The Prosthodontic Management of Endodontically Treated Teeth: A Literature Review. Part I. Success and Failure Data, Treatment Concepts

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Part I of this three-part literature review discusses the incidence of endodontic treatment required after prosthodontic procedures, whether crowns are needed on endodontically treated teeth, the primary purpose of posts, the causes of post and core failure, root fracture incidence data, and post design considerations. Pertinent questions are addressed based on the past 25 years of dental literature.


INDEX WORDS: endodontically treated teeth, posts and cores, incidence data

A PLETHORA OF articles have been written in the dental literature regarding the prosthodontic management of endodontically treated teeth. Many of these papers have discussed techniques of fabricating posts and cores, whereas others have presented clinical and laboratory data that help answer difficult questions regarding the best prosthodontic treatment for these teeth. The purpose of this report is to address some of these difficult questions by reviewing the dental literature of the past 25 years and providing a summary opinion based on the reviewed scientific studies.

What Is the Incidence of Endodontic Treatment Required After Teeth Are Prepared for Single Crowns and Fixed Partial Dentures?

One study reported that the incidence of endodontic treatment after cementation of single crowns was 3% after 5 years. Another single crown study found that the incidence was 4% after 34 months.

The incidence of fixed partial denture abutments requiring endodontic treatment has varied in different studies. The results have been: 3% after 5 years, 3% after 10 years, 6% after 2 to 6 years, 10% after 10 years, 14% after 7 years, and 21% after 6 years. The generally higher incidence with fixed partial dentures is assumed to be related to the greater tooth reduction required to align multiple teeth and perhaps also related to the greater occlusal forces on some types of prostheses. These assumptions are supported by Randow et al who reported an increasing incidence related to the size of the prosthesis: 7% for 7-unit prostheses, 9% for 8-unit prostheses, and 23% for 10-unit prostheses.

Reuter and Brosic found a difference between abutments with little or no caries at the time of tooth preparation and abutments with deep carious lesions. Three percent of the teeth with little or no caries required endodontic treatment after 5 years, whereas 10% of the teeth with deep carious lesions required treatment. Bergenholtz and Nyman reported on the need for endodontic treatment in patients with advanced periodontal disease who received both periodontal and prosthodontic treatments. Three percent of the periodontally treated teeth that were not prepared for fixed prostheses required endodontic therapy 4 to 13 years after treatment, whereas 15% of the periodontally treated teeth that were prepared for fixed prostheses needed endodontic treatment. There was an increase in the need for endodontic therapy when the bone loss exceeded one third of the root length. They also noted that 50% of the pulpal problems occurred 7 to
12 years after prosthesis placement, rather than within the first few years as one might expect. Abou-Rass coined the term “stressed pulp” and proposed the concept to help identify those teeth that have a greater potential for developing pulpal disease after prosthodontic treatment (Figs 1 and 2). He reported that “stressed pulps” are vital pulps that have been subjected to repeated injury, including accidental trauma, operative procedures, prosthodontic tooth preparation, or other dental procedures. Abou-Rass suggests that endodontic treatment should be considered before pulpally traumatic dental procedures are performed on teeth with pulps that have already been stressed on multiple occasions.

**Summary**

The incidence of endodontic treatment required after tooth preparation has ranged from 3% to 23%. Fixed partial dentures and complex prostheses had higher incidence rates than single crowns. It has been assumed that the higher rates are because of the greater tooth reduction sometimes required to align multiple teeth. The incidence is higher when the prepared teeth have deep carious lesions and when periodontal disease has resulted in considerable bone loss. Many pulpal problems occur after several years rather than in the first few years, and one study showed that 50% of the pulpal problems occurred after 7 to 12 years. It has been suggested that “stressed pulps” are more prone to developing pulpal disease after prosthodontic treatment.

