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Influence of the endodontic access cavity design and restorative technique on hard tissue removal and fracture resistance of mandibular premolars

Influência do desenho de cavidade de acesso endodôntico e da técnica restauradora na remoção de tecido duro e resistência à fratura de pré-molares inferiores

Influencia del diseño de la cavidad de acceso endodóntico y la técnica de restauración en la eliminación de tejido duro y la resistencia a la fractura de premolares inferiores

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Abstract
This study assessed the influence of traditional (TradAC) and conservative access (ConsAC) with different restorative techniques on the percentage of hard tissue removed (%HTR) and on the fracture resistance of mandibular premolars. 45 premolars were scanned in a micro-computed tomography and assigned into four groups according to access (TradAC or ConsAC) and restorative technique: composite resin (CR) or fiber post (FP) + CR. After post preparation, the teeth were rescanned to determine the volume enlargement and %HTR from the crown and root canal. After restoration, the load at fracture was recorded. Data were analyzed statistically by one-way ANOVA and Tukey's post-hoc test, ANOVA repeated measure, and chi-square tests ($P<0.05$). TradAC (RC or FP) resulted in the increase (Δ%) of root canal volume and hard tissue removed up to 14 mm (%) in comparison with ConsAC (RC or FP). TradAC + FP removed a greater percentage of hard tissue from the crown when compared to TradAC + CR. The percentage of hard tissue removed in the crown in the ConsAC groups was statistically lower than in the TradAC groups. The control group showed higher fracture resistance than all experimental groups, with no differences among the latter. Restorable fracture patterns were more prevalent. Traditional endodontic access cavities removed a higher percentage of dentine than conservative endodontic access cavities. However, no differences in fracture resistance were observed. Restorations using composite resin or fiber post associated with composite resin showed similar results of fracture resistance.
Keywords: Root canal preparation; Flexural strength; X-ray microtomography; Dental restoration permanent.

Resumo
Este estudo avaliou a influência do acesso tradicional (TradAC) e conservador (ConsAC), com diferentes técnicas restauradoras, na porcentagem de tecido duro removido (% TDR) e na resistência à fratura de pré-molares inferiores. 45 pré-molares foram escaneados por microtomografia computadorizada e divididos em quatro grupos de acordo com o acesso (TradAC ou ConsAC) e a técnica restauradora: resina composta (RC) ou pino de fibra (PF) + RC. Após o

preparo, os dentes foram re-escaneados para determinar o aumento de volume e % TDR na coroa e no canal radicular. Após a restauração, a carga na fratura foi registrada. Os dados foram analisados estatisticamente pelos testes one-way ANOVA, post-hoc de Tukey, ANOVA de medidas repetidas e teste de qui-quadrado (P <0,05). O TradAC (RC ou PF) resultou no aumento do volume do canal radicular (Δ%) e de tecido duro removido em até 14 mm (%) em comparação com o ConsAC (RC ou PF). O TradAC + PF removeu maior porcentagem de tecido duro da coroa quando comparado ao TradAC + RC. A porcentagem de tecido duro removido na coroa nos grupos ConsAC foi estatisticamente menor do que nos grupos TradAC. O grupo controle apresentou maior resistência à fratura do que todos os grupos experimentais, sem diferenças entre os últimos. Os padrões de fratura restauráveis foram mais prevalentes. As cavidades de acesso endodôntico tradicionais removeram maior porcentagem de dentina do que as cavidades de acesso endodôntico conservadoras. No entanto, não foram observadas diferenças na resistência à fratura. Restaurações usando resina composta ou pino de fibra associado à resina composta mostraram resultados semelhantes de resistência à fratura.
Palavras-chave: Preparo do canal radicular; Resistência à flexão; Microtomografia de raios-x; Restauração dentária permanente.

