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EVALUATION OF FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH RESTORED WITH PREFABRICATED POSTS AND COMPOSITES WITH VARYING QUANTITIES OF REMAINING CORONAL TOOTH STRUCTURE

AVALIAÇÃO DA RESISTÊNCIA À FRATURA DE DENTES TRATADOS ENDODONTICAMENTE RESTAURADOS COM PINOS PRÉ-FABRICADOS E RESINAS COMPOSTAS VARIANDO O REMANESCENTE DENTÁRIO CORONAL

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ABSTRACT

Objectives: The aim of this study was to evaluate the influence of remaining coronal tooth structure on endodontically treated teeth restored with prefabricated posts and two different composites for core build-up: dual-cured resin (Enforce Core) and light-cured resin (Z-250). Methods: Fourty freshly extracted canines were endodontically treated and divided into four groups: Group I - teeth with 3mm remaining coronal structure, restored with Enforce Core; Group II – teeth with 3mm remaining coronal structure, restored with Z-250; Group III – teeth with no remaining coronal structure, restored with Enforce; Group IV – teeth with no remaining coronal structure, restored with Z-250. After restoration, the teeth were embedded in acrylic resin and the fracture resistance was measured on a universal testing machine at 45 degrees to the long axis of the tooth until failure. Results: Data were analyzed by two-way analysis of variance, which showed significant differences between groups (p=0.00). The Tukey test did not show significant differences between specimens with and without remaining coronal structure. Conversely, significant difference was observed between groups with different core build-up. The highest values of fracture resistance were found in the group restored with light-cured resin. Significance: The remaining coronal tooth structure did not influence the resistance of endodontically treated teeth; however, the change of core build-up was able to modify this resistence.
Uniterms: Post and core technique; Composite resins; Fracture strength.

RESUMO

O objetivo desta pesquisa foi avaliar a influência do remanescente dentário coronal de dentes tratados endodonticamente, restaurados com pinos pré-fabricados e duas resinas como núcleos de preenchimento, uma de presa dual (Enforce Core) e outra fotopolimerizável (Z-250). Foram utilizados 40 caninos superiores humanos extraídos, divididos em quatro grupos de 10 espécimes: Grupo l – com remanescente dentário coronal de 3mm e restaurados com Enforce Core; Grupo ll – com remanescente dentário coronal de 3mm e restaurado com Z-250; Grupo III – sem remanescente dentário coronal e restaurado com Enforce Core; Grupo IV – sem remanescente dentário coronal e restaurado com Z-250. Após restaurados, os dentes foram levados a uma Máquina de Ensaio Universal e submetidos a uma força de compressão à 45º até que ocorresse fratura da restauração. A análise dos resultados (ANOVA, p>0,05) mostrou não haver diferença estatisticamente significativa entre os dentes com e sem remanescente dentário coronal. Com relação ao material utilizado para o preenchimento coronário, constatou-se diferença significativa, sendo que os valores mais elevados de resistência à fratura foram encontrados no grupo restaurado com a resina fotopolimerizável.
Unitermos: Pinos de retenção dentária; Resinas compostas; Resistência a fratura.

INTRODUCTION

Restoration of endodontically treated teeth is an important aspect of dental practice that involves a range of treatment options of variable complexity. Nowadays, cast post-core restorations are the option of choice for endodontically treated teeth[6,19,20,24], but this kind of restoration, according to many authors, makes teeth fragile and more susceptible to fracture[9,11,12,19,26]

Prefabricated post systems have recently become increasingly popular because they can provide satisfactory results [2,4,5,17,18].

According to Cohen, et al.[14] the association of prefabricated intraradicular posts, light-, chemical- and dual-cured resins, and dentin primers used for core build-up allows higher core preservation as well as adequate resistance.

The use of prefabricated posts has brought special attention to core materials. This core build-up was designed to be made of composite, yet more specific materials have been developed[15].

It has been shown that composites have adequate resistance to compressive strength and fracture[3,5,12,14]. With recent improvements in the bonding of composite resins to dentin, true internal support is now available. In 1998, Zalkind and Hockman[30] recommended the use of composite as core material only when adequate coronal dentin structure is available.

