

INFLUENCE OF GLASS FIBER POSTS AND CLASS III DIRECT RESTORATIONS ON THE RESISTANCE OF ANTERIOR TEETH

INFLUENCIA DE PINOS DE FIBRA DE VIDRO E RESTAURAÇÕES DIRETAS EM CLASSE III NA RESISTÊNCIA DE DENTES ANTERIORES

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ABSTRACT: This study objectives to evaluate the fracture strength of upper central incisors (UCI) restored with composite resin (CR) in Class III cavities and endodontically treated teeth with or without glass fiber post (GFP), analyzing their failure mode. Sixty human UCI were randomly divided into four experimental groups: endodontically treated teeth without GFP (G1), endodontically treated teeth with GFP (G2), teeth with mesial/distal Class III cavities restored with CR without GFP (G3), and teeth with mesial/distal Class III cavities restored with CR with GFP (G4). The samples were submitted to the fracture strength test in a universal testing machine with a compression shear load applied at speed of 1.0 mm/min until fracture occurred. The data were submitted to one-way ANOVA ($\alpha=0.05$) and the samples were analyzed for failure mode. The analysis did not show a significant statistical difference in fracture strength between the groups ($p>0.05$). The results showed that only endodontically treated teeth (G1) (753.4N) presented behavior similar to teeth with GFP (G2) (702.1N). The same occurred when comparing teeth with Class III cavities without GFP (G3) (670.2 N) and with GFP (G4) (746.1N). It can be concluded that glass fiber posts do not change the fracture strength of incisors with endodontic treatment and Class III cavities.

KEYWORDS: Cavities. Composite resins. Endodontically treated teeth. Fracture.

INTRODUCTION

Endodontically treated teeth with little remaining crown structure are considered more fragile than healthy teeth due to the loss of healthy dental structure (KARZOUN et al., 2015). In such cases, the use of an intraradicular post is indicated to promote retention to the future restoration. For many years, the cast metal cores (CMC) and the intraradicular metal posts were the only form of tooth retention (SMITH et al., 1998). However, research indicates that such posts may cause irreparable fractures (BARCELLOS et al., 2013; GUO et al., 2016), for requiring the wear of the dentin structure (CHUANG et al., 2010) and for presenting both a high modulus of elasticity (SANTOS-FILHO et al., 2008; FARINA et al., 2015) and the possibility of corrosion (LASSILA et al., 2004) thus limiting their use.

Glass fiber posts (GFP) have advantages over metal posts because they provide better aesthetics and dentin-like biomechanical properties

(GORACCI et al., 2007; MARTELLI et al., 2008; SANTOS-FILHO et al., 2008; MOSHARRAF et al., 2012; AMARNATH et al., 2015). Their retention is related to specific characteristics such as post length, type of cement used, and amount of remaining tooth structure (ALOMARI et al., 2011; MAKADE et al., 2011; INAGAKI et al., 2014; KHOROUSHI et al., 2016).

It is also known that the clinical applicability of GFP is directly related to the reconstruction of the dental element lost (MAKADE et al., 2011; AMBICA et al., 2013; WANDSCHER et al., 2014; REZAEI et al., 2015; RAHMAN et al., 2016). Thus, an intraradicular post should be selected with caution, verifying the amount of remaining tooth structure, root canal anatomy, post length and diameter, as well as the physical properties and modulus of elasticity (ALOMARI et al., 2011; HATTA et al., 2011; LE BELL-RÖNNLÖF et al., 2011). The higher the amount of remaining crown, the higher the resistance of the dental element (ZOGHEIB et al., 2008;

ARUNPRADITKUL et al., 2009; CORRÊA et al., 2018) considering that the post length and the composite resin (CR) core do not significantly increase the fracture strength of endodontically treated teeth (VALLE et al., 2007).

However, in the case of gingival fractures between crown and root, there is a possibility of prosthetic reconstruction of the dental element, which does not occur in longitudinal or oblique fractures in the middle and cervical thirds of the root (BARCELLOS et al., 2013). Thus, the classification of the fracture pattern may be an important guide for the clinician to select the most suitable restorative protocol for the resolution of fractured teeth cases.

Therefore, this study aimed to evaluate fracture strength and failure mode in human upper central incisors in dental elements with or without GFP. The hypothesis tested was that GFP does not interfere with the fracture strength of endodontically treated teeth and restored Class III cavities.

