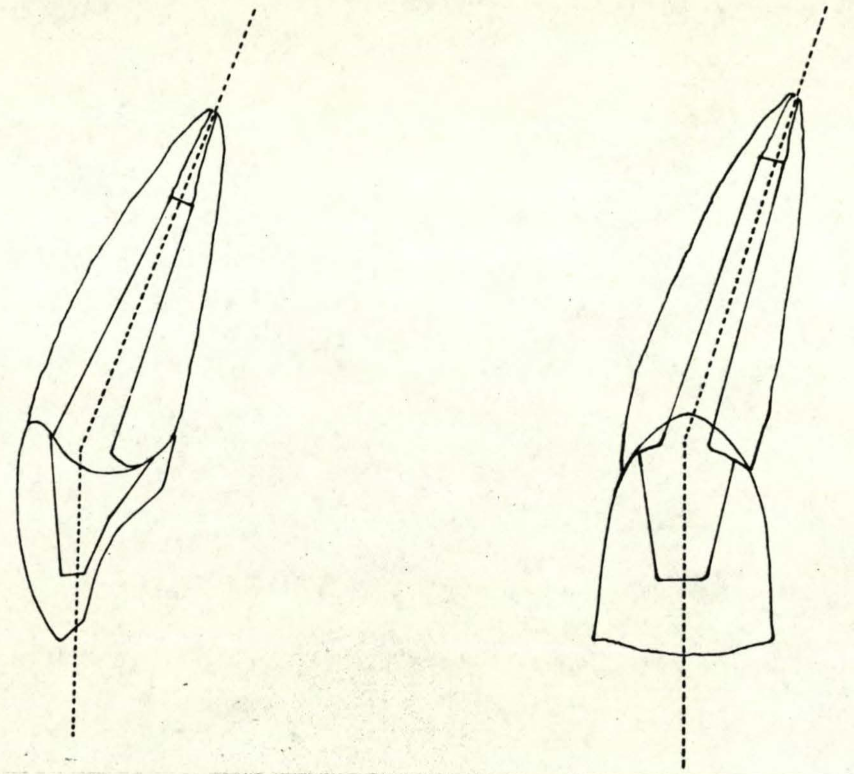


Maximum bone support is utilised for maximum resistance to fracture. Adequate bone support also provides a safety factor against physiologic changes due to age where gingival recession and/or alveolar bone recession may take place.

(ii) <u>Position in Relation to the Root</u>

The post should lie in the direction of the long axis of the root, even if the core may have to deviate from this because of the design of the retainer[9]. See Fig. 4 : 6

(Figure 4 : 6) Post in relation to long axis of the root.

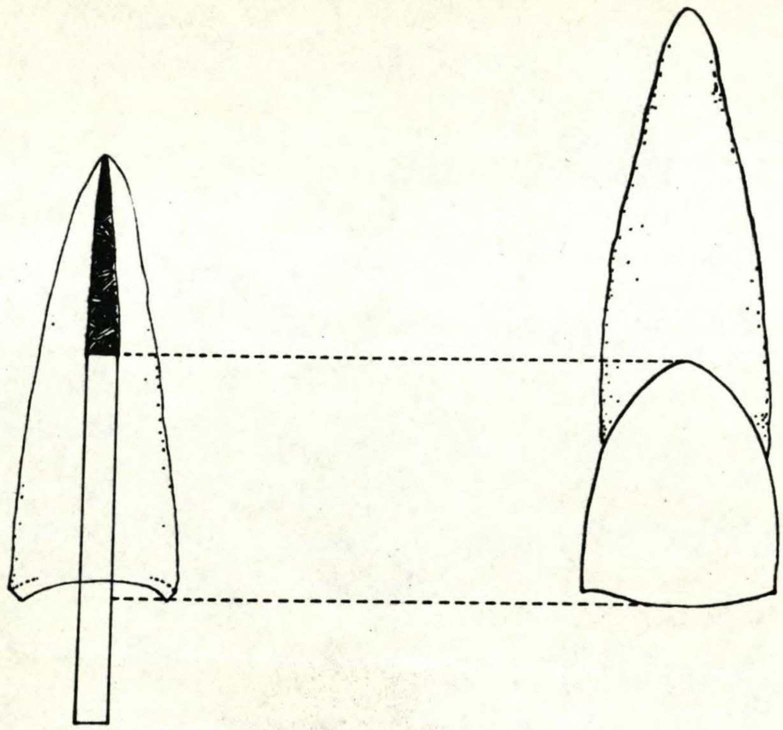


(iii) <u>Length of Post</u>

The length of the post, according to a consensus of opinion in the literature reviewed, should be at least as long as the clinical crown being replaced. Cooper[10] believes that the maximum length attainable is barely enough. Some teeth with large canals will allow a post of three quarter the total root length. Metrick[11] advocated filling the root canal utilising a precious metal post as an endodontic filling as well as a restorative post and core. This method has not met with popular acclaim. Johnson[12] found that although a post 11 mm long was the most retentive, no significant difference in retention existed between 7 and 9 mm long dowel posts. See Fig. 4 : 7.

The only limiting factor in the length of a post is the requirement of the maintenance of the apical endodontic seal.

(Figure 4 : 7) Post length at least as long as crown.



(iv) <u>Width of Post</u>

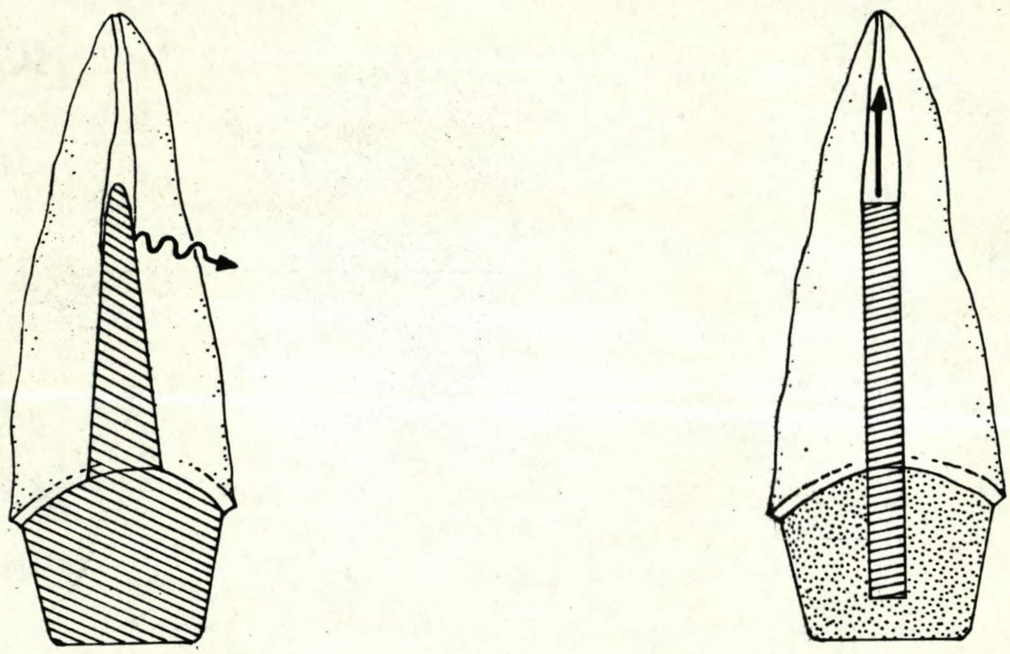
The diameter of the post must be adequate to avoid bending when under pressure[3]. The width is generally governed by the factor that overenlargement of the canal will weaken the root because of the loss of dentine and may result in perforation or fracture. One suggestion has been that the width of the post be one third of the width of the root[13].

Using two posts of different diameters viz. 1.50 mm and 1.7 mm Standlee et al[14] found that these post diameters had no influence on the retentive capacity of the post.

(v) Shape of the Post

Cylindrical posts are more retentive than similarly sized tapered posts[13]. Johnson[12] states that they are 4.5 times more retentive. Cylindrical posts transmit axial forces in line with the long axis of the tooth, whereas the tapered post transmits forces to the walls of the root canal, resulting in wedging, which may split the root. See Fig. 4 : 8.

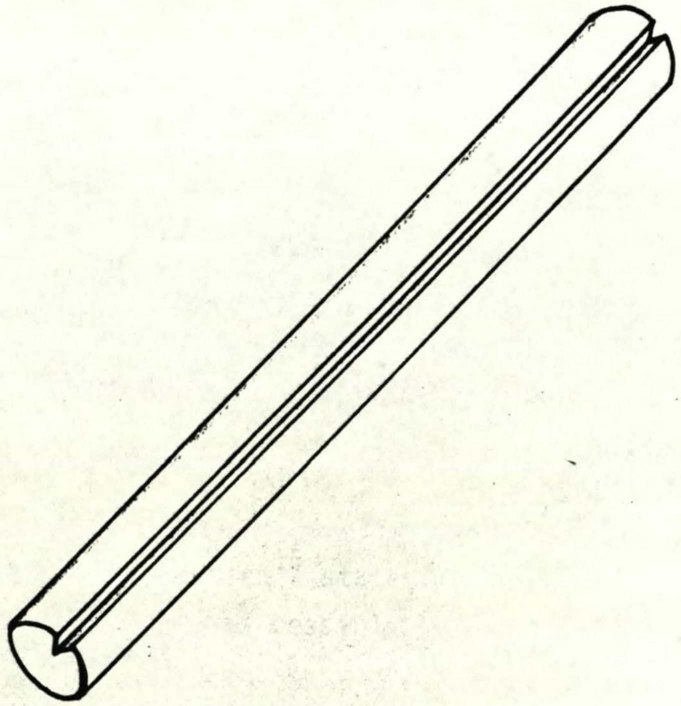
(Figure 4 : 8)



(vi) Post Anatomy

Serrated posts are 30% - 40% more retentive than smooth posts[13]. Cast posts are considered to be smooth[4]. Venting the post, by means of a groove or channel, permits cement to escape when the post is fitted, resulting in complete seating during cementation and a closer fitting post in the root canal[4]. This may be achieved by cutting a groove lengthwise along the post.

(Figure 4 : 9) Vented post.



Some systems supply a post that has been threaded. This is described under Kurer Posts in the appropriate chapter.

Standlee et al.[14] found that the post design had a very definite effect on retentive capacity.

- the tapered post was the least retentive
- the serrated cemented post showed intermediate retentive ability
- the threaded tapped post was extremely retentive.

(vii) Materials Used for Posts

These materials are more fully described in Chapter 14. Suffice to say at this point that wrought gold alloy posts are two to four times stronger than cast gold alloy posts of equal diameter[4].

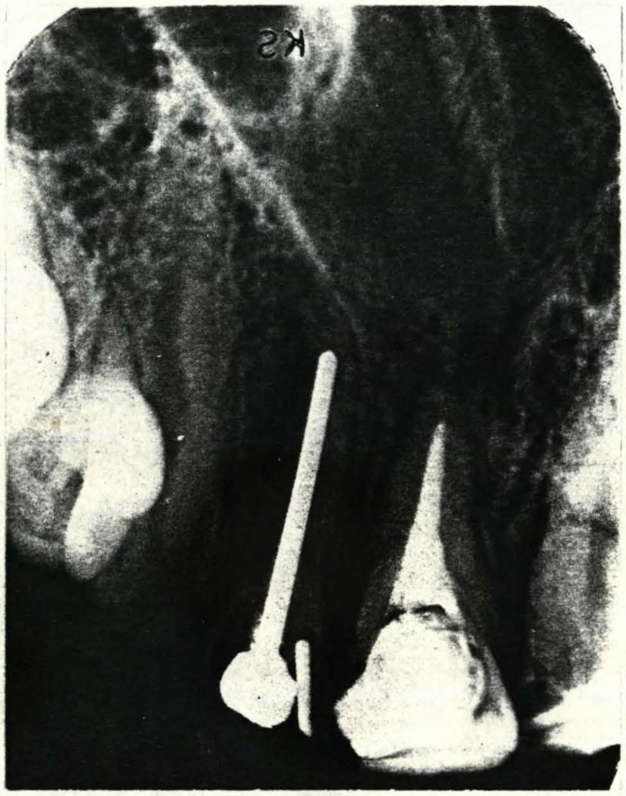
(viii) Adaptation of Post to Canal

Proper internal adaptation of the post will distribute the internal stresses of its circumference as evenly as possible without undue stress at any one place and will allow for only a thin, even layer of cement seal. This compensates for the weaknesses inherent in the cementing medium.

Hirschfeld and Stern[15] state that the post shape should follow as closely as possible the anatomic contours of the root canal both transversely and vertically so as to prevent the danger of perforation, as well as the rotational movement of the post without any additional means, for example a labial groove or a box at the entrance of the root canal. These grooves and boxes invariably tend to weaken the tooth structure.

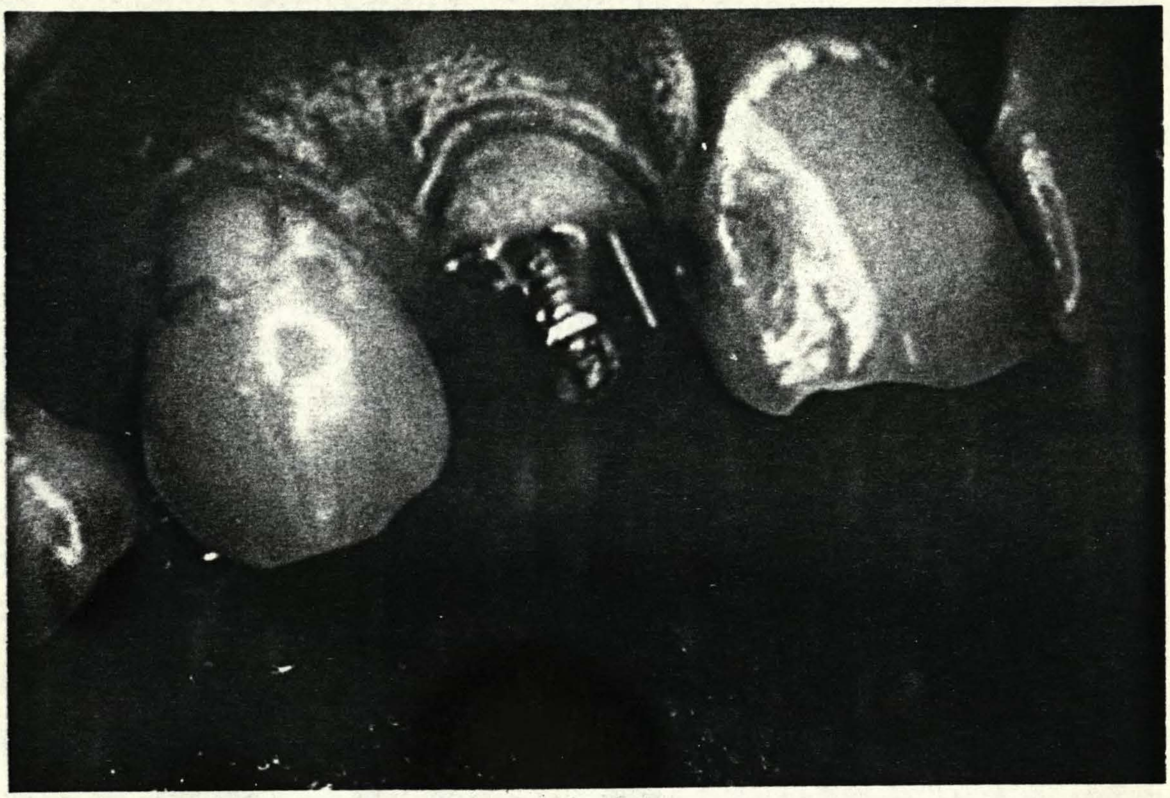
Goldrich[16] has written that in order to prevent a wedge-like action of the post, which could lead to a splitting of the root, a positive occlusal seat must be incorporated in the design. This should be in the shape of a flat surface perpendicular to the root axis and its function is to prevent the post from entering the canal beyond the predetermined level. These grooves and notches must be carefully placed as they tend to concentrate forces which lead to fracturing of the root[10].

(Figure 4 : 10) Well adapted post.



Preparation of the post canal should avoid the round configuration in order to provide rotational resistance. However, in the Parapost system the canal is prepared with a round configuration but anti-rotational pins are placed alongside the post[4], which also increase retention and lateral stability. See Fig. 4 : 11.

(Figure 4 : 11) Parapost with anti-rotational pin.



THE CORE

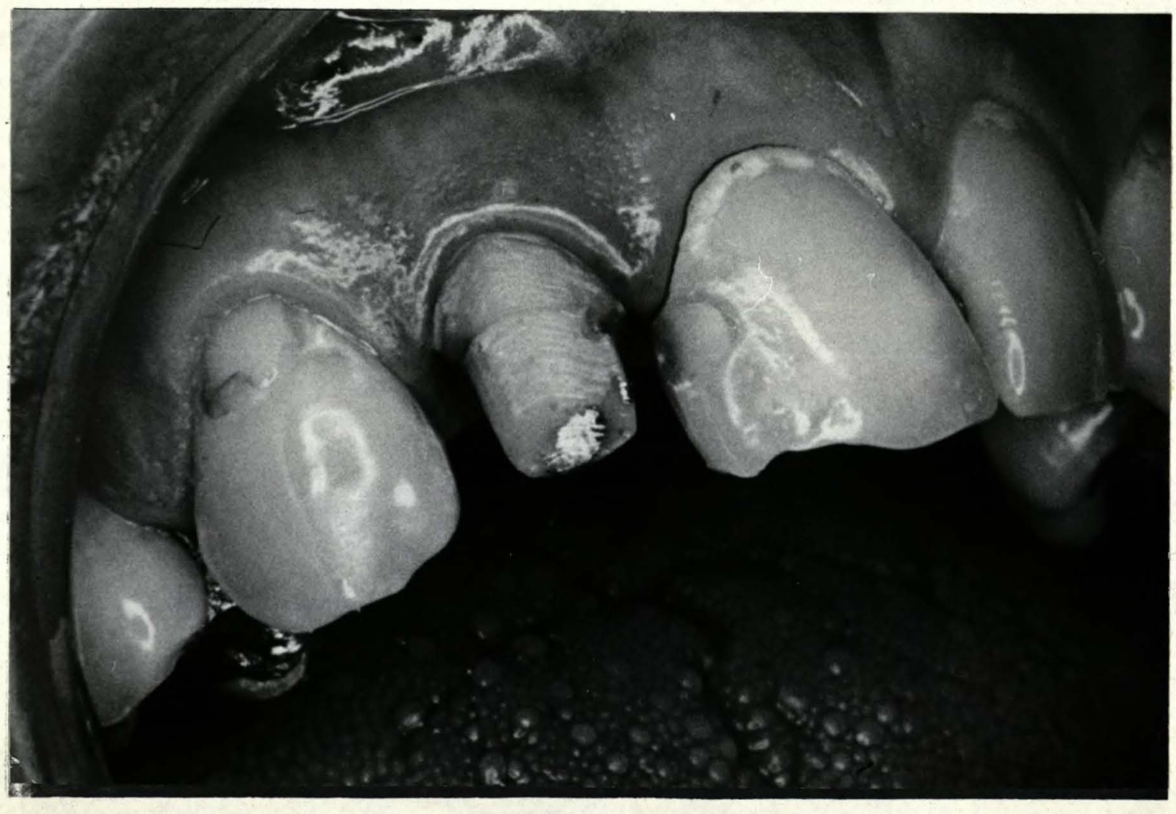
This must assume various shapes depending upon the amount of sound, solid dentine which is present coronally. The coronal portion of the tooth need not be completely eliminated in order to be replaced by a cast core. The core should replace only that missing tooth structure which, because of decay, fracture, or inherent weakness has to be cut away ——— most important. Core build-up whether with anchored pins or posts must be engineered to resist rotational and lateral stresses.

The core should be shaped so that the axial walls have angles of 2.5^{o} - 6.5^{o} and should be symmetrical mesially - distally[17]. The labial and palatal walls should be prepared with no more than a 10^{o} taper to each other[18]. Sharp angles must be avoided and there must be sufficient clearance for placement of the superstructure. See Fig. 4 : 12 and 4 : 13.

