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IN VITRO EVALUATION OF THE EFFECT OF DIFFERENT DIAMETERS OF QUARTZ FIBER POSTS ON FRACTURE RESISTANCE OF DENTAL ROOTS

Avaliação in vitro *do efeito de diferentes diâmetros de pinos de fibras de quartzo na resistência à fratura de raízes dentais*

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Abstract

OBJECTIVES: One of the controversial factors in fracture resistance of endodontically treated teeth that are reconstructed with fiber posts is the diameter of these posts. The aim of this study is to evaluate the effect of three different sizes of quartz fiber post (#0.5- #2 - #3) on fracture resistance of dental root. **MATERIAL AND METHOD**: In this *in vitro* study, 30 mandibular premolars were selected, sectioned from CEJ, endodontically treated and randomly assigned to three groups (n=10). Post spaces were prepared and quartz fiber posts) D.T. Light-Post™ (with three different sizes (#0.5- #2 - #3) were seated respectively in three groups. All posts were cemented with Panavia F 2.0 dual cure resin bonding and cement. Composite resin cores were built up using a preformed polyester matrix. Specimens were embedded in acrylic resin blocks with a layer of elastic polyether Impergum around roots as PDL. A compressive load at a crosshead speed of 1mm/min was applied axially to the central fossa of each specimen using a Universal Testing Machine, until the occurrence of root fracture. Data were analyzed using one-way analysis of variance. **RESULTS**: There was no significant statistical difference in fracture resistance among three groups (P>0.05).Mean fracture load was 1010±250.95 N for group A with post #0.5 and 934.4± 295.18 N for group B with post #2 and ±1001301.42 N for group C with post #3. **CONCLUSIONS**: According to the findings, larger sizes of fiber posts do not decrease the fracture resistance of the root structure. Larger diameters have higher fracture resistance and furthermore by increasing the bonding area between post and root canal wall and core material, they can improve the unity within root structure and provide more stability for core material.Unlike larger sizes of metal posts, fiber posts with larger diameters adhere to the root structure more efficiently. As a result, they will not reduce the fracture resistance of root. Therefore, when restoring endodontically treated crownless teeth, it is advisable to use fiber posts having larger diameters to stabilize the core material and to increase bonding area and bonding strength between post and root canal wall.

Keywords: Quartz fiber post. Fracture resistance. Post diameter. Root structure.

Resumo

OBJETIVOS: *Fator controverso na resistência à fratura de dentes endodonticamente tratados, reconstruídos com pinos de fibra, é o diâmetro destes pinos. O objetivo deste estudo é avaliar o efeito de três diferentes tamanhos de pinos de fibras de quartzo (#0,5 – #2 - #3) na resistência à fratura de raízes dentárias.* ***MATERIAL E MÉTODO:*** *Neste estudo in vitro, 30 pré-molares mandibulares foram selecionados, seccionados, tratados endodonticamente e designados aleatoriamente em três grupos (n=10). Condutos foram preparados e pinos de fibras de quartzo (D.T. Light – Post ™) com três diferentes tamanhos (#0.5- #2 - #3) foram fixados, respectivamente em três grupos. Todos os pinos foram cimentados com cimento Panavia F 2.0. Pinos de resina foram construídos usando uma matriz pré-formada de poliéster. Os corpos de prova foram embebidos em blocos de resina acrílica com uma camada de Impregum™ ao redor das raízes. Cargas compressivas na razão de 1 mm/min foram aplicadas axialmente na fossa central de cada corpo de prova, usando uma máquina universal de testes até a ocorrência de fratura radicular. Os dados foram submetidos à análise de variância.* ***RESULTADOS***: *Não houve diferenças estatisticamente significantes na resistência à fratura entre os três grupos (P>0,05). A carga média de fratura foi 1010+-250.95 N para o grupo C, com o pino # 3.* ***CONCLUSÕES***: *De acordo com os achados, tamanhos maiores de pinos de fibra não diminuem a resistência da estrutura radicular. Maiores diâmetros têm mais resistência à fratura e, além disso, pelo incremento da área de cimentação entre o pino e a parede da raiz, podem melhorar a união dentro da estrutura radicular e proporcionar mais estabilidade para o material de núcleo. Ao contrário de pinos metálicos de maior tamanho, os pinos de fibra de maior diâmetro aderem à estrutura radicular com mais eficiência. Como resultado, não reduzirão a resistência à fratura da raiz. Assim sendo, quando restaurarem-se dentes endodonticamente tratados é aconselhável usar pinos de fibra com diâmetros maiores para estabilizar o núcleo e aumentar a área de cimentação e força de cimentação entre pino e parede da raiz.*