MATERIAL AND METHODS

Sample selection

This project was approved by the Research Ethics Committee of the University of Passo Fundo (UPF), RS, Brazil (Protocols # 886.261/2014 and 1.082.717/2015). Sixty human upper central incisors were collected from the Tooth Bank of the Faculty of Dentistry of UPF and the teeth recently extracted for periodontal reasons and with intact marginal ridges were selected. Teeth with Class IV or V lesions, erosion/abrasion lesions, excessively weakened, and with disparate dimensions were excluded from the study. After the selection, the dental elements were cleaned with periodontal curettes and ultrasound.

Experimental groups

After sample randomizations, the sixty central incisors were divided into four groups (n=15):

- Group I - Endodontically treated teeth without GFP.
- Group II - Endodontically treated teeth with GFP.
- Group III - Endodontically treated teeth with mesial and distal Class III crown cavity (without involving the incisal angle) restored with CR without GFP in the root portion.
- Group IV - Teeth with the same conditions of Group III, but with intraradicular GFP.

Endodontic treatment

The groups received endodontic treatment accessed with spherical diamond tips, establishing a triangular crown opening with the base facing the incisal aspect. The preparation of the cervical and middle thirds was performed with #2 and #3 Largo™ burs (Dentsply, Maillefer, Ballaigues, Switzerland) and instrumentation was performed using 1st-series K-Flex endodontic files (Dentsply, Maillefer, Ballaigues, Switzerland) with 2% chlorhexidine gel (2% Chlorhexidine S™, FGM, Joinville, SC, Brazil) as the auxiliary chemical substance. The root canals were filled with gutta-percha cones and Endofill™ endodontic cement (Dentsply Maillefer, Ballaigues, Switzerland) using the lateral condensation technique. After the endodontic treatment, the teeth of groups II and IV received intraradicular GFP (White Post™, FGM, Joinville, SC, Brazil).

GFP installation and restorative procedure

For the groups that received GFP (II and IV), the following protocol was adopted: application of 37% phosphoric acid (Condac™, FGM, Joinville, SC, Brazil) for 30 s in the root canal, washing and drying with absorbent paper cones (Endopoints™, Paraíba do Sul, RJ, Brazil). Then, the Scotchbond™ Multipurpose adhesive (3M ESPE, St. Paul, MN, USA) was applied to the root canal, followed by the removal of excesses and photopolymerization for 40 s. The posts from White Post™ were treated according to the manufacturer's instructions. So, the posts were disinfected with 70% alcohol and then silane (Prosil™, FGM, Joinville, SC, Brazil) was applied over the whole surface of the posts and the drying time of 1 minute was waited. After, the posts were cemented with resin cement (All Cem Core™, FGM, Joinville, SC, Brazil).

Next, the restorations were produced in groups III and IV. Prior to such restorations, the teeth were etched with 37% phosphoric acid for 30 s on enamel and 15 s on dentin. Then, the teeth were washed with water for 1 minute and dried with moistened cotton balls. Light air blasts on the buccal and palatal surfaces were used to assist the removal of excess moisture. A Singlebond 2™ adhesive layer (3M ESPE™, St. Paul, MN, USA) was applied and polymerized for 40 seconds on each aspect. The restorative process was initiated in the pulp chamber using small increments of CR in the A2 shade (Opallis™, FGM, Joinville, SC, Brazil) and with approximately 2 mm in thickness, up to complete cavity filling, as shown in Figure 1.

