Cumhuriyet Dental Journal, 26(1): 87-96, 2023
DOI: https://doi.org/10.7126/cumudj. 1236585

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

General Consideration of Post Systems

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Review

History

Received: 16/01/2023
Accepted: 31/01/2023

ABSTRACT

Endodontic treatment needed teeth are generally with a presence of carious tissue or have had large restorations in the past. Sometimes the defects cannot be treated with restorative procedures alone, they need the addition of a technique that involves the pulp chamber, such as additional root canal treatment to the teeth. The requirement for extra retention for the core structure and coronal restoration to be performed therefore makes posts essential components in the roots of teeth with structural damage.

More often than not endodontically treated teeth remain relatively intact after conservative endodontic treatment. Endodontically treated teeth become more brittle for some reasons and one of the reasons is the masticatory function of the jaws. As a result of this known phenomenon, dental professionals have been looking for strategies to prevent pulpless teeth from breaking. Restoration and reinforcement of pulpless teeth is a crucial preventative step in endodontic therapy. A post may be used in the root of a structurally damaged tooth in which additional retention is needed for the core and coronal restoration. A widely used technique for repairing teeth that have undergone endodontic treatment is post and cores.

Retention applied onto the root thorough final restoration using the post and core restoration as a substructure. Therefore, post placement in the root is crucial. In order to ensure retention for a fixed restoration, endodontically treated teeth are frequently treated with posts and cores. Teeth that had gone through endodontic treatment often suffer from severe coronal damage. In order to ensure retention for full or partial coverage restoration, these teeth may require a coronal substructure or core for retention of a full or partial bonding restoration. Generally, primary retention feature of a core is an intraradicular post. Posts and cores are routinely used for endodontically treated teeth. This article provides a review presentation about utilization of post systems on the pulpless tooth.

Keywords: Root Canal Treatment, Post Implementation, Post Classification, Prefabricated Post, Advantages of Post, Post Indication.

Post Sistemlerine Genel Bakış: Derleme

Süreç

Geliş: 16/01/2023
Kabul: 31/01/2023

ÖZ

Endodontik açıdan tedavi gerektiren dişler sıklıkla büyük miktarda çürük doku içeren, ya da daha önceden üzerinde büyük restorasyonlar bulunan dişlerdir. Bu durumdaki dişlere bir de ilave kök kanal tedavisi gibi pulpa odasını da içine alan bir işlem eklendiğinde bazen tekbaşlarına restoratif işlemlerle eksiklikler yerine konulamazlar. O zaman postlar, yapısal olarak hasar görmüş dişlerin köklerinde, yapılacak olan kor yapı ve koronal restorasyon için ek retansiyon ihtiyacını sağlamak amacıyla vazgeçilmez unsurlardır.

Endodontik tedavi görmüş dişlerde koronal hasar sıklıkla şiddetlidir. Bu dişler, tam veya kısmi bir kaplama restorasyonunun tutulması için bir koronal altyapı veya core gerektirebilir. Postlar ve corelar rutin olarak endodontik dişleri restore etmek için kullanılır. Kök kanal tedavisi görmüş dişler, konservatif endodontik tedaviden sonra sıklıkla nispeten sağlam kalır. Endodontik tedavi görmüş dişlerin sağlıklı dişlere göre daha kırılgan olduğu gösterilmemesine rağmen, pulpasız dişlerin çiğneme sırasında kırıldığı bilinmektedir. Diş hekimleri, bu deneyimin bir sonucu olarak pulpasız dişlerin kırılmasını önlemek için strateji aradılar. Endodontik tedavide, pulpasız dişlerin restorasyonu ve güçlendirilmesi çok önemli bir koruyucu adımdır. Postlar ileri derecede hasar görmüş olan endodontik tedavili dişlerde üzerine yapılacak olan kor yapı ve protetik restorasyona dayanak sağlamak amacı ile yerleştirilirler. Endodontik tedavi görmüş dişleri onarmak için yaygın olarak kullanılan bir teknik, post ve corelardır. Son restorasyonun köke retansiyonu, alt yapı olarak post ve core restorasyon kullanılarak yapılabilir. Bu nedenle, postu köke yerleştirmek çok önemlidir. Sabit bir restorasyon için retansiyonu sağlamak amacıyla, endodontik tedavi görmüş dişler sıklıkla post ve corelarla tedavi edilir. Bir core'un birincil tutucu özelliği genellikle bir intraradiküler posttur. Bu makale post sistemlerinin pulpasız dişlerde kullanımını gözden geçirerek sunmaktadır.

Anahtar Kelimeler: Kanal Tedavisi, Post Uygulaması, Post Sınıflaması, Prefabrike Postlar, Post Avantajları, Post Endikasyonları.