Palavras-chave: *Pinos de fibras de quartzo. Resistência à fratura de raiz. Diâmetro de pinos. Estrutura radicular.*

INTRODUCTION

Fracture resistance is an influential factor in treatment method selection for endodontically treated teeth. Different methods of tooth reconstruction produce different levels of stress. Prosthetic treatment mostly involves endodontically treated teeth that normally had suffered previous trauma, restoration or other endodontic interventions. Prognosis of an endodontically treated tooth largely depends on its condition before root canal treatment, the quality of endodontic treatment, the amount of remained tooth structure and the amount of bone support (1-3). Teeth restored with post and core systems show lower fracture resistance compared to normal teeth. Therefore, this kind of treatment should only be used to provide suitable retentive and resistance forms for full coverage crowns (1-3).

One of the controversial factors in fracture resistance of dental roots is the diameter of the endodontic posts (1). Nearly all post materials require an increase in diameter to achieve favorable physical characteristics, maintaining satisfactory resistance against functional and parafunctional forces without post fracture (1, 3). On the other hand, post space should be prepared conservatively and at least 1.0 mm thickness of sound dentinal wall should remain around the post (2). In case of metal posts, when larger sizes are used, as these posts do not have the ability to bond with root structure, the likelihood of root fracture during function increases. Nonmetal posts, due to their bonding ability to dentin, cause the stress to distribute evenly through the root and therefore provide higher tooth fracture resistance (1-3).

Despite previous studies, the effect of fiber post diameter on fracture resistance of root remains controversial from many aspects, as some studies consider the post size an effective factor while others consider it as ineffective. Some authors suggested that there is a direct relation between diameter of root and the remaining dentin thickness around the post and the ability of tooth, resisting lateral forces (3). In a research performed on new zirconia posts, it was found that the amount of fracture force primarily depends on post diameter in all Zirconia posts and that, posts with larger diameter provide higher root fracture resistance (4). Another study showed a linear relationship between fracture load and diameter of posts for both glass fiber and carbon fiber posts and that post diameter can affect the amount of fracture load and flexural resistance of root (5).

On the other hand, in another study the researchers found that fiber posts induced a stress field quite similar to that of the natural tooth, with maximal stresses that did not vary with post diameter or length (6, 7). Some authors suggested that stresses in tooth structure as well as in composite resin core were slightly reduced with increase in fiber post diameter (8).

Therefore, considering the above controversies, this study with the aim of evaluating the effect of three different sizes of quartz fiber post (#0.5, #2, #3) on fracture resistance of dental root was performed.

MATERIAL AND METHOD

This experimental study was performed on 30 human mandibular premolars with similar root length and without any root caries, fillings, restorations, previous endodontic treatments or cracks at 2X magnification, that might affect their fracture resistance to loading (9, 10). Each specimen was measured with a caliper to ensure size range of 7-8 mm buccopalataly and 5.5-6 mm mesiodistally (11). Ethical clearance was obtained for the collection of teeth for this research. After disinfecting the specimens in timol 0.2% solution for 48 hours, specimens were stored in normal saline (12, 13). All teeth were decoronated from cemento-enamel junction (CEJ), with 0.2 mm thick metal discs (D&Z, Switzerland) (14). After that, with step back method using k-files (Maillefer, Switzerland) and frequent hypochlorite sodium 5.25% irrigation, the root canal of all teeth was filed and prepared and using the lateral condensation technique the canal in each specimen was obturated with gutta percha cones and AH-26 resin sealer (Densply,Maillefer). After that, specimens were assigned randomly to 3 groups with 10 samples in each: (4, 6, 12, 15, 16)

