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Original Article

Resistance to fracture of endodontically treated teeth: Influence of the post systems and cements

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ABSTRACT

Background: Endodontically treated teeth with extensive structural damage present higher fragility due to the low amount and worse quality of the reminiscent tissues of the crown.

Materials and Methods: The present *in vitro* study evaluated the effect of different intraradicular retainers and cementation agents on the fracture resistance of devitalized teeth. Incisive teeth (n = 40) of bovine mandibles were used. After preparation of the root canals, they were immersed in polyether, in a polyvinyl chloride cylinder containing acrylic resin, to simulate the periodontal ligament. The specimens were randomly divided into four groups (n = 10), according to the type of retainer (anatomical or main with accessory posts) and resin cement used (conventional resin cement – RelyX ARC or self-adhesive resin cement – RelyX U200). The specimens were stored in distilled water at 37°C and submitted to fracture resistance testing. ANOVA and Tukey's test were applied for data analysis, with significance level set at 5%.

Results: There was no interaction between cement type and intraradicular retainers (P = 0.56) or even between the types of cement used (P = 0.65). However, in the variation of the types of retainers, the group using main with accessory posts presented greater resistance to the fracture than the anatomical post (P = 0.04).

Conclusion: Different cementing agents have no effect on the fracture strength of devitalized teeth, unlike the use of posts, in which the use of accessory post proved more resistant when compared to the anatomical post.

Key Words: Dental cements, dental pins, tooth fractures

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INTRODUCTION

Endodontically treated teeth with extensive structural damage present higher fragility due to the low amount and worse quality of the reminiscent tissues of the crown, which might result in a restorative treatment with biomechanical failures.[1] Strategies have been created to restore such teeth, and among the most common options are cast metal post and core[2] and prefabricated postsystems.[3]

Cast metal post and core have been widely used for more than three decades.[4] Meanwhile, restoration with prefabricated postsystems is a more recent technique that provides an esthetic result to the

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restorative treatment, which is commonly searched by the patients.[5]

Prefabricated postsystems are made up of inorganic carbon, glass, or quartz fibers embedded in an epoxy or methacrylic matrix. Silane is used to promote the adhesion between organic and inorganic compounds of the prefabricated postsystems.[6] According to literature reports,[7] different types of glass are used to produce prefabricated glass fiber posts, such as electric glass, high-resistance or quartz fiber glass, and glass with silica fibers and oxides.

The elastic modulus of the intraradicular posts is an important requisite to consider when restoring a tooth less resistant to fractures, such as the ones endodontically treated. In this scenario, restoration using glass fibers are known to exhibit lower tension when compared to carbon fiber posts when the same load is applied.[8] When the load is applied in different directions, it was shown that the two systems present distinct physical properties and variable elastic modulus. Moreover, glass fiber posts are compatible with BIS-GMA resin,[9] which is present in the cement used to fix the posts into the root canal.

The resin cements used in the restorative treatment with intraradicular posts are classified as follows: conventional (phosphoric acid and adhesive), self-etching (primer), and self-adhesive (direct on the tooth). The use of a three-step cement demands more time when compared to the use of a self-adhesive product.[10] However, when self-adhesive cements are used, no hybrid layer is formed, which might result in a worse clinical performance when compared to other materials.[11]

The purpose of this study was to evaluate the influence of different postsystems and cements on the resistance to fracture of endodontically treated teeth. The null hypothesis is that there is no difference in terms of resistance to fracture of endodontically treated teeth restored with accessory or anatomic glass fiber posts and conventional or self-adhesive cements.

MATERIALS AND METHODS

Specimen preparation and root standardization

Bovine incisors were used in the present *in vitro* study. The research protocol was submitted to the analysis of the Ethics Committee on the Use of Animals-FACID-WYDEN and approved with number 077/14. Teeth with similar length and width and that presented a completely formed and straight root were preselected. The specimens were cleaned and codified using a pencil to mark a code on the vestibular side of the root. Then, they were stored in 0.1% thymol until the day of the experiment.

The final selection of the specimens was made after taking a periapical radiograph of each tooth and confirming that the root canal was straight and did not present any malformation. Moreover, the external and internal diameters of the roots were measured with a pachymeter, and the root diameter was classified as small, medium, or large. After that, the teeth were sectioned at 14 mm from the root apex using diamond discs under refrigeration. Specimens that presented medium external and internal diameters of 5.3–6.32 mm and 1.35–2.24 mm, respectively, were included in the investigation [Figure 1].