Resumen
Este estudio evaluó la influencia del acceso tradicional (TradAC) y conservador (ConsAC) con diferentes técnicas restauradoras con respecto al porcentaje de tejido duro removido (% TDR) y la resistencia a la fractura de premolares inferiores. Se escanearon 45 premolares con microtomografía computarizada y se dividieron en cuatro grupos según el acceso (TradAC o ConsAC) y la técnica restauradora: resina compuesta (RC) o perno de fibra (PF) + RC. Después de la preparación de los dientes, fueron escaneados de vuelta para determinar el aumento del volumen y el% HTR de la corona y del conducto radicular. Luego de la restauración, se registró la carga en el momento de la fractura. Los datos se analizaron estadísticamente utilizando ANOVA de una vía y prueba post-hoc de Tukey, ANOVA de medida repetida y pruebas de chi-cuadrado (P <0,05). TradAC (RC o PF) dio como resultado un aumento (Δ%) del volumen del canal de la raíz y hasta un 14 mm% de tejido duro eliminado en comparación con ConsAC (RC o PF). TradAC + PF eliminó un mayor porcentaje de tejido duro de la corona en comparación con TradAC + RC. El porcentaje de tejido duro eliminado en la corona en los grupos ConsAC fue estadísticamente más bajo que en los grupos TradAC. El grupo control mostró mayor resistencia que todos los grupos experimentales, sin diferencias entre estos últimos. Los patrones de fracturas restaurables fueron más frecuentes. Las cavidades de acceso endodóntico tradicionales eliminaron un mayor porcentaje de dentina que las cavidades de acceso endodóntico conservadoras. Sin embargo, no se observaron diferencias en la resistencia a la fractura. Las restauraciones que utilizan resina compuesta o perno de fibra asociado con resina compuesta mostraron resultados similares de resistencia a la fractura.
Palabras clave: Preparación del conducto radicular; Fuerza flexible; Microtomografía de rayos X; Restauración dental permanente.

1. Introduction

Minimally invasive endodontic access cavities have been proposed as an alternative to traditional endodontic access cavities (TradAC) to preserve as much tooth structure as possible and thus theoretically maintain the resistance to fracture of root-filled teeth (Clark & Khademi, 2010). However, this superior resistance has not been scientifically validated. Some studies have shown an increase in fracture resistance (Krishan et al. 2014, Plotino et al. 2017), but most of them have observed that access cavity design does not interfere with the fracture resistance of endodontically treated teeth (Rover et al. 2017, Sabeti et al. 2018, Silva et al. 2020). Previous reviews have concluded that there is no evidence supporting the use of minimally invasive endodontic access cavities to improve the fracture resistance of root-filled teeth when compared to TradAC (Silva et al. 2018, Silva et al. 2020). Moreover, several studies have also demonstrated that minimally invasive endodontic procedures might impair other outcomes of root canal treatment such as cleaning, shaping, and filling procedures (Lima et al. 2020, Rover et al. 2017, Silva et al. 2020, Silva et al. 2020).

In addition to access cavity design, other factors might also be related to fracture resistance of root-filled teeth, such as the type of coronal restoration (Gillen et al. 2011, De Rose et al. 2015). The restoration of root-filled treated teeth varies from a direct composite resin to a post associated with a crown, depending on the remaining structure (Naumann et al. 2018, Trushkowsky 2014, von Stein-Lausnitz et al. 2019). Fiber posts are indicated mainly for teeth with a reduced coronal structure to provide retention of the core material (Trushkowsky 2014). However, previous studies evaluating different groups of teeth with coronal access and maintenance of the four coronary walls have shown a significant increase in fracture resistance when the teeth are restored with fiber posts (Fadag et al. 2018, Nam et al. 2010).

Owing to the effect of access cavities and the importance of coronal restoration for the long-term success of root canal treatment, this study aimed to assess the impact of traditional and conservative access cavities associated with different restorative techniques on the percentage of hard tissue removed and on the fracture resistance of mandibular premolars. The null hypotheses tested were that there would be no difference between access cavities (traditional or conservative endodontic access) and restorative techniques (fiber post or composite resin) in (i) % of hard tissue removal in the crown and until 14mm of the teeth and (ii) fracture resistance of teeth.

