

Factors affecting retention of post systems: A literature review

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Statement of problem. An extensive review of the published literature has revealed a wide divergence of opinion regarding the suitability of different post systems for endodontically treated teeth. As a result, the dentist has no clear guidelines concerning the selection of suitable post systems that will provide adequate retention while minimizing subsequent root fracture.

Purpose. This study formulated, through the literature search, a set of guidelines to assist the dentist in selecting an endodontic post system that would optimize retention while limiting root fracture.

Results. For most clinical situations, the literature indicates that a passive parallel-sided post will, in the hands of the average practitioner, allow the dentist to successfully restore most endodontically treated teeth. (J Prosthet Dent 1999;81:380-5.)

CLINICAL IMPLICATIONS

Dentists must accommodate the individual requirements of the tooth being restored. A unique balance exists between maximizing retention and maintaining resistance to root fracture. The literature indicates that a passive, parallel-sided post is the post of choice to restore most endodontically treated teeth.

A review of the literature suggests that many endodontically treated teeth are not reinforced with the use of a post.¹⁻³ Further, some studies have indicated that minimally damaged endodontically treated teeth without posts are more resistant to fracture than teeth restored with posts and cores.⁴⁻⁷ Resistance to fracture is directly related to the thickness of remaining dentin, especially in the buccolingual direction.^{4,8,9} Therefore excessive flaring during endodontic treatment or over-preparation of the canal space for a post can increase the risk of failure.^{2,10,11} Laboratory studies have investigated the retention of various post systems, and the variables reported to affect retention include length, diameter and design of the post, canal shape and preparation, luting medium, method of cementation,¹² and location in the dental arch.⁴ Retentive failure of crowns supported by posts has been reported.¹³⁻¹⁵ Although cast post-core restorations are often the restoration of choice for endodontically treated teeth, prefabricated post systems have recently become increasingly popular¹⁶ because they can provide satisfactory results while saving chair time and reducing costs to the patient.¹⁷

Eight factors have been identified to affect the retention of prefabricated post restorations. Therefore the purpose of this article is to review the literature on post systems, focus on prefabricated systems, and discuss their clinical relevance.

POST LENGTH

Various guidelines have been recommended to den-

tists in regard to post length. These guidelines include the following:

1. The post should equal the incisocervical or occlusocervical dimension of the crown.¹⁸⁻²⁵
2. The post should be longer than the crown.²⁶
3. The post should be $1 \frac{1}{3}$ the length of the crown.²⁷
4. The post should be a certain fraction of the length of the root such as one half, two thirds, or four fifths.²⁸⁻³⁵
5. The post should end halfway between the crestal bone and the root apex.³⁶⁻³⁸
6. The post should be as long as possible without disturbing the apical seal.³⁸

Studies have reported that the length of the post has a significant effect on its retention and in most instances, the more deeply the post is placed, the more retentive it becomes.⁴⁰ Leary et al.⁴¹ also found that posts with a length of at least 3-quarters of the length of the root offered the greatest rigidity and least root deflection (bending) when compared with posts that were a half or a quarter the root length (Fig. 1). Short posts are especially dangerous and have a much higher failure rate (Fig. 2).^{2,42,43}

POST DIAMETER

Several in vitro studies have confirmed the importance of the remaining bulk of tooth structure with regard to strength and resistance to root fracture.^{4,7,10,44} Increasing the diameter of the post does not provide a significant increase in the retention of the post^{40,45}; however, it can increase the stiffness of the post at the expense of the remaining dentin and the fracture resistance of the root.^{5,10}

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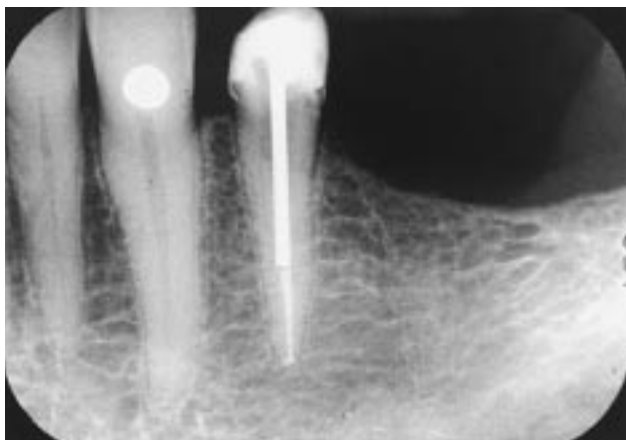


Fig. 1. Post that is $\frac{3}{4}$ length of root.

