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Leevairoj Chalermpol

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Current Thinking on Post and Core System and other Options for Restoration of the Endodontically Treated Tooth

Leevairoj Chalermpol , D.D.S.
Department of Restorative Dentistry, Faculty of Dentistry, Chulalongkorn University, Bangkok

Abstract

In the past few decades, there are the controversies in the proper treatment of the teeth after receiving endodontic treatment. The solutions seem to be concluded. This review of literature summarized the current thinking on post and core system, also the options for restoration of the endodontically treated teeth. Many concepts have been collected from the articles published by 1997. Many ideas have been given and may be useful for the reader to choose the proper techniques and materials when restoring the endodontically treated teeth.

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Keyword: *Restorations, Endodontically treated teeth, Post & core systems, Core materials*

Introduction

In the past few decades, there are controversies in the proper treatment of the teeth after receiving endodontic treatment. Many dentist assume that endodontically treated teeth are weakened and more prone to fracture because of desiccation or premature loss of fluids supplied by vital pulps.[1] Therefore, they always give the routine treatment for endodontically treated teeth with post and core. They believe that posts or dowels which are inserted in to the pulpless tooth will strengthen and reinforced the tooth. Is these philosophies true?

From the nationwide survey of contemporary philosophies and techniques of restoring endodontically treated teeth in 1994[2], the majority of dentists in the United States use either cast posts exclusively or both cast posts and prefabricated posts to restore endodontically treated teeth in their practices. The most popular prefabricated post is the parallel-side serrated post and composite resin is the most popular core material for general dentists (45%) and educationally qualified prosthodontists (43%). Silver amalgam is the most popular core material for board-certified prosthodontists (52%). Philosophies and techniques of restoring endodontically treated tooth vary significantly by geographic region, age, faculty status, and specialty status.[2]

Are the endodontically treated teeth weaker than the normal vital teeth?

Many studies had been done to answer this question. Helfer *et al.*[1] determined the moisture content of vital teeth comparing with pulpless teeth. They found that the calcified tissues of the pulpless teeth contain 9% less water than those of vital teeth.[1] Carter et al. found that shear strengths and toughness of dentin from endodontically treated teeth were lower and significantly different from the values for dentin of vital teeth, while Fusayama and Maeda[4] demonstrated that there are no changes in the modulus of elasticity, hardness, or fracture toughness of pulpless teeth. However these are not the main reasons used to support that the endodontically treated teeth are weaker than the vital teeth.

The reasons used to explain why the endodontically treated teeth trend to be weaker than the normal teeth are that;

1) after an endodontic therapy, there is an appreciable loss of dentin including anatomic structures, cuspal

ridges, and the arched roof of the pulpal chamber. As more tooth structure was removed, the resistance to occlusal forces was diminished and the possibility of fracture increased.[5,6]

2) the teeth that need root canal treatment are often associated with neglect, extensive decay or big restoration. The larger the restoration, the lower the fracture resistance of the tooth. From Vale's study[7,8], he demonstrated that, when the isthmus width was one-quarter the intercuspal dimension, the fracture force was the same as for the intact controls. And when the isthmus width was one-third the intercuspal dimension, the fracture force was two-thirds that of the intact controls.

For these reasons, every effort should be made to minimize loss of sound tooth structure during endodontic and restorative procedures.

Usually, the endodontic procedures do not produce a significant decrease in the existing cusp stiffness.[9] The stiffness is reduced approximately 5 percent. But the operative cavity procedures were much more detrimental to cuspal stiffness and tooth strength, especially when one or more marginal ridges were lost, 63% reduction in cusp stiffness for a MOD preparation.[9] Therefore the pulpless tooth may not be significantly weaker than a healthy pulp one with a big cavity.

Strength of the endodontically treated teeth depend on how the quality and quantity of the remaining tooth structure left after root canal treatment procedure.