**Do Endodontically Treated Teeth Need Crowns?**

Sorensen and Martinoff reported the results of a retrospective study of 1,273 teeth that had been endodontically treated 1 to 25 years before the study. Endodontically treated teeth with coronal coverage restorations (onlays, partial or complete metal crowns, and metal ceramic crowns) were compared with endodontically treated teeth with no coronal coverage restorations. Coronal coverage did not significantly improve the success of endodontically treated anterior teeth (Fig 3). This finding supports the placement of only resin in the access openings of otherwise intact anterior teeth. However, some incisors and canines may need complete coverage crowns because of the presence of large and/or multiple previous restorations or because of esthetic conditions that cannot be adequately addressed with more conservative forms of treatment.
Figure 3. The maxillary left central incisor suffered a traumatic injury that necessitated endodontic therapy. The tooth is intact except for a conservative access opening. Because the tooth is not facially discolored and is intact except for the access opening, a resin restoration can be placed in the access opening as the definitive treatment.

This same study found a significant improvement in the clinical success of maxillary and mandibular premolars and molars when coronal coverage restorations were present. This finding supports the placement of crowns on posterior teeth that cover sufficient coronal tooth structure to prevent fracture when occlusal forces attempt to separate the cusp tips.

Gutmann has very aptly summarized the special needs of endodontically treated teeth by reviewing several interesting articles. Pulpless dog teeth were found to have 9% less moisture than vital teeth. With aging, greater amounts of peritubular dentin are deposited, which decreases the amount of organic materials that may contain moisture. Reeh et al showed that endodontic procedures reduce tooth stiffness by 5%, attributed primarily to the access opening. Tidmarsh described the structure of an intact tooth that allows it to deform under loading and still exhibit elastic recovery after removal of the load. Grimaldi discussed the direct relationship between tooth structure lost during tooth preparation and the deformation of the tooth under load. Carter et al indicated that dentin from endodontically treated teeth shows significantly lower shear strength and toughness than dentin from vital teeth. Rivera et al stated that the degree of work required to fracture dentin may be less in endodontically treated teeth because the collagen intermolecular cross-links may be weaker.

Summary
Crows should generally be used on endodontically treated posterior teeth but are not necessary on relatively sound anterior teeth.

Do Posts Reinforce Endodontically Treated Teeth?
Most laboratory studies have shown that placement of a post and core does not increase the fracture resistance of endodontically treated extracted teeth when a force is applied via a mechanical testing machine. Lovdahl and Nicholls found that endodontically treated maxillary central incisors were stronger when the natural crown was intact except for the access opening than when they were restored with cast posts and cores or pin-retained amalgams. L found that posts placed in intact endodontically treated central incisors did not lead to an increase in the force required to fracture the tooth nor in the position and angulation of the fracture line. Guzy and Nicholls determined that there was no significant reinforcement achieved by cementing a post into an endodontically treated tooth that was intact except for the access opening. Lcary et al measured the root deflection of endodontically treated tooth before and after posts of various lengths were cemented into prepared root canals. They found no significant differences in strength between the teeth with or without a post. Trope et al determined that preparing a post space weakened endodontically treated teeth compared with ones in which only an access opening was made, but no post space. They also found that cemented Paraposts (Coltene/Whaledent Inc, New York, NY) did not increase the fracture resistance.

Kantor and Pines determined that cementing a stainless steel rod into prepared post spaces of teeth that had also been prepared for complete coverage crowns increased the fracture resistance compared with teeth that were only prepared for complete crowns but had no post. Using photoelastic stress analysis, Hunter et al determined that removal of internal tooth structure during endodontic therapy is accompanied by a proportional increase in stress. They also determined that minimal root canal enlargement for a post does not substantially weaken a tooth. However, if considerable root canal enlargement has occurred, a post substantially reinforces the tooth.
One study used two-dimensional finite element analysis to study the effect of posts on dentin stress in pulpless teeth. When loaded vertically along the long axis, a post reduced maximal dentin stress by as much as 20%. However, only a small (3% to 8%) decrease in dentin stress was found when a post was present and when the teeth were subjected to masticatory and traumatic loadings at 45° to the incisal edge. Ko et al determined that the reinforcement effect of posts is doubtful for anterior teeth because they are subjected to angular forces.

