

Universidade Federal de Uberlândia
Faculdade de Odontologia
Programa de Pós-Graduação em Odontologia

Marcio Alex Barros Gomes

**Perda de dentina no acesso ao canal e remoção de pinos de fibra para
retratamento em molares – Análise por tomografia e microtomografia
computadorizada**

Tese apresentada à Faculdade de Odontologia
da Universidade Federal de Uberlândia, como
requisito parcial para obtenção do Título de
Doutor em Odontologia na Área de
Concentração de Clínica Odontológica
Integrada.

Uberlândia, 26 de outubro de 2020

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“Os dois dias mais importantes da sua vida são: o dia em que você nasceu, e o dia em que você descobre o porquê”.

Mark Twain

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RESUMO

A confecção de cavidades de acesso para retratamento endodôntico em molares e a remoção de pinos de fibra podem sacrificar estrutura dental sadia. O uso de resinas fluidas ou ionômero de vidro têm sido propostos para selar a câmara coronária e conduto radicular. Para remoção de pinos de fibra têm sido indicados pontas diamantadas, insertos ultrassônicos, ou mesmo o acesso guiado. Este estudo tem como objetivo geral avaliar métodos de acesso de condutos radiculares em dentes restaurados com resina composta ou ionômero de vidro, e com pinos de fibra de vidro em função da sua eficiência e efetividade. Esse estudo foi dividido em três objetivos específicos: **objetivo específico 1**, Avaliar o efeito do uso de turbina de alta rotação equipada com luz branca ou violeta e do uso de ionômero de vidro ou resina flow no assoalho na câmara pulpar na restauração de molares superiores tratados endodonticamente na remoção de dentina sadia no acesso endodôntico para retratamento; **objetivo específico 2**, Avaliar o efeito da técnica de insertos ultrassônicos, pontas diamantadas e acesso guiado na efetividade e eficiência de remoção de pino de fibra de vidro mensurando tempo consumido, perda de dentina e desvio do canal radicular em molares superiores; **objetivo específico 3**, Apresentar relatos de casos clínicos que trasladam conhecimento obtido nos estudos laboratoriais acerca da remoção de pino de fibra de vidro abordando vantagens, limitações e necessidade de avanços tecnológicos nessas técnicas. Dentro dos limites impostos pelo delineamento desses estudos foi possível concluir que: **1)** O acesso com alta equipado com luz branca, independentemente do material restaurador usado na câmara pulpar, permitiu menor perda dentinária; **2)** O uso do cimento de ionômero de vidro facilita o acesso aos canais com redução da remoção de dentina do assoalho pulpar e menor número de paredes afetadas; **3)** A remoção de pino com acesso guiado resulta em menor tempo de trabalho que o uso de ultrassom e menor perda estrutural que o uso de ponta diamantada e insertos em ultrassom; **4)** A remoção de pino com ponta diamantada resulta em maior transposição e alargamento do canal que quando realizado com ultrassom e acesso guiado; e **5)** Remoção de pino de fibra de vidro é um desafio

para o clínico e necessita de avanço tecnológico e efetivo treinamento profissional para gerar eficiência e reprodutibilidade do procedimento.

PALAVRAS-CHAVES: Retratamento do canal radicular, remoção de material restaurador, remoção de pino de fibra, remoção de dentina, endodontia guiada.

ABSTRACT

*Making access cavities for endodontic retreatment in molars and fiber post removal can sacrifice intact tooth structure. The use of flowable resin composites or glass ionomer cement has been proposed to seal the pulp chamber and root canal entrance. For removal of fiber posts, diamond burs, ultrasonic inserts, or even guided access have been indicated. This study has as general objective to evaluate methods of root canal access in teeth restored with composite resin or glass ionomer, and with fiberglass posts depending on their efficiency and effectiveness. This study was divided into three specific objectives: **specific objective 1**, Evaluate the effect of using a handpiece equipped with white or violet light and the use of glass ionomer or flow resin on the floor in the pulp chamber in the restoration of endodontically treated upper molars in the removal of intact dentin in the endodontic access for retreatment; **specific objective 2**, Evaluate the effect of the technique of ultrasonic inserts, diamond burs and guide access on the effectiveness and efficiency of removing fiberglass post measuring time consumed, loss of dentin and root canal deviation in maxillary molars; **specific objective 3**, To present clinical case reports that transfer knowledge obtained in laboratory studies about the fiberglass posts removal, addressing advantages, limitations and the necessity of technical advances in these protocols. Within the limits imposed by the design of these studies, it was possible to conclude that: **1)** Access with handpiece equipped with white light, regardless of the restorative material used in the pulp chamber, allowed less dentin loss; **2)** The use of glass ionomer cement facilitates access to the root canals with reduced dentin removal from the pulp floor and fewer affected walls; **3)** The post removal with guide access results in less work time than the use of ultrasonic and less structural loss than the use of diamond bur and ultrasonic inserts; **4)** The post removal with a diamond bur results in greater transposition and widening of the root canal than when performed with ultrasonic and guide access; and **5)** Removal of a fiberglass post is a challenge for the clinician and requires technical advancement and effective professional training to generate efficiency and reproducibility of the procedure.*

KEYWORDS: *Root canal retreatment, restorative material removal, Fiberglass post removal, dentin removal, guided endodontics.*

1. INTRODUÇÃO E REFERENCIAL TEÓRICO

A remoção do material restaurador presente na câmara pulpar para localização dos condutos radiculares e eventual necessidade de remoção de pinos de fibra de vidro podem gerar ansiedade no profissional. Os riscos de desgastes acidental de dentina podem comprometer a biomecânica de dentes tratados endodonticamente e ainda resultar em perfuração radicular ou do assoalho da câmara pulpar.¹

Diversos materiais têm sido indicados para restaurar dentes posteriores após o tratamento endodôntico, como resinas compostas convencionais ou *bulk fill* associadas ou não com cimento de ionômero de vidro.²⁻⁴ Resinas compostas *bulk fill* fotoativadas podem ser inseridas em incrementos de 4-5 mm, reduzindo tempo de trabalho e apresentando bom desempenho.⁵ Esses materiais produzem, em geral, menor contração de polimerização quando comparados às resinas compostas convencionais, a depender de sua composição, viscosidade e módulo de elasticidade.⁶ Já o cimento de ionômero de vidro gera menores tensões de contração possuem capacidade de adesão química à estrutura dental.⁷ A dificuldade de distinguir estrutura dental e material restaurador no interior da câmara pulpar pode dificultar a localização dos canais na eventual necessidade de reabertura endodôntica. Durante o acesso aos canais, visando retratamento endodôntico; podem haver danos à dentina sadia nas paredes laterais ou no assoalho da câmara pulpar devido à similaridade de cor e maior resistência ao desgaste da resina composta.⁸ Em situações extremas, pode ocorrer perfuração da câmara pulpar, considerada complicação severa em procedimentos endodônticos e restauradores.^{1,9} Esta intercorrência tem sido considerada uma das principais causas de falha do tratamento endodôntico e pode levar à perda do dente.^{1,9}

Para a remoção de materiais restauradores no interior da câmara pulpar, o uso de turbina de alta-rotação convencional com ponta diamantada tem sido usualmente utilizada pelos profissionais. Em virtude de alguns materiais restauradores apresentarem alta fluorescência, o que os torna mais facilmente evidenciados quando expostos à luz ultravioleta,¹⁰ turbinas de alta rotação com

lâmpadas de LED ultravioleta podem potencializar a fluorescência desses materiais restauradores, criando contraste com a estrutura dental.^{10,11} Isso pode ser relevante, em especial na detecção de restaurações nas faces palatinas e oclusais de molares, por serem áreas particularmente difíceis de identificar.¹² Isso pode ser minimizado pela adequada distinção entre estrutura dental e resina composta, a partir de propriedades fluorescentes desses materiais.¹² Com isso tornaria mais visível o campo operatório diminuindo a chance de desgaste indesejável ou iatrogênico da estrutura dental sadia.

A restauração de dentes tratados endodonticamente constitui procedimento complexo que envolve necessidade de restabelecer biomecanicamente dentes enfraquecidos devido à perda estrutural.¹³ A perda de mais da metade da estrutura coronária, causada por cáries, fratura ou extenso preparo cavitário determina a necessidade de uso de pinos.¹⁴ Nesse sentido, pinos de fibra de vidro têm se tornado cada vez mais a alternativa de primeira escolha na substituição aos pinos metálicos.¹⁵

Quando o tratamento endodôntico falha, ou mesmo diante da indicação de retratamento endodôntico por finalidade protética, um novo acesso aos canais radiculares deve ser realizado para permitir efetiva limpeza, formatação e nova obturação dos canais radiculares.¹⁶ A presença de pinos de fibra de vidro cimentados intracanal pode ser um agravante dessa situação. Esses pinos podem falhar por fratura sem comprometer o remanescente dental¹⁷, o que determina também a necessidade de remoção dos mesmos. Por outro lado, a presença de pinos de fibra de vidro pode dificultar o retratamento de dentes com infecções periapicais via coroa.¹⁸ Essas condições clínicas, implicam na necessidade de usar métodos atraumáticos e eficientes para removê-los evitando-se procedimentos cirúrgicos.¹⁸ Nesse sentido, vários métodos para remoção de pinos de fibra de vidro têm sido utilizados, tais como: desgaste do pino com brocas ou ainda a utilização de vibração ultrassônica com insertos.¹⁸ A utilização do microscópio operatório associado aos insertos de ultrassom tem sido reportado como método eficiente, pela visualização adequada do campo operatório, permitindo maior visualização de detalhes anatômicos e estruturais¹⁹, e com isso se evite desgastes desnecessários.

Outra opção mais recente que pode auxiliar na remoção de pinos de fibra de vidro é o planejamento virtual.²⁰ O acesso guiado a partir do volume tridimensional gerado por tomografias computadorizadas de feixe cônico tem sido adotado com vistas à confecção de direcionamento adequado para a remoção do pino de fibra.²¹ Com isso tornam mais previsíveis os limites anatômicos da raiz, minimizando a ocorrência de desgaste indesejável ou iatrogênico da estrutura dentinária. O planejamento virtual do acesso leva em consideração a anatomia radicular²²⁻²⁴, orienta a cavidade de acesso para remoção de pinos de fibra de vidro cimentados adesivamente e facilita o procedimento clínico, tornando-o mais seguro por preservar estrutura radicular.²⁰

Nos limites do nosso conhecimento, nenhum estudo avaliou a eficiência do uso de cimento de ionômero de vidro em substituição à resina composta fluida para selar câmaras pulpaes e também o uso de turbinas de alta rotação com iluminação de LED branca ou ultravioleta com vistas a evitar a remoção iatrogênica de dentina sadia durante a cavidade de acesso para retratamento endodôntico. Da mesma forma, também dentro dos limites do nosso conhecimento, nenhum estudo avaliou a eficiência e eficácia do uso de acesso guiado comparado a protocolos de insertos ultrassônicos e pontas diamantadas usadas em associação com microscopia operatória na remoção de pinos de fibra de vidro. O tempo de execução de tais procedimentos também deve ser considerado para que essas técnicas possam se popularizar. Mostra-se pertinente e oportuno o desenvolvimento de estudos que avaliem esses protocolos e favoreça a geração de conhecimento para que clínicos possam executar protocolos com maior previsibilidade e menor riscos aos pacientes.

2. OBJETIVOS

2.1. Objetivo Geral

Avaliar métodos de acesso de condutos radiculares em dentes molares superiores restaurados com resina composta ou ionômero de vidro e remoção de pinos de fibra de vidro em função da sua eficiência e efetividade.

2.2. Objetivos Específicos

Objetivo específico 1

Capítulo 1 - *Handpiece lighting and glass ionomer filling pulp chamber on dentin removal during root canal retreatment*

Avaliar o efeito do uso de turbina de alta rotação equipada com luz branca ou violeta e do uso de ionômero de vidro ou resina fluida no assoalho na câmara pulpar na restauração de molares superiores tratados endodonticamente na remoção de dentina sadia no acesso endodôntico para retratamento

Objetivo específico 2

Capítulo 2 - *Fiber post removal using guide access, ultrasonic inserts and diamond burs – Analysis of efficiency and effectiveness.*

Avaliar o efeito da técnica de insertos ultrassônicos, pontas diamantadas e acesso guiado na efetividade e eficiência de remoção de pino de fibra de vidro mensurando tempo consumido, perda de dentina, perfuração radicular e desvio do canal radicular em molares superiores.

Objetivo específico 3

Capítulo 3 - *Guide access and ultrasonic inserts under operatory microscope as an alternative technique to failure in fiber post.*

Apresentar relatos de casos clínicos que trasladam conhecimento obtido nos estudos laboratoriais acerca da remoção de pino de fibra de vidro com acesso guiado abordando vantagens, limitações e necessidade de avanços tecnológicos nessas técnicas.

