Review Article

Current concepts in the restoration of endodontically treated teeth

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With a plethora of postsystems available, it is often difficult to decide which one to use. This is made more difficult by the fact that new posts are introduced before existing ones are fully evaluated in laboratory and clinical studies. This article is an evidence-based description of the different post types and the main advantages and disadvantages of each and changing trends in treatment planning, understanding of the subject, options available to us with regard to materials. Though the choice of post will be driven by personal preference and a history of clinical success, there are certain pit falls to avoid and these are outlined.

Key words: Core, post and postendodontic restorations, postsystems

Endodontically treated teeth generally have a good prognosis. It can resume full function and serve as an abutment to fixed partial denture also. However, special techniques are needed to restore such a tooth because a considerable amount of tooth structure has been lost because of caries or previous restoration or endodontic treatment itself. This loss of tooth structure makes retention of a subsequent restoration problematic and increases the likelihood of fracture during function. Extensive research has gone into the subject of endodontically treated teeth, yet it remains controversial from many perspectives. This article focuses mainly on recent publications and changing trends in treatment planning, understanding of the subject, options available to us with regard to materials.

Traditional belief was that endodontically treated teeth were weaker or more brittle than vital teeth. Their moisture content was reduced and clinical fracture occurred. It was assumed that, for this reason the tooth had to be strengthened by removing part of the root canal filling and replacing it with a metal post. A metal post was used to retain a core that replaced the lost tooth structure and resulted in the shape of a conventional preparation on which a crown could be fabricated. Recent studies have challenged this theory.

In 1991, Huang *et al*[1] compared the physical and mechanical properties of dentin specimens from teeth with and with out endodontic treatment at different levels of hydration. They concluded that neither dehydration nor endodontic treatment caused degradation of physical or mechanical properties of dentin. Sedgley and Messer[2] tested biomechanical preparations of dentin from 23 endodontically treated teeth with an average of 10 years of posttreatment. They compared them to their contra-lateral vital teeth and concluded that the properties were comparable except for a slight difference in hardness. This study again did not conclude that endodontically treated teeth were more brittle. Hence it the loss of the tooth structure associated with caries, subsequent access preparations that lead to a higher fracture rate in endodontically treated teeth compared with vital teeth, rather than changes in dentin.[3] Fennis *et al*[4] studied more than 46000 patients from insurance claims and reported significantly more fractures in teeth with endodontic treatment. These studies indicate that the restorations that enhance structural integrity would be expected to increase the prognosis of endodontically treated teeth exposed to heavy masticatory loading forces

PURPOSE OF POST AND CORE

The primary purpose of a post is to retain a core in a tooth with extensive loss of coronal tooth structure.[5,6] Preparation of a post space adds a certain degree of risk to a restoration procedure. Procedural accidents in the form of perforation can occur. The placement of posts also may increase the chances of root fracture and treatment failure, especially if an oversized post

channel is prepared. Hence posts should only be used when other options are not available to retain a core. The need for a post varies greatly between anterior and posterior teeth.[7,8]

Anterior teeth

Anterior teeth with minimal loss of tooth structure may be restored with a bonded restoration in the access opening. A post is of little or no benefit in a structurally sound anterior tooth and increases the likelihood of a nonrestorable failure.

If an endodontically treated tooth is to receive a crown, a post is often indicated. In most cases, the remaining coronal tooth structure is thin after it has received root canal therapy and has been prepared for a crown. Anterior teeth must resist lateral and shearing types of forces and hence the amount of remaining tooth structure and the functional requirements of the tooth determine whether anterior tooth requires a post.

Molars

Endodontically treated molar teeth should receive cuspal coverage, but in most cases, they do not require a post. Unless the destruction of coronal tooth structure is extensive, the pulp chamber and canals provide adequate retention for a core build-up. Molars must primarily resist vertical forces. If a post is required, post should be placed in the largest canal, which is the palatal canal in the maxillary molars and a distal canal in the mandibular molars. Rarely more than one post is required in a molar.

Premolars

Premolar is usually bulkier than anterior teeth, but often are single rooted teeth with relatively small pulp chambers. For these reasons, they require posts more often than molars. Premolars are more likely than molars to be subjected to lateral forces during mastication. Remaining tooth structure and functional demands are the determining factors. Because of the delicate root morphology in some premolars, special care must be taken when preparing a post space.