Therefore post diameter must be controlled to preserve radicular dentin, reduce the potential for perforations, and permit the tooth to resist fracture.^{10,46} Goodacre⁴⁷ suggested that post diameters should not exceed one third of the root diameter at any location. Studies also indicate that the diameter at the tip should usually be 1 mm or less.^{47,48} Although no technique is capable of completely avoiding perforations, there are methods to reduce the potential for such occurrences. These approaches include thoroughly evaluating a current radiograph,⁴³ limiting the width of this post to one third of the root diameter,⁴⁷ limiting the post tip to 1 mm or less,^{47,48} limiting the post to a length of 7 mm apical to the canal artifact in maxillary and mandibular molars,⁴⁹ and avoiding if possible the mesial roots of mandibular molars and the buccal roots of maxillary molars.⁴⁷

POST DESIGN

There are over 100 different prefabricated post systems available; however, there are 6 basic commercial systems available. These are as follows:

1. Tapered, smooth-sided posts, such as Kerr Endopost dowels (Kerr Manufacturing Co., Romulus, Mich.).
2. Parallel-sided, serrated, and vented posts, such as Whaledent Parapost dowels (Whaledent International, New York, N.Y.).
3. Tapered, self-threaded posts; for example, Dentatus screws (Weissman Technology International, Inc., New York, N.Y.).
4. Parallel-sided, threaded, split-shank posts, such as FlexiPost dowels (Essential Dental Systems, S Hackensack, N.J.).
5. Parallel-sided, threaded posts; for example, Radix anchors (Maillefer/L. D. Caulk, Milford, Del.) or Kurer anchors (Teledyne Getz, Elk Grove, Ill.).
6. Carbon-fiber posts, such as C-Post dowels (Bisco

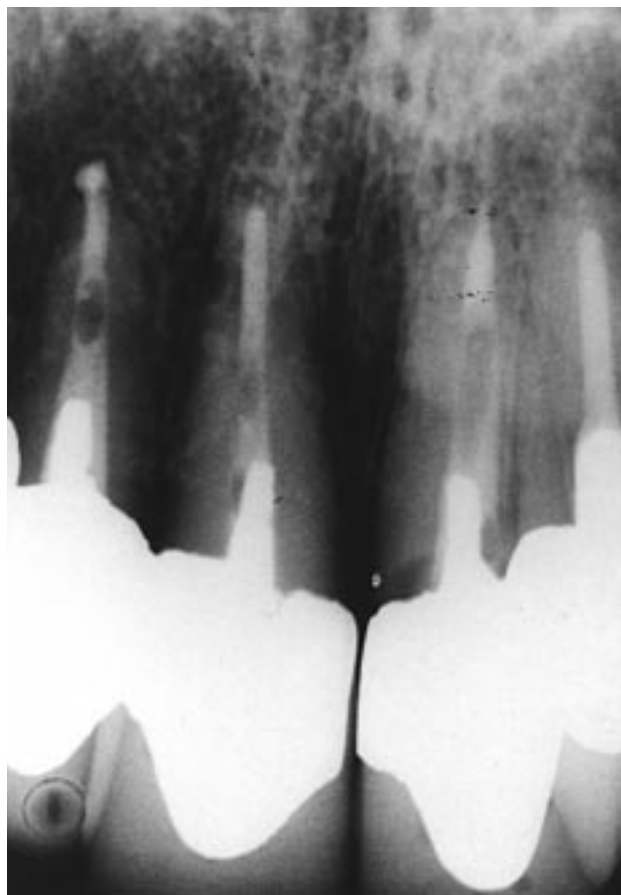


Fig. 2. Several anterior teeth with short posts and failure.

Dental Products, Itasco, Ill.) or Composipost dowels (RPT, Meylan, France).

Some studies^{41,50,51} reported that the parallel-sided posts provided superior retention when compared with tapered posts; however, others^{41,51,52} have indicated that threaded posts are the most retentive, followed by parallel posts, with tapered posts the least retentive. Another study reported that serrations on the post surface increased retention when compared with a smooth surface.⁴⁹

Tapered posts produced the greatest stress at the coronal shoulder, and parallel posts generated their greatest stress at the apex of the canal preparation.⁵³ Parallel posts resisted tensile, shear, and torquing forces better than tapered posts and distributed stress more uniformly along their length during function.⁵¹ Several studies have reported that a well-adapted, passively luted, parallel-sided post provided the most retentive post with the least stress.^{42,52,54} Of the 5 post systems studied by Ross et al,⁵⁴ the Para-Post dowel was the easiest to place and produced the lowest level of apical and coronal stress. Of the threaded designs, the tapered screw produced the greatest wedging effect and highest stress levels.^{46,55} Parallel-

sided, threaded posts can generate high stress levels if extreme care is not exercised during their insertion. Parallel-sided, threaded, split-shank posts also generate extremely high stress levels when the countersink is fully engaged.⁵⁶ Burns et al⁵⁶ further reported that the FlexiPost dowel (Essential Dental Systems) produced significantly higher shoulder stresses and substantially greater stresses along the coronal surface of the length of the post than Para-Post dowels and Para-Post Plus dowels (Whaledent International). These extreme stress levels at the shoulder can be reduced by a counterrotation of the post of one-half turn after full engagement of the countersink. However, the counterrotation cannot undo any crack formation that may have occurred during full engagement.⁵⁴