3. CAPÍTULOS

3.1. Capítulo 1 – Artigo submetido ao periódico *Brazilian Dental Journal*

Handpiece lighting and glass ionomer filling pulp chamber on dentin removal during root canal retreatment

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Short title: Dentin removal in retreatment reaccess

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Handpiece lighting and glass ionomer cement filling pulp chamber on dentin removal during root canal retreatment - micro-CT analysis.

SUMMARY

This study evaluated the effects of glass ionomer cement (GIC) and flowable bulk fill composite resin (BFRC) used for filling pulp chambers and the type of high-speed handpiece lighting on dentin removal in endodontic retreatment access preparation in molar teeth. Twenty maxillary molars were endodontically treated. Ten teeth were restored using BFRC (Opus Bulk Fill Flow APS, FGM) to fill the pulp chamber and coronal dentin and conventional composite resin (Opallis, FGM) to restore the enamel layer. The other teeth were restored using GIC (Maxion R, FGM) to fill the pulp chamber and composite resin (Opallis, FGM). The samples were divided into two groups, and the root canals were reaccessed using a handpiece with white or ultraviolet lighting. The teeth were scanned using micro-CT before and after root canal reaccess. The volume of dentin removed was calculated, and the data were analyzed using 2-way ANOVA and Tukey's test ($\alpha=0.05$). The dentin walls affected were classified and described using the frequency. Root canal reaccess with GIC resulted in fewer affected pulp chamber walls and a lower volume of dentin removed at the pulp floor. No effect was observed on the dentin coronal walls regarding the filling protocols. The white lighting handpiece reduced the dentin removal from the pulp chamber irrespective of the filling protocol used. The use of a white lighting handpiece and the use of GIC to fill the pulp chamber reduced dentin removal from the pulp floor and affected fewer dentin walls.

Key Words: retreatment root canal, reaccess, glass ionomer cement, bulk fill composite resin, dentin removal.

INTRODUCTION

Several materials have been indicated for restoring posterior teeth after endodontic treatment (1), such as conventional composite resins or bulk fill composite resins associated or not with glass ionomer cement (GIC) (2). The use of GIC for filling the pulp chamber has been implemented to reduce shrinkage stress (2). Definitive restoration is important to maintain the quality of endodontic treatment (3). When endodontic treatment fails, new root canal access should be realized to allow effective cleaning, shaping and reobturation of the root canal (4). The inability to distinguish between the tooth structure and the restorative material during retreatment can result in damage to intact dentin on the lateral walls or at the pulp chamber floor due to the similarity between resin composite and tooth structure (5). In extreme situations, accidental perforation of the pulp chamber can occur, which is a severe complication in endodontic and restorative procedures (6, 7), and is considered one of the major causes of failure of endodontic treatment (6).

The color and stiffness of the restorative material used in the pulp chamber can influence the identification of this material, preventing accidental dentin removal. GIC has lower mechanical resistance (8) and higher opacity than composite resin (9). Flowable composite resin that is easy to inject inside the pulp chamber is normally more translucent (10), mimicking the adjacent tooth structure. For removal of restorative materials in coronal cavities and inside the pulp, a conventional high-speed handpiece with a diamond bur has usually been used. Some restorative materials present higher fluorescence that makes them more visible when exposed to ultraviolet light (11). High-speed handpieces with ultraviolet LED headlamp systems can highlight the fluorescence of these restorative materials, creating a contrast to that of the dental structure (11, 12).

This specific illumination from the handpiece can facilitate the selective removal of these composites and reduce the damage to intact dentin compared to that from conventional high-speed handpieces. To the best of our knowledge, no study has tested the efficiency of using GIC or a flowable resin layer for filling pulp chambers and that of using white or ultraviolet LED high-speed handpieces to prevent iatrogenic intact dentin removal during endodontic access cavity preparation for retreatment. The aim of this study was to evaluate the influences of the type of restorative material used for filling endodontic treated molars and the type of light presented by the headpiece during reaccess preparation for retreatment of root canals in first upper molars on intact dentin removal and the location of the dentin removal.

MATERIALS AND METHODS

Teeth selection and access

This study was approved by an ethics committee (protocol #2.570.199). Twenty intact human first upper molar teeth with similar size and shape were imbedded in polystyrene resin (13). The teeth were endodontically treated using a round diamond bur (#1014, KG Sorensen, Cotia, SP, Brazil) in a high-speed handpiece (Kavo, Joinville, SC, Brazil) under refrigeration to access the pulp chamber, and an Endo-Z drill (KG Sorensen, Cotia, SP, Brazil) was used to ensure a standardized cavity contour, allowing the location of the canal orifices.

Canal instrumentation and obturation

The teeth were instrumented 1.0 mm above the apical foramen. A Prodesign S system (Easy Equipamentos, Belo Horizonte, MG, Brazil) was used for irrigation with NaOCl 2.5% (ASFER, São Caetano do Sul, SP, Brazil) using a 5 mL syringe (Ultradent, South Jordan, Utah, USA) and NaviTip (Ultradent, South Jordan, Utah, USA). AH Plus endodontic cement (Dentsply, Petrópolis, RJ, Brazil) and the lateral condensation technique were used for obturation, with the apical portion of the gutta-percha cone kept 1.0 mm from the radiographic apex.

Restorative procedures

The endodontically treated teeth were randomly sorted into two groups (n=10) using www.random.org. *Group GIC* (Figure 1A): Glass ionomer cement (Maxxion R, FGM, Joinville, SC, Brazil) was used to cover the pulp chamber floor with a 1.5-2.0 mm layer using a Centrix syringe (Maquira, Paraná, Brazil). The restoration was completed using selective enamel phosphoric acid 37% (Condac 37%, FGM) etching for 30 s, and a self-etching adhesive system (Clearfil SE Bond, Kuraray, Japan) was applied and light cured for 20 s. The conventional composite resin (Opalis, FGM) was inserted in 2.0 mm increments and light cured for 40 s. *Group BFCR* (Figure 1B): Bulk fill flowable composite resin (Opus Bulk Fill Flow, FGM) was used to cover the pulp chamber floor with a 4-mm layer, and the occlusal restoration was filled using a conventional composite resin similar to that of group A. All the materials were light activated by using a VALO Cordless (Ultradent Products, South Jordan, UT, USA) light curing unit with irradiance of 1400 mW/cm², and the curing was verified by a MARC resin calibrator (BlueLight, Halifax, Canada).

Reaccess preparation in teeth

The teeth of each restorative protocol were randomly sorted into two groups (n=5) using www.random.org, and each group was subjected to a different method to reaccess the root canal for retreatment: Group WLHP, high-speed handpiece with white lighting (Kavo, Joinville, SC, Brazil) using 1.3 mm rounded high length diamond bur (#1013 HL, KG Sorensen, Cotia, SP, Brazil) and Group VLHP, ultraviolet LED light high-speed handpiece (Ultra Vision Cobra LED, Gnatus, Ribeirão Preto, SP, Brazil) (Figure 1C). Root canal access preparation was performed until the gutta-percha in the root canal orifices were localized.

Micro-CT analysis

To evaluate the amount of intact dentin removed by the access cavity preparation, the teeth were scanned after restoration and after reaccess preparation using a micro-CT device (SkyScan 1272, Bruker, Belgium). The image acquisition took approximately thirty-six minutes for each tooth, with a standardized position, using the following parameters: an exposure time of 1800 ms, an energy 100 KV-100 μ A, a 180° rotation with a step of 0.700, a Cu filter 0.11 mm thick, and a 15 μ m voxel size.

The images acquired by micro-CT were imported to a computer and rebuilt using Nrecom software (version 1.6.10.1, SkyScan, Bruker, Belgium) with approximately 1.050 slices, respecting the anatomical limits of the samples. The reconstructed images were overlaid using DataViewer software (version 1.5.1.2, SkyScan, Bruker, Belgium) and then analyzed with micro-CT analyzer software (CTAn, version 1.13, SkyScan, Bruker, Belgium) (14). The restored tooth reference image (Figure 1D) and the tooth image after endodontic re-access were superimposed (Figure 1E). A volume difference image (Diff), which represented the volume of dentin removed during root canal access for retreatment, was generated. Eight hundred layers with a resolution of 0.4 μ m were used to generate the volume of dentin removed. The volume was obtained in mm³, and the percentage was calculated as a function of the total volume of each tooth. Using CTVOL software (CTVol, version 2.0, SkyScan, Bruker, Belgium), 3D images of the volume of dentin removed were generated. The number and face (M: Mesial; D: Distal; B: Buccal; and L: Lingual) of the damaged dentin walls in the pulp chamber and crown during access to the root canal for endodontic retreatment were recorded (Figure 1F).

Statistical analysis

The normality of the distributions (Shapiro Wilk's test) and the equality of variances (Levene's test) of the dentin volume removal (mm³) data were tested, followed by parametric statistical tests on the data. Two-way analysis of variance (ANOVA) was performed, followed

by Tukey's test. The number and location of the dentin walls affected were described using the frequency. All the tests employed a significance level of $\alpha = 0.05$ and were carried out with the statistical package Sigma Plot version 13.1 (Systat Software Inc., San Jose, CA, USA).

RESULTS

The dentin volume removed (mm^3) during root canal access preparation for endodontic retreatment for all the tested combinations is shown in Table 1. Two-way ANOVA revealed that the restorative material ($P < 0.001$) and handpiece lighting ($P < 0.001$) had significant effects on only the dentin removal in the pulp chamber. The material used ($P = 0.812$) and handpiece lighting ($P = 0.452$) had no influence on the dentin removal in the coronal region. In general, dentin removal was more evident in the pulp chamber than in the coronal portion. When using GIC for filling the pulp chamber, the dentin removal was significantly lower than when flowable bulk fill composite resin was used, irrespective of handpiece lighting used.

The affected faces and the numbers of damaged dentin walls during access for root canal retreatment are shown in Table 2 and Figure 2. The use of GIC on the pulp chamber reduced the number of involved dentin walls affected by dentin removal during access preparation. The buccal and lingual walls were the most affected walls in the pulp chamber. The volumetric representation generated by micro-CT analysis is shown in Figure 2. Greater dentin removal was observed in the pulp chamber than in the coronal portion.

DISCUSSION

The use of the white light high-speed handpiece associated with GIC to fill the pulp chamber reduced the volume of dentin removed from the pulp chamber and resulted in fewer affected dentin walls.

Preservation of the remaining coronal dentin should be a primary goal to prevent fractures in endodontically treated teeth (15). The stiffness of the cusps is significantly reduced when endodontic access involves the axial walls of dentin adjacent to each proximal cavity (16). Endodontic access and axial walls can weaken the tooth by up to 60% compared with nonrestored teeth (15). The final shape of the root canal access is clinically relevant because poorly performed access preparation may compromise the next steps of the treatment, resulting in an increased risk of treatment failure (17). The remaining composite resin can create an obstacle for endodontic file access, making correct instrumentation more difficult. To avoid this situation, a straight-line pathway into canals is necessary to enhance instrumentation efficacy and prevent procedural errors (18).

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3 Although the success rate of endodontic treatment is close to 90% (19), even well-
4 performed root canals may fail (20). Endodontic retreatment is the most recommended option
5 in solving these failures, demanding the removal of restorative materials for root canal access.
6 Maintaining dentin integrity should be a goal when access to the root canal for retreatment is
7 necessary, as intact dentin removal can increase tooth fracture after the final restoration (21).
8 During root canal access for retreatment, a significant amount of dentin can be removed
9 laterally and from the pulp floor, which might lead to a higher occurrence of fractures (22). The
10 use of micro-CT is an important non-destructive methodology that allows interpretations of
11 images before and after clinical protocols (23).

12
13 Depending on the material used for filling the pulp chamber and the handpiece lighting
14 used to perform root canal access preparation for retreatment, the dentin walls may be better
15 preserved. In the case of retreatment necessity, the restorative material used for filling cavities,
16 mainly the pulp chamber in molar teeth, after endodontic treatment is determinant to avoiding
17 accidental dentin removal (24). The use of flowable bulk fill composite resin to fill the pulp
18 chamber makes insertion easy, reducing time and bubble formation (25). However, the
19 similarity of the color of this fill to that of root dentin (10) makes it difficult to identify the exact
20 limit of the restoration during the removal process. The use of bulk fill flowable composite
21 resin resulted in more intact dentin removal during root canal reaccess preparation. Greater
22 damage to the floor was verified, increasing the possibility of accidental perforation (7). In
23 contrast, when the pulp chamber was filled using GIC, lower damage to the pulp floor was
24 observed. The higher stiffness of the bulk fill flowable composite resin requires more force
25 applied during material removal, increasing the possibility of undesirable contact of the bur
26 with the root dentin. Mainly when associated with white lighting, GIC removal from the floor
27 of the pulp chamber was facilitated by better visualization and by its texture and lower stiffness
28 (8). In some cases, the use of only an exploratory probe with a straight and sharp tip was enough
29 to remove the GIC from the walls, resulting in less accidental dentin removal. This study
30 demonstrated that using GIC to fill the pulp chamber and seal the entrance to the root canal in
31 molar teeth is recommended for reducing dentin removal during reaccess preparation for root
32 canal retreatment. The use of ultraviolet light was tested to demonstrate that the fluorescence
33 of the composite resin tested could more easily identify the limit of the restorative material. The
34 ultraviolet light helped to identify the material only at the occlusal surface during the initial
35 removal because the light intensity was able to highlight the fluorescence of the composite resin
36 (11, 12). The obstruction of the view with a high-speed handpiece head, as well as the angle of
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direction, and consequent reflection of the lighting on the tooth crown limited the visualization in deeper regions.