The purpose of this article is to compare the resistance of endodontically treated teeth with variable amounts of coronal structure restored with prefabricated posts and different core build-up materials. The null hypotheses are as follows: (1) there is no significant difference in the effect of different remaining coronal structures on the fracture resistance; and (2) there is no significant difference between the types of core build-up materials.

MATERIAL AND METHODS

Fourty recently extracted maxillary canines with similar root sizes were selected from approximately 93 maxillary canines extracted for periodontal reasons. The teeth were stored in distilled water at 37ºC. The inclusion criterion was teeth with root length between 16mm and 19mm.

Each canal was prepared within 1mm of the radiographic apex. The root canal of each tooth was instrumented with a conventional step-back technique to an International Standardization Organization (ISO) file #35 at the apical constriction. Each canal was obturated by lateral condensation of gutta-percha points against an ISO 35 primary gutta-percha cone and Endométhasone Ivory (Specialites Septodont - Fran). Post preparations were made with a bur to remove gutta-percha at up to 11mm from the cementoenamel junction (CEJ) from each filled canal. After selection, the teeth were randomly divided in four groups with 10 teeth each.

Group I – teeth with 3mm remaining coronal tooth structure, restored with prefabricated posts and dual-cured resin (Enforce Core – Dentsply Ind. E Com. Petropolis – RJ - Brasil);

Group II – teeth with 3mm remaining coronal tooth structure, restored with prefabricated posts and light-cured composite (Z-250 – 3M Dental Products Division St. Paul, Minisota, USA);

Group III – teeth with no remaining coronal tooth structure, restored with prefabricated posts and dual-cured resin (Enforce Core - Dentsply Ind. E Com. Petropolis – RJ - Brasil);

Group IV – teeth with no remaining coronal tooth structure, restored with light-cured composite (Z-250 - 3M Dental Products Division St. Paul, Minisota, USA).

In Groups I and II, the coronal structure was reduced to a flat plane at a height of 3.0mm incisal to the CEJ at the proximal, buccal and lingual aspects. In groups III and IV, the coronal portions of teeth were removed at the CEJ perpendicular to the long axes of teeth.

Then, 15-mm #308s posts were selected (Unimetric intraradicular abutment system – Dentsply Ind. e Com., Petrópolis, RJ, Brazil). Prefabricated posts were cemented with zinc phosphate cement. The cement mix was prepared according to the manufacturer's instructions and introduced into each root canal with a lentulo spiral drill (Maillefer instruments) on a low-speed handpiece. Cement was placed on the post and seated under finger pressure. During cementation, the pressure was released and the post was gently reseated and held in place until final setting of the cement. Excess cement was removed, and each specimen was returned to storage in distilled water.

All cores were fabricated in a standardized manner using a core-forming matrix of polymethylmethacrylate resin (Figure 1).

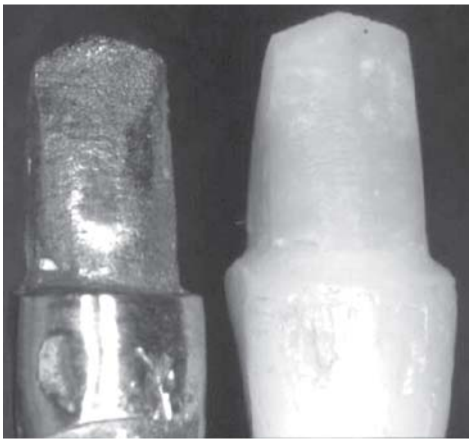
In the groups restored with Z-250, the coronal structure was etched with 37% phosphoric acid and a bonding agent placed on the dentin as recommended by the manufacturer (Primer-Bond 2.1, Dentsply Ind. Com, Petropolis, Brazil). The composite was placed using the incremental technique.

In the groups restored with Enforce Core dual-cured resin, after dentin treatment as recommended by the manufacturer, the composite was placed into the plastic molds, positioned over the core and light-cured for 20 seconds. Excess was removed and the composite was light-cured for 20 seconds on each side.

