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Fracture strength of teeth with access cavity preparation with operating microscope or on buccal surfaces

Resistência à fratura de dentes submetidos a cavidade de acesso endodôntico com microscópio operatório ou nas faces vestibulares

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ABSTRACT

Objective: The present study assessed the fracture strength of teeth subjected to endodontic access cavity preparation on buccal surfaces, or with the aid of operating microscopy when compared to the conventional technique. **Material and methods:** Sixty mandibular incisors were split into four groups (n=15): conventional access cavity preparation (CCP); conservative (C); buccal surface (BS); and control. The canals were prepared and filled and the cavities were restored. A static compressive strength test was conducted until crown fracture. The force data were compiled and assessed statistically. Kolmogorov-Smirnov and Shapiro-Wilk tests were performed to assess normality, Levene's test to assess variance homogeneity, the one-way ANOVA to compare fracture strength in the assessed groups. Tukey's HSD test was used to determine whether the differences in the means were significant between the groups. **Results:** The experimental groups did not show any statistically significant differences in mean fracture strength (CCP = 585.65 N±107.64 N)(BS = 530.52 N±129.35 N) (C = 517.83 N±114.68 N). **Conclusion:** Therefore, the selection of surface or size of access cavity proposed did not influence the fracture strength of mandibular incisors when compared to conventional cavity preparation.

KEYWORDS

Dental pulp cavity; Dental stress analysis; Root canal therapy.

RESUMO

Objetivo: O presente estudo avaliou a resistência à fratura compressiva de dentes submetidos as cavidades de acesso endodôntico nas faces vestibulares, ou com o auxílio de microscópio operatório quando comparados à técnica convencional. **Material e métodos:** Sessenta incisivos inferiores foram divididos em quarto grupos (n=15): cavidade de acesso convencional (CAC); conservadora (C); na face vestibular (FV); e controle. Os canais foram preparados e obturados, e as cavidades restauradas. O teste estático de resistência compressiva foi procedido até a fratura coronária. Os dados de força foram compilados e analisados estatisticamente. Os testes de Kolmogorov-Smirnov e Shapiro-Wilk foram realizados com o intuito de avaliar a normalidade. O teste de Levene para verificar a homogeneidade de variâncias. O teste de análise de variância a um critério (ANOVA) para comparar a resistência à fratura entre os grupos. O teste de Tukey HSD foi realizado para determinar se as diferenças entre as médias dos grupos apresentava significância. **Resultados:** Os grupos experimentais não apresentaram diferenças estatisticamente significantes com relação a média de resistência à fratura. (CAC = 585.65 N±107.64 N)(FV = 530.52 N±129.35 N) (C = 517.83 N±114.68 N). **Conclusão:** Portanto, a variação da face ou do tamanho da cavidade de acesso endodôntico não exerceram influência na resistência à fratura de incisivos inferiores quando comparados a tradicional cavidade de acesso endodôntico.

PALAVRAS-CHAVE

Cavidade pulpar; Endodontia; Fratura dos dentes.

INTRODUCTION

The possibility of straight and direct access to root canal content is one of the principles of endodontic access cavity preparation [1,2]. In the case of mandibular incisors, wear should occur on the buccal or incisal surface [3]. For the sake of aesthetics, the buccal surface is preserved and the lingual surface is then chosen.

Knowledge of the anatomy guides all steps in endodontic treatment. Thus, with the advent of microtomography [4,5], along with the popularization of clinical microscopes, there have been a broad array of questions about the endodontic procedures performed so far [6,7]. Magnification has allowed for less invasive and more controlled procedures [8], as observed in access cavity preparation, known as conservative access cavity preparation.

Conservative access cavity preparation reduces dentinal removal, thereby minimizing the risk of fractures. However, root canal cleaning and shaping quality may be compromised [9]. The extent to which the wear performed in access cavity preparation interferes with mechanical strength is still riven by controversy [10]. Therefore, some parameters of the conservative access cavity need clarifications. The present study assessed the fracture strength of teeth subjected to endodontic access cavity preparation on buccal surfaces, or with the aid of operating microscopy when compared to the conventional technique.

MATERIAL AND METHODS

After approval by the local Research Ethics Committee (process no. 1.787.993), 60 human mandibular incisors were chosen according to the following criteria: straight single roots (with single canals) measuring at least 12mm in length, absence of cracks, carious lesions, restorations, fractures, prosthetic crowns, or pathological wear (abrasion/attrition/erosion), detected by transillumination, light microscopy, and periapical radiographs.