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How to Cite: Kocacıklı M. (2023) General Consideration of Post Systems, Cumhuriyet Dental Journal, 26(1):87-96.

Introduction

A tooth that maintains crown integrity with no structural defects has sufficient strength against masticatory forces. However, if a certain tooth has undergone root canal treatment because of trauma or caries, its dentin integrity would be weakened due to excessive loss of material and cannot provide sufficient strength against functional forces.[1] Supporting such a tooth with a post system, ensures that the survival time of the teeth in mouth.[2]

Endodontically treated teeth with excessive loss of material in the crown section are observed to suffer more fractures against functional forces in comparison to vital teeth.[3,4] It has been shown in literature that stress resistance of these teeth decreases while brittleness increases, both caused by insufficient moisture and material loss in dentin.[3]

Tooth supported crown and bridge prosthesis have biomechanical and physiological advantages over mucosa-supported prostheses. Therefore, oral rehabilitation based on tooth-supported occlusion is preferred. Most significant benefits include masticatory muscle efficiency and tooth stabilization, as well as preservation of vertical size and supporting tissue. Therefore, even when excessive crown destruction is observed, remaining tooth structure utilization should be maximized.[5]

Endodontically treated teeth may have lost a significant portion of their existing crown structure due to an access cavity, an existing restoration, or caries, which may be the main cause of endodontic problems. In many cases, crown section support from root canals may be required to ensure durability and retention of restoration. Post and core systems are the significant parts of this procedure.[6]

Problems may arise in the treatment of excessively tapered and wide canals caused by incomplete root development, endodontic restorations, pulp pathologies, caries, or idiopathic reasons. Utilizing traditional, tapered, or cast posts may cause fractures in the coronal section, already weakened by wedge effect. Crown restoration conducted by supporting the weak root through the canal with appropriate adhesives and post-core procedures may help prolong teeth functionality in the mouth. Many researchers have advocated that composite resins are similarly suitable materials for core and post construction as well as traditional metallic root posts, and reported successful results.[7]

The idea of traditional posts and plastic filler material utilization to replace fabricated post and core systems was introduced in 1960s.[8] However, it has been reported that post-core systems have been used in dentistry for more than 250 years.[9]

In addition tooth structure loss caused by endodontic procedures, subsequent material removal for crown preparation often results in inadequate crown support. Replacing lost tooth structure with a core made of moldable filling materials can provide adequate support for the crown. However, when the remaining tooth structure is insufficient for crown retention, a post and core are often required.[10,11]

Schillingburg *et al.*[11] suggested that prefabricated post and core systems have been the most commonly used systems after 80s to provide restoration for support.

Indications of Post Core Restorations[12]:

1- In cases where observed crown section loss cannot be repaired by pinned core procedure or utilizing undercut, auxiliary cavities, retaining grooves, acid etching or bonding methods,
2- In cases where pulp integrity is impaired by axial or occlusal reconstruction of the malposed tooth,
3- In cases where crown/root ratio of teeth with weak periodontal support needs to be strengthened with the help of endodontic supports,
4- In cases where bar and stud attachments require root retention in overdenture applications,
5- In cases of severely defected teeth with pulp prognosis suspicion, as post-restoration endodontic treatment will be difficult otherwise.

Advantages of Post Core Application[12]:

A- Two-stage restoration is utilized to support the cast superstructure of root canal treated teeth.
1- When prosthetic restoration fails partially or marginally, treatment can proceed without intra-coronal restoration renewal.
2- When posts are not in cast form, undercuts on teeth can be filled, which could help preserve the tooth structure to be removed for cast superstructure restoration.
3- Post-core structure reduces the amount of cast alloy used in the final restoration.
B- Posts can be utilized for temporary restoration during periodontal and orthodontic treatment applied to teeth with previous root canal treatment.
C- Posts establish connection between root and crown.
D- Take into account the advantages of use when tooth structure is insufficient locally, in terms of size, or in contrast to the quantity of displacing forces. Notable indications include lost or insufficient pulp chamber wall, or lack of opposing walls to support one another.

Disadvantages of Posts[13]:

1- Post is placed through additional operation.
2- Preparations for post placement on tooth could cause more material loss in the tooth.
3- If the cavity required for post construction is not smooth enough or excessively wide, the core will be inadequate for restoration, which may result in failure to cement post core restoration onto cavity. Also due to this problem cementation and leakage problems may occur.
4- Using posts in restoration that are not suited for repeated root canal procedures may result in a number of complications or prevent retreatment.

Requirements for Post Placement Teeth:[13,14]

1- A good apical seal must be achieved.
2- There should be no sensitivity in pressure.
3- There should be no exudation.