After reconstruction, all prepared specimens were embedded in acrylic resin (Clássico – Artigos Odontológicos S/A – Brazil) poured into molds.

Fracture resistance was evaluated in a universal testing machine (Dinamômetros KRATOS Ltda., São Paulo, Brazil) with load at a 135º angle to the root long axis (45° to the horizontal plane), simulating class I occlusion relationship of the antagonist tooth (Figure 2). Number 1 load cell capacity, #2 scale and 0.5mm/min crosshead speed were used.

A special device (Figure 3), named "Aranha", adapted to the lower part of the universal testing machine, was developed at an angle of 45° to simulate the natural occlusal forces on canines during fracture tests. On the upper part of the machine, an adapted active tip positioned on the palatal surface of the core was responsible for the compressive strength in that region. When tests were finished, values were recorded and organized in tables for future statistical analysis (two-way ANOVA and Tukey test).



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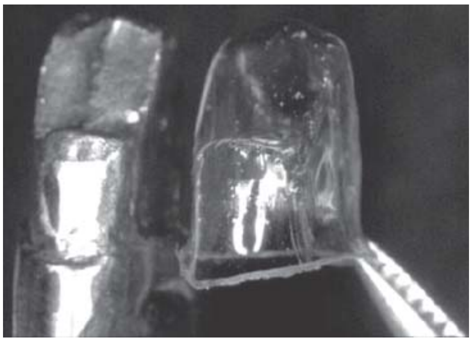

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FIGURE 1- Construction of acetate molds
a) cast pattern obtained from core molding constructed in a pilot study;
b) vacuum molds obtained from metal die.

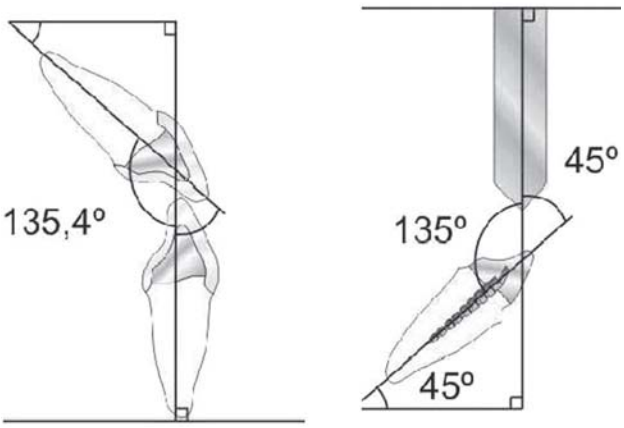
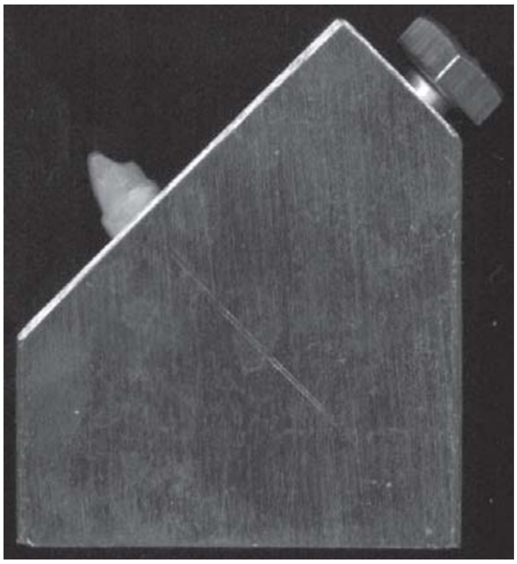


FIGURE 2- Scheme of load application at an angle of 45°
a) 135.4° angle formed by contact between the maxillary and mandibular central incisors in a Class I occlusal relationship;
b) schematic representation of load at an angle of 135° to the root long axis (45° to the horizontal plane).

RESULTS

Mean and standard deviation values for each group are shown in Table 1.