Tooth preparation

The teeth were randomly classified into four groups with 15 specimens. In the conventional cavity preparation (CCP) group, the access cavity was prepared in a conventional fashion, i.e., on the lingual surface at two millimetres from the cingulum to the incisal edge. Trepanation was performed with round-ended tapered diamond burs (1011 – KG Sorensen, São Paulo, Brazil), and the cavity was then abraded into a triangular shape, with the base oriented towards the incisal edge. The lingual dentinal deposition was abraded with diamond bur #3080 (Figure 1A). In the buccal surface (BS) group, the access cavity was prepared as in the CCP group, but on the buccal surface (Figure 1B). The access cavity in the conservative (C) group was prepared with a clinical microscope, exposing the coronal chamber wide enough for insertion of a WaveOne Gold Primary (Dentsply Indústria e Comércio Ltda, Rio de Janeiro, Brazil) reciprocating instrument (Figure 1C). The control group was not subjected to any intervention (Figure 1D).

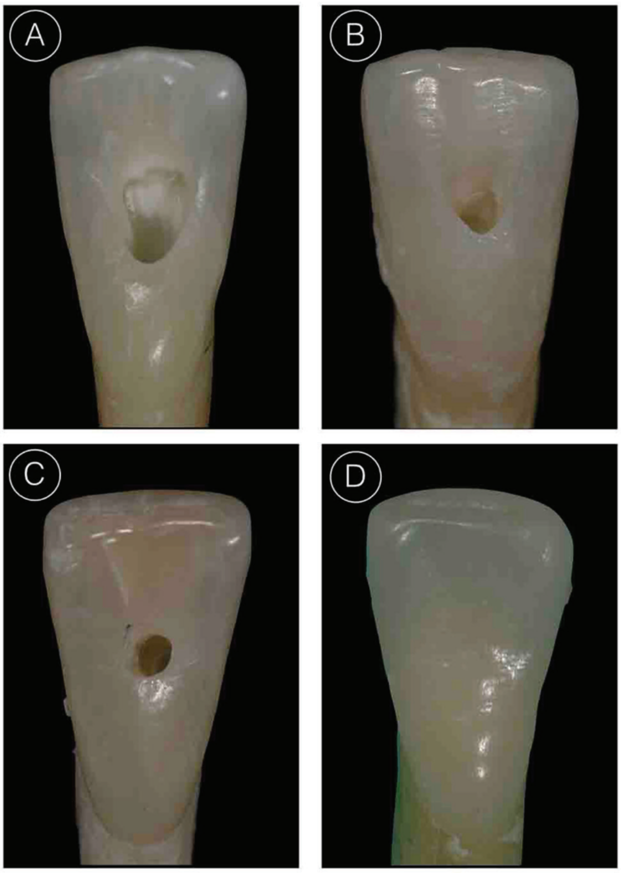

Figure 1 - (A) Conventional cavity access preparation. (B) Cavity access preparation on the buccal surface. (C) Conservative cavity access preparation with the aid of an operating microscope. (D) No intervention - control.

The coronal chamber of each tooth was irrigated with ten milliliters of 1% sodium hypochlorite (NaOCl). The working length was set as one millimeter short of the apical foramen and was defined visually using a K #10 file (Dentsply Indústria e Comércio Ltda, Rio de Janeiro, Brazil).

The glide path was obtained with K #10 and #15 files and later prepared with WaveOne Gold Primary (#25.07) files. Twenty milliliters of 1% NaOCl was used for each canal. In the end, three millimeters of 17% EDTA was used and left in the canals for three minutes. The canals were re-irrigated with ten milliliters of NaOCl and aspirated with flexible cannulas and dried with two absorbent paper points (#30).

The canals were filled with thermoplasticized gutta-percha and zinc oxide cement and eugenol. After radiographic confirmation of filling quality, the obturations were sectioned two millimeters below the cementoenamel junction on the buccal surface. The coronal crown was cleaned with cotton pellets saturated with 70% ethanol. The cleaning was performed until all the root canal sealer on the dentin was removed. Before bonding procedures, low-speed burs (nº 2) were applied with slight pressure against the dentinal walls to remove most superficial dentin. All teeth were irrigated with 5mm of physiologic solution and then restored with composite resin using the incremental technique. After the restoration procedure, to simulate the periodontal ligament, roots have to be covered with twice thick layers of a polyether adhesive, as its width and modulus of elasticity are similar to those natural periodontal membranes [11-13].

Polyvinyl chloride (PVC) cylinders measuring two centimeters in diameter were placed on a bench. Each cylinder was filled up with acrylic resin. The specimens were centrally placed in the PVC cylinders containing the resin, and each specimen was placed at two millimeters from the root (below the cementoenamel junction, in the apical direction) exposed, i.e., without being covered by the resin. After the resin was totally polymerized, the set was kept in a medium with 100% humidity at room temperature for 48 hours for rehydration of the samples prior to the mechanical assay.