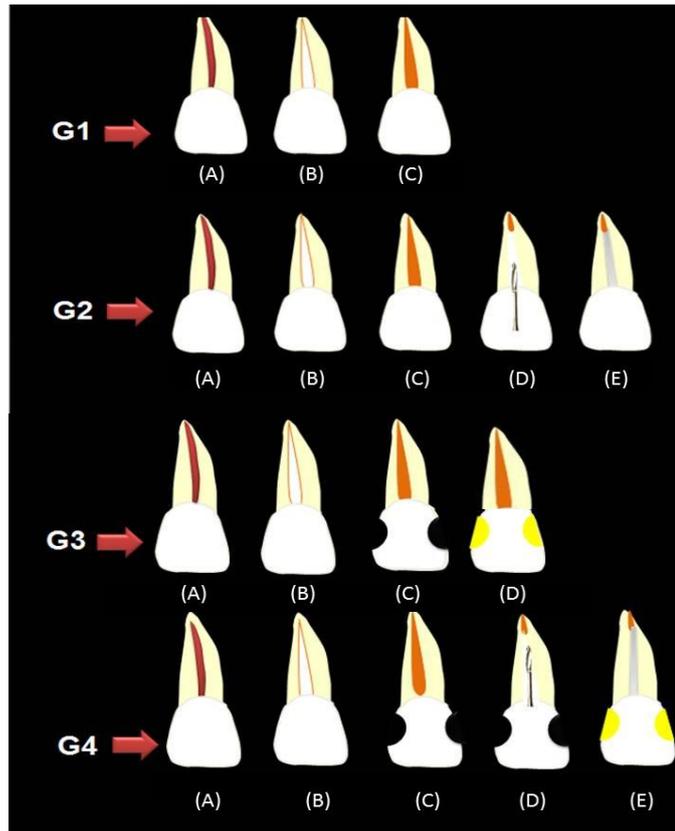


Figure 1. Diagram of the sample groups: All groups - (A) healthy tooth, (B) preparation of canals with Largo burs. Group 1 - (C) endodontically treated tooth. Group 2 - (C) endodontically treated tooth, (D) canal opening, (E) GFP cementation. Group 3 - (C) endodontically treated teeth with mesial and distal Class III cavity, (D) restored tooth. Group 4 - (C) endodontically treated teeth with mesial and distal Class III cavity, (D) canal opening, (E) tooth restored with GFP cementation.

Inclusion of specimens and strength test

All roots were inserted in colorless acrylic resin (Jet™, São Paulo, SP, Brazil) and poured into PVC rings (Tigre Brasil™, Osasco, SP, Brazil) with the aid of a dental surveyor (Bio-Art™, São Carlos, SP, Brazil) for a standard positioning of the teeth. Small depressions on the palatal face of the teeth were produced with half the active tip of a diamond spherical drill 1011 (KG Sorensen™, Cotia, SP, Brazil) for supporting the application of compressive load. Such depressions were made in the center of the palatal concavity in order not to cause stress zones in the teeth. The samples were submitted to a compression shear load test in a universal testing machine (EMIC DL 2000™, São Jose dos Pinhais, PR, Brazil). The specimens remained at an approximate inclination of 135° (CECCHIN et al., 2010; CARLINI-JUNIOR et al., 2011; BARCELLOS et al., 2013), with the force applied at speed of 1 mm/min until fracture, using a constant load.

The failure modes were classified as longitudinal or transverse, as described next: Type 1 (T1) - fracture at the cemento-enamel junction; Type

2 (T2) - transverse fracture in the cervical third; Type 3 (T3) - transverse fracture in the middle third; Type 4 - (T4) transverse fracture in the apical third; Type 5 - (T5) longitudinal fracture (in the long axis of the tooth). The fractures were also divided according to the possibility of reconstruction in Type A - Repairable (fracture favorable to posterior reconstruction: T1 and T2) and Type B - Irreparable (longitudinal or oblique radicular fractures resulting in exodontia: T3, T4, and T5) (GUO et al., 2016), according to Figure 2.

Statistical analysis

The normal distribution of the fracture strength data was confirmed by the Kolmogorov-Smirnov test ($p > 0.05$). Data were evaluated by one-way ANOVA. Failure mode distribution was evaluated by the chi-square test ($\alpha = 0.05$). Data were analyzed using Stat Plus AnalystSoft Inc. version 6.0 (Vancouver, BC, Canada).