4- Use gutta-percha restorative material to completely fill without gaps.
5- There should be no sign of infection on lateral or apical periodontium.
6- Repeat incomplete canal fillings; in case of any doubt, monitor the tooth until you are confident. Post should only be placed after all suspicions are clarified.
7- Remaining clinical crown length and remaining apical distance after post placement should be taken into consideration.
8- Inspect for any potential subgingival caries.
9- Lamina dura continuity and bone must be evaluated for resorption.
10- Evaluate root canal morphology for potential complications before opening post cavity.
11- Occlusal relationship and undesirable mastication relations should be taken into consideration.

There are many classifications about posts in modern day.

According to the classical classification, posts are divided into two classes:[15,16]

1- Conventional posts made by casting method: this is the traditional post type produced by taking measurements through direct or indirect methods, preparing a model, and finally casting.
2- Prefabricated standard posts: prefabricated standard posts are also divided into two classes based on application method:[5,16]
   A- Passive posts: this is the type of post cemented directly into prepared post cavity by its own drills, without any requirement to screw into the root canal. These posts can be either grooved or flat. Two types are defined based on shape:
1- Parallel-edged,
2- Tapered.
   B- Active posts:
1- Threaded parallel-edged posts with a special guide drill Flexipost: A groove is created by using a lead bur followed by a guide bur, after which the post is screwed clockwise into the canal.[5,16]
2- Directly screwed self-tapping threaded parallel-edged posts: Screwed clockwise into root prepared with a guide bur applicable to selected post diameter.[5,16]
3- Directly screwed self-tapping threaded tapered posts: These may cause more root fractures and cracks than parallel-edged ones.

Methods Used for Restoration of Teeth with Previous Root Canal Treatment and Excessive Material Loss[2]:

   A- Cast post-core: Prepared by direct or indirect method. Direct method features wax or acrylic model prepared in mouth, and indirect method on die.[2]
   B- Amalgam or composite resin coronal-radicular core for posterior teeth: There are two techniques:
1- Post-core and pin supported amalgam or composite resin core:[2,17] Entry path for post-core may be problematic in multi-rooted teeth with divergent canals. In this method, posts are cast separately and inserted into the canal through the opening in core during cementation.
   C- Coronal-radicular amalgam or composite resin post-core:[18] In this method, post and core are prepared together by placing amalgam or composite in the pulp chamber and coronal part of the tooth from the pulp chamber to the canals in molar teeth.
   D- Prefabricated post with amalgam or composite core: This commonly preferred system involves amalgam or composite resin core structure shaped by direct method following the application of prefabricated standard posts onto the tooth by direct method.

Sorensen and Martinoff classify posts as follows:[18]

1- Threaded metal posts
a- Obturation screws e.g.: FKG
b- Dentatus screw posts e.g.: Unitek, Swedia, Medidenta
c- Radix-Anchors
d- Flexipost
e- Kurer Posts: Anchor, fin-lock, crown saver, press stud

2- Non-threaded metal posts:
a- Endopost
b- Charlton crown post kit
c- Post kits
d- Nu-bond post

3- Plastic models:
a- Endowels
b- Norm plastic pins
c- Standard plastic pins

4- Combination kits:
a- C-I kit
b- PD posts
c- Colorama
d- Para-post

Mumford and Jedynakiewicz divide prefabricated posts into 5 main groups:[19]

1. Charlton System: Features a directly inserted stainless steel post and a steel core attached to it. The core is appropriately prepared outside the mouth and mounted into the mouth. May cause excessive tooth tissue loss during adaptation.
2. Kurer System: A threaded post system which can be applied with or without a core. Preparing the flat surface on cervical region of the tooth for the core after parallel-edged post cavity prepared with a reamer will cause loss of last remaining tissue of the crown, which is the primary disadvantage of this system
3. Schenker System: Utilized posts feature parallel edges and two different diameters. The diameter is narrower in the apical part. Difficulties may be encountered while preparing the socket and mounting the post.
4. Dentine Screwed Systems: Posts are screwed onto dentin in the canal with a hand tool. Costs less and can

be applied rather quickly. May create stress which could lead to root cracks and fractures.

5. Parapost System: It is a popular post system which can be used in many cases. It is a parallel-edged and grooved system. Its longitudinal groove causes excess cement to come out.

Caputo and Standlee classify posts in two different groups based on surface properties and shapes:[20]

A- Tapered and Flat Surface Posts: These include Kerr Endopost, Mooser Post, Unitek Post, Schenker Post, Stutz Post systems. They are the oldest and most commonly used posts. As tapered form is the natural form of canal, preparation and cementation is easy. Cement escape is also a possibility, so they might cause minimum hydrostatic pressure. A major disadvantage is that wedge effect may cause root fractures.