Root canal preparation

The specimens were mechanically prepared using #2 and #3 Gates Glidden drills (AR Maillefer-Dentsply Sirona, York, Pennsylvania, USA). During the mechanical instrumentation, the root canal was irrigated with a 2.5% sodium hypochlorite solution (ASFER – São Caetano do Sul, São Paulo, Brazil). Then, the root canal was dried with an absorbent paper, and obturation was performed with a gutta-percha cone of a diameter compatible with the size of the last Gates Glidden drill used. The obturation was performed using the single cone technique with endodontic cement and a 21-mm n° 70 McSpadden (AR Maillefer-Dentsply Sirona, York, Pennsylvania, USA) condenser to condense the gutta-percha cone.

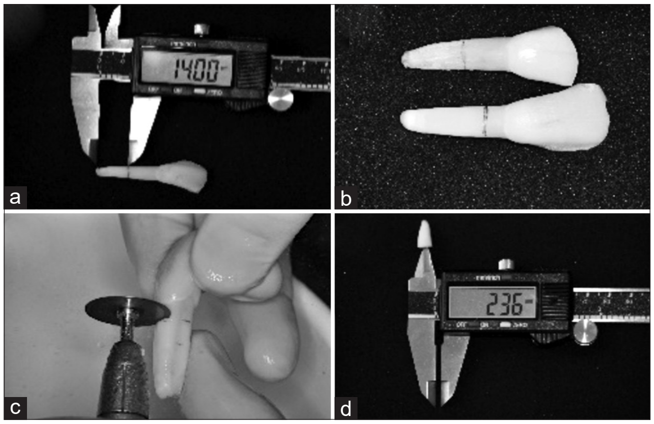

Figure 1: (a) Measurement of teeth using a digital caliper; (b) root markings in 14 and 19 mm; (c) the teeth cut in the marking performed; and (d) measurement of root canal's internal diameter.

Seven days after the obturation, the gutta-percha cone was removed from the root canals using #3 and #4 Largo drills (Peeso CA Maillefer-Dentsply, Sirona, York, Pennsylvania, USA). Each root had 11 mm of obturation removed from the root canal and 3 mm of gutta-percha cone left at the root apical third. After this process, the root canal opening was sealed with zinc oxide cement without eugenol (Coltosol, Coltene, Rio de Janeiro, Brazil). The foramen of the roots was sealed with wax, and the roots were stored in distilled water at room temperature.

Periodontal ligament simulation

Periodontal ligament simulation followed an already described method.[12] The roots were immersed in hot liquid wax (New Wax – TechNEw, Rio de Janeiro, Brazil). Thus, a pellicle of 0.2–0.3 mm of wax was formed on the root length after the wax cooled down. In the sequence, polyvinyl chloride cylinders were filled with acrylic resin (Jet – Clássico Ltda, São Paulo, Brazil), and the roots covered with wax were positioned parallel to the longer axis of the cylinder and then they were immersed into the resin. After resin polymerization, the teeth were removed from the resin and the wax was removed from the roots using a 2-min bath in hot water (55°C) and a scalpel. A polyether was then placed where the roots were before, and the teeth were immersed again into the cylinders in the same position (Impregum F, 3M-ESPE, Seefeld, Germany). This technique allows the polyether to fill the place preshaped by the wax and then a 0.2–0.3-mm layer of material is formed to simulate the periodontal ligament. After these procedures, the specimens were stored for 24 h at 37°C [Figure 2].

Experimental groups

The specimens were randomly assigned to experimental groups according to the type of post and cement used [Figure 3].

Double-conicity glass fiber posts were used in all groups (DC 0.5 White Post – FGM-Joinville, Santa Catarina, Brazil). For Group 1, the posts were anatomically shaped to the root canal using a composite resin (Z100, 3M ESPE, Maplewood, Minnesota, Estados Unidos). To produce the anatomically shaped post, an aqueous lubricant was used in the root canal, and silane was concomitantly applied on the root canal walls. In the sequence, the resin was applied, and the anatomically shaped post was inserted into the root canal to perform partial photopolymerization (5 s). Finally, the post was removed from the root canal, and the final photopolymerization was performed (35 s). For Group 2, one double-conicity glass fiber post was used with three accessory glass fiber posts [Figure 4].