In conclusion, the use of GIC for filling the pulp chamber reduced accidental dentin removal. The use of handpieces with ultraviolet light offered no advantage in preventing dentin removal. When using a handpiece with white light, the intact dentin removal was lower than when using a handpiece with ultraviolet light, irrespective of the restorative material used. Extra caution should be exercised when removing restorative material located on the palatal and especially on the buccal walls of the pulp chamber.

RESUMO

Este estudo avaliou os efeitos do cimento de ionômero de vidro (GIC) e da resina composta fluida bulk fill (BFRC) usados como preenchimento da câmara pulpar; e o tipo de iluminação das turbinas de alta rotação na remoção dentinária após cavidades de acesso para retratamento endodôntico em dentes molares. Vinte molares superiores foram tratados endodonticamente. Dez dentes foram restaurados usando BFRC (Opus Bulk Fill Flow APS, FGM) para preencher a câmara pulpar e dentina coronária; e resina composta convencional (Opallis, FGM) para restaurar a camada de esmalte. Os outros dentes foram restaurados usando GIC (Maxion R, FGM) para preencher a câmara pulpar e resina composta (Opallis, FGM). As amostras foram divididas em dois grupos e os canais radiculares foram novamente acessados com turbina de alta-rotação com iluminação branca ou ultravioleta. Os dentes foram escaneados usando micro-CT antes e após o novo acesso ao canal radicular. O volume de dentina removida foi calculado e os dados foram analisados por ANOVA bidirecional e teste de Tukey ($\alpha=0,05$). As paredes de dentina afetadas foram classificadas e descritas pela frequência. A reabertura do canal radicular com GIC resultou em menos paredes afetadas da câmara pulpar e menor volume de dentina removida no assoalho. Nenhum efeito foi observado nas paredes de dentina coronária considerando aos protocolos de preenchimento. A turbina com iluminação branca reduziu a remoção de dentina da câmara pulpar, independentemente do protocolo de restauração utilizado. O uso de turbina com iluminação branca e GIC para preencher a câmara pulpar reduziram a remoção de dentina do assoalho e afetaram menos paredes dentinárias.

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Table 1. Mean and Standard deviation values of dentin volume wear (mm³) during root canal access for endodontic retreatment.

Restorative Protocols	White Light		Ultraviolet Light	
	Pulp Chamber	Crown	Pulp Chamber	Crown
Bulk Fill Composite Resin	8.8 (1.1) Bb	3.3 (1.6) Aa	11.4 (3.2) Bb*	4.9 (1.2) Aa
Glass Ionomer Cement	5.0 (1.9) Aa	3.8 (1.0) Aa	6.9 (2.4) Ba*	3.5 (1.8) Aa

Different letters and * represent significant differences between the factors. Capital letters used to compare tooth regions for each lighting mode; lower case letters used to compare restorative materials used to fill the pulp chamber. * Used for comparing lighting modes within each region. Comparisons by Tukey's test ($P < 0.05$).

Table 2. Number and location of damaged dentin walls generated during re-access of root canals for endodontic retreatment.

Restorative Procedures	White Light								Ultraviolet Light							
	Pulp Chamber				Crown				Pulp Chamber				Crown			
	M	D	B	L	M	D	B	L	M	D	B	L	M	D	B	L
Bulk Fill Composite Resin	2	3	3	2	2	0	1	1	1	0	5	3	2	1	3	1
Glass Ionomer Cement/Incremental Technique	1	1	4	5	1	2	1	2	0	3	3	1	1	2	2	1

M: Mesial; D: Distal; B: Buccal; and L: Lingual.

Figures Legends

Figure 1. A. Schematic illustration of the flowable bulk fill composite resin/conventional composite resin group; B. schematic illustration of the glass ionomer cement/conventional composite resin group; C. handpiece with ultraviolet light during re-access opening; D. micro-CT image of the sample after endodontic treatment and coronal restoration; E. micro-CT image of the sample after re-access opening; F. 3D volumetric superposing micro-CT before and after re-access opening.

Figure 2. Volumetric micro-CT representation of dentin removed from coronal and pulp chamber regions, considering the restorative materials and handpiece light used for retreatment root canal access; A. handpiece with ultraviolet lighting/BFRC; B. handpiece with white lighting/BFRC; C. handpiece with ultraviolet lighting/GIC; D. handpiece with white lighting/GIC; (l, lingual face; b, buccal face; m, mesial face; and d, distal).

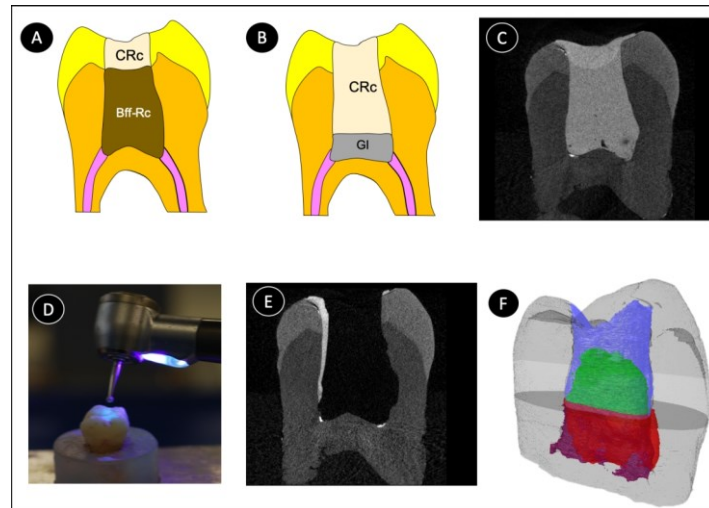


Figure 1. A. Schematic illustration of the flowable bulk fill composite resin/conventional composite resin group; B. schematic illustration of the glass ionomer cement/conventional composite resin group; C. handpiece with ultraviolet light during re-access opening; D. micro-CT image of the sample after endodontic treatment and coronal restoration; E. micro-CT image of the sample after re-access opening; F. 3D volumetric superposing micro-CT before and after re-access opening.

121x87mm (300 x 300 DPI)

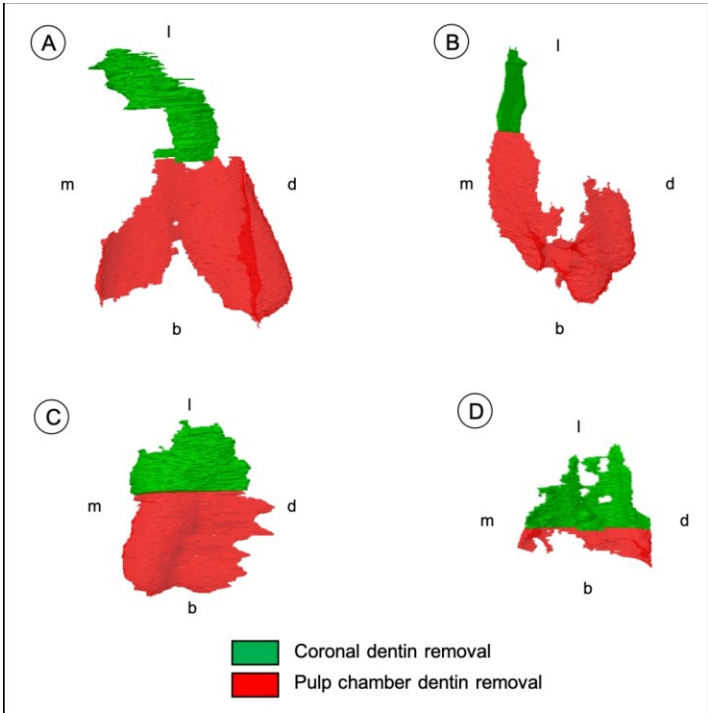


Figure 2. Volumetric micro-CT representation of dentin removed from coronal and pulp chamber regions, considering the restorative materials and handpiece light used for retreatment root canal access; A. handpiece with ultraviolet lighting/BFRC; B. handpiece with white lighting/BFRC; C. handpiece with ultraviolet lighting/GIC; D. handpiece with white lighting/GIC; (l, lingual face; b, buccal face; m, mesial face; and d, distal).

103x104mm (300 x 300 DPI)

3.2. Capítulo 2 – Artigo a ser enviado para publicação no periódico *Journal of Endodontics*

Fiber post removal using guide access, ultrasonic inserts and diamond burs – Analysis of efficiency and effectiveness.

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Short title: *Dentin removal in fiber post removal*

Keywords: *Fiberglass post removal, dentin removal, root perforation, canal alignment.*

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Fiber post removal using guide access, ultrasonic inserts and diamond burs – Analysis of efficiency and effectiveness.

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ABSTRACT

Introduction: Fiber post can fracture and root canal can need to be retreated demanding the necessity of fiber post removal. The undesirable root dentin removal and the possibility of root perforation make this process a challenge procedure. The aim of this cone beam–computed tomographic study was to evaluate the influence of the fiber post removal technique on the root dentin removal, the preservation of the original root canal alignment and the root perforation after fiber post removal. **Methods:** Thirty extracted human maxillary molars with fully formed apices and were randomly assigned to 3 groups: mic-Ult, FGP removed using ultrasonic inserts with microscopy magnification; mic-DiB, FGP removed using diamond burs with microscopy magnification; and Endo-G, using endodontic guide access. The root canal accesses were performed using rounded diamond bur and microscopy magnification. Samples were scanned initially, after root canal access and after FGP removal. The CBCT images were reconstructed by using InVesalius for resin volume of structure removed and Mimics softwares (Materialise) to evaluate the root canal alignment and the root perforation. The time spent for root canal access and FGP removal were recorded. **Results:** The volume of the resin composite removed for root canal access were similar for all groups, proving the standardization of this process. Endo-G showed a greater preservation of the original root canal alignment, caused less root dentin removal and spent less time than mic-Ult and mic-DiB. The time consumed. **Conclusions:** Within the limitations of this study, Endo-G may lead to a better preservation of the original canal alignment, save root dentin structure and consume less time during FGP removal compared with mic-DiB and mic-Ult.

Keywords: Fiberglass post removal, dentin removal, root perforation, canal alignment.

Significance: The use of guided endodontics has been used in complex conditions to reduce the possibility of iatrogenic effects and excessive dentin removal. For removing FGP the use of guided endodontics demonstrated to be a promising alternative.

INTRODUCTION

The adhesively cemented fiberglass posts may be removed due the post fracture¹⁻⁵, or when the tooth require endodontic retreatment⁶⁻⁸. Mechanical removal using drills, specific devices developed by post manufactures, or ultrasonic methods have been used to FGP removal⁷⁻¹². These techniques may generate complication such as excessive loss of tooth structure¹³, deviations in the root canal path, perforation and heating^{8,14}, which is a particular concern when using ultrasonic vibration¹². The operator experience can also influence the quantity of surround dentin removed and time consumed for post removal^{8,10}. Recently, three-dimensional guided removal posts have been proposed as alternative to the conventional techniques¹⁵⁻¹⁷. Guided endodontic was initially developed to access calcified root canals^{18,19}. This concept combines information obtained by cone beam computed tomography (CBCT), surface scanning of teeth or models, and virtual planning to obtain a prototype guide used to endodontic access^{9,19,20}. According to current literature, this method presents precision²¹, preserve the tooth structure, avoid perforations, reduces working time, and is not influenced by the operator's experience¹⁹.

To date, on the best of the author's knowledge there are no studies that compare the dentin loss of and the alteration of the canal transportation promoted by FGP removal using guided endodontics, compared with ultrasonic inserts and diamond burs. The aim of this *in vitro* study was to evaluate the time consumed, the dentin loss and the canal transportation promoted during the removal of FGP by using endodontic guide, ultrasonic or diamond drills through CBCT associated with 3D reconstruction softwares analysis. The null hypothesis was that the endoguide would not reduce the time consumed for FGP removal and would not in difference between the methods.

MATERIAL AND METHODS

Teeth selection, endodontic treatment and fiber glass post cementation

Thirty freshly extracted maxillary first permanent human molars with fully formed apices were used in accordance with the local ethics committee (protocol 85533718.1.0000.5152). The teeth had the lingual cusp and coronal

portion removed and the pulp roof was removed simulating the structured compromised teeth that required endodontic treatment. The teeth were embedded in polystyrene resin (Crystal, Piracicaba, SP, Brazil) and mounted in a polyacetal device designed for this study that allowed the stabilization and standardization of the positions during all procedures (Figure 1).