Group A with size #0.5 quartz fiber posts (D.T. Light-Post™, RTD, France)

Group B with size #2 quartz fiber posts (D.T. Light-Post™, RTD, France)

Group C with size #3 quartz fiber posts (D.T. Light-Post™, RTD, France)

In all three groups, 10 mm of the root filling was removed from canal with the D.T. Universal drill in a way that allowed 4 mm apical seal (11). Next, the canal in each tooth was shaped with the D.T. finishing drill corresponding to the selected D.T. Light-Post™ size and 10 mm long post spaces were prepared. (A rubber stop was used on the drill as a reference point for canal depth). Each post was tried in canal to ensure proper fit (9, 10). Post spaces were cleaned with paper points. Equal amounts of ED Primer II A & B from Panavia F2.0 (Kuraray, Japan) were mixed according to the manufacturer's instructions and were applied to coronal and post hole tooth structure with a small brush. After 30 seconds, the primer was gently air-dried with air from a dental triple syringe and excess primer was removed with paper points (9, 10). Equal amounts of pastes A & B from Panavia F2.0 (Kuraray, Japan) were mixed and posts were coated with mixed cement. Afterwards, each post was seated inside each canal to full depth and excess cement was applied to coronal tooth structure. Then, using preformed polyester matrixes, the core was built-up in each specimen with 3M Z250 resin composite (ESPE, USA). Preformed polyester matrixes were filled with composite and were seated on the coronal portion of posts followed by curing the composite cores for 40 seconds from each direction,(Buccal, lingual, mesial, distal) with Coltolux 2.5 (Coltene, Germany) light cure device (380 mw/ cm2). In order to build artificial periodontal ligament (PDL) to represent the natural periodontium around roots, each sample was marked 2 mm beneath CEJ portion with a marking pen. A piece of 0.2 mm thick aluminum foil was placed on the root from the marked area to the root tip and was adapted evenly on the entire root area (adaptafoil). The roots were embedded in auto polymerized acrylic resin blocks. As soon as first polymerization signs were visible, specimens were removed from acrylic blocks. After that, a suitable amount of elastic polyether Impergum (3M, ESPE, USA) was injected into each acrylic space formed by dental roots. After removing the foils, samples were replaced in blocks. Excess of Impergum was removed after setting. Therefore, an even 0.2 mm thick Impergum functioned instead of natural PDL around each specimen while upper limit of acrylic resin blocks was 2 mm beneath CEJ (Figure 1). In this way, specimens were stabilized during load application (12, 17, 18, 20). Subsequently, specimens were placed in a Universal Testing Machine (Instron1195 Co UK) (4, 21).

A compressive load at the crosshead speed of 1mm/min was applied axially to the central fossa of core material in each sample with a rounded end steel rod (Figure 2). Specimens were loaded to the point of root fracture. Finally, the fracture pattern and load were recorded for each sample and data were analyzed with SPSS 10 analytical software. (Inc. Chicago IL USA)

FIGURE 1 - The roots are embedded, 2 mm beneath CEJ in auto polymerized acrylic blocks, while an even 0.2 mm thickness of Impergum functions instead of natural PDL around the specimens

FIGURE 2 - Specimen under compressive load

RESULTS

Kolmogorov-Smirnov test proved the normal distribution of data. Therefore, one-way analysis of variance (ANOVA test) was used to compare mean fracture loads in groups. Note that one sample from each group was excluded from the results.

Mean fracture load was 1010±250.95 N for group A with post #0.5 and 934.4± 295.18 N for group B with post #2 and ±1001301.42 N for group C with post #3. Results of ANOVA test indicated that there was no statistically significant difference among the three groups regarding fracture resistance (P>0.05).

