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Fracture Resistance of Endodontically Restored Teeth with Two System Root Post

Resistencia a la Fractura de Dientes Restaurados Endodónticamente con Postes Radiculares de Dos Sistemas

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ABSTRACT: The objective of this study was to determinate the fracture resistance of endodontically treated teeth and restored with two root post systems : i) resin post, ii) fiber post. A total of 60 teeth were freshly extracted, endodontically treated and randomly divided in two groups (n= 30/each group) for standardized restoration; Group 1 (Group R): Resin post and resin restoration, Group 2 (Group FP): Fiberglass post and resin restoration. Both groups' samples were mounted in a metallic base at 135º to allow them to be stabilized and held in the universal testing machine by applying a vertical force at cross speed of 1mm/min. Data were recorded in Newtons (N) Previous to test the fracture resistance; all samples were stored in distilled water at 37 ºC for 24 hours. Data were subject to the Saphiro-Wilk test for normality distribution and Student's t test. Significance was considered at 0.05 values. The values of fiber post group showed normal distribution compared to the resin group, demonstrating less variability among the values. The group FP displayed higher fracture resistance (299.77±100 N) than group R (205.57±86.40 N), with significant differences (p= 0.00002). The greatest fracture resistance was recorded for the group having fiber post reinforced and composite cores. It is suggested that fiberglass post restoration is the first option when endodontic treatment requires core restoration.

KEY WORDS: composite resins, endodontically-treated tooth, synthetic resin, young modulus.

INTRODUCTION

Endodontically treated teeth are a difficult procedure to solve and give up the anatomy and function in the stomatognathic system. Furthermore, teeth treated with post that have lost dental structure should be rebuilt to resist the occlusion forces and maintain the definitive restoration during long time (Goto *et al*., 2005; Coelho *et al*., 2009; Khaled Al-Omiri *et al*., 2010). In past decades, teeth endodontically treated have been restored with metallic post made up in the same size of root canal; however, one of the major disadvantages is that metallic structure translucent through dentin when post is positioned in anterior teeth affected pointedly the aesthetic appearance. In response to this problem, nowadays, post made of glass fiber, quartz, and carbon fiber can solve the esthetics (Abo El-Ela *et al*., 2008; Mohammadi *et al*., 2009).

Resistance is mentioned as the highest tension that a material can struggle before fracture, resistance is necessary after post reconstruction performed intra root canal. The restoration of endodontically treated teeth is a complex procedure to return the anatomy and function of teeth that have lost structure. In fact, is essential to plan the adequate via to increase retention and resistance of a permanent restoration (Goto *et al*.;

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Coelho *et al*.; Khaled Al-Omiri *et al*.). The loss of structure integrity is the main reason about the vulnerability of endodontically treated teeth and their resistance to fracture (Mohammadi *et al*.).

Vertical root fractures of teeth with endodontic treatment that were prepared to receive root post were more frequent in teeth of older patients, more than 60 years old, and where dentine thickness was reduced (Mireku *et al*., 2010). Internal root fortification is not enough to prevent fracture if the tooth is retraumatized with an acute accident results in root fracture, it is necessary an adequate adhesive procedure that hold the best promise for root fortification (Seghi *et al*., 2013).

In a review where investigate the overview of fracture resistance of teeth restored with dowel-retained restorations, general agreement among researchers that post *per se* do not offer reinforcement of restored teeth; on the contrary, their insertion involves procedures that usually sacrifice tooth structure and reduce the fracture resistance. Unrepairable root fractures have been frequently reported as the most catastrophic mode of failure that was associated with post placement, especially when rigid posts were used (Khaled Al-Omiri *et al*.).

Fiber post are considered as an option to restored teeth treated endodontically due to its reformed with epoxy resin and cemented by methacrylate adhesive system and dual resin cement (Pirani *et al*., 2005). Fiber posts have higher elastic modulus than metallic, similar modulus than dentine structure and such kind of features confer a better distribution of tensile forces to prevent tooth fracture at long time during mastication (Abo El-Ela *et al*.). Teeth enamel is a crystalline structure with high resistance to fracture, elastic modulus (41 GPa), proportional limit and fragile due to less resilience than dentine (18.6 GPa) (Eskitascioglu *et al*., 2002; Coelho *et al*.).