The endodontic treatment was performed using Logic system (Easy Equipamentos, Belo Horizonte, Brazil) for root canal preparation, then the root canals were filled with gutta-percha and resinous sealer, AH Plus (Dentsply, Pennsylvania, USA). The root palatal canal was prepared with 2/3 of root length, leaving at least 5mm of endodontic filling material the fiber glass post (#2, WhitePost, FGM, Joinville, SC, Brazil) was cemented using self-adhesive resin cement (Rely U200, 3M Oral Care, St. Paul, MN, USA).

Cone beam computerized tomography (CBCT) images and FGP removal

The initial CBCT images were taken with the XP 68 Prexion 3D, (Tokyo, Japan) device at 110 kV, 6.19 mAs, using a FOV of 5cm. The root canal access of all teeth was performed using rounded diamond bur (#1014, KG Sorensen) and Endo-Z bur (Prima Dental, Gloucester, New England) to access the FGP into the entrance of the root canal. The CBCT images were obtained after root canal access following the same protocol. The teeth were randomly allocated in three groups for FGP removal:

Mic-Ult: FGP was removed using E3D and E2D ultrasonic inserts (Helse, São Paulo, SP, Brazil) accoupled to an ultrasonic device (Newtron Satelec, Merignac, France) with clinical microscopy magnification (OPMI Pico Zeiss, Jena, Germany);

Mic-DiB: FGP was removed using rounded diamond bur (1011 HL, KG Sorensen, Barueri, SP, Brazil) accoupled a high-speed handpiece (Dabi-Atlante, São Paulo, Brazil) with clinical microscopy magnification (OPMI Pico Zeiss, Jena, Germany) under continue irrigation with saline solution;

Endo-G: FGP was removed using prototyped endodontic guide with drill diameter according to the endodontic post length and diameter (Ref 103.395,

Neodent, Curitiba, Brazil) at 950 rpm and 5-Ncm torque. Initially, the teeth were scanned to generate the STL file, which was uploaded to a guided implant software (CoDiagnostiX, Dental Wings, Montreal, Canada) and the access was planned to all samples with a 1.3mm diameter drill (Ref 103.395, Neodent, Curitiba, Brazil) from the beginning to the end of the post. The 3D-printing of the guide was performed by a Moonray DLP 3D-Printer (Sprintray, Los Angeles, USA) with a Surgical Guide Resin (Sprintray, Los Angeles, USA). The guide made every two samples was tested in model to assess adaptation to the supporting structures, insertion axis, mismatch or any alteration that could change the accuracy of the guided access.

The FGP removal was confirmed when the gutta-percha was detected by using microscopy magnification for groups Mic-Ult and Mic-DiB and at the end of the bur planned length penetration for Endo-G. The time spent for root canal access and fiber post removal was recorded for all specimens. The CBCT images were obtained again after fiber post removal.

Analysis of dentin removal during root canal access and FGP removal

Evaluation of tooth structure wear was performed using InVesalius software (Renato Archer Information Technology Center, Campinas, São Paulo, Brazil) on an Macbook Air, operational system Sierra 10.12.6 (Apple Inc, Sunnyvale, California, USA). The threshold was established by gradually increasing the minimum density value until the support was wholly excluded from the image. The initial and final volume of enamel and dentin of each tooth was calculated in cubic millimeters. The volume of tissue removed at the coronal opening and FGP removal was calculated using the following formula: $V_r = V_t - V_f$, where the V_t was the volume of tooth after tissue removed at the coronal opening and V_f was the volume of tooth after FGP removal.

Qualitative analysis of root canal alignment and root canal perforation

The different hard tissues visible on CBCT images were identified using interactive medical imaging software (Mimics 16.0; Materialise, Leuven, Belgium). Segmentation of the tooth structures and restorative materials were accomplished based on image density thresholding. The 3D reconstruction was

used for define the root alignment and to generated the 3D reconstructed images before and after fiber post removal that were qualitatively evaluated by 3 experience professionals regarding the alteration of root canal alignment and the presence of root canal perforation following the scores:

- a. Score 0 – no root canal alignment alteration and no root perforation;*
- b. Score 1 – small alteration without apical center modification and no root perforation;*
- c. Score 2 – moderate alteration with apical center alteration without root perforation;*
- d. Score 3 – Severe alteration with root perforation.*

Statistical analysis

Volume of dentin (mm³) and time spent (minutes) data were tested for normal distribution (Shapiro-Wilk) and equality of variances (Levene test), followed by parametric statistical tests. One-way analysis of variance (ANOVA) was followed by the Tukey test. The qualitative analysis of root canal alignment and root perforation were subjected to the chi-square test. All tests used statistical significance of $\alpha = 0.05$ level of and all statistical analyses were carried out with Sigma Plot version 13.1 (Systat Software Inc., San Jose, CA, USA).

RESULTS

Time spent for root canal access using microscopy and diamond burs and for fiber post removal are shown in Fig. 2. Similar time was spent for root canal access for all groups ($P = 0.200$). The fiber post removal using microscopy and ultrasonic inserts spent significantly more time than microscopy and diamond burs protocol. The use of Endo-G for fiber post removal spent significantly less time than both other techniques.

The volume of resin composite removed during for root canal access using microscopy and diamond burs and the volume of root dentin removed during the fiber post removal are shown in Fig. 2. Similar volumes of resin

composite were removed during root canal access for all groups ($P = 0.203$). The fiber post removal using microscopy and diamond burs caused significantly more root dentin removal than when used microscopy and ultrasonic insert protocol ($P < 0.001$). The use of Endo-G for fiber post removal resulted in significantly smaller volume of root dentin removal time than both other techniques ($P < 0.001$).

The frequency root canal transportation, the root canal perforation and the representative 3D reconstruction of specimens for all groups before and after fiber post removal are shown in Fig. 3. Fiber posts removed using microscopy/ultrasonic insert and microscopy/diamond burs caused significantly more root canal alignment alteration and root perforation than Endo-G ($P < 0.001$).

DISCUSSION

This is the first study comparing dentin loss and treatment duration promoted by FGP removal using guided access, ultrasonic and diamond burs in molars. The null hypothesis was rejected as guided access outperforms the other techniques in the investigated parameters. These finds are confirmed recent clinical reports which demonstrated that fiber post removal using endodontic guide is safer, maintain the axis of the drill in the root canal axis and contribute to the preservation of root structure¹⁵⁻¹⁷. This method was compared to ultrasonic devices and burs which are generally used for disassembly the FGP^{7, 8}.

The use of conventional diamond burs to remove FGP is usually carried out through a hole in the center of the post and for additional milling with large-diameter drills^{9,11}. This kind of removal process is prone to accidents as it is difficult to control high-speed burs within small space of root canals, which tend to slip off the surfaces⁸. This situation was noted in current study as high amount of surround dentin was removed in the drilled group. This protocol also caused the alteration of root canal alignment and resulted in one specimen with root canal perforation. Ultrasonic devices are also commonly used for the removal of luted posts being related to reduced quantity of dentin removed and risk of root

perforation¹³. The ultrasonic energy is not transmitted to the post and the cement as occurs on metal posts⁸. The resin-based cements neutralize the ultrasonic vibrations and fiber post/resin cement removal occurs mainly by the action of ultrasonic cutting tips which turns the dental structure wear unavoidable. The ultrasonic insert protocol spent significantly considerably more time than other techniques and also caused root dentin perforation in two specimens. Ultrasonic inserts used into the root canal can heat the dentin¹², needs clinical experience, familiarity in handling ultrasonic devices¹⁰, and use of magnification¹³. Post removal with ultrasonic tips may took longer than when associated with drill method, which is in part confirmed by current literature²².

Other alternatives for FGP removal as the use of Er:YAG laser¹², and specific kits have been evaluated^{8,9,11,23}. It has been demonstrated that referred methods are faster than ultrasonic tips^{11,12,23,24}. However, in most cases the type of fiber post is unknown and removal kits are ineffective because they are specifically designed by their respective post systems^{9,11}. Guided endodontic emerges as a new alternative for management of complicated cases of FGP removal¹⁵⁻¹⁷. resulting in faster and secure procedure than conventional methods. Even for an experienced endodontist using operating microscope, conventional access with diamond burs or ultrasonic inserts resulted in more dentin wear, alteration on the root canal alignment and root dentin perforation during post removal than guided removal. Previous studies evaluating the use of endodontic guides for access simulated calcified canals demonstrated lower dentinal loss and working time, and higher canal location than conventional technique regardless of previous professional experience²⁵. Although the present study did not compare the performance of removal methods depending on the operator's skills, it is evident that the use of virtual guided planning for FGP removal significantly decreases the chances of iatrogenic occurrences. However, it is important emphasize that this method can also result in deviation of root canal axis as observed in one sample, indicating that it's the utmost importance perform radiographic images during the post removal to avoid catastrophic occurrences.

Another point of interest in current study was determine the role that the access cavity would play in total dentin removal. For this purpose,

intermediate CBCT images were performed after design the access cavity, with no statistical differences found between the groups in this stage. Although pre-clinical studies have used microtomographic images for analysis of canal deviation and changes in dentinal volume promoted during post removal^{11,13}. the use of CBCT was chosen because this is the image exam used for planning the treatment.

Despite the promising results of studies enrolling the guided endodontics approach¹⁸, is important to emphasize that in 3 samples were observed expressive amounts of residual materials on the root canal walls. These residues were also observed in drills and ultrasonic groups, as previously demonstrated by other studies^{23,24}. Most fiber post removal techniques leave cement, gutta-percha, or fiber post residues on the dentin walls which is undesirable^{9,11,23,24}. In this way, some improvements need to be performed for use guided post removal as the development of special drills to differential cut of fiber post and intermediate restoration, that allow better irrigation and avoid temperature increase¹⁷. and the specific design for posterior tooth due the limited accessibility in the posterior area^{16,21}. The absence of a model that mimics the insertion of the endodontic guide in upper molar region was the major limitation of the present study as the samples were not inserted in jaw models, which may have facilitated the post removal and reduced the total time necessary for the procedures. This might have not been a source of inaccuracy as all the tooth were included similarly. In conclusion, within the limitations of this in vitro study, the guided endodontics access reduces the treatment duration and amount of dentin loss promoted during the fiber post removal.

Acknowledgments

The authors deny any conflicts of interest related to this study.

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FIGURES AND LEGENDS

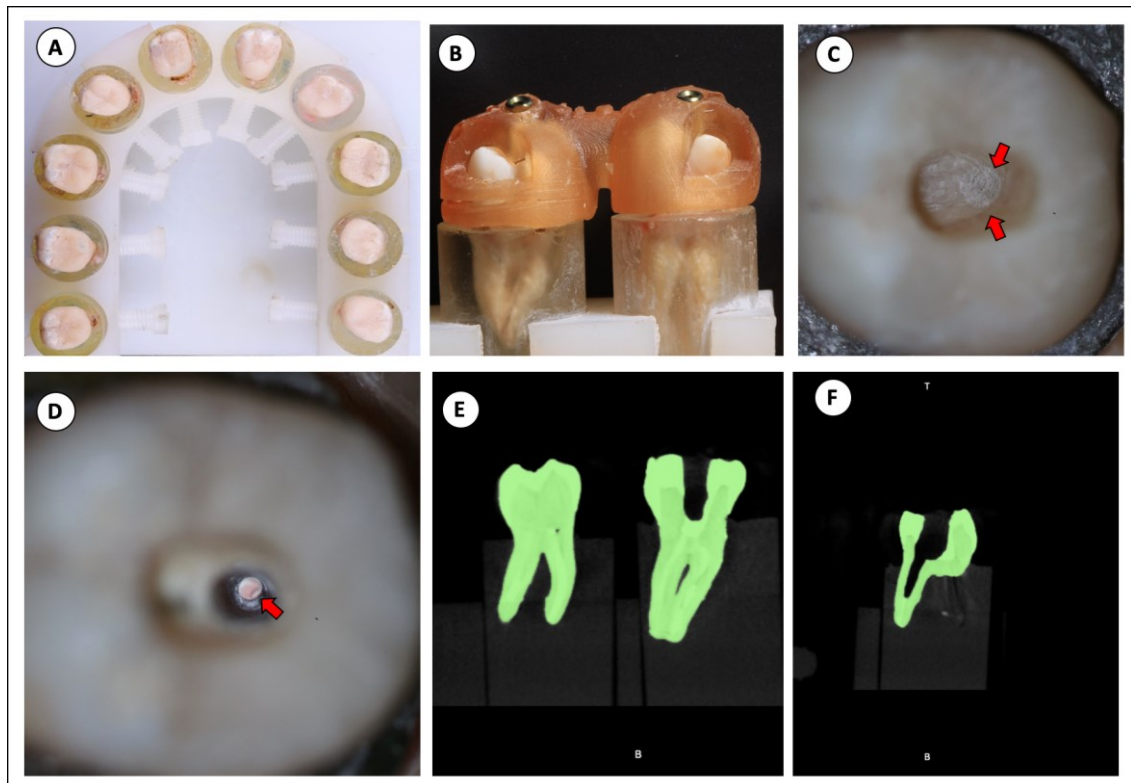


Figure 1. A. Polyacetal device with 10 samples fixed for root canal access and FGP removal; B. prototyped printed guide installed and fixed on the pared specimens; C. Root canal access finalized with visualization of FGP (red arrow); D. FGP removal finalized with visualization of gutta-percha (red arrow); E. 3D reconstructed images of specimens after root canal access; F. 3D reconstructed images of specimens after fiber post removal.