Factors on which structure strength and fracture resistance of a tooth depend[10]

1. Anatomy :	Tooth type, location, and position Number of root, root length, width, and curvature, root defects.
2. Occlusion :	Occlusal type and loads, Bruxism, Parafunctional forces, Masticatory habits and function.
3. Pathology :	Periodontal disease, Osseous support, Caries Fracture, Resorption, Pulp loss and Calcification
4. Structure :	Dentin composition, Developmental defects, Structural cracks
5. Restoration :	Restoration type and design, Post type and design
6. Endodontics :	Proper preparation, Overflaring, Overinstrumentation Overcondensation, Endodontic leakage

Restorative option for endodontically treated teeth

1. Access closure
2. Direct core built-up
3. Post and core built-up which can divided into

3.1 Use some materials as coronal-radicular stabilizer, for example, amalgam, reinforced composite resin.

3.2 Cast post and core

3.3 Prefabricated post and direct core built-up

3.4 Modern post and core system

The varieties of these questions should be answered before the decisions for choosing the optimum method to restore the endodontically treated teeth are made :

- Can a direct buildup be made, or does the tooth require a dowel (post) and core?
- If a direct buildup can be done. What is the best material to be used?
- If a dowel is required, is a cast dowel and core or a prefabricated post and core indicated?
- What will be the optimum design of the dowel?
- Does the tooth required a crown?

Functions of posts and cores

Posts and cores are commonly advocated to 1) protect or strengthen the tooth against intraoral forces by equally distributing torquing forces within the radicular dentin to supporting tissues, thus dispersing the forces along the root, and 2) provide retention for the core that replaced lost coronal tooth structure and retain the restoration.[11,12] Most studies today believe that posts do nothing to reinforce or strengthen teeth because tooth structure often needs to be removed in order to fabricate the dowel.[13,14,15] Use of posts should be avoided when they are not required to provide retention for a core. If the adequate tooth structure are provided by the pulp chamber itself, there is no reason to place a post. In this case, the direct restoration is used as the final restoration for protecting the remaining tooth structure.

Restorative options

1) Access closure

Restoration for access opening of full coverage

If endodontic treatment is performed through an existing full coverage restoration, it is not necessary to place a post in the canal to reinforce the tooth. The access opening can be closed with direct gold foil.[16] Because coefficient of thermal expansion of the gold crown and that of gold foil materials are closed, and the similar gold color of both materials, gold foil is

considered to be the ideal material for closing the access. However, other materials, for example, glass ionomers and resin composites, may be used for this purpose.

Restoration for access opening of intact anterior endodontically treated teeth

In vitro studies[5,13,14,17] showed that endodontically treated anterior teeth with conservative lingual access do not require post placement.[13,14,18,19]

Clinically, endodontically treated anterior teeth with other intact clinical crowns are optimally restored with any of the modern composite resins, which are based with glass ionomer, with out the placement of a post.[20]

Restoration for access opening of intact posterior endodontically treated teeth

Composite resin can be used to closed the access of endodontically treated posterior tooth by using with new generations dentin-bonding agents, such as, Scotchbond MP, Optibond, All Bond 2, Permagen, Mirage ABC, Syntac.[21,22,23,24]

2) Direct core build-up

Restoration of posterior teeth, in case that the remaining tooth structure is enough, both composite resins and amalgam can be used to restored the pulpless effectively.

The amalgam is a suitable material for cusp restoration of pulpless teeth.[25] When using amalgam as a restorative material for endodontically treated molar, the cuspal coverage is recommended. Endodontically treated molar teeth are considered susceptible to fracture because of loss of tooth bulk. In case that there is restoration on the tooth, the loss of only one marginal ridge led to a weakening of all remaining cusps.[25] All cusps need protection during restoration. From Vale's study[7,8], no difference was evident between the fracture force for an empty cavity and a similar cavity restored with amalgam. Moreover, there are studies[26-31] suggested the need for routine occlusal coverage as the minimal restoration of the endodontically treated molar despite the presence of one intact marginal ridge. They suggested to sacrifice the remaining marginal ridge. Preserving a marginal ridge in molars did not fully conserve the strength of adjacent cusps; selective cusp coverage reinforced only the capped cusps. Complete occlusal coverage with amalgam strengthens all cusps of the tooth.[28] In clinical study, 100 pulpless teeth were restored with amalgam overlays, which were successful after 3 years.[32]

Using of pin retained amalgam or bonded amalgam as the pulpless tooth's restoration are considered ineffective. One study found that fracture resistance of the cuspal replacement restorations using composite resin and a dentin adhesive is higher than the groups that use amalgam with a META adhesive and a pin-retained amalgam respectively.[33] With destructive loading study[34], there was no statistical difference between the composite and amalgam groups. But the long-term durability of the composite tooth bond is questionable.