2. Methodology

Sample size and group selection

The study was approved by the Ethics Committee of the Institution (Approval number 2.431.596). The donation of teeth was obtained through to sign informed consent. The effect size was established based on data from a previous study (=0.6) (Augusto et al. 2020). The ANOVA: Fixed effects, omnibus, one-way test was selected from the F tests family in G*Power 3.1 software for Windows (Heinrich-Heine-Universität, Düsseldorf, Germany). Accordingly, for an analysis with $\alpha=0.05$, 95% power, and effect size of 0.6, a total of 36 samples (n=9) were indicated as the ideal size. Ten samples per group were used in each of the following groups: TradAC-CR (traditional endodontic access + composite resin), TradAC-FP (traditional endodontic access + fiber post), ConsAC-CR (conservative endodontic access + composite resin) and ConsAC-FP (conservative endodontic access + fiber post). Control with 5 intact teeth was included.

Seventy mandibular premolars were observed by visual inspection at 10X magnification and periapical radiographs were obtained (CDR Elite, Long Island, NY, USA) to select teeth with similar characteristics, with a single canal, and without endodontic treatment. The width of the crowns in the buccolingual and mesiodistal directions and the total length of the tooth and the root were measured with a digital caliper (Matrix®- MTX, ToolsWorld, China).

The specimens were then scanned with a micro-CT device (SkyScan 1172; Bruker micro-CT, Kontich, Belgium) using the following parameters: 100 kV and 100 μA, 0.5-mm-thick aluminum filter, pixel size of 27.07 μm, 180o rotation, and rotation step of 0.6o. The original images were reconstructed using the NRecon software (Bruker, micro-CT) with smoothing (7), ring artifact reduction (6), and beam hardening (40%). The images were aligned with the Data Viewer morphometric visualization software (Bruker, micro-CT).

The CTan (1.15.4.0, Bruker, micro-CT) and Image J softwares were used to quantify hard tissue volume in the crown and up to the cervical 14 mm of the root, as well as the volume (mm^3) of the pulp chamber and root canal. The CTvol software (Bruker, micro-CT) was used to verify the three-dimensional configuration of the root canal. Only mandibular premolars with type 1 anatomy were selected (Ahmed et al. 2017). The teeth were then divided into four experimental groups (n=10) and one control group (n=5) based on a similar initial amount of hard tissue, root canal volume, and tooth length.

Access cavity preparation

Access cavities were prepared in all groups except the control.

TradAC: Access cavities were prepared with 1014HL and 3081 burs (KG Sorensen, São Paulo, SP, Brazil) as described in the literature (Ingle 1995, Patel & Rhodes 2007) with complete removal of the pulp chamber roof.

ConsAC: Access was prepared with 1011HL burs (KG Sorensen) and was extended just as needed for the canal orifice to be detected by the instrument, preserving the pericervical dentine and part of the pulp chamber roof (Rover et al. 2017, Silva et al. 2020).

Root canal preparation and filling procedures

Preflaring was performed with 35/.05 rotary instruments (Bassi Logic™, Belo Horizonte, MG, Brazil) up to one third of the root canal. Patency was achieved with a size 10 C-Pilot instrument (VDW, Munich, Germany) and the working length was established 1 mm beyond the apical foramen. The apical third was then prepared with 35/.01 and 35/.05 instruments (Bassi Logic™). During preparation, the teeth were irrigated with 2% chlorhexidine and 17% EDTA was used for smear layer removal. Saline solution was used as the final irrigant.

For root canal filling, a calibrated gutta-percha cone (Odous de Deus, Belo Horizonte, Minas Gerais, Brazil) was used with a sealer (AH Plus, Dentsply Maillefer, Ballaigues, Switzerland) and a thermoplasticized technique. The pulp chamber was cleaned with H141.205.014 burs (Komet Dental, Germany) and rinsed with saline.