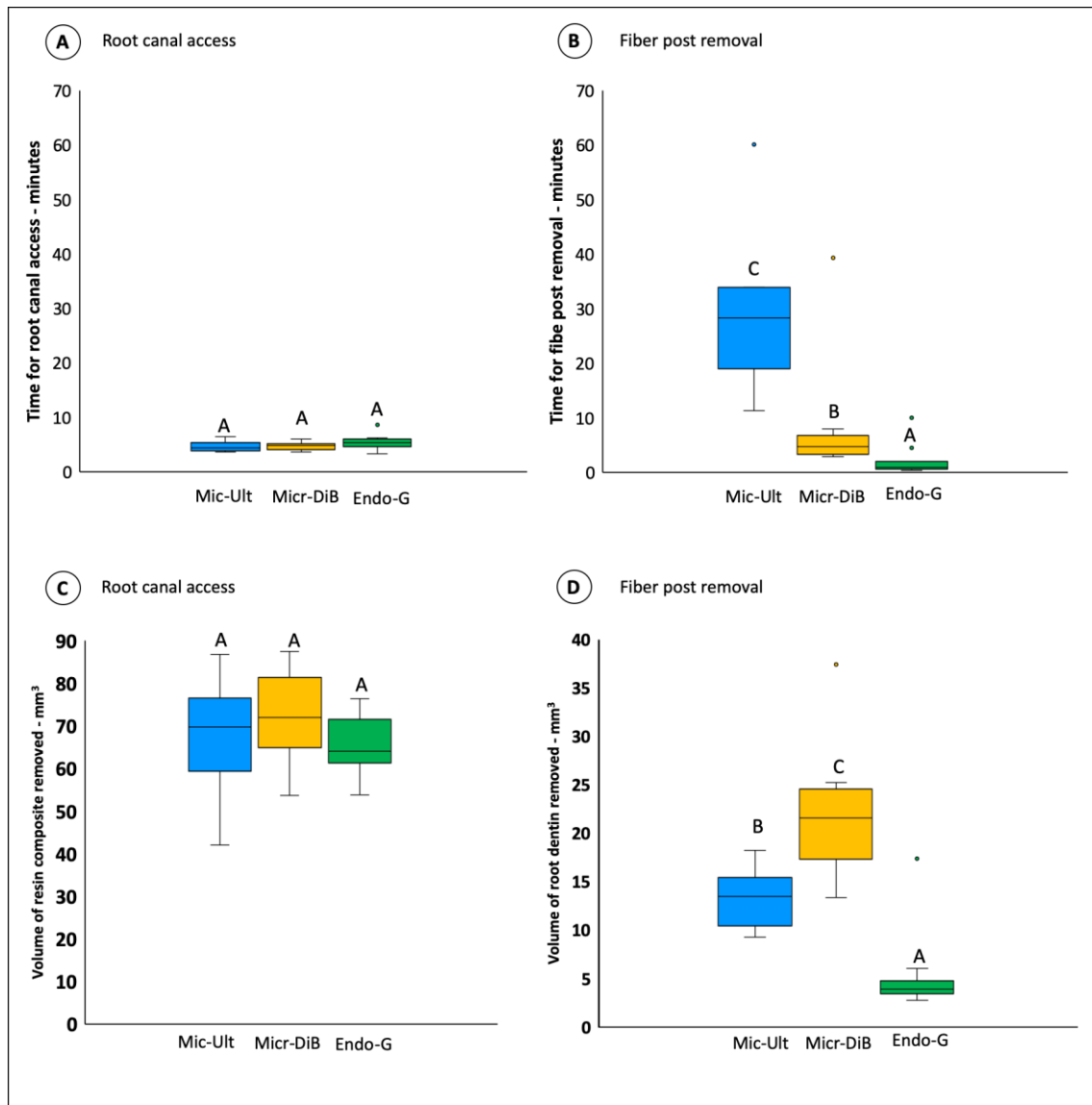


Figure 2. A. Time (minutes) spent for root canal access using microscopy visualization and diamond bur; B. Time (minutes) spent for FGP removal by using three protocols; C. volume of root dentin removed (mm^3) after root canal access for all groups using spherical diamond bur; D. volume of root dentin removed (mm^3) after FGP removal using three protocols; different letter means significant difference among tested protocols (Tukey test, $P < 0.05$).

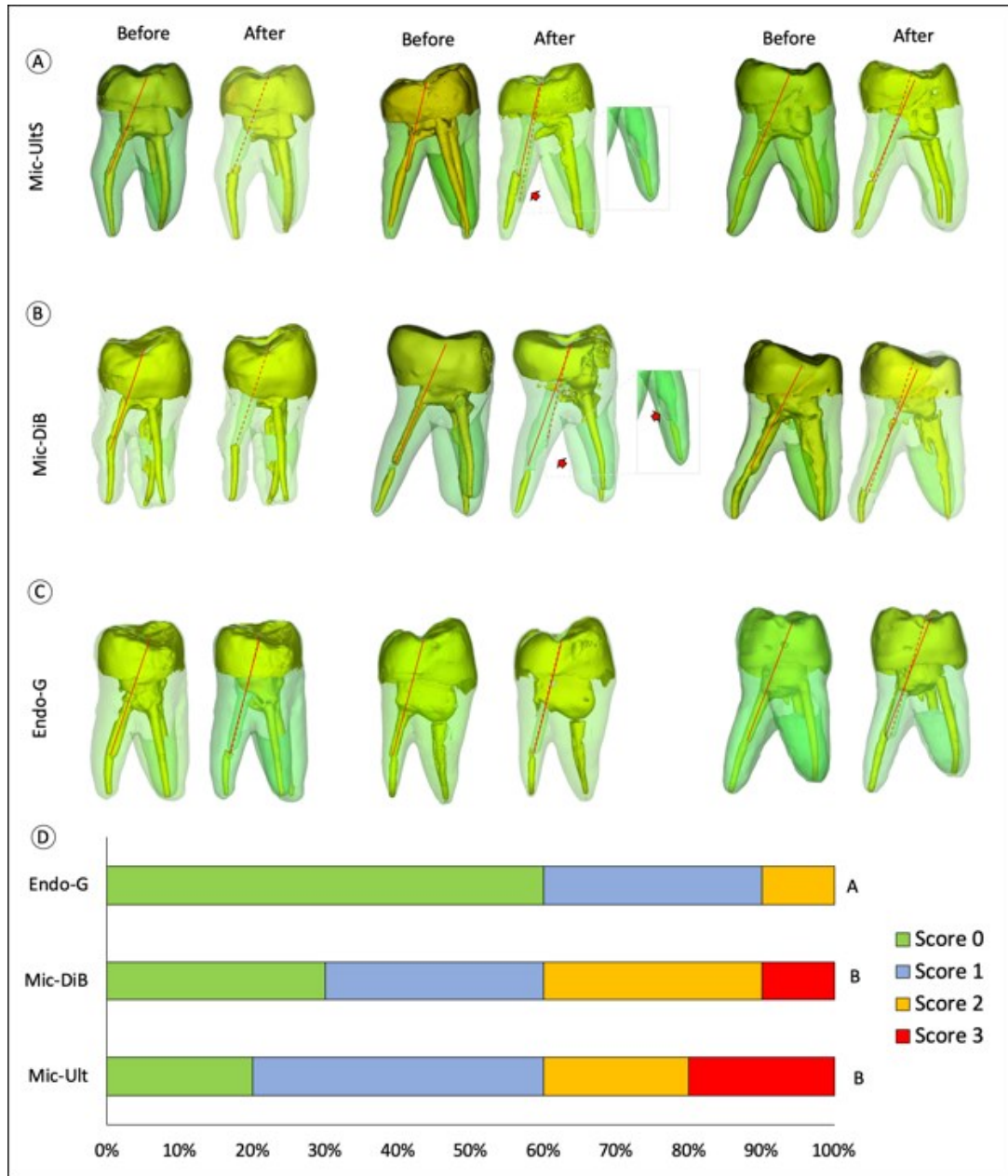


Figure 3. Representative 3D images of specimens before and after root canal access and FGP removal using all protocols; A. specimens of Mic-Ult group showing considerable root dentin removal located closer to pulp chamber; red arrow shows the root perforation; B. specimens of Mic-DiB group showing considerable root dentin removal along the entire root canal; red arrow shows the root perforation; C. specimens of Endo-G showing consistently less root dentin removal along the entire root canal; D. distribution of root canal alignment alteration and root dentin perforation; different letter means significant difference among groups (Qui-square test, $P < 0.05$).

3.3. Capítulo 3 – Artigo clínico a ser enviado para publicação no periódico *Journal of Prosthodontics*

Guided access and ultrasonic inserts under operatory microscope as an alternative technique to failure in fiber post.

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Guided access and ultrasonic inserts under operatory microscope as an alternative technique to failure in fiber post.

ABSTRACT

This study presents two cases report of fiberglass post (FGP) removed by using digital planning endodontic guide. The first clinical case demonstrated a successful protocol for removal a fractured FGP cemented adhesively in a maxillary lateral incisor. The second clinical case shows the therapeutic alternative in unsuccessful removal of fiber posts by guided access. After the virtual planning made by CBCT and the oral cavity scanning, during the removal procedure there is any deviation in the intended direction evaluated by trans operative radiographs. This procedure avoided iatrogenic procedures, the wear of the fiber post may also be performed by ultrasonic diamond inserts under microscope magnification, considering it a possible alternative to continue the fiber post removal. The endodontic guide has been gained popularity and shows a promising alternative for FGP removal, however the planning is complex and the execution can be associated with constant x-ray evaluation.

INTRODUCTION

Fiberglass posts (FGP) have been increasingly used due to their excellent aesthetic properties, low cost and biomechanical properties.¹ Flexural strength and modulus of elasticity similar to dentin optimize the stress distribution to the root dentin, reducing the chances of catastrophic fractures.^{2,3} Although FGP has clinical success greater than 90%,⁴ failures can occur, which are always undesirable and can compromise the maintenance of the tooth. The most frequent complication is post debonding; which is influenced clinically by many factors, such as the amount of remaining dental structure, occlusal pattern, periodontal status, parafunction, presence of ferrule, and quality of bonding interaction mediated by root dentin and FGP surface treatment.⁴⁻⁷

The treatment of the adhesive surface, the absence of bubbles and porosity and the thickness of the cement layer influences the performance of the restorations.⁶ Endodontic procedures performed before the luting of FGP may jeopardize the cement-dentin bonding interaction.⁸ Endodontic failures can also compromise the longevity of restored teeth, requiring its removal the FGP for performing the endodontic retreatment. The similarity of color between root dentin, the cement layer and the FGP, associated to the improvement of adhesive systems has made the removal of FGP a complex challenging.⁹ The FGP can be removed by fragmentation within the root, which can result in accidental dentin removal and severe complications.¹⁰ Previous endodontic treatment and preparation with drills for post installation reduces the dentin thickness in critical areas, weakening the root structure.¹¹ During the removal of FGP careful attention should be done regarding the dimensions of the access cavity preparation, the diameter and length of the FGP and the compatible dimensions of the instrument used for FGP removal, in order to minimizing iatrogenic removal of healthy dentin, predisposing to root fracture.¹²

The most commons methods used to remove FGP are drills,^{13,14} removal kits for a specific FGP,⁹ ultrasonic inserts,¹⁴ and recently three-dimensional (3D) guided endodontics.¹² The endodontic guide was generated from the perspective initially used in the implantology, for the installation of guided implants. The clinicians started to use the 3D information obtained from cone beam computed tomography (CBCT) associated with the information obtained through intraoral scanning to create a guided virtual planning.^{15,16} This technique has improved the performance of apical surgeries,¹⁶ the location of calcified canals in previously traumatized teeth,¹⁶⁻¹⁹ and also FGP removal.^{10,12}

The 3D guided endodontics consider the root anatomy and canal direction to realization of the access cavity and FGP removal.^{10,12} This protocol has been described to make the procedure safer, more predictable, and can also preserve greater amount of root dentin.¹⁶ However, clinical reports of its use for removing FGP have not raised questions regarding the limitations of the guided procedure, only extolling its advantages. Thus, the aim of these two case reports were to describe a successful FGP removal using guided endodontics and also

the limitations of the technique when the direction of access does not match that of virtual planning.

CASE REPORTS.

Both cases presented were referred by clinicians to endodontics specialist to remove a fractured FGP, aiming to installing another post and indirect restoration. The referrers did not send any information about the brand and model of the FGP used, or which cement was used for FGP cementation. Patients received information regarding technical complexity of FGP removal, the alternative protocols were presented with limitations and risks, then they decided for endodontic guided removal. An informed consent form was signed allowing the scientific use of their images.