Cementation of the glass fiber posts

RelyX™ ARC and Scotbond Multi-Purpose adhesive (3M – Maplewood, Minnesota, USA) were used for the group of conventional cement. For the RelyX™ U200 (3M – Maplewood, Minnesota, USA), the posts were cemented according to the manufacturer's instruction [Table 1]. A lentulo spiral (Lentulo® Paste Carrier 25 mm CA Maillefer – Dentsply, Ballaigues, Switzerland) was used to allow the cement to fill all the root canal extensions.

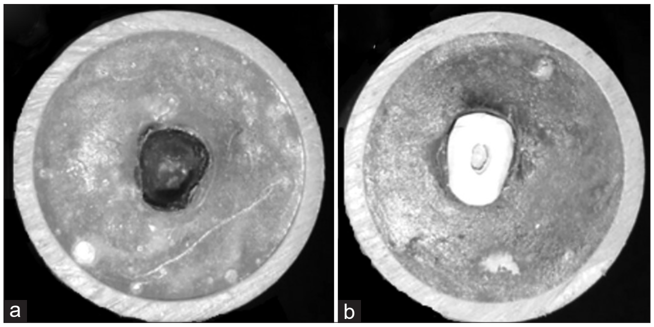

Figure 2: (a) Simulation of the periodontal ligament and (b) root inserted in acrylic resin.

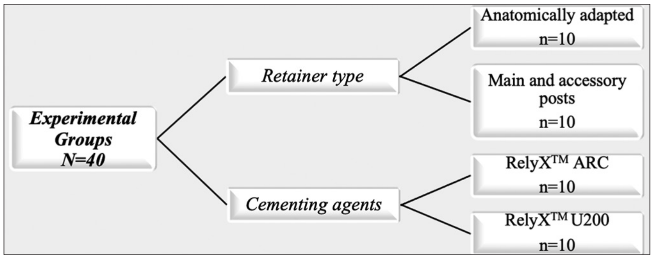

Figure 3: Flowchart of the study groups.

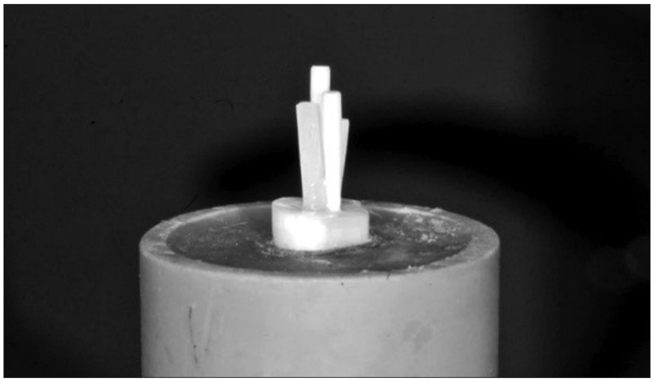

Figure 4: Root with accessory posts.

Table 1: Resin cement tested

Material (manufacturer)	Monomers	Particle size (μm)	Filler content (percentage weight)	Shade
RelyXTM ARC (3M dental products, St Paul, MN, USA)	BIS‑GMA, TEGDMA	1.5	67.5	A1
RelyXTM U200 (3M dental products, St Paul, MN, USA)	Bifunctional metacrilatos	12.5	70	A2

Core confection

After the cementation of the posts, the crowns of the teeth were prepared (chamfer finish line) and reconstructed with a dual polymerization composite resin (Bis‑Core – BISCO, Schaumburg, Illinois, U.S.A.). After the polymerization of the resin, the core was prepared with diamond drills under refrigeration. The crowns were duplicated with a silicon of condensation modeling material (Speedex – VIGODENT, Rio de Janeiro, Brazil) to obtain a mold of the core [Figure 5]. For each specimen, a Ni‑Cr copping was produced and adapted to the core constructed with the composite resin. The copping was passively adapted on the cores in order to receive the compression load on the same point of the structure for every specimen.

Test of resistance to fracture

The specimens were mounted on a universal testing machine (Shimadzu AG‑IS; Shimadzu Corp, Nakagyo‑ku, Japan), adapted to a metallic base forming a 45° angle with the base of the machine. The load (100 kgf) was directed toward the lingual face of each specimen at an angle of 135° with the root's long axis. A speed of 1 mm/min was set, and the specimen continued to receive the load until its fracture. The rupture force was registered by the software of the universal assay machine (Trapezium Lite X, Shimadzu Corp, Nakagyo‑ku, Japan) [Figure 6].

