Post and core build-ups in crown and bridge abutments: Bio-mechanical advantages and disadvantages

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Dentists often place post and core buildups on endodontically treated abutments for crown and bridge restorations. This article analyzes the bio-mechanical purposes, advantages and disadvantages of placing a core or a post and core in an endodontically treated tooth and reviews literature on post and core biomechanics. The author assesses the scientific rationale of the claim that the main purpose of a post is to retain a core, or the claim that posts weaken teeth. More likely, the main function of a post is to help prevent the abutment, on which a crown is cemented, from fracturing such that the abutment separates from the tooth root, at a fracture plane that is located approximately and theoretically at the level of the crown (or ferrule) margin. A post essentially improves the ferrule effect that is provided by the partial fixed denture prosthesis. This paper also explores the difference between bio-mechanical failures of crowns caused by lack of retention or excess taper, versus failures due to a sub-optimal ferrule effect in crown and bridge prostheses. ***[J Adv Prosthodont 2017;9:232-7]***

KEYWORDS: Post and core technique; Finite element analysis; Tooth crown; Dental abutments; Denture; Partial; Fixed

INTRODUCTION

Several bio-mechanical failures can occur with fixed partial dentures (FPD): debonding, where the FPD separates from the abutment/s due to cement failure, such that the abutment/s are left completely intact intra-orally; root fracture of the underlying abutment/s; or fracture of the abutment/s at a fracture plane that is located approximately and theoretically at the level of the FPD margin (here, the FPD separates from the abutment/s such that the supra-ferrule-margin aspect of the abutment/s is still cemented inside the FPD). A core or a post improves the bio-mechanical stability of an abutment or FPD if it can prevent either of these failures. This article analyzes the bio-mechanical advantages or disadvantages of placing a post in an endodontically treated tooth and explores the scientific validity of the claims that the main purpose of a post is to retain a core and that posts weaken teeth.

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THE FERRULE EFFECT

The ferrule effect occurs when a ferrule, or a metal or porcelain band, is cemented 360 degrees around a tooth or an abutment and binds the tooth and/or core and/or post structures that exist superior to the ferrule margin. This binding results in two "effects." First, the ferrule prevents independent flexure of the different components of these supra-ferrule-margin structures in response to occlusal forces, which would normally occur if the structures were not ferruled. Second, the ferrule has the effect of transferring the occlusal forces from these supra-ferrule-margin structures to the margin of the ferrule.[1-6] Instead of occlusal forces applying energy to a variety of different stress planes within the supra-gingival tooth/core/post structures of the non-ferruled tooth, the occlusal force energy is transferred by the ferrule to the cross sectional area or the plane of tooth/core/post structure that exists approximately and theoretically at the level of the ferrule margin (Fig. 1). The occlusal forces on a ferruled tooth are therefore resisted by

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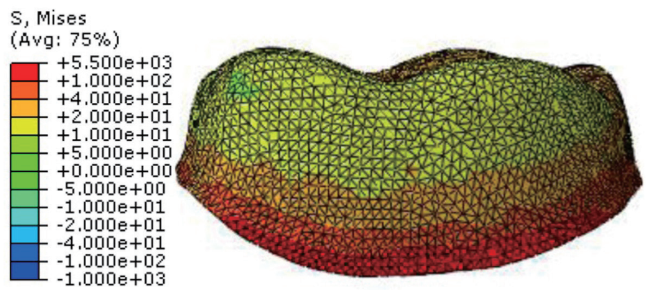

Fig. 1. Finite Element Analysis Diagram shows how a crown transmits most occlusal force (in red) to the level of the crown margin (photo courtesy of Dr. Seung-Ryong Ha, with permission from J Adv Prosthodont[1]).

the inter-molecular bond strength of the cross sectional area or interface of tooth/core/post structure that, at a molecular level, bonds the sub-ferrule-margin tooth/core/post structures to the supra-ferrule-margin tooth/core/post structure.[3]