Case 1

An 80 years old male patient attended the dental office with crown and FGP fractures of tooth right central incisor (Fig 1A). There was a necessity for new indirect restoration, after the removal of the FGP. On the initial periapical radiograph, extension of the FGP was checked locating at the middle third of root (Fig 1B). A CBCT scan (Morita Accuitomo 80; J Morita, Kyoto, Japan) was requested for virtual planning and a silicon impression was taken from the upper jaw using a polyvinylsiloxane impression material (Elite HD, Zhermack, Badia Polesine, Italy). The patient was scheduled for a new consultation, considering the time interval necessary for planning and executing the guide. The model was scanned (7 Series Dental Wings, Montreal, Canadá) and aligned with the CBCT data using software CoDiagnostiX (Dental Wings, Montreal, Canadá) to generate a virtual guide. The CBCT specifications were: field of view 5 cm, 16 bits; 481 images; voxel size 0,125 mm³. The association of the data obtained enabled the 3D impression of the endodontic guide (Moonray S, Sprinray, Los Angeles, California). In the following consultation, the guide was tested, confirming the adequate adaptation. Due to the good retention, fixing screws were unnecessary (Fig 1C).

Under constant irrigation with saline solution (Cristália, Itapira, Brazil) the procedure was performed using a drill (Ref 103.395, Neodent, Curitiba, Brazil) in an endodontic engine (XSmart plus, Dentsply, Pennsylvania, USA) with 950 rpm and 4N of torque. At each 3 mm of drill penetration depth, the procedure was stopped, the guided removed and a periapical radiograph obtained with a digital sensor (Fit T2, Microimagem, Indaiatuba, Brazil) using a portable X-ray device (Diox, Microimagem, Indaiatuba, Brazil) This procedure aimed to ensure that the direction of drill remained consistent with the root anatomy as previously planned (Fig 1D). Complete removal of the FGP was confirmed by clinical analysis and radiographic image (Fig 1E). All the procedure was performed without anesthesia, under constant irrigation with saline, without any painful complaints from the patient. After removing the FGP, a temporary crown with intraradicular retention was performed, giving the patient esthetics and tooth function. The patient was returned to the referred professional for definitive rehabilitation.

Case 2

Female patient, 45 years old, was referred by another professional after a failed attempt to remove a FGP. According to the referred professional, a rounded diamond bur in handpiece and direct vision had been used. In the first consultation, a periapical radiographic examination confirmed the deviation from the original direction of FP on tooth # 13 (Fig 2A). The data obtained by CBCT field of view 5 cm, 16 bits; 481 images; voxel size 0,125 mm³ (Morita Accuitomo 80; J Morita, Kyoto, Japan) and the oral cavity scanning made by Trios (3Shape, Copenhagen, Denmark), were used for virtual planning using the software OrthoAnalyzer (3Shape, Copenhagen, Denmark). A virtual guide was created, the model was exported as a standard tessellation language (STL) file, was printed in a 3D printer (Moonray S, Sprintray, Los Angeles, California, USA) for guide printing. At the next consultation, under local anesthesia, the guide was adapted and stabilized by fixation according to criteria defined by Lara-Mendes et al.¹⁸

The removal of FGP was initiated according to the same protocol described on case 1. It was observed in the second radiographic a continuation

of root canal deviation which probably would result in lateral root perforation (Fig 2B). It was opted to suspend the initial plan defined for removing the FGP changing the alternative for using ultrasonic diamond inserts (Helse ultrasonic, São Paulo, Brazil). After absolute isolation and use of a gingival barrier, using an operating microscope (OPMI Pico Zeiss, Jena, Germany), the FGP removal was continued with ultrasonic tip E3D (Helse Ultrasonic, São Paulo, SP, Brazil) coupled to an ultrasonic device (Neo, Dabi Atlantic, Ribeirão Preto, SP, Brazil) at power 20%, without refrigeration. Every 5 seconds, irrigation was performed with 10 mL of saline solution to remove residues, generating cooling of the dental structure and minimizing damage to the periodontal ligament. The delimitation of the FGP and dentin structure was clear (Fig 2C), which facilitated the procedure, but did not prevent undesirable removal of healthy dentin in some portions of the canal. After progressive intervention, it was possible to identify the gutta-percha (Fig 2D), indicating that the FGP removal had been completed. To confirm, a radiographic examination was performed (Fig 2E). Temporary restoration was carried out and the patient was returned to the refereed professional. Due to successive interruptions for irrigation and cooling, the time consumed with this procedure was approximately 3 hours.

Post removal with endodontic guide proved to be quite effective in case 1, where no previous attempt to remove it had been made. In case 2, where the tooth had been previously manipulated by another professional, indicating a lateral deviation, the technique proved to be inadequate, as the professional did not return to the original direction of the root canal. In such case, the careful use of ultrasonic inserts associated with magnification by an experienced professional was more effective.

DISCUSSION

The removal of FGP using the 3D endodontic guide proved to be an effective technical option with preservation of root dentin in case 1, with less time spent and professional fatigue during the procedure. In fact, the use of guided technique has been associated to less time consuming, both by experienced

specialists and by recently graduated clinicians.^{16,20} The accuracy and reproducibility of endodontic guide to access cavity preparation was assessed *in vitro*,^{21,22} and *in vivo*.²³ These studies confirmed that unlike conventional procedures, using special drills or tips for locating the canals, the guides can be used by any professional with minimal deviation.²¹⁻²³ However, most of studies that have been used endodontic guides is restricted to the applicability in calcified canals,¹⁷ anatomic variations,²⁵ or apical surgeries.²⁶ The use of this technique for removing FGP have been also indicated,^{10,12,24} however technical adjustments must be made for the best results.¹²

In case 2, in which the root canal was previously deviated due to inadequate access under high speed diamond bur, the use of drills in a guided access was unable to return the original canal path and the deviation was maintained. Radiographs were taken every 3 mm of the drill's penetration to confirm the path, so the guided removal was interrupted before a possible accident, allowing a re-planning the access. At least two periapical radiographs at different angles during guided access have been recommended to calcified anterior teeth,¹⁸ and in fact this is an essential precaution also when performing guided FGP removal. In fact, during guided access is expected the possible bur deviation ranging from 0.14 mm,²² to 0.47 mm,²³ depending on the region evaluated, which has been classified as acceptable accuracy.²³ Although it is not possible to explain exactly the reasons for the deviation observed in this case, some hypotheses can be raised: such as the use of implant drills whose design and diameter are not specific for removing FGPs, and even the interference that the FGP may have in the CBCT image and consequently in the virtual planning.

The continuity of removal using ultrasonic inserts associated with microscopy magnification was successful, probably due to the great experience of the professional. However, the isolated use of ultrasonic inserts consumes a considerable time,⁹ and without very well-established criteria can generate an increase in temperature on the external surface of the root,²⁷ in addition to excessive and iatrogenic dentin removal.²⁸ The heating generated during this process can potentiate ligament necrosis as demonstrated previously.²⁷ Guided endodontic access also result in dentin loss,²⁰ but in a concentric pattern, in

opposition to conventional access using magnification which leads to unpredictable destruction of root structure despite of the experience of the operator.

Despite the lack of reports of root perforation when performing guided endodontics to coronal access,¹⁶ it is not possible to make the same statement when using it to remove FGP, as case reports are still scarce. Among the factors that may be related to the success of guided endodontics, the CBCT image has a considerable value.^{16,23} CBCT devices whose voxel size is larger, does not allow the visualization of small diameter canals,²³ and probably also interfere in the planning of FGP removal, although there is still no data in the literature. Before requesting the CBCT from the patient, the professional needs to recommend a radiology center whose equipment meets the requirements necessary for endodontic planning, considering that to create higher resolution images the voxel size must be reduced.²⁹ Another factor potentially capable of influencing virtual planning is the method for obtaining the guide, whether performed by oral scanning or scanning the models.¹⁹ The two related cases used different methods to obtain the intraoral impression. The use of conventional impression, followed by the scanning of a gypsum cast, increases the number of steps and consequently can result in summative of small interferences in the final result.³⁰ Therefore, the case 1 would be prone although this is not considered essential to achieve success in the procedure.¹⁶ Dentin thickness should also always be considered when planning guided procedures, as this results in the demand for smaller diameter drills,²² or even the development of drills with taper that accompany the root canal.¹² Especially when it comes to removing the removal of fiber posts, there are still no specific drills for removing this material, using the precepts developed for access to calcified root canals. The development of specific drills for removing fiber posts can further improve the success of the cases by reducing excessive wear, as well as the possibility of deflection of the drill and guide, with consequent deviation of the path.

CONCLUSION

The use of endodontic guided access is a viable alternative for FGP removal, although preexisted deviations in the long axis of the root canal may not be corrected. The use of high resolution CBCT should be recommended for planning, as well as the use of reconstruction software that minimize the effects of electron spreading by the FGPs. The performance of trans-operative radiographs with the drill in position at different depths, is essential for checking the removal direction, reducing the risk of complications such as root perforation. Laboratory and clinical studies seeking to specifically access guided FGPs removal are needed.

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FIGURES

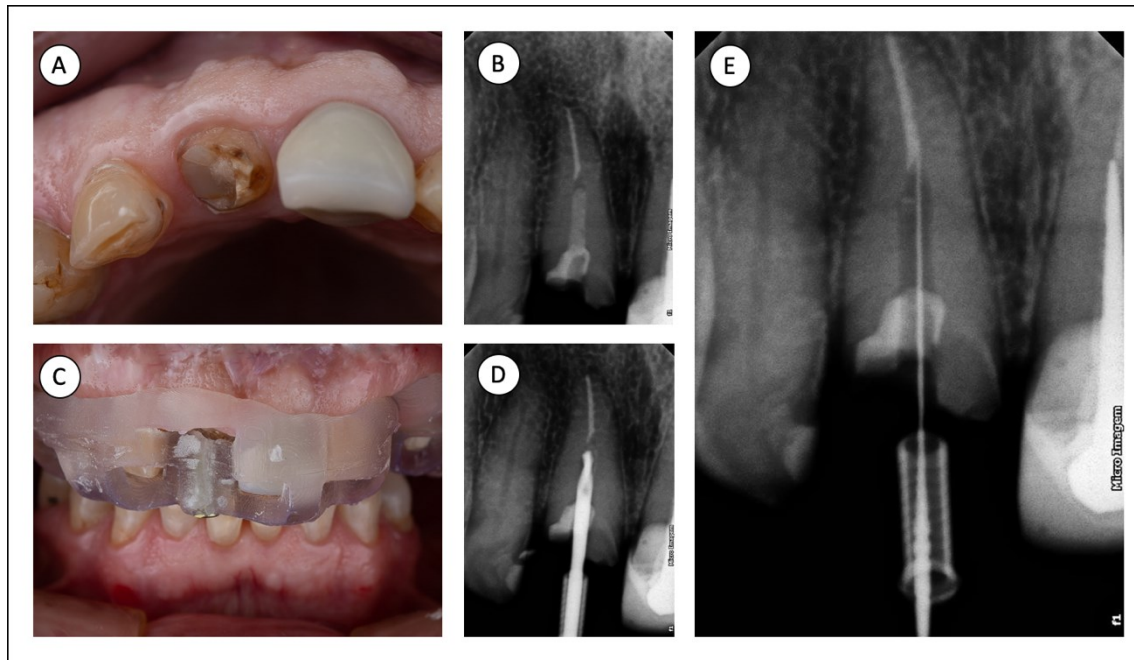


Figure 1. A. Initial clinical aspect of the fractured fiber post inside the root canal right central incisor; B. Initial X-ray of right upper central incisor with fractured fiber post; C: Initial positioning of the access guide with perfect adaptation to dental surfaces; D. Transoperative X-ray with bur to check the wear direction; E: X-ray with #15 endodontic file in contact with gutta-percha, ensuring complete removal of the fiber post.

