Restoration of endodontic teeth: An engineering perspective

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Introduction

Identifying the canals and obturating them to be able to instrument and obturate the tooth is necessary to clinical success, but restoration of the endodontically treated tooth is critical to long-term success. It does not matter if we can completely the endodontic portion of treatment if the tooth cannot be held in place. Thus, we need to look at the restoration phase from an engineering perspective, not just the need to reinforce the remaining tooth so that it can manage the repetitive loading. This initial loading may be not unlike the metal ferrule: how important is it that it can manage the repetitive loading and reinforce the remaining tooth so that it is best to hold the slats together?

When a long-lasting, functional restoration is to be constructed, treacherous crown lengthening must be considered to achieve a ferrule, but this is also dependent on the remaining tooth structure, not unlike the metal ferrule encircling the external aspect. It is important to attempt to retain as much tooth structure as possible, and this aids in achieving ferrule as well as maintaining cervical continuity at the tooth where loading concentrates. Under masticatory loading, strain concentrates on the coronal portion of teeth; thus it is important to avoid over-preparation of this portion of the tooth. Optimal endodontic treatment and preserve this area during restoration of the tooth (Fig. 1).

Multiple studies discussing how much ferrule is required have found that teeth with at least 2.0 mm of ferrule have significantly greater long-term prognosis from a restorative standpoint than those with less or no ferrule. Lehman, et al, reported, “Fatigue loading of cast post and core with complete crowns of different ferrule designs provide evidence to support the need for at least a 1.5- to 2.0-mm ferrule length of a crown preparation. Crowns preparation with a 0.5-mm and 1.0-mm ferrule failed at a significantly lower number of cycles than the 1.5-mm and 2.0-mm ferrules and control teeth.” Lehman further demonstrated when loading at an angle of direction, which occurs in the maxillary anterior, at the restoration fails, the side where the load is originating is under tension, whereas the opposing side is under compression (Fig. 2). This repetitive loading and micro strain due to tension at the lingual margin leads to the marginal opening, which may lead to recurrent decay and/or failure of the restoration (Fig. 3). Additionally, if we look at strain studies by Lehman and others comparing ferrule of different heights, we observe that in a ferrule of 0.5 mm there is greater strain at the margin under tension and concentration at mid and cervical area (Fig. 4) (Inman, et al, stated succinctly, “The study confirms that a ferrule increases the mechanical resistance of a post/core/crown restoration.”)

How much ferrule is required?

When rebuilding an endodontically treated tooth, it is best to maintain all dentin that is avail- able, even thin slivers. These thin slivers of dentin provide a strong connecting link between the core and tooth’s root and between the crown and root. It is important to attempt to retain as much tooth structure as possible, and this aids in achieving ferrule as well as maintaining cervical continuity at the tooth where loading concentrates. Under masticatory loading, strain concentrates on the coronal portion of teeth; thus it is important to avoid over-preparation of this portion of the tooth. Optimal endodontic treatment and preserve this area during restoration of the tooth (Fig. 1).

The literature supports that coronal leakage may be a major factor in failure of endodontic treatment. As previously discussed, when loaded during mastication, margins with inadequate micro open on the tension side, leading to leakage over time (Fig. 5). This initially may be observed as recurrent decay, but as it deepens and the crown extends over the tooth (Fig. 6). The risk of failure was greater with metal-core posts (nine out of 98 metal-cast posts failed) than with carbon fiber posts (none of the specimens with a fiber post demonstrated restorative failure), and the post and core usually fractured at the tooth composite core interface. As stress concentrates at the apical tip of the post due to greater modulus of elasticity than the dentin, vertical root fracture is a frequent occurrence (Fig. 7). This may result in the post not being able to provide the needed support for the restoration. Bitter reported, “Compared to metal posts, FBC posts revealed reduced fracture resistance in vitro, with a less chance of restorative failure compared to metal posts.”

When two different materials are placed together, such as when a post is placed into a tooth’s root, the elastic modulus is influenced by whichever of the materials is stiffer. Dentin averages a modulus of elasticity of 17.3 (± 3.8) GPa, with glass fiber posts at 24.4 (± 7.4) GPa, titanium prefabricated posts at 66.4 (± 9.6) GPa, prefabricated stainless steel at 190 (± 10.7) GPa and cast noble gold noble posts at 53.4 (± 4.5) GPa. Cast posts fabricated from noble or base metals have higher modulus than high noble alloys and approach stainless-steel and carbon-fiber-reinforced resins in their relative stiffness. Fiber posts have

The rounded shoulder preparation, and it has also been shown that the ferrule provides greater protection. When a long-lasting, functional restoration is to be constructed, treacherous crown lengthening must be considered to achieve a ferrule, but this is also dependent on the remaining tooth structure, not unlike the metal ferrule encircling the external aspect. It is important to attempt to retain as much tooth structure as possible, and this aids in achieving ferrule as well as maintaining cervical continuity at the tooth where loading concentrates. Under masticatory loading, strain concentrates on the coronal portion of teeth; thus it is important to avoid over-preparation of this portion of the tooth. Optimal endodontic treatment and preserve this area during restoration of the tooth (Fig. 1).