The ferrule tooth structure is the tooth structure located approximately 1.5 - 2.0 mm superior to the projected ferrule margin.[7-10] The greater the cross sectional area of the natural tooth structure at the level of the ferrule margin, the more resistant will be the ferruled tooth/core/post structure to fracture at the interface between the sub-ferrule-margin tooth/core/post complex and the supra-ferrule margin tooth/core/post complex. A post is not a good substitute for lack of natural tooth structure within the ferrule tooth/core/post complex. The quantity of natural tooth structure within the ferrule tooth/core/post complex is more important than a post in determining whether an abutment, on which a crown is cemented, will eventually fracture away from the root.[2,11-16]

The ferrule tooth complex is the complex of tooth structure, core material, and post material, which is located approximately 1.5 - 2.0 mm superior to the projected ferrule margin. The total bond strength of that cross sectional area of the ferrule tooth complex, that is located at the interface between the sub-ferrule-margin tooth/core/post complex and the supra-ferrule-margin tooth/core/post complex, is a sum of the respective bond strengths of tooth structure, core structure, and post structure that molecularly bond the sub-ferrule-margin tooth/core/post complex with the supra-ferrule-margin tooth/core/post complex.[3]

If the molecular bond strength at the interface of tooth/core/post complex is weak, then eventually the ferruled tooth will fail bio-mechanically. Here, the tooth/core/post complex, on which the ferrule is cemented, fractures from the tooth root at a fracture plane that is theoretically located at the level of the ferrule margin. The cement binding the tooth/core/post structure to the ferrule is still intact, and the ferrule is still cemented onto the tooth/core/post complex, on which it was originally cemented. However, the ferrule is separated from the root with the tooth/core/post complex still inside the ferrule, failing bio-mechanically due to a weak ferrule tooth complex.[3]

PURPOSE OF THE POST

If a core build up is placed on an abutment that does not have a post, the core will be retained primarily by undercuts in the remaining natural tooth structure and additionally by mechanical undercuts in the pulp chamber floor, or by bonding the core to the pulpal floor. To "retain the core" means that the apical aspect of the core is held in intimate contact with the pulp chamber floor. If an abutment without a post is crowned, occlusal forces placed on the crown may cause the natural tooth structure retaining the core to flex at a fulcrum that is theoretically located at the level of the crown or ferrule margin (Fig. 1). Eventually, after numerous cycles of occlusion, the tooth structure retaining the core may fracture, at a fracture plane located at this fulcrum.

When a post is placed such that the post transcends the interface between the sub-ferrule-margin tooth/core structure and the supra-ferrule-margin tooth/core structure, the molecular bond strength at the cross sectional area of the post that is located at the level of ferrule margin adds to the total bond strength at the cross sectional area of tooth/core structure that is located approximately at the level of the ferrule margin. Placing a post therefore results in an increase in the number of chewing cycles that are required before the abutment tooth structure, which primarily retains the core, fractures. This implies that the main purpose of a post is to help prevent the tooth/post/core complex, on which a ferrule is cemented, from fracturing from the abutment root, at a fracture plane that is located approximately and theoretically at the level of the ferrule margin. If there is no post, the canal, in which the post would have been placed, would be filled with gutta percha, which would not add to the bond strength at this interface.

Some dentists claim that the main purpose of a post is to retain the core.[10,17-19] However, some experiments show that the amount of natural ferrule tooth structure in an abutment is much more important than the presence of a post, in determining whether or not a ferrule/tooth/core/post complex will fracture.[2,11-12] This implies that retention of a core by strong supra-ferrule-margin natural tooth structure, containing mechanical undercuts or bonding loci to retain the core, is the most important factor in determining whether the core will be retained for a clinically useful amount of time. A post may "indirectly" help retain the core by preventing fracture of the supra-ferrule-margin tooth structure that primarily retains the core. Although a post can help retain a core, a crown that is cemented on an abutment tooth/core/post complex, where only the post retains the core, will generally be bio-mechanically unstable.