Fiber post space preparation

Fiber post preparation was performed with #3 and #2 Largo drills in the TradAC-FP and ConsAC-FP groups, respectively, parallel to the long axis of the root, at a depth of 14 mm, from the coronal to the apical third, and the post space was then rinsed with saline.

Micro-CT assessment

After root canal treatment and post preparation, a new micro-CT scan was performed using the same parameters mentioned earlier. The open-source 3D Slicer software, available online at http://slicer.org - National Institutes of Health, was used to register the 3D models pre- and post-preparation with an affine algorithm and the CTAn software (Bruker, micro-CT) was then used for all image analysis procedures. The region of interest was 14 mm, as mentioned previously, resulting in 600-670 transverse cross-sections per tooth. Next, the gray scale range required to recognize hard tissue (enamel and dentine) and the root canal was determined with a density histogram using an automatic threshold tool.

The mean percentage increase (Δ%) of root canal volume was calculated as described previously (Versiani et al. 2018). The percentage of hard tissue removed after root canal preparation and post preparation was calculated in the crown and up to the cervical 14 mm of the root canal according to the formula:

$$\frac{(Initial\ hard\ tissue\ volume - final\ hard\ tissue\ volume)}{Initial\ hard\ tissue\ volume}\ x\ 100$$

The CTvol software (Bruker, micro-CT) was used for comparison of the overlapping images before (green) and after the endodontic access and post preparation (red).

Restorative procedures

Composite resin

In the CR groups, 37% phosphoric acid (Condac 37, FGM Produtos Odontológicos, Joinville, SC, Brazil) was used for 15 seconds, followed by washing and drying with air jets. The Scotchbond Multipurpose adhesive system (3M, St. Paul, MN, USA) was used. First, the Adper Activator was applied with a micro applicator (Cavibrush, FGM), followed by drying with an air jet for 5 seconds and with absorbent paper points. Next, the Adper Primer (3M) was applied in the same way and finally, the Catalyst was applied, with the solvents being volatilized with an air jet and absorbent paper cones being used to remove the excess.

The teeth were restored with composite resin only in the coronary portion (Filtek Z250, 3M) using the incremental technique. Increments were polymerized for 20 seconds with light curing (Flash Lite 1401, Discus Dental Inc, Culver City, CA, USA) at an intensity of 1400 MW/cm2 and wavelength between 465 and 475 nm, followed by polishing with 3018F burs (KG Sorensen).

Fiber post cementation

The #1 DCE and # 0.5 DC prefabricated fiberglass posts were used in the FP groups (Whitepost, FGM, Joinville, SC, Brazil), respectively. Posts were cleaned with 37% phosphoric acid for 60 seconds, washed for 30 seconds, and air-dried. Next, the silane coupling agent (RelyX Ceramic Primer, 3M) was applied and the solvent was volatilized with an air jet for 3 minutes.

The resin cement (RelyX ARC, 3M) was inserted into the root canal and the post was positioned inside the root canal at 14 mm. Excess cement was removed and the buccal and lingual surfaces were photoactivated for 1 minute. Excess post material in the coronal portion was removed 1 mm below the occlusal surface and this area was restored with composite resin.

Load to fracture

Prior to the fracture test, the periodontal ligament and alveolar bone were simulated based on previous studies (Soares et a. 2005). First, a high fusion wax (New Waxx, Technew, Rio de Janeiro, RJ, Brazil) was used at a thickness of 0.3 mm around the root to simulate the periodontal ligament space. Then, to simulate alveolar bone, the teeth were encased in epoxy resin (Carplast, Maxi Rubber, Diadema, SP, Brazil).

The specimens were loaded at their central fossa at a 30º angle from the long axis of the teeth in a universal testing machine (Emic, São José dos Pinhais, PR, Brazil), with a load cell of 200 kgf and a constant speed of 1.0 mm/min. The values of maximum load at fracture were recorded in Newtons (N).