In a clinical study of endodontically treated teeth, Sorensen and Martinoff found that post placement was associated with a significantly decreased success rate for single crowns, produced no significant change in the success of fixed partial denture abutments, and significantly improved the success of removable partial denture abutment teeth.

**Summary**

The primary purpose of a post is to retain a core that can be used to retain the definitive prosthesis. Posts do not reinforce endodontically treated teeth and are not necessary when substantial tooth structure is present after teeth have been prepared (Fig 4). A post and core may help prevent coronal fractures when the remaining coronal tooth structure is very thin after tooth preparation (Figs 5 and 6).

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**Figure 4.** No post and core was used in the mandibular second molar abutment because substantial tooth structure was present after endodontic treatment was complete.

**Figure 5.** After preparation of the maxillary left central incisor for a ceramic restoration, only a thin layer of coronal tooth structure was remaining periapical to the endodontic access opening and pulp chamber. Note the white blotchy areas (arrow) visible through the thin facial tooth structure, which is the provisional cement placed in the pulp chamber. If a crown was cemented over this prepared tooth, the remaining thin coronal tooth structure could fracture when occlusal forces were applied to the crown, resulting in failure. A post and core could prevent the fracture of this thin coronal tooth structure.

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**What Are the Most Common Types of Post and Core Failures?**

There are only a limited number of clinical studies that contain data relative to post and core failures. Turner reported on 100 failures of post-retained crowns and indicated that post loosening was the most common type of failure. Of the 100 failures, 59 were caused by post loosenings. Apical lesions and caries were the next most common occurrences, followed by fractured or loose crowns. There were 10 fractured roots and 6 fractured posts. In another paper, Turner reported the findings of a 5-year retrospective study of 52 post-retained crowns. Six posts had come loose, and there were no tooth fractures. Bergman et al. reported that he found 8 failures in 96 posts after 5 years. Six posts had come loose, and there were 2 root fractures.

Sorensen and Martinoff evaluated 1,273 endodontically treated teeth, 420 of which had posts and cores. There were 36 post and core failures. Thirteen of the 36 failures were caused by post dislodgement, 8 were related to restorable tooth fractures, 12 were related to nonrestorable tooth fractures, and 3 were related to post perforations. Weine et al. found 9
failures in 138 posts and cores after 10 years or more. There were 3 failures related to restorative procedures, 2 related to the endodontic therapy, and 2 related to periodontal causes. Two roots had fractured, and no posts had come loose.

Hatzikyriakos et al4 reported the 3-year results of 154 posts and cores. Five posts had come loose, 5 crowns had come loose, 4 roots had fractured, and 3 roots had caries.

Summary

Although there are many types of post and core failures, loosening of the post and tooth fractures were two of the most common occurrences. Three papers reported that post loosening occurred more often than tooth fractures. Two studies found slightly higher incidences of tooth fracture than post loosening, and one study found comparable incidences of post loosening and tooth fracture.

Which Post Design Is the Most Retentive?

There have been many laboratory studies on post design and retention. Parallel-sided, threaded posts have been found to be the most retentive.\textsuperscript{35-37} Cemented, parallel-sided posts have been found to be more retentive than cemented tapered posts.\textsuperscript{33,37-39} Cemented, parallel-sided posts with serrations are more retentive than cemented, smooth-sided parallel posts.\textsuperscript{33,37,38,40}

Clinically, Weine et al\textsuperscript{33} reported no retention problems when they evaluated their experience with cemented, tapered posts over 10 years or more. In a clinical study of cemented tapered posts placed by dental students, Bergman et al\textsuperscript{32} stated that this design can be strongly recommended.