When tooth lose structure by caries or trauma, is required to restore the tooth with different materials in order to replace missing structure, to return the anatomy and achieve function (Khaled Al-Omiri *et al*.). An important factor to restore teeth with composite resin is the resistance of the restorative material, this mechanical property of the material allows to restoration serves its functions effectively, safely and for a reasonable period. In other words, resistance refers to the maximum capacity that a material can withstand forces before it fractures. A measurement of the resistance of a tooth restored with resin, up to breaking, allows us to investigate changes in cavity design that can improve the resistance to failure of the restorations in the oral environment. The analysis of the possible failure of a restoration under applied forces must be related to the mechanical properties of restorative materials, dental remnant of the interface between the two materials (Naumann *et al*., 2009).

The fracture resistance of teeth with endodontic treatment is influenced by a large number of parameters such as age, plaque, number of adjacent teeth, occlusal contacts, remaining tooth structure, tooth position in the dental arch, type of restoration (Goto *et al*.), degradation of collagen (Eskitas¸ciog˘lu *et al*.; Coelho *et al*.; Naumann *et al*.).

The aim of this study was to determinate the fracture resistance of endodontically treated tooth and restored with two root post systems: I) resin post, II) fiber post with universal testing machine. We hypothesized that fiber post restoration withstands higher applied force before fracture.

MATERIAL AND METHOD

Sample preparation. A total of 60 teeth were freshly extracted, collected and stored in thymol at 1 %. The inclusion criteria corresponded to teeth without root caries, microscopic fractures, and root curvature less than 20°. All teeth were analyzed microscopically (Magnification digital microscope, DMS1000, Leica, Wetzlar, Germany). The access was made with high-speed carbide burs, the formation of the third cervical and middle root canal was instrumented with LA Axxes (Sybron Endo, CA, EUA) and irrigated with 0.25 % sodium hypochlorite (NaOCl). The working length was adjusted at 0.5 mm before the apex and corroborated with digital radiography (Kodak, Rochester, NY, USA). The instrumentation was manually instrumented with K3 system (Sybron Endo, CA, EUA) and obturation was executed by fluid gutta-percha filling (Obtura III MAX Spartan, Algonquin, IL, USA) at 3 mm and confirmed by digital radiography.

Once the root canal treatment was performed teeth were randomly divided in two groups (n= 30/each group): Group 1 (Group R): Resin post and restoration (TE-Econom plus, shade A2, Ivoclar Vivadent, Schaan, Liechtenstein), Group 2 (Group FP): Fiberglass post and resin restoration (Reforpost, Angelus, Londrina, PR, Brazil).

For group 1, intraradicular reconstruction engraving of the surface with phosphoric acid at 37 % for 20 seconds, washed with tap water for 20 seconds and surface drying using cotton points and the application of 5th generation bonding agent (Heliobond, Ivoclar Vivadent, Schaan, Liechtenstein) was photocuring with LED light lamp (Optilight, Gnatus, Ribeirao Preto, Sao Paulo, Brazil) for 20 seconds, the resin was taken to root duct using an instrument designed for this purpose, small increments less than 2 mm was placed by oblique layering technique and polymerized for 40 seconds until cover the entire root canal and from here was formed the stump with oblique layering technique. In case of group 2 glass fiber posts were cemented intraradicular preparation of each post according to the manufacturer's instructions with dual resin cement (RelayX ARC, 3M ESPE, St. Paul, MN, USA). After cementation, small increments of composite resin with oblique layering technique were deposited and polymerized for 40 seconds, the post was cutting at 12 mm length and adjusted the high of composite core. The groups and the stump dimensions are diagrammatic represented in Figure 1.

