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Evaluation of Different Post Length's Effect on Fracture Resistance of a Quartz Fiber Post System

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Abstract: Objectives: *The purpose of this in vitro study was to evaluate the influence of different post lengths on the fracture resistance of endodontically treated teeth.*

Material and methods*. Forty intact human maxillary canines were selected and divided into 4 groups, the control group consisting of teeth restored with a custom gold cast post and core, with a length of two-thirds of the root. Other groups received prefabricated quartz fiber posts in different lengths: group 1/3, removal of one-third of the sealing material (5 mm); group 1/2, removal of one-half of the sealing material (7.5 mm); and group 2/3, removal of two-thirds of the sealing material (10 mm). All the posts were cemented with resin cement, and the specimens with quartz fiber posts received a composite resin core. All the specimens were submitted to a compressive load until failure occurred. The results were evaluated by 1-way ANOVA, and the all pairwise multiple comparison procedures (Tukey honestly significantly difference test) (α-05).*

Results. *The ANOVA showed significant differences among the groups (P<.002). The Tukey test showed that the control group presented significantly higher resistance to static load than the other groups (control group, 598.96 N; group 1/3, 213.34 N; group 1/2, 229.20 N; and group 2/3, 246.08 N). Although teeth restored with a cast post and core supported a higher compressive load, all of them fractured in a catastrophic manner. For teeth restored with quartz fiber posts, the failure occurred at the junction between the composite resin core and the root.*

Conclusion*. The length of quartz fiber posts did not influence fracture load, but cast post and cores that extended two-thirds of the root length had significantly greater fracture resistance than quartz fiber posts.*

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I. Introduction

As root filled teeth often have insufficient coronal tooth structure, placement of a post is occasionally necessary to provide adequate retention for the core and final restoration.[1] The more frequent types of failure are loss of post retention, root fracture, and loss of crown retention.[2]Regarding the post length, various recommendations have been proposed in the past. Eventually, it was believed that, given at least 4–5 mm of apical seal, the more apical into the canal the post was placed, the higher the retention of the restoration.[3-5]

Some studies have reported that increasing the post length resulted in a significant increase in retention, fracture resistance, and a decreased shear stress concentration.[6-7] However, when the post is placed beyond two-thirds of the root depth, the level of stress in the apical region increases.[8] Early studies revealed that longer metal posts reduce stresses in the coronal third of restored roots compared to shorter posts. Accordingly, it has been suggested that post length be at least equal to the crown height or two thirds of the root length to facilitate even stress distribution and provide resistance to occlusal loads.[10-12]

For many years, the restorative method of choice for endodontically treated teeth has been the cast post and core, with a high rate of success.[9] Alternatives to cast post-and-cores have been developed and include the use of pre-fabricated posts and custom-made cores with composite that facilitate a chair-side restorative procedure. In particular, fibre-reinforced composite (FRC) posts luted with adhesive materials have become more popular because of their favourable mechanical and aesthetic properties. For example, the elastic modulus of FRC posts is close to that of dentine, and results in the stress transmitted by a fibre post to the root dentine being lower than that caused by other materials such as titanium.[13-14]Translucent quartz fiber post systems recently were introduced to achieve optimal esthetics; they can be light-polymerized during cementation.[17]

Given the relationship between intraradicular length and the success of restorations, The purpose of this in vitro study was to evaluate the fracture resistance of roots with cast posts and cores and Qartz-fiber posts of different length. The null hypothesis was that there would be no difference in the fracture resistance of endodontically treated canines restored with post systems of different lengths and that no significant difference would be found among the types of post.

II. Material And Methods

Forty freshly extracted maxillary canines free of cracks, caries, and fractures were selected for the study. All external debris was removed with an ultrasonic scaler, and the teeth were stored in saline solution when not under testing. The crowns of the test teeth were removed by horizontal sectioning 2 mm above the cemento-enamel junction, with the use of a water-cooled diamond fissure bur.