Summary

From a retention standpoint, the laboratory evidence indicates that threaded posts are the most retentive followed by cemented, parallel-sided posts. Serrations increase post retention. Cemented, tapered posts are the least retentive, but some clinicians reported that they have successfully used this design and did not have retention problems.

What Data Is Available Regarding Root Fractures From Posts?

One clinical study\textsuperscript{34} reported that 2.6% of post and core failures were because of root fracture, whereas another report\textsuperscript{30} indicated that 10% of post and core failures were attributable to root fracture. In a study\textsuperscript{4} of crown and fixed partial denture failures from all causes, tooth fractures accounted for 3.9% of the failures. In this study, fractures were further subdivided into coronal fractures and root fractures. Approximately three quarters of the fractures were coronal with the rest being root fractures. Only 4 of the 13 coronal fractures occurred on endodontically treated teeth, whereas all of the root fractures were found in endodontically treated teeth. Ross\textsuperscript{41} evaluated 200 endodontically treated teeth at least 5 years after treatment: 134 with no posts and 86 with posts. None of the teeth with or without posts showed any clinical or radiographic evidence of fracture.

In a photoelastic study, Henry\textsuperscript{42} found that screw posts produced undesirable levels of root stress. Standlee et al\textsuperscript{43} found that tapered, threaded posts were the worst stress producers. In comparing three threaded prefabricated posts, Deutsch et al\textsuperscript{44} found...
that tapered, threaded posts increased the incidence of root fracture in extracted teeth by 20 times that of the parallel threaded post. Stanlee and Caputo\textsuperscript{35} found that split, threaded posts (Flexi-posts; Essential Dental Systems, New York, NY) caused high internal stresses during loading like other threaded posts. Thorsteinsson et al\textsuperscript{36} also found that split, threaded posts did not reduce the stress concentration during loading when compared with other threaded designs. One study\textsuperscript{37} showed that split, threaded posts reduced the stress created during cementation compared with a rigid, threaded post. Rolf et al\textsuperscript{38} found that cemented posts produced less stress than threaded posts.

Trabert et al\textsuperscript{39} indicated that increasing post length increases the resistance of a root to fracture (Fig 7), and increasing post diameter decreases the resistance of a root to fracture.

**Summary**

Three percent to ten percent of post and core failures are attributable to root fractures (Fig 8). Threaded post forms are the most likely to cause root fracture and split, and threaded flexible posts do not reduce stress concentration during function. Cemented posts produce the least root stress.

**Are Parallel-Sided Posts Less Likely to Cause Root Fracture Than Tapered Posts?**

In a laboratory study of extracted teeth, Sorensen and Engelman\textsuperscript{50} found that tapered posts caused more extensive tooth fractures than parallel-sided posts, but one of the tapered post groups required a much higher load to initiate root fracture than the parallel post group. From a retrospective clinical study, Sorensen and Martinoff\textsuperscript{51} determined that the highest success occurred with parallel-sided, serrated posts, and they found that tapered cast posts and cores showed a higher failure rate. They also reported that tapered cast posts and cores caused more catastrophic failures. Bergman et al\textsuperscript{52} found 2 root fractures in 96 teeth 6 years after placement of tapered posts and cores by dental students. They concluded that this design of the cast post and core can be strongly recommended. In a retrospective study of tapered posts in place for 10 years or more, Weine et al\textsuperscript{53} found 2 root fractures in
desirable results. Turner performed a 5-year retrospective evaluation of 32 posts and cores and found that many of the posts were short and 6 were loose, but there were no root fractures. In a photoelastic stress analysis study, Henry found that parallel-sided posts distribute stress more evenly to the root than to the tapered posts. Two finite element analysis studies found similar results. Two photoelastic studies found that parallel posts concentrate stress apically, whereas tapered posts concentrate stress at the post-to-core junction.

Summary

Although there are several laboratory studies and some clinical data that indicates that parallel-sided posts are less likely to cause root fracture, other clinical studies have shown good success with tapered posts. It seems that additional clinical studies of a prospective nature are required to resolve this issue.

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