Mounted and tested samples. Each endodontically and core reconstructed samples were placed vertically in a PVC pipe with acrylic self-curing resin, the PVC pipe were mounting in metallic base at 135 degrees

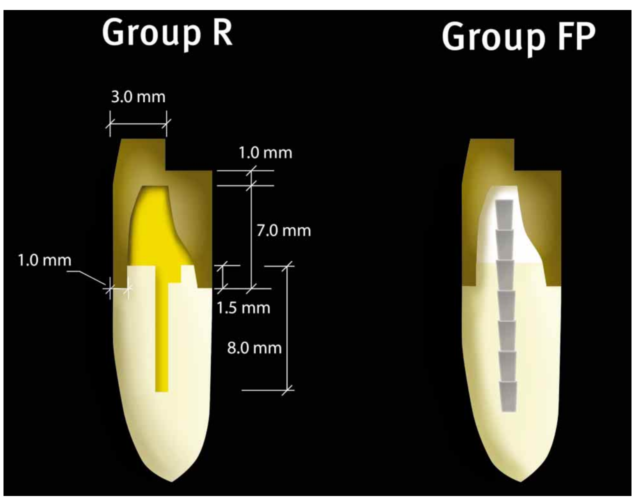

Fig. 1. Diagrammatic representation of study groups, Group R: Resin post and restoration and Group FP: Fiberglass post and resin restoration.

allowing them to be stabilized and held in the universal testing machine. The fatigue resistance was tested in universal testing (AGS-X, Shimadzu, Kyoto, Japan) by applying a vertical force at cross speed of 1 mm/min (Fig. 2). Data were recorded in Newtons (N). Before the fracture resistance test, all samples were stored in distilled water at 37 ºC for 24 hours.

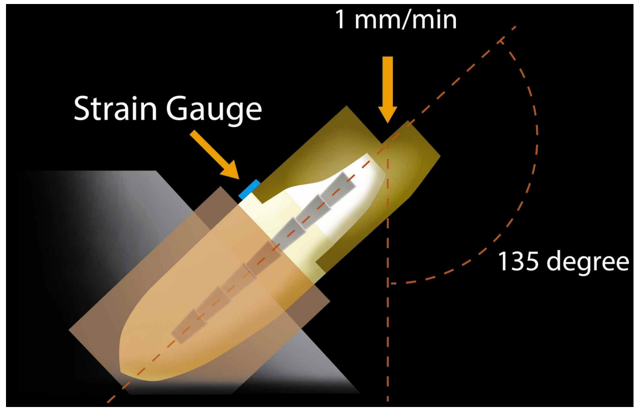

Fig. 2. Diagrammatic depiction of load value, load application angle, holding device, and strain gauge location.

Statistical analysis. All data were examined and tested for normality distribution using the Saphiro-Wilk test. The mean values and standard deviations were estimated. Student's t test was used to compare fracture resistance between the groups. A value of 0.05 was considered to be statistically significant, which was obtained using SPSS 15.0 statistical analysis software (SPSS Inc., Chicago Ill., USA).

RESULTS

The values and descriptive statistics of the fracture resistance of groups are shown in Table I. The values of fiber post group showed normal distribution compared to resin group, demonstrating less variability among de values. The group FP displayed higher fracture resistance (299.77±100 N) than group R (205.57±86.40 N), with significant differences (p=0.00002) observed between groups based on student´s t tests results.

Table I. Descriptive statistics of fracture resistance of groups (n=30/group)

Group	*Mean±SD* (*Newtons*)	Confidence interval	Significance
Group resin (R)	205.57±86.40	173.31;237.83	0.00002**
Group fiber post (FP)	299.77±100.6	262.20;337.34	

SD: Standard deviation. **Based on Student's t test.

DISCUSSION

It has been suggested that the bending stiffness of the dowel in an endodontically treated tooth compromised by lost tooth structure can be a reinforcing medium. Viscoelastic properties of a tooth structure affect stress distribution within the tooth. If viscoelastic properties are undetermined, the tooth will be mechanically compromised in terms of stress distribution, values, and concentration. Root canal treatment, post and core restoration are examples of conditions in which tooth viscoelasticity is reduced and this explain the reason that the teeth are more liable to fracture (Khani *et al*., 2009; Shegi *et al*.). There exist many factors that influence the fracture resistance of post-restored teeth. Some factors are directly related to the post-core system including the followings: post length, post diameter, post design (Khani *et al*.), post material, post fitting, core material, ferrule effect, and luting cement. Nerveless, other factors are related to restored tooth and include cuspidal coverage, remaining tooth structure and alveolar bone support (Ma *et al*., 2009; Tang *et al*., 2010; Khaled Al-Omiri *et al*.). Other influenced factor of fracture resistance is related with the age of patients, the evaluation of vertical fracture of young and elder teeth has been determinate by Mireku *et al*. whereas vertical root fracture of teeth receiving root canal treatment with posts is more likely to occur in the teeth of older patients (60+) and particularly in those with low dentine thickness. Although intraradicular dentin hybridization is not compromised irrespective with the adhesives cement systems, the universal occurrence of interfacial gaps along the hybrid layer surface or the post-cement interface reflects the challenge in bonding to post spaces with low compliance and high C-factors. The clinical success associated with bonded fiber posts is probably due predominantly to frictional retention (Pirani *et al*.).