Retention of a core only by a post generally occurs when the post retains the core but there is no ferrule tooth structure superior to the apical aspect of the core, and the core is not attached to the pulp chamber floor with mechanical undercuts or bonding forces. Here, the post/core/crown complex is retained by the root via a retentive cement layer that may fracture soon. Another example is a core retained by a post via a thin cement luting layer, but not via mechanical retention provided by the post, due to the core not engaging the undercuts in the post or because the part of the core that engaged these undercuts fractured from masticatory forces. Another example is a tooth/post/core abutment complex, on which a crown had been cemented, that had previously fractured from the abutment root, at a fracture plane that was located approximately at the level of the crown margin, although the post itself did not fracture. The dentist then re-cemented the post/core/crown such that only the post, via a cement layer, is retaining the post/core/crown in intimate contact with the pulp chamber floor (Fig. 2).

A post alone may retain the core and crown to the abutment for a short period of time but will often separate from the abutment with fracture within 1 - 3 years. Here, the post functions to temporarily retain the post/core/crown complex to the abutment root until the patient extracts the tooth and gets another prosthesis. If the abutment root remains undamaged after each de-cementation incident, the dentist may repeatedly re-cement the post/core/crown complex, thereby making the post/core/complex function "indefinitely." Although these kinds of functions are useful, they are also arguably of minimal therapeutic value and merely prolong the existence of a bio-mechanically unstable crown. Therefore, the main advantage or purpose of a post is not to retain a core, since this function is arguably of minimal therapeutic value.

It is possible for a post alone to retain the core, in situations where there exists ferrule tooth structure superior to the apical aspect of the core, if the core is not attached to this tooth structure via mechanical undercuts of bonding. A crown or ferrule placed over this abutment may be bio-mechanically stable, if the core rests over ferrule tooth structure that is 1.5 - 2.0 mm or more in height, and a ferrule or crown is cemented over the abutment such as to cover the ferrule tooth structure (Fig. 2). One example of this situation is if the supra-chamber-floor tooth structure is bowl-shaped with no mechanical undercuts, the core and post are placed within this bowl-shaped enclosure, and a ferrule is cemented over this abutment. Here, the ferrule margin is not exactly located at the level of the apical aspect of the core. At this level, the cross-sectional area of natural tooth structure would be minimal, resulting in a weak cross section that may eventually fracture. Instead, the ferrule margin is located 1.5 - 2.0 mm. apical to the most apical aspect of the core. Here, the ferrule tooth structure apical to the core would have enough bond strength, at the interface between the sub-ferrule-margin tooth/core/post complex and the supra-ferrule-margin tooth/core/post complex, to prevent fracture of the tooth/ core/complex at the level of the ferrule margin. Consequently, the crown is bio-mechanically stable, even though only the post holds the core.

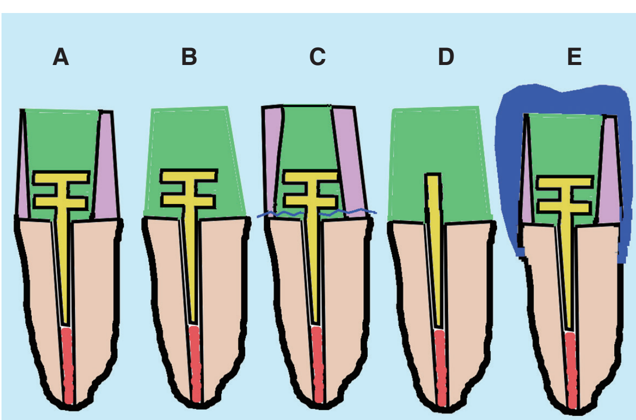

Fig. 2. Five examples of post/core restorations, where the core is retained only by the post, include situations where the abutment tooth structure has no undercuts to retain the core (A); the post is in a root tip (B); a tooth/core/post complex that fractured from the abutment was re-cemented and is retained only by a cement layer (C); a core separated from the post and was re-cemented and is retained only by the post cement (D); a core is not retained by tooth structure undercuts, but the crown margin is at 2.0 mm apical to the core on ferrule tooth structure (E). Only (E), and possibly (A), may be bio-mechanically stable.