B- Parallel Edged Posts: Whaledent Parapost, Unitek Charlton Post, Degussa Post systems are included in this group. Parallel-edged posts may not always be available in narrow, tapered or non-straight root canals; canal preparation requires more dentin removal apically. Not suitable for mandibular incisors, mesial roots of molars, and upper first molars. Yields better results in long, wide-rooted teeth with a wide dentin wall. High probability of root fracture should be kept in mind when using such posts.[5,15,20,21]

There are two types:

1- Parallel-edged posts with flat surface: Parallel-edged posts with tapered end have been developed to increase normally low retention. However, the tapered end acts like a wedge at the root and causes fatigue.[5,15,20]

2- Parallel-edged posts with grooved surface: Most deny cement escape, which makes placement with hydrostatic pressure more difficult. While cement escape might occur if the canal is widened excessively, this would decrease retention as the space between post and canal would also be widened.[5,19,22]

Walton and Trobinejad[16] showed that these posts distribute stress more evenly than tapered posts with flat surfaces and do not trigger a wedge effect. Caputo and Standlee showed that these posts distribute stress equally between post-cement-supporting tooth tissue in the face of compressive loads.[20]

C- Tapered Posts with Threaded Surface: Some examples of this system include Blue Island, Buffalo, and Dentatus Post. Mount post by turning it clockwise on its own axis. Triggers great stress on root during application. Root fractures may also occur with masticatory pressure. Stress concentration is higher in short length than in long length. This is the post group that causes the most root fractures.[19,20,23,24]

D- Parallel Edged Posts with Threaded Surface: Kurer Anker and Radix Anker post systems are in this group. Dentin usage is increased for mechanical retention. These are mounted on canals prepared by special burs that create a ledge form.[20] Caputo and Standlee determined that when grooves are sharper and fewer in numbers, there would be less stress formation around them.[20] They concluded that Radix Anker posts create less stress than Kurer Anker posts.

Caputo and Standlee and Cohen *et al.* have shown that cylindrical posts with threaded surfaces are the most retentive posts. However, thick diameter may cause root fracture and perforation.[15,20]

Standlee and Lui reported that stress distribution and retention properties of all post groups are related to post fully adapting on the canal.[20,22]

Current classification[25]

A. Classification of Cast Post:

I. According to type of alloy.

1. Gold alloy
2. Chrome-Cobalt alloy
3. Nickel-Chromium alloy

II. According to number of Post.

1. Single Post
2. Multiple Post
   a.One Piece Post
   b.Two Piece Post

B. Classification of Prefabricated Post

I. According to Taper

1. Parallel
2. Tapered
3. Parallel Tapered

II. According to surface character

1. Smooth
2. Serrated
3. Self threading

III. According to fit

1. Active
2. Pasive

IV. According to material

1. Metallic
   i. Titanium
   ii. Stainless steel
   iii. Brass
2. Non-Metallic*
   i. Non-Esthetic
   a. Carbon fibre post
   ii. Esthetic Post
   a. Polyethelene fibre
   b. Glass fibre
   c. Quartz
   d. Ceramic

V.According to light transmission
1. Light transmitting
2. Non-Light transmitting

VI.According to Vent
1. With Vent
2. Without Vent

VII.According to Monoblock formation
1. Monobloc formation
2. No Monobloc formation

Monoblock system: This concept gained popularity in 1996 when epoxy resin posts reinforced with carbon fiber were mechanically connected to root dentin as a homogenous monoblock. To create a three-dimensional seal, the root dentin, canal walls, sealer, and obturating material should all attach to one another and come together to form a solid, homogenous unit. The phrase "monoblock effect" refers to this.[26]

Depending on the number of contacts between the bonding substrate and the core bulk material, replacement monoblocks that are produced in the root canals may be categorized as primary, secondary, or tertiary. In a primary monoblock, the root canal wall and the core material make just one circumferential contact. Secondary monoblocks include two circumferential contacts between the cement and the dentin and the cement and the core material. Then a third circumferential contact is introduced between the abutment material and the bonding substrate, a tertiary monoblock is produced. Fiber posts with a silicate coating or an unpolymerized resin composite known as tertiary monoblocks are used to fill large canal gaps that cannot support conventional fiber posts.[26]

Post systems will continue to play a significant role in the restoration of teeth that have undergone endodontic treatment. Meta-analysis of long-term clinical investigations has revealed that fiber posts have greater success rates than other post systems.[27,28] Due to their physical similarities to dentin, ability to evenly distribute functional stresses across the root surface, ease of application, and aesthetic compatibility with neighboring tissues and all-ceramic restorations, fiber-reinforced composite post systems are frequently preferred by clinicians. To demonstrate whether fiber reinforced composite post system is more effective and favorable in clinical applications, further well-designed in vitro and in vivo investigations are required.[29]

Primary purpose of every single post is to provide retention for the core.[30] Following factors affect posts' retention.[11,31-33]

- Canal shape,
- Post size length-diameter,
- Form and surface features,
- Adhesive materials.