Data analysis

The normal distribution of error was evaluated by Shapiro–Wilk's test. The groups anatomic post ($P = 0.141$), accessory post ($P = 0.194$), and self‑adhesive cement ($P = 0.405$) all exhibited normal distribution, whereas the same was not observed in the conventional cement group ($P = 0.037$). Because the majority of the groups presented normal distribution of errors, and a tendency to normality was observed in all the data using histogram, parametric tests were used to analyze the results.

Thus, two‑way ANOVA was performed, with type of posts being one factor in two levels (anatomic and accessory) and type of cement being the other factor in two levels (conventional or self‑adhesive). Tukey's multiple comparisons test was performed, and the homogeneity of the variances was evaluated using Levine's test (0.101).

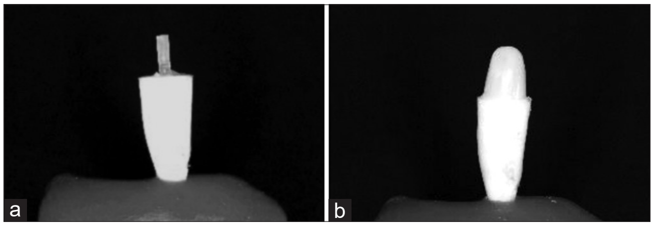

Figure 5: Construction of the fill core. (a) Root with cemented fiberglass pin and (b) root with the filling core made.

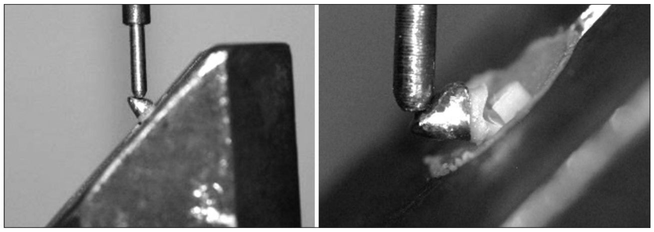

Figure 6: Fracture strength test.

The data were analyzed using the software Statistical Package for the Social Sciences (SPSS for Windows, version 21.0, SPSS Inc., Chicago, IL, USA) with the significance level set at 5%.

RESULTS

No association was found between the type of post and the cement used ($P = 0.566$). The group in which accessory posts were used presented higher resistance to fracture (459 N) than the one in which anatomic post was employed (437.5 N, $P = 0.04$), with fracture type II.[13]

Regarding the type of cement, no difference was observed in the force needed to cause fracture when comparing the groups studied ($P = 0.653$). Both types of materials supported over than 400 N of load, as shown in Figure 7.

DISCUSSION

Due to the extensive loss of organic tissue and mineral structure, endodontically treated teeth are more susceptible to fracture than vital teeth. In most of the cases, there is the need to use intraradicular posts in the restorative treatment of nonvital teeth to promote a homogeneous distribution of the masticatory loads.[14]

In our study, we used endodontically treated bovine incisors in which intraradicular posts were used to simulate *in vitro* a clinical condition of a restorative treatment of teeth with loss of structure. Bovine teeth were chosen because they present histological and anatomical similarities with the human teeth. Moreover, they are more easily obtained, are free of dental caries, and present a homogeneous composition when compared to human teeth.[15]

Our *in vitro* study demonstrated that different types of cement do not influence the resistance to the fracture of endodontically treated teeth. However, heavier loads are needed to fracture endodontically treated teeth when accessory posts are used compared to anatomic posts in the restorative treatment.

The specimens used in our investigation were prepared according to a widely used method[16,17] and were also submitted to an experimental condition that simulates the occlusal contact. Thus, the specimens were subjected to a load applied on the palatal side of the crown, which simulates the contact observed between maxillary and mandibular incisors.

The periodontal ligament was simulated with the use of a molding material. Such simulation guarantees that the resilience of the resin will not interfere with the tests because it concentrates the stress at only one point. Thus, the simulated periodontal ligament allowed a better distribution of the load on the tooth root, which was a tentative to reproduce a situation of fracture in the oral cavity.[18]

The use of glass fiber posts to restore endodontically treated teeth is effective once such type of material presents an elastic modulus similar to the one of the dentine, which makes it less susceptible to fracture.[19] Figure 8, for instance, shows that teeth restored with accessory posts are more resistant to fracture than anatomically shaped posts. This result is explained because the resin present in the anatomic posts changes its elastic modulus, which explains why such material was more susceptible to fracture.[20]

Our findings regarding accessory posts differ from what has been reported in the literature when comparable methods were used.[21,22] However, the already published studies used human teeth, which are similar to bovine teeth but present singularities in terms of their anatomy. The number of intraradicular posts might also have influenced our results because we used three posts and the literature shows investigations in which only two posts are used.