It has been investigated the flexural modulus, the strength of dentin and different materials for endodontic reconstruction, the study state that the flexural modulus of dentin was 17.5±3.8 GPa, mean, the values for posts ranged from 24.4±3.8 GPa for silica fiber posts to 108.6±10.7 GPa for stainless steel posts. The flexural strength for dentin was 212.9±41.9 MPa, while the posts ranged from 879.1±66.2 MPa for silica fiber posts to 1545.3±135.9 MPa for cast gold posts. Fiber reinforced composite posts have an elastic modulus that more closely approaches that of dentin while that for metal posts was much higher. The flexural strength of fiber and metal posts was respectively four and seven times higher than root dentin (Plotino *et al*., 2007).

The study of Abo El-Ela *et al*. to determine the fracture resistance of anterior endodontically treated teeth concluded that a novel glass fiber post was associated with the highest mean fracture force for maxillary anterior teeth, regardless of the bonding agent used, whereas the stainless-steel post was associated with the lowest mean fracture. Contrary, the study of D´Arcangelo *et al*. (2008) where studied the influence of endodontic therapy, veneer preparation, and their association on fractures resistance and deflection of pulpless anterior teeth stated that veneer preparations and endodontic treatment did not significantly influence fracture resistance of maxillary incisors. On the contrary, preparation for veneer significantly increased the deflection values Fiber post restorations seemed to significantly increase mean maximum load values. Fiber reinforced post restoration can be suggested when endodontic treatment is associated with veneer preparation. Opposite, the elastic modulus of mandibular molars restored using resin composites with or without fiber posts, with respect to the number of residual cavity walls. Teeth were loaded and resistance of specimens was measured as the axial compressive load to cause fracture and macroscopic fracture patterns were observed. Revealed significant differences between groups as samples restored with fiber posts exhibited mostly restorable fractures. It was concluded that the resistance of endodontically treated mandibular molars restored with composite resins is mainly affected by the number of residual walls. Using fiber reinforced posts optimized fracture patterns (Salameh *et al*., 2006)

However, in vivo loading is a dynamic and repetitive fatigue loading, and this type of loading was not used in the study. Since the dowels used in the present study had the same cross-sectional areas and shapes, the bending stiffness of the dowels would be directly proportional to the modulus of elasticity of each material. Consequently, if the bending resistance of the dowel is a significant factor in tooth reinforcement, based on bending stiffness alone, one would expect the teeth with titanium alloy dowels to have survived a significantly higher number of fatigue cycles compared to those with the glass fiber dowels. This was not the case. The specimens with resin-reinforced glass fiber dowels survived roughly twice the number fracture resistance.

On contrary, endodontically treated teeth restored with direct composite resin with (999.07±200.17 N) or without fiber post (1111.47±227.84 N) had similar fracture resistance under 90° static loading (Mohamadi *et al*.; Ma *et al*.). Our results are not according with previous conclusion; here it was found that the fiber post core with oblique layer technic composite resin restoration (299.77±100 N) significantly increase the fracture resistance more than direct layering composite resin and core restoration (205.57±86.40 N) at 135° static applied forces (1 mm/min). Similarly, our methodology here used and with the same cross speed applied force recorded in newtons, the fracture resistance of roots filled with a bonded material, fiber posts, or titanium post systems. There was no statistically significant difference between (p>.05) titanium posts, fiber posts, and resilon/epiphany root canal filling systems were found to have no reinforcing effect on endodontically treated roots (Sagsen *et al*., 2013). Additionally, the ultrastructure and resistance to fracture of different types of fiber post has been evaluated to verify the existence of a correlation between structural characteristics and flexural strength. The test was carried out until fracturing of the post. Of the various structural characteristics investigated, only the fiber/matrix ratio showed a significant correlation to the flexural strength (r=0.922, p=0.003). Significance: The fiber reinforced posts investigated displayed significant differences regarding fracture load and flexural strength. A strong and significant linear correlation between the fiber/matrix ratio and the flexural strength was found (Seefeld *et al*., 2007).