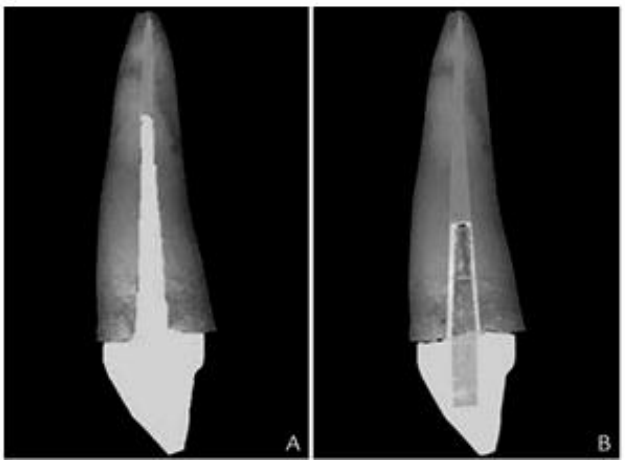
The exploration of the radicular canal was accomplished with #25 K-files (Dentsply Maillefer, Ballaigues, Switzerland) . The root preparation was accomplished with a rotary cutting instrument (HERO 642; Micro-Mega) at 300 rpm. The final instrument (#40 master apical file; Dentsply Maillefer) was standardized for all specimens. During preparation, the canals were irrigated with 2 ml of 1% sodium hypochlorite, alternating with 17% EDTA (ethylenediaminetetraacetic acid). Final irrigation was performed with 10 ml of distilled water, and the canals were dried with absorbent paper points (Dentsply, Petrópolis, Brazil). Root canals were obturated by the warm vertical condensation technique with gutta-percha points (Dentsply), accessory gutta-percha points (Dentsply), and sealer (AH Plus; Dentsply).

The roots were fixed with acrylic resin in Stainless steel block of size 19×19×20. The specimens were then randomly divided into 4 groups (n¼10). All the specimens were identified according to the group to which they belonged. The length of root canal preparation varied according to the post length: the control group and group 2/3 had 10mm of endodontic filling material removed; group 1/3 had 5mmof endodontic filling material removed, and group 1/2 had 7.5 mm of endodontic filling material removed.(Fig.1) During and after the endodontic preparations, irrigation was performed with solutions of 2.5% sodium hypochlorite and 17% EDTA and saline solution to remove remnants of gutta percha and dentin.

Cast posts and cores were obtained from acrylic resin patterns of the root canals .The patterns were cast in Type IV gold alloy. After casting, they were adjusted and adapted to their respective post spaces. The quartz fiber posts used were no. 2 (diameter, 1.25 mm) (AAA Fiber post, USA). The posts were inserted into the prepared post spaces to evaluate whether they achieved the desired length and crown extension of 4 mm. Marks were made, and the final length of the posts was achieved by cutting off the excess with a diamond disk under water cooling. Before cementation, the posts were cleaned with 70% ethanol and water, air-dried, and silanized.

The remaining root dentin of specimens from groups 1/3, 1/2, and 2/3 were etched with 37% phosphoric acid for 30 seconds, washed for 10 seconds, and partially dried with air jets and absorbing paper points, which left the dentin moist. The adhesive system (Excite; Ivoclar Vivadent) was applied to both the root surface and quartz fiber post and was photopolymerized for 20 seconds with a polymerization unit (Confident) used then a composite resin core (SPECTRUM, DENSPLY) was made. The specimens were then stored in 100% relative humidity, at a constant temperature of 37°C (±2°C), for a period of 72 hours.

The specimens were then subjected to a compressive test in a universal testing machine (Star testing system, India). A device was used to standardize the position of the specimens at the base of the apparatus. A crosshead speed of 1 mm/min was applied until the root fractured.(Fig.2) The value of the force (N) to cause failure in each specimen was recorded for statistical analysis.



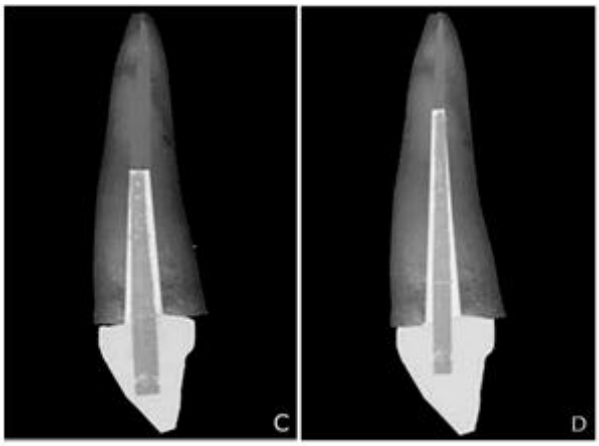


Fig 1. A, Control group, cast post and core with 10 mm of intracanal length.
B, Group 1/3, prefabricated glass fiber post with 5 mm of intracanal length.
C, Group 1/2, prefabricated glass fiber post with 7.5 mm of intracanal length.
D, Group 2/3, prefabricated glass fiber post with 10 mm of intracanal length.

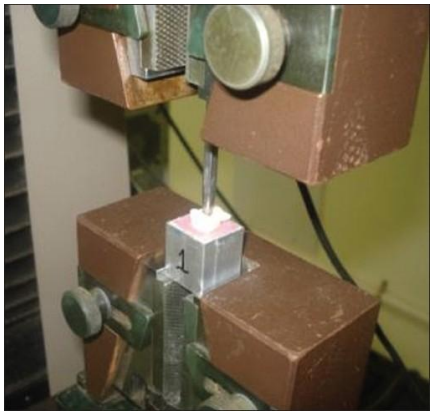


Fig.2 Loading of the specimens in the instron universal testing machine

Statistical Analysis

Data was analyzed using SPSS version 20 (SPSS Inc., Chicago, IL).Statistical tests performed were a 1-way ANOVA and the all pairwise multiple comparison procedure (Tukey test) ($a \leq .05$).

