Influence of an innovative dental post approach in dentin mechanical behavior

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ABSTRACT

The restoration of seriously damaged teeth often requires an endodontic post. A number of different materials and shapes of dental posts have been manufactured, which leads to different mechanical behaviors. The currently used post systems frequently result in failure or fracture of the tooth, due to the difference between tooth and dentin mechanical properties. Recently, a bundle of fine individual posts made of reinforced fiberglass has been developed. This new approach is not a single-post and it can be spread apart, being individually distributed in the tooth canal. With this configuration, the fine posts can adapt to suit into any root canal anatomy. Biomechanical properties similar to the dentin are being reported as an advantage for the use of this new dental post. The purpose of this study is to understand if the bundle post introduces an improvement in the results of endodontic treatment, compared with the currently used post systems. This study was carried out using the finite element method to determine the influence of stress distribution on dentin, when these two different approaches are used. The results show that stresses at the dentin changed with the dental post used. The use of bundle post appears to better accommodate the developed stress, reducing the stresses in the tooth.

Keywords: Dental post, endodontic treatment, bundle post, single-post, finite element analysis

INTRODUCTION

The reconstruction of a damaged teeth often require an endodontic treatment. Usually, when the tooth function is seriously compromised, a dental post is needed to enable the rebuilding of the tooth structure. There are multiple systems of dental posts, so, to achieve a good result in endodontic treated teeth when a post is used, some parameters have a significant role. Post material and design, core build-up material, ferrule height and the amount of coronal tooth surface are some of the parameters to care about. The selection of the most suitable system is left to the dentist, who ultimately has the responsibility to balance all the factors and to choose the system for each patient case [1].

A common complication after a restoration of endodontic treated teeth is the tooth fracture. This complication can be associated to the mechanical properties of the post. Some research has been done in this subject, however, there is no literature in consensus to what could be the better post material or configuration for the tooth restoration. For many years, metal posts were the preferred choice of dentists. In fact, metal posts have a high stiffness, i.e., they have a modulus of elasticity significantly greater than the one of the dentin. Nevertheless, the use of metal posts can lead to a higher stress concentration in apical region, and consequently can result in the fracture of the tooth. Fiber reinforced resin posts were introduced in the endodontic treatment, since they show a homogeneous stress distribution when compared to the metal posts. This type of posts was reported to be an alternative as a restorative dental material for fabricated posts, because they have a modulus of elasticity similar to dentin [1]–[6].

MATERIALS AND METHODS

A 3D model of mandibular first premolar tooth was build using DICOM images (Digital Imaging and Communications in Medicine) of a computerized tomography (CT) of the natural teeth.

Two 3D models of the tooth were created accordingly with the averaged anatomical dimensions found in the literature [4]. The geometry of these two models consist of dentin, post cement, dental post, core, layer cement and artificial crown. The models were assembled with two kinds of dental post: (1) endodontically treated teeth with single-post (SP); and (2) endodontically treated teeth with bundle glass fiber-reinforced post (BP). A thickness of 0.5 mm and 0.1 mm was considered for the crown and for the bonding layers at all interfaces, respectively. The post occupied two-thirds of the length of the root [4]. The single-post has a conical shape with its end with 0.8 mm and its top with 1.5 mm. The new type of dental posts can have a

different number of fine individual posts [6]. In the present work, a bundle of 12 fine individual posts was used with a 0.3 mm of diameter each.
The simulations were conducted by the finite element method to evaluate stress distribution. The models were imported into FEA software Abaqus®. Each component of the tooth was defined in term of its mechanical properties (Young's modulus and Poisson's ratio). All materials were assumed to be homogeneous, isotropic and linearly elastic. The values used for dentin, post cement, fiberglass post, core, layer cement and crown (lithium dissilicate) are reported in the literature [4], [6], [7]. The 3D model of the tooth was then fixed in an aluminum base that promotes an angulation of 45º degrees. A concentrated vertical load of 250 N was applied on a small area on the surface of the crown, to simulate the masticatory force [3]. Perfect bonding was assumed without any gaps at the interfaces between different components. A linear static analysis was carried out to calculate the stress distribution in both models.

RESULTS AND DISCUSSION

Von Mises equivalent stress were chosen as parameters for the evaluation of the results. The main focus of the results was on the stress concentration at the dentin. In both systems, the highest stress distribution at the dentin is accumulated at the third cervical region of the root. However, the results also show that stresses at the dentin changed with the dental post used. The single-post induced a high stress concentration (229 MPa) in this region as it can be seen in Figure 1a. On the other hand, this stress concentration has a lower value (195 MPa) when a bundle post is used (Figure 1b). Furthermore, concerning to the individually behavior of the posts, the results show that the stresses at the bundle post were higher (107 MPa) than the stresses at the single-post (52 MPa). This can indicate that the bundle post accommodates and supports a higher stress concentration, for this stress to not be transferred to the tooth structure.

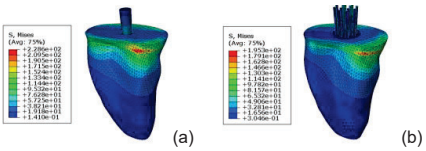

Figure 1: Von Mises stress distribution (MPa): (a) dentin with single-post; and (b) dentin with bundle post.

CONCLUSION

Finite element analysis results indicate that the bundle post may be a more suitable approach than the single-post, since it appears to better accommodate the developed stress, reducing the stresses in the tooth. Moreover, the use of bundle post may reduce the possibility of root fracture.
To evaluate the fracture resistance the authors predict to perform experimental tests on tooth restorations with both single and bundle post, in order to validate the present FEA model.

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