Next, the specimens were analyzed under a light microscope at 10X magnification to determine the fracture patterns. The specimens were classified as “restorable” when the failures were above the level of bone simulation (site of fracture above the acrylic resin) and “unrestorable” when the failures extended below the level of bone simulation (site of fracture below the acrylic resin).

Statistical analysis

The normality of the data was determined by the Kolmogorov-Smirnov test using the SPSS software (version 19.0, Statistical Package for the Social Sciences). Since the micro-CT and load at fracture data showed a normal distribution, parametric tests were chosen for statistical analysis. Data were analyzed statistically by one-way ANOVA and Tukey’s post-hoc test for increase Δ%, Hard tissue removed up to 14 mm (%), Hard tissue removed crown (%) and Load to fracture. ANOVA repeated measures was carried out to analyze the difference between groups according to time (the sphericity was assumed for the analysis). The chi-square test was used for fracture patterns. The level of significance was set at 5% in all analyses.

3. Results

The morphological similarities (baseline) of the tested groups were measured with the use of a caliper. No significant differences were observed in the dimensions of the crown in the buccolingual and mesiobuccal direction, total tooth length, or root length. The degree of homogeneity (baseline) of the tested groups was also confirmed by micro-CT scanning regarding hard tissue volume and root canal volume (mm³) ($P>0.05$) (Table 1).

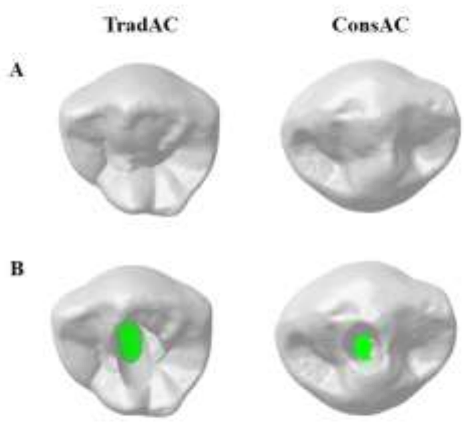
Table 1. Mean values (SD) of teeth measured with a caliper in mm.

Groups	**Total length**	**MD (crown)**	**BL (crown)**	**BL (cervical third)**	**MD (cervical third)**
TradAC-CR	22.63 (1.34)^{A}	7.29 (0.63)^{A}	7.85 (0.66)^{A}	6.57 (0.57)^{A}	4.71 (0.44)^{A}
ConsAC-CR	22.84 (1.57)^{A}	7.54 (0.49)^{A}	8.03 (0.36)^{A}	6.90 (0.58)^{A}	4.86 (0.30)^{A}
TradAC-FP	22.74 (1.50)^{A}	7.21 (0.40)^{A}	7.37 (1.13)^{A}	6.57 (0.88)^{A}	4.65 (0.40)^{A}
ConsAC-FP	21.96 (1.65)^{A}	7.37 (0.51)^{A}	8.25 (0.59)^{A}	7.12 (0.75)^{A}	4.68 (0.51)^{A}
Control	21.95 (1.75)^{A}	7.32 (0.38)^{A}	6.46 (1.49)^{A}	6.90 (0.70)^{A}	4.56 (0.14)^{A}

Means followed by different superscript letters differ significantly between the different groups (One-way ANOVA, P<0.05) .
MD: mesiodistal direction; BL: buccolingual direction. Source: Authors.