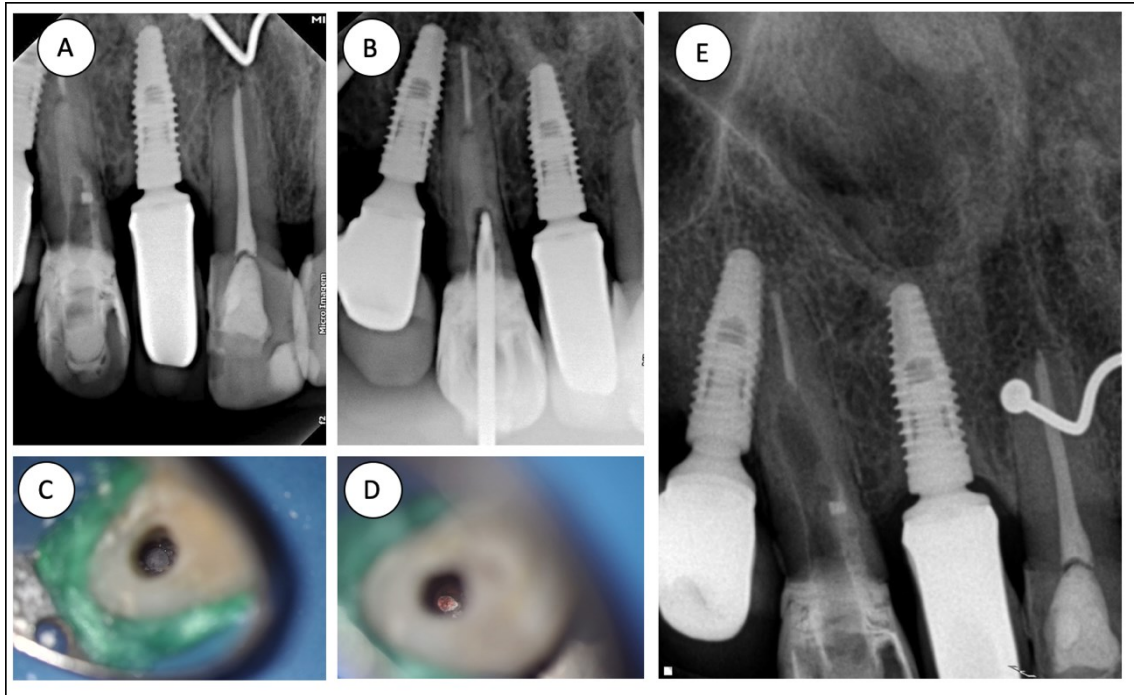


Figure 2. A. Initial X-Ray showing root canal deviation caused by diamond round bur removal; B. Trans operative X-Ray with bur to check the wear direction, showing deviation from the desired path; C. intra-coronal microscopy view of the interface between the fiber post and root canal dentin; D. intra-coronal microscopy view of the gutta-percha, demonstrating that the desired fiber post removal depth had been reached; E. Final X-Ray showing complete removal of the fiber post.

4. CONCLUSÕES

Dentro das limitações metodológicas destes estudos que envolveram dois estudos laboratoriais e um relato de caso clínico pode-se concluir que:

- a. acesso com alta equipado com luz branca, independentemente do material restaurador usado na câmara pulpar, permitiu menor perda dentinária;
- b. O uso do cimento de ionômero de vidro facilita o acesso aos canais com redução da remoção de dentina do assoalho pulpar e menor número de paredes afetadas;
- c. A remoção de pino com guia endodôntico resulta em menor tempo de trabalho que o uso de ultrassom e menor perda estrutural que o uso de ponta diamantada e insertos em ultrassom;
- d. A remoção de pino com ponta diamantada resulta em maior transposição e alargamento do canal que quando realizado com ultrassom e guia endodôntico;
- e. Remoção de pino de fibra de vidro é um desafio para o clínico e necessita de avanço tecnológico e efetivo treinamento profissional para gerar eficiência e reprodutibilidade do procedimento.

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* De acordo com a Norma da FOUFU, baseado nas Normas de Vancouver.

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ANEXOS

Anexo 1 - Parecer do Comitê de Ética em Pesquisa – UFU



PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Análise biomecânica de instrumentação endodôntica e remoção de restaurações e pinos de fibra de vidro para retratamento em molares

Pesquisador: Carlos José Soares

Área Temática:

Versão: 1

CAAE: 85533718.1.0000.5152

Instituição Proponente: Universidade Federal de Uberlândia/ UFU/ MG

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.570.199

Apresentação do Projeto:

A pesquisa fará análise biomecânica de instrumentação endodôntica e remoção de restaurações e pinos de fibra de vidro para retratamento em molares (seu título). Usará dentes doados que seriam descartados pela clínica. Terá consentimento e garante privacidade e sigilo.

Objetivo da Pesquisa:

Analisar efeitos de técnicas de instrumentação e caracterizar laboratorialmente os instrumentos.

Avaliação dos Riscos e Benefícios:

Não há risco significativo relacionados a saúde ou integridade física dos participantes, que participam doando dentes que, extraídos por razões médicas, seriam descartados; não serão informados, em nenhuma hipótese os nomes dos doadores e nem o procedimento cirúrgico realizado; Os resultados serão divulgados de forma global e focado nas amostras; há TCLE adequado. Há benefícios científicos, educacionais e em saúde esperados.

Comentários e Considerações sobre a Pesquisa:

Pesquisa eticamente adequada.

Considerações sobre os Termos de apresentação obrigatória:

Estão adequados.

Recomendações:

Não há.

Endereço: Av. João Naves de Ávila 2121- Bloco "1A", sala 224 - Campus Sta. Mônica
Bairro: Santa Mônica **CEP:** 38.408-144
UF: MG **Município:** UBERLÂNDIA
Telefone: (34)3239-4131 **Fax:** (34)3239-4335 **E-mail:** cep@propp.ufu.br

Conclusões ou Pendências e Lista de Inadequações:

De acordo com as atribuições definidas na Resolução CNS 466/12, o CEP manifesta-se pela aprovação do protocolo de pesquisa proposto.

O protocolo não apresenta problemas de ética nas condutas de pesquisa com seres humanos, nos limites da redação e da metodologia apresentadas.

Considerações Finais a critério do CEP:

Data para entrega de Relatório Final ao CEP/UFU: Dezembro de 2019.

OBS.: O CEP/UFU LEMBRA QUE QUALQUER MUDANÇA NO PROTOCOLO DEVE SER INFORMADA IMEDIATAMENTE AO CEP PARA FINS DE ANÁLISE E APROVAÇÃO DA MESMA.

O CEP/UFU lembra que:

- a- segundo a Resolução 466/12, o pesquisador deverá arquivar por 5 anos o relatório da pesquisa e os Termos de Consentimento Livre e Esclarecido, assinados pelo sujeito de pesquisa.
- b- poderá, por escolha aleatória, visitar o pesquisador para conferência do relatório e documentação pertinente ao projeto.
- c- a aprovação do protocolo de pesquisa pelo CEP/UFU dá-se em decorrência do atendimento a Resolução CNS 466/12, não implicando na qualidade científica do mesmo.

Orientações ao pesquisador :

- O sujeito da pesquisa tem a liberdade de recusar-se a participar ou de retirar seu consentimento em qualquer fase da pesquisa, sem penalização alguma e sem prejuízo ao seu cuidado (Res. CNS 466/12) e deve receber uma via original do Termo de Consentimento Livre e Esclarecido, na íntegra, por ele assinado.
- O pesquisador deve desenvolver a pesquisa conforme delineada no protocolo aprovado e descontinuar o estudo somente após análise das razões da descontinuidade pelo CEP que o aprovou (Res. CNS 466/12), aguardando seu parecer, exceto quando perceber risco ou dano não previsto ao sujeito participante ou quando constatar a superioridade de regime oferecido a um dos grupos da pesquisa que requeiram ação imediata.
- O CEP deve ser informado de todos os efeitos adversos ou fatos relevantes que alterem o curso normal do estudo (Res. CNS 466/12). É papel de o pesquisador assegurar medidas imediatas adequadas frente a evento adverso grave ocorrido (mesmo que tenha sido em outro centro) e enviar notificação ao CEP e à Agência Nacional de Vigilância Sanitária – ANVISA – junto com seu

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Continuação do Parecer: 2.570.199

posicionamento.

• Eventuais modificações ou emendas ao protocolo devem ser apresentadas ao CEP de forma clara e sucinta, identificando a parte do protocolo a ser modificada e suas justificativas. Em caso de projetos do Grupo I ou II apresentados anteriormente à ANVISA, o pesquisador ou patrocinador deve enviá-las também à mesma, junto com o parecer aprobatório do CEP, para serem juntadas ao protocolo inicial (Res.251/97, item III.2.e).

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_974194.pdf	16/03/2018 10:00:46		Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	16/03/2018 10:00:32	MARCIO ALEX BARROS GOMES	Aceito
Declaração de Instituição e Infraestrutura	DeclaracaoInstituicao.pdf	15/03/2018 16:12:35	MARCIO ALEX BARROS GOMES	Aceito
Outros	TermoCompromisso.pdf	15/03/2018 16:12:00	MARCIO ALEX BARROS GOMES	Aceito
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Outros	Curriculo_Carlos.pdf	15/03/2018 16:11:32	MARCIO ALEX BARROS GOMES	Aceito
Projeto Detalhado / Brochura Investigador	ProjetoDetalhado.docx	15/03/2018 16:10:49	MARCIO ALEX BARROS GOMES	Aceito
Folha de Rosto	FolhaRosto.pdf	15/03/2018 15:44:36	MARCIO ALEX BARROS GOMES	Aceito

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Não

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UBERLÂNDIA, 28 de Março de 2018

Assinado por:
Sandra Terezinha de Farias Furtado
(Coordenador)

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Anexo 2 – Normas do Periódico 1 - Brazilian Dental Journal

Disponível em: <<https://www.scielo.br/revistas/bdj/iinstruc.htm>>



INSTRUÇÕES PARA OS AUTORES

- [Escopo e política](#)
- [Forma e preparação de manuscritos](#)
- [Submissão de manuscrito](#)

Escopo e política

O Brazilian Dental Journal é um periódico científico com revisão por pares (sistema duplo-cego) que publica Artigos Originais Completos, Comunicações Curtas, Relatos de Casos e Revisões Convidadas, tratando das diversas áreas da Odontologia ou áreas afins, com acesso aberto. Apenas artigos originais serão considerados para publicação. Ao submeter um manuscrito, os autores devem declarar na carta de apresentação que o material não foi publicado anteriormente e não está sendo analisado por outra revista em versão eletrônica ou impressa.

ENDEREÇO ELETRÔNICO PARA SUBMISSÃO

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OS MANUSCRITOS DEVEM SER ENVIADOS EM INGLÊS. Autores cujo idioma principal não seja o inglês devem ter seu manuscrito revisado por alguém com proficiência em inglês. **Os manuscritos aceitos para publicação serão submetidos à Revisão Técnica para revisão da gramática e redação científica do inglês e para adequação do texto aos padrões da Revista. O custo da Revisão Técnica será cobrado dos autores. A submissão de um manuscrito ao BDJ implica na aceitação destes termos.** A decisão de aceitação para publicação é dos Editores e é baseada na recomendação do Conselho Editorial e / ou *ad hoc* revisores. Autores de manuscritos não recomendados para publicação receberão um e-mail explicando a decisão. Os conceitos emitidos nos artigos publicados no BDJ são de responsabilidade exclusiva dos autores, não refletindo necessariamente a opinião do Conselho Editorial.

Todos os manuscritos serão submetidos à revisão por pares. Autores e revisores serão mantidos anônimos durante o processo de revisão. Os artigos aceitos para publicação passam a ser propriedade da revista.

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O Brazilian Dental Journal manterá os direitos autorais e de publicação de todos os artigos publicados, incluindo traduções. Os usuários podem usar, reutilizar e desenvolver o material publicado na revista, mas apenas para fins não comerciais e desde que a fonte seja mencionada de forma clara e adequada.

A Revista adota sistema de identificação de plágio (AntiPlagiarist - Software ACNP)

O Brazilian Dental Journal é indexado pela base de dados DOAJ para acesso público.

Forma e preparação de manuscritos

AS SEGUINTES DIRETRIZES DEVEM SER CUIDADOSAMENTE SEGUIDAS.

Geral

- Os autores devem submeter o manuscrito em Word e PDF, contendo página de título, texto, tabelas, legendas de figuras e figuras (fotografias, micrografias, radiografias, desenhos esquemáticos, gráficos, imagens geradas em computador, etc).
- O manuscrito deve ser digitado em fonte Times New Roman 12, com espaçamento 1,5, margens de 2,5 cm de cada lado. **NÃO USE** letras em negrito, marcas d'água ou outros recursos para tornar o texto visualmente atraente.
- As páginas devem ser numeradas consecutivamente, começando com o resumo.
- Manuscritos completos são agrupados nas seguintes seções:
 - 1) Página de rosto
 - 2) Resumo e palavras-chave
 - 3) Introdução; Material e métodos; Resultados; Discussão
 - 4) Resumo em português (um item necessário para Serviços de Indexação da América Latina que será fornecido para autores não brasileiros pela revista)
 - 5) Agradecimentos (se houver)
 - 6) Referências
 - 7) Tabelas
 - 8) Legendas das figuras
 - 9) Figuras
- Todos os títulos das seções (Introdução, Material e Métodos, etc.) devem ser capitalizados em fonte normal (não em negrito).
- Os resultados e a discussão **NÃO DEVEM** ser reunidos em uma única seção.

- Comunicações breves e relatos de casos devem ser divididos em seções apropriadas.
- Produtos, equipamentos e materiais: a razão social deve vir acompanhada do nome do fabricante, cidade, estado e país, entre parênteses na primeira citação. Para outras menções, apenas o nome do fabricante é necessário.
- Todas as abreviaturas devem ser explicadas na primeira menção.