Factors to be considered while planning posts:

1. Retention and resistance form.
2. Mode of failure.
3. Preservation of tooth structure.
4. Ferrule effect.
5. Retrievability.

Retention and resistance form

Post retention refers to the ability of a post to resist vertical dislodging forces. Retention is influenced by post length, diameter, taper, luting cement used and whether a post is active or passive.[9,10]

Increasing the length and diameter of the post can increase retention of the post. Parallel posts are more retentive than tapered posts. Active posts are more retentive than passive posts. Diameter is the least important of all the factors.

Resistance refers to the ability of the post and tooth to withstand lateral and rotational forces. Factors influencing resistance form are post length, rigidity, presence of anti-rotational features and the presence of a ferrule. A restoration lacking in resistance form is not likely to be a long-term success regardless of the retentiveness of the post.

Mode of failure

All post systems have some percentage of failure. Some posts have a higher percentage of failure that result in teeth that are nonrestorable. Teeth restored with less rigid posts (fiber posts) tend to have failures that are more likely to be restorable. Teeth prepared with a ferrule also tend to fail in a more favorable mode. Composite resin cores, tend to fail more favorably than amalgam or gold.[11-15]

Preservation of tooth structure

Coronal and radicular tooth structure should be conserved whenever possible. Preparation of post space should require minimal removal of additional radicular dentin beyond the requirements for endodontic therapy. Further enlargement only weakens the root. It has been shown that cemented metal posts do not strengthen the root. Bonded posts are reported to strengthen the root initially but this strengthening effect is lost over time as the tooth is exposed to functional stresses and the resin bond to dentin weakens. Minimal enlargement of a post space means the post must be made of a strong material that can withstand functional and parafunctional forces.[16,17]

The ferrule effect

Ferrule is defined as a vertical band of tooth structure at the gingival aspect of crown preparation. It primarily provides resistance form and enhances longevity. A ferrule with 1-2 mm of vertical tooth structure doubles the resistance to fracture versus teeth restored with out a ferrule. It was reported that there was no difference in fracture resistance with or with out a 2 mm ferrule using prefabricated posts and resin cement. But fracture patterns were more favorable when a ferrule was present. In some cases, especially in anteriors, it is necessary to perform crown lengthening / orthodontic eruption of a tooth to provide an adequate ferrule.[15]

Retrievability

Endodontic treatment can fail. Therefore, it is important that posts can be retrieved if re-treatment becomes necessary. Metal and fiber posts are easy to retrieve. In contrast ceramic and zirconium posts are

considered to be very difficult and sometimes impossible to retrieve.[18]

Longevity studies

Mentick *et al*[19] reported 82% success for 516 anteriors restored with metal posts for more than 10 years. Torbjorner *et al*[20] reported a 2.1% fracture rate per year for 788 teeth with metal posts during a 5 year period. Median survival rate of teeth with metal posts was found to be 17.4 years.[21] Weine *et al*[22] reported nine failures of 138 restored with post and core. Minimum recall was 10 years.[22] In a twenty five year follow up,[23] longevity of teeth restored after endodontic treatment with post and core and crown were same as teeth with vital pulps and crowns.

The clinical studies with fiber posts are recent publications with a short recall period. Ferrari *et al* found that 3.2% was the failure rate of 1306 fiber posts placed in recalls of 1-6 years.[24] Carbon fiber posts showed a 7.7% failure rate in 52 teeth with average follow up of 28 months. Quartz fiber posts showed a 1.6% failure rate in 180 teeth with an average recall of 30 months.[25] Initial results seem promising with this relatively newer technology.

Different types of posts available can be grouped as:

1. Active or passive.
2. Parallel or tapered.
3. By material composition.

Active/passive

Active posts are threaded and are intended to engage the walls of the canal, where as passive posts are retained only by the luting agents. Active posts are more retentive than passive posts, but introduce more stress into the root than passive posts. Active posts should be used in short roots where maximum retention is needed.[10]

Parallel/tapered

Parallel posts are more retentive.[9] Parallel posts induce less stress into the root; there is less of a wedging effect and lesser chance of root fracture than tapered post. Tapered posts on the other hand require less dentin removal because most roots are tapered. They are indicated in teeth with thin roots and delicate morphology.