Data were statistically analyzed by the two-way ANOVA



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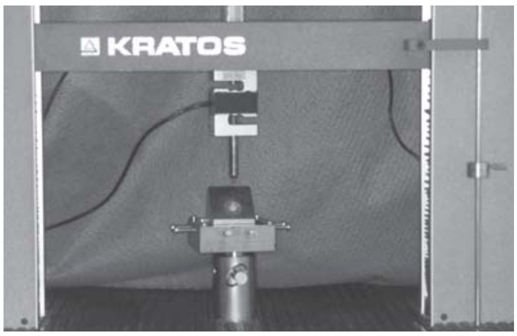

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FIGURE 3- Device used for fixation and positioning of specimens subjected to fracture resistance tests in a universal testing machine
a) 45° device;
b) load being applied on the palatal aspect;
c) KRATOS machine.

(p<0.05) (Table 2). Significant statistical difference was observed between groups. Comparison of mean values was performed by the Tukey test, p< 0.05 (Table 3).

No significant statistical difference was detected between groups with and without remaining coronal tooth structure. Conversely, significant difference was found beetwen the different core build-up materials.

DISCUSSION

The results found in this study showed no statistical difference in the fracture resistance of endodontically treated teeth with or without remaining coronal tooth structures (Groups: I – 47.19 Kgf; II – 57.90 Kgf; III – 48.00 Kgf; IV – 56.91 Kgf). Notwithstanding, evidences revealed that the type of resin may influence the fracture resistance, since composite Z-250 proved to be significantly more resistant than Enforce Core resin (17.1%).

These results are in accordance with Sorensen and Engelman[28], who observed no significant difference when investigating the resistance of endodontically treated teeth with and without remaining coronal structures.

Although the two-way analysis of variance showed no significant statistical difference between Groups I and II, the groups restored with Z-250 showed better performance (57.40Kgf), which was significantly higher than the mean recorded for groups restored with Enforce Core resin (47.63 Kgf).

It is known that one of the critical factors concerning the use of light-cured composite is the adhesive interface, which can be impaired due to the stress generated by polymerization shrinkage of the material[10]. In order to minimize these effects, the incremental insertion technique was used.

The single increment insertion technique, in spite of reducing the time required for clinical work, demands greater amount of material, and the risk of formation of bubbles and

TABLE 1- Individual, mean and standard deviation values for each experimental condition (in Kgf)

Specimen	GROUP I Enforce Core with remaining structure	GROUP II Z-250 with remaining structure	GROUP III Enforce Core without structure	GROUP IV Z-250 without structure
1	38.50	65.40	54.50	45.30
2	53.70	50.70	53.60	58.15
3	55.25	37.70	45.10	36.60
4	34.10	39.40	52.80	66.70
5	54.05	72.45	40.30	58.70
6	34.20	48.15	51.80	56.60
7	40.65	58.40	33.85	49.45
8	56.70	81.00	37.05	63.20
9	45.50	78.25	63.25	55.35
10	59.30	47.50	48.45	79.00
Mean value	47.19	57.90	48.00	56.91
Standard deviation	9.73	15.71	9.02	11.71

TABLE 2- Two-way analysis of variance of the fracture resistance values

Effect	df Effect	MS Effect	df Effect	MS Effect	F	p
Material	1*	954.0406*	36*	139.9787*	6.815613*	.013089*
Remaining	1	.0331	36	139.9787	.000236	.987823
Interaction	1	8.6956	36	139.9787	.062121	.804592

*statistically significant (p<0.05)

TABLE 3- Individual comparisons - Tukey test

MATERIAL	mean value	1	2
Enforce	47.632	x	
Z-250	57.400		x

x significant statistical difference (p<0.05) void spaces inside the resin should always be considered, as shown in the study of Mentink, et al.[27]. This fact was verified in the present study, namely by observation of presence of bubbles inside the Enforce Core resin. These bubbles were almost always found next to the fracture line, suggesting that their presence may constitute one of the factors responsible for the lower fracture resistance values for the Encore resin.

The chemical composition is one of the most important factors influencing resistance. Different behaviors may be expected depending on the individual chemical formulations of resins and adhesive systems.