Of the first 5 systems, the parallel-sided, serrated, vented post produced stresses that were distributed most uniformly along its length and appeared best able to protect the dentin.^{40,52,57-59} Retention must be weighed against distribution. Tapered self-threaded screws are the most likely to cause stress fracture and are not recommended.^{40,43,46,60,61} Parallel-sided threaded posts that are tapped may be considered when additional retention is needed.⁴³

The carbon fiber post system has recently been introduced to dentists with the claim by the manufacturer that the system will allow homogeneous mechanical and chemical bonding to reinforce the tooth. The manufacturer also claims that the post has a Young's modulus approximating that of natural teeth, which should result in decreased stress concentration and therefore an increased longevity of the restoration. There have been few independent scientific studies to substantiate these claims. Two studies^{6,62} have found that the carbon fiber post had inferior strength when subjected to forces simulating clinical behavior and compared with established metal posts. Additional studies are necessary to fully evaluate this system. At this time, it is recommended that the carbon fiber post system be used when ample coronal and root dentin remain and the artificial crown is well-supported by the remaining tooth structure.^{6,62}

LUTING AGENTS

Luting agents, including zinc phosphate, polycarboxylate, glass ionomer, and filled and unfilled resin cements have been investigated extensively. The literature does not consistently suggest that 1 luting agent is superior to another.^{19,63-77} Both zinc phosphate and glass ionomer cements are frequently used because of their ease of manipulation along with their history of success in luting procedures.⁷⁸

The use of filled and unfilled resins as luting agents has increased. Although some clinical studies have shown a significant increase for post retention with resin

cements,^{5,79} others have not confirmed these findings.⁸⁰ There are 2 potential problems with the use of resin agents: They are technique-sensitive because of their short working time and they are more adversely affected by improper root canal preparation than other cements.

LUTING METHOD

The actual method of luting of a post has been investigated, including placing the luting agent on the post and/or placing the luting agent in the canal with a lentulospiral, a paper point, and an endodontic explorer.^{79,81} The lentulospiral was the superior method of placement. The luting agent may also be placed in the canal with a needle tube, as long as the tip of the tube is inserted to the bottom of the canal space and the material is excluded from the tip as it is slowly removed from the canal. After the luting agent is placed in the canal, the post is coated with the luting agent and inserted.⁷³

CANAL SHAPE

Because the predominant canal shape is ovoid and the walls of prefabricated posts are commonly parallel, the majority of luted prefabricated posts are unlikely to adapt well along their entire interface with the canal walls. As a result, the post may not fit the preparation closely, and the luting agent may not totally fill the interface.⁷³

PREPARATION OF THE CANAL SPACE AND TOOTH

Several methods of preparing the post space and their effect on the apical seal have been investigated and include rotary instruments, heated instruments and solvents.⁸²⁻⁸⁶ The literature is equivocal on post space preparation and no method has been found consistently superior. When necessary, gutta percha should be removed with an endodontic heat carrier until the desired length is reached. A minimum of 4 to 5 mm of gutta percha must remain to preserve the apical seal.⁸⁷ Preservation of the apical gutta percha should be confirmed radiographically before the post is cemented. After gutta percha removal, root canal reamers can be used to widen the canal space by a reaming action to ensure a relatively round preparation. For each prefabricated post system, the accompanying twist drills are then used to shape the canal following the direction and depth created by the hand instruments. These twist drills should not be used to remove filling materials. Twist drills also should not be forced but should passively follow the course of the previously established canal. Stops should be placed on engine-mounted drills at the desired depth as an added precaution. Drills can gouge the dentin and cause undesirable vertical angulation of the preparation or perforate the root (Fig. 3). The goal should be to choose the prefabricated system



Fig. 3. Preparation of lateral incisor has created perforation.

consistent with the smallest possible canal diameter to preserve the inherent strength of the root.^{3,42}

