RESTORATION OF ENDODONTICALLY TREATED TOOTH- CONCEPTS AND TECHNIQUES

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Abstract

The extraction of grossly decayed teeth with least remaining tooth structure has now become the history. With advances in the field of dentistry, teeth formerly considered for extraction are now being saved. However, it is clear that significant reconstruction is often required, and evident that a wide variety of ways exist to achieve this. The longevity of endodontically involved teeth has been greatly enhanced by continuing developments made in endodontic therapy and restorative procedures. It has been reported that a large number of endodontically treated teeth (ETT) are restored to their original function with the use of intraradicular devices. These devices vary from a conventional custom cast post and core to one-visit techniques, using commercially available prefabricated post systems. Despite the vast literature that had been published with regards to the restoration of ETT, the organization and subsequent formulation of such information into a proper treatment protocol remains cumbersome for many clinicians. This article aims to provide a review of the aforementioned literature and then to highlight some of the significant guidelines for the restoration of ETT.

Keywords: Endodontically treated tooth (ETT), post and core
Introduction

The restoration of endodontically treated teeth (ETT) has traditionally been known as an empirical practice without entirely predictable result\(^1\). A good percentage of clinicians have been carrying out their treatment plans based on past clinical experience without resorting to a specific treatment protocol\(^2\). However, recent technological advances in endodontics, periodontics and restorative dentistry have contributed to a shift in such practices paving the way for more predictable restorative results due to the gradual development of reliable treatment protocols.

Provision of proper endodontic treatment and subsequent coronal restoration to teeth that were once thought of as “hopeless” or “lost” contributes to maintaining the stability of the dental arches, as well as improving aesthetics\(^3\). Furthermore, the use of ETT as abutments for fixed or removable prosthesis has provided successful clinical results over time\(^4\).

Special care needs to be taken in the restoration of endodontically treated teeth because a considerable amount of tooth structure is often lost because of caries\(^5,6\), previous restorations and the endodontic treatment performed. Also the neuro-sensory feedback mechanism is impaired with the removal of the pulpal tissue, which may result in decreased protection of the tooth during mastication\(^7,8\).

It is generally agreed that the successful treatment of a badly broken down tooth with pulpal disease depends not only on good endodontic treatment but also on a good subsequent prosthetic reconstruction. The objectives of reconstruction are form, function, aesthetics, prevention of fracture of the remaining roots and retention of the final restoration. This reconstruction usually includes some combination of a dowel, core and a coronal restoration or a more conservative approach depending upon the tooth in question.

Selecting the optimum restorative modality to compensate for the loss of coronal tooth structure is considered the key to restorative success\(^9\). Prior to choosing a post and core system, the dentist must have a clear understanding of several variables regarding the post-tooth combination. These variables include the post length, diameter, shape or design, venting, surface roughness, in addition to the canal preparation, method of cementation and luting medium.

Are endodontically treated teeth different?

Several classic studies have proposed that the dentin in endodontically treated teeth is substantially different than dentin in teeth with “vital” pulps\(^10, 11, 12\). It was thought that the dentin in ETT was more brittle because of water loss\(^10\) and loss of collagen cross-linking. However, more recent studies dispute this finding\(^12\). In 1991, Huang et al\(^13\) compared the physical and mechanical properties of dentin specimens from teeth with and without endodontic treatment at different levels of hydration. They concluded that neither dehydration nor endodontic treatment caused degradation of the physical or mechanical properties of dentin. Sedgley and Masser\(^14\) were able to show that vital dentin is harder than dentin from contra lateral ETT, but there was no significant biomechanical change that would indicate that the ETT had become more
brittle. This result is also supported by Papa et al.

Various studies support the interpretation that it is the loss of structural integrity associated with the access preparation, rather than changes in the dentin, that lead to a higher occurrence of fractures in ETT compared with “vital” teeth.\textsuperscript{15,16} Access preparations result in increased cuspal deflection during function and increase the possibility of cusp fracture and microleakage at the margins of restorations. In most ETT, there also is missing tooth structure caused by caries or existing restorations.