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- A primeira página deve conter o título do manuscrito, um título curto (máximo de 40 caracteres, para ser usado como título corrido), nome (s) do (s) autor (es) (não mais que 6) e seu (s) Departamento (s), Escola (s) e / ou Universidade (s). **NÃO INCLUA** os títulos do autor (DDS, MSc, PhD, etc.) ou posição (Professor, Aluno de Graduação, etc.).
- Fornecer nome e endereço **completo** do autor para correspondência (informar e-mail, telefone e fax).
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Manuscrito

- A primeira página do manuscrito deve conter: título do manuscrito, ladrilho curto com no máximo 40 caracteres e NÃO o nome ou identificação dos autores.

Resumo

- A segunda página deve conter um resumo de no máximo 250 palavras, declarando os objetivos, métodos, resultados e quaisquer conclusões extraídas do estudo. Não use tópicos e parágrafos e não cite referências no Resumo.
- Uma lista de palavras-chave (não mais de 5) deve ser incluída abaixo do resumo em letras minúsculas, separadas por vírgulas.

Introdução

- Resuma o objetivo do estudo, dando apenas referências pertinentes. Não revise extensivamente a literatura existente. Indique claramente a hipótese de trabalho.

Material e métodos

- O material e os métodos devem ser apresentados com detalhes suficientes para permitir a confirmação das observações. **Indique os métodos estatísticos utilizados, se aplicável.**

Resultados

- Apresente os resultados em uma seqüência lógica no texto, tabelas e figuras, enfatizando as informações importantes.
- Não repita no texto os dados contidos nas tabelas e ilustrações. As observações importantes devem ser enfatizadas.
- Não repita os mesmos dados em tabelas e figuras.
- Descreva os dados estatísticos nesta seção.

Discussão

- Resuma as descobertas sem repetir em detalhes os dados fornecidos na seção Resultados.
- Relacione suas observações a outros estudos relevantes e aponte as implicações dos resultados e suas limitações. Cite estudos pertinentes.
- Apresente suas conclusões ao final da discussão, indicando como seu estudo é pertinente e / ou suas implicações clínicas. A apresentação das conclusões em tópicos deve ser evitada.

Resumo em português (apenas para autores brasileiros)

- O Resumo em português deve ser **IDÊNTICO** à versão em inglês (Resumo). **NÃO INCLUA** título e palavras-chave em português.

Reconhecimentos

- O apoio financeiro de agências governamentais deve ser reconhecido. Se for o caso, a assistência técnica ou assistência de colegas pode ser reconhecida.

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- Todos os autores de cada artigo devem ser incluídos na Lista de Referências, a menos que haja 7 ou mais. Neste caso, devem ser indicados os primeiros 6 autores, seguidos de "et al.".
- A lista de referências deve ser digitada ao final do manuscrito em seqüência numérica. **Não podem ser citadas mais de 25 referências.**
- A citação de resumos e livros, bem como de artigos publicados em periódicos não indexados, deve ser evitada, a menos que seja absolutamente necessário. **Não cite referências em português.**

- As abreviaturas dos títulos dos periódicos devem estar de acordo com as usadas no Dental Index. O estilo e a pontuação das referências devem seguir o formato ilustrado a seguir:

Artigos de periódicos

1. Lea SC, Landini G, Walmsley AD. Um novo método para a avaliação das características de oscilação da escova de dentes motorizada. *Am J Dent* 2004; 17: 307-309.

Livro

2. Shafer WG, Hine MK, Levy BM. *A Textbook of Oral Pathology*. 4ª ed. Filadélfia: WB Saunders; 1983.

Capítulo em um livro

3. Walton RE, Rotstein I. Bleaching descoloridos dentes: interno e externo. In: *Principles and Practice of Endodontics*. Walton RE (Editor). 2ª ed. Filadélfia: WB Saunders; 1996. p 385-400.

Mesas

- Cada tabela com seu título deve ser digitada após o texto. As tabelas devem ser numeradas com algarismos arábicos. **NÃO USE** linhas verticais, letras em negrito e letras maiúsculas (exceto as iniciais).
- O título correspondente deve aparecer no topo de cada tabela.
- As tabelas devem conter todas as informações necessárias e ser compreensíveis, sem alusão ao texto.

Figuras

- **A BDJ NÃO ACEITA FIGURAS INCORPORADAS EM ARQUIVOS ORIGINADOS EM SOFTWARE DE EDIÇÃO DE TEXTO (WORD OU SEMELHANTE) OU FIGURAS ORIGINADAS EM POWER POINT.**
- Os arquivos digitais das imagens devem ser gerados no Photoshop, Corel ou qualquer outro software de edição de imagens e salvos no CD-ROM. Os arquivos de imagem devem ter extensão TIFF e resolução mínima de 300 dpi. Somente figuras em PRETO E BRANCO são aceitas. Salve as figuras no CD-ROM.
- As letras e as marcas de identificação devem ser claras e nítidas, e as áreas críticas das radiografias e fotomicrografias devem ser demarcadas e / ou isoladas.
- Partes separadas de figuras compostas devem ser rotuladas com letras maiúsculas (A, B, C, etc). Figuras simples e figuras compostas devem ter largura mínima de 8 cm e 16 cm, respectivamente.
- As legendas das figuras devem ser numeradas com algarismos arábicos e digitadas em página separada, após as listas de referências ou após as tabelas (se houver)

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 - tabelas, legendas de figuras e figuras no final do manuscrito.
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Anexo 3 – Normas do Periódico 2 - Journal Of Endodontics

Disponível em: <<https://www.elsevier.com/journals/journal-of-endodontics/0099-2399/guide-for-authors>>



JOURNAL OF ENDODONTICS

Official journal of the American Association of Endodontists

AUTHOR INFORMATION PACK

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• Editorial Board	p.2
• Guide for Authors	p.8



DESCRIPTION

The *Journal of Endodontics*, the official journal of the American Association of Endodontists, publishes scientific articles, case reports and comparison studies evaluating materials and methods of **pulp conservation** and **endodontic treatment**. Endodontists and general dentists can learn about new concepts in **root canal treatment** and the latest advances in techniques and instrumentation in the one journal that helps them keep pace with rapid changes in this field.

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GUIDE FOR AUTHORS

INTRODUCTION

The *Journal of Endodontics* is owned by the American Association of Endodontists. Submitted manuscripts must pertain to endodontics and may be original research (eg, clinical trials, basic science related to the biological aspects of endodontics, basic science related to endodontic techniques, case reports, or review articles related to the scientific or applied aspects of endodontics). Clinical studies using CONSORT methods (<http://www.consort-statement.org/consort-statement/>) or systematic reviews using meta-analyses are particularly encouraged. Authors of potential review articles are encouraged to first contact the Editor during their preliminary development via e-mail at JEndodontics@UTHSCSA.edu. Manuscripts submitted for publication must be submitted solely to JOE. They must not be submitted for consideration elsewhere or be published elsewhere.

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PREPARATION

General Points on Composition

Authors are strongly encouraged to analyze their final draft with both software (eg, spelling and grammar programs) and colleagues who have expertise in English grammar. References listed at the end of this section provide a more extensive review of rules of English grammar and guidelines for writing a scientific article. Always remember that clarity is the most important feature of scientific writing. Scientific articles must be clear and precise in their content and concise in their delivery because their purpose is to inform the reader. The Editor reserves the right to edit all manuscripts or to reject those manuscripts that lack clarity or precision or that have unacceptable grammar or syntax. The following list represents common errors in manuscripts submitted to the Journal of Endodontics:

a. The paragraph is the ideal unit of organization. Paragraphs typically start with an introductory sentence that is followed by sentences that describe additional detail or examples. The last sentence of the paragraph provides conclusions and forms a transition to the next paragraph. Common problems include one-sentence paragraphs, sentences that do not develop the theme of the paragraph (see also section "c," below), or sentences with little to no transition within a paragraph.

b. Keep to the point. The subject of the sentence should support the subject of the paragraph. For example, the introduction of authors' names in a sentence changes the subject and lengthens the text. In a paragraph on sodium hypochlorite, the sentence, "In 1983, Langeland et al, reported that sodium hypochlorite acts as a lubricating factor during instrumentation and helps to flush debris from the root canals" can be edited to: "Sodium hypochlorite acts as a lubricant during instrumentation and as a vehicle for flushing the generated debris (Langeland et al, 1983)." In this example, the paragraph's subject is sodium hypochlorite and sentences should focus on this subject.

c. Sentences are stronger when written in the active voice, that is, the subject performs the action. Passive sentences are identified by the use of passive verbs such as "was," "were," "could," etc. For example: "Dexamethasone was found in this study to be a factor that was associated with reduced inflammation," can be edited to: "Our results demonstrated that dexamethasone reduced inflammation." Sentences written in a direct and active voice are generally more powerful and shorter than sentences written in the passive voice.

d. Reduce verbiage. Short sentences are easier to understand. The inclusion of unnecessary words is often associated with the use of a passive voice, a lack of focus, or run-on sentences. This is not to imply that all sentences need be short or even the same length. Indeed, variation in sentence structure and length often helps to maintain reader interest. However, make all words count. A more formal way of stating this point is that the use of subordinate clauses adds variety and information when constructing a paragraph. (This section was written deliberately with sentences of varying length to illustrate this point.)

e. Use parallel construction to express related ideas. For example, the sentence, "Formerly, endodontics was taught by hand instrumentation, while now rotary instrumentation is the common method," can be edited to "Formerly, endodontics was taught using hand instrumentation; now it is commonly taught using rotary instrumentation." The use of parallel construction in sentences simply means that similar ideas are expressed in similar ways, and this helps the reader recognize that the ideas are related.

f. Keep modifying phrases close to the word that they modify. This is a common problem in complex sentences that may confuse the reader. For example, the statement, "Accordingly, when conclusions are drawn from the results of this study, caution must be used," can be edited to "Caution must be used when conclusions are drawn from the results of this study."

g. To summarize these points, effective sentences are clear and precise, and often are short, simple and focused on one key point that supports the paragraph's theme.

h. Authors should be aware that the JOE uses iThenticate, plagiarism detection software, to ensure originality and integrity of material published in the journal. The use of copied sentences, even when present within quotation marks, is highly discouraged. Instead, the information of the original research should be expressed by the new manuscript author's own words, and a proper citation given at the end of the sentence. Plagiarism will not be tolerated and manuscripts will be rejected or papers withdrawn after publication based on unethical actions by the authors. In addition, authors may be sanctioned for future publication.

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Structured abstract

A structured abstract, by means of appropriate headings, should provide the context or background for the research and should state its purpose, basic procedures (selection of study subjects or laboratory animals, observational and analytical methods), main findings (giving specific effect sizes and their statistical significance, if possible), and principal conclusions. It should emphasize new and important aspects of the study or observations.

Abstract Headings

Introduction, Methods, Results, Conclusions

Keywords

Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

Acknowledgements

Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

The authors deny any conflicts of interest related to this study.

Original Research Article Guidelines

Title Page

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Abstract

The Abstract concisely describes the purpose of the study in 250 or fewer words. It must be organized into sections: Introduction, Methods, Results, and Conclusions. The hypothesis is described in the Abstract Introduction. The Abstract describes the new contributions made by this study. The Abstract word limitation and its wide distribution (eg, PubMed) make it challenging to write clearly. This section is written last by many authors. Write the abstract in past tense because the study has been completed. Provide 3-5 keywords.

Introduction

The introduction briefly reviews the pertinent literature in order to identify the gap in knowledge that the study is intended to address and the limitations of previous studies in the area. Clearly describe the purpose of the study, the tested hypothesis, and its scope. Many successful manuscripts require no more than a few paragraphs to accomplish these goals; therefore, do not perform extensive literature review or discuss the results of the study in this section.

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but pain reported was the same for both groups over the next 96 hours. In this case, the trend of the results is the primary finding; the actual pain scores are not as critical as the relative differences between the NSAID and placebo groups.

Tables

Tables are appropriate when it is critical to present exact numeric values; however, not all results need be placed in either a table or figure. Instead of a simple table, the results could state that there was no inhibition of growth from 0.001%-0.03% NaOCl, and a 100% inhibition of growth from 0.03%-3% NaOCl (N=5/group). If the results are not significant, then it is probably not necessary to include the results in either a table or as a figure.

Acknowledgments

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SCOPE

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Article type	Description	Abstract type	References	Figures and tables	Total Word pages*
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Technique articles	Describes a solution to a particular technical problem in clinical dentistry, in a step-by-step format	Non-structured	20	10	10
Letters to the Editor**	Report original data, discuss published articles, or present hypotheses	None required	15	2	4
Reviews	Systematic reviews preferred, contact the editor prior to submitting a non-systematic review	Structured: Purpose/Methods/Results/Conclusions	No limit	7	No limit

*Text only (page count does not include title, references, tables, or figures)

**Letter to Editor policy:

While we will read and respond to all letters, we will only publish a select few. We are most likely to publish letters that deal with a controversial topic, advocate for the field of prosthodontics, or that take issue with research published in the *Journal of Prosthodontics*. While a letter may be critical, in order to be considered for publication, it must not be insulting.

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