ORIGINAL ARTICLE

Influence of Fiber Posts on the Fracture Resistance of Endodontically Treated Maxillary Central Incisors with Different Dental Defects

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Abstract

Objective: *Obtain information on the influence of fiber post placement on the fracture resistence of endodontically treated maxillary central incisors with different dental defects.* ***Materials & Methods:*** *Forty human maxillary central incisors were endodontically treated and randomized into four groups. Each group was prepared according to the number of residual walls, ranged from 0 to 3. Then each group was divided into two subgroups: first restored with glass fiber post and the second without post. In no-post group, gutta percha point 2mm below the CEJ was removed. In the other group, glass fiber post was cemented by leaving at least 4mm of apical seal. Both groups were restored with light-cured composite resin. Then all specimens were subjected to static linear loading in a universal testing machine at an angle of 135° to the longitudinal axis of the tooth with a crosshead speed of 0.5mm/min until fracture.* ***Results:*** *In groups with glass fiber posts, the subgroup with three coronal walls showed the highest fracture resistance (717.9 N). The group with glass fiber posts and without coronal walls showed the lowest fracture resistance (451.0). The results show that there was no significant difference in the fracture resistance among groups with and without fiber posts when there were three coronal walls (P=0.24). The same results were obtained with no coronal walls left (P=0.805).The placement of the fiber post had no significant effect on the fracture mode (P>0.05), and the fracture pattern was mainly favorable.* ***Conclusion:*** *Endodontically treated teeth restored with glass fiber posts did not have significantly increased fracture resistance.*

Keywords*: Glass fiber post; Fracture resistance; Endodontically treated teeth; Central incisors*

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Received on: 18/03/2017 Revised: 22/03/2017 Accepted : 24/03/2017

Introduction

Major anxiety in dentistry comes from restoring the oral functions of endodontically treated teeth. After root canal treatments, most teeth are structurally damaged and become much weaker[1].The strength of the teeth depends on the amount of remaining dentin, and endodontically treated teeth are at higher risk of failure[2, 3, 4].

For many years, cast posts and cores have been the most widely used type of post[5]. However, they have some disadvantages, such as root fractures[6], corrosion[7] and even loss of post retention[8]. Tooth preparation for cast posts and cores requires removing a larger amount of root dentin, which leads to higher risk of tooth fracture[9].The new development of glass fiber post systems provides an alternative for the final restoration of endodontically treated teeth. Glass fiber posts exhibit significantly lower failure loads than metal posts and cores[10].Glass fiber posts also have a similar modulus of elasticity and rigidity to those of dentin, they have favorable aesthetic properties, and they can be bonded to dentin[11].

Many studies have investigated different posts materials, post lenghts, luting agents, and ferrule effects on fracture resistance[12]. However, the results have been inconsistent. Some studies report that the fracture resistance of endodontically treated teeth is remarkably increased when restored with fiber posts[13]. However, other studies have found that the fracture resistance of fiber posts is equal to that of metal posts[14]. It is thus uncertain whether or not fiber posts make endodontically teeth stronger.

The purpose of this *in vitro* study is therefore to evaluate the influence of fiber post placement on the fracture resistence of endodontically treated maxillary central incisors. The experiments were carried out using different dental defects and static loading.

Materials and Methods

Teeth selection

Forty human maxillary central incisors were obtained from the Maxillofacial Surgery Department of Lithuanian University of Health Sciences. Teeth were gathered after obtaining informed consent, and the study was approved by the Comission for Biomedical Research Ethics. Teeth were collected irrespective of age, sex, and side of the arch. None of the teeth had coronal or root caries, coronal or root fillings, or root cracks, and they had a minimum root length of 15 mm with mesio-distal and bucco-palatal dimensions varying between 6 and 8 mm. Dental calculus and periodontal tissues were removed. Teeth were stored in 0.9% saline solution during all subsequent procedures[15].

Root canal treatment

The pulp chamber of each tooth was opened using a diamond bur. Root canals of the specimens were prepared using hand files and the conventional step-back method. Each tooth was instrumented using an International Standardization Organization (ISO) size 50 master apical file at 0.5 mm above the apex. Irrigation was performed after every change of instrument by alternating 2.5% NaOCl solution and 17% EDTA solution. After drying the canals with absorbent paper points, Adseal polymeric resin sealer was mixed and coated onto the walls of the canals. Endodontic spreaders were used to condense the gutta-percha points and to obturate the canals using the lateral condensation technique. All teeth were then stored at 37°C and 100% moisture in Heracell 150i solution for 5 days to create conditions similar to the mouth environment.

