

# Flexural strength of adhesive materials employed in the filling of weakened roots associated to glass fiber posts

*Resistência flexural de materiais adesivos empregados no preenchimento de raízes fragilizadas associados a pinos intra-radiculares de fibra de vidro*

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## Abstract

This study evaluated the flexural strength of two adhesive materials employed in the filling of weakened root structures, associated to prefabricated glass fiber posts. Forty-four specimens were fabricated (n=11), and were divided into: G1 – composite resin core (Enforce Core – Dentsply); G2 – resin-modified glass ionomer cement (Vitremmer-3M ESPE); G3 – composite resin core (Enforce Core) + glass fiber post (Fibrekor Post System – Jeneric Pentron); G4 – resin-modified glass ionomer cement (Vitremmer) + glass fiber post (Fibrekor Post System). The specimens were fabricated with dimensions of 3x3x15mm, being stored in distilled water for 24 hours at 37 °C up to the accomplishment of the three-point bending test. The achieved data (MPa) were submitted to Anova and Tukey's tests. Group G1 (164.21 MPa) was statistically better ( $p < 0.001$ ) than the others. Groups G2 (73.67 MPa) and G4 (66.90 MPa) were statistically similar to each other and worse than the others. Thus, it was concluded that the composite resin Enforce Core was better than the resin-modified glass ionomer

cement Vitremmer regarding flexural strength. The use of the glass fiber post reduced the flexural strength values for both studied materials.

*Key words: flexural strength, composite resin, glass ionomer cement, mechanical properties.*

## Introduction

Endodontically treated teeth, with minimal loss of crown structure, may be restored with conservative procedures, with the use of components inside the roots to provide retention for the restorative materials not being needed. However, in several situations, these teeth present significant crown destruction, which affect the support for a future restoration (SMITH; SHUMAN; WASSON, 1998; GORACCI et al., 2005).

Therefore, there is the need to use components inside the root, which may provide retention and support to the restoration (LASSILA et al., 2004). Thus, the utilization of cast or prefabricated posts associated to filling materials aims

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at creating a surface for a restoration placement, thus providing proper retention to support the functional and pathological forces applied to teeth.

Traditionally, prefabricated metallic posts are fabricated with titanium and stainless steel alloys. Several types of prefabricated non-metallic posts are currently available, such as the carbon fiber posts, glass fiber posts, quartz fiber posts, and ceramic posts (CONCEIÇÃO; CONCEIÇÃO, 2002).

In clinical situations on which part of the root dentin was lost in addition to the loss of crown structure, there is a reduction in the thickness of root canal walls, yielding a remarkable taper. This aspect increases the risk of fracture and significantly reduces the retentive ability of the post to be employed (LUI, 1999).

An option for the treatment of weakened roots is the utilization of prefabricated posts associated to root filling with restorative materials whose properties are similar to those of the dentin structure, aiming at root reinforcement to reduce the risk of fractures.

The introduction of the root reinforcement technique, comprising the reconstruction of dentin, allowed the maintenance of teeth whose prognosis would otherwise be doubtful. Initially, this technique involved acid etching of dentin, application of an adhesive system and filling of the dentinal walls with self-curing composite resin (LUI, 1987).

Regarding the composite resin, besides acting as a substitute for the root dentin, it also establishes a proper shape for the placement of a post (SAUPE; GLUSKIN; RADKE, 1996).

The existence of correlation between the material employed for fabrication of the root post and root fracture was discussed by Fernandes and Dessai (2001). According to these authors, the elasticity modulus of the post should be similar to that of root dentin in order to uniformly distribute the forces applied to the tooth. When a system formed by components that present different values of rigidity is submitted to load, the

most rigid element is able to resist to large forces with no deformation. The less rigid one fails and usually relieves the tension.

Ishikiriyama and Mendes (1999) investigated the tensile strength to the tangential load by compression of materials employed for core build-up, being four types of glass ionomer cement and two types of composite resins compared to dentin preparations. Reconstructions were accomplished with root posts with height up to half of the preparation and up to the occlusal aspect. The height of the posts influenced the resistance according to the type of test applied, recommending extension of the post up to the occlusal aspect. With regard to the materials employed with the post height up to the occlusal aspect, Chelon Silver™, Bis-Core™, Vitremer™ and Vidrion R™ demonstrated similar values to each other and to dentin posts.

Therefore, the aim of this study was to conduct an *in vitro* evaluation of the resistance of two adhesive materials (composite resin and resin-modified glass ionomer cement) employed for the filling of weakened root structures, associated to prefabricated glass fiber posts, with the utilization of the three-point bending test.