PURPOSE OF A CORE BUILDUP

After placing a post, dentists routinely place a core. This core permeates the post, fills in empty space in the endodontic chamber, seals the endodontic chamber against future bacterial invasion, and presumably "reinforces" the tooth. However, a core can only "reinforce" a tooth if the core adds to the bond strength at the cross sectional area located at the interface of the sub-ferrule-margin and supra-ferrule-margin, which resists fracture of the abutment on which a ferrule is cemented. Theoretically, the core can do this if the core is resin-bonded to the floor of the pulp chamber, in which case the bond strength of this bonding adds to the aforementioned interface bond strength. A core might also do this if multiple tiny loci of micro-mechanical retention are created in the floor of the pulp chamber, perhaps by using a crude diamond bur to roughen the floor of the pulp chamber, or a 33 1/2 bur to create multiple tiny undercuts, to micro-mechanically attach the core to the pulp chamber floor. However, since the major limiting factor that determines if an abutment, on which a crown or ferrule is cemented, will shear off the abutment root is the bond strength at the cross sectional area of tooth structure located at the aforementioned interface, a core adds minimally to this bond strength in comparison to the bond strength of the area of natural tooth structure at this interface.

The main function of a core may be a "force transmission" medium, in that flexure of part of a tooth due to a masticatory force will cause that tooth part to flex into the stiff core material such that the core will cause the force to transmit from the flexing tooth part through the core to other tooth parts or a post that are in contact with the core. The result is that, instead of all of the masticatory force being concentrated on one stress plane, the force is distributed among multiple planes within the tooth such that (theoretically) there is less probability of any one tooth flexure plane experiencing fracture within that flexure plane. Assuming that the core is not bonded to the pulp chamber floor, the core does not reduce the total amount of force resisted by the tooth structure at the level of the gingiva. However, the core presumably enables this force to be more evenly distributed among the tooth structure, which may help prevent fracture of the tooth structure in the non-ferruled abutment.

ACTIVATION OF THE POST

Although the purpose of the post is not mainly to retain the core, it is necessary for the core to infiltrate undercuts in the post such that the core is part of a continuous volume of mass that connects the supra-ferrule-margin tooth structure, core, and post. The continuity of the mass of the tooth/core/post complex makes possible the transfer of occlusal force energy from the supra-ferrule-margin tooth structure to the core, then to the post, then to the root. A core is therefore necessary to "activate" the post, that is, to result in the cross sectional area of post material, which is located at the interface between the sub-ferrule-margin tooth/core/post complex and the supra-ferrule-margin tooth/core/post complex, to experience occlusal stresses that are transferred to this interface and thereby add to the resistance to occlusal forces that facilitate fracture of the abutment at the level of the ferrule margin. A post is particularly useful if it significantly prolongs the amount of time before the area of tooth structure at the interface between the sub-ferrule-margin tooth/core/post structure and the supra-ferrule-margin tooth/core/post structure begins to fracture. A post placed in an empty pulp chamber cannot experience forces from flexure of supra-ferrule-margin tooth structure because the post is not physically connected to that tooth structure via the core, and this post will not transfer occlusal energy to the root.

If the post is not activated, occlusal stresses on the ferrule will concentrate in the tooth structure located at the ferrule margin, instead of in the post or root. A post is more likely to be activated if the ferrule is cemented on an abutment that has minimal or no ferrule tooth structure.

Theoretically, a post can be placed in a root and not be activated, if there is enough ferrule tooth structure around the post to absorb all occlusal stresses that transmit to the level of the ferrule margin. Until the post is activated, the post is theoretically non-functional, unless the ferrule tooth structure fractures to such an extent over time so that the remaining intact ferrule tooth structure flexes enough in response to occlusal forces to activate the post. Eventually, occlusal forces may cause all of the ferrule tooth structure to fracture at the interface between the sub-ferrule-margin tooth/core/post complex and the supra-ferrule-margin tooth/core/post complex. This will result in the post resisting all occlusal forces transferred to the ferrule margin by the ferrule.