Static compressive fracture test

The set consisting of the tooth covered with acrylic resin and the PVC cylinder was coupled to a mechanical testing device (EMIC DL 2000; Instron Universal Testing Machine). Each specimen was placed in such a way that the load was applied to the long axis of the tooth (positioned perpendicularly to the ground). A 500 kg round-ended load cell was used to apply a continuous compressive force on the incisal edge at a controlled speed (1 mm/min) until fracture of the specimen. The load needed for the fracture was recorded in Newtons (N) in a specific table.

Statistical analyses

The preliminary statistical tests were performed to assess Kolmogorov-Smirnov and Shapiro-Wilk normality, and Levene's test was used to assess variance homogeneity. The one-way analysis of variance (ANOVA) was used to compare fracture strength in the assessed groups. Finally, Tukey's HSD test was used to determine whether the differences in the means were significant between the groups. All tests were performed using the SPSS Statistics 23 software (IBM, New York, USA) at a 5% significance level.

RESULTS

The BS and C groups revealed significantly lower fracture strength means when compared to the control group *($P > 0.05$)*. However, there was no difference when the three groups were compared (Table 1 and Figure 2).

Table 1 - Fracture strength (mean and standard deviation) (N) according to the type of access cavity preparation

Fracture strength (N)							
Conservative (C)		Conventional (CCP)		Buccal (BS)		Control	
517.83	±114.68[b]	585.65	±107.64[ab]	530.52	±129.35[b]	719.52	±177.59[a]

The same letters indicate lack of statistically significant differences *(P > 0.05)*.