PREFABRICATED POST AND CORE

Prefabricated posts are made of stainless steel, nickel chromium alloy, brass or titanium alloy. They are all very rigid except titanium. They are round and offer little resistance to rotational forces. Hence they should be used only when adequate tooth structure remains. When minimum tooth remains, anti-rotational features should be incorporated into post preparation with slots or pins. Bonded material must be used as core. Titanium posts have a radiodensity similar to gutta-percha and sealer. Sometimes they are hard to detect on radiographs. They have low fracture strength and removal is difficult. Brass can corrode. For these reasons titanium and brass posts should be avoided.

Custom cast post and core

Cast post and core remain the standard for many years and are still used by clinicans. They do not perform as well as other types of posts during *in vitro* tests and clinical studies. They do offer some advantages. When multiple teeth require posts it is more efficient to make an impression and fabricate them in the laboratory rather than placing a post and build up in individual teeth as a chair side procedure. A cast post and core may be indicated when a tooth is misaligned and the core must be angled in relation to the post to achieve proper alignment with the adjacent teeth.

Ceramic and zirconium posts

Metal posts are visible through the more translucent all ceramic crowns and even with less translucent restorations; they may cause the marginal gingival to appear dark. Hence the esthetic posts like zirconium and other ceramic materials have been developed. They are good esthetically but the disadvantages are that they have to be thicker to be stronger. Zirconium posts cannot be etched; therefore, it is not possible to bond a composite core to post. Retrieval of zirconium and ceramic posts is very difficult. Some ceramic materials can be removed by grinding away the remaining post material with a bur, but this is a tedious and dangerous procedure. It is impossible to grind away a zirconium post.

Fiber posts

They are more flexible than metal and are approximately of the same modulus of elasticity (stiffness) as dentin. When bonded with resin cement they distribute forces evenly in the root resulting in fewer root fractures. They are available as carbon fiber, quartz fiber, glass fiber, silicon fiber posts. Except carbon fiber, all the others are better esthetically. They are radiolucent. They are relatively easy to remove by boring through the middle of the post with ultrasonic or rotary instrument. The orientation of fibers helps keep the removal instrument in proper alignment.

Post space preparation

The length of the post should be three quarters the length of the root canal or at least same as the length of the final crown. About 4-5 mm of gutta percha should remain apically to maintain an adequate seal and not 3 mm as thought traditionally.

LUTING CEMENTS

Common luting agents are zinc phosphate, resin, glass ionomer and resin-modified glass ionomer cement. Recent trend has been towards resin cements. Resin cements increase retention, tend to leak less than the other cements and provide at least short-term strengthening of root. They are recommended especially for roots with thin walls. Disadvantages of resins are that they are technique sensitive than most others. They need extra steps like preparing the canal walls with acid or EDTA and placing a dentin-bonding agent. Contamination of dentin or post can be a problem. Eugenol containing root canal sealers inhibit polymerization of resin cements. Thorough cleaning and etching of the canal walls can avoid problem. Fourth generation adhesive systems (3 step systems) provide better adhesive seal to radicular dentin than the more recent fifth generation 2 step systems. Self cure or dual cure cements should be used because of limited light penetration into the root, even with translucent posts.[10]

CORE MATERIALS

The purpose of the post is to retain a core, which in turn helps retain the crown. With cast post and core, the core is formed on the post directly on the tooth or on the cast. Prefabricated posts are used with a restorative build-up material, which is formed after cementation of the post. Currently the best choices are amalgam and composite resin.

Amalgam has good physical and mechanical properties and works well in high-stress areas. But crown preparation must be delayed to permit the material to set. Amalgam can cause esthetic problems and can make the gingiva look dark. Moreover they have no natural adhesive property. Composite resin is the most popular core material presently. It can be bonded to many of the current posts and to the remaining tooth structure. They possess high tensile strength and tooth can be prepared for crown immediately. It is tooth colored and can be used under translucent restoration.[26]

CONCLUSIONS

Most post systems can be used successfully if the basic principles are followed. Some posts can be excluded because of inadequate strength and difficulty in retrieval. Titanium alloys are relatively weak and are subject to fracture in thin diameters. They are more difficult to retrieve than the other metal posts. Active, threaded posts should only be used when maximum retention is required. Ceramic and zirconium posts are not retrievable in most cases.

The trend in clinical practice is towards fiber posts and literature is generally, in favor of them. Their performance is similar to that of the metal posts and their failure mode is more favorable than with metal posts. If future long-term clinical research studies report similar levels of success as seen in the presently available short-term studies, fiber posts are here to stay.