BIO-MECHANICAL FAILURE DUE TO INADEQUATE FERRULE EFFECT VERSUS INADEQUATE RETENTION

If an abutment has minimal ferrule tooth structure, the ferrule tooth structure will minimally resist the occlusal forces that the ferrule transfers to the crown margin. Consequently, a post absorbs more force at the interface, inside the post, between the sub-ferrule margin and the supra-ferrule margin. Consequently, the post is more likely to fracture at this interface, and the root is more likely to fracture due to the post transferring more occlusal force to the root (Fig. 3). Also, the cement layer, that retains the tooth/post/core/ferrule complex to the root, is more likely to fracture, resulting in separation of the complex from the root. If the abutment tooth/core/post complex has adequate abutment height and taper (averaging 4 mm of height circumferencially and approximately 6 degrees or fewer average taper[20-27]), the ferrule will continue to be cemented to the complex even if the complex fractures from the abutment at the level of the ferrule margin. Here, the ferrule fails bio-mechanically due to an inadequate ferrule effect, but not due to inadequate retention.

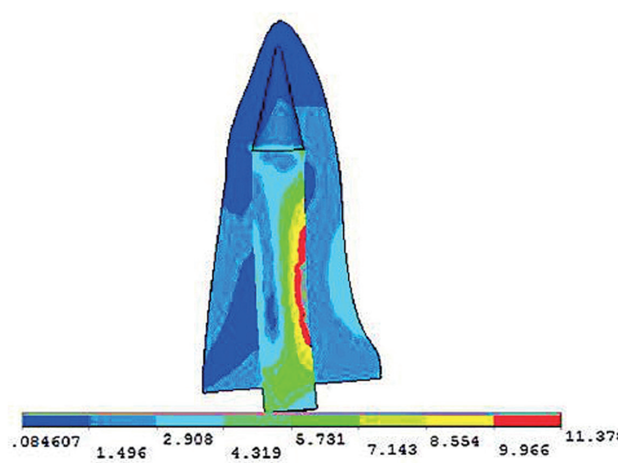

Fig. 3. Finite Element Analysis Diagram of a post/core restoration shows how the post transmits moderate amounts of occlusal forces (in green) to the cemento-enamel-junction area of the post (where the crown or ferrule margin is often located), but also transmits most of the force (in red) to the root (photo courtesy of Dr. Prajna P. Shetty, with permission from Eur J Dent[29]).

DO POSTS WEAKEN TEETH?

Dentists sometimes claim that posts weaken teeth. Generally, posts "strengthen" teeth by increasing the resistance to fracture of the supra-ferrule-margin tooth/core/post complex from the abutment root, at the cross sectional interface located at the ferrule margin. However, posts can weaken an abutment root by putting forces on the root.[2,12,28-29] If the amount of force that the post transmits routinely to the root exceeds the force that the root can withstand before beginning to fracture, then the post eventually will fracture the root. Ideally, this will occur after enough years of use that the crown will be considered a clinically successful restoration. If there is no post in an endodontically treated, crowned tooth, occlusal stresses will be resisted by the cross sectional area of tooth/core material located theoretically at the level of the crown or ferrule margin, with minimal or no stress put on the tooth root.[1] Also, post space preparation can result in reducing the resistance of an abutment to fracture at the cross sectional interface at the ferrule margin when ferrule tooth structure must be removed[18] to be able to fit the post or post head inside an endodontic chamber or a root canal.

CONCLUSION

This article suggests that the main purpose of a post is to help prevent the tooth/core/post complex, on which a ferrule is cemented, from separating from the abutment root at a fracture plane that is located approximately and theoretically at the level of the crown or ferrule margin. Specifically, the bond strength, at the cross sectional area of the post, existing at the interface between the sub-ferrule-margin post structure and the supra-ferrule-margin post structure, contributes to the overall bond strength of the cross sectional area of tooth/core/post complex material existing at the projected level of the crown margin, thereby preventing such abutment fracture. The main purpose of a post is not to retain the core, since this functionality is of minimal clinical value and since cores that are mainly held by posts result in fixed prostheses that are often bio-mechanically unstable.

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