(Figure 4 : 12)

CORE SHAPES

(Figure 4 : 13)



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CHAPTER 5

PREPARATION OF THE TOOTH FOR THE FITTING OF A POST

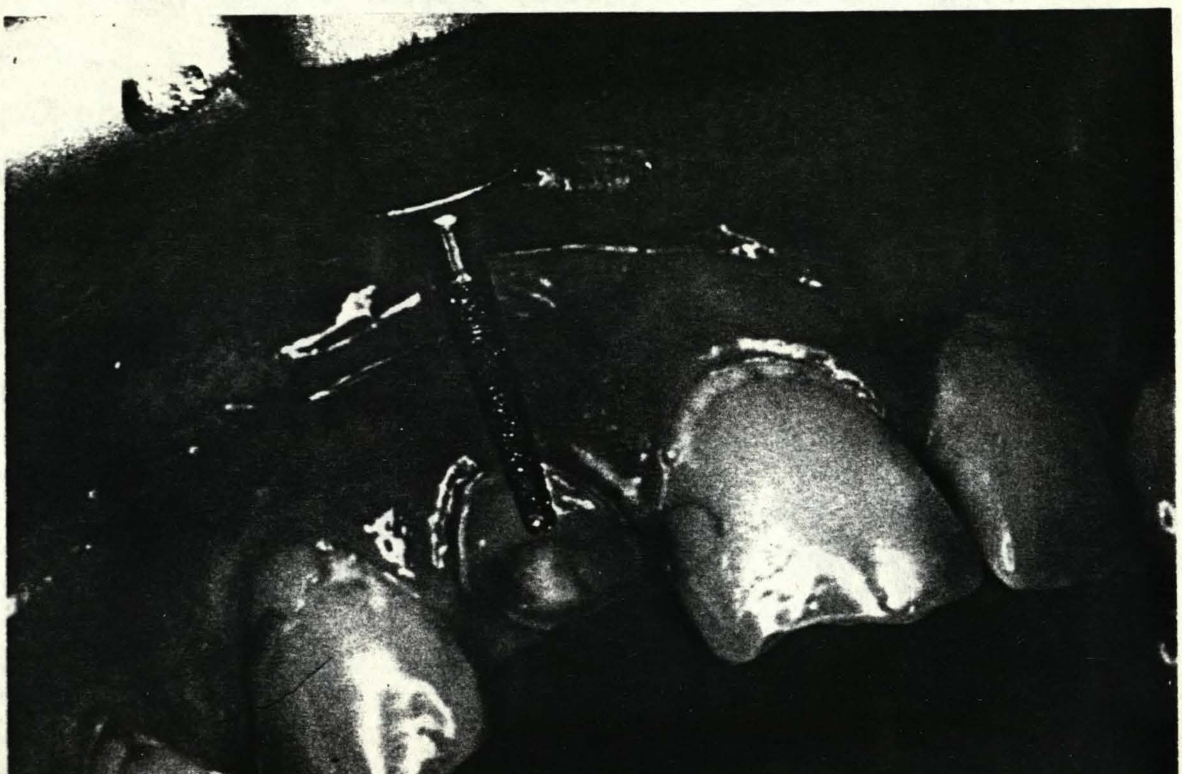
When preparing the root canal it is essential to keep in mind the lowered mechanical resistance of the endodontically treated tooth[1].

The burs referred to are of the Horico series with their appropriate numbers.

CORONAL SECTION

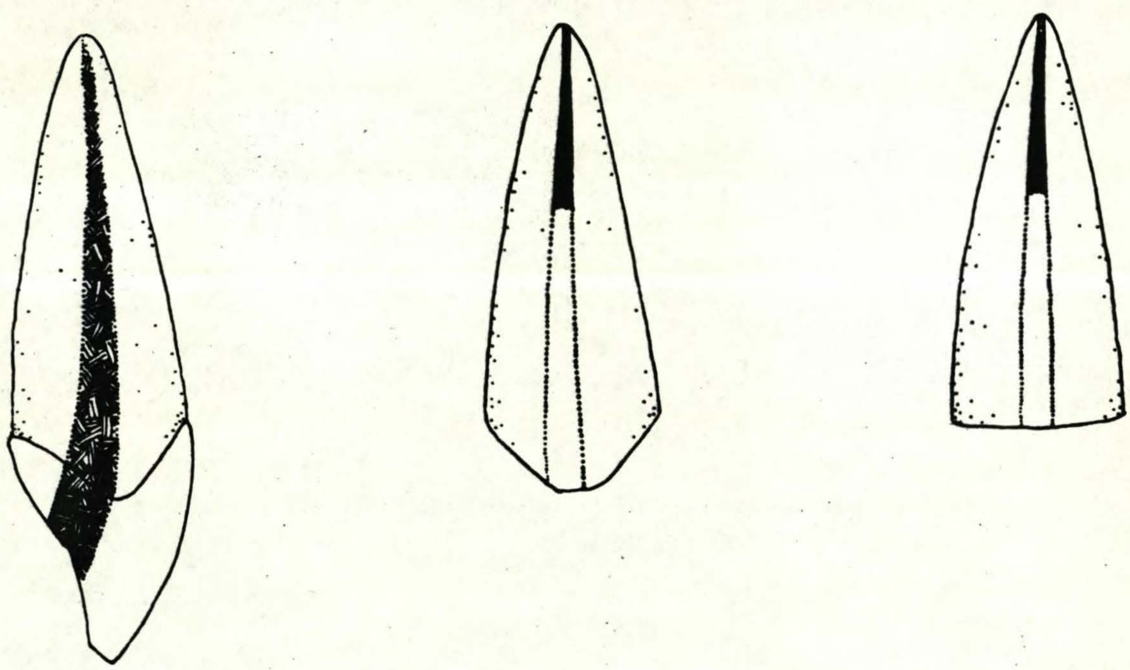
The major portion of the crown that is to be removed is executed with a #297/016 fissured diamond bur in the high speed handpiece. 2 - 3 mm of sound dentine should be left supragingivally where possible. Caries, weakened dentine, or fractured dentine may not allow for supragingival margins and a subgingival margin is then necessary.

(Figure 5 : 1) Removal of Crown.



Once the remaining crown is removed the root surface must now be shaped. It should not be entirely flat but shaped in two planes, one towards the labial and one towards the palatal, giving the root surface a labio-palatal convexity. This aids in the resistance to displacement and prevents injury to the interdental tissue[2]. The degree of slope on the labial and palatal faces will be largely dictated by the contour of the gingiva of the individual patient, and the ridge between the labial and palatal faces of the preparation should be slightly rounded to prevent difficulties in seating the casting due to slight casting faults in otherwise acute angles[3]. See Fig. 5 : 2.

(Figure 5 : 2) Correct and incorrect contours.



When preparing the interstitial margins great care should be taken not to traumatise the tissue as this can lead to labial recession[4]. The anatomy of the cemento-enamel junction is important to follow, with its rise and fall from labial to interstitial and back to lingual. Whenever possible, external cavosurface bevels should be placed so that the final casting will provide a degree of resistance form to prevent tooth fracture[5].

THE ROOT CANAL

The removal of the gutta percha root filling is performed with great caution to prevent perforation of the root canal. Cooper[6] states that accidental perforation of the root canal or a disturbance of the apical seal is usually caused by a lack of care and can lead to the loss of the tooth. Perforations, when they occur, require surgical repair where possible as they will otherwise create a periodontal problem[7]. They also result in a weakened root structure and can lead to fractures[7].

Bower and Henry[8] discuss the methods whereby a root perforation can be repaired and conclude that a full thickness mucoperiosteal flap be raised, the perforation located and the area repaired using an amalgam alloy.

Sinai[9] presents five treatment approaches to a perforation viz :

(i) Using gutta-percha and a solvent as the root filling and

(ii) Sealing with amalgam via the pulp chamber, but this technique is not advisable

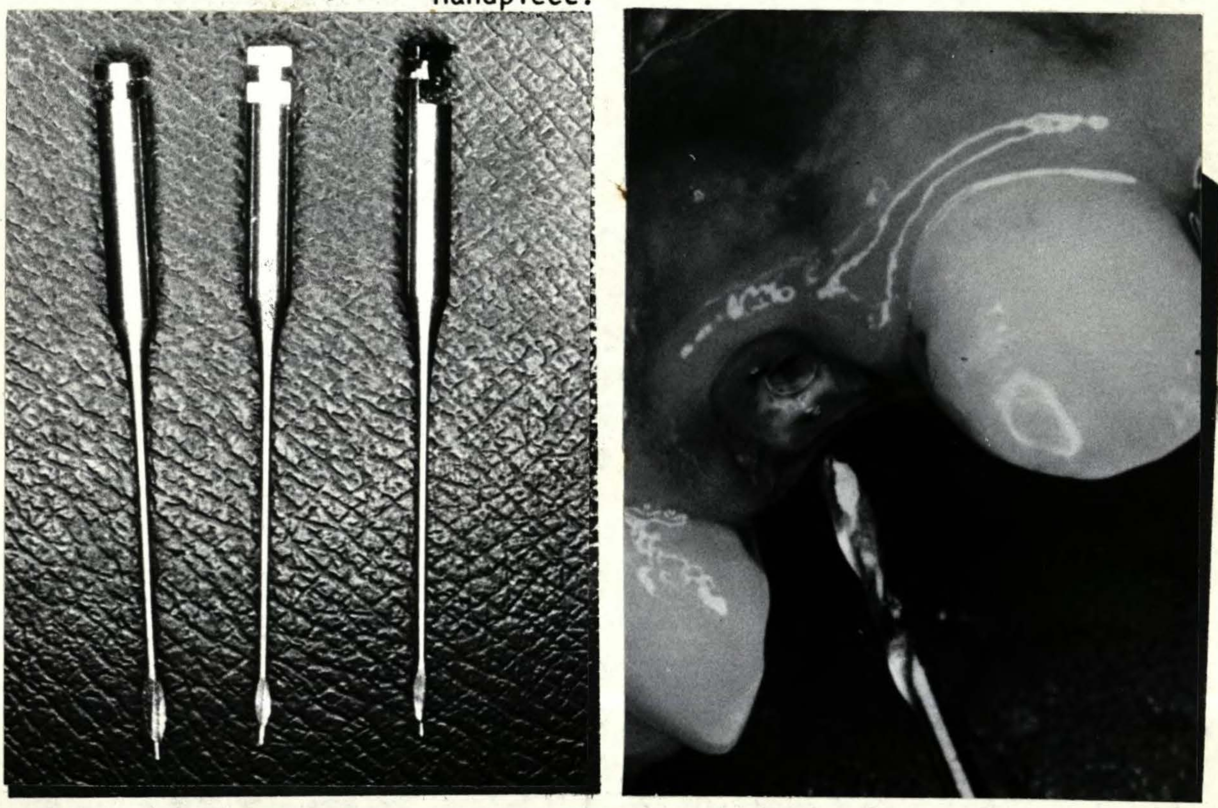
(iii) Using amalgam with a surgical approach. If the approach via the pulp chamber is not feasible, the post can be prepared and cemented short of the perforation and the perforation can then be approached using a flap procedure and sealed with amalgam. There is then little likelihood of disturbing the cemented post.

(iv) Calcium hydroxide used to stimulate calcification to close the perforation.

(v) Finally, if these methods cannot be instituted or found to be unsuccessful, apicectomy, root amputation or hemisectioning may have to be resorted to.

Technique. The initial removal of the root filling is performed with a Gates-Glidden or a Peezo bur, used at a slow speed, starting with a #1 size bur, carried to its full depth, and gradually increasing to the larger sizes[10]. See Fig. 5 : 3.

(Figure 5 : 3) Gates-Glidden Burs and Peezo reamer in Handpiece.



A #246 fissured diamond bur in the high speed handpiece, using direct vision with delicate feel can be used, but, because of the dangers of perforation, should be left in the hands of the experienced operator. When using this technique the preparation is started with a #2 round bur at the slow speed. Gutman[7] feels that the use of high-speed cutting instruments within the root canal should be avoided as they cause irregular gouging of the dentine, which can create an unnatural angulation or root perforation.

Kahn and Malone[11] recommend that only a heated instrument e.g. endodontic pluggers, spreaders or probes, be used to remove the gutta percha, followed by hand-reamers to serially widen the canal. These reamers should be pre-measured to the proper depth with a rubber stop and used with a reaming action. In this way the apical seal will not be disturbed or the root canal be perforated. Gutman[7] states that the insertion of the hot instrument to the desired depth removes most of the coronal filling material, directs minimal apical pressure, and maintains the apical seal. Excessive pressure could force the filling material beyond the apex, expecially in large canals, thereby affecting the apical seal. Schnell[12] investigated the effect of using hot endodontic pluggers for removal of gutta percha on the apical seal and found that the immediate preparation of the post space had no effect on the apical seal. He added that the chloropercha technique itself showed evidence of very high leakage when used to fill the root canal.

REMOVAL OF SILVER POINTS

Where a silver point has been used to fill the root canal a round bur of a diameter similar to that of the silver point is used in an ultraspeed handpiece, provided the operator has excellent and constant visual access, and uses extreme care so as not to perforate the root. Once the point has been removed to the proper depth, the canal is tapered with an extra-long-shank bur or diamond stone with the handpiece operated well below maximum speed. It is desirable to have the tooth isolated with a rubber dam so that if the point is inadvertently loosened, the canal may be refilled without delay.

SHAPE OF CANAL

The shape of the dowel should follow, as closely as possible the anatomic contour of the root canal[1]. The root canal is centrally located in the root and its internal contour approximates the exterior contour of the tooth. Vertically, the root canal tapers towards the apex.

The initial canal length having been drilled with the Peezo reamers, drills as used in the Para-Post[7] system, are now employed to complete the preparation. These drills may be used in a contra-angle handpiece or a straight handpiece. Up to 16 mm of drill is available.

These drills have

(a) a spiral flute designed for efficient elimination of debris,

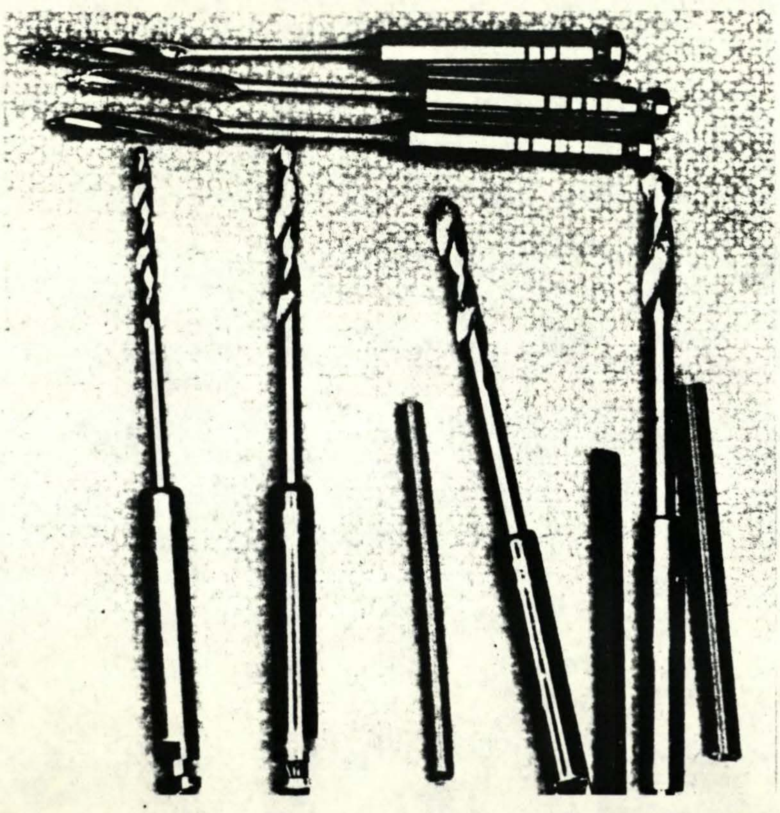
(b) a reverse taper on the flute to permit frictionless drilling as an aid for debris removal,

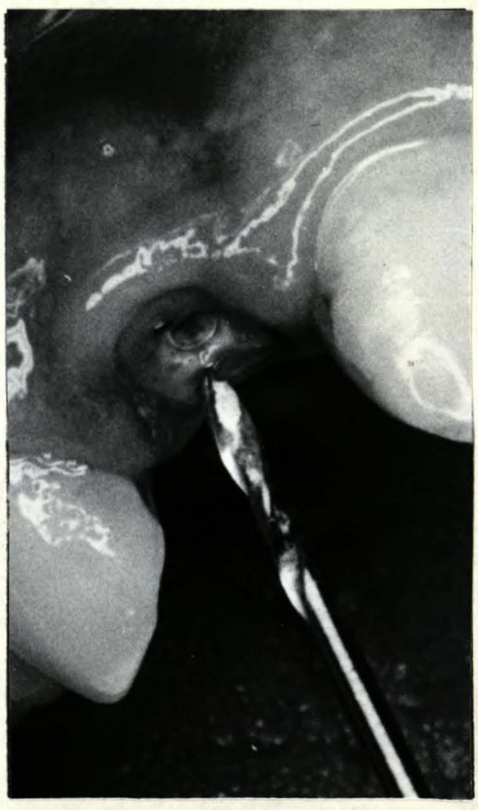
(c) a modified safe tip design, which reduces the chance of perforating the root canal,

(d) colour-code shades to facilitate selection of sizes as follows :-

0,9 mm	(.036")	brown
1,0 mm	(.040")	yellow
1,25mm	(.050")	red
1,5 mm	(.060")	black
1,75mm	(.070")	green

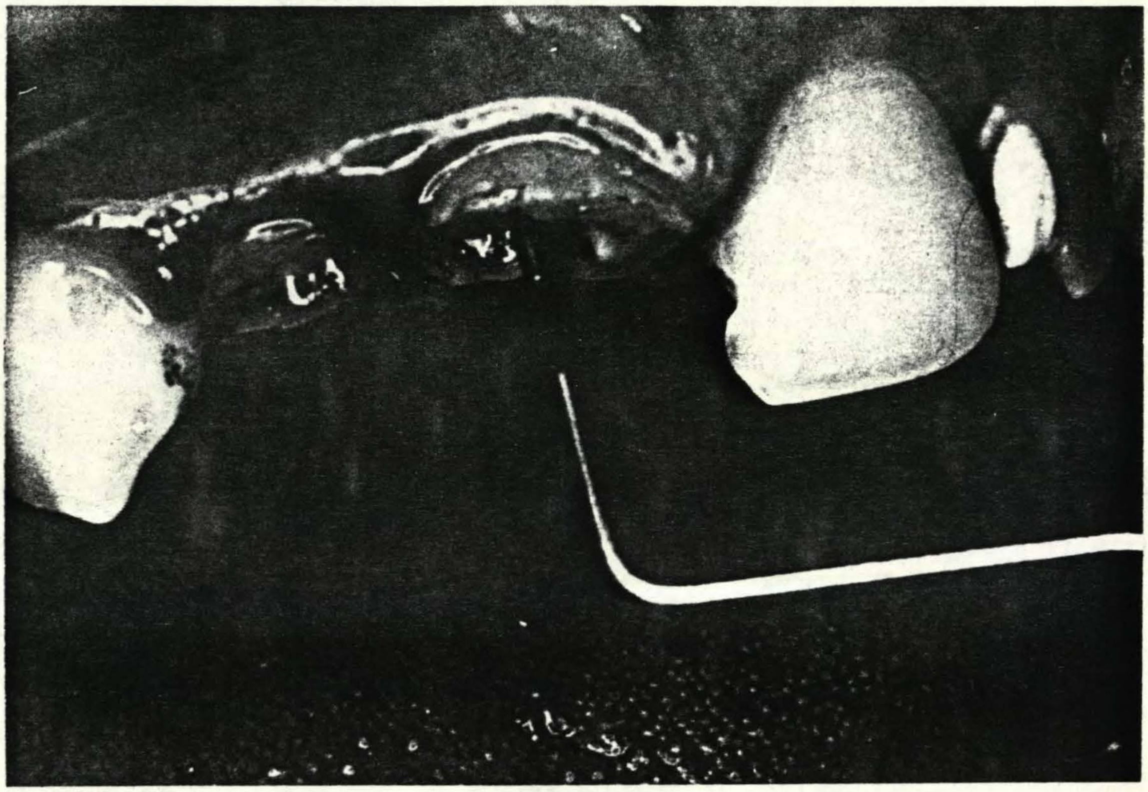
(Figure 5 : 4) Parapost drills, Peezo reamers with drill in canal.





The use of fibre optic lights assist in the evaluation of the post-hole.
The total length of the hole should be checked to ensure that retention of the apical seal and maximum length have been achieved. A Hu-Friedy periodontal probe is useful for this procedure as well as X-rays.

(Figure 5 : 5) Periodontal probe in canal.



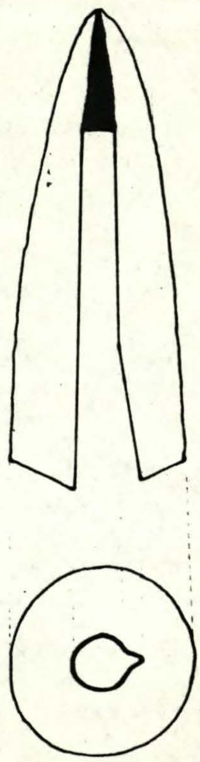
Successively larger drills are used until the optimum size for the particular root canal is reached. The walls of the post-hole may be planed smooth with minimal rotational speed using a cylindrical diamond stone of sufficient length to reach the full depth. This eliminates minor undercuts.

Shelby[13] writes that if the canal is round provision must be made to prevent rotation of the post, with eventual loosening of the post and splitting of the root. This is provided by placing an additional groove, notch, or countersunk portion of the post. These should always be placed in line in the same direction as the greatest force exerted on the post and not perpendicular to it. If the force is in a linguo-labial direction, as on an upper incisor, the countersunk portion should be placed on the lingual side. When these additional prepared areas are placed across the line of stress, they act to weaken the root by serving as wedges to help create cleavage and fracture of the root. See Fig. 5 : 6.

These anti-rotational notches should not be deeper than 1 mm as a deep notch may encourage longitudinal splitting of the root[3]. A notch should not be necessary if some other anti-rotational factor is present - for example if the root canal is oval in section.

The blending of the cervical areas into the canal opening with rounded bevels reduces the possibility of small fractures of weakened dentine. The final finish line with bevels and chamfers may be completed with a # 242 flame-shaped finishing bur, thus assuring a smooth finish line easily reproducible by impression techniques[6].

(Figure 5 : 6) Anti-rotational notch.



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CHAPTER 6

THE POST AND CORE IMPRESSION TECHNIQUES

1. DIRECT IMPRESSION

Casting wax or specific cold-curing Acrylic Resins such as Resincap or Duralay are used to record the impression of the post and core in the mouth. This technique is usually limited to the anterior teeth because of accessibility and ease of operation.

