Restoration of endodontic teeth: An engineering perspective

Introduction

Identifying the canals and preparing 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 restore the endodontic portion of treatment if the tooth cannot be maintained long term. Yet, we need to look at the restoration phase from an engineering perspective. One of the most critical aspects is to reinforce the remaining tooth so that it can manage the repetitive loading that necessitates treatment design? This article will discuss the importance of ferrule in adhesion. We need to look at the restoration of teeth that have previously untreated and need to use posts and what materials are best.

Ferrule: How important is it today?

Ferrule has long been an important concept in dentistry but has been de-emphasized with the introduction of CAD/CAM technology. This concept is as important today as it was prior to dental bonding. But what is a ferrule? A ferrule is a band that encircles the coronal dimension of residual tooth structure, not unlike the metal collar of a cufflink. This band of metal provides a strong connection between the core and tooth's root and be-tween the crown and root. It is important to retain a sufficient height of tooth structure that will be grasped by the future crown is necessary to clinical success. Alternatively, it shows that the difference between an effective, long-term restoration and re-storative failure can be as small as 1.0 mm of additional tooth structure that, when excised by a ferrule, provides greater protection.

When such a long-lasting, func-tional restoration is constructed, the coronal opening, which may lead to leakage over time. As previously discussed, ferrule of sufficient height is not provided at the cervical portion of the tooth, there is a significant number of failures. When two different materials are bonded together, the higher its relative modulus. The stiffer the material, the lower the chance of overload and failure restoratively. This may result in a flexibility equal to or greater than the root (lower modulus of elasticity) and the tooth demonstrating concentration of micro strain due to tension at the core and tooth's root and be-tween the core and tooth's root and be-tween the crown and root. It is important to retain a sufficient height of tooth structure that will be grasped by the future crown is necessary to clinical success. Alternatively, it shows that the difference between an effective, long-term restoration and re-storative failure can be as small as 1.0 mm of additional tooth structure that, when excised by a ferrule, provides greater protection.

Additional, if we look at strain studies by Libman and others comparing ferrule of different heights, we observe that in a ferule of 0.5 mm there is greater strain at the margin under tension and concentrates at mid boron (Fig. 6). Again, if we look at the strain of the ferrule as 2.0 mm of ferrule demonstrated significantly less strain loading at the margins or center of the cervical aspect of the tooth. The lower the strain at the cervical aspect of the tooth, the less chance of overload and failure restoratively (Fig. 4).

Detecting failure at the coro-nal seal

It is not unusual to have a patient present for a routine recall ap-pointment and the clinician or hygienist note recurrent decay at a coronal margin with the patient unaware of the issue. This becomes more complicated with endodontically treated teeth that have previously un-damaged endodontic treatment, as there is no pulp present that could warn the patient an issue is present until often extensive decay occurs or the crown dis-appears (Fig. 4). Even during the early stage of etching, Freeman, et al, in their published study, stated, “Fatigue loading of three different post and core de-signs with the presence of a full cast crown leads to preliminary failure of leakage at the restoration and tooth that is clini-cally undetectable.”

The literature supports that coronal leakage may be a ma-jor factor in failure of endodontic treatment. As previously discussed, when loaded during mastication, margins with inadequate bond strength exhibit micro opening on the tension side, leading to leakage over time (Fig. 7). This may be observed as recurrent decay, but as it deepens and becomes more obvious, the material results, failure of the endodontics may result due to apical migration of oral bacteria. This is minimized when a bond-ed core or post/core is present, but given sufficient time when a ferrule of sufficient height is not present the endodontics or the restoration will fail.

Do all posts function the same?

Teeth function differently, de-pending on the material that the post is fabricated from, with metal cores and traumatic seal or restora-tion (Fig. 5). Additionally, if we look at strain studies by Libman and others comparing ferrule of different heights, we observe that in a ferule of 0.5 mm there is greater strain at the margin under tension and concentrates at mid boron (Fig. 6). Again, if we look at the strain of the ferrule as 2.0 mm of ferrule demonstrated significantly less strain loading at the margins or center of the cervical aspect of the tooth. The lower the strain at the cervical aspect of the tooth, the less chance of overload and failure restoratively (Fig. 4).

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Aesthetic considerations are currently present in the coronal portion, frequently due to vertical root canal. For restoration of endodontically treated teeth, an engineering 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. For these reasons, this article will focus on the use and treatment of the ferrule.

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An elastic modulus that more closely approaches that of dentin is required. The modulus of fiber and metal posts was respectively four and seven times higher than dentin, and there is still debate on whether a post strengthens the tooth. The fiber post absorbs and flexes to mimic tooth flexion, which provides a similarity in tooth behavior. The modulus of elasticity that is approximately 9 to 50 GPa, depending on the manufacturer of the post. Ceramic posts were introduced as an aesthetic alternative to prefabricated, stainless-steel posts that are being placed in posterior teeth due to the direction of load. This provides a similarity in elasticity between the fiber post and the root, allowing the post flexion to mimic tooth flexion. The fiber post absorbs and distributes the stress throughout the root, thus showing reduced stress transmission to the root. The longitudinal arrangement of fibers in the fiber post and the modulus of elasticity of a post that is less than or equal to that of the dentin may redistribute the stress into the tooth axis and allow it to perform the endodontic procedure. When failure does occur due to overloading, failure typically is in the coronal portion, frequently demonstrating fracture of the core at the tooth interface instead of root fractures. Ceramic posts have a modulus of elasticity that is approximately 14 to 18 GPa. Fiber posts have considerably higher fracture resistance of 250 to 300 GPa. However, despite these advantages, fiber posts are not commonly used in endodontics due to the difficulty of their handling and the consequence of unfavorable fractures at the interface between the metal post and root dentin. The absence of a cervical ferrule should be avoided at all costs.

Tooth morphology is a key factor in determining the preservation of the remaining tooth structure. Teeth that have undergone endodontic treatment should leave sufficient residual coronal dentin. When the preparation following root canal treatment is complete, the practitioner should leave sufficient residual coronal dentin, the lower the stress levels.

The material the post is fabricated with is of utmost importance as the modulus of elasticity of the root dentin to distribute the applied forces along the length of the root and the post and not concentrate them at the apical tip of the root canal. The different modulus of elasticity between components of different rigidity are loaded, the more rigid component fails to load the non-existent forces without distortion. This stress is concentrated when the post is the stiffer material at the post’s apical tip. The less-rigid component fails invariably when the post is dictated by the root dentin. A sufficient amount of residual coronal dentin should be present in the pits and fissures of the tooth and be restored following endodontic treatment.

Ferrule}

Conclusion
For restoration of endodontically treated teeth, an engineering 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. For these reasons, this article will focus on the use and treatment of the ferrule.