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Comparative evaluation of fracture resistance between vertical and horizontal post system in endodontically treated teeth - an in vitro study

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Abstract

Aim: The purpose of this study was to evaluate the effect of a horizontal glass fiber post on the fracture strength of endodontically treated molars with mesiocclusaldistal (MOD) cavities.

Material And Methods: Forty five extracted intact molars were collected, treated endodontically, and divided into 3 test groups (n = 15) depending on the restoration type: G1 (MOD preparation with resin composite restoration), G2(MOD preparation with a vertical fiber post) and G3(MOD preparation with resin composite restoration and a horizontal fiber post inserted between buccal and palatal walls). The specimens were stored in normal saline at 37°C for 7 days. Then specimens were quasi-statically loaded in a universal testing machine until fracture occurred. Failure loads were then analysed with one-way analysis of variance, followed by multiple comparisons by using Tukey honestly significant difference test (a = .05). The mode of failure was determined by visual inspection.

Result: Mean (standard deviation) failure loads for groups ranged from 1251.85 N to 1795.29 N. Among all the groups, vertical post group showed the highest fracture resistance followed by horizontal post. All groups had almost favorable fracture mode within the cervical third of the roots.

Conclusion: Within the limitation of this study, vertical fiber post showed the highest fracture resistance, it reinforced the crown as well as the root as compared to horizontal fiber post.

Keywords: Endodontically treated teeth, Fracture Resistance, Horizontal post, MOD cavity, Universal Testing Machine, Vertical post,

Introduction

Endodontically treated teeth are considered to have a higher risk of fracture of their inherently poor structured integrity as a result of pre-existing caries and/or tooth preparation.[1] The prognosis of restored endodontically treated teeth requires understanding their biochemical properties and conduct. Clinically relevant physical properties of dentin refrain to be affected by root canal treatment.[2] Endodontically treated teeth (ETT) are structurally different from non-restored vital teeth, and they require particular restorative treatment. The differences incorporate decreased moisture and dentin fracture resistance and reduced proprioception. In an examination done by Dietschi et al., the results of these progressions are in consequential.[3]

The significant limitations with ETT appear to be the coronal destruction got from caries, fractures of previous restorations, loss of dentin due to the removal of the roof of the pulp chamber, and the weakening of the peri-cervical dentin during access preparation. As a result of the compromised structural integrity, an increased fracture tendency during normal function is striking.[4] notwithstanding, in most ETT, the utilization of intra-radicular post is suggested to promote the retention of the final restoration and to biomechanically reinforce the remaining tooth structure.[5]

The material from which the post is constructed plays a crucial role in the biomechanical performance of root canal treated teeth. The fracture vulnerability of teeth restored with posts may be related to factors such as the amount of remaining tooth structure, which gives resistance to the fracture of the tooth, as well as the characteristics of the post, such as the material composition, modulus of elasticity, diameter, and length. A root fracture is the most serious kind of failure in post-restored teeth.[6]

Fiber-strengthened posts are as of late being utilized in restorative dentistry due to their superior properties, for example, dentin-like rigidity high tensile strength and good fatigue resistance. Furthermore, the elastic modulus of fiber posts is similar to that of dentin. These posts additionally have higher aesthetic properties, require less dentin removal during treatment methods, and can be bonded to dentin with adhesive luting resins Moreover, fiber-fortified posts don't bring about metal erosion or allergic reactions and can be easily removed from a root canal when failure occurs due to endodontic treatment.[7,8]

Recent studies have shown that post space preparation for placing the post may weaken the remaining tooth structure further, thus paradoxically, the conventionally accepted process of strengthening the tooth may cause further increase in root fracture risk. This emphasises the importance of trying to preserve the original anatomy of the root canal and minimising dentin loss throughout the endo-restorative treatment.[9,10]

In endodontically treated teeth, a Horizontal fiber reinforcement might enhance the fracture resistance. Therefore, the aim of this study to evaluate a more conservative approach than the traditional procedures when restoring endodontically treated molars. The null hypothesis of the study was that there is no difference in fracture resistance between vertical and horizontal post.