## Materials and method

This *in vitro* study comprised assessment of the following materials: composite resin for core build-up Enforce Core™ (Dentsply), resin-modified glass ionomer cement Vitremer™ (3M ESPE), and glass fiber posts Fibrekor Post System™ (Jeneric Pentron).

Forty-four specimens (n=11) were fabricated and distributed according to Table 1.

Table 1 - Division of groups according to the filling material used and employment of glass fiber post

Group	Filling Material	Glass Fiber Post
G1	Enforce Core™	No
G2	Vitremer™	No
G3	Enforce Core™	Yes
G4	Vitremer™	Yes

The specimens were fabricated with the use of a metallic template

measuring 3x3x15mm, according to manufacturers' instructions for the material preparation. The composite resin for core build-up Enforce Core™ (Dentsply) was used with equal amounts of base paste and catalyst paste, mixed for 30 seconds. The glass ionomer cement Vitremer™ (3M Espe) was used at the ratio of 2.5/1 in weight (one spoon of powder / one drop of liquid) and mixed for 45 seconds.

For the fabrication of specimens in Groups G1 and G2, the materials were inserted into the template with the aid of a syringe (Centrix – Mark III P™ – Centrix Inc. Shelton – USA). After completing the filling, a polyester matrix strip (3M) was pressed with a 1-mm thick glass slab and light-curing (Optiligh 600™ – Gnatus Equip. Médico-Odontológicos Ltda, Ribeirão Preto / Brazil – 480mW/cm<sup>2</sup>) was performed for 40 seconds on the upper portion and 40 seconds on the lower portion of the specimen.

For the groups on which the glass fiber posts were associated to the filling materials (G3 and G4), a groove was prepared at the lateral portion of the metallic template, with dimensions so as to allow standardized, centralized positioning of the posts in all specimens. A silane agent (Silano™ -Dentsply) was applied on the posts before fabrication of the specimens. After mixing, the materials were inserted up to half of the template, the silanized glass fiber posts were positioned, and the template was filled with the filling material. Curing of the materials was performed as described for Groups G1 and G2.

After checking the dimensions of the specimens with a digital caliper with 0.01-mm precision, the specimens were stored in distilled water for 24 hours at 37 °C (±2 °C) until the accomplishment of the bending test.

For the accomplishment of the test, the specimens were positioned in a metallic base attached to the inferior portion of a universal testing machine Instron 4411, submitted to a constant load delivered by a blunt-ended chisel at a crosshead speed of 1.0mm/min, with a 10-mm distance between the sup-

ports. The value of the maximum force (Newton) applied on each specimen was used for achievement of the flexural strength (MPa) with the use of the following formula:

$$\sigma = 3FI / 2bd^2, \text{ where:}$$

$\sigma$  – flexural strength; F – maximum force (N) at the fracture point; I – distance between the supports; b – width of the specimen; and d – specimen thickness

The data achieved (MPa) were submitted to analysis of variance (Anova) and to Tukey test (significance level 0.01%).

## Results

Table 2 presents the results of the comparative tests, revealing that Group G1 – Enforce™ (164.21 MPa) was statistically better ( $p < 0.001$ ) than the others, followed by Group G3 – Enforce™ + post (144.02 MPa). Groups G2 – Vitremer™ (73.67 MPa) and G4 – Vitremer™ + post (66.90 MPa) were statistically similar to each other and worse than the other ones.

Table 2 - Mean and Standard Deviation values of flexural strength according to the filling material employed and utilization of glass fiber post (MPa)

Group	Flexural strength / Standard deviation
G1 Enforce™	164.21 ± 18.23 a
G2 Vitremer™	73.67 ± 8.54 b
G3 Enforce™ + post	144.02 ± 12.68 c
G4 Vitremer™ + post	66.90 ± 9.22 b

Means followed by different letters present statistically significant differences according to the Tukey test ( $p < 0.001$ ).

## Discussion

According to Anusavice (1998), the action of an external force on a solid body produces a reaction of equal magnitude, yet in opposite direction. The force applied, divided by the area of the body on which it acts, is equal to the tension delivered on the structure. Therefore, a tensile force produces tensile tensions, a compressive force produces compressive tensions, and a shear force produces shear tensions.

Among the studies that evaluate the mechanical properties of dental materials, the bending tests have been significantly hi-

ghlighted in the literature (ZHAO; BOTSIS; DRUMMOND, 1997; ASMUSSEN; PEUTZFELDT, 1998; CASTRO FILHO; GARCIA; NEISSER, 2000; CHONG; CHAI, 2003; DRUMMOND; BAPNA, 2003; IKEJIMA; NOMOTO; McCABE, 2003; LOHBAUER et al., 2003; WANG et al., 2003; GRANDINI et al., 2005). This wide utilization is probably based on the fact that a flexural force delivered on a structure reproduces the tensions that act simultaneously during mastication. In this situation, the tensile and compressive tensions are the main tensions, whereas the shear tension yields a combination of tensile and compressive components (ANUSAVICE, 1998).