There are a number of different suggestions on optimal post length[5,13,24,34,35], which can be summarized as follows:
1. It should be greater than or equal to length of clinical crown,
2. It should be half the size of the root,
3. It should be equal to length of anatomical crown,
4. It should be half the distance between apex and alveolar crest,
5. It should be long enough to leave 3-5 mm of canal filling material at the root tip,
6. It should be 2/3 of the remaining root length,
7. It should be 3/4 or more of the root.

Post length: Studies have shown that retention and post length are positively correlated.[36,37] However, excessive increase in post length may lead to disruption of apical occlusion and/or apical region may be curved, which could lead to perforations.[13]

According to Weine, average post length for maxillary central incisor should be 10.5 mm, and average post length for maxillary canine should be 9.5 mm.[38] According to Amartnath *et al.*, the post material and post length had a significant impact on the fracture resistance of teeth that had undergone endodontic treatment. After increasing the fracture resistance of the teeth by about two-thirds of the root length after being rebuilt with posts, post length started to decline. With an increase in FP length, the teeth's fracture resistance increased correspondingly.[39]

Studies have shown that, although threaded posts maintain retention advantages, they also cause stress concentration at root tip and lateral walls during mounting and may cause root fractures around crown-root border. Hence when choosing a post, make sure root diameter and post diameter are compatible with each other.[5,15,20]

A number of factors affect post retention[11,31,32,40], including canal shape, post size length-diameter, post shape, surface features, and adhesive materials.

Studies have shown that retention and post length are positively correlated.[36,37] However, excessive increase in post length may lead to disruption of apical occlusion and/or apical region may be curved, which could lead to perforations.[13]

Krupp et al.[41] reported that the most important factor affecting post retention was post depth. Rueping et al.[42] reported that increasing post length from 5 mm to 8 mm increased retention 1.23 times. They also reported that increasing post length from 7 mm to 11 mm increased post retention by 30%, and increasing post length from 9 mm to 11 mm increased post retention by 24%. Sidoli *et al.*[43] reported in their photoelastic study that stress concentrations could be decreased by increasing post length.

Post Diameter: While according to some researchers post diameter is insignificant for retention another study demonstrated that retention increased by 24% when diameter was increased in parallel-edged posts tapering towards the tip, and thus in conclusion they suggested that post diameter should be 1/3 of root diameter.[33,37] Caputo and Standlee argue for a dentin thickness of at least 1 mm around the canal.[20] It was observed that stress increases when post diameter is increased, and stress on dentin and tooth supporting structure decreases by using posts smaller in diameter.[44] Ideally, post diameter should be determined

in accordance with anatomy of root canal without intact tooth tissue loss.[35] In a study conducted by using different post diameters, Hanson and Caputo reported that medium-sized 0.6-inch diameter posts were more retentive than 0.5 and 0.7-inch diameter posts.[45] Another study reported that minimizing post diameter would not only preserve tooth structure, but also reduce root fracture risk.[36] Weine *et al.*[38] determined that increasing post diameter does not strengthen tooth structure nor increase retention, and that stronger retention could be achieved by increasing post length instead of diameter. Tjan and Whang, reported that over-expanded canals would cause weaker teeth due dentin tissue loss, and may lead to fractures as a result of incoming forces.[33] According to Hudis and Goldstein, there are 3 primary principles for preparing post cavity for teeth with previous root canal treatment:[35]

1- Conservative approach: argues that prepared post space should be as small as possible.
2- Proportional approach: argues that apical section of the post should be 1/3 of the diameter at the point it meets the root.
3- Protective approach: argues that the dentin around the post should be 1 mm thick all around at minimum.

Surface Characteristics of Posts: It has been proven that threaded or roughened posts have stronger retentive properties than smooth ones. Tapered posts are reported to bear stronger retention by creating small grooves on post surface and in the canal. Standlee *et al.*[46] reported that post shape affects retention more than post length. According to the study, threaded posts are the most retentive, followed by parallel-edged posts, and tapered posts are the least retentive ones. One study showed that post shape is the most important factor in post retention, with parallel sided posts being 4.5 times more retentive than tapered ones. Snoek and Creugers conducted a study to determine whether aluminum or zirconium oxide coatings could improve retention of non-threaded titanium posts.[47] They concluded that aluminum or zirconium oxide coated post surface with Panavia 21 adhesive created same level of bonding as threaded posts. Mansfield *et al.*[48] found that retention values of glass ionomer cement and resin cement modified with micro etching increased in tensile test performed with posts.