The complete occlusal coverage with gold is considered to be the ideal restoration for this situation. Teeth restored with gold overlays are twice as strong as unrestored teeth with the same cavity preparation.[35] The retrospective study of Sorensen and Martinoff in 1984 found that there was no significant increase in resistance to fracture or dislodgment gained with intracoronal reinforcement (post and core) for the six anatomic groups of teeth, maxillary and mandibular incisor, premolar and molar group.[15] While coronal coverage did not significantly improve the rate of clinical success for maxillary and mandibular anterior teeth, the rate of clinical success was significantly improved with coronal coverage of maxillary and mandibular premolars and molars.[15]

In conclusion, complete occlusal coverage with gold or amalgam strengthens all cusps, but gold does so more consistently than amalgam.[28]

3) Post and core built-up

Endodontic consideration

The post space is best prepared immediately after the gutta percha filling. Adequately condensed gutta percha can be safely removed immediately after endodontic treatment[36], when the root length measurement, canal dimensions and root morphology are most familiar to, and well remember by, the clinician. Both rotary and hand instruments can safely be used to remove adequately condensed gutta percha.[37-39] Four to five mm of gutta percha should be retained apically to ensure an adequate apical seal[18,38,40] because none of the post systems are capable of consistently achieving a fluid-tight seal.[41] Final restoration should be accomplished within 1 to 2 weeks after nonsurgical endodontics and 8 to 12 weeks after surgical endodontics.[10] Delaying the restoration in expectation of lesion regression or resolution is risky because the tooth may be jeopardized by caries, fracture, periodontal disease, movement and treatment failure.[10]

3.1) Some materials used as coronal-radicular stabilizer

Amalgam :

Silver amalgam has very high values for compressive and diametral tensile strength and excellent dimensional stability. It has been used as a coronal-radicular core. Nayyar et al.[42] introduce the use of amalgam as a coronal-radicular core. In this method, the pulp chamber and any other areas of missing tooth structure are restored with amalgam. Extending the amalgam in to the root canal should be carefully done because of the risk of perforation and it is suggested only when the pulp chamber height is less than 2 mm., teeth without clinical crowns. If there is a normal 4 to 6 mm pulp chamber height, there is no need to extend the amalgam into the canal.[43-45] Presently, amalgam continues to be the most predictable choice as a built up material.

Kern et al.[46] found higher mean fracture loads for post-retained amalgam core build-ups than for amalgam coronal-radicular build-up, while others[47-49] found no differences between these two methods. Pin-retained amalgam cores were found less retentive than the amalgam coronal-radicular core and should be avoids.[49]

Composite post and cores :

The method of post fabrication using a bondable reinforcement fiber (Ribbond, Seattle, WA) with dual-cure hybrid composite resin as the post for the foundation of core material has been reported.[50] the technique relies on the inherent tensile strength of the reinforcement fiber, the flexibility and strength of the resin/polyethylene fiber complex, and the high bond strength of a fourth generation bonding agent. This technique is introduced as the alternative post when the prefabricated metal posts are not appropriated for using in certain pulpless tooth.

The factors used to determine whether a custom cast post and core or a prefabricated post is used :[51]

- *Shape of the canal :* The prefabricated post is suitable for round shape canal while for the ovoid or triangular canal, the cast post and core is considered more suitable.

- *Quantity and quality of remaining dentin :* The self treaded prefabricated post can produce the stress to the dentin of the root. For the low quantity and low quality of remaining tooth structure, the active post systems are contraindication.

- *Length of the root :* The prefabricated post will provide more retention when compare with cast post and core. Therefore, in case that retention is need, the prefabricated post system is preferable.