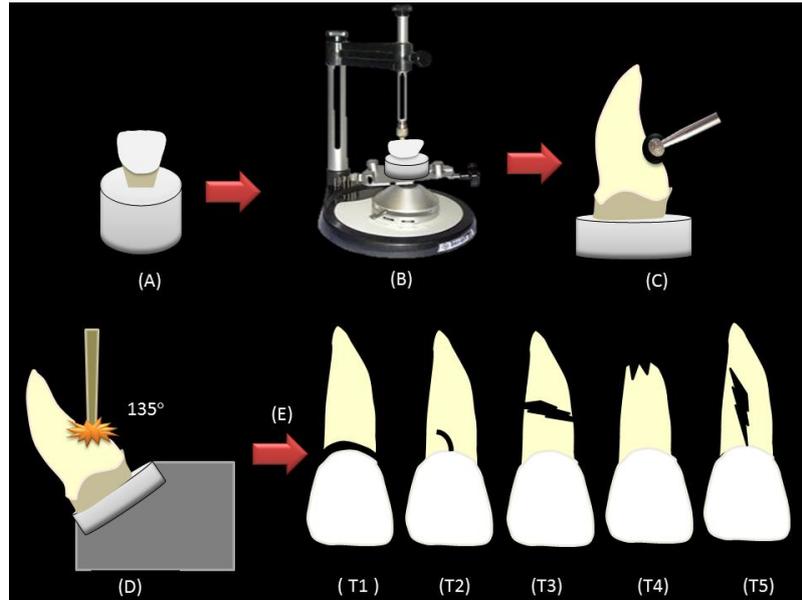


Figure 2. Strength test and classification of failure modes. (A) insertion of samples in acrylic resin PVC cylinders, (B) positioning of the sample, (C) production of the palatal small depressions, (D) fracture strength test (Emic), (E) classification of failure modes (T=fracture type).

RESULTS

Table 1 presents the means and standard deviations related to the fracture strength (N) test. The one-way ANOVA showed a value of $p=0.6426$, meaning there was no statistical difference between the groups evaluated (Table 1).

Table 2 shows the data regarding the failure mode and the possibility of repair (A: repairable and B: irreparable). Overall, it was possible to observe a greater amount of T3 failure. Regarding the possibility of repair, most of the samples presented irreparable fractures.

Table 1. Mean and standard deviations of the fracture analysis in each sample group.

Groups	Means (SD) (N)	Statistics (ANOVA/Tukey's)
G1 – Without GFP	753.4 (± 267.5)	A
G2 – With GFP	702.1 (± 328.4)	A
G3 – CIII without GFP	670.2 (± 175.5)	A
G4 – CIII with GFP	746.9 (± 239.9)	A

*Equal letters represent no statistical difference between the groups ($p > 0.05$).

Table 2. Failure mode distribution and possibility of repair in experimental groups.

Groups	T1(%)	T2(%)	T3(%)	T4(%)	T5(%)	Repairable(%)	Irreparable(%)
G1: Without GFP	1(6.7)	3(20)	7(46.6)	4(26.7)	0(0)	5(33.3)	10(66.7)
G2: With GFP	0(0)	4(26.7)	11(73.3)	0(0)	0(0)	4(26.7)	11(73.3)
G3: CIII without GFP	0(0)	4(26.7)	10(66.6)	1(6.7)	0(0)	4(26.7)	11(73.3)
G4: CIII with GFP	0(0)	6(40)	9(60)	0(0)	0(0)	6(40)	9(60)
Total	1(1.7)	17(28.3)	37(61.7)	5(8.3)	0(0)	19(31.7)	41(68.3)

*Failure mode data were tabulated and evaluated statistically by the chi-square test, with no difference between G1 and G2 ($p=0.1967$) or between G3 and G4 ($p=0.835$).

DISCUSSION

Glass fiber posts (GFP) are widely used to restore anterior teeth (NAUMANN et al., 2012; STERZENBACH et al., 2012) because they present a modulus of elasticity similar to that of dentin (LASSILA et al., 2004; DIETSCHI et al., 2007; ZICARI et al., 2013), contrary to the cast metal cores (CMC) that require higher root dentin wear, a greater number of clinical sessions for preparation, and present a modulus of elasticity around 200 GPa, which increases the chances of fracture of the dental element (ARTOPOULOU et al., 2006; SARKIS-ONOFRE et al., 2014). Hence, Murali Mohan et al. (2015), affirm that the use of CMC causes stress concentration, which may produce dental fractures in up to 91% of the cases of their use.

The present study evaluated the influence of GFP on the fracture strength of endodontically treated teeth with marginal ridges, which absence might affect the resistance of the dental element, considering that such fracture strength depends mainly on the amount of remaining crown structure (MONDELLI et al., 1980). According to Corrêa et al. (2018), in the absence of remaining crown structure in anterior teeth, the fracture strength values tend to be lower than in teeth with remaining crown structure.