Table 1 shows that all three groups have high fracture resistance and the three sizes of quartz fiber posts that were studied, do not affect the fracture resistance of the root (P>0.05).

TABLE 1 - Mean and standard deviation of fracture loads (Newton) in three groups

Load (N)	Mean groups	S.D.	minimum	maximum	P value P>0.05 Not Significant
A: post size #0.5	1010 N	250.95	N640.00	N1380.00	—
B: post size #2	934.4 N	295.18	N440.00	N1300.00	—
C: post size #3	1001 N	301.42	N620.00	N1600.00	—

In group A, post and core were debonded in two samples, while in six samples fracture started in core material and ended in 1/3 cervical portion of root and one sample was fractured vertically. In group B, one debonding occurred, while in six samples fracture was limited to 1/3 cervical portion of root and two samples were vertically fractured. In group C, no debonding was visible but seven specimens were fractured to 1/3 cervical portion of root, while two samples were fractured vertically.

Fracture load for each sample and mean fracture load in three groups are compared in Figures 3 and 4.

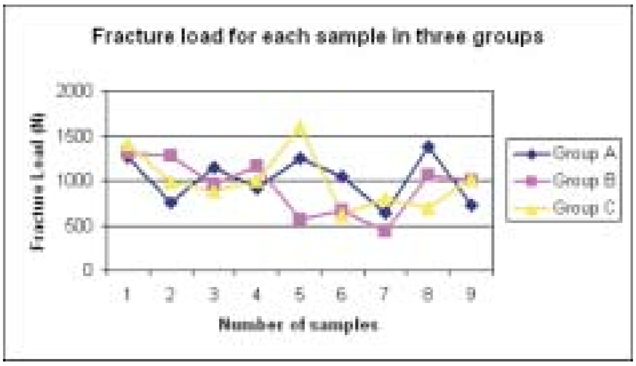

FIGURE 3 - Fracture load (N) for each sample in three groups

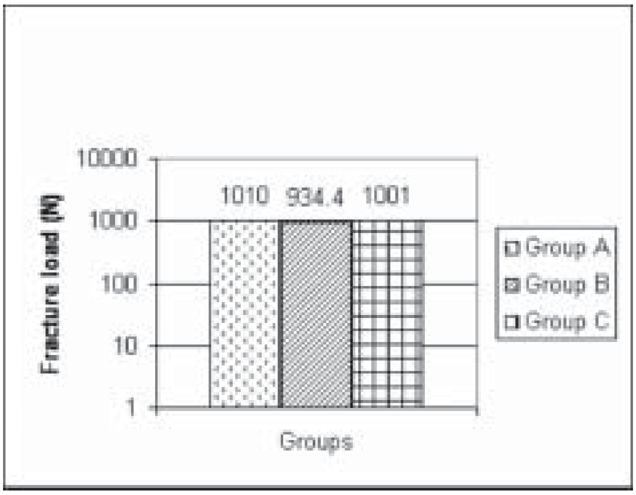

FIGURE 4 - Mean fracture load (N) in three groups

DISCUSSION

The present study showed that the diameter of quartz fiber posts does not affect fracture resistance of the dental root. The structure and the bonding ability of these posts enable them to adhere to the root structure (1). Consequently, when the post is loaded, the force will not concentrate on the junction between post and root canal wall. Instead, it distributes through the root and controlled by the surrounding bone structures. If larger posts are used, although the thickness of remaining tooth structures will become less, due to more extensive bonding area, adhesion also improves and that can compensate for the decreased dentin thickness, as long as 1 mm of sound dentin is remained around root (1-3).

In this study, we found that larger sizes of quartz fiber posts do not decrease fracture resistance of root. Therefore, when restoring crownless teeth, in order to compensate for the low MOE (modulus of elasticity) in these posts, it is recommended to use larger diameters. In this way, both post strength and bonding area to the core material will increase, so the core material will become more stable (8, 21-23).

It is difficult to compare significantly the findings of similar in vitro studies discussing fracture resistance of tooth, due to numerous variables such as pulpal condition, root dimension, anatomy and age of tooth in time of extraction, as well as angle and magnitude of applied load (11).