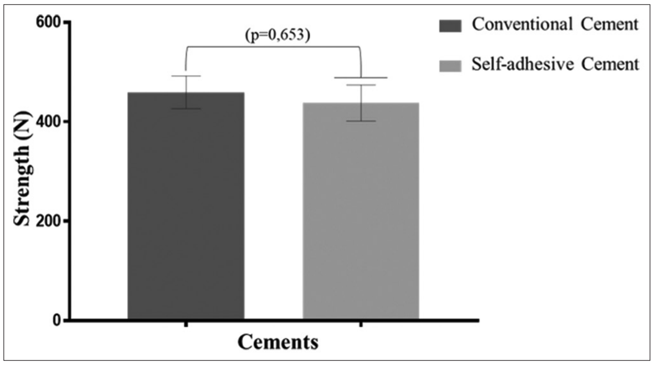

Figure 7: Required strength for fracture of restored teeth with conventional and self-adhesive cements.

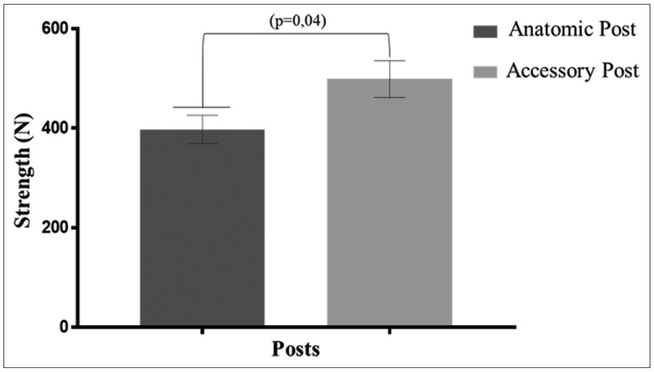

Figure 8: Required strength for fracture of restored teeth with anatomical and accessory posts.

Conventional and resinous cements were used in our study. An important aspect of resinous cement used to restore endodontically treated teeth is the amount of fillers, which is related to the fluidity and adaptation of the cement to the root canal walls. As it is already known, the C factor of the root canal is greater than one of the cavities in the tooth crown. Thus, if a thick layer of cement is formed, a higher amount of monomer is retained, which results in higher polymerization contraction.[23]

It is known that both conventional and self-adhesive cements present comparable amount of inorganic fillers.[24] In our study, both types of cements were used with anatomic or accessory posts, which allowed a thin layer of cement to be formed. This aspect of our study explains why we did not find differences in the resistance to fracture when comparing the performance of the two types of cements tested.

The silane used promotes higher adhesive union between the intraradicular post and the cement, regardless of being conventionally conditioned or self-adhesive.[25] In our study, silane was used as it is recommended by the manufacturer of the conventional cement (RelyX ARC) and intraradicular posts. Regarding the use of silane, it has been proposed that when this union agent is used, it creases the retention of glass fiber posts.[26] However, such a concept is still unclear once other investigations have shown the contrary.[27]

The literature supports the use of glass fiber posts with the aim of reinforcing the remaining dental structures. The use of glass fiber posts provides superior or similar fracture resistance[28-30] to other restorative techniques. However, an important use is offered by the fracture type because the teeths can be restored, thus preserving the dental structure. Despite the need of extensive studies, our findings suggest that the final clinical decision about the restorative technique to be used in endodontically treated teeth relies on the analysis of the characteristics of the restorative as well as on the characteristics of the patient, such as occlusion, masticatory force, alveolar insertion level, and presence of parafunctional habits.

Thus, our investigation presented the common limitations of tests performed with bovine teeth, such as specimen size, static compression force, and fixed angulation. Although we tried to simulate as closely as possible what happens in the oral cavity, even simulating the periodontal ligament, we cannot entirely pass on our *in vitro* findings to the clinical practice.

CONCLUSION

Under the limitations of our study, it was possible to evaluate that conventional or self-adhesive resinous cement do not influence the resistance to fracture of endodontically treated teeth. However, the use of accessory posts increased the resistance to fracture when compared to the use of anatomically shaped posts.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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