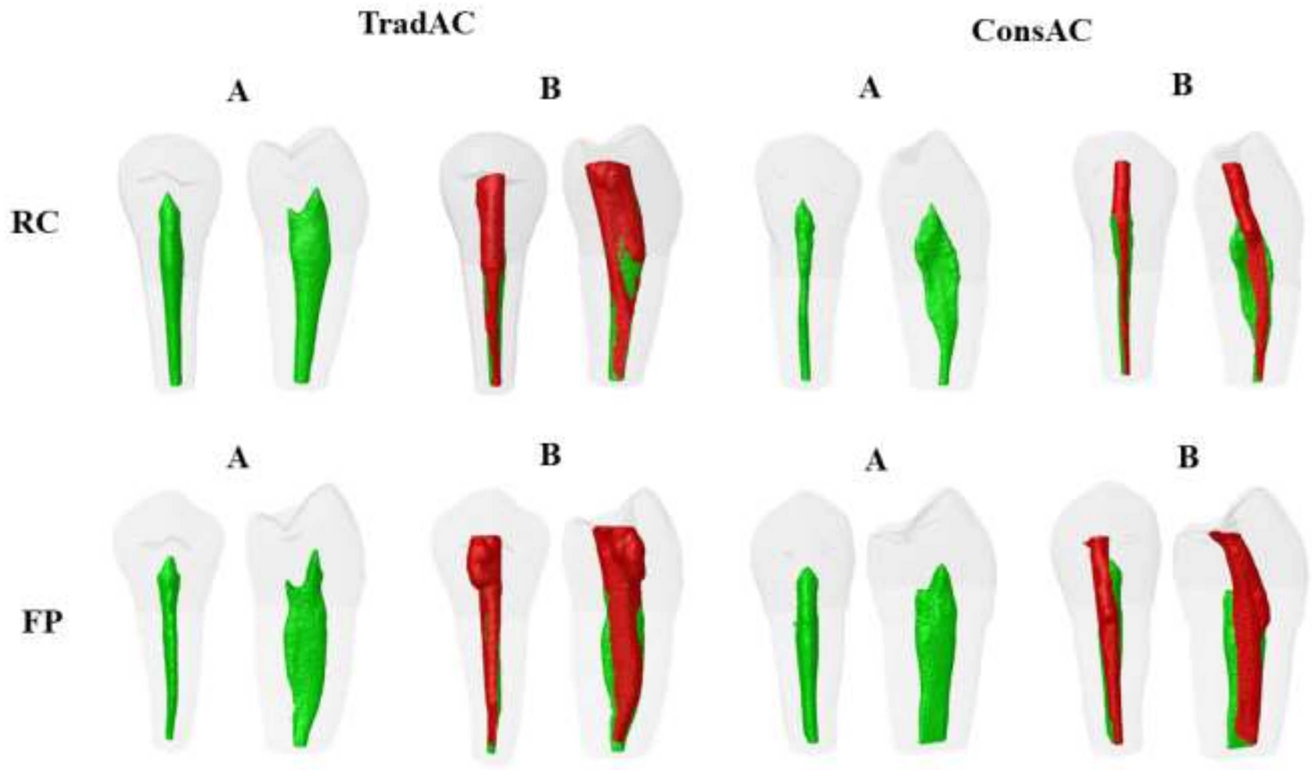
Figures 1 and 2 show representative images of the experimental groups. TradAC (RC or FP) resulted in the increase (Δ%) of root canal volume and hard tissue removed up to 14 mm (%) in comparison with ConsAC (RC or FP). TradAC + FP removed a greater percentage of hard tissue from the crown when compared to TradAC + CR. The percentage of hard tissue removed in the crown in ConsAC groups was statistically lower than in the TradAC groups (one-way ANOVA and Tukey's post-hoc test; P<0.05) (Table 2).

Figure 1. Micro-CT images of teeth of the TradAC and ConsAC groups in the occlusal view (A) before and (B) after endodontic access cavity preparation.



Source: Authors.

Figure 2. Representative 3D images of teeth of the TradAC-CR, TradAC-FP, ConsAC-CR and ConsAC-FP groups in the buccolingual and mesiodistal view (A) before (green) and (B) after (red) root canal preparation.



Source: Authors.

For root canal volume in the ANOVA repeated measure test (Table 2), it was observed the effect of time among the 4 groups, and the interaction between time and groups, but not among the type of groups. In the initial time, there was no difference between the groups, but in the final time TradAC-CR group was statistically different than ConsAC-CR; ConsAC-CR group was different than TradAC-FP group; TradAC-FP group was different than ConsAC-CR and ConsAC-FP groups. For hard tissue volume up to 14 mm it was observed effect of time among the 4 groups, and the interaction between time and groups, but not among the groups (access cavities and restorative technique). There was difference between initial and final, however, no difference was visualized between groups. For hard tissue volume in the crown, it was observed effect of time among the 4 groups, but not in the interaction between time and groups. There was difference between initial e final in all groups, except for ConsAC-CR; however, between groups, there was no statistical difference.

