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Influence of Prefabricated Post Material on Restored Teeth: Fracture Strength and Stress Distribution

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Clinical Relevance

When restoring teeth, a higher restoring success rate can be achieved by using posts with an elastic modulus similar to that of dentin and a core, with equal or higher strength, such as glass fiber posts. Moreover, the failure mode for these post systems will allow for further repair.

SUMMARY

Aims

This work studied how prefabricated intraradicular post material affects the mechanical performance of restored teeth. The effect of using two different materials (glass fiber and stainless steel) with significantly different elastic moduli was studied.

Methods

A combined theoretical and experimental method was used: first, an experimental fracture strength test was performed on 60 extracted human maxillary central incisors. The teeth were decoronated, treated endodontically and restored, 30 with glass fiber posts and 30 with stainless steel posts. The data were recorded and the results compared using an ANOVA test.

Then, the finite element technique was used to develop a model of the restored tooth. For both post systems, the model allowed for the study of stress distribution patterns on the restored tooth under external loads.

Results

For teeth restored with stainless steel posts, a significantly lower failure load was found, as compared with those teeth restored with glass fiber posts (520 N versus 803 N). The estimated

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distributions confirmed a worse mechanical performance on teeth restored using stainless steel posts, with a high stress concentration due to the significant difference between the elastic moduli of the steel and the surrounding materials.

Conclusion

Within the limitations of this study, post systems, where the elastic modulus of the post is similar to that of dentin and core, have a better biomechanical performance.

INTRODUCTION

Dentistry has undergone a significant evolution since its beginnings. Many technological advances have taken place since the first extracting theories. Today, the tendency is to keep any tooth, even if only a small piece remains. This is possible because of advances in endodontics, which allow the tooth to be kept once it is devitalized, and advances in restorative dentistry, with its modern restoring techniques (Qualtrough & Mannocci, 2003). Devitalized teeth usually present important biomechanical shortcomings, such as the loss of dental substance, due to caries or previous restorations (Walton & Torabinejad, 2002). In order to restore devitalized teeth, modern restoring techniques use an external element—the intraradicular post—as a retention system for the material used in the tooth restoration, which is carried out later. These posts primarily retain the crown, supporting the final restoration. The post has been proven to not reinforce the endodontically treated tooth; instead, it can weaken it (Milot & Stein, 1992), contradicting what was thought to be true in the past.

Many different kinds of posts have been described in the literature (Fernandes, Shetty & Coutinho, 2003). At first, cast metal alloy posts and prefabricated posts made of stainless steel, titanium or precious alloys were used. The cast post core system is more time consuming and entails an intermediate laboratory phase to elaborate the retaining system, making the procedure more expensive. Prefabricated posts do not require this intermediate phase and, therefore, allow the whole restoration to be performed in one visit, resulting in an easier, less expensive technique. However, adaptation of the post to the root canal may be less accurate (Chan, Harcourt & Brockhurst, 1993).

Some confusion or disparity of results concerning how the post material affects the resistance performance of restored teeth has been observed in the literature (Fernández, Méndez & Torassa, 2002). Some studies claim that metallic posts perform better than fiber posts (Martínez-Insúa & others, 1998; Ludi & others, 1998); others, however, state the opposite (Isidor, Odman & Brondum, 1996; Ferrari & others, 2000a; Dietschi, Romelli & Goretti, 1996; Mannocci, Ferrari & Watson, 1999). Recently, the influence of the material on cast post core systems (Eskitascioglu, Belli & Kalkan, 2002) has been studied. While the results from a finite element model estimated better performance for metal, the results from a fracture strength test did not corroborate this finding. Nevertheless, today, it is commonly accepted that better performance is achieved if the stiffness of the post's material is similar to that of dentin (Fernandes & Dessai, 2002).

In order to clarify the apparent confusion of results found in the literature, the current research studied the influence of the material used to manufacture prefabricated intraradicular posts on the resistance performance of restored teeth. An experimental fracture strength test was performed on extracted human teeth that were restored using two different post materials, and a 3D finite element model of the restored tooth was then used to analyze the stresses that originated with the different post materials.

METHODS AND MATERIALS

Two different post materials were selected for the study: glass fiber and stainless steel. The posts selected were the ParaPost Fiber White and the ParaPost Stainless Steel (Coltène/Whaledent Inc, Mahwah, NJ, USA). The geometry of both posts is similar, and they are manufactured in the same sizes, although the elastic moduli of both posts are significantly different (20-30 GPa for the ParaPost Fiber White and 207 GPa for the Parapost Stainless Steel).

This research studied how the post material affects the mechanical performance of teeth that need a restoration. A combined theoretical and experimental method was used. In the first study, an experimental fracture strength test was performed on endodontically treated and restored teeth. This test analyzed the differences in strength between the two intraradicular post systems. In the second study, the finite element technique was used to develop a 3D model of the restored tooth. This model allowed the authors to study the stress distribution pattern of the restored tooth under external loads for both post systems. The stress distribution pattern provided information about the fracture mechanism of the restored tooth. Finally, the results from the fracture strength test were used to check the validity of the finite element model and the results from the simulations.

Fracture Strength Test

The goal of the fracture strength test was to analyze how much the selected prefabricated post material affected the final biomechanical performance of the teeth. Sixty human maxillary central incisors without fractures or cracks, which had been extracted for periodontal reasons, were selected for this study. Thirty specimens were restored using glass fiber posts and 30 specimens were