The acrylic materials are preferred by some researchers who find that a more precise and better fitting casting can be obtained than when wax is used[1]. This might be due to a decreased possibility of distortion between the formation and investment phase of the procedure[2]. Eissman and Radke[3] state that wax can be manipulated in the mouth with greater ease than resin. The author's experience of the two materials does not necessarily correspond with this view and although wax can be manipulated in the anterior segment of the mouth with little difficulty, preference to the resin is given as it can be more readily shaped to resemble the final casting and hence save time in the fitting of the post and core.

(i) Procedure With Wax - See Fig. 6 : 1.

(a) The root canal must be well lubricated. A thin oil, used for highspeed handpiece lubrication, is conveyed to the canal on a cotton pledget or paper point.

(b) The wax is heated in a bunsen burner or spirit lamp and rolled into a thin section which is then placed in the root canal.

(c) Here it is compressed with a flat plastic instrument or an amalgam plugger or similar instrument.

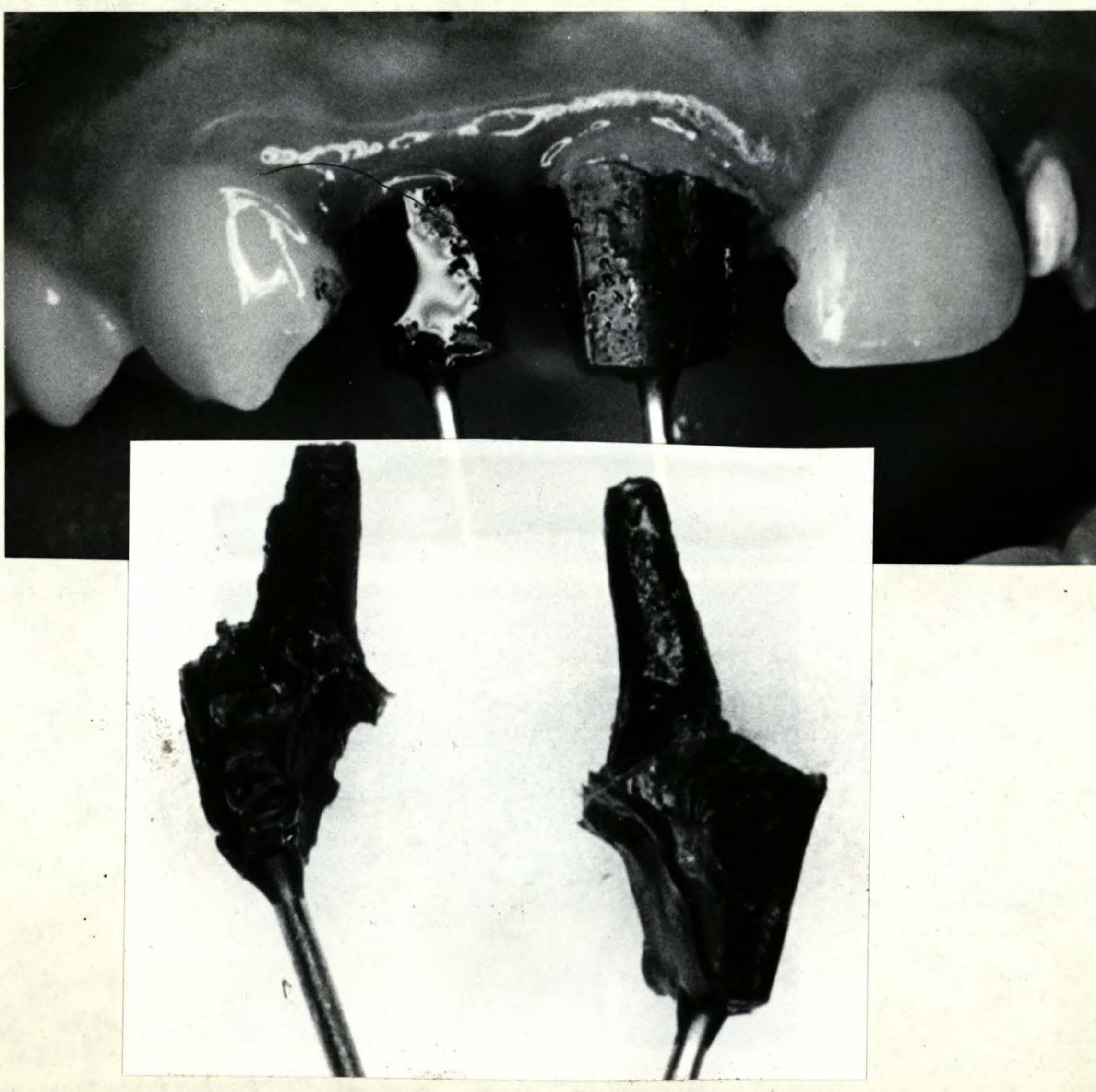
(d) A thin pre-cut steel pin is heated and placed in the root canal or the wax is first heated in the canal and a plastic pin inserted.

(e) Onto either pin more wax is added and a core built up and contoured.

(f) The two parts now fuse and are withdrawn and ready for casting.

N.B. - When using wax it is advisable to protect the tongue and lower lip with a gauze square so that the hot wax will not burn the patient.

(Figure 6 : 1) Wax procedure.



(ii) <u>Procedure With Acrylic</u> - See Fig. 6 : 2.

(a) A prefabricated plastic casting sprue is adapted to fit loosely in the root canal.

(b) The occlusal end is shortened to the occlusal level of the adjacent teeth.

(c) The canal is now lubricated with a specially supplied lubricant.

(d) The cold-curing acrylic resin is mixed, and in a high flow consistency, is inserted into a jiffy tube.

(e) The narrow end of the jiffy tube is placed in the canal and by squeezing the tube the material is pushed up into the canal.

(f) The plastic pin is now inserted and carries the acrylic resin with it. This pin should be notched at a number of spots to aid retention.

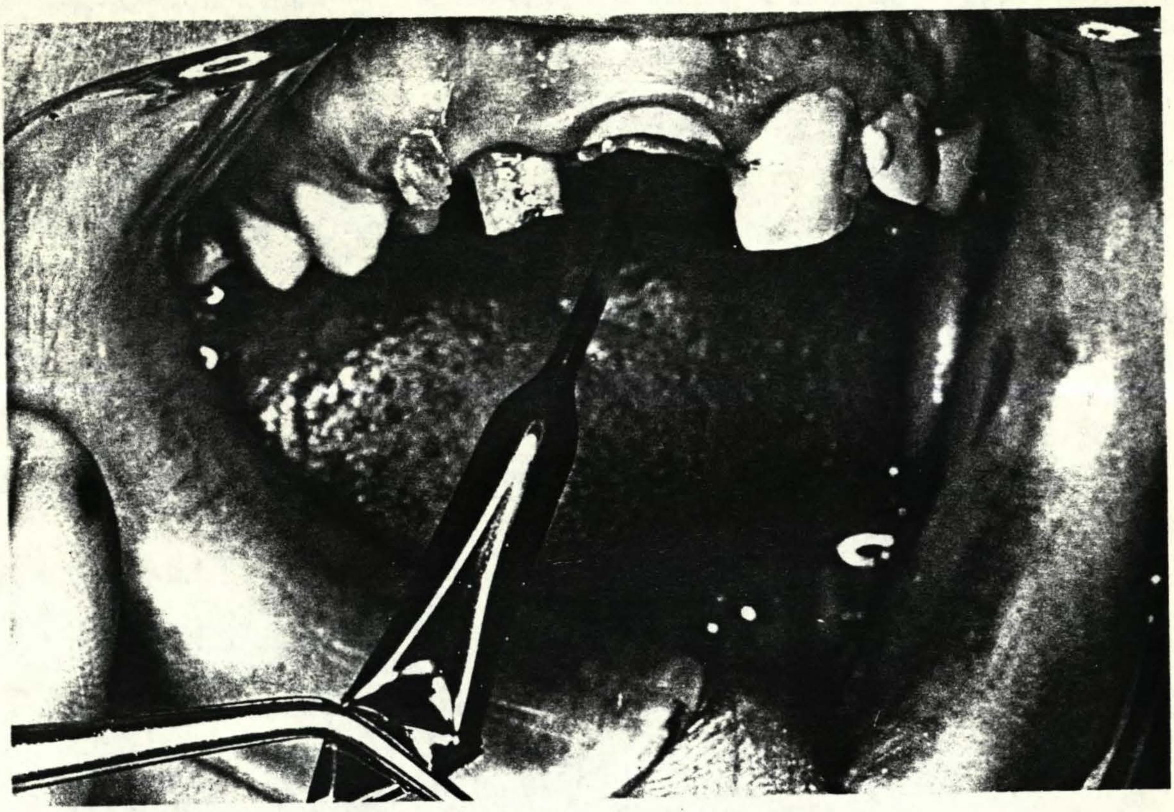
(g) The pin is held until the resin sets (about 5 minutes). To avoid locking the acrylic resin in the undercuts of the adjacent teeth or in an undercut in the canal, the resin material should be removed with pliers, before its final setting and replaced to ensure ease of placement before continuing. Then, using a small camel hair brush more acrylic in a slightly firmer consistency is added to form the core or alternatively a celluloid crown cut to size and filled with acrylic can be placed over the pin to form the core.
Special attention should be paid to condensing the resin material at the gingival margins to copy important structural details.

(h) Once the unit has set (about another 5 minutes) it is withdrawn from the canal and the strength of the acrylic resin pattern permits holding the assembly in the fingers for adjustment and preparation of the core. This is performed with sand-paper discs at low speed, or with tapered diamond burs with an adequate flow of coolant.

Should there be any deficiencies in the acrylic pattern more resin can be added and the pattern reinserted in the canal fór confirmation of fit.

(i) The pattern is now ready for casting.

(Figure 6 : 2) Acrylic procedure with Jiffy tube.



(iii) <u>Combined Procedure</u>

Metrick[5] describes a technique where wax and acrylic are used for the same post - core construction.

(a) The post hole is lubricated with microfilm and a piece of lightly softened round inlay wax is inserted and compressed into the canal.

(b) A metal sprue is heated and forced into the wax to the end of the post hole.

(c) The sprue is chilled with cold air and the wax impression is withdrawn slowly to test the frictional retention. The wax is dipped into microfilm and returned to the post hole.

(d) Next an acrylic core is brushed onto the sprue to simulate a crown preparation. This acrylic is shaped as in the method previously described and the whole structure cast.

Metrick[8] also describes a technique for making round inlay wax to be inserted into the canal, as this shape is not commercially available. A stick of inlay wax is inserted into a disposable plastic 3 mm syringe and immersed into boiling water. This softens the wax just enough to permit the plunger to extrude it through the orifice and onto the counter top.

THE PARAPOST SYSTEM

Perel and Muroff[6] stated in 1972 that a prefabricated post should be avoided as their use determines that the tooth be designed to receive the post rather than the casting be designed to fit the tooth. Furthermore the use of preformed commercially available post core systems means that the intended path of insertion of the crown dictates the direction of the post preparation. This may not coincide with that of the root canal and perforation into the periodontal membrane can occur. As canal morphology becomes ovoid or ribbon-shaped, cylindrical systems become less efficient. For example, some young cuspid teeth have broad ribbon-shaped canals, in such cases the teeth are unacceptable for cylindrical posts[7]. Silverman[8] stated that most preformed posts without additions or modifications are not adequate to withstand the occlusal force in steep overbite occlusions, or when the tooth is used as an abutment for a long span bridge, especially if associated with a cuspid. It is usually necessary to widen the canal and take an impression in wax or acrylic and cast a custom formed post.

Courtaud[9] however, states that the Para-post system, meets the requirements of the principles of post support. The Para-post system consists of the following :

(i) Drills : These may be used in the latch contra-angle handpiece or with a straight handpiece. Upto 16 mm of drill is available.

The drill has

(a) a Spiral flute design for efficient elimination of debris

(b) a reverse taper on the flutes to permit frictionless drilling as an aid for debris removal

(c) a modified safe tip design to reduce the chance of perforating the root canal.

(d) colour - coded shanks to facilitate selection of sizes, as follows

0,9	mm	brown
1,0	mm	yellow
1,25	mm	red
1,5	mm	black
1,75	mm	green

For special situations, when the creation of new post channels is desirable, such as channels adjoining broken posts or adjoining cemented silver points, para-post lead drills are available.

(ii) Gold alloy and stainless steel posts, wrought, serrated, and vented which mate with all drill sizes. For cast cores the posts are of gold alloy, for amalgam or composite cores they are of stainless steel.

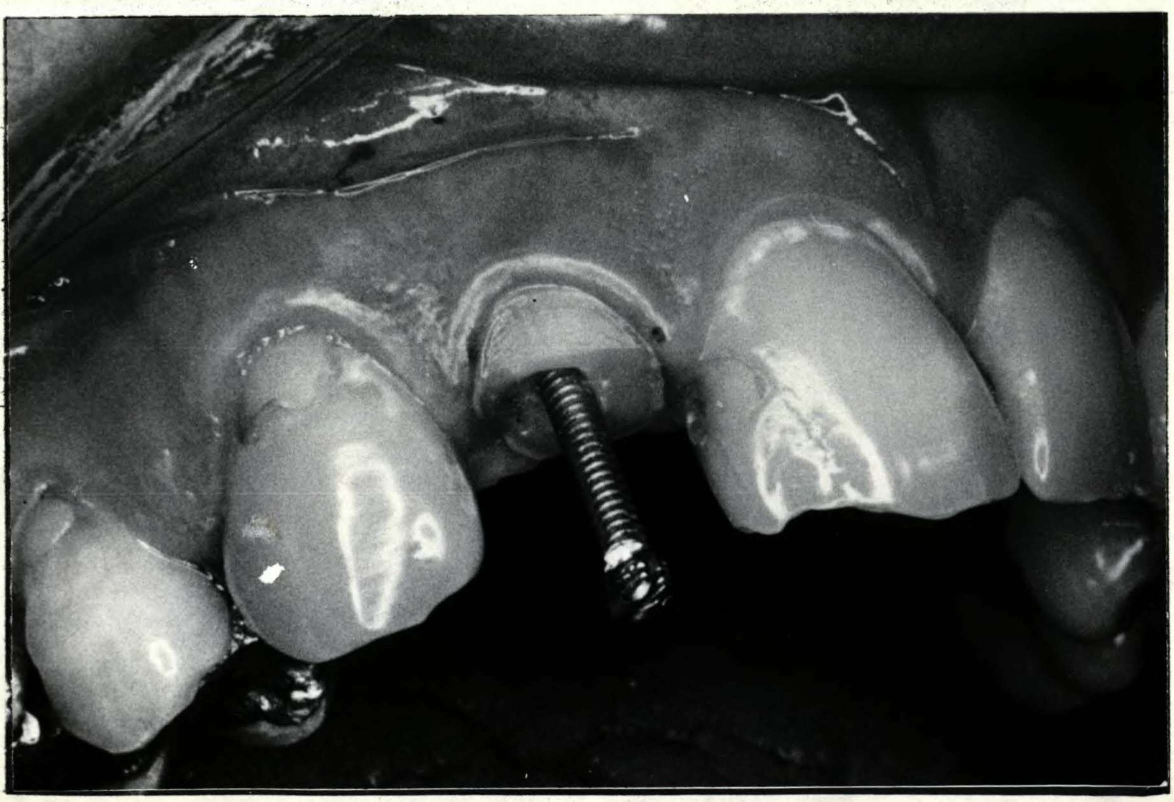
(iii) Plastic and aluminium posts, these are smooth or serrated, colour coded and mate with all drill sizes. Plastic posts are used for impression pins, aluminium posts for temporaries. See chapter dealing with temporarisation.

(iv) Miniature paralleling jigs. These mate with the 3 larger Para-post drills. The free floating 0,7 mm twist drill is used with the jig. These jigs are used to drill parallel auxiliary channels.

(v) Small headed plastic pins and orthogold alloy pins which mate with the 0,7 mm twist drill.

(vi) Aluminium temporary pins for the 0.7 mm auxiliary pin channels.

(Figure 6 : 3) Stainless steel Para-post in canal.



OPERATIVE PROCEDURE

(i) The weak coronal portion of the tooth is eliminated

(ii) The Peezo drill is first used to remove the gutta-percha root filling, followed by the smallest Para-post drill intially to create the cylindrical channel and then the successively larger Para-post drill is used to widen the channel according to the specific root size. As a rule the minimum post length should be at least 8 mm long - the fluted portion of the drill terminates 8 mm from the tip.

(iii) 0,7 mm channels parallel to the major canal are drilled with the aid of the appropriate size Para-post jig for precise orientation and additional retention. The Para-post jig is placed in the canal and rotated to the most desirable position.

The accessory parallel channels are accomplished by the placement of the Paramax Free Floating 0,7 mm drill through the selected guide channels in the Para-post jig. The interdistances and depth of channels are placed for best structural support and retention for the restoration.
There are some dangers attached to this system as there is not always sufficient dentine available for the placement of accessory canals an d these are best left out rather than fracturing the root.
See chapter on pins.

DIRECT BUILD UP TECHNIQUE

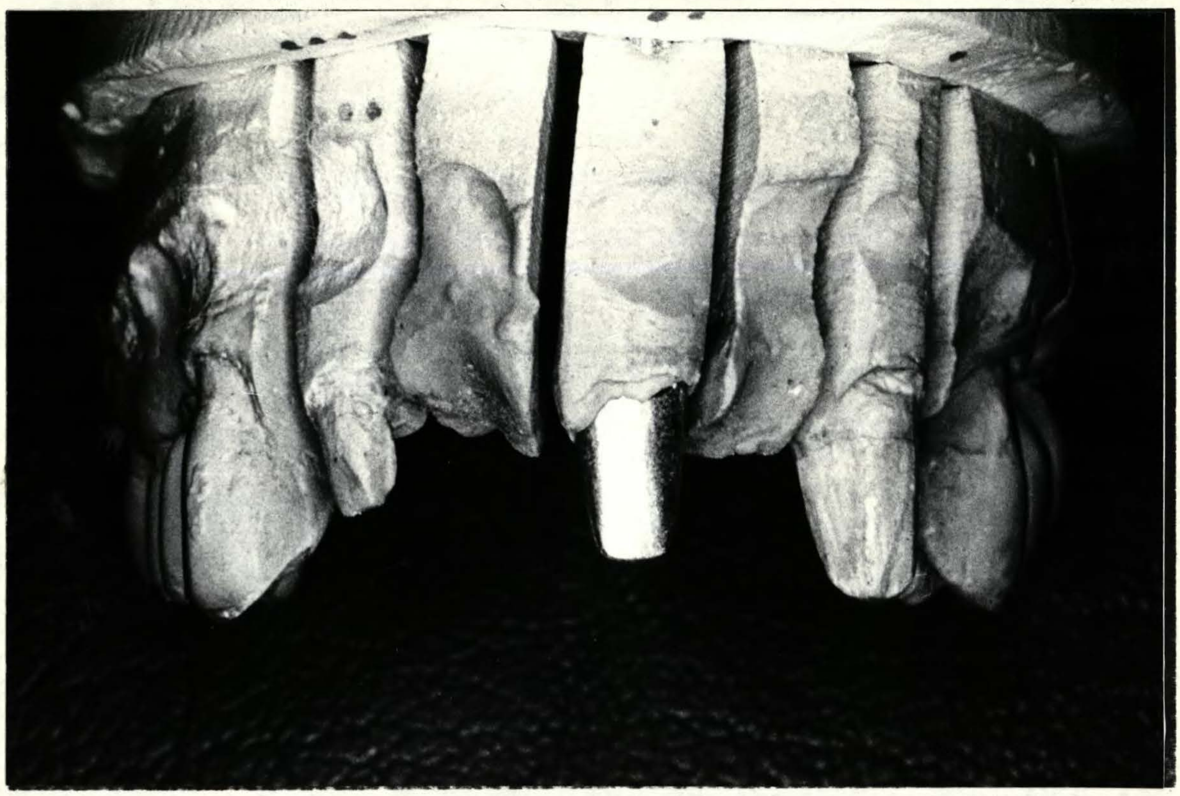
A thin lubricant or fine separating film is applied on the operating surface of the tooth. The preformed precious alloy post is placed into the canal opening. The 0,7 mm Ortho number 2 headed precious

alloy pins are placed into the accessory channels and fastened together with a self-curing resin, brush technique. The core is built up to the desired size and shape with the self-curing resin or hard wax and may be fully re-shaped with a disc or finishing bur.
It is then sprued and cast by conventional methods.

2. THE INDIRECT METHOD - See Fig. 6 : 4.

Using the elastic impression materials, such as the polysulphides, polyethers, silicones or the hydrocolloids, an impression is made of the endodontically treated tooth and a working die is made. The procedure at this stage parallels the direct technique.

(Figure 6 : 4) Post and core constructed on stone model.



This method has the advantage of being easier to use than the direct method in the less accessible areas of the mouth[10]. In the case of a miscast there is no need to recall the patient as in the direct method where the clinical procedures must be repeated. However, in the direct method there are fewer laboratory procedures which reduce the possibility of distortion leading to a better fitting casting[4].