**Functions of Post**

The post and core restorations must satisfy the 3R rule - Retain (obtain retention), Reinforce (increase resistance of hard dental tissue against occlusal forces) and Restore (replace the lost parts of the hard dental tissue).\textsuperscript{17}

1. Posts retain the restoration. Posts provide retention for the core that replaces lost coronal tooth structure. Its use should be considered where two adjacent walls of a tooth are missing. When significant coronal tooth structure is present and access preparation is conservative, a crown can often be placed without a post.

2. Posts protect the remaining tooth structure. They reinforce the remaining tooth structure by transferring the load away from areas susceptible to stress concentration and by increasing the stiffness and resistance to bending. However, it is mainly the structure and amount of remaining dentin around the post that provides strength and resistance to fracture rather than the post itself.

**Indications and contraindications of post and core:**

The post and core requirement and selection mostly depend on the clinical finding, quantity of the remaining dental tissue, function of devitalized tooth and occlusal forces.

**Indications for Post:**

1. When complete or almost complete clinical crown is missing and what remains does not enable sufficient retention for filling or individual fixed restoration\textsuperscript{17}.

2. When the retention surface of the clinical crown is reduced by high-degree attrition or abrasion and the post and core is performed for protective and/or prophylactic reasons.

3. When the non-vital tooth is to be protected against fracture as the bridge abutment.

**Contraindications for posts**

1. Abnormal root anatomy.
2. Extensive caries including root caries.
3. Perforations.
4. External root resorption.
5. Short dilacerated roots.
7. Young patients with coronal fracture and incomplete root formation.
8. Poor oral hygiene.
9. Improper root canal treatment
10. Tooth with periapical pathology
11. If there is less than 2 mm sound dentine coronal to the proposed crown margin;
12. If the mechanical resistance of the restoration is inadequate for the intended occlusal loading.

**Factors affecting selection of post**

**Post Length (Figure 1)**

Opinions on optimal or ideal post and core length differ among authors. The preparation depth is determined by the root and root canal morphology, apical third of the root, required retention of permanent restoration and alveolar...
bone. If the post length is compared with the proportion of the natural crown and root, the post lengths may be:

1. Equal to one half of the remaining root length.
2. Equal to two thirds of the root length.
3. Equal to three quarters of the root length.
4. Approximately equal to the length of the clinical crown.
5. Equal to the permanent restoration length.
6. Should be placed centrally between the root tip and the highest point of the alveolar septum.

Different lengths are recommended for the filling remaining after the canal preparation. Colman, Schillingburg and Kahn leave a minimum 3 mm, Zmaner 4 mm, Baraban 3.5 to 4 mm, Perel and Muroff 3 to 5 mm, and Camp 5 mm of filling. The unprepared apical part of the root longer than 5 mm would reduce the post and core retention, and longer preparation is not necessary since it is equal to two thirds of the root length.\textsuperscript{17}

**Post Width**

Preserving tooth structure, reducing the chances of perforation, and permitting the restored tooth to resist fractures are criteria in selection of the post width.\textsuperscript{18,19} Various investigators\textsuperscript{20,21,22} have recommended different approaches regarding the selection of the post diameter. These approaches were summarized by Lloyd and Palik\textsuperscript{23} into 3 categories, conservationist (13 proponents), preservationist (7 proponents), and proportionist (6 proponents) approaches. The first group includes conservationists that advocate the narrowest diameter for fabrication of a dowel to a desired length. They advocate minimum instrumentation after removal of the guttapercha and consider that such preparation should reduce the chances of root wall fracture. The second group encompasses the preservationists who consider that minimum quantity of dentine around the post and core is sufficient to prevent the root fracture. For example, Caputo and Standlee\textsuperscript{24} recommend only 1 mm of dentine around the post and core. The third groups are proportionists who advise that the post and core diameter should be equal to one third of the root width. Such proportional relation ensures sufficient width of dentine which will resist stresses. Tilik et al\textsuperscript{20} prepared a table showing indicated and optimum diameters for prefabricated post preparation. The root part of the post and core should not exceed one third of the root width; however, the root canal must be surrounded with a minimum 1 mm of dentine. The apical area is particularly problematical, since that is where the root narrows under concentrated forces. Preparation with a narrower diameter has higher resistance to stresses, and the width has no significant effect on the post and core retention.