On the other hand, finite element analysis (FEA) has been used to investigate the influence of different post systems on the stress distribution of weakened teeth under oblique-load application. Studies have been evaluated cast metallic post, stainless steel post, fiberglass post, carbon fiber post, zirconium dioxide post, fiber composite laminated and titanium post cored with resin. Materials and structures were considered linear elastic, homogeneous, and isotropic, except for fiberglass and carbon fiber posts which assumed orthotropic behavior. Therefore, results from the FEA images suggested that the use of non-metallic post systems could result in improved mechanical behavior for the weakened restored teeth (Eskitas¸ciog˘lu *et al*.; Coelho *et al*.).

There exist just a few randomized controlled trials that compared the survival of glass fiber and cast metal dental posts used to restore endodontically treated teeth with no remaining coronal wall. In the study fifty-four participants and 72 teeth were evaluated during a follow-up period of up to 3 years. Teeth were randomly allocated to the glass-fiber and cast-metal post groups. All teeth were restored with single metal-ceramic crowns. The 3-year recall rate was 92.3 % and the survival rates of glass fiber and cast metal posts were similar (97.1 % and 91.9 %, respectively; p= 0.682). Four failures were observed: two glass fiber posts in a premolar and anterior tooth debonded, one glass fiber post in a premolar debonded in association with root fracture, and one root fracture occurred in a molar with a cast metal post. The researchers conclude that glass fiber and cast metal posts showed similar clinical performance in teeth with no remaining coronal wall after 3 years (Sterzenbach *et al*., 2012; Zhou & Wang, 2013; Sarkis-Onofre *et al*., 2014). Nevertheless, a meta-analysis compares the fracture resistance of cast posts versus the fracture resistance of fiber posts by means of meta-analysis when they were used in the restoration of endodontically treated teeth indicated that the cast post group displayed significantly higher fracture resistance than the fiber post group (Naumann *et al*.).

Here we studied a static loading at constant angle of endodontically restored tooth as many other studies. However, masticatory forces are multidirectional and repeatedly applied on large areas. It is recommended for future studies in order to mimic such conditions, cycling loading applied forces

CONCLUSION

Within the limitations of this in vitro study, the greatest fracture resistance was recorded for the group having fiberglass post reinforced and composite cores, Group FP. It is suggested that fiber post restoration is he first option when endodontic treatment is requires cores restoration.

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RESUMEN: El objetivo del estudio fue determinar la resistencia a la fractura de dientes tratados endodónticamente y restaurados con dos sistemas de endopostes radiculares: I) poste de resina, II) poste de fibra.

Un total de 60 dientes recién extraídos fueron tratados endodónticamente y divididos al azar en dos grupos (n= 30 / cada grupo) para la restauración estandarizada; Grupo 1 (Grupo R): Pilares de resina y restauración, Grupo 2 (Grupo FP): Pilares de fibra de vidrio y restauración de resina. Las muestras de ambos grupos se montaron en una base metálica a 135º para permitir su estabilización y sujeción en la máquina universal de ensayos aplicando una fuerza vertical a velocidad transversal de 1 mm/min. Los datos se registraron en Newtons (N), para probar la resistencia a la fractura; todas las muestras se almacenaron en agua destilada a 37 ºC durante 24 horas. Los datos se sometieron a la prueba de normalidad de Saphiro-Wilk y la pruebas t de Student. La significancia se consideró con un valor de 0,05. Los valores del grupo de postes de fibra mostraron una distribución normal en comparación con el grupo de resinas, demostrando menor variabilidad entre los valores. El grupo FP mostró mayor resistencia a la fractura (299,77±100 N) que el grupo R (205,57±86,40 N) que el grupo con diferencias significativas (p= 0,00002). La mayor resistencia a la fractura se registró para el grupo que tenía núcleos compuestos y reforzados con postes de fibra. Se sugiere que la restauración posterior de fibra de vidrio es la primera opción cuando el tratamiento de endodoncia requiere una restauración del núcleo.

PALABRAS CLAVE: resinas compuestas, diente tratado endodónticamente, resina sintética, módulo young.

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