METHOD

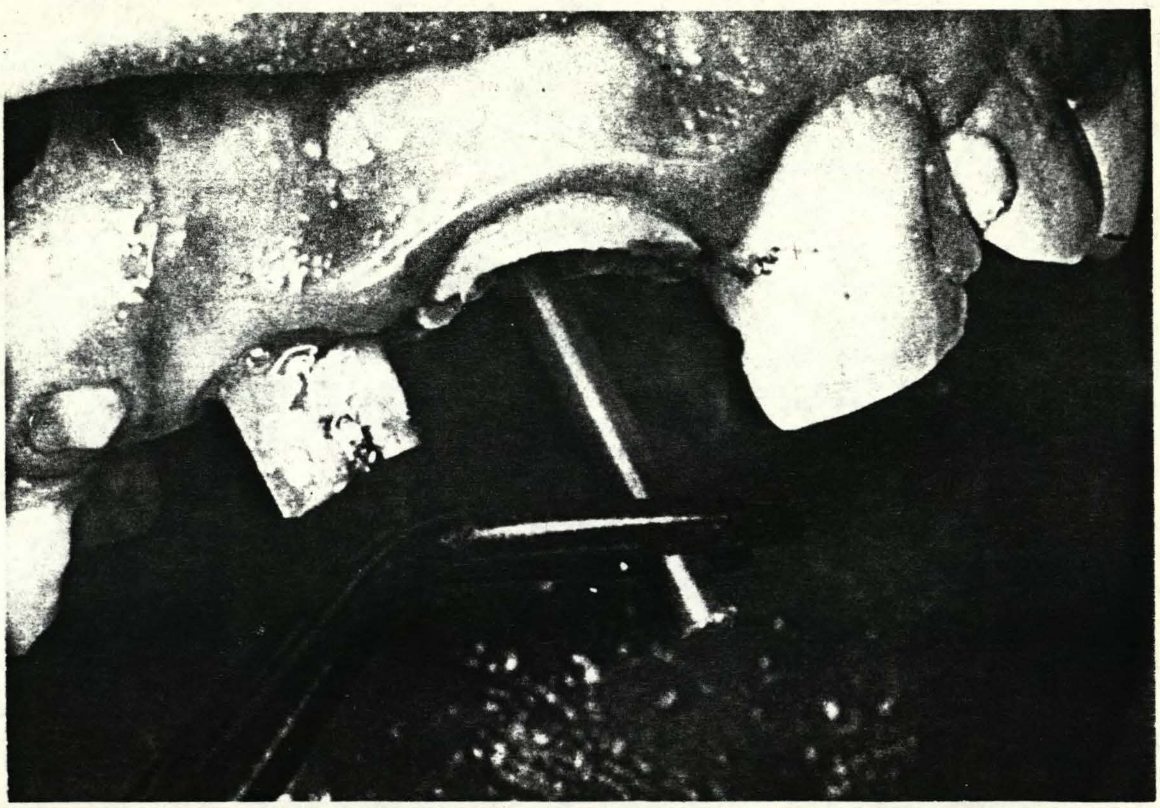
The tooth is prepared in the usual manner and

(i) an acrylic or metal plus wax post can be inserted in the canals and an overall impression taken. See Fig. 6 : 5.

(ii) or with the use of a lentulo reamer the impression material is spun into the canal and a preformed plastic or metal pin inserted into the canal. This pin must be of the correct length so as not to impinge on the custom tray used for the impression[11].

(iii) or the Para-post system used. (vide infra)

(Figure 6 : 5) Plastic pin in canal.



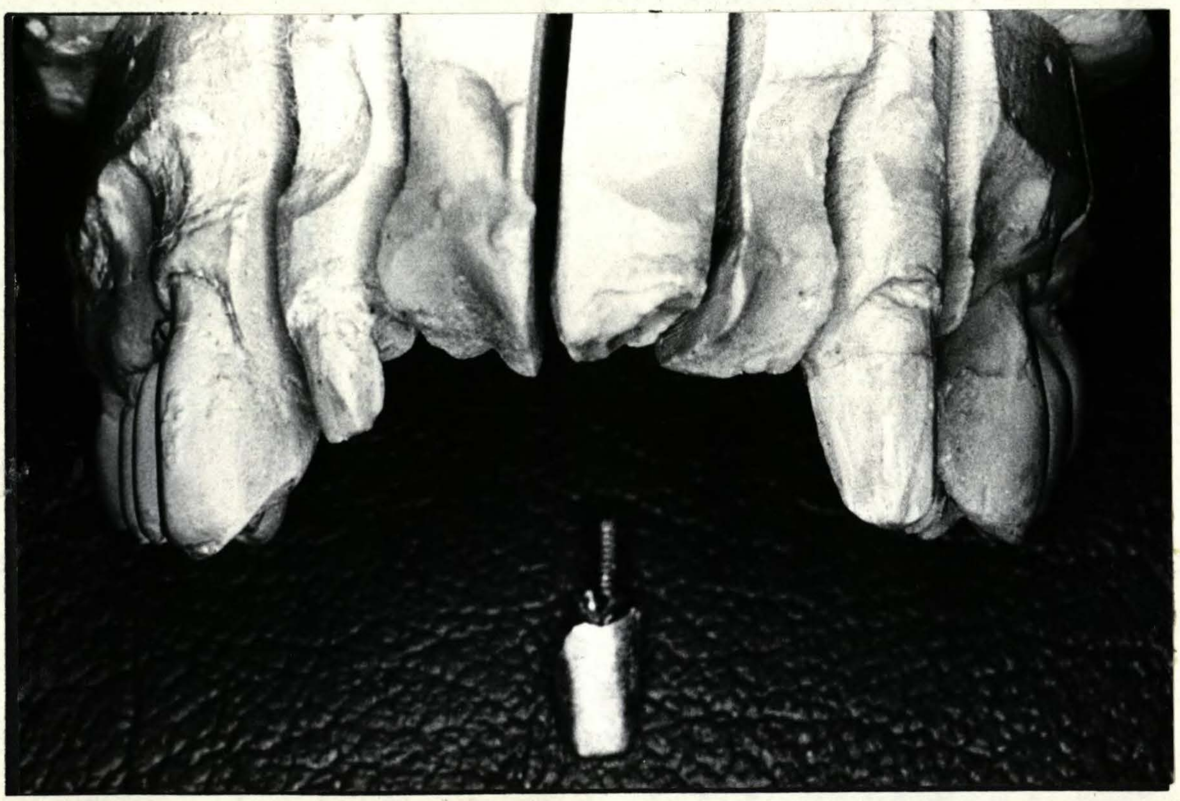
INDIRECT TECHNIQUE WITH THE PARAPOST

The equivalent size colour coded plastic pin is inserted into the canal. The 0,7 mm headed plastic pins are inserted in the accessory channels and a silicone or rubber based impression material of choice is used. Having obtained an accurate impression, a cast with dies is fabricated.

After removing the pins from the cast or dies, an equivalent precious alloy prefabricated grooved and vented post is inserted into the major canal and Ortho 0,7 mm precious alloy headed pins are inserted into the accessory channels. The core is waxed and cast to the dimensionally stable and rigid prefabricated precious alloy post and pins. Conventional waxing and casting techniques are employed.

The indirect technique is more efficient than the direct technique when working on posterior teeth where accessibility is not readily available and also for use in a multi-restoration procedure.

(Figure 6 : 6) Indirect technique for multi-restorations.



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CHAPTER 7

THE CASTING AND CEMENTATION

1. THE FITTING OF THE CASTING

The post and core have now been cast in the material of choice (see chapter 14) and must be fitted to the prepared root canal.

Checking Casting - The casting, prior to placement, should be checked for flaws or any extraneous pieces of metal on the surface that could possibly damage the prepared post hole if forced into position. The initial try-in must be executed with care in order to ensure that no undue force is applied to the root. Most important, the occlusion must be checked to ensure that there is sufficient space between the core and the opposing teeth to accommodate the superstructure[1].

Cementation - When the fit of the casting is acceptable it must be cemented into position. The field must be free from moisture and the preselected cement is spiralled into the canal with the aid of a lentulo reamer. Cement is also applied to the post, which is then gently eased into the root canal and vertical pressure is applied to seat the casting. Provided that the post has been vented no undue pressure will result that could lead to a fractured root.

A combined post, core and superstructure should never be cast as a single unit[2]. The crown retainer might have to be removed at some future time and provided that the original components are separate, the task is no more difficult than it would have been had the crown been cemented to the natural tooth structure. It is possible to fabricate both the post, core and superstructure on the same die obtained from the elastic impression technique. However, the cementation of the post and core may introduce a discrepancy which affects the fit of the crown, (after the try-in but before cementation it is sometimes advisable to just fractionally round off sharp margins of the core prior to trying-in or fitting of the crown due to marginal errors or microscopic fractures of the model if done in the one-stage technique), or the operator may wish to alter the contours of the core, thus negating the use of the coronal structure[3]. It is more judicious to cement the post and core, make corrections to the coronal surface where necessary, and then proceed with the routine technique for the fabrication of the crown.

2. CEMENTS AND CEMENTATION

Zinc Phosphate Cement - Zinc phosphate cement is the most commonly used material for permanent cementation of crowns and bridges[4]. The basic constituent of the powder is zinc oxide with magnesium as a modifier. Some small amounts of other oxides, e.g. bismuth and silica may also be added. The liquids are essentially solutions of aluminium phosphate, phosphoric acid and, in some cases, zinc phosphate. Waerhaug[5] found that this cement is well tolerated by the gingival tissues although some researchers found it to be more toxic to the gingivae than other types of cement. However, this is of little clinical significance provided that the marginal adaptation is good.

EBA-Cement - The aluminous EBA-cements are cements that have an addition of ortho-ethoxy-benzoic acid to the eugenol and with alumina as a filler. These cements are well tolerated by the tissues but have the possibility of the hypersensitizing effect on the mucosa of eugenol.[4]

Polycarboxylate Cement - The polycarboxylate cement is the only one for which there is evidence of adhesion to tooth structure. The liquid is an aqueous solution of polyacrylic acid and copolymers.

The powder is principally zinc oxide with some magnesium oxide and may also contain small quantities of calcium hydroxide, fluorides and other salts. This cement is found to be the least irritant to the gingival tissues of all cements[6].

Cement Efficacy - Hanson and Caputo[6] initiated a study to provide dentists with guidelines for the retention of dowels employing various dental cements, viz. zinc phosphate, polycarboxylate (Durelon), and ethyl cyanoacrylate. Long term tests did not reveal any significant difference in the retention of the dowels with any of these cements. In a later study[7] it was found that with the exception of the tapered post the type of cement used was statistically insignificant. Zinc phosphate cement was the most retentive, carboxylate cement was in the intermediate range and epoxy cement was the least retentive. The cement had no significant effect on the Kurer or Para-post systems.

CEMENTATION OF POST AND/OR SUPERSTRUCTURE

It is essential that all dowels and superstructures be held firmly in position and under pressure for approximately 30 seconds. Thereafter, the pressure can be released but the casting or crown must be kept immobile until the final set is obtained. The field of operation should be kept as dry as possible as all cements will not reach their maximum strength if contamination by moisture is allowed.

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CHAPTER 8

THREADED POSTS

1. THE KURER CROWN ANCHOR SYSTEM

Kurer[1] described a technique for the construction of a core for a jacket crown in which a stainless-steel post was screwed into a specially prepared root canal.

The technique required the enlargement of the apically sealed canal with a special engine reamer, slightly smaller than a hand tap, to produce a screw thread in the dentine of the canal. The coronal portion of the root face is then countersunk, and the post screwed into place with a staked brass head fitting snugly into the depression. The post is removed, coated with a luting cement, and screwed home tightly. When the cement has been allowed sufficient time to harden, the brass portion is prepared for a jacket crown and an indirect impression taken.

The assortment of core sizes ranges from a diameter of 1.56 mm to one of 4 mm, and is made of stainless-steel. In order to impart increased strength to the post, the threads near the brass head are shallowest[2].

Messing[2] states that the manufacturers' recommendations regarding counter-sinking should be followed carefully, and when this is not feasible owing to the shape of the root, an alternative method for the construction of a core should be adopted.

Kurer, Combe and Grant[3] state that there must be adequate counter-sinking so that the base of the core of the dowel is contained entirely or largely within tooth substance, providing resistance to the non-axial forces applied during mastication. The rotation lock is of two-fold significance. It prevents rotation in the counterclockwise direction when the configuration of the root face and the crown may fail to do this. Equally valuable is the fact that placement of a dowel without cementation is possible, thus facilitating subsequent removal of the dowel where clinical considerations make this desirable. The rotation lock is provided by a restoration (composite or amalgam) placed in a prepared cavity on the root face/core junction. To be effective, it is suggested that the cavity be 3 mm long and 2 mm deep and that it extends at each side of the interface 1 mm into the core and root face[3].

Henry and Bower[4] are of the opinion that screwed posts subject the root to high stress and are thought to be unfavourable, although their retentive porperties are high.

Messing[2] found that under laboratory conditions it was not possible to fracture the posts that had an "S" thread and wider core diameters.

In their paper published in 1977 Kurer et al[3] concluded that threaded dowels appear to have better resistance to axial displacement than other types i.e. cast gold, standard stainless steel, both tapered and grooved and that the resistance of threaded dowels to torsional forces can be significantly improved by a rotation lock technique.

The Kurer Crown Saver system is similar to the Kurer Anchorage System but no head is provided. It is suitable for use with composite resins or any other core material[5].

Crown Savers are available in two sizes only, small (diameter 1.45 mm) and universal (diameter 1.65 mm). However, if other sizes are required, the brass head can be removed from the conventional Kurer Anchorage posts to provide the screw post alone[5].

(Figure 8 : 1) The Kurer Crown System.

2. THE DENTATUS SYSTEM

The posts are made of flexible brass-like alloy and are supplied in six diameters (1.05 - 1.80 mm) and four lengths (7.8 - 14.2 mm), providing a total of 20 different sizes.

To facilitate final fit, the root canal may be reamed to the exact sizes of the appropriate post with a corresponding reamer. Two keys for insertion of the posts are provided, one in the form of a wrench and the other in the form of a cross screwdriver that is used for cavities with narrow access[5].

In the Journal of Operative Dentistry, 1977, Eduardo Durney and Harry Rosen[5] published the results of an experiment to determine what degree of torque was required to fracture roots when seating the Kurer or Dentatus Posts. They found that the torque required to insert Dentatus posts ranged from 4 to 6 oz f. in (0.028 - 0.042 Nm)

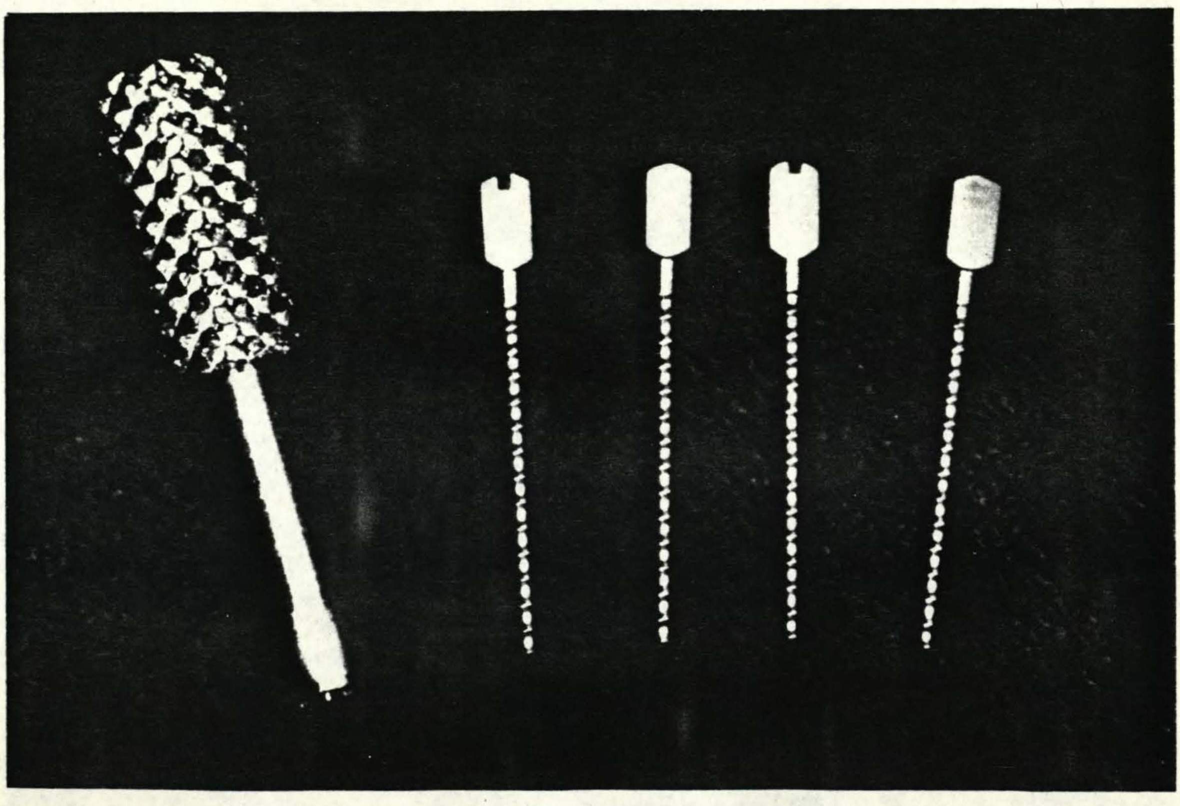
oz f. in = ounce inches

Nm = Newton metres squared.

The torque required to cut threads with Kurer taps ranged from 10 to 12 oz f ins. (0.07 - 0.84 Nm) if the tap was not cleaned periodically during tapping and from 4 to 8 oz f. ins. (0.028 - 0.056 Nm) if it was. The least torque required to fracture a root with a Dentatus post was 22 oz f. in (0.154 Nm) and at a torque of 30 oz f in (0.21 Nm) only 8.33% of the roots fracture. Before this torque was reached some of the posts fractured or stripped threads. No roots were fractured when the torque on the Kurer tap was raised to 30 oz f in (0.21 Nm) though some taps were broken and some threads stripped before this torque was reached . Thus the torque required to fracture roots with either technique was substantially greater than that required to seat posts or to tap threads.

They conclude that the techniques for placing screw posts are simple and relatively safe as long as they are understood and correctly performed. They should be used only for canals that are narrow and not too tapering and these canals should be round or almost round in cross section. The remaining root dentine should be thick and a well designed crown restoration should brace the root.

(Figure 8 : 2) The Dentatus Screw Post System.



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CHAPTER 9

PINS IN CORE CONSTRUCTION

Baraban[1] states that the use of pins as an aid to building up a core is adovocated where

(i) the canal of the tooth is short, curved, or tortuous

(ii) the canal has been previously filled with a silver point and cement and this root filling is not to be disturbed

(iii) a tilted multirooted tooth does not lend itself to a path of insertion for a post and core

(iv) a post has been previously cemented and cannot or should not be removed.

These pins are placed in the remaining dentine and allow the operator a chance to build a core in either gold, base metal, amalgam, or a composite over which the crown will be placed.

Properties - Properly placed pins will resist dislodgement due to the forces of mastication. They do not "reinforce" amalgam or composite but allow for a better retention of the material. Retention may be defined as "The inherent property of a restoration to maintain its position without displacement under stress"[2].

Types - Three types of pins have been described. Cemented dentinal pins were introduced by Markley in 1951[3]. Threaded pins, with superior retentive properties, were introduced later[4]. The third type is the friction-lock pin.

The cemented pin system employs serrated metal rods 0.64mm (.025") in diameter cemented into a .69mm (.027") hole drilled 2 - 5 mm into dentine. Zinc oxyphosphate cement is the medium used for retention. In this technique pins would be preformed and precut to proper length prior to cementation.

Goldstein introduced the friction-locked pin system in 1966. This method took advantage of the elasticity of dentine to hold the pins in position. Stainless steel pins .56mm (.022") in diameter are driven into .53mm (.021") holes drilled 2 - 3 mm deep[2].

The self-threading pin system consists of pins of various diameters that are threaded into undersized channels. Two types of self-threading pins are currently available in South Africa viz :

(i) Stabilok - 2 sizes - small .6mm suitable for both anterior and posterior teeth and medium .76mm, mainly for posterior teeth.

(ii) T.M.S. these are available in 4 different diameters,

.35 mm	-	Minuta
.425mm	-	minikin
.525mm	-	minim
.675mm	-	regular

with drills slightly narrower than the pins.

Clinically, the pin channels will always be larger than the twist drill used, by as much as 1/1000 of an inch (.025mm) and will generally be noncylindrical in shape[2]. The pin screwed into these channels either by hand or with the auto-klutch handpiece has excellent retention. Lately T.M.S. have developed a new type of pin, the Link System, whereby the pin is inserted into the channel directly on the end of a bur.

The T.M.S. Minim Pin, a .525mm (.021") threaded pin, when used with zincoxyphosphate cement, is found to be one of the most retentive. This indicates a dual use of the threaded pin in both the cemented and self-threading techniques, thereby reducing the variety of pins for different situations[5].

For the cemented and self-threading pins, retention increases as the diameter of the pin is increased. The larger diameter pins have the most rigidity and offer the greatest resistance to uneven displacement of the restoration. The weakest link in pin retention is at the pin-dentine interface. Evidence of dentinal crazing in stress bearing areas of teeth was found in a study of threaded pins; this type of crazing results from stress concentration and creates potential fracture sites[6]. This is also applicable to the friction-lock pins. The modulus of elasticity is the "ratio of the stress to the strain". The lower the modulus the greater will be the strain for a given stress application. The friction-locked and self-threading pin techniques involve the insertion of a pin in a hole that is from .025 - .10mm smaller than the pin. Hence the technique relies on the elasticity properties of dentine for its success. Since the cemented pin technique does not include the application of stresses to the dentine, it would be the safest as far as the production of cracking or crazing of the enamel is concerned.