Prioritized posts with threads do not contact the canal wall, but retention reliability on cement is considered passive, while mechanically treated dentin is considered active. Active or threaded posts are more retentive than passive conforming posts, and parallel-edged posts are more retentive than tapered posts.[11]

In their recent study on post retention, Standlee and Caputo showed that parallel-edged threaded posts are more retentive than parallel-edged serrated posts, and parallel-edged posts are more retentive than tapered smooth surface posts.[37]

Active posts with dentin-inserted threads create more stress during production and mounting than other forms.[13] One step backward rotation of active posts, limited by the number of post grooves in the post canals prior to compression, is used in some techniques to remove stress. Threaded tapered post creates the greatest level of stress among all post designs. 49 Passive tapered posts contain an escape route and create a little stress during application. However, tapered posts, whether active or passive, can create compression during mounting.[10,31,50,51] In contrast, a serrated post with parallel-edged cement escape holes distributes stress more evenly than other designs.[13,31,50,51]

Post choice depends on tooth root anatomy and shape of prepared canal.[49] Tapered posts fit more easily into endodontically prepared canals, and are more conservative in their adaptation to tooth structure.[13]

Another significant expectation from posts and cores is to make sure the lateral forces on remaining tooth structure are distributed over a wider area.[13] Posts distribute forces on them according to their shape, diameter and length. While tapered posts are considered to increase root fracture risk through wedge effect, parallel-edged posts reduce this risk. Posts mounted solely with cement distribute the forces on them better. Cement creates a buffer between the tooth and the post. Same buffer feature can also be observed in threaded posts. Increasing post diameter and length helps distribute occlusal forces better. However, optimum apical dentin thickness must be maintained while increasing the diameter.[24]

Research on the effect of post shape on stress distribution has revealed the following results:[13]

1- Highest levels stress occurs at the apex of tooth cervical region. Therefore, dentin in this section should be preserved as much as possible.
2- Stress decreases as the post length increases.
3- Posts with parallel edges can distribute stresses better than tapered posts.
4- Sharp edges and angles should be avoided due to high stress that can occur with overload.
5- Very high stress values can occur during placement of posts with parallel edges with no cement escape route.
6- Threaded posts can reach high stress values during mounting and utilization.

The Importance of Coronal Tooth Structure in Post Applications: Cohen and Burns argue that post choice should be based on amount of remaining dentin, and classify accordingly[21] According to this;

1- Cases where the crown is completely preserved and access cavity is shaped between crown structures: In such cases, post application is not necessary. Trope *et al.*[52] reported that posts applied in such cases increase fragility.
2- Cases where at least half of the crown remains: A post suitable for root length is selected Parapost, Flexi-Post, BCH post, CI post, Endopost, Boston post systems. The canal is prepared with a guide bur. After the necessary procedures for core retention are performed, the post is cemented. Restoration is then completed with the crown finished on shaped core material.
3- When less than half of the crown remains and there is no dentin support: Any post system can be used. Two

methods can be used to prepare the core. In the direct method, modelling is conducted in the mouth, and removed together with the post and sent to casting. In the indirect method, core is modelled according to measurements taken while post is in the canal, and sent to casting. Post alloy and core alloy must be compatible, or corrosion will cause negative effects on the system.

Ferrule Effect: The metal ring that surrounds the cervical region of the tooth is a significant element in post application, preventing root fracture and supporting the crown. Extending as far as possible in the direction of the gingiva on the core, the ring will surround the root and prevent vertical fractures. It will also prevent the post from rotating due to horizontal forces. It is reported that this metal ring creating the ferrule effect should surround the tooth with a width of at least 1-2 mm, and a parallel sidewall form ending in solid tooth structure.[5,14]

For teeth with fillings at the root, a 1.5–2 mm circumferential ferrule is advised. An partial ferrule, however, is seen to be preferable to a completely absent ferrule if the clinical circumstance does not allow for a circumferential ferrule.[53] To reduce the risk of unfavorable failures, it is advised to utilize glass fiber posts with ferrule heights of at least 1 mm.[54] Different research that were considered have different definitions of ferrule. The ferrule's height was specified as 2 mm by Cagidiaco *et al.*, but Signore *et al.*[55,56] described it as a circumferential collar of dentine with a height of at least 1.5 mm but not more than 2 mm in teeth that had completely lost their coronal walls. In both investigations, there were a number of instances where the loss of tooth structure was not uniform, but the ferrule height was never less than 1 mm. Ferrari *et al.*[57,58] defined ferrule as the absence of an axial wall but with at least a 2 mm high collar of dentine that was preserved circumferentially, whereas no-ferrule defined the absence of an axial wall but with less than 2 mm height of dentine but without any description of minimal circumferential dentine. According to their definition, a ferrule's height cannot range from less than 2 mm to as low as the gingival edge.[59]