Specimen grouping and preparation

All teeth were randomly divided into four groups of ten teeth each. Each group was prepared with different numbers of residual coronal walls. Excess walls were removed using a diamond bur. The specimens were prepared as follows:

Group A: Teeth containing three coronal walls (distal, mesial, and buccal), with just the endodontic cavity opened palatally

Group B: Teeth containing two coronal walls (buccal and mesial or distal), with mesial or distal walls removed 3 mm above the CEJ

Group C: Teeth containing one coronal wall (buccal), with the other walls eliminated to 3 mm above the CEJ

Group D: Teeth with no coronal walls, but with 3 mm above the CEJ

The groups were divided into two subgroups of five teeth each numbered with subscripts 1 and 2. In subgroups A_1-D_1, the gutta percha point was removed 2 mm below the CEJ. Light-cured composite resin was then used to shape the tooth anatomy layer by layer. For subgroups A_2-D_2, gutta-percha was removed using no. 1, 2, and 3 Peeso reamers, leaving at least 4 mm of apical seal. The prepared root canal was finally flushed with 2 ml of NaOCl solution (2.5%) and EDTA (17%). The teeth were then etched. For final irrigation, the prepared root canals and teeth were irrigated with distilled water, dried with absorbent paper points, and bonded with single universal bond. Glass fiber posts of 1.5-mm diameter (size N4) were cleaned with alcohol and coated with silane using a disposable applicator. They were then left for one minute and gently air-dried. Posts were seated into the canals with normal finger pressure and cemented according to the manufacturer's instructions. Excess cement was removed, and light curing was carried out for 60 s to achieve complete polymerization. The light-cured composite resinwas used to shape the tooth anatomy layer by layer.

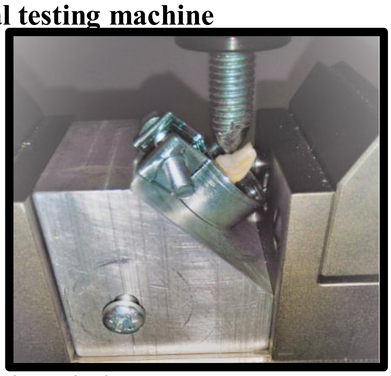
Each root was thinly covered with a silicone impression material, which was applied in the root region with an avarage thickness of 0.1 mm to stimulate the periodontal ligament. Next, 40 acrylic resin cylinders were fabricated by mixing self-cure acrylic resin and pouring it into plastic pipes of 3-cm height and 1.8-cm diameter. All specimens were embedded in these acrylic resin blocks. To simulate the biological width, a margin 2 mm apical to the crown was not covered with acrylic[16].

Fracture resistance test

All specimens were subjected to static linear loading in a universal testing machine (Maximum capacity: 100 kN) at an angle of 135° to the longitudinal axis of the tooth (Figure 1). Load was applied on the palatal surface of the crown on a step 3 mm away from the most incisal edge. The load was applied with a crosshead speed of 0.5 mm/min until fracture and was measured in Newtons (N).

Each sample was then examined to determine the mode of failure. Resin core or post fracture was considered as a favorable (restorable) mode of fracture. All other fractures involving the root were considered as unfavorable (unrestorable).

Figure 1: Specimen positioned for testing in universal testing machine



Statistical analysis

The data were analyzed using SPSS 23.0. One-way analysis of variance was used to determine differences in fracture resistance among groups with different dental defects, and pairwise comparison was used to examine differences between groups with and without a post. Probability values of 0.05 were set as a reference for statistically significant results.

Results

Fracture resistance

The mean fracture resistance is listed in Table 1. In groups with glass fiber posts, the subgroup with three coronal walls showed the highest fracture resistance (717.9N). The group with glass fiber posts and without coronal walls showed the lowest fracture resistance (451.0). The results demonstrate that there was no statistically significant difference (P=0.147).Without glass fiber posts, the subgroup with two coronal walls showed the highest fracture resistance (626.8), while the lowest without coronal walls (478.0N). The results show that there was no statistically significant difference (P=0.238). The results demonstrate that there was no significant difference in the fracture resistance among groups with and without fiber posts when there were three coronal walls (P=0.24). The same results were obtained with no coronal walls left (P=0.805).

Fracture modes

The failure mode was determined by visual inspection as shown in Figure 2. The failure mode and frequency are shown in Table 2. The placement of the fiber post had no significant effect on the fracture mode (P>0.05), and the fracture pattern was mainly favorable.

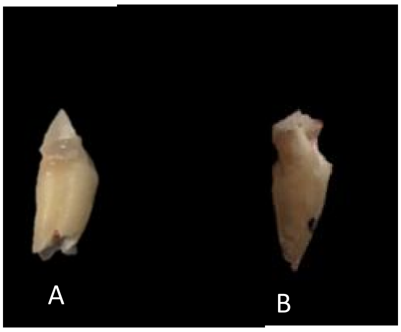
Table 1: Mean & Standard Deviations of Fracture Resistance

Group	Coronal Walls	Mean Without Post	Mean With Post	SD Without post	SD With post
A	3	502,5	717,9	156,2	345,5
B	2	626,8	607,8	175,9	203,3
C	1	607,3	553,8	221,6	85,3
D	0	478,0	451,0	192,7	137,6

Table 2: Fracture modes

Failure Modes	A (3 walls)		B (2 walls)		C (3 wall)		D (0 walls)	
	A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2
Favorable	3	4	3	5	4	5	5	5
Unfavorable	2	1	2	0	1	0	0	0

Figure 3: A-Unfavorable fracture mode, B-Favorable fracture mode



Discussion

This *in vitro* study investigated the fracture resistance of maxillary central incisors with different numbers of residual walls that were restored with or without fiber posts. This is the first study to evaluate the fracture resistance of glass fiber posts after restoring them with light-cured composite resin for different dental defects.