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Table 2. Analysis of root canal, hard tissue up to 14 mm and crown, by micro-CT according with time (initial and final).

	TradAC-CR Mean ± SD	**ConsAC-CR** Mean ± SD	**TradAC-FP** Mean ± SD	**ConsAC-FP** Mean ± SD
Initial root canal volume (mm³)	12.99 ± 4.50Aa	14.68 ±4.48Aa	11.35 ±2.76Aa	14.50 ±5.36Aa
Final root canal volume (mm³)	33.88 ± 7.32Ba,d	24.01 ± 5.35Bb	35.03 ± 4.10 Ba,c	26.65 ± 5.44Bb,d
Increase (Δ%)*	**173.15 ± 56.96a**	**71.66 ± 47.22b**	**231.07 ±107.96a**	**101.29 ± 68.52b**
Initial hard tissue volume up to 14 mm (mm³)	347.64 ± 59.33Aa	363.08 ± 36.86 Aa	330.93 ± 33.17 Aa	367.17 ± 38.47 Aa
Final hard tissue volume up to 14 mm (mm³)	320.49 ± 54.85Bb	350.88 ± 34.66 Bb	302.41 ± 36.53 Bb	351.08 ± 41.25 Bb
Hard tissue removed up to 14 mm (%)*	**7.54 ± 1.10a**	**3.10 ± 4.33b**	**8.49± 2.18a**	**4.31 ± 2.14b**
Initial hard tissue volume crown (mm³)	237.48 ± 39.47 Aa	239.75 ± 20.36 Aa	216.35 ± 17.15 Aa	239.36 ± 22.02 Aa
Final hard tissue volume crown (mm³)	215.70 ± 37.49 Bb	231.43 ± 19.96Ab	191.60 ± 18.14 Bb	227.49 ± 22.86 Bb
Hard tissue removed crown (%)*	**9.27 ± 1.91b**	**3.47 ± 1.19c**	**11.52 ± 2.36a**	**5.02 ± 1.72c**

Note: ANOVA repeated measure for time (initial and final) between the groups tested, Lower case different show significantly between groups (p<0.05)
Upper case different show significantly initial and final time (p<0.05)
** One-way ANOVA and Tukey's post-hoc test, p<0.05.* Source: Authors.

The maximum strength to fracture is shown in Table 3. The control group differed significantly from the other groups (P<0.001), with no difference among experimental groups (P=0.373). A restorable fracture pattern was more prevalent in all groups, with no statistical difference (chi-square test, P=0.81). Figure 3 shows representative images of the restorable and unrestorable fracture patterns.

Table 3. Maximum force applied until fracture and fracture patterns of the different groups.

Groups	**Load to fracture** Mean ± SD	**Fracture pattern** Restorable (n)	Unrestorable (n)
TradAC-CR	398.90 ±142.28b	9	1
ConsAC-CR	458.70 ±134.23b	9	1
TradAC-FP	392.60 ±140.03b	9	1
ConsAC-FP	342.50 ±162.86b	10	0
Control	814.60 ±195.49a	10	0

Means in the same column followed by different letters differ significantly between groups (One-way ANOVA and Tukey's post-hoc test, p<0.05). Source: Authors.

Figure 3. Representative images of the restorable (A) and unrestorable (B) fracture pattern.

Source: Authors.

4. Discussion

The present study evaluated the impact of different access cavities and restorative techniques on the percentage of hard tissue removed and on the fracture resistance of mandibular premolars. The length of 14 mm of preparation depth for fiber post cementation was used since this measure corresponds approximately to the value of the middle and cervical thirds of the premolars used, which is an acceptable length for post preparation and because most fractures of root canal-filled teeth occur in the cervical region (Pierrisnard et al. 2002).