Physical Properties of Post Materials: Traditional prefabricated posts are made of stainless steel, titanium and its alloys, platinum-gold-palladium, chromium-containing alloys, or brass.[13,24,32] Today, non-metal carbon fiber epoxy posts are finding more and more applications.[13,49]

The modulus of elasticity of metal and the cross-section geometry of the post determine the vertical stiffness. Insufficient vertical stiffness causes deformation against force. Yield strength of post metal must also be high. If the yield strength is low post and core may be deformed, crown margins could be widened, and restoration may fail.[24]

Allergy and sensitivity potential of nickel among post materials is also interesting. Biocompatible titanium appears less radiopaque on radiography than nickel and stainless steel alloys. Radio opacity of titanium posts is similar to that of gutta-percha, and radiographic image may be obscured by other opaque cements. Titanium posts are difficult to distinguish in root canals filled with condensed gutta-percha. According to Alaçam *et al.*[12], although titanium based materials are weaker than nickel chromium alloys, this difference is clinically insignificant.

Titanium, more commonly used in recent years, is only half as durable as steel. Modulus of elasticity for titanium is 15 psi, while that of steel is 28 psi. Both yield strength and tensile strength of titanium are lower than steel. Thus, post strength is sacrificed to use a biocompatible material. As properly mounted posts will not come into contact with living tissue, biocompatibility will not be of much importance.[24]

Corrosion on Posts: Corrosion is responsible for weakening both post and tooth, leading to root fractures. Although ion exchange between different metals titanium, steel, amalgam, gold used to make the post and core is claimed to be the cause of corrosion, it has been recognized that the real cause of corrosion is microleakage.[13]

Modulus of elasticity and corrosion of posts are factors to be considered in metal selection.[11,13,32,50] Titanium alloys have the highest corrosion resistance. However, titanium is much less resistant to fracture than cobalt-chromium-molybdenum or stainless steel. Stainless steel and brass both show low corrosion resistance. Platinum-gold-palladium, cobalt-molybdenum metal alloys and titanium are the most suitable metals for endurance and corrosion resistance.[11,13,32,50] According to Jacobi and Schllingburg, brass is the least preferred alloy because of its low strength and low resistance to corrosion. 49 Nickel-containing alloys are avoided in nickel-sensitive patients.[32]

Effects of Root Morphology on Post Selection: Both internal and external contour of the root influence post selection. All roots end in a narrowing form from cervical region to the apex. Some especially narrow down even more in the apical triad. Using parallel posts on such teeth may cause root perforation, therefore tapered or short parallel posts should be preferred. However, using tapered posts creates a wedge effect via force transfer. In addition, short posts spread the load over a short root area, and thus their stress distributing function is limited.

If the transverse section of the root canal is oval or octagonal, preparing a circular post canal would be difficult. Cast posts may help protect tooth structures while they also require less apical preparation. Coronal section of cast posts also provide an anti-rotational feature. If a root canal can be opened to be equal to or longer than the clinical crown of the tooth, coronal core and combined parallel post will be the best option.[16,24]

Preparation Geometry: Root canals with a circular cross-section makes post preparation comfortable, whereas root canals with an elliptical cross-section require root canal preparation to be tapered, usually at 6°, to eliminate unwanted undercuts.

Optimal post geometry should include high-strength, corrosion-resistant material, with adequate retention and ability to distribute forces appropriately, minimizing the risk of perforation and tooth structure loss during application.[13,32,37,50]

Despite clear disadvantages, researchers defend placing posts on endodontically treated teeth. However, some studies have reported that placing posts on teeth with previous root canal treatment does not strengthen tooth

structure.[15,20,52,60-62] When tooth is overloaded, stress is placed on lingual and facial part of the root, while the post inside the root is minimally affected by this stress.[18,52] Therefore, it is not effective in preventing fractures. 13 There are also those who argue the opposite of this thesis.[63,64]

Prefabricated post and core system consists of two parts, the post and the core, the latter being a moldable filling material. However, the system cannot exist without an adhesive cement to improve retention and help sealing along the canal. Regardless of surface configuration and features, adhesive cement is used when placing posts. Thus we conclude all three components of a prefabricated post and core system: prefabricated post, plastic core material, adhesive cement.

Core Materials

Cores are restorative segments that are removed from the tooth's post structure where coronal tooth tissues have been destroyed. The chosen post system and the tooth tissue should be compatible with the optimal core material.