- *Tapering of the root :* The prefabricated post system usually has parallel shape, it is considered inappropriate for taper root or taper canal.

The optimum design of the post

- *Cylindical vs Taper shape post*

Cylindrical posts are considerably more retentive than tapered post.[52] However cylindrical posts produce more stress at the apex. They have sharp angles at their apical ends, where forces are concentrated. These posts exert compressive forces on the root apical to the sharp angles and can create dentinal cracks from the tip of the post to the circumference of the root.[53] Moreover, the preparation of the canal for this post leaves a thin dentinal wall at the apex of the preparation, where concentration of forces is greatest, and also increase the risk of perforation. Tapers posts exhibit lowers concentrations of stress in the apical portion, probably because of the absence of sharp angles and conservation of tooth structures in this area.[54] It is argued that a tapered post can act as a wedge and fracture the root during function. In vitro tests on this subject have shown various results.[55-58] In studies that investigate compressive and tensile forces on the teeth with various post designs, the load has been applied mainly to the post or core structure. In clinical practice, a post and core is generally covered by a crown with a margin that embraces healthy tooth structure. Under such circumstances photoelastic and mechanical studies have reported no significant difference between tapered and cylindrical posts[59-63];that is, the type of post may be of minor importance to the risk for root fracture if the tooth is cover by a complete crown with a good ferrule effect at the crown margin area. The shape of the root should be used to judge what type of the post is properly.

- *Length of the post*

Retention of a dowel has been shown to be directly proportional to it's length.[64] Thus, the longer the dowel, the greater the retention. And the longer the post, the better is its ability to distribute stress. With short dowels, tremendous stress concentrations occur at the coronal end of the root. This can result in fracture of the root.

- *Diameter*

The diameter of the post do not relate with the retention of the post, but larger post diameters decreased the maximum tooth stresses for both the cylindrical and tapered designs tested.[65]

3.2) Cast post and cores

The use of cast-post restorations are declining because of the cost, chair-side time consumption. The reinforcement of the posts appear limited.[66]

From laboratory studied, a length guideline ideally would be three fourths of the root length. Clinically, each tooth must be individually evaluated for root length and amount of remaining gutta percha before establishing the desired post length.[65] Ideally, the length of the dowel in the root below the level of bony support should be at least equal to the length of the tooth above the bony support.[32] And ideally, post diameters should not exceed one third of the root diameter at any location, and post tip diameter should usually be 1 mm or less.[67]

There are two major considerations regarding the shape of the dowel. First, a parallel-sided dowel will give maximum retention and stress concentration when compared with a tapers dowel.[11] Second, many roots are not round, but are quite ovoid, thus are not readily fitted with a parallel-side post. Therefore, in round roots, parallel-sided dowels are preferred, while in ovoid roots, cast custom-tapered dowels are preferred.

Custom-cast dowels should be sandblasted prior to cementation to improve adhesion between the luting agent and the post. Moreover, the 1.5 and 2 mm ferrule lengths of post design significantly increase the strength of the pulpless tooth.[65,68]

3.3) Prefabricated post and core buildup

Prefabricated post and core can be divided in to three groups; active, passive, and semi-active post. Another consideration related to dowel design is whether a dowel should be active or passive.

- *Active prefabricated post:* Active dowels actually use a tapping procedure in which threads are created in the dentin and then a post with matching threads is actually screwed into the dentin. Active screw posts clearly provide the most retention of any dowel system, however they also clearly develop tremendous strains in the remaining tooth structure, with the potential to initiate cracks in the tooth.[69,70] These cracks will result in root fracture.[70]

- *Passive prefabricated post:* The Parapost system (Whaledent International, New York, N.Y.) is the parallel, serrated passive post that relies on cement to hold the post in place. Using the passive-post option is safer.[52] It had been reported high retention values compared to tapered post.[71-73]

- *Semiactive prefabricate post:* Flexi-Post system is the split shank threaded posts. This system offers a combination of safe, high retention of the post in the root, superior distribution of stresses under insertion and function, and long-term resistance to metal fatique.[26]