**Post Design (Figure 2)**

The ETT are restored either with a cast post-core or prefabricated post. The prefabricated posts are classified according to their shapes and surface characteristics. They may be parallel, tapered, or parallel-and-tapered combination. According to their surface characteristics, the posts are active or passive.\textsuperscript{25,26,27} The passive post depends on the cement and its close adaptation to the canal wall for its retention.

The post should be chosen, in part, by the amount of retention which the clinical situation requires. If the post length is adequate, usually
considered to be 7 or 8 mm and the canal configuration is normal, either the tapered or parallel prefabricated post may be selected.

**Post Material (Figure 3)**

To achieve optimum results, the material used for the post should have physical properties similar to that of dentin, be bonded to the tooth structure, and be biocompatible in the oral environment. It should also act as a shock absorber by transmitting only limited stress to the residual tooth structure. Unfortunately, the materials used for post and cores, as well as luting agents, have distinct physical properties different from dentin and exhibit fundamentally different fatigue behavior. Traditionally, posts were made of metal alloys. Recently, nonmetallic posts have been introduced. Several studies have examined post and cores made of various alloys and other materials with different rigidity and demonstrated that rigid materials resisted greater forces without distortion.

Recently introduced carbon fiber posts are purported to have mechanical properties that closely match those of the tooth. The presence of the parallel fibers in the resin of carbon fiber posts enable them to absorb and dissipate stresses. In vitro studies have demonstrated that carbon fiber posts have inferior strength compared with metal posts when subjected to forces simulating those in the oral cavity.

Zirconium ceramic, which is presently used for posts, has a high modulus of elasticity, and therefore the forces are assumed to be transmitted directly from the post to the tooth interface without shock absorption. The stiffer ceramic post may cause more root fractures compared with the carbon fiber post.

Although various claims are made with regard to nonmetallic posts, there is a need for long term clinical evaluation of both metallic and nonmetallic post systems to allow a definitive recommendation of either of them. Until such time, metallic posts continue to be the standard for most situations because they have stood the test of time.

**Core Material**

The ability of a post to distribute stress can be affected by core material. The choice of core material and the stress-producing characteristics must be considered by the clinician. Cast posts and cores and prefabricated post systems using composite, glass-ionomer, or amalgam core material have been described in the literature. The modulus of elasticity of the core material affects the distribution of the stress. Davy et al. showed a reduction in stress concentration around loaded serrated posts with composite resin cores when compared with posts without cores, whereas Yaman and Thorsteinsson reported that stiffer core material increases the cervical stresses and diminishes apical stress. This was considered to be because of inhibition of the intrusion of the loaded posts.

The amalgam and composite resin core has been reported to help in distribution of stresses to the surface underneath the core, thus creating less cervical stresses. The strength of glass-ionomer–based material is reported to be lower compared to amalgam and composite. Gateau et al. reported that under cyclic loading, a core fabricated from amalgam has the lowest rate of defects, followed by composite. The glass-ionomer core material
shows the highest rate of defect. Recently, bonding techniques have been introduced to improve the retention and resistance of the cores.

**Role of Hydrostatic Pressure**

Cementation plays a significant role in enhancing retention, stress distribution, and sealing irregularities between the tooth and the post. During cementation, an increase in stress within the root canal has been reported because of the development of hydrostatic pressure. This pressure affects the complete seating of the post and may also cause fracture of the root. Fortunately, there is evidence that the fitting stresses can be reduced by careful placement of the post and by using a proper post design with a cement vent to permit escape of the luting agent and thus reduce the hydrostatic pressure. Tapered posts, however, are self-venting and will permit the cement to flow out along the entire surface. Pressure development is also dependent on the viscosity of the cement. The more viscous the cement, the greater the development of the hydrostatic pressure.