The friction-locked pin technique presented the greatest danger of crack and craze formation, especially when the pins were closest to the dentino-enamel junction. The self-threading pin technique demonstrated a definite craze potential at the dentino-enamel junction but no evidence at a distance of .5 - 1 mm from the junction[2].

The difference between the friction lock and self-threading technique is the method of insertion of the pin. The driving action of the friction-locked pin is the cause of more crazing whereas the self-threading pin screwed into the dentine has the effect of the threads to compel the pin to seek the proper orientation in the hole. The friction-lock pins create lateral stresses and the self-threading pins produce an apical stress[7]. These added stresses combined with those produced by normal function increase the chances of fracture[8].

When clinical conditions demand that the pin retaining device be placed at or very close to the dentino-enamel junction, the cemented pin technique is recommended since it has the least potential for crack formation in the enamel, the friction-lock pins, with its greatest cracking potential, should be used when the distance to the amelo-dentinal junction is 1mm or greater. The self-threading pin technique may be employed if the minimal distance to the amelo-dentinal junction is .5mm or greater.

The self-threading pin is the most retentive, the friction-lock intermediate, and the cemented types are the least retentive[9]. The length of time the tooth has been non-vital should be a factor when the use of pins is being considered. The greater the time since endodontic treatment the less elastic the dentine will be and the greater the possibility of initiation of fracture lines as a result of the placement of pins, which rely on the compression of the dentine for retention[10].

Despite criticism that self- threading pins have a potential to endanger tooth structure, they are acceptable if used with their limitations in mind.

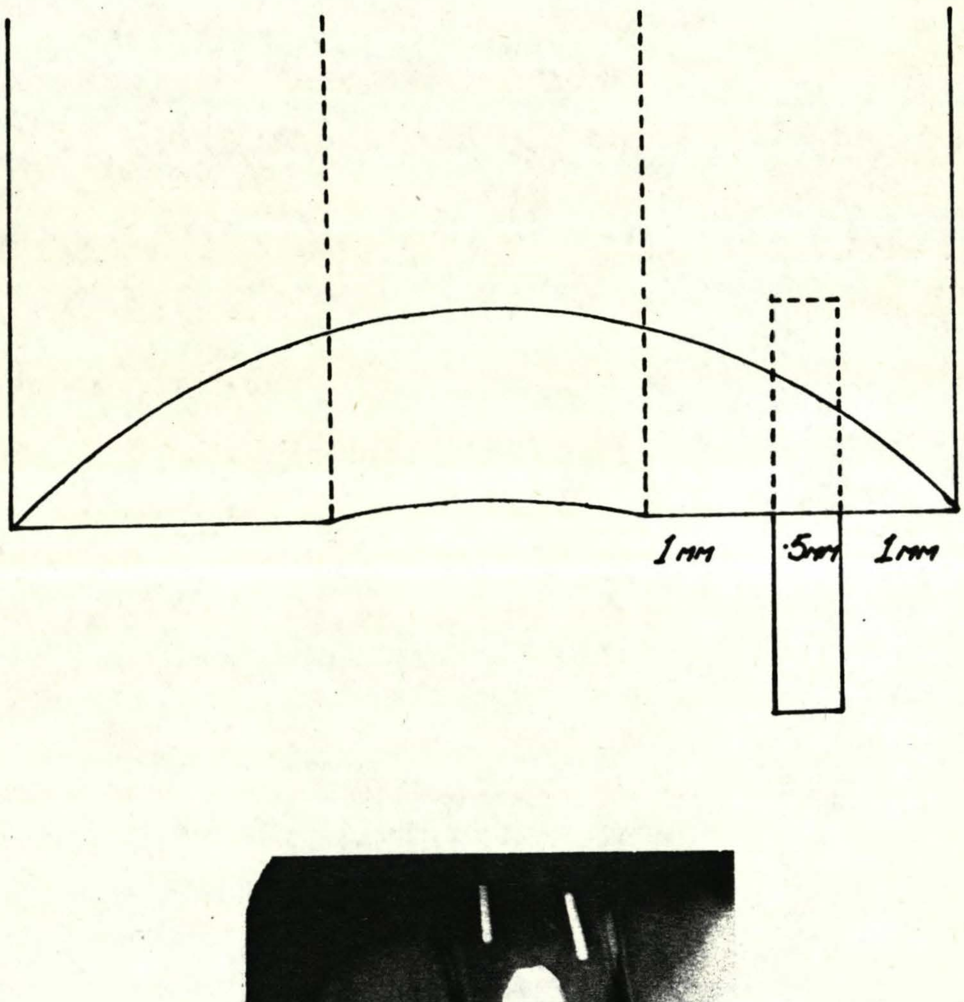
PLACEMENT OF SELF-THREADING PINS[6].

As the number of pins increases the retention of the core material increases due to reciprocal action. Generally it may be said that at least one pin should be placed for each missing cusp. This, however, is not always possible due to insufficient tooth material available.

There is a finite amount of tooth tissue available for the placement of pins. The danger of root perforation increases dramatically as the number, length and diameter of the pins are increased[7].

The pin should be surrounded by 1mm of sound dentine to avoid fracturing of the dentine. This means that a minimum of 2,5mm of dentine is required for pin placement (0,5mm for the pin plus 1mm on either side of the pin). See Fig. 9 : 1.

(Figure 9 : 1)



Once areas of adequate dentine have been located, a twist drill is held flush with the root surface adjacent to all the proposed channel locations which have been marked with a ½ round bur countersunk. The ½ round bur is advocated for creating a depression for starting the twist drill. This prevents skidding of the drill and provides the operator with the opportunity to re-evaluate this selection of the site for pin placement[5].

The self-threading pins need be only 2mm into dentine to achieve maximum retention. The channel depth should be completed with the minimum number of insertions to prevent enlargement of the pinhole[5]. The channels should be coated with varnish to fill the discrepancy between pin and dentine in order to prevent microleakage as studies have shown that the pin does not fill the pin channel precisely. Varnish is used to counteract the microleakage which could lead to damage of the vital pulp. However, as this thesis is concerned with the non-vital tooth microleakage is not of importance. When cavity varnish is applied the self-threading pins are 8 times more retentive than the cemented pins[2].

Evans and Wetz[5] in their article published in 1977 conclude that until more objective and controlled studies are completed, the use of cemented pins as opposed to self-threading pins remains a matter of empirical and personal preference.

In their article "a comparative study of restoration techniques for pulpless teeth" Kantor and Pines[8] state that multiple pin techniques are used primarily for the restoration of vital teeth but due to the stresses brought to bear on a non-vital tooth due to moisture loss they are not as effective when used in endodontically treated teeth due to dentine crazing.

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CHAPTER 10

PLASTIC FILLING MATERIALS - Amalgam and Composites Used as Core Structure.

INTRODUCTION

Not all endodontically treated teeth are receptive to dowel-core therapy. Canals with narrow diameters, or short and widely divergent roots preclude the use of dowels. At times the location of canals, lack of access, or poor visibility complicate the successful use of dowels and cores. Such teeth, contra-indicated for dowel-core therapy, may receive the needed support with pin-retained amalgams or composite.

This chapter describes the use of amalgam and composite resins as core structures. The plastic materials can be used with or without pins.

Amalgam and Pins - In 1958 Miles Markley[2] wrote that silver amalgam, reinforced with threaded, stainless steel pins, is as different from ordinary amalgam as the concrete in a sidewalk is different from the reinforced columns of a modern skyscraper. Well condensed amalgam as a foundation has a compressive strength of 37×10^7 Pa - 41×10^7 Pa (55,000 - 60,000 p.s.i.) comparable to that of dentine and provides an ideal stress resistant base[3].

Amalgam is an ideal foundation because of its

(i) stress against crushing forces
(ii) insolubility
(iii) caries resistance.

However, it is brittle and in a weak tooth it lacks shear strength to support lateral stresses. Reinforcement and retention of the amalgam with pins changes such potential failure into dependable success and pins become a valuable supplement to the traditional forms of retention.

Evans and Wetz[4] reviewed the literature on the pin-amalgam restoration and found that in 1965 Wing presented objective evidence that stainless steel wire did not reinforce amalgam but actually weakened it as evidenced by a decrease in its compressive strength.

Duperon found that serrated stainless steel pins offered greater resistance to withdrawal from the amalgam than did the electroplated pin. Duperon and Karshoff found that although retentive pins did diminish the compressive strength of amalgam, the use of up to 4 pins did not diminish the compressive strength to a clinically significant degree. Dhuru found that the greatest amount of stress concentration was produced by a very stiff pin which did not bond with the amalgam. Stresses were minimised when a metallurgical bond was present between a plated pin and the amalgam.

In a separate article Moffa[5] states that the adaptation of amalgam to the stainless steel pin and to the silver and gold plated stainless steel pin contains voids and no adhesive bond to amalgam was demonstrated. On the other hand adaptation of the silver pin is excellent.

Reviewing the article by Evans and Wetz[4], they write that Galindo found that nickle-silver plated pins and sterling silver pins formed good metallurgical bonds with amalgam. Intimate contact between the freshly mixed amalgam and the pin was essential for achieving a good bond between them. In this technique the first portion of the initial mix was rubbed against the surface of the pin with the flat end of a plastic instrument. While it was shown that smooth stainless steel pins did not form a bond with amalgam and were therefore inadequate, the plated stainless steel exhibited superior physical properties. The effect of various pins on the tensile strength of amalgam was studied by Duperon and Karshoff.

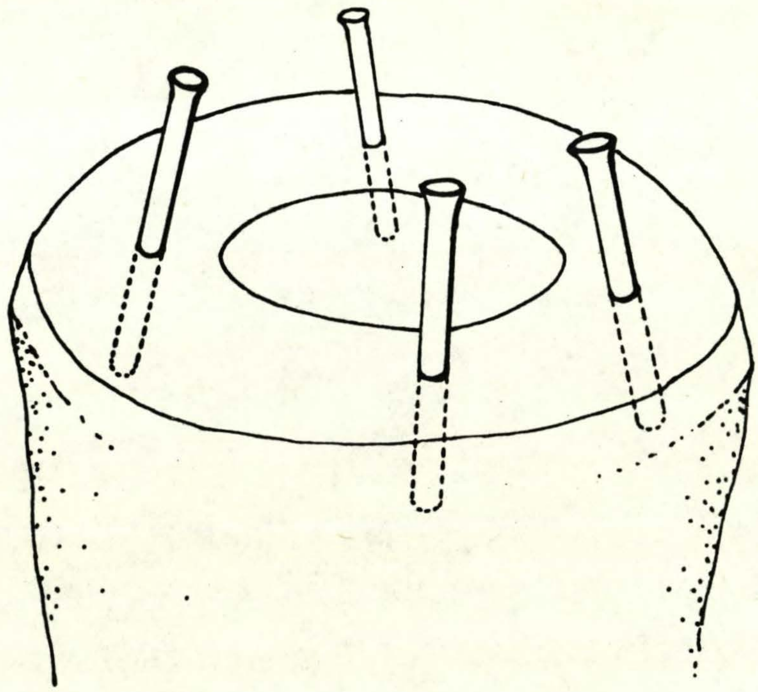
Tensile strength is defined as "a constrained condition of the particles of a body when subjected to forces acting in opposite directions away from each other, thus tending to draw them apart, balanced by forces of cohesion holding them together"[6]. They recommend a minimal number of pins adequately spaced because of the progressive decrease in the strength in specimens containing a number of pins placed close together.

Going et.al.[7] conducted experiments which indicated that the transverse strength of amalgam was significantly decreased by the presence of pins. The most pronounced reduction in tensile strength occurs when the specimens are stressed perpendicular to the pin direction, a less pronounced reduction when they are stressed at a 45^{o} angle and no significant reduction when they are stressed parallel to the placement of pins. The presence of 1 or 4 pins did not increase the compressive strength of the amalgam as compared to the control.

Clinical Procedures

(i) Pin-holes are drilled using the special pre-sized drill for each type of pin used. These should be spaced around the periphery of the sound dentine, making certain that the direction of the drill is parallel to the periodontal membrane. In devitalised teeth it is as well to incline the pins towards the root canal[8]. Pins are more retentive if they are not parallel[2]. The recommended technique is 1 to 4 pins placed in a non-parallel relationship. Bending the pin provides maximum benefit[8]. See Fig. 10 : 1.

(Figure 10 : 1) Non-parallel pin placement.



(ii) Total depth of each pin will vary according to the amount of tooth structure available, 2 mm being the recommended minimum[8].

(iii) The pin length must be controlled so that no interferences with the final restoration preparation or opposing occlusal surface occurs.

(iv) A matrix, anatomically correct and perfectly stable is most important to enable the amalgam to be well condensed.
Markley[2] described a method whereby a seamless copper band is annealed by heating red-hot and immersing in alcohol or water. It is then contoured with curved contouring pliers to restore tooth form and festooned to the gum attachment with curved scissors.
Contacting areas of the band are reduced to paper thinness

with a coarse sandpaper disc and are then recontoured. The band is then tightened at the cervical margin of the cavity by pinching up a tuck at the gingival edge in an area accessible to a flat-nosed plier. The band is then surrounded and stabilised with modelling compound and amalgam packed in and well condensed.

(v) Condensing the amalgam well around the pins will be found to require painstaking effort, otherwise voids will occur to mar the result. The condenser must be small enough to fit between pin and surrounding tooth structure[4].

(vi) Final polish and contour of the reinforced core is achieved by using sandpaper discs and similar instruments, after allowing 24 hours for the amalgam to harden[8].

(vii) However, in a more recent article Reuter[9] describes a technique using an amalgam that can be carved within 25 minutes. It is one of the alloys with a high copper content, the compressive strength of which after 1 hour approaches the compressive strength of normal alloy at 24 hours.
The matrix is removed after 45 seconds and immediately carved using a # 12 scalpel for approximal shaping and normal carvers for the remainder.
Carving is complete within 4 minutes. After 25 minutes the preparation is completed with diamond burs and steel finishing instruments, smoothing the occlusal third with green rubber points.

(viii) The cervical margin is preferably finished on the tooth structure and not on the amalgam.

Amalgam Without Pins

Mondelli and Vieira[10] write that amalgam, having excellent physical properties, can be used to restore cavities that are larger than usual. Recommendations have been put forward whereby the disto-buccal cusp of the lower first molar can be restored with amalgam[11]. Mondelli and Vieira found that the cavity which provides for greater bulk of amalgam leads to a stronger restoration. Amalgam is easily adapted to the walls of a cavity and is stable in the fluids of the mouth. The crushing strength of amalgam is satisfactory but its poor tensile properties are a disadvantage which limits its use to cavities of moderate size. Because of this it is not the most suitable filling material for restoring large amounts of the occlusal surfaces of teeth.

However, when a tooth has a large amalgam filling in situ and due to a fracturing of part of the tooth a crown is to be constructed to restore the tooth, the amalgam can be satisfactorily used as the core foundation. This amalgam will be more secure if part of the pulp chamber has been utilised for retention. It is of importance that when preparing the amalgam for the crown sufficient filling is removed from the gingival edge in order that the superstructure finish on sound tooth structure.

Composites, Pin

The compressive strength of composite resins commonly reaches 31×10^7 Pa (45,000 p.s.i.) compared with that of amalgam 37×10^7 Pa - 41×10^7 Pa (55 - 60,000 p. s. i.)

Tensile strengths are comparable at 48×10^6 Pa (7,000 p.s.i.) as are co-efficients of thermal expansion[3].

Studies of composite resin materials reveal that the addition of pins improves their physical properties[12]. Several authors have reported that the strength of some of the composites approached that of dentine[12].

Newburg and Pameijer[12], in an experiment performed at the Boston University School of Graduate Dentistry investigated the retentive properties of different post and core systems examining three vectors viz :- tension, shear and torque.

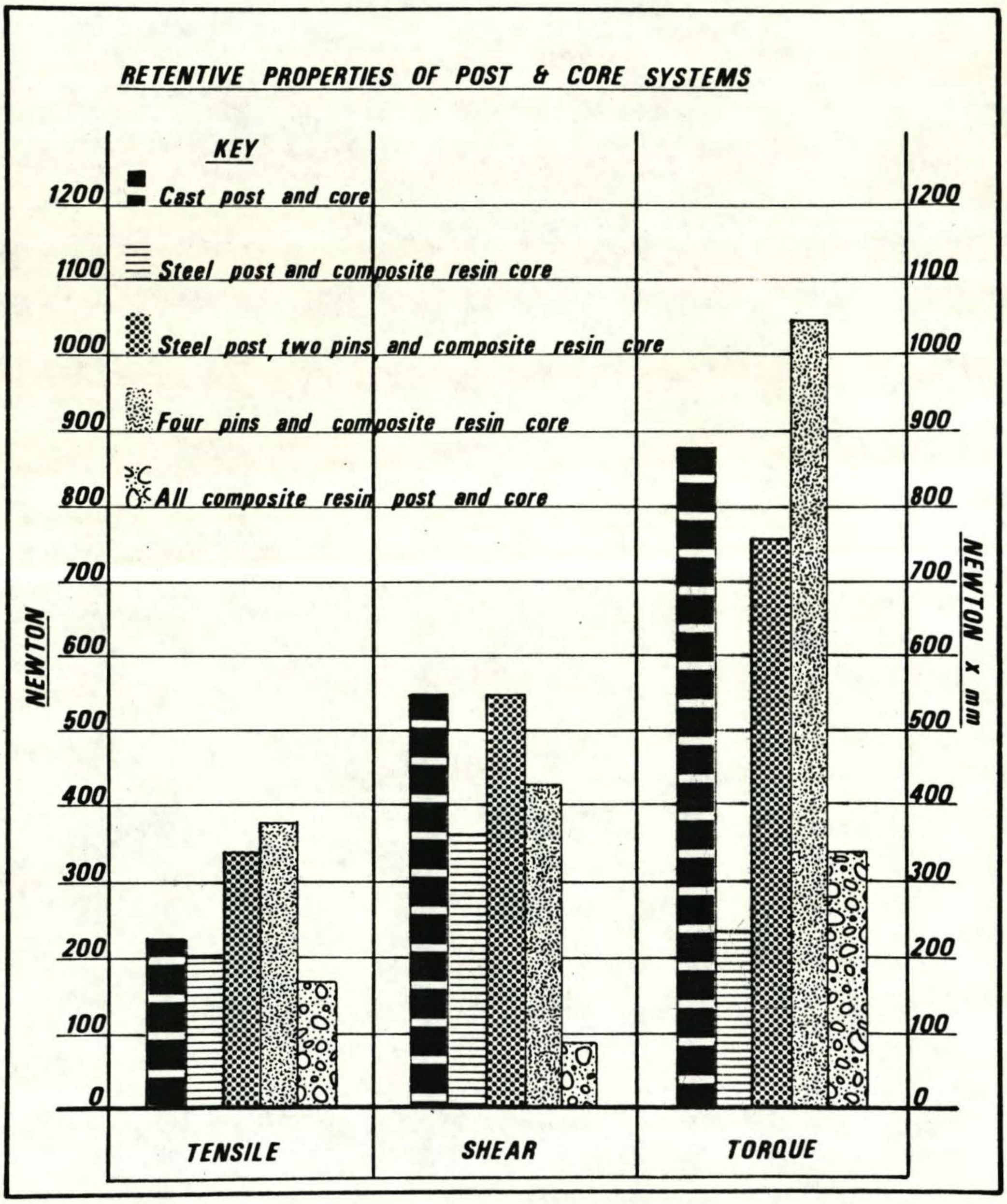
Definitions[6]

Tension : "A constrained condition of the particles of a body when subjected to forces acting in opposite directions away from each other thus tending to draw them apart, balanced by forces of cohesion holding them together".

Shear : "A kind of strain consisting in a movement of planes of a body that are parallel to a particular plane in a direction parallel to a line in that plane through distances proportional to their distance from that plane".

Torque : "The twisting or rotary force in a piece of mechanism or the movement of a system of forces producing rotation".

Their results are illustrated in this graph, which has been redrawn to convert the measurements to the metric system.



Advantages of a Composite Resin Core

The advantage of using a composite resin core are outlined by Steele[13].

(i) its fabrication is less involved than that of a cast post and core

(ii) its cost is minimal when compared to a gold post casting. This, however, it not valid when a non-precious metal is used, except of course, for the laboratory fee.

(iii) it reduces the possibility of perforation of the root canal wall during pattern construction. Undercut areas within the canal itself become advantageous for retention.

(iv) it negates the hydrostatic back pressure in cementing smooth-sided parallel posts.