Also with regard to the flexural strength, the literature reports it may be measured by the three- and four-point bending test (CASTRO FILHO; GARCIA; NEISSER, 2000). Several investigations that evaluate this mechanical property of adhesive materials used the three-point bending test (PEUTZFELDT; ASMUSSEN, 1992; FERRACANE; MITCHEM, 1994; ASMUSSEN; PEUTZFELDT, 1998; FREIBERG; FERRACANE, 1998; CHONG; CHAI, 2003; IKEJIMA; NOMOTO; McCABE, 2003). This test corresponds to the resistance of a bar supported at both ends under the action of a static load (ANUSAVICE, 1998).

Aspects related to the properties of non-vital teeth and the restorative procedures involved were addressed in the dental literature (GUTMANN, 1992; SAUPE; GLUSKIN; RADKE, 1996). Within this context, the endodontic involvement and further restorative treatment would yield modifications in the structures involved, making the teeth less flexible and more susceptible to fracture, justifying the use of the mechanical bending test for the prediction of probable performance of these materials in the oral cavity.

According to the results of the present study, the comparison of groups regarding the flexural strength of filling materials reveals that the mean for the composite resin Enforce Core™ (164.20 MPa) was higher than the value

observed for the resin-modified glass ionomer cement Vitremer™ (73.67 MPa).

The selection of two restorative materials for filling was primarily based on its curing characteristics. The resin for core build-up Enforce Core™ may occur by light or dual curing (self- and light-curing). With regard to the resin-modified glass ionomer cement Vitremer™, according to its manufacturer, it allows triple curing: acid-base reaction; light; and chemical curing. In the opinion of McCabe and Walls (1998), this last curing reaction (called ‘dark curing’) is similar to the reaction that occurs in conventional glass ionomers. The resin-modified glass ionomer cement presents the additional advantages of bonding to the tooth structure, low shrinkage, fluoride release and biocompatibility.

Therefore, since in many clinical situations the curing light is unable to reach all areas inside the root, the manner through which the material is cured is fundamental for the achievement of proper internal filling and bonding to the root walls.

In relation to the prefabricated posts, the selection of glass fiber posts was based on the need of biocompatibility between the elasticity modulus of the post and dentinal structure, proper resistance and flexibility (FRIEDLER; LEINFELDER, 1999), and possibility of bonding to composite resins and cements (BRITO, BRAZ; CONCEIÇÃO, 2000; GORACCI et al., 2005). These characteristics allow the formation of a single body that is able to resist to masticatory impacts, reducing the risk of displacement and “wedge effect” in the root.

Comparison between the present results and those reported in the literature reveals that, in general, the direct composite resins present flexural strength values ranging from 122 to 235MPa (PEUTZFELDT; ASMUSSEN, 1992), 108 to 121MPa (ZHAO; BOTSIS; DRUMMOND, 1997), 137 to 167MPa (ASMUSSEN; PEUTZFELDT, 1998), 70.54 to 148.35MPa (SINHORETI et al., 2000), 83.88 to 195.78MPa (YAP; TEOH, 2003) and 121.3 to 127.5

MPa (SMISSON; DIEFENDERFER; STROTHER, 2005) whereas the glass ionomer cement displays values of 65.48MPa (SINHORETI et al., 2000), 65 to 80MPa (McCABE; WALLS, 1998) and 107MPa (PEUTZFELDT, 1996).

According to Sinhoreti et al. (2000), the flexural strength outcomes of the resin-modified glass ionomer cement reflects its fragile nature, as also mentioned by McCabe and Walls (1998). In the opinion of El-Kallahi and Garcia-Godoy (1999), fracture of these cements occurs by rupture of the union between the glass particles and the matrix. The small amount of resin compounds in the composition is unable to provide the material with a better performance as to flexural strength.

Association of fiber posts to the filling materials employed led to a reduction in the flexural strength values. The reduction was statistically significant for the resin Enforce Core™, whereas the reduction in the mean for the glass ionomer cement Vitremer was not significant.