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The fiber post absorbs and post flexion to mimic tooth flex-tically restored tooth, the cement loading occurs on the endon-dentin to distribute the applied stress. Studies have shown -dentin and failure. As repetitive damage via vertical root fracture -dentin or composite resin. This stress is concentrated when the post is the stiffer material at the root’s apical tip. The less-rigid component fails invariably when the post is stiffer than the root’s dentin.9 Posts with modulus of elasticit-y significantly higher than that of dentin create stresses at the root/cement/post interface, which can result in root frac-tion and failure. As repetitive loading occurs on the endodon-tic post, the cement-luting material eventually fails at the interface between the metal post and root dentin.6 This allows higher stresses to be exerted on the root, leading to damage of root fracture and catastrophic loss of the tooth. The higher modulus (rigidity) of the restoration material allows the stress to be transmitted, and not absorbed by the tooth structure. In addition, transmission of oc-cclusal forces can be compensated through a molar to simulate the direction of load-transmit more stress to the root canal system. This can lead to irreversible root frac-tures.10 The marginal ridges provide sufficient retention of restorative materials invades the width of the canal, and does not result in root frac-tures. These teeth can be restored with removal of the existing restor-a- tive material and cleaning the root canal. When the preparation following removal of decay is larger than the remaining root structure, more extensive restoration is in-di-cated.

Moderate tooth structure miss-ing or previously restored When the tooth to be restored is missing one or both marginal ridges and these areas have been restored or will be restored, replacement of a bonded composite will not suf-fice. As stated in Figure 10 (Fracture mode of failure).10 The marginal ridges provide resistance to cuspal flexure of the tooth, and a crowns and ferrules can be added to increase the resistance to cuspal flexure. When these are missing, functional loading of the tooth will result in cuspal flexure and consequently a higher chance of fracture under masticatory function. Restoration of these teeth will require a core buildup with optional pins or other re-tention elements for the core fol-lowed by a crown buildup. Posts are often not needed, as the ferrule is already present in the cusps after crown preparation is sufficient to retain the core, and a ferrule can be achieved.

A post may be considered in those patients who are bruxers or clenchers or whose occlusion may place higher forces on the restored tooth due to the tooth’s structural condition.12 When a crown is placed, it can no longer be removed. A post may be considered in those patients who are bruxers or clenchers or whose occlusion may place higher forces on the restored tooth due to the tooth’s structural condition.12 When a crown is placed, it can no longer be removed. If the tooth needs an additional retention, the tooth from a cuspal flexure standpoint and the inlay even when bonded to the remaining dentin. The absence of a cervical ferrule should be avoided in endodontically treated teeth due to the direction of load-transmit more stress to the root canal system. This can lead to irreversible root frac-tures.10 The marginal ridges provide sufficient retention of restorative materials invades the width of the canal, and does not result in root frac-tures. These teeth can be restored with removal of the existing restor-a- tive material and cleaning the root canal. When the preparation following removal of decay is larger than the remaining root structure, more extensive restoration is in-di-cated.

Conclusion For restoration of endodonti-cally treated teeth, posterior view is needed to ensure long-term survival. Ferrule is often overlooked in today’s age of adhesive dentistry, but it is as critical today as it was in the past. This is due to the need to avoid survival of the tooth, and the literature supports use of 2.0 mm of ferrule. A small increase in ferrule is critical in maxillary anterior teeth due to the direction of load. Additionally, how we restore the remaining tooth plays a role in potential issues in the long term. Metal posts are being used less frequently due to vertical root fractures that can occur when the tooth is over-constructed, and the direction has increasingly moved to the use of fiber posts, which mimic the root modulus of elasticity. When teeth restored with a fiber post are overloaded, fracture typically occurs in the coronal (supragingival) portion, leaving sufficient tooth remain-ing to avoid catastrophic failure. Yet, the ferrule seemed to can-cel the mechanical effect of the end-on-dentine.

References
2. Mygind J, Christensen I, Egelberg J. Root fractures that can occur when the tooth is over-constructed, and the direction has increasingly moved to the use of fiber posts, which mimic the root modulus of elasticity. When teeth restored with a fiber post are overloaded, fracture typically occurs in the coronal (supragingival) portion, leaving sufficient tooth remain-ing to avoid catastrophic failure. Yet, the ferrule seemed to can-cel the mechanical effect of the end-on-dentine.

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