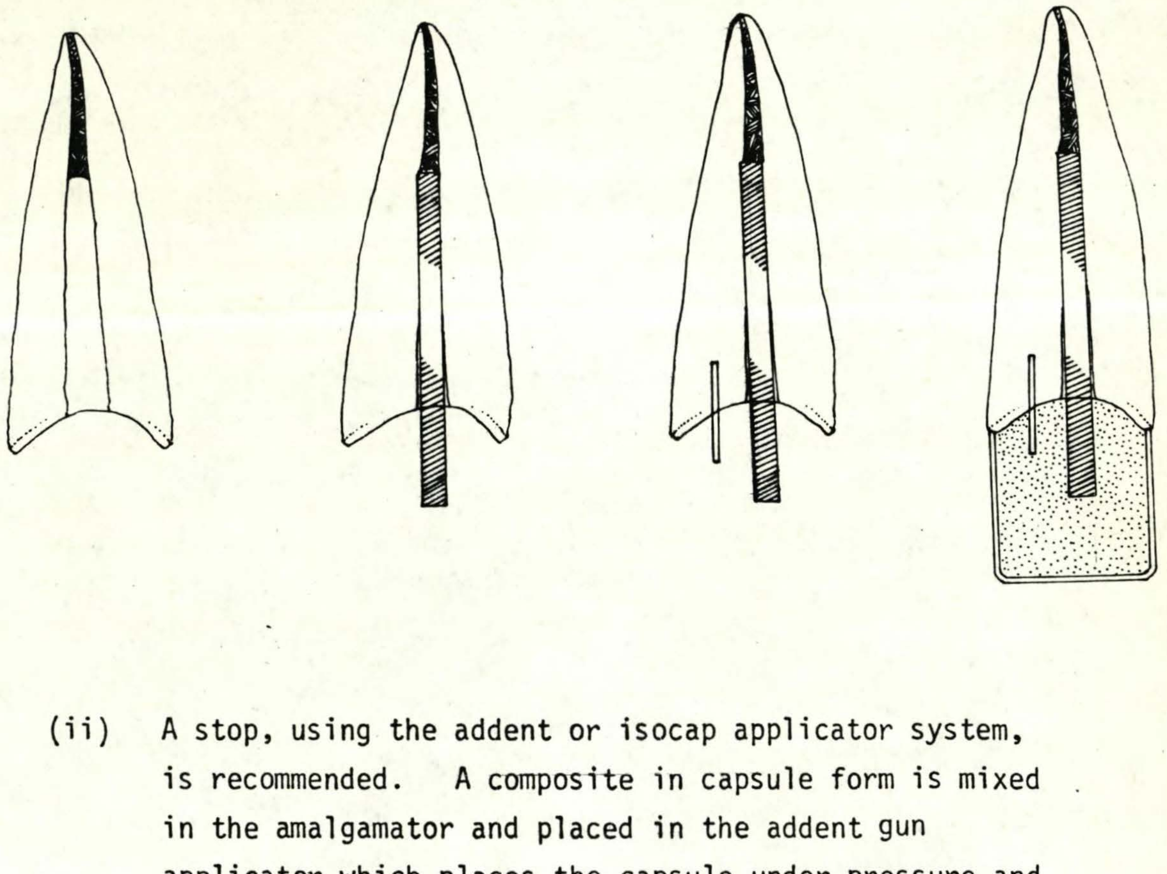
(v) it negates the wedging dangers of tapered post cementation and fracturing with a threaded post.

Kantor and Pines[14] found that composite resin cores have a definite disadvantage in that they are friable and therefore not indicated for use in teeth that require combined prosthodontic-periodontic treatment or in restorative procedures where the temporary restorations are frequently removed and recemented.
However, they may be successfully used in single restorations that are not likely to become abutments.

Clinical Procedures

(i) Where possible, a stainless steel post (Parapost) is inserted into the prepared canal to add strength to the core.
McPhee[15] describes a technique whereby a series of retentive pins are placed in the sound dentine. Both mechanisms can be used where possible.

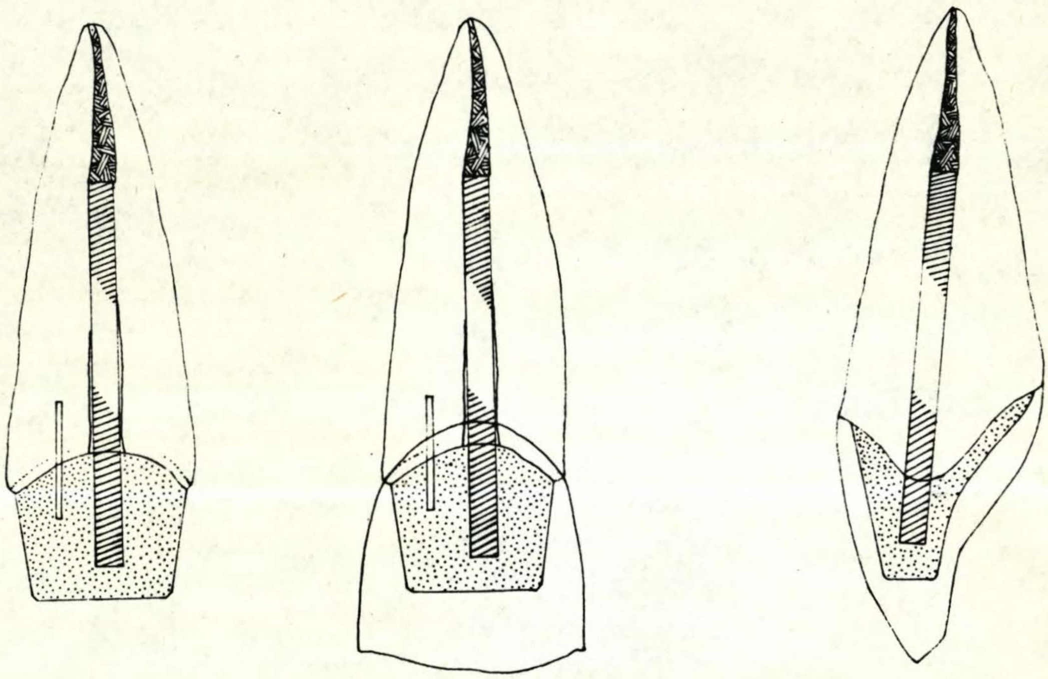
(Figure 10 : 3) Illustrating post and pin placement for composite core.



(ii) A stop, using the addent or isocap applicator system, is recommended. A composite in capsule form is mixed in the amalgamator and placed in the addent gun applicator which places the capsule under pressure and extrudes composite through a fine nozzle in the capsule.

(iii) (a) In anterior teeth a celluloid crown is carefully adapted to the root. The mesial and distal margins of this well adapted crown are wedged in tightly. A hole is drilled on the incisal edge of the crown form to allow either excess composite to escape when compressed or to give access to the nozzle of the addent gun for extruding the composite.

(Figure 10 : 4) Illustrating the preparation for the Superstructure.



(b) In posterior teeth an aluminium crown form (e.g. King's Aluminium Shell Crowns) is contoured to fit the cervical margin of the tooth. It should be fitted to allow it to seat slightly beyond the margin. A hole is cut in the top of the crown form to vent excess resin.

(iv) The gingival sulcus is packed with retraction cord to prevent excess resin from being expressed into the sulcus. See Fig. 10 : 5.

(v) The crown forms are now filled with resin (lubricate the aluminium crown first) and placed over the post and/or pins and held firmly in position. Excess material is immediately removed from the cervical margin.

(vi) Once set (approximately 3 minutes) the crown forms are removed, either with a large excavator or a # 12 scalpal blade.

(vii) The composite is now prepared to the required shape of the core and polished.

(Figure 10 : 5) Retraction cord in sulcus.

With the resin materials activated by ultraviolet light (e.g. Nuva - Fil), a crown form is not necessary as the resin core is built up in layers to the desired shape and size. Kantor and Pines[14] recommend that the composite be condensed into a tight fitting copper band matrix. They maintain that in the technique described using a celluloid crown or the Nuva-Fil technique, lack of compression results in inadequate density.

Shillingburg et. al.[1] recommends the placing of a prominent contrabevel around the external periphery of the preparation with a flame-shaped diamond stone. This bevel provides a metal collar around the occlusal circumference of the preparation, helping in holding the tooth together and preventing fracture of the remaining tooth structure.

McPhee[15] provides a cervical shoulder with a sharp bevel to complete the preparation.

Composites Without Pins

Various techniques have been mentioned whereby the root canal is prepared with undercuts and composite resin forced up the canal and a core constructed in a manner similar to that just described. At present there is no literature available on this technique and therefore it is not possible to comment at this stage. The author has been assured that literature will become available in the near future.

However, in referring to the graph on page 77 it will be noted that the all composite post and core presents the least impressive record.

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CHAPTER 11

POSTERIOR TEETH : Special Considerations

INTRODUCTION

Posterior teeth that have been endodontically treated require the same amount of attention and care as anterior teeth. Therefore, all relative factors as mentioned in previous chapters would apply to posterior teeth as well as to the anterior teeth. The differences are in the various difficulties encountered in dealing with divergent roots and this factor is stressed in the following text, as well as a short description given of the onlay, three-quarter crown and full crown techniques.

THE RESTORATION OF THE ENDODONTICALLY TREATED POSTERIOR TOOTH.

Protective Mechanisms - Some clinicians accept the placement of a Class 1 restoration in teeth that require nothing more than occlusal access and that possess sufficient structure after completion of the endodontic therapy[1]. Frank[2] states that when the marginal ridge of a pulpless tooth is no longer intact, the cusps should be "shoed" or "capped". Blair[3] and Baraban[4] regard onlay or shoeing of the cusps as the minimal consideration for restoration of a non-vital posterior tooth. Complete cuspal protection is the minimum that should be provided for all endodontically treated posterior teeth[2]. A vertical fracture is thus prevented. In pre-molars the potential for horizontal fracture is increased due to the intensified transverse stresses placed upon the teeth anteriorly in the mouth. Therefore vertical or axial support should be placed within the pulpless tooth so that it will be strong enough to resist a horizontal fracture. This vertical support is obtained by using a post permanently cemented within the tooth. Harper and Lund[5] state that a casting should not be placed on an endodontically treated tooth without first providing support to resist fracture from longitudinal, or vertical, and transverse, or horizontal, forces.

Where the remaining crown of the tooth has to be removed, a core must be built up to support the superstructure. If the canals and pulp chamber can be utilised for sufficient retention amalgam or composite can be used, being well condensed into the retentive areas.

Pins and posts are needed to reinforce the amalgam or composite if there is any doubt about the retention of these materials.

The Onlay ("Shoe").

The M.O.D. onlay is an inlay that has been modified by covering the entire occlusal surface with metal to prevent stress concentrations that can cause fracturing or shearing of a cusp[6]. This is accomplished by covering the occlusal surface with buccal and lingual extensions (reverse bevel) beyond the functioning range of contact with the opposing teeth[7].

Undue stress on the weakened tooth may also be avoided by reducing the cusps at least 1 mm in all occlusal relationships, inclusive of lateral excursions. Since the tooth is to be restored by a crown or onlay, reduction of cusps is not contra-indicated. Once a tooth has been reduced occlusally, however, it should be restored as soon as possible.

In those instances where cuspal reduction has brought about a reduction in retention, pins can be incorporated in the casting. The V.I.P. Kit is found to be useful in these instances.

The MOD only should not be used as a bridge retainer as it lacks adequate retention to successfully resist displacement by the additional forces placed on an abutment tooth by a bridge[6].

Preparation - See Fig. 11 : 1.

(i) Occlusal reduction, establishing clearance of 1.5 mm on the functional cusp and 1 mm on the supporting cusp. An occlusal shoulder is cut to give structural durability.

(ii) The isthmus is next prepared, planing the walls to allow for withdrawal. This feature of the preparation provides space for a reinforcing bulk of metal in the centre of the restoration and also adds some retention and resistance.

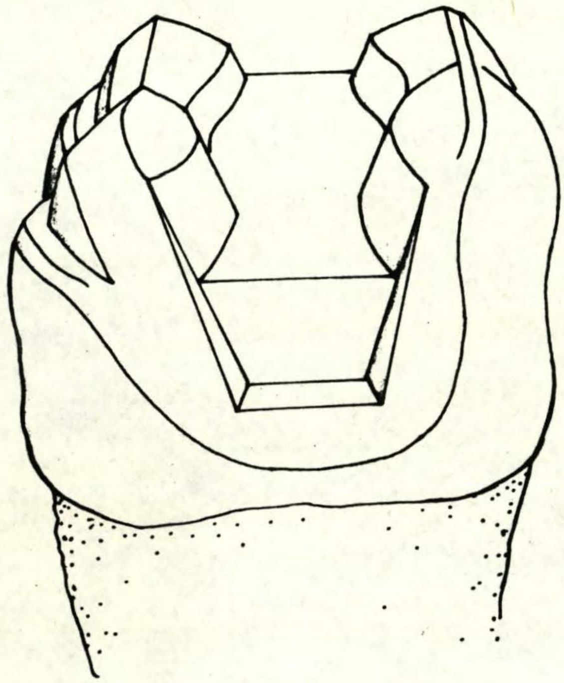
(iii) The proximal boxes are prepared, the walls being carried far enough buccally and lingually to break contact with the adjacent teeth. The boxes must be checked for withdrawal with one another.

(iv) Proximal flares are added to provide resistance to lateral displacement.

(v) A bevel is added to the gingival cavosurface angle of each box to provide an acute edge of metal in these areas.

(vi) Finishing bevels of 0.5 - 0.7 mm are placed at the buccal and lingual surfaces.

(Figure 11 : 1) Onlay preparation.



Three-Quarter or Full Crown

On the basis of the amount and condition of the remaining tooth structure, a three-quarter or full cast gold or veneer crown may be indicated. Although these restorations provide protection against vertical fracture, they require the removal of a greater amount of tooth structure; this weakens the tooth even more and may render it more susceptible to horizontal fracture. Horizontal fracture can be prevented by the placement of a post[2].

Kornfeld[7] writes that these crowns can withstand heavy functional stresses. They tie the structural elements of the crown more tightly together, thus preventing fractured walls and cusps. He states that the three-quarter crown gives maximum retention with a minimum loss of tooth structure.

However, the preparation of a three-quarter crown requires special expertise and a longer marginal fit is involved. The three-quarter crown is not as retentive as the full veneer crown[6]. While it has adequate retention for single restorations and most fixed bridge retainers, it should not be used for retaining long span prostheses[6].

The full veneer restoration has long been considered the most retentive of the veneer preparations but its use should be limited to those teeth whose restoration demands maximum retention[6].

<u>PREPARATION OF THE FULL CROWN</u>[6] See Fig. 11 : 2.

(i) An occlusal reduction of the cusps, 1.5 mm clearance on the functional cusps and 1 mm on the non-functional cusp, is performed. The occlusal surface is kept in the configuration of the geometric inclines that make up the occlusal surface of any posterior tooth.

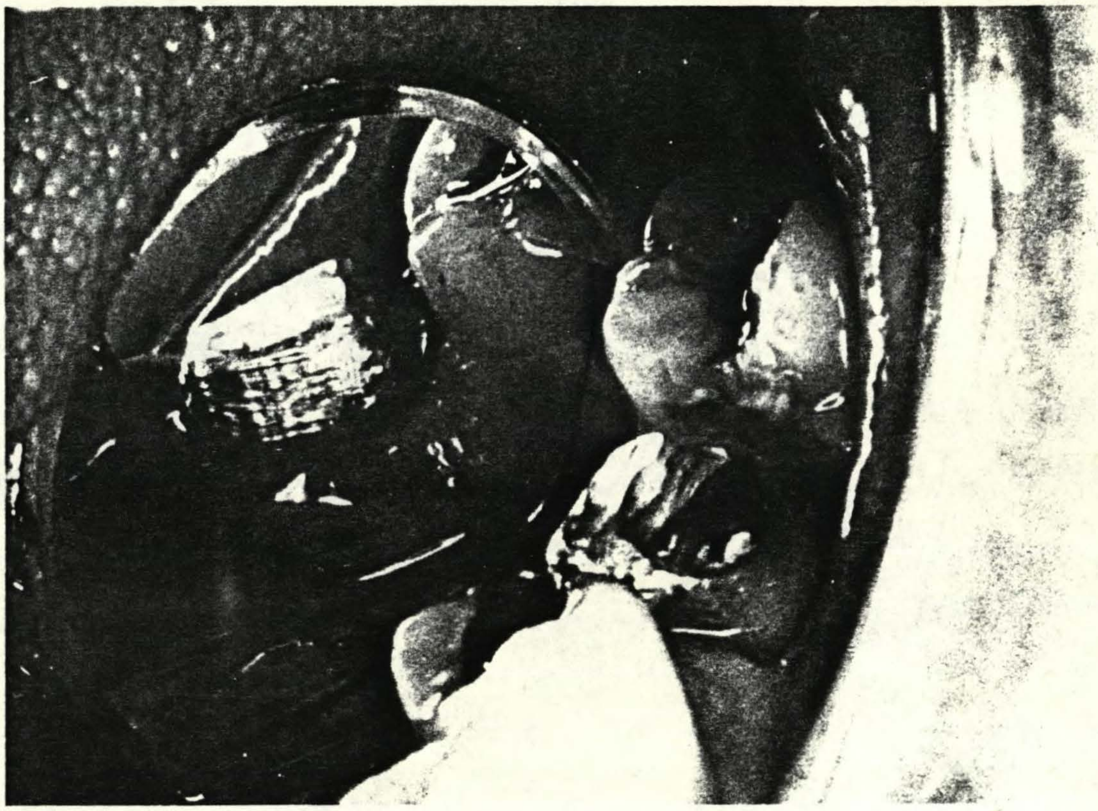
(ii) A wide bevel is placed on the functional cusp

(iii) The proximal cuts are made with various shaped burs and a chamber is formed at the gingival finish line or a shoulder with a sharp bevel.

(iv) The buccal and lingual walls are reduced

(v) A seating groove can be placed to prevent any rotating tendencies during cementation. It is placed on the buccal surface of mandibular preparation and the lingual surface of maxillary preparation.

(Figure 11 : 2) Full crown preparation.



Posts and Cores

Perel and Muroff[8] state that in a multirooted tooth where a post and core is necessary, at least one root must be utilised with the aid of a positive seat in the pulp chamber. This will suffice provided a single retainer is placed over the tooth as a separate entity. If, however, this same tooth is to be used as an abutment for a fixed prosthesis, additional canals must be used so as to fabricate a multiposted post and core or a post and core coping. This will dissipate the internal stresses over as wide an area as possible and will prevent root fracture due to torque. It will also help to redirect the forces imposed by the fixed prosthesis along the long axis of the tooth.

Kornfeld[7] stated that posts for multirooted teeth need not be as long as posts in single-rooted teeth provided that these posts can be fitted into two or more canals.

Mandibular Molars - Discussing the placing of posts in multi-rooted teeth, Harper and Lund[5] state that in the mandibular molars the post can easily be placed in the large distal canal and, if needed, a shorter auxiliary post can be placed in the mesial canal.

Maxillary Pre-Molars - Maxillary first premolars have two distinct canals that usually diverge. If the canals are large enough two parallel posts should be made, but if the canals are too narrow a common core can be constructed using both canals with one post being longer than the other. The smaller post, or key, gives little retention, but aids in seating and prevents rotation. The canals are connected with a slot which acts as a guide in seating and prevents rotation.

Maxillary Molars - Maxillary molars have a large straight palatal root for the easy insertion of a post. Occasionally the buccal root is usable and permits the insertion of two parallel posts, one buccal and one palatal. There should be no undercuts in the pulp chamber and a flame shaped diamond should be used to place a prominent contrabevel around the external periphery of the upper part of the preparation to provide a gold collar which helps to prevent fracture of the root.

Auxiliary Dowel Technique - Lovdahl and Dumont[9] describe a technique for constructing a cast dowel and core which receives additional retention from an auxiliary dowel. The canal of choice for the cast dowel is the one which permits the easiest path of insertion. Prior to fabrication of the dowel and core pattern 18 gauge stainless steel wire is painted over with melted wax and Duralay resin then painted onto the wax to form a sleeve 5 mm long and not more than 3 mm in diameter. The wire is then heated so that the sleeve can be removed. The wire is cut to a length of 3 cm and the tip beveled to allow maximal seating.

A plastic sprue is inserted into the canal selected for the cast dowel. The Stainless steel wire into the second canal and the Duralay sleeve fitted over this wire in contact with tooth structure.

With these components in position, the core pattern is built up with Duralay resin by the brush-on technique. This incorporates the dowel into the core pattern. After the resin has set, the stainless steel dowel is removed with a haemostat and set aside. The resin dowel and core are then removed for trimming and adjustment. Casting follows the normal procedures and at the next visit the casting is cemented into position, at the same time the stainless steel dowel is cemented through the core canal into its root canal. The unit is trimmed and prepared for the superstructure.

Kerr Endoposts - Johnson et.al.[2] describe a method using Kerr Endoposts. The length and final size of file used in endodontic preparation of the canal is recorded and used to determine post size and length. After the removal of the gutta percha from the root canal the endopost corresponding to the file last used is fitted. The end should be slightly beveled for ease of insertion. The post is seated and the core fabricated out of wax or self-curing resin. If only one post is used, an antirotational device, such as a pin or a keyway, must be incorporated into the core to prevent rotation. Rotational forces are best resisted by a flat plane parallel to the long axis of the root.

The post and core are sprued and the core cast to the post and the whole unit cemented into position.

The Kurer Crown Anchor System[10]. - (See Chapter 8)
A No. 5 post designed for use in posterior teeth is available. The head portion of this Kurer screw post has undercuts for the retention

of amalgam or composite resin. The Kurer system uses both dentine elasticity and cementation for retention.

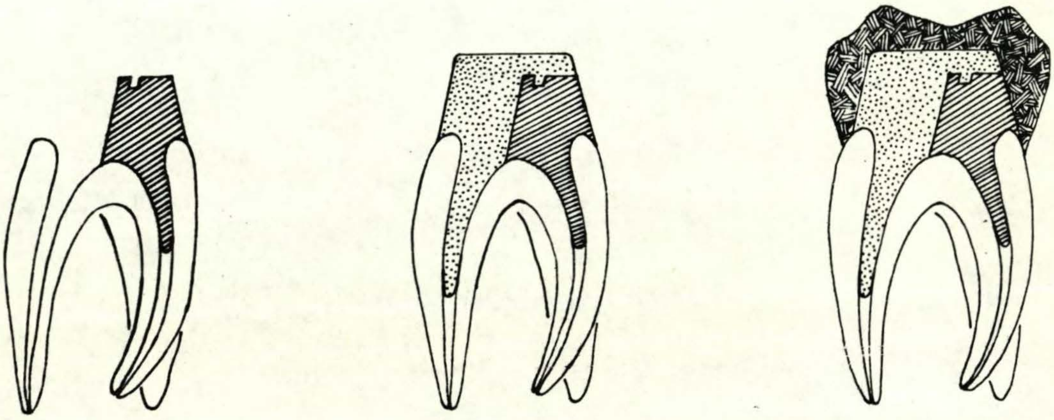
This system is only indicated if some coronal tooth structure remains. The screw posts are capable of producing excessive lateral forces on the root structure on insertion, and, thus, great caution and minimal force is required during placement.