**Practical Considerations**

To ensure long-term serviceability of the restored ETT, the following factors are to be considered:

- Posts should be placed along the long axis of the tooth and should be in the center of the root or canal, as this is considered as a neutral area with regard to force concentration.
• The length of the post has a significant effect on retention and resistance. It should be as long as possible but must not weaken the apical seal or cause perforation of the root\textsuperscript{11}.
• The narrowest possible post diameter should be chosen, but it should be sufficient to resist bending and preserve as much dentin as possible\textsuperscript{52}.
• The post selected should be parallel sided, serrated, vented, and passive. It must be well adapted to the canal wall\textsuperscript{51}.
• Active posts are to be considered in case there is a need for increased retention, but care must be taken to avoid insertion stresses.
• Ideally, dissimilar metals should not be used in the post, core, and crown.
• Of the various cements available, zinc phosphate cement is a time tested one. Resin cement has been demonstrated to provide greater retention and resistance, but should be chosen only in conditions where excess retention is required and when the clinician is well versed in its manipulation, as this cement is technique sensitive\textsuperscript{53}.
• When a prefabricated post is used, the core material should be either amalgam or composite resin. This core material should be used with a bonding agent.
• The clinician should retain as much coronal dentin as possible. In case the exposed dentin is not sufficient, surgical crown lengthening and/or orthodontic extrusion can be considered to give an adequate ferrule of 1.5 to 2 mm for the final crown\textsuperscript{54}.
• In endodontically treated posterior teeth, complete coverage is mandatory\textsuperscript{55}.
• Tooth function must be considered when determining the need for a post and core\textsuperscript{56}.
• Reconstructed endodontic teeth may not be suitable as abutments in individuals with a history of bruxism or those requiring a long-span fixed partial denture\textsuperscript{56}.
• Avoid use of a reconstructed endodontic tooth as abutment for a distal extension removable partial denture or cantilever fixed partial denture\textsuperscript{57}.
• The use of a restored tooth to support a noncantilever fixed partial denture must be done carefully on an individual basis\textsuperscript{57}.

Post and cores contribute in providing predictable restorative options for ETT. After reviewing the literature, it appears that an ideal post system should have the following features: (a) physical properties similar to dentin, (b) maximum retention with little removal of dentin, (c) distribution of functional stresses evenly along the root surface, (d) esthetic compatibility with the definitive restoration and surrounding tissue, (e) minimal stress during placement and cementation, (f) resistance to displacement, (g) good core retention, (h) easy retrievability, (i) material compatibility with core, (j) ease of use, safety and reliability, and (k) reasonable cost. Therefore, the clinician should be knowledgeable in selecting the right type of post and core systems to meet the biological, mechanical, and esthetic needs for each individual tooth.

**Conclusion**

Accurate diagnosis and indication, successful selection of post and core type and accurate placement into the root canal of the abutment tooth prolong the lifetime of the fixed prosthetic work on the ETT. The post and core must ensure good and lasting retention of the crown or bridge and provide...
for adequate stress transfer on the entire root and the surrounding supporting tissue. Individual cast post and core shows better clinical results when it restores the whole clinical crown, than the prefabricated post and core design. This results from difference in individual post and core which enables precise imitation of the morphology of the prepared clinical crown and root.

If certain basic principles are followed in the restoration of ETT, it is possible to achieve high levels of clinical success with most of the current restorative systems. These principles include:

1. Avoid bacterial contamination of the root-canal system
2. Provide cuspal coverage for posterior teeth
3. Preserve radicular and coronal tooth structure
4. Use posts with adequate strength in thin diameters
5. Provide adequate post length for retention
6. Maximize resistance form including an adequate ferrule
7. Use posts that are retrievable.

References

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