The inefficiency of the post to reinforce weakened tooth structure may be explained mechanically[26]. As load is applied on the palatal tooth surface, the support used is the buccal bone crest of the alveolar ridge[21,22]. That generates concentration of compressive stresses on the buccal side of the tooth and, opposed to that, traction forces are developed on the palatal aspect[21]. These opposing forces meet and nullify one another at the longitudinal center of the tooth, exactly where the root post is cemented. The closer to the tooth surface, the greater the magnitude of these stresses, which demonstrates the need of peripheral rather than central tooth reinforcement[22]. When load applied on the tooth exceeds the proportional limits, a crack or fracture may start, most likely on the palatal aspect, where enamel rods are under traction forces. This fracture line may propagate transversally from the place where load is applied to the support over the bone crest[26].

This pattern of fracture may be modified when a post is cemented into the root canal. When the fracture line reaches the region where the post is cemented, the post dissipates part of the stresses through its own structure, guiding the crack to the longitudinal direction of the root. In addition, Cailleteau, Riggel and Akin[7] showed, in 1992, the existence of variation in the concentration of stresses around a prefabricated post, as well as a higher possibility of root fracture. This pattern of fracture was not found in the present study, as the vast majority of fractures were found on the coronal surface and were likely to be repaired, which is in accordance with Bex, et al.[6], who stressed that composite core may be repaired after failure, but that does not happen to rigid materials that, in general, lead to root fracture and eventual tooth loss.

The pattern of fracture might be different under real conditions, because the load applied was continuous and exceeded that commonly exerted during mastication[25]. Nevertheless, this study is correlated with the work carried out by Isidor, Brondum and Ravnholt[23], in which intermittent low intensity load was used, in similar conditions to those of the oral cavity. Observation of the fracture pattern showed a higher tendency to core build-up fracture in the groups without remaining coronal structure; on the other hand, in the groups with remaining tooth structure, longitudinal fracture was recorded, yet with probability of repair.

Analysis of the fracture mode of specimens in Group I (Z-250) showed that 70% of the specimens suffered fracture of the remaining coronal structure, which yet were likely to be repaired. In agreement with Verluis, Tantbirojn and Douglas[29] that may be attributable to the use of the incremental technique, since it might increase tooth deformation leading to tooth/composite deformation and higher stress levels in restorations with adequate adhesion.

Furthermore, according to Abdalla and Alhaydainy[1], the better result obtained with the light-cured resin Z-250 is probably related to its large amount of fillers.

The present results are in agreement with Candido[8], who recorded that the Z-250 resin, in comparison with indirect resins Solidex and Artglass, presented the highest mean value of surface microhardness. The author suggested clinical applicability of Z-250 due to its fine properties, such as easy handling and shorter work time.

In the present study, 47.5% of failures involved the core build-up, whereas 32.5% involved both repairable core build-up/remaining coronal structure. These results are also in concordance with those reached by Cohen, et al.[13], who observed that 79% of failures affected the core build-up.

Little is known about the influence of the quantity of remaining coronal structure on the fracture resistance of endodonticallly treated teeth. Although full crowns were not used for complete restoration of teeth, the authors of this article consider the present results as relevant, since resistance was tested under critical conditions, as Cohen et al.[16] had already concluded, because satisfactory results were achieved even under these circumstances, and the load necessary for causing tooth/restoration failure was much superior to the mean resistance that canines bear under maximum bite load (35Kgf) found in the study performed by Lyons[25]. Further studies should be carried out for total elucidation of the influence of remaining tooth structure and core build-up when covered with a crown.

The most important fact to be considered is that the successful outcome of the reconstruction of endodontically treated teeth is much more dependent on the remaining tooth structure and its implantation than on the right choice of the intraradicular retention system.

CONCLUSIONS

From analysis of the results, the following can be concluded:

5.1 no significant statistical difference was found in the fracture resistance between teeth with or without remaining coronal structure;

5.2 significant difference was observed between the resins used in the experiment;

5.3 groups restored with Z-250 were significantly more resistant than those restored with Enforce Core.

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