BIBLIOGRAPHY

1. Huang TJ, Schilder H, Nathanson D. Effects of moisture content and endodontic treatment on some mechanical properties of human dentin. J Endodon 1991;18:209-15.
2. Sedgley CM, Messer HH. Are endodontically treated teeth more brittle? J Endodon 1992;18:332-5.
3. Reeh ES. Reduction in tooth stiffness as a result of endodontic restorative procedures. J Endodon 1989;15:512-6.
4. Fennis WM, Kuijs RH, Kreulen CM, Roeters FJ, Creugers NH, Burgersdijk RC. A survey of cusp fractures in a population of general dental practices. Int J Prosthodont 2002;15:559-63.
5. Robbins JW. Guidelines for the restoration of endodontically treated teeth. J Am Dent Assoc 1990;120:558-66.
6. Goodacre CJ, Spolnik KJ. The prosthodontic management of endodontically treated teeth: A literature review. Part I. Success and failure data, treatment concepts. J Prosthodont 1994;3:243-50.
7. Heydecke G, Butz F, Strub JR. Fracture strength and survival rate of endodontically treated maxillary incisors with approximal cavities after restoration with different post and core systems: An in-vitro study. J Dent 2001;29:427-33.
8. Kane JJ, Burgers JO. Modification of the resistance form of amalgam coronal-radicular restorations. J Prosthet Dent 1991;65:470-4.
9. Standlee JP, Caputo AA, Hanson EC. Retention of endodontic dowels: Effects of cement, dowel length, diameter and design. J prosthet Dent 1978;39:401-5.
10. Felton DA, Webb EL, Kanoy BE, Dugoni J. Threaded endodontic dowels: Effect of post design on incidence of root fracture. J Prosthet Dent 1991;65:179-87.
11. Akkayan B, Gulmez T. Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent 1998;80:527-32.
12. Cormier CJ, Burns DR, Moon P. *In vitro* comparison of the fracture resistance and failure mode of fiber, ceramic and conventional post systems at various stages of restoration. J Prosthodont 2001;10:26-36.
13. Newman MP, Yaman P, Dennison J, Rafter M, Billy E. Fracture resistance of endodontically treated teeth restored with composite posts. J Prosthet Dent 2003;89:360-7.
14. al-Hazaimeh N, Gutteridge DL. An *in vitro* study into the effect of the ferrule preparation on the fracture resistance of crowned teeth incorporating prefabricated post and composite core restorations. Int Endod J 2001;34:40-6.
15. Stankiewicz NR, Wilson PR. The ferrule effect: A lit-

erature review. Int Endod J 2002;35:575-81.
16. Guzy GE, Nichols JI. *In vitro* comparison of intact endodontically treated teeth with and with out endo-post reinforcement. J Prosthet Dent 1979;42:39-44.
17. Mannocci F, Ferrari M, Watson TF. Intermittent loading of the teeth restored using quartz fiber, carbon-quartz fiber and zirconium dioxide ceramic root canal posts. J Adhes Dent 1999;1:153-8.
18. Abbott PV. Incidence of root fractures and methods used for post removal. Int Endod T 2002;35:63-7.
19. Mentick AG, Meeuwiseen R, Kayser AF, Mulder J. Survival rate and failure characteristics of the all metal post and core restoration. J Oral Rehabil 1993;20:455-61.
20. Torbjorner A, Karlsson S, Odman PA. Survival rate and failure characteristics for two post designs. J Prosthet Dent 1995;73:439-44.
21. Nanayakkara L, McDonald A, Setchell DJ. Retrospective analysis of factors affecting the longevity of post crowns. J Dent Res 1999;78:222.
22. Weine FS, Wax AH, Wenckus CS. Retrospective study of tapered, smooth post systems in place for 10 years or more. J Endodon 1991;17:293-7.
23. Valderhaug J, Jokstad A, Ambjornsen E, Nordeim PW. Assessment of the periapical and clinical status of crowned teeth over 25 years. J Dent 1997;25:97-105.
24. Ferrari M, Vichi A, Mannocci F, Mason PN. Retrospective study of the clinical performance of fiber posts. Am J Dent 2000;13:9B-13.
25. Malferrari S, Monaco C, Scotti R. Clinical evaluation of teeth restored with quartz fiber-reinforced epoxy resin posts. Int J Prosthodont 2003;16:39-44.
26. Pilo R, Cardash HS, Levin E, Assif D. Effect of core stiffness on the in vitrofracture of crowned, endodontically treated teeth. J Prosthet Dent 2002;88:302-6.

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