Materials And Methods

Forty five recently extracted caries-free molars, were selected and then stored in 5% formol/saline solution at

room temperature. The teeth were cleaned with a hand scaler and stored at room temperature during the study. Teeth with similar dimensions were assigned to 3 groups of 15 specimens. Buccopalatal and mesiodistal dimensions at the level of the cervical margin were recorded. Endodontic access cavities were prepared as small as possible by using a water-cooled air turbine handpiece and round burs. During root canal preparation the working length was set at 1 mm short of the apical foramen. The canals were prepared with a rotary system (NEO ENDO FLEX FILES, ORIKAM) according to the manufacturer's guidelines.

Sodium hypochlorite solution (3%) was used to irrigate the canals throughout instrumentation. The root canals were dried with paper points. The lateral condensation technique was used for the obturation of the prepared canals by gutta-percha cones to the working length and sealed with eugenol-free resin sealer (AH Plus Sealer; Dentsply DeTrey, Constance, Germany). Subsequently, the access cavities were sealed with temporary filling. The teeth were stored in distilled water at room temperature for at least 72 hours. The samples will be divided into 3 groups depending upon the placement of glass fiber posts. After that, the teeth roots were embedded into an auto-polymerizing resin up to 2 mm apical to the cemento-enamel junction (CEJ).

Diamond burs were replaced after 6 preparations to ensure high cutting efficacy. For teeth preparations, cylindrical diamond burs under copious air-water cooling were used in a high-speed handpiece. The teeth were assigned randomly to three groups of 15 teeth as follows. G1 (MOD preparation with resin composite restoration), G2 (MOD preparation with vertical post and resin composite restoration), G3 (MOD preparation with horizontal post and resin composite restoration). Standard MOD cavities were prepared for all groups. MOD cavities had a width of one third of intercuspal distance for occlusal portion preparation, and one third of total buccopalatal dimension was used to determine the width of proximal boxes. A depth of 1 mm above CEJ was determined for cavity preparation. After finishing the preparation, all internal edges were smoothed and rounded.

The holes were made with rounded diamond bur with air-water spray. Burs were replaced after every 6 holes to ensure high cutting efficacy. Smear layer solvent gel (EDTA; Meta Biomed Co) was applied to the surface of all MOD cavities. Then the gel was removed by air-water spray. The posts were brushed and fixed in place by using self-adhesive resin cement (RelyX Unicem; 3M/Espe, Neuss, Germany) in accordance with the manufacturer's instructions. Extremities of post were cut near the buccal and palatal surfaces. The walls of MOD cavities were etched by using 37% phosphoric acid (N E Etch) for 15 seconds, rinsed with water spray, and air dried. Then MOD cavities were bonded by using dentin bonding agent (Tetric N-Bond) according to the manufacturer's instructions. Flowable composite (multicore N, Ivoclar Vivadent) was used for core build up.

Loading of the Specimen

All specimens were quasi-statically loaded with a crosshead speed of 0.5mm parallel to the long axis of the tooth in a universal testing machine (Instron Corp, Canton, MA) until they were fractured. A cylindrical steel bar 6 mm in diameter and 10 mm long was used. The bar was in non-contact mode with any points on the resin composite. The failure load of the specimen was determined when the force vs time graph showed an abrupt change in load, indicating a sudden decrease in the specimen's resistance to compressive loading. Specimens were visually examined for the type and location of failure, as well as the direction of failure.

Statistical Analysis

For statistical analysis data was entered into a Microsoft excel spreadsheet and then analyzed by IBM SPSS statistics for windows, version 22.0. Armonk, NY:IBM corp., and for Graphs we used M.S office 2010 software. Data had been summarized as mean and standard deviation for numerical variables,count and percentages for categorical variables.

One-way and two-way analysis of variance (ANOVA) was used to analyze the data for significant differences. Bonferroni adjustment test and Independent sample t test was used for intergroup comparison. For categorical variables, 'Chi-squared test' often is used as short for Pearson's chi-squared test. Paired proportions were compared by Chi-square test. Significance for all statistical tests was predetermined at $P < 0.05$.

Result

The mean values of the fracture resistance and standard deviations are displayed in table 1. They ranged from 1251.85N to 1795.29 N. The highest fracture resistance was recorded for G2 (vertical post group), and the lowest one was recorded for G1 (MOD preparation with restoration). One-way ANOVA revealed significant differences between groups (P # .05). The mean comparison between the groups is shown in table 2. The mode of failure was determined by visual inspection of all specimens. There were 2 typical root fracture modes, cervical third fracture (favorable mode) and middle and apical thirds (catastrophic mode). Almost all groups had a favorable fracture mode. The fracture mode of each group is shown in table 3.