While the post and core are cast together and assessed as a unit in cast post-core restorations, core materials for prefabricated posts might include amalgam, glass ionomer cement, ceramic materials, and composite resins. Core materials should have appropriate mechanical qualities including mechanical resistance, dimensional stability, and elastic modulus, as well as be simple to use. The core material of choice has an impact on the stress distribution seen in the post-core system.[65]

For ultimate repair, the core provides retention and resistance. For prefabricated resin composite and glass ionomer cement post and core systems, amalgam is used to shape the core.[10,11] Amalgam is quite simple to manipulate and has a high compressive strength and minimal microleakage. As a temporary repair in situations when the cast superstructure is delayed, amalgam offers acceptable wear resistance. Their drawbacks, however, are their long-term hardness and lack of adherence to the tooth structure.[10,32,66] Despite this, fast-curing high-copper amalgam has low tensile strength and sufficient compressive strength within the first hour of preparation.[67] Amalgam cores that are not prepared properly are prone to breakage.

Studies on the effectiveness of dentin bonding agents used with amalgam have resulted in a variety of findings. Mahler *et al.*[68] observed no distinction in the bond strength of bonded and unbonded amalgam in two excellent clinical trials. While Donald *et al.*[69,70] discovered in a laboratory investigation that the use of adhesive bonding with an amalgam core improves the amalgam's resistance to brittleness, Belcher and Stewart developed restorations for retention and discovered an amalgam adhesive that may be clinically useful.

Despite the development of amalgam bonding systems, they are unable to achieve the same amount of bonding as composite bonding systems. Some studies indicate that the advantages of resin composites include their reinforced strength, bonding ability, and rapid and simple application.[11,32,71,72] However, a significant drawback is their tendency to microleakage and poor dimensional stability.[10,32]

Glass ionomer, also known as silver-containing reinforced glass ionomer, has a low coefficient of thermal expansion, fluoride release, and demonstrates chemical and to some extent mechanical attachment to tooth structure. However, its brittleness and lack of resilience are clear downsides.[11,32,71,73]

Modified glass ionomer restorative materials offer the benefits of being simple to apply, hardening when required, and preventing early moisture contact; nevertheless, the resin has the drawbacks of being weaker than composite resin and lacking resilience in case of loading.[74,75]

The core material must be simple to apply, quick to cure, highly resistant, dimensionally stable, have little microleakage, and be applied with a strong bonding mechanism.[11,32,71,75]

AMALGAM CORES: It is a core building component that is simple to use, has strong mechanical characteristics, and works well with posts, pins, and other retentive parts.[76] When there is adequate tooth tissue left, amalgam core performs better.[77] Amalgam's thermal expansion coefficient, limited corrosion resistance, slow setting time, and unfavorable visual characteristics are only a few of its disadvantages. Additionally, resin-based cement-bonded aesthetic crowns cannot be effectively bonded with amalgam cores.[65]

GLASS IONOMER CORES: Because of their low coefficient of thermal expansion, which is comparable to that of tooth structure, chemical bonds to enamel and dentin, and the release of fluoride ions, glass ionomer cements are recommended as core materials. Despite these benefits, glass ionomer cements with or without silver are not appropriate for use as core materials because they lack the necessary tensile strength and fracture resistance.[65]

RESIN CORES: They are favoured in the clinic because to their simplicity of use, attractiveness, and ability to regulate polymerization, among other factors. Dentin adhesives and composite resins can be combined.[65]

When used in combination, they offer the tooth structure a strong bond that increases retention. Due to their mechanical qualities and benefits in chemical bonding, they can be used successfully in teeth that have seen a lot of material loss. Some products' hardness is enhanced up to the dentin hardness ratio depending on the kind and quantity of fillers, making further preparation easier. Its elasticity modules are on level with or higher than those of dentin, and these characteristics provide the material increased resistance. When used with all-ceramic restorations on anterior teeth, it also provides cosmetic benefits. Border compatibility is a significant issue with contemporary composite materials. The restoration's marginal alignment is negatively affected by polymerization shrinkage, and a space is created between the cavity walls and the resin. Negative consequences include marginal discolouration, fracture, and secondary caries might result from fluids, germs, and ions seeping from this cavity.[65]

CERAMIC CORES: The usage of high fracture strength ceramics as the core material in anterior teeth has increased during the past ten years. Depending on the kind of ceramic employed, these materials can, in addition to the cosmetic benefit, be chemically linked to the tooth structure following surface treatments. In the lab, a core structure can be created by pressing around a post that has already been prepared, or a post core can be cast in one piece from glass-infiltrated alumina ceramic. Making the hide and core structure separately and cementing them together during placing is an additional alternative.[65]

Conclusions

Posts are frequently used to support the restoration of the crown part in endodontically treated teeth.

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