A split for the Flexi-Post system clearly eliminates insertion and cementation stresses for this post system. The split post also acts as a vent during the cementation of the post into the canal and minimizes stress concentration during cementation.[74,75]

Which system is the best? It is hard to answer. Some studies claimed that this split shank system resisted significantly higher tensile loading before failure than did the ParaPost XT.[75,76] In another study, they found that the parapost No 4.5 (diameter 1.14 mm) had significantly lower fracture resistance compared to roots restored with Flexi-post No.2 (diameter 1.25 mm) and 3 (diameter 1.5 mm).[77]

A post with relatively large spacing between threads has demonstrated a greater degree of safety than a post with more and closer spacing of the thread.[78]

From the retrospective study[79] for survival rate of two types of post systems; custom-cast tapered posts and parallel-sided serrated posts, after 4 to 5 years post cementation, a significantly higher success rate was recorded for parallel-sided serrated posts. Loss of retention was the most frequent reason for failure for both types of posts.[80]

3.4) Modern post and core system

Carbon fiber-reinforced carbon posts

A new nonmetallic composite prefabricated post was studied by King and Setchell.[80] These new carbon fiber posts, Composipost (RTD) system, have the potential to replace metal posts in many clinical situations. They are adequately rigid, fatigue and corrosion resistance, high tensile strength, but a modulus of elasticity similar to dentin.[81-83] In these posts, conditions of short-term or local overload stresses resulted in the cracking of only some fibers and not in the failure of the whole structure. There are no difference in resistance to fracture between the carbon fiberreinforced carbon post and the cast post and core or the composite post and core.[80] While the study of Isidor et al. found that the failure rates of the parapost and castpost system were significantly higher than those of the carbon fiber posts.[81-83]

The configuration of Composipost head is smooth that significantly affected the retention of the resin composite cores and the mode of fracture on tensile loading. The new designed head of the post to serrated is done to increase the retention of this post type.[84]

Castable ceramic post/cores

The ceramic have been used as post and core to achieve the optimal esthetics.[85,86] Optimal esthetics can be achieved with a full-ceramic restoration as the quality of light transmission imparted by the nature of the porcelain mimics that of natural tooth structure.

The IPS Empress ceramic system (Ivoclar, Amherst, NY) has been developed using a leucite-reinforced glass ceramic and an innovative staining system for colorization and characterization. The laboratory can cast this post/core and crown through the very accurate lost-wax technique. The esthetic appearance of the all ceramic crown with the underlining dentin-shade core will provide a visual restorative depth that give the excellent esthetic. This technique is called "Monobloc technique".

In case that there are excessive loss of tooth structure

A new restorative concept for pulpless teeth with excessive loss of radicular dentin utilizes light transmitting plastic posts (Luminex, Dentatus) for curing composites inside the root. The internal composite buildup is used to strengthen the compromised root prior to post and core restoration. The plastic posts (60 seconds total) gave a depth of cure of 8 mm and was found to be an effective method for curing composites inside the root.[87]

Post Cementation

The concentration of stress should be minimized during post insertion. There is a significant rise in hydrostatic pressure during cementation.[88] Therefore, a vent should be used in parallel, active, and custom cast posts to minimize this result.

Post can be cemented with either glass ionomer luting cement or zinc phosphate cement, but the cemented post should not be disturb until the cement completely set, approximately 45 minutes to 1 hour.

When anatomical limitations require a dowel that is shorter than desirable, or in situations in which additional retention is required, or when supragingival tooth structure is compromised, the use of a resin cement should be considered.[52] The smeared layer of dentin must be removed prior to cementation. This can be done effectively with EDTA and with acid of a number of the new dentin-bonding agents. (Scotchbond Multipurpose, or Allbond 2). Do not remove the smeared layer of dentin with 37% phosphoric acid because this will severely demineralize and weaken the dentinal walls in the canal.[52,89]

The core built-up materials

Amalgam

Amalgam has been used as a coronal-radicular core alone as a core material in conjunction with a cemented prefabricated post. The only drawback to the use of silver amalgam is that some time is required for it to develop maximum strength values, so it has generally been recommended that freshly condensed amalgam should not be prepared for 24 hours. The optimum commercial product would be a high copper-containing spherical alloy because these alloys are readily condensed into small amalgapin's hole and other secondary retentive features and achieve very high early and ultimate strength.[90] In fact, the one-hour strength of most spherical alloys approaches the values achieved with admixed alloys at 24 hours. It is permissible to prepare such spherical alloys one hour after placement, which can avoid a separate preparation appointment.