Table 1: Mean comparison among the groups.

Groups	MEAN	SD	P value
GROUP I	1251.85	290.76	<0.001 Significant
GROUP II	1795.29	356.84	
Group III	1450.17	328.64	

Statistical Analysis: ANOVA oneway test. S: statistically significant at the 0.05 level.

Table 2: Mean comparison between the groups.

Groups	Mean	SD	Mean difference	P value
GROUP I	1251.85	290.76	543.44	<0.001 Significant
GROUP II	1795.29	356.84		
GROUP I	1251.85	290.76	198.32	0.231 Not Significant
Group III	1450.17	328.64		
GROUP II	1795.29	356.84	-345.12	0.016 Significant
Group III	1450.17	328.64		

Statistical Analysis: Tukey post hoc test. S: statistically significant at the 0.05 level.

Table 3: Fracture Mode of Each Group

Type of fracture	Group 1 [n=15]		Group 2 [n=15]		Group 3 [n=15]		P value
	n	%	n	%	n	%	
Favourable	13	86.7	12	80.0	10	66.7	0.407
Unfavorable	2	13.3	3	20.0	5	33.3	NS

Statistical Analysis: Chi-square test. S: Statistically significant at the 0.05 level,

NS: Not significant

Discussion

The present study investigated the influence of a vertical and horizontal glass fiber post on the fracture resistance of endodontically treated teeth (ETT). Fracture resistance of the roots is one of the most important factors when restoring ETT that have lost a considerable amount of their crown tissue. Several studies have tried to identify the best technique and materials to be used to increase the fracture resistance of ETT.[11,12] Glass fiber posts were selected because of their low elastic modulus similar to dentin so they can distribute the load forces evenly along the root.[13,14]

A study by Grandini et al reported that restoration of ETT with fiber posts and resin composites is a treatment option that in the short-term conserves remaining tooth structure.[15] This investigation compared the fracture resistance of ETTs with different strategies of restoration that represented the clinical situations. In the present study the null hypothesis was rejected, as there was a difference in fracture resistance between vertical and horizontal post.

In the present study Group 2 (MOD preparation with vertical post and resin composite restoration) showed significantly higher fracture resistance than Group 1(MOD preparation with resin composite restoration) and Group 3 (MOD preparation with horizontal post and resin composite restoration). Vertical fiber post showed increased fracture resistance which could be due to the equal distribution of force along the root as well as crown. Since, the fiber post is placed in the root as well as in the crown, this could have resulted in reinforcement of the tooth structure.

When Group 3 was compared with Group 1, Group 3 showed higher fracture resistance than Group 1 however the difference was statistically not significant. Because the extension of a horizontal glass fiber post through the buccal and palatal cusps strengthens the composite resin filling and through adhesion reinforces the cusps and enhances the fracture resistance of ETTs.[11] All groups had almost favorable fracture mode, which means that the fracture occurred in the cervical third of the root, which is considered a restorable fracture in many clinical instances. This can be explained by the morphology of the MOD preparations, leaving limited amounts of residual tooth structure at level of the cervical margin of the specimens.[16,17]

On comparison of type of fracture among all the groups there were no significant difference between all the groups. But horizontal post showed the more catastrophic fracture. This can be explained by the fact that the presence of a horizontal glass fiber post reinforced the residual tooth structure in the coronal part. Because the modulus of elasticity of a glass fiber post is similar to that of dentin and the resin composite, the compressive load will be redistributed and prevented from discharging on the crown or in the cervical third of root. Therefore, the stress released was limited to middle and apical thirds of root, and the fracture occurred as a catastrophic mode. It has been suggested that glass fiber posts show reduced

stress transmission to the root because of similar elasticity compared with dentin.[11]

Conclusion

Within the limitation of this study,

1) Vertical fiber post showed the significantly higher fracture resistance than horizontal fiber post and without post.

2) All groups had almost favorable fracture mode within the cervical third of the roots.

However, further in vitro studies are obligatory to evaluate the success of horizontal post system.

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