Indirect Technique - The indirect method can be quick and precise with a technique using an impression material of polysulphide rubber but although an accurate reproduction of the post hole can be obtained, reproducting a post of proper length in gold poses a difficult challenge to the laboratory technician[5].

The post canal is prepared and a plastic or metal post inserted into the canal or canals to check the fit. These are withdrawn, the canals lubricated and the impression material is spun into the canal with a lentulo reamer. The posts are then inserted and an impression taken of the overall structure. The construction of the post and core then takes place on the cast model[5].

Sectional Cores - With the indirect technique single dowels can be fabricated for each canal. A Keyway or interlocking mortise is optional in the core for joining them together. This procedure is very precise, and the final posts must be cemented in sequence[2]. See Fig. 11 : 3.

(Figure 11 : 3). Sectional cores.



A technique has been described by Abdullah and Bjorndal[11] where the wax pattern is built in two parts one mesial and one distal. The two halves of the cast gold base are stabilised and locked together by means of two pins. A chamber of ½ millimeter is left uncovered at the base, allowing the gingival margin of the tooth to directly support the crown.

A method is described by Michnick and Raskin[12] where plastic pins are adapted to the root canals of a molar and cut to project 5mm past the coronal opening of the canal. The pins are adapted to the root canals and a soft wax is placed over the portions of the pins extending from the openings of the canals. A heavy-bodied rubber-base impression material is used for the primary impression and the pins are then removed from the canals and covered with a thin layer of adhesive. The light-bodied impression material is now spun into the canals and the pins inserted and the tray with the light-bodied material added to the heavy-bodied material is placed over the tooth. A stone die is now made from the impression.

The patterns are prepared and cast for the two smaller canals and fitted into position on the model. The master canal post is then prepared and acrylic resin (Duralay or Resincap) poured around the previously cast, lubricated posts, and shaped to an ideal core form. The accessory posts are removed from the core-post pattern which is then cast. The casting is fitted and replaced on the die. The cast posts are placed through the openings and the assembled casting checked for accuracy of all components.

The core-post casting is now fitted to the tooth with cement and the accessory posts are cemented into position. Once set the accessory posts, which extended slightly beyond the occlusal surface of the core, are trimmed flush with the core.

The superstructure can be constructed on the same die at the same time as the construction of the posts and core or a new impression taken once the posts and core have been cemented.

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CHAPTER 12

THE SUPERSTRUCTURE

In the description of various methods for the restoration of the endodontically treated tooth the emphasis has mainly been on the construction of a sound foundation for this tooth. The placement of a superstructure would follow the similar pattern designed for the restoration of any tooth that was to be restored in the mouth, vital or non-vital. It is, therefore, only necessary to give attention to a few salient points.

The crowns to be fitted as superstructures may be constructed in

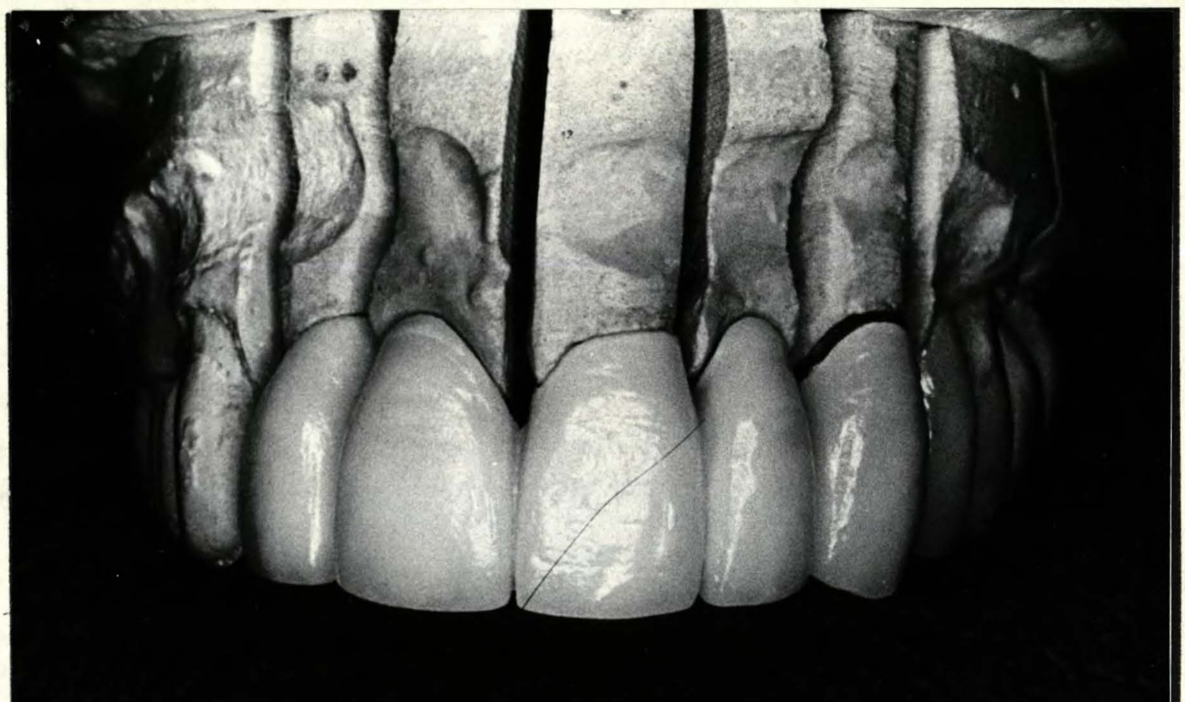
- gold
- non-precious alloys
- porcelain
- porcelain - fused to gold
- porcelain - fused to non-precious alloys
- acrylic
- acrylic fused to gold
- acrylic fused to non-precious alloys

Function and aesthetics must always be taken into account and the combination to be used by the operator is at his discretion.

The superstructure should always finish on tooth substance rather than on the core material, except in the case of similar metals where a shoulder of core material is sometimes advisable. The tooth should be finished to end in a chamfer or shoulder with a beveled angle[1].

Beaudreau[2] states that the gingival chamfer conserves the tooth structure while providing a definite finish line and insuring adequate marginal strength and aesthetics.
The axial walls should have angles of 2.5^{o} - 6.5^{o}. Where porcelain is used alone instead of fused to a metal, Craig and Farah[1] state that the core must be symmetrical mesially - distally, the surfaces must be smooth, sharp angles should be avoided, thicker walls reduce the stress, the bulk of the metal should be in the gingival area, the porcelain - metal joint near the shoulder should be 30^{o} to the horizontal. There should also be a restricted occlusal surface, the porcelain - metal joints being as far as possible from the loading sites.

(Figure 12 : 1) Superstructure on model.



Contour - Yuodelis et.al.[3] warn that over contouring or faulty placement of a contour is a much greater harzard to periodontal health than an undercontour, since over-contouring may enhance both supra - and subgingival plague accumulations. Even more critical than the buccal and lingual surfaces is the interproximal contour of crowns and there should be no encroachment upon the space required for a normal interdental papilla.

Impression for Superstructure

The method used for taking an impression for the construction of the superstructure is usually the indirect technique. Silicone rubber base or the hydrocolloid materials are usually left to the operator's own preference. The most important factor in the use of these materials is to follow diligently the manufacturers instructions with regard to the mixing and pouring of these materials. The copper ring technique combined with the use of the compound, and as described in Ewing's book[4], has its adherents and, provided the band is used with great care so as not to injure the soft tissues, is a useful method and an accurate one of recording an impression of the core and remaining tooth structure.

Retraction of Gingiva

(i) Cords - Prior to any impression being recorded the gingiva surrounding the tooth must be retracted. Gingival retraction cords, widely used during impression procedures, can be used with relative safety, according to Schluger et. al.[5] However, they stress that precautions must be taken not to use too much cord or cords of excessive diameters in the sulcular space which could cause damage to the attachment. Retracting thin and delicate free gingival tissue and in cases where the attached gingiva is inadequate must be carried out with the utmost care as undue insult in such cases can cause rapid recession of the gingiva. Three types of retraction cord are used by the author following the method described by Koper[6].

These cords are impregnated with either aluminium sulphate, Epinephrine (adrenaline) or zinc chloride.

The zinc chloride cords are only used to remove redundant tissue around the margins of the preparations and should be left in place for no longer than 1 - 1½ minutes. The sulcus must be thoroughly rinsed after removal.

The epinephrine cord is not advisable where large amounts are to be used for multirestorations as they may have an adverse affect on the patient's circulatory system.

The Aluminium Sulphate cord is used in two sizes. A small cord is placed in the gingival sulcus completely around the tooth and below the gingival margin, being careful not to overlap the ends. A larger cord is placed on top of the smaller cord in the same manner and left in place for approximately 3 minutes. The large cord is then removed, the sulcus is rinsed and dried and the impression taken leaving the small cord in the sulcus. This is removed immediately after the impression has been taken.

(ii) Electrosurgical Retraction[5]

This is currently accepted as a means of creating a trough surrounding the subgingival finish line. If carefully used, this method greatly facilitates accurate impression taking. Where inflammation is present or the gingival tissue is extremely thin, electrosurgical retraction is not recommended as it will usually result in recession.

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CHAPTER 13

TEMPORISATION

During the preparation in the laboratory of any of the crown or post procedures, the tooth must be covered with a temporary crown. Frequently a tooth must be well temporised to improve the gingival condition prior to the impression being taken. Josephson[1] writes that any temporary coverage procedure must be accomplished quickly at the chair with the final result being aesthetic, comfortable to the patient, durable and most important, capable of holding the particular tooth or teeth in the correct occlusal position for the patient under treatment.

When the Parapost is used an aluminium post of the same diameter as the wrought post or plastic pin that has been used is chosen to act as the temporary post. Similarly, aluminium pins are supplied in the V.I.P. Kit to fit as temporaries in the prepared pin holes. These posts should be cemented with a temporary cement e.g. Zinc Oxide-eugenol to allow for easy removal. The posts may sometimes not require temporary cementing and the pins are usually not cemented into position. The temporary superstructure is placed over these posts or pins with a temporary cement.

For single abutments there are several types of prefabricated temporary crowns manufactured in tin, aluminium and methyl methacrylate.

Well - fitting, preformed crowns of methyl methacrylate cemented with a thick mixture of zinc oxide and eugenol (due to a reaction between methyl methacrylate and eugenol, the temporary crown should be protected by applying a thin film of a silicone lubricant to its internal surface prior to cementation[2]) do not have a deleterious effect on the gingival tissues[3], provided that these crowns are shaped to the almost - exact contour of the tooth. The crown should not be placed too deeply into the gingival sulcus and it must never be apical to the border of the preparation. The marginal fit of the temporary crown should approach that of the permanent crown.

Schluger et. al.[4] points out that an over extended temporary crown can lead to gingival hyperplasia or recession if the epithelial attachment has been severely injured. Poor proximal - contact relationship leads to food impaction and retention and to possible drifting of the approximating teeth. Yuodelis[4] uses Coe-pac to cement temporary acrylic crowns that are purposefully under extended and that are to remain in position for less than one week.

Ramfjord[5] states that compression of the free gingival margin and the interdental papillae is unlikely to be of permanent periodontal significance when present for a relatively short time. However, over a prolonged period the chance of plaque accumulation increases and periodontal destruction may be produced.

Donaldson[6] noted that gingival recession was common with temporary crowns and increased with the time of wearing of these crowns. He states that 33% of patients who had gingival recession at the time of insertion of the permanent crown experienced complete rebound of the recession. In 10% he found permanent recession of 1 mm.

Where a number of crowns are to be constructed, the temporary coverage can be made directly in the mouth using a preformed acrylic template polyporpylene sheet.and a quick setting acrylic such as Scutan or Trim. Bergman[3] reports that some allergic reactions to Scutan have been reported in the literature and contact allergy has been found in the oral mucosa. Baraban[2] states that when a temporary acrylic crown is to be placed over a composite resin core a silicone lubricant is applied to the resin. This prevents adhesion of the freshly placed acrylic resin to the underlying composite resin. The removal and reinsertion of the present temporary crown once or twice will also help to prevent adhesion of the two resins.

The aluminium crowns used for temporary coverage are limited, because of aesthetics, to the posterior teeth. They have the disadvantage of poorer occlusal adaptation leading to a greater chance of tooth movement.

Two types of these crowns are available viz :

(i) Kings Aluminium Shell Crowns
(ii) Ion Brand Ni - Chro Crowns

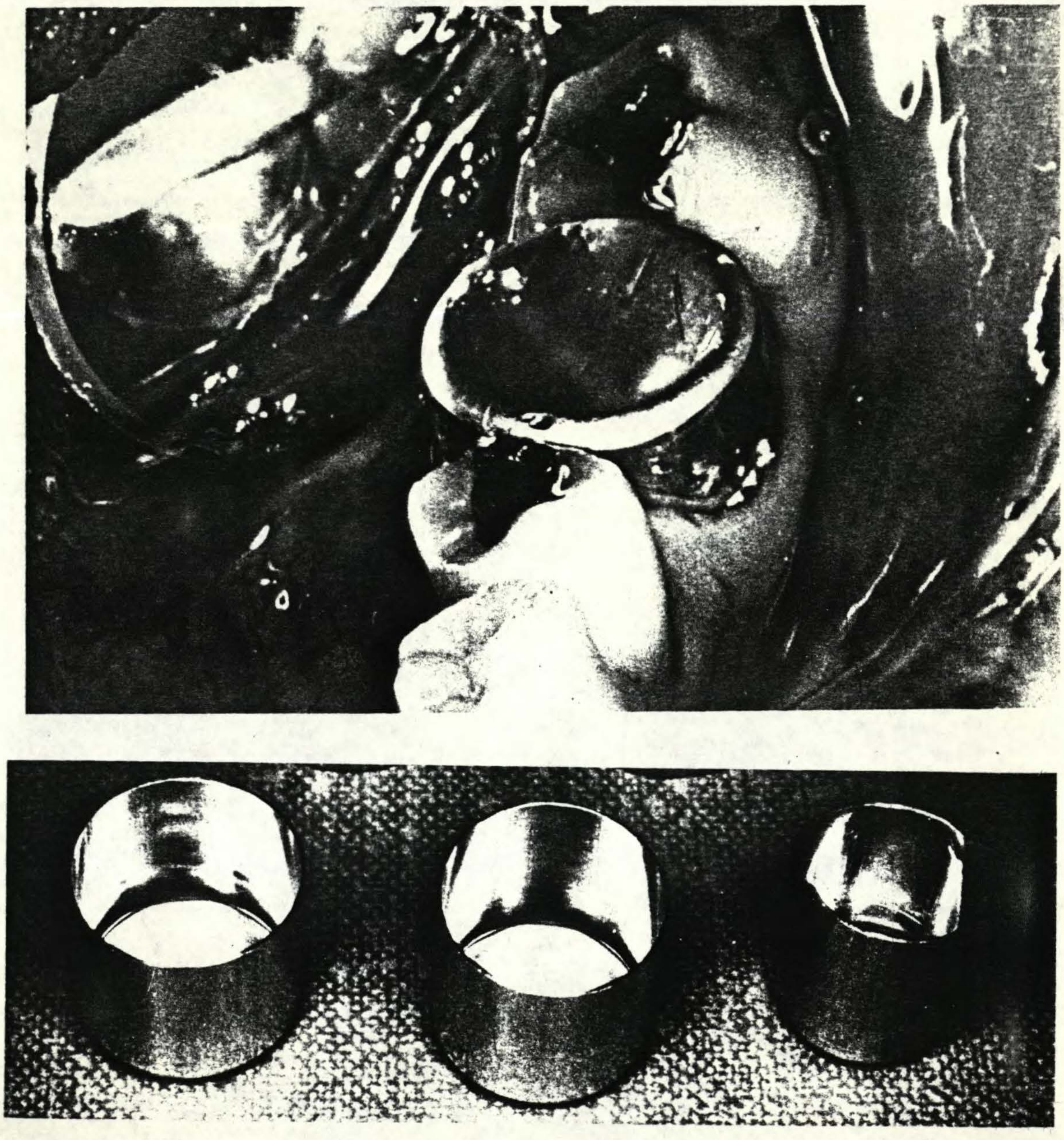
These crowns must be well contoured and the edges smoothed before being fitted to the tooth. They do have a certain ease of manipulation.

Ramfjord[5] states that it is most important to maintain a stable functional occlusal contact as well as lateral contacts with the temporary crown. If this principle is not adhered to the fitting of the permanent structure becomes more difficult in that the tooth may have overerupted or drifted laterally and to force such a tooth back to its original position may be very difficult.

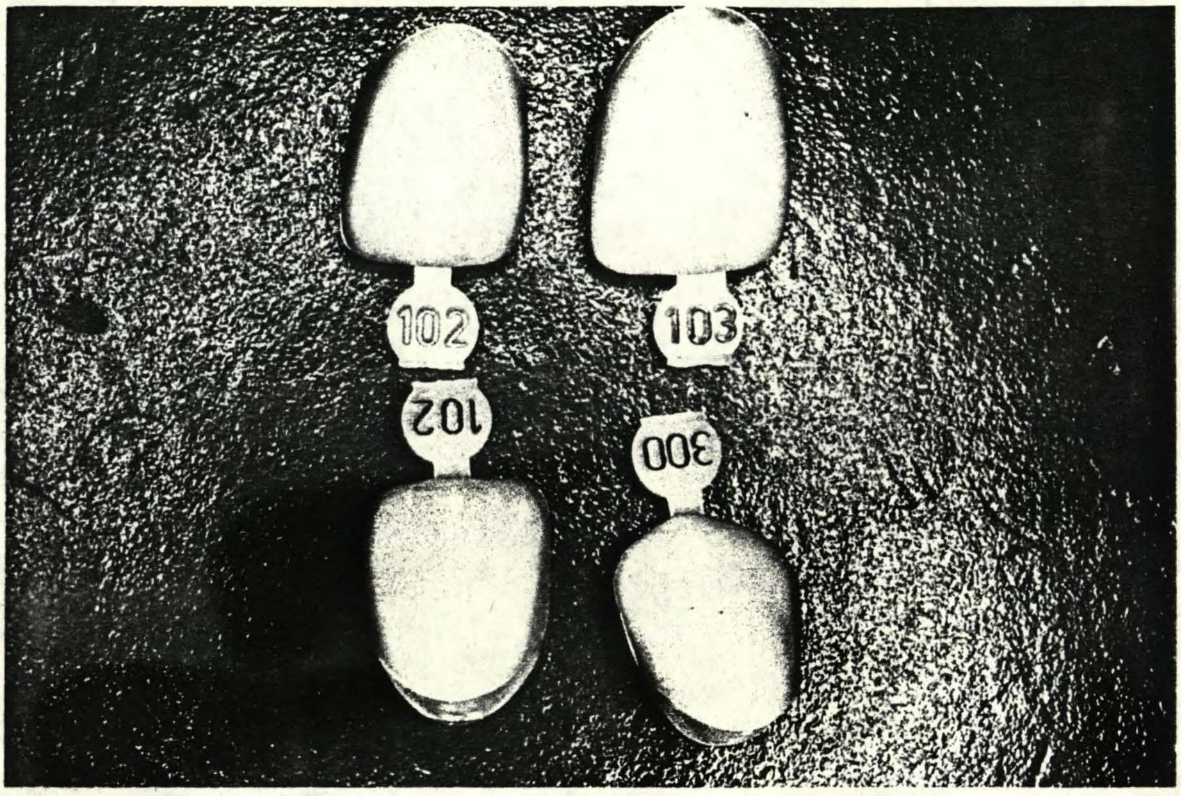
A method is described by Nayyar and Edwards[7] using the Ion metal shell crowns. A crown slightly larger than the tooth is selected, cut to size and smoothed over and the patient instructed to close in the maximum intercuspal position. The tooth is now well lubricated and the crown filled with self-curing acrylic resin. When the resin reaches the doughy consistency the crown is placed over the tooth and the patient bites down firmly. The crown is removed from the tooth when the acrylic has almost set. The acrylic is now trimmed and the whole structure should be shaped to produce contours that are complimentary to the rest of the teeth in the quadrant.

Nayyar and Edwards prefer the use of Temp Bond as a cementing medium for the temporary crown as it is easy to manipulate, sets moderately hard, and is easy to remove from the preparation prior to cementing the final superstructure. They note that if a liquid-powder zinc oxide-eugenol system is used the excess eugenol will attack the acrylic resin and render it soft and spongy. Furthermore, if a second reline is desired at the next appointment the eugenol will inhibit polymerization of the fresh acrylic resin.

(Figure 13 : 1) Kings Aluminium Crowns.



(Figure 13 : 2) Ion Polycarbonate Crowns.



(Figure 13 : 3) In the Mouth.

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CHAPTER 14

MATERIALS USED FOR CASTING OF DOWELS AND CORES

For many years gold of varying hardness has been used in the construction of posts and cores, with great success.