Glass fiber posts contain a structure of fibers that provide high tensile strength and a resin matrix capable of withstanding compressive forces, composed of an epoxy or bis-GMA resin (bisphenol glycidyl methacrylate), and the posts are non-corrosive and have a modulus of elasticity similar to that of dentin (FERRARI et al., 2007).

The present study shows that the GFP does not interfere with the fracture strength of teeth with crowns weakened by Class III restorations on the proximal surfaces. These data corroborate previous studies (VALDIVIA et al., 2012; ABDULJAWAD et al., 2017; STEIN-LAUSNITZ et al., 2019). The results of the present study allow suggest that when an anterior tooth element presents Class III restorations, the use of GFP is not required to retain the restoration, similar to that stated by Lima et al. (2010).

On the other hand, differing from the findings obtained in this research, Scotti et al. (2015) affirm that endodontically treated posterior

teeth with GFP showed an increase in fracture strength. Additionally, Ayna et al. (2018) report that GFP may be used clinically to aid the retention of CR restorations, increasing the resistance of the tooth/restoration set.

Corrêa et al. (2018) state that teeth with GFP are more prone to repairable fractures when compared to teeth with cast metal core. Despite that, in the analysis of the failure modes realized in the present study, it was observed that most of them were irreparable (even on teeth with GFP) and located in the middle third of the teeth, agreeing with the findings by Hayashi et al. (2006).

In this study, most of the samples (with or without GFP) presented irreparable fractures and no statistical difference was observed in the failure mode between groups. Thus, it may be suggest that teeth with GFP present types of fractures similar to teeth with endodontic treatment without intraradicular retainers. These results differ from the findings by Seraj et al. (2015), who tested three types of prefabricated posts and found favorable fractures as the most frequent mode in both groups.

From the results found in this research, it may be suggest that anterior teeth with direct Class III restorations associated with GFP present the same fracture strength value and the same failure mode as restored teeth without posts. Thus, in teeth with satisfactory remaining dental crown, the use of GFP is not indicated. Studies such as by Alomari et al. (2011) show that the use of posts promotes a significant loss of dentin structure in endodontically treated incisors and the use of GFP is indicated in cases of extensive dental crown loss.

CONCLUSIONS

The use of GFP in anterior teeth is not required when such teeth present crowns weakened by Class III restorations.

Anterior teeth with GFP present strength and failure modes similar to endodontically treated teeth without intraradicular posts, and the use of GFP is not required when there is a satisfactory remaining dental crown.

Class III restorations in anterior teeth without intraradicular retainers were not a decisive factor for either the reduction of fracture strength or the variation of failure modes.

RESUMO: Este estudo objetiva avaliar a resistência à fratura de incisivos centrais superiores (ICS) restaurados com resina composta (RC) em cavidades Classe III e dentes tratados endodonticamente com ou sem pino de fibra de vidro (PFV), analisando seu padrão de fratura. Sessenta ICS humanos foram divididos aleatoriamente em quatro grupos experimentais: dentes tratados endodonticamente sem PFV (G1), dentes

tratados endodonticamente com PFV (G2), dentes com cavidades mesiais/distais Classe III restauradas com RC sem PFV (G3), e dentes com cavidades mesiais/distais Classe III restauradas com RC com PFV (G4). As amostras foram submetidas ao teste de resistência à fratura em uma máquina universal de ensaios com uma carga de cisalhamento de compressão aplicada na velocidade de 1,0 mm / min até a ocorrência da fratura. Os dados foram submetidos à ANOVA unidirecional ($\alpha=0,05$) e as amostras foram analisadas quanto ao modo de falha. A análise não mostrou diferença estatisticamente significativa na resistência à fratura entre os grupos ($p>0,05$). Os resultados mostraram que os dentes apenas tratados endodonticamente (G1) (753,4N) apresentaram comportamento semelhante aos dentes com PFV (G2) (702,1N). O mesmo ocorreu ao comparar dentes com cavidades Classe III sem PFV (G3) (670.2 N) e com PFV (G4) (746.1N). Pode-se concluir que pinos de fibra de vidro não alteram a resistência à fratura de incisivos com tratamento endodôntico e cavidades Classe III.

PALAVRAS-CHAVE: Cavidade. Resinas compostas. Dentes tratados endodonticamente. Fratura.

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