Extracted maxillary central incisors are the most commonly used for in vitro testing of post restoration [17, 18, 19]. Some studies did not use human teeth but rather resin teeth [20] or bovine teeth [21,22]. Resin teeth can recreate the standardized size of teeth but do not capture the bonding and elastic properties of natural human teeth [23]. Furthermore, their adhesion to fiber posts is different from clinical situations [24]. Bovine teeth are similar to human teeth in their bonding characteristics and modulus of elasticity, but they are unacceptably large [25].

All teeth were treated endodontically for this study. This step was done because teeth restored with posts are always endodontically treated, which results in a loss of tooth structure [26]. Endodontic treatment produces reliable results and does not influence the outcome.

The resistance to fracture depends on the length of the post [27]. Decreased fracture resistance is associated with post lengths of up to two thirds of the root length [28]. Cecchin et al. [29] reported that longer fiber posts (8 to 12-mm long) are associated with higher fracture resistance of teeth in comparison with shorter ones (3 to 4-mm long). In the present study, gutta-percha was removed from two-thirds of the root, leaving at least 4 mm of apical seal and keeping posts at an equal and optimum length.

Soares et al.[30] showed that the root embedment method and stimulation of the periodontal ligament have important effects on fracture resistance. For better clinical conditions in practice, a small layer of silicone impression material was added to imitate the periodontum in the present study, which allowed limited freedom of movement[16].

Standardization of the specimens is very important for obtaining comparable results because the deformation and fracture resistance depend on the tooth geometry [31]. Valdivia et al.[32] allowed a maximal deviation of 10% from the determined mean of the tooth structure in their *in vitro* study. The results obtained from the present study show that teeth with three coronal walls restored with glass fiber posts have higher fracture resistance (717.9N) than those without posts (502.5N). Teeth from group A without posts were smaller and not standardized. As a result, the variability in shape and morphology can explain the greater volatility of the results in this group, especially those related to different dental defects.

The results showed that the presence of posts in groups B, C, and D did significantly affect the fracture resistance ($P>0.05$). Abduljawad et al.[33]demonstrated that the placement of the fiber post did not affect the fracture resistance of endodontically treated maxillary central incisors that were restored with composite resin. These results may be explained by the fact that when there is less of the remaining tooth structure, the tooth is weakened (the amount of remaining dentin decreases during the removal for post space preparation). These results also confirm that the primary purpose of restoring teeth with posts is to retain a restoration and not to strengthen a root canal.

Signore et al.[34] indicated that conservation of the tooth structure increases the fracture resistance of endodontically treated teeth. However, a loss of dentin decreases the fracture resistance. Our results also showed that fracture resistence is strengthened as the number of coronal walls increases. Although the lowest fracture resistance was recorded in almost all specimens with glass fiber posts, it does not mean that fiber posts are not suitable for use in clinical practice. In specimens with one, two, or no coronal walls left that were restored without glass fiber posts, the fracture resistance ranged from 478.0 to 626.8 N. This result is very similar to those of teeth restored with glass fiber posts, which ranged from 451.0 to 607.8 N, and there was no significant effect of the number of residual walls on the fracture resistance (P>0.05).

Almost all failure modes were classified as favorable, except for those without fiber posts with two or three coronal walls. Almost all specimens in the zero-wall group and one-wall group showed favorable behavior. This means unfavorable modes appeared with increased number of residual walls. When increasing the number of remaining coronal walls, stress starts to concentrate from the cervical to the apical tooth, which results in moving down a fracture line[35]. With fewer coronal walls reduce, stresses are concentrated in the cervical area and lead to favorable failure modes. However, with more remaining walls, stresses move to the apical area, which leads to unfavorable failure modes.

As in many *in vitro* studies, it is hard to transfer all the results of our study directly to clinical situations because simulating all the conditions of the oral environment is not possible. The limitations of this study should be considered. Teeth were collected without considering patient age, and there were only five samples in each group, which is too small. This resulted in various mean values of fracture resistance. Furthermore, only a single load was examined, and dynamic loading should be used as a masticatory simulator to approxmate an actual clinical environment more closely. However, the study results improved the trial method, which will help in later experiments.

Conclusion

The following conclusions can be drawn from this study:

1. The fracture resistance of endodontically treated teeth improved with increasing number of coronal walls.
2. The fracture resistance of endodontically treated teeth improved with ferrule effect. Glass fiber post made better retention, but decreased the fracture resistance.
3. Endodontically treated teeth restored with fiber posts did not have different failure modes, and the fracture pattern was mainly favorable.

Conflict of Interest: *None declared*
Source of Support: *Nil*
Ethical Permission: *Obtained*

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