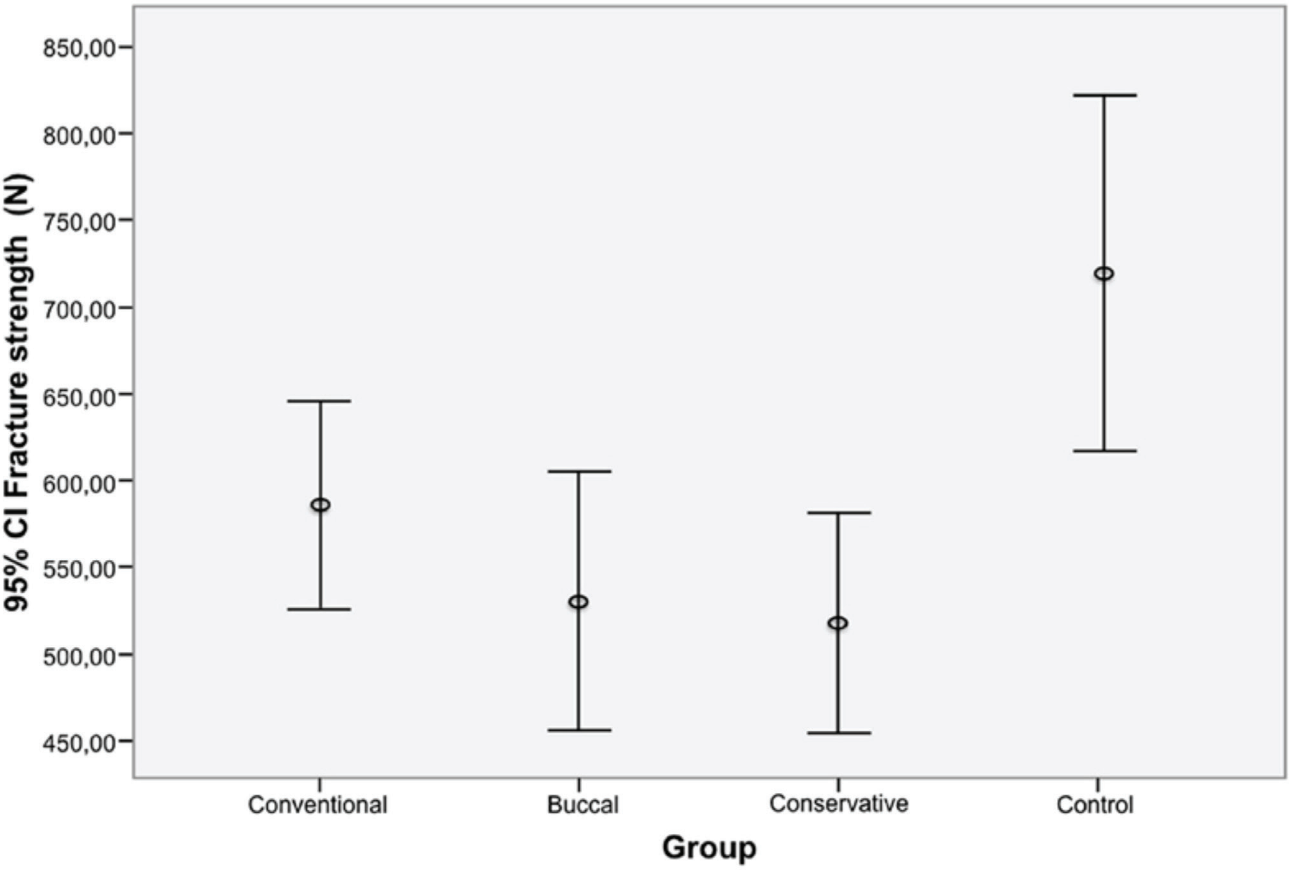

Table 2 - Comparison of mean fracture strength (N) according to the type of access cavity preparation

DISCUSSION

Some goals are traditionally associated with access cavity preparation, such as direct access to the root canal, preservation of the pulp chamber floor, and total removal of the pulp chamber roof, among others [14]. Total removal or partial preservation of the roof has recently fueled controversy in the scientific community [9,15,16]. Total removal of the roof during cavity access preparation allows for visual identification of the desired structures such as floor, size limits of the chamber and, especially, the entrance into the root canals. In cases of pronounced dentin deposition in the chamber walls or within the root canals, even after total removal of the chamber roof, identification of root canals could be a challenge even to experienced clinicians [2]. Roof removal allows clearing away the organic content from areas of retention (e.g., pulp horns), reducing the availability of substrate to those bacteria that remain after endodontic treatment and also minimizing possible darkening of the crown and interference with the restoration/rehabilitation of the tooth crown [15,16].

With the advent of operating microscopy, several procedures and steps of endodontic treatment have been reexamined. The microscope allows magnifying images and obtaining a better illumination than do light reflectors [17]. Bearing in mind the paradigms of the search for minimally invasive dentistry, cavity access preparation has gone through a conceptual change. Currently, some authors and clinicians advocate reducing the size of cavity accesses for the preservation of the structure, with a consequent increase in fracture strength of endodontically treated teeth [9,16]. When conservative cavity access preparation is chosen, the determination of how small the access can be should evaluate if it is possible to eliminate unnecessary stress on the rotary instruments, recognize and access directly all of the root canals and thereby avoid unnecessary increased treatment time [18]. The correct endodontic cavity access should allow the instrumentation without any coronary interference, allowing an accurate shaping, and consequently, potentialize the cleaning of the root canal system. Subsequent steps should be favored, as well as the obturation, the chamber cleaning, and the coronary restoration.

Still, with respect to the use of more rational procedures, selection of the tooth surface for cavity access preparation should be discussed. The lingual surface is essentially selected for esthetic reasons. The indication of buccal or incisal surfaces for access to teeth that require veneers is obviously aimed at avoiding the unnecessary wear of two coronal surfaces. Also, a pathway with less anatomical interference is obtained when compared to the conventional technique [3].

Studies on the fracture strength of endodontically treated teeth often simulate conditions observed in posterior teeth (premolars and molars) [16,19-21]. We chose the mandibular incisors because they have a lower coronal volume. Accordingly, the type of access cavity preparations could have a stronger effect on the strength of the tested teeth, especially in the case of conservative preparations, as the type of tested tooth is closely related to mechanical strength [15]. Krishan et al. assessed the influence of conventional or conservative endodontic cavity preparations on the amount of dentin removed from the canals after shaping, on the magnification of preparations, and on the fracture strength of maxillary incisors, mandibular premolars, and mandibular molars. Those authors concluded that conservative cavity preparations allowed better preservation of the coronal structure in molars, moderate preservation in premolars, and smaller preservation in incisors. They also noted an increase in mechanical strength in 2.5X molars and 1.8X premolars when both methods of cavity preparation were compared. However, in line with the findings of our study, they did not observe a statistically significant difference in incisors.

Cavity access restorations with composite resin were performed to bring the experiment closer to routine clinical practice. The procedure managed to restore the lost structure, to seal the root canal, and to strengthen the remaining dental structure [20,21]. Restoration of the access cavity in posterior teeth after endodontic treatment can increase fracture strength by up to 72% when compared to healthy teeth [15,22]. Krishan et al. decided not to use such restorations since they thought some variables could be biased. However, they did not specify which variables they were referring to, nor the possible consequences.

Given the limitations of this study, variations in cavity access preparations were similar to those observed in the conventional technique regarding fracture strength. Thus, the choice of conservatives and rational techniques should not be discouraged. Further studies should look into other anterior teeth.

CONCLUSION

The alteration of surface or size of access cavity proposed did not influence the fracture strength of mandibular incisors when compared to conventional cavity preparation.

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