III. Results

Statistically significant differences among the groups were found (ANOVA) ($P<.002$). The Tukey honestly significantly difference (HSD) test confirmed that the mean shear strength for the control group was significantly higher than for the other groups. When the shear strength among the groups restored with glass fiber posts was compared, no significant differences were found among them ($P>.05$) (Table 1).

Table 1. Means (SDs) of failure load for each group and Tukey honestly significantly difference test

GROUP	MEAN
Control	598.96 ± 48.6a
1/3	$213.34 \pm 32.47_b$
2/3	$229.20 \pm 12.12_c$
1/2	$246.08 \pm 64.00_d$

SD, standard deviation. Groups with same superscripted letters are not significantly different at $P<.05$.

IV. Discussion

The first null hypothesis, that no significant difference would be found in the effect of post length on fracture resistance was not rejected, but the second null hypothesis that no significant difference would be found among the types of posts was rejected.

Esthetic, functional, and structural rehabilitation of pulpless teeth is critically important for successful endodontic therapy.[1]To restore back the strength of fractured root canal treated teeth, a post and core would

serve as an ideal solution which protects the weakened tooth.[2,7] Clinically, longevity of post-core-crown system for endodontically treated teeth depends on the design, length and diameter of the post, ferrule effect, cementation and amount of remaining tooth substance.[3] Use of prefabricated posts reduces laboratory and chair‑side time. Prefabricated posts are available as metallic and nonmetallic types. Nonmetallic posts are esthetically acceptable and have been observed by many studies to possess good physical properties.[4,5] Fiber posts consist of a resin matrix enveloping quartz or glass fibers.[9] The microstructure of each post is based on the diameter and density of the individual fibers and on the quality of adhesion between the and resin matrix.[6]

There are several formulas to determine the intraradicular length of metal prefabricated posts or custom cast posts and cores.In this study, in a similar manner to the study performed by Isidor et al,24 intraradicular lengths of glass fiber posts were used. At least 4.5 mm of apical gutta percha was retained in the canal to assure apical sealing of the root canal. Catastrophic root fractures occurred when cast post and cores were tested. This has been observed in other studies.3,11 In contrast, retrievable core fractures occurred in the groups restored with glass fiber posts. All restored teeth with quartz fiber posts failed because of cementation failure between the core and the remaining root dentin.

The teeth in this study presented no remaining coronal dentin and no ferrule. This represented the more challenging condition for the use of posts because the presence of at least 2.0 mm of remaining coronal dentin increases the resistance to fractures of teeth restored with prefabricated posts.3,5 However, it is important to highlight that in vitro studies present several limitations. The most important is the difficulty in simulating the mechanical condition present in the oral environment. First, the tooth is not rigidly fixed in the bone because the periodontal ligament allows micromovement of the root and modifies the distribution of forces, thereby acting as a buffer. A second important factor was that this study was performed in vitro by using static loading, which could not completely replicate clinical conditions. For more meaningful results, further studies should incorporate thermocycling and mechanical fatigue until failure.

In the control group, because the cast post and core had a much higher modulus of elasticity and rigidity,[15] the core transmitted more stress from the crown to the post and core, and, therefore, to the remaining root dentin, and the failure occurred when the load exceeded the limit of resistance to the root fracture.[2] Although many suggestions have been made regarding the intraradicular length of posts, few studies have been performed to specifically evaluate this variable with metallic, glass and quartz fiber posts.[5,25]

Post length, although important to the mechanical behavior of metal posts, is not as important in quartz fiber posts. In this study, all the experimental specimens were made of quartz fiber with different lengths and failed at similar loads. These loads are below those expected during function when considering the masticatory forces reported by Neill et al.[27] Catastrophic root fracture is a rare occurrence, and the major clinical complication of fiber reinforced composite posts is adhesive failure .[23] Pereira et al [7] reported that the self adhesive resin cements and the glass ionomer cements presented higher push-out bond strength values than the dual-polymerizing resin cements.

Limitations of the study

This *in‑vitro* study may not accurately reflect *in‑vivo* situation in determining stress distribution. However, quartz post have very good modulus of elasticity closer to dentin, which helps in improving the fracture resistance of endodontically‑treated teeth. Further long‑term clinical research is required to assess clinical performance and acceptability.

V. Conclusion

The length of quartz fiber posts did not influence fracture load, but cast post and cores that extended two-thirds of the root length had significantly greater fracture resistance than quartz fiber posts.

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