In the present study, the specimens were selected carefully to ensure similar dimensions. In addition, elastic polyether substance (Impergum) was used to simulate the natural periodontium structure that allowed natural range of tooth movement (12, 17, 18). If the elastic substance had not been used, rigid acrylic resin blocks would have produced a ferrule effect and the fracture resistance would have appeared higher than its real amount (14). Also, similar to Baldissara et al. (21) studies in 2007, in the present study full coverage crowns were not placed on core material of study samples and compressive force was applied directly to core material (24, 25). In this way, factors like material, size, shape and thickness of crown that could intervene with the results, were eliminated (25). It has been shown that by excluding these variables, structural durability and fracture resistance in post and core systems can be examined and measured in a more precise manner (25). In addition, in this way the entire load is applied directly to the core. On the contrary, with full coverage crowns placed over the core material, load is partially conveyed through crown's margins directly to the root (26).

Rodriguez-Cervantes et al. (7) used the finite element method (FEM) to predict stress distribution patterns in dentin and core of endodontically treated teeth, restored with glass fiber posts of varying diameters and lengths. Based on the simulation results, they concluded that glass fiber post induced a stress field quite similar to that of the natural tooth, with maximal stresses that did not vary with post diameter or length. Also in 2007, using 3D finite element analysis method, Okamoto et al. (8) realized that when fiber posts with larger diameters are used, the stress amount in root structure and core material slightly lessens. In addition, Baldissara et al. (21) reported that although the root fracture rate was not significantly correlated to the post diameter, the emerging (coronal) diameter of fiber post was extremely important to stabilize the core. Valandro et al. (15) in 2003 and Lassila et al. (5) in 2002 announced that smaller diameters of fiber posts cause them less fracture resistance. Accordingly, larger fiber posts have higher fracture resistance and considering the results of our study, they do not decrease the fracture resistance of the remaining root structure due to their bonding ability.

Therefore, in order to benefit from the advantages of added bonding area between post and tooth structure and between post and core material, we recommend the usage of larger sizes of fiber posts. In this way, the strength of bonding and the stability of core material can be improved (8, 21-23). Note that Valandro et al. (15) and Lassila et al. (5) examined the flexural properties of fiber posts without inserting them in root canals. However, in the present study, we examined the effect of fiber post's diameter on fracture resistance of the root by inserting them in natural root canals.

Conversely, findings of the present research are not in accordance with Oblak et al. (4) studies regarding fracture resistance of zirconia posts with varying diameters. They announced that larger zirconia posts increase the fracture load in canals. It can be suggested that ceramic posts demonstrate different flexural characteristics from that of fiber posts.

In addition, Oblak et al. (4) studied the effect of post size along with the effect of different methods of post surface treatment like grinding or airborne-particle abrasion. This can cause complexity in examining the actual effect of post size independently. As the authors conclude, that grinding leads to a significant drop in load to fracture, whereas airborne-particle abrasion increases the fracture load (4). Moreover, zirconia posts were cemented in artificial root canals, which can cause different environment from that of natural root canal.

It has been reported that adhesive luting agents can improve retention between post and core material surrounding it (25, 27). Accidental voids that result from improper placement of composite resin around fiber post's coronal portion, weaken the bonding between post and core and can jeopardize the fracture resistance of tooth structure (25).

Therefore, in the current study adhesive luting agents were applied around coronal portion of each post prier to forming the core material, to strengthen the bond between post and core system.

CONCLUSIONS

According to the findings of this research, we can conclude that larger sizes of fiber posts do not decrease fracture resistance of the root. Larger diameters of fiber post can increase the bonding area and consequently the strength of bonding between post and tooth structure and can compensate for the decreased dentin thickness and improve the unity within root structure. In addition to their higher strength, larger sizes of fiber posts provide more bonding area with core material. Therefore, when restoring endodontically treated crownless teeth, it is advisable to use fiber posts having larger diameters to stabilize the core material and to increase bonding area in root structure.

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