LOCATION IN THE DENTAL ARCH

The location of the tooth in the dental arch necessitates different restorative requirements to ensure the longevity of endodontically treated teeth.^{4,10,88-91} Several *in vitro* studies^{4,6,89} have confirmed the greater fracture resistance of minimally damaged endodontically treated maxillary anterior teeth when compared with post-core crown restored maxillary central incisors. Thus, it is the responsibility of the dentist to select coronal coverage only when large restorations exist, or for esthetics. Nevertheless, cuspal coverage is commonly recommended for posterior endodontically treated teeth.¹¹

Clinically, a post in a maxillary anterior tooth is subjected to compressive, tensile, shear, and torquing forces. At the dentin-post interface, the forces that tend to dislodge the post are predominately labially inclined shear forces,^{92,93} and studies have suggested resistance form can be increased with the use of a beveled preparation.^{94,95} The maxillary anterior region is considered to be a high risk area for failure, which may be due in part as a result of unfavorable directional loading during function.^{11,14}

CLINICAL RECOMMENDATIONS

A diagnostic radiograph is essential to evaluate the root and post space to determine the post length, diameter, and type to be used. Post length must be evaluated for each situation. Although three fourths of the root length would be ideal, this is not achievable for many teeth without compromising the apical seal. When restoring long-rooted teeth, achieving a length as close as possible to three fourths of the root is desirable, whereas many teeth will have posts that are equal in length to the clinical crown because of a shorter root and the need to maintain at least 4 mm of gutta percha apical seal. There is no evidence that the use of a post with a diameter greater than one third of the root diameter improves retention of the post (Fig. 4).



Fig. 4. Overly wide post and resultant root fracture.

Therefore the dentist should select a post that is as long as possible within the long axis of the tooth, and of a minimum diameter to maximize preservation of remaining dentin. The selected post is tried in the post space to confirm fit. It may be necessary to confirm the position of the post with a radiograph. Although there is no universal post core system that is optimal for all teeth, the parallel-sided, serrated, vented post can satisfy many clinical situations. The exceptions are the wide, tapered canal (immature pulp and/or aggressive endodontic preparation), the slender root where the apical preparation could risk perforation, and the short and/or curved canal where increased retention may be required from a shorter post. The other system worth considering is the parallel-sided, threaded, split-shank system; however, the potential for generating higher stress levels with threaded posts far exceeds that of a passive post.^{39,40,46,54,56,60} To minimize installation stresses, threading should be stopped before the post reaches the bottom of the prepared channel rather than allowing the post to bottom out followed by counter-rotation.^{10,52} Smooth tapered⁹⁶ posts may have a role to play; however, data suggest that long-term success

may be difficult to achieve.^{17,40,43,51,52,60} Self-threaded tapered posts are not recommended and the parallel-sided post with tapped hole must be inserted with extreme care to prevent root fracture.^{46,55}

Luting is often more dependent on technique than the material used. An important factor is the density of the cement film. The quality of the cement lute depends on the handling characteristics of the luting agent, particularly its flowability. For many years, zinc phosphate cement has demonstrated its reliability and its ability to provide consistent retention. Glass ionomer cement such as GC Fuji I cement (GC America, Chicago, Ill.) and Ketac-Cem cement (Espe-Premier, Norristown, Pa.) are popular because of their ease of use, ability to adhere to dentin, and strength properties. Resin luting agents such as Bisco C&B cement (Bisco Dental Products, Itasca, Ill.) have demonstrated very high compressive and tensile strengths, a potential for a strong micromechanical bond to dentin, and for those situations requiring increased retention. However, resin cements are technique sensitive, and the dentist should practice with these luting agents before using them clinically.

Zinc phosphate, glass ionomer, and resin cements specifically formulated for luting have excellent flow. Placing the luting agent both in the canal with a lentulo-spiral and onto the post is the recommended method to achieve a dense cement film and therefore a well-cemented post. This process may have to be expedited because some of the resin luting agents have short working times compared with zinc phosphate. For example, Panavia 21, which sets anaerobically, may set before the post is fully sealed if placed in the post space first. Resin-reinforced glass ionomer cements demonstrate some excellent properties; however, there has been a suggestion of post-set expansion that may make this cement unsuitable for post cementation.

SUMMARY

Retention and resistance to fracture are 2 important factors that must be achieved with post-and-core retained restorations. Nevertheless, retention often requires the removal of tooth structure, a procedure that may reduce the strength of the root. When placing a post, the dentist must evaluate each tooth individually to determine the best approach to obtaining the maximal fracture resistance. Because a single post system is unlikely to satisfy retentive requirements for all clinical situations, a variety of post systems are suggested to achieve the optimal balance between post retention and resistance to root fracture. This flexible approach should allow the dentist to successfully restore most endodontically treated teeth.

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