Sodium hypochlorite affects the mechanical properties of dentin by degradation of the organic dentin components. Also, due to its oxidative power, which leaves an oxygen-rich layer on the dentin surface, its use affects the polymerization of adhesive materials (Prado et al. 2016). Thus, in the present study, 2% chlorhexidine was chosen as irrigant during root canal preparation. Other advantages of chlorhexidine as irrigant include broad-spectrum antimicrobial activity, substantivity and a positive effect on dentin adhesion, showing the capacity to preserve the durability of the hybrid layer and bond strength (Gomes et al. 2013).

Regarding the crown and root canal up to the cervical 14 mm of the root, increase root canal volume(Δ%) and a greater amount of hard tissue removed (%) were observed in the TradAC groups than in the ConsAC groups, an expected result since the entire roof of the pulp chamber was removed and a conical and elliptical shape of the pulp cavity was achieved (Patel & Rhodes 2007). Thus, the first null hypothesis was partially rejected.

When only the crown was evaluated, the percentage of hard tissue volume removed was higher in the TradAC-FP group than in the TradAC-CR group, showing that the fiber post promoted a higher percentage of dentine removal, in line with previous studies (Ikram et al. 2009, Shaikh et al. 2018). Moreover, a greater percentage volume of hard tissue was removed in the TradAC groups when compared to the ConsAC groups, in agreement with previous studies that evaluated traditional and conservative access cavities (Isufi et al. 2020, Silva et al. 2020).

Regarding the impact of access cavities on the fracture resistance of premolars, this study did not observe a significant difference between access cavities, in line with other studies that compared these types of access using different types of teeth (Rover et al. 2017, Sabeti et al. 2018). However, Krishan et al. (2014), in a study on premolars and molars, observed an increased fracture resistance in minimally invasive access when compared with traditional access. This divergence may be due the fact that the teeth evaluated by the cited authors were not restored.

Clinically, dentists may not choose fiber posts to restore teeth with four intact walls. However, previous studies found that fiber posts could improve the fracture resistance of teeth with four walls (Fadag et al. 2018, Nam et al. 2010), justifying the clinical significance of this type of study.

In the present study, no difference in fracture resistance was observed between the restorative procedures, in agreement with a previous study (von Stein-Lausnitz et al. 2019). However, other studies respectively evaluating premolars and incisors (Fadag et al. 2018, Nam et al. 2010) have reported that fiber posts improved the fracture resistance of teeth with four walls. These differences may be linked to differences in sample preparation, fiber post preparation/cementation, and the dental group.

The similar fracture resistance results in the experimental groups and the restorable fracture patterns can be explained by the maintenance of the four surfaces of all teeth that reinforces the dental structures and increases the resistance of the premolar (Soares et al. 2008). When a fiber post is used, it permits good stress distribution since the elastic modulus of the fiber post is like that of dentine (Nam et al. 2010, Soares et al. 2008).

In this study, the smaller hard tissue volume removed with ConsAC had no positive effect on fracture resistance. Composite resin is a good option as a restorative procedure for root canal-filled teeth with four walls because it is of low cost, it is a faster clinical procedure since it does not require post preparation or cementation, and it is a less error-sensitive technique than the use of a fiber post (Silva et al. 2020, Soares et al. 2008).

A great effort was employed to ensure the homogeneity of the specimens regarding configuration, volume and surface area of the root canals based on preoperative scans, however, as it is a laboratory study, it has some limitations, such as performing the static fracture test and the absence of the simulation of chewing in the oral cavity. Thus, it is suggested to carry out further studies with the use of cyclic fatigue to approach the simulation of clinical conditions.

5. Conclusion

Traditional endodontic access cavities removed a higher percentage of dentine than conservative endodontic access cavities. However, no differences in fracture resistance were observed. Restorations using composite resin or fiber post associated with composite resin showed similar results of fracture resistance and fracture patterns.

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