The amalgam core has been more predictable than a composite resin core[91] and has exhibited the greatest retention to the posthead.[92,93]

Composite resin

The critical factor in the use of composite post and core methods is that the coronal restoration margins should cover a minimum of 2 to 3 mm[94] of solid tooth structure and should never terminate where the margin extend subgingivally. The composite post and core have some disadvantages:

1) Composite shrinkage during polymerization may cause cuspal movements.

2) Composites have poor dimensional stability. Composites absorb water, particularly in wet conditions.

3) The thermal coefficient of expansion is two to ten times the value of natural tooth structure.

4) The modulus of elasticity for composite resins is poor; thus, anterior composite core are fragile and should be avoided.

Lindhe[93] has reported long-term successful clinical use of composite resin as a core materials.

Composite core (Core-Paste, DentMat) was significantly stronger in both compressive and tensile modes than titanium reinforced composite.[96]

Glass ionomer post and cores

Glass ionomer materials are probably unsuitable as core buildup materials, particularly anterior tooth, because of their weak tensile strength and low fracture toughness.[97] The glass ionomer cement core can easily separate from the post.[98] Some of newer light-cured glass ionomer materials (Vitremer, Fuji II LC) have physical properties that are three times as high as conventional product in terms of important parameters such as diameter tensile strength, flexural strength and fracture toughness. They are very convenient to use and may well be acceptable for moderate direct buildups.

Ferrule

All restorations for pulpless teeth required covering the cusp with a completed cast crown having margins

that embrace sound tooth structure apical to the finish line of the core. This sound tooth structure apical to the finishing line of the margin of core and tooth should have 2 mm or more to achieve the ferrule effect. This will make the restoration high fracture resistance. Crown lengthening may be required to achieve the desired extension onto sound tooth structure.[32]

Conclusion

Many studies support that the endodontically treated teeth are not weaker than the normal vital teeth. The predominant opinion today is that a post and core should be used to increase the retention for the fixed prosthetic reconstruction and not for reinforcement[11,15,21,35,99,100], therefore post and core are not the routine treatment for these teeth anymore. The restorative options should be properly chosen basing on the quality and quantity of the remaining dentin. In case that need only direct core built-up, coronal coverage is recommended. Post should be used only for retention of a core within remaining tooth structure where there are no other alternatives.[22] The maximal preservation of coronal tooth structure was ultimately essential for fracture resistance, so when deciding to use the post, the chosen post system should be the system that requiring the removal of a minimal amount of specific tooth structure.[22] Nowadays, the new post and core systems have been introduced in many studies, however, long term clinical studies are needed to prove the success of all these systems. Then the appropriated core built-up material should be selected. As we know, natural tooth structure is more resistance to fracture than are any of the artificial core materials, so the conservative preparation is imperative. Ferrule effect should be include in the preparation design. It is proved that about 2 mm. sound enamel around the core can increase the fracture resistance of the endodontically treated tooth. Post head design, type of core material, and ferrule effect have been intimately involved in restoration of endodontically treated teeth.

Summary of restorative approaches for endodontically treated teeth recommended in the literature.[101]

1. Cuspal coverage or extracoronal restorations should be provided for all posterior teeth.

2. Anterior teeth with intact marginal ridges and small access cavities may be restored with a direct restoration of the access cavity.

3. When an intermediate or non-cuspal coverage restoration is chosen, it is preferred that enamel acid-etch composites, not amalgam, be used.

4. Dowels (posts) should be used only when insufficient tooth structure remains to support a core (foundation) restoration. Dowels are required more often in anterior teeth than in posterior teeth.

5. Intermediate definitive restoration should be provided within weeks of completion of the root canal treatment to avoid potential coronal microleakage due to breakdown of temporary Restorations.

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