The performance of Groups G3 and G4 may be related to two aspects. The first is related to the union between the materials employed. As highlighted by Brito, Braz and Conceição (2000), an effective union between the materials employed for reconstruction of teeth receiving posts is fundamental. This union should comprise the post, cement, filling material, adhesive system and the tooth structure. In this study, a post of intermediate diameter presenting proper texture to allow better mechanical union to the luting and filling agents was used. Despite this characteristic, the silane agent was used to promote chemical bonding to the filling materials, in accordance to previous studies (GALLO et al., 2000; CONCEIÇÃO; CONCEIÇÃO, 2002; GORACCI et al., 2005). In case there is any failure at this interface, the union may be impaired, and the expectation of increase of the flexural strength by increase of the post would not occur.

The second aspect is related to the mechanical characteristics of the materials. In relation to

the elasticity modulus of the post, Scotti and Ferrari (2003) mention that the mechanical performance of the glass fiber posts is considered anisotropic, since they present different performances, depending on the direction of forces. Analysis of their moduli when submitted to perpendicular forces, as performed in the present study, reveals a value of 8 GPa. This value is lower than those of several composite resins, which range from 10 to 23GPa (YAP; TEOH, 2003). This might explain the reason why the post did not yield an increase in the flexural strength of the filling material in the test employed, since it may probably have been bent, allowing rupture of the material. Also with regard to mechanical properties, it should be highlighted that the presence of the post in the root at the central portion of the specimen exactly positions it at the area on which the neutral axis is established, which divides the upper portion, submitted to compression, from the lower portion, submitted to tension. According to Guzy and Nicholls (1979), from a mechanical perspective, the presence of the post at this portion has minor influence on the resistance of the assembly. It is also highlighted that, during occlusal function, the concentration of stress is higher at the tooth circumference, and lower at the central portion (TORBJÖRNER; FRANSSON, 2004).

It should be highlighted that, although a reduction in the flexural strength values with association of the root post was observed, its clinical utilization, not only provides support to the filling material, it provides retention to the assembly as well. It also allows uniform distribution of the forces applied on the tooth along its extension and from the tooth to the root walls, avoiding permanent deformation and reducing the potential for root fracture (FRANSSON; DESSAI, 2001).

In fact, it has been clinically established that the longevity of root-post-crown systems employed for the restoration of endodontically treated teeth may be affected by several factors namely design, length and diameter of the post, the splint

effect, cementation and amount of remaining tooth structure.

Therefore, the benefits of fiber-resin posts are primarily related to their elasticity modulus close to that of the dentinal structure (GRANDINI et al., 2005). However, it should be highlighted that the elasticity modulus of the material represents only one parameter which influences the formation of stress (LASSILA et al., 2004).

## Conclusion

According to the methodology employed and considering the statistical analysis of the results achieved, the following could be concluded:

- 1 - the composite resin for core build-up Enforce Core™ presented better values than the resin-modified glass ionomer cement Vitremer™ regarding flexural strength;
- 2 - the use of glass fiber post, associated to the composite resin for core build-up Enforce Core™, significantly influenced the flexural strength of the assembly, leading to the reduction of values when compared to the resistance values of the resin when solely used;
- 3 - the use of glass fiber post associated to the resin-modified glass ionomer cement did not significantly influence the flexural strength of the assembly, when compared to the resistance of the cement when solely employed.

## Resumo

Este trabalho avaliou a resistência flexural de dois materiais adesivos empregados no preenchimento de estruturas radiculares fragilizadas associados a pino pré-fabricado de fibra de vidro. Foram confeccionados 44 corpos-de-prova (n = 11) distribuídos em: G1 – resina composta para núcleo de preenchimento (Enforce Core® – Dentsply); G2 – Ionômero de vidro modificado por resina (Vitremer® – 3M ESPE); G3 – Resina composta para núcleo de preenchimento (Enforce Core®) + Pino intra-radicular de fibra de vidro (Fibrekor Post System® – Jeneric Pentron); G4 – Ionômero de vidro

modificado por resina (Vitremer®) + Pino intra-radicular de fibra de vidro (Fibrekor Post System®). Os corpos-de-prova foram confeccionados com dimensões de 3 x 3 x 15mm, sendo armazenados em água destilada por 24 horas a 37 °C, até a realização do ensaio de flexão de três pontos. Os dados obtidos (MPa) foram submetidos aos testes Anova e de Tukey. O grupo G1 (164,21 MPa) foi superior estatisticamente ( $p < 0,001$ ) aos demais. Os grupos G2 (73,67 MPa) e G4 (66,90 MPa) foram estatisticamente semelhantes entre si e inferiores aos demais. Assim, concluiu-se que a resina composta Enforce Core® foi superior ao ionômero de vidro modificado por resina Vitremer® quanto à resistência flexural. A utilização do pino de fibra de vidro reduziu os valores de resistência flexural para os dois materiais testados.

**Palavras-chave:** resistência flexural, resina composta, ionômero de vidro, propriedades mecânicas.

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