However, because of the high cost of precious metals today, the need for an inexpensive, non-precious metal in the fabrication of a cast post and core has come about[1]. The possibility that precious metals may become difficult to obtain has further led to the development of the non-precious metals[2].

Gourley[3] pointed out that a dental alloy is judged by its function, accuracy of fit, and physical properties. Any substitute alloy must, therefore, demonstrate properties similar to those of the gold alloys if they are to be clinically successful.
Dale and Moser[4] state that the most important clinical requirements are the accuracy of fit of the casting, and the castings ability to be burnished at the margin, and its resistance to tarnish and corrosion.

Dedomenico[1] states that non-precious chromium cobalt alloys have been used for several years in the fabrication of partial denture frameworks and have nearly replaced the use of gold because of their strength, low cost and decreased weight. However, the size of the ingots and the high melting temperature of the metal have made them somewhat impractical for use in casting a single small post and core.

Engelman and Blechner[5], in recent work state that the early problems of Nickel - chromium alloys in the fabrication of ceramo-metal crowns and fixed prostheses have been overcome. A series of interrelated steps which must be faithfully followed both clinically and in the laboratory and if followed meticulously, produce excellent results.

Pinkley and Morris[6] wrote that one of the most significant disadvantages of present day gold substitutes is their relatively low elongation level. However, this poses no problem for post and core castings as the final margins of the crown will be on sound tooth structure beyond the margins of the post and core. Burnishability of the post and core is, therefore, not a relevant factor.

Dale and Moser[4] did a study in which an examination was made of the accuracy of fit of five popular semi-precious metals for cast dowel and posts, comparing them statistically with the fit of posts made from a gold alloy. The metals used were :

Alborium, Forticast, Paladin 3, Strengold 66 and Williams' W.L.W. hard.

These metals are essentially silver - palladium.

It was found that the presence or absence of gold did not affect the accuracy of the fit of the casting. They did, however, tend to be harder than gold but this was no disadvantage as it is not necessary to burnish these castings. The authors state that further examination for resistance to tarnish and corrosion be carried out before considering these semi-precious alloys as final restoration.

Reisbich[2], using a non-precious ceramic metal casting alloy (Gemini 11) found that

(i) casting with a gas - O2 flame was satisfactory
(ii) joining of units by soldering to be difficult and possibly hazardous. One-piece castings are preferable at this time. However, one piece casting with a long span may not be accurate enough.

(iii) The fused ceramic takes on a blueish or greyish cast that is undoubtedly related to the alloy substructure or its oxide.

(iv) Castings required additional time for metal finishing

(v) Intra-oral occlusal adjustment is difficult and time consuming.

After a two year period he found that there was no corrosion of the metal.

The author has been using a metal known as Wiron for some years now with great success. The only disadvantage would be the hardness of the metal which makes for difficult adjustment. This is overcome by preparing the acrylic or wax impression to an almost exact replica of what is desired from the casting. Wiron 77 is now available and has a softer consistency to allow easier management. Wiron is a precious metal free bonding alloy similar to precious metal as far as the melting characteristics are concerned. Due to its hardness it can be cast to a very thin edge.

INVESTMENT AND CASTING[7].

The principal constituents of the non-noble alloys melt at temperatures which require the refractory capabilities of phosphate or ethyl silicate bonded investments. Use of a water-mixed gypsum-bonded investment results in a thermal breakdown of the investment at the required burn-out casting temperatures. The sulphur dioxide thereby produced is deleterious to the physical and mechanical properties and surface integrity of the casting obtained.

The metal must not be over-heated. The familiar spheroiding of dental gold alloys at the temperature of casting does not occur during centrifugal casting of non-precious alloys. Waiting for spheroiding can therefore be very detrimental to the composition and therefore to the physical properties of these alloys.

Effect of Materials on Oral Tissues

When discussing the use of gold and non-precious alloys as posts and cores it is not important to consider their effect on the oral tissues. However, their use in the fabrication of the superstructure, make it essential to know how these metals relate to the oral tissues. Bo Bergman[8], in Sweden, has reviewed the literature and states that gold is the most important metal in crown and bridge prosthetics. Pure metal gold has no demonstrable cytotoxic effect and gold alloys are generally well tolerated by the oral mucosa. However, allergic reactions have been reported in the literature.

Cases have been reported where roots had been fractured due to electrochemical corrosion made possible by the combination of a stainless steel pin with a cast gold alloy. In one study[9], corrosion of root canal pins and/or posts were indicated as the cause of root fracture. The majority of the pins and posts consisted of non-precious metal alloys.

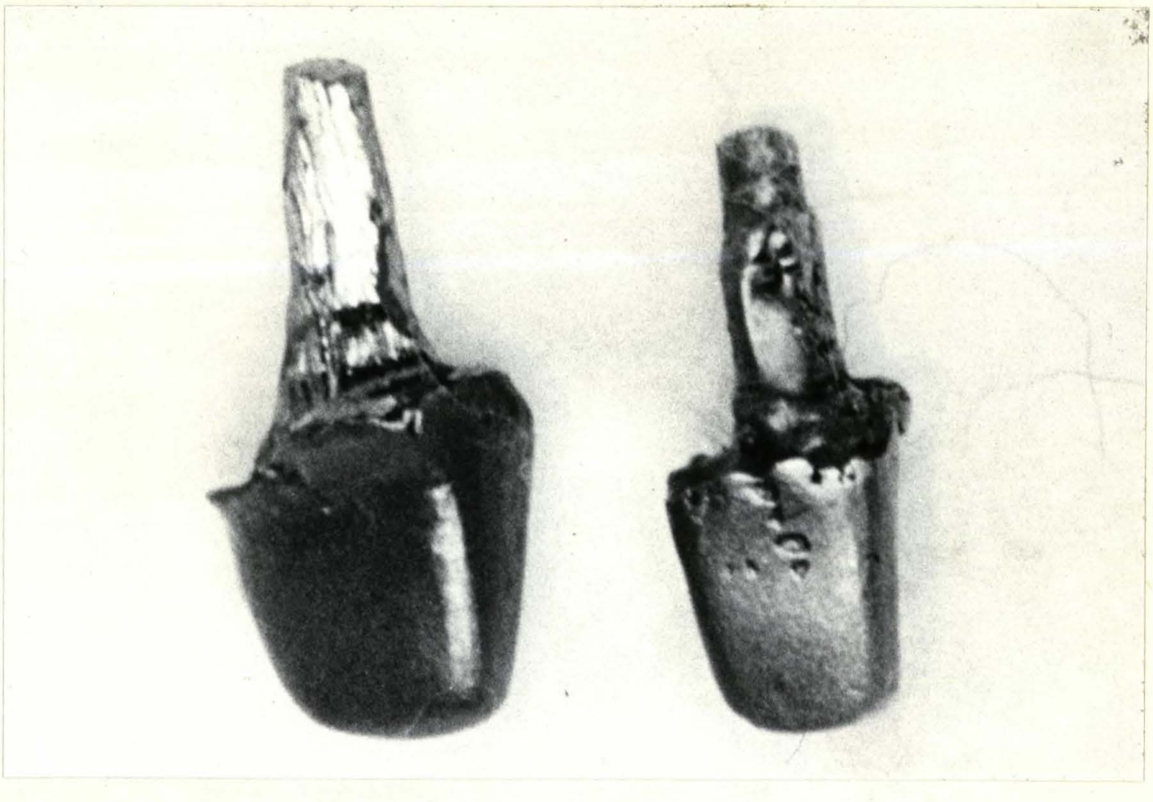
Monasky and Taylor[10] reported that a cast gold alloy did not increase the wear of tooth substance on the opposing teeth. This is in contrast to a rough procelain crown.

Metals containing nickel in high percentages increase the risk of hypersensitivity to nickel or for nickel - allergic patients to have an allergic reaction[8].

It has been indicated that porcelain is moderately toxic. However, when implanted subdermally in rats, fused porcelain caused only mild inflammatory reactions[11]. It has been shown that implanted glazed porcelain is less irritating to rat connective tissue than gold or methyl methacrylate[12].

Cured methyl methacrylate has been reported to have a negligible toxicity and is well tolerated by the surrounding tissues, except where permanent contact is present e.g. saddle type pontic[8].

(Figure 14 : 1) Wiron Castings.



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CHAPTER 15

REPAIRS

(i) Fractured Crown with no Reinforcement

In the clinical experience of the author, the most common repair that presents itself is when an anterior tooth has been endodontically treated with no post reinforcement and a crown placed on the remaining structure. This tooth is easily subjected to fracture, most commonly at the junction of the superstructure and gingival line of the tooth.

A technique has been developed to restore the tooth without having the added expense of reconstructing a new superstructure. This technique is also useful where the patient is wearing a partial denture which is adjacent to the crown[1].

The gutta perca root canal filling is removed with the previously described Peezo reamers and para-post drills, to the prescribed depth. Casting wax is placed in the canal, melted with a hot instrument and a plastic post placed into the wax. This post projects slightly beyond the gingival level of the root. The inner surface of the superstructure is now lubricated with oil or a similar lubricating substance and then filled with casting wax. The wax is heated to melting point and placed onto the root plus plastic sprue, allowed to cool and any wax projecting from around the edges is trimmed away. The superstructure is then removed leaving the wax post and core in situ. This is sprued and cast. Once completed the cast post and core is fitted to the tooth and any minor adjustments made. This part is cemented and the superstructure is fitted, adjusted if necessary and cemented.

(ii) Core Fracture with Post in Situ

In those circumstances where the core has snapped off leaving the post in situ the best procedure is to remove the broken post and reconstruct the post-core. A tungsten carbide bur in the high speed drill may be used to remove the post or a fine tapered diamond bur used to drill around the post to loosen it, after which it can be removed with an artery forcep. If this does not dislodge the post a hollow metal tube may be filled with cold-curing resin and pushed over the exposed portion of the loosened post. The resin will engage the roughened parts of the post which will have been created by cutting around the post with a bur. When the resin has hardened, the tube and post may be removed together.

Another method describes the use of a regular T.M.S. pin screwed into the post. Using the Eggler Post-Puller to grip the pin, the whole structure is removed from the root[3].

(iii) Where Post cannot be Removed.

It may not always be possible to remove the post or to remove it without serious risk of root fracture. Henry and Bower[4] write that a new restoration should be designed on the existing substructure reducing the dowel crown to "conceive a preparation of amended classical form". They advocate leaving a satisfactory post in situ and fabricating a pinned casting with long pins and burn-out resin. The separate sections are further united and supported by the overlying crown designed to hold the tooth together.

Similarly T.M.S. pins can be used to support a composite or amalgam core. The new core can be shaped to create an exact fit corresponding to the inner surface of the crown.

When using pins, because of the high risk of cracking or crazing the enamel cemented, rather than the screw type of pin would be considered preferable.

Samani and Harris[2] describe two methods to replace the fractured core.

Method (a)

A fissure is used to cut a partial slot around the post to a depth of 3 mm. This C-shaped slot is cut in the thickest portion of the root, the buccal, leaving the lingual portion uncut to avoid weakening the tooth. A pin hole 0.7mm in diameter is drilled to a depth of 3mm in the lingual portion of the root structure. The wall of the slot and the pin hole are made parallel to the protruding post. Gingival tissue is removed by electrosurgery to allow for a long bevel on the periphery of the tooth in order that a gold band can be placed around the root to increase retention and support. The core is waxed with a pin of precious alloy and cast in one piece, fitted and a crown constructed over this. In some instances the core and crown can be constructed in one.

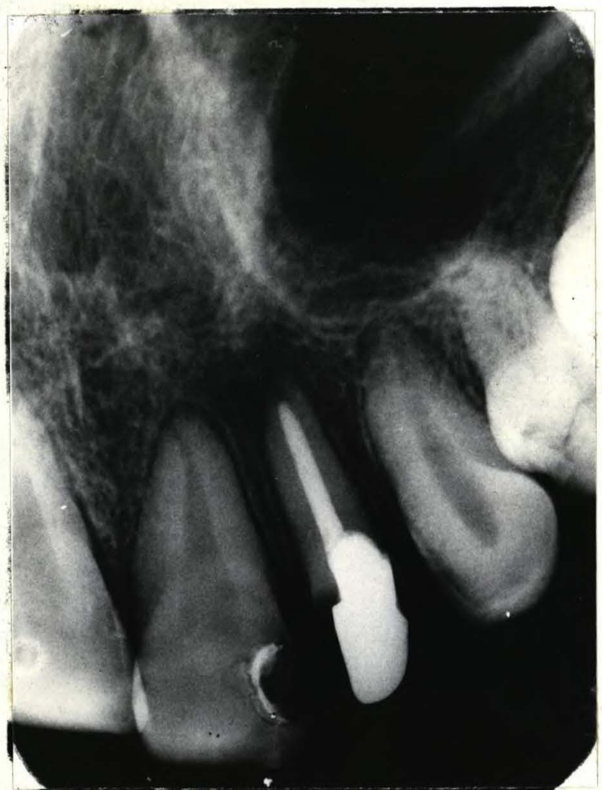
Method (b)

A special hollow end-cutting bur is used to cut a canal around the post to a depth of 5.5mm. A plastic sprue pin, comparable in size to the special bur, is hollowed out to fit over the protruding post, which is then lubricated and the hollow pin is fitted with cold-curing acrylic resin, placed over the post, and left until the resin sets. The hollow pin is removed and returned to place after resin is painted on the outside wall of the plastic pin to fill the remainder of the canal surrounding the post. A core is then built up to restore the missing coronal tooth structure. The resin pattern is removed from the tooth and a stainless steel post of comparable size to the one inside the tooth is fitted into the canal in the pattern. After painting the post with anti-flux it is seated into the pattern, and the entire unit is sprued and invested and cast. After fitting, the superstructure is constructed.

(iv) Removal of the Post and Core

In certain circumstances e.g. a flare-up of the periapical tissue, it may be necessary to remove the post and core in order that the endodontic treatment can be reinstituted. One method of removing the cast structure would be drilling the whole unit out. This, however, can present great difficulties, more expecially if one of the non-precious metals have been used with their extra hardness. Ewing[5] describes a method whereby a hole is drilled through the core, wire threaded through the hole and with the aid of a crown remover (e.g. the Simcrest crown remover with a Rand crown removing Adaptor) a force is applied to the casting in order to dislodge it. The author has met with limited success using this method and the possibility of fracturing the root must be considered. The Eggler Post-Puller can also be used.

(Figure 15 : 1) Incorrectly placed post should be removed.



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CHAPTER 16

A CRITICAL SUMMATION

The science of endodontic therapy has advanced to the point where the treatment of the pulpally involved tooth has become a highly predictable procedure[1]. Before embarking on the restoration of the tooth it is essential to have good quality diagnostic radiographs to help in the location of the root canal that is to be used for the strengthening of the tooth.

A healthy periodontium is essential before proceeding with any restorative work. Blair[1] points out that no single restorative technique can answer every clinical situation. The practitioner should use the method most suitable in his hands based, of course, on sound scientific foundations.

Some personal and subjective opinions with reference to the literature reviewed, are now offered the reader.

WHEN TO BEGIN TREATMENT

The time to commence the restoration of the tooth remains controversial. However, in asymptomatic teeth, 1 - 2 weeks should be allowed between the endodontic therapy and commencement of the permanent restoration[2].

POSTS AND CORES

The operator has, as his main objective, the construction of a post and core foundation to strengthen the endodontically treated tooth in order that this tooth can be utilised as an individual restoration or as an abutment for a fixed or removeable bridge.

The Para-post system has proved to be an invaluable aid in post and core construction, particularly when used with pins and a composite or amalgam core build-up. The author prefers to use composite as the preparation can then be completed in one visit, with the impression for the superstructure at the same appointment. This saves an extra visit for the patient and at the same time reduces surgery time for the operation. However, when building a core on a posterior tooth, where saliva is not easily controlled, amalgam may be easier to handle. Admittedly rubber dam can be used thus preventing contamination of the composite, but the rubber dam is not always easily applied to a broken down posterior tooth. The strength of composite and amalgam has been found to be very satisfactory and in fact data published indicates that the tensile strength and elastic modulus of composite resins approaches those of amalgam after 24 hours[3].

Combe[4] gives relative figures for amalgam and composite materials as follows :

<u>Tensile Strength</u> (MN/m^2)

Amalgam	:	60
Composite	:	40

<u>Compressive Strength</u> (MN/m^2)

Amalgam	:	300
Composite	:	200

This is compared with enamel and dentine :

		Tensile Strength MN/m^2	Compressive Strength MN/m^2
Enamel	:	35	200
Dentine	:	60	300

When using the composite a celluloid crown form is always fitted in preference to "painting" the resin onto the post and pins. The "paint on" technique can result in an inadequate density of composite. Kantor and Pines'[5] observation that the composite resin core be used in single restorations that are not likely to become abutments is endorsed by the author who has found that in high stress areas the composite can separate from the post and pins.

The Para-post system has certain limitations and as canal morphology becomes ovoid or ribbon shaped, cylindrical systems are found to present difficulties. A cast post and core is then recommended.

Mention is made here of a clinical study conducted by Roberts[6], one of the few studies of this type, where he found the failure rate of post crowns used as bridge retainers to be 4,26 per cent per year, a figure that he considered high and which he felt emphasised the extreme care which must be taken if a post crown is to be used for bridge abutments.

In the anterior segment of the mouth the direct method of constructing a post and core is found to be most satisfactory. The casting is assured of being an excellent fit and from an economic point of view of value as the laboratory costs are obviously reduced. Adequate occlusal clearance can be readily checked throughout the entire range of occlusal movements making for an easier fit of the superstructure without too many adjustments.

The indirect method can be used but is always prone to inaccuracies in the casting of the model and the waxing up in the laboratory.

The author prefers to use a quick-setting acrylic such as Duralay or Resincap which once set, allows for exact trimming of the core. However, if time is of the essence blue wax is used as the post and core can then be waxed up in a matter of minutes compared to the acrylic resin which requires approximately 10 - 15 minutes for the setting of the post and then core attachment. The author has found Metrick's method a good compromise[7]. (Page 44)

For posterior teeth the indirect method of impression taking is more efficient and sectional cores have proved to be highly stable and retentive. However, the Para-post with amalgam or composite is often used with success.

The reader is referred to the graph on page 77 which gives a very good guide to five different systems. The point must be stressed that the cast post must be at least the same length as the crown, as the greatest number of failures of cast posts have been found to be with posts that are too short and also of insufficient diameter. (See page 22).

The anti-rotational notch must always be included in the casting and venting the casting with a narrow fissure bur allows for easier seating during cementation.

MATERIALS FOR CASTING

Gold is approximately five times the cost of the non-precious metal e.g. Wiron, a factor to be considered when costing a crown. Wiron has been found to be highly satisfactory with an excellent reproduction of the acrylic or wax impression.

THREADED POSTS

When the Kurer Anchor System is used, it is essential to adhere to the manufacturer's instructions with regard to the necessary amount of countersinking.

The base of the core of the dowel is thereby contained entirely or largely within tooth substance, providing resistance to the non-axial forces applied during mastication[8]. The Kurer system is highly retentive but the danger of fracturing the root during placement is to be taken seriously. Fractures have occurred longitudinally in one clean split. The author recommends that the Kurer System be used only in those roots that display an adequate amount of dentine surrounding the channel.

COMPARATIVE STUDY

Mention must be made of a study conducted by Standlee et. al.[9] comparing the retentive capacity of three preformed endodontic dowel designs viz : (i) a smooth-sided, tapered dowel

(ii) a parallel-sided, serrated, vented dowel and

(iii) a threaded dowel.

The threaded dowel in this study proved to be the most retentive, the parallel-sided, serrated dowel provided intermediate retention, and the smooth-sided tapered posts were the least retentive for the same length of post. Increasing the depth of the dowels in the root canal added to their retention.

The Kurer System in this study was found to have approximately twice the retentive capacity of the Para-post System and four times that of a tapered post.

In the same study it was found that the type of cement used was not of importance, except where tapered dowels were used. Here zinc oxyphosphate cement was the most retentive.

POSTERIOR TEETH

Onlays, to protect the cusps of the teeth, are considered to be the minimum requirement needed in the restoration of the endodontically treated posterior tooth. In recent years, with the refinement of the porcelain-fused-to-metal techniques a definite swing to the full crown has been effected.

Placed in the mouths of patients with good oral hygiene, this restoration has given very rewarding results. Due to the fact that the posterior tooth may, in many instances, be very badly broken down, the margins of the preparation may have to be placed subgingivally to aid in retention. However, provided that aesthetic requirements can be met and the patient be amenable to surgery, crown lengthening procedures are preferred to create supragingival margins.

The chamfer preparation is the one of choice. The three-quarter crown must be reserved for the highly skilled operator as the preparation requires the utmost care and precision and is more difficult to prepare than the full crown. A longer clinical crown is also necessary to aid the retention.

THE SUPERSTRUCTURE

It is recommended to construct the superstructure as a separate entity from the post and core. This allows for a far better marginal adaptation once the post and core have been cemented and a new impression taken. Furthermore, if the superstructure has to be removed at a later date due to fracturing or a colour change it is far easier and safer to remove a separate superstructure than a post, core and superstructure constructed as one unit.

In certain circumstances if a single impression technique is to be used instead of first constructing the post and core it is advisable to have the impression either copper-or silver-plated to have a stable die.

Impression composition can be copper-plated, a technique not considered suitable for the elastomeric materials - they are not dimensionally stable in an acid solution. These materials can be silver plated but because of the risk of cyanide gases being given off this method is not often used[10].

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