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## Fracture resistance of endodontically treated maxillary premolars with Mesio-occluso-distal (MOD) cavities supported by horizontal glass fiber posts versus vertical glass fiber posts: An *in vitro* study

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### Abstract

**Aim:** The aim of this study was to assess the fracture resistance of endodontically treated maxillary premolars with mesioocclusodistal (MOD) cavities supported by horizontal glass fiber posts.

**Methodology:** Thirty three extracted maxillary premolars were collected and grouped into three. MOD cavities were prepared and all of them were endodontically treated. Teeth were supported with horizontal glass fiber posts; vertical glass fiber posts and composite restoration alone in the three groups respectively. Fracture resistance assessed using Universal testing machine. Type of fracture was assessed using visual examination. Type of failure was assessed using Stereomicroscope.

**Results:** Highest fracture resistance was shown by samples supported by horizontal fiber post (Group C). Group B had higher chances of Type 1 failure (Adhesive failure between post and luting cement) compared to other groups. Group A had higher chances of Type 4 failure (Cohesive failure) and Group C had higher chances of Type 5 failures (Mixed type; combination of any two of the above-mentioned types). There was no statistically significant association between groups and fracture mode (repairable and unrepairable). Majority of samples from Group A and Group C underwent repairable fractures.

**Conclusion:** Fracture resistance of horizontal fiber post group was significantly higher compared to the other two groups.

**Keywords:** Adhesive failure, cohesive failure, endodontically treated teeth, glass fiber post, horizontal post, resin composite, repairable fracture, unrepairable fracture, temporisation, vertical post

### Introduction

A root canal treated tooth can be compromised by coronal destruction caused by caries, fractures, previous restorations and endodontic access [1]. MOD cavities reduce the tooth strength by 20 to 63 percent as compared to occlusal cavity which leads to a reduction of 14 to 44 percent [2]. Access cavity preparation in teeth with destructed mesial and distal marginal ridges may lead to maximum teeth fragilization.

The function of vertical post is to retain the core severely mutilated teeth. But considering the mechanical constraints, such teeth are more prone to some inherent dangers like vertical root fracture, loss of cervical dentin or strip perforations in the furcal areas [3]. Whereas immediate placement of horizontal post takes minimum time, requires minimum tooth preparation and studies have shown less chances of fractures [4]. A composite core supported by a horizontal fiber post may add longevity in some clinical situations such as periodontal conditions, Apexification or root resorption that may require long-term temporization.

Aim of the present study was to evaluate and compare the fracture resistance of endodontically treated maxillary premolars with mesioocclusodistal (MOD) cavities supported by horizontal glass fiber posts versus vertical glass fiber posts.

### Methodology

Hundred recently extracted maxillary premolars which were removed for orthodontic reasons were collected.

Protocols for control of infection as per OSHA and CDC guideline regulations in collection, cleaning, sterilization, storing and handling of tooth specimens were followed. Teeth without restorations and those with closed apices were selected. Standardisation of measurements at cervical level was done using vernier callipers to ensure uniform selection. final samples included thirty three teeth which was stored in 3% H<sub>2</sub>O<sub>2</sub> for 7 days.

MOD cavities were prepared using diamond bur (SF 41) for all three groups. Access cavity was prepared using BR45 bur. Canals were prepared 1 mm short of the working length using Protaper file system upto F<sub>2</sub> size and obturated with thermoplastic obturation technique (Obtura) and resin based sealer (AH plus). Sodium hypochlorite (2.5%) and EDTA

(17%) was used as irritant with each instrument change. For further post endodontic restoration the teeth were then grouped into the following groups of eleven each

**Group A:** MOD cavity restored with resin composite restoration

**Group B:** MOD cavity restored with vertical fiber post and resin composite restoration

**Group C:** MOD cavity restored with horizontal glass fiber post and resin composite restoration (Fig 1)



**Fig 1:** Group A, B and C samples respectively.

For Group B (vertical fiber post group), post spaces were prepared with post drills (Tenax fiber post 1.1mm) to a depth 5 mm short of working length. The post were cleaned with an alcohol wipe and surface treated with silane. Glass fiber post was luted with resin cement into the post spaces. The cavity was restored using resin composite.

For Group C (horizontal post), holes prepared at the centre of both buccal and palatal surfaces using round bur to receive 1.1 mm diameter post (Tenax). After surface treatment with silane, posts were luted using self-adhesive rein cement. Excess was removed using bur. Cavity restored with resin composite. All samples were then stored in physiological saline at 37 °C for 60 days.

To simulate the periodontal ligament space, teeth roots were dipped in melted wax. Samples were then mounted on autopolymerising acrylic resin 2mm apical to CEJ level. The wax spacer was later replaced with addition silicone impression material. (Fig 2).



**Fig 2:** Sample mounted on acrylic block with addition silicone simulating periodontal ligament space

#### Fracture testing procedure

The samples of each group were tested with a Universal testing machine using a metal indenter. (Fig - 3) This was mounted on the upper arm jig and the sample block containing the tooth mounted on the lower arm jig. A cross head speed of 0.5 mm/min was set and the load applied on the palatal cusp 2 mm from the tip of the cusp towards the central fossa. The maximum load at which fracture occurred was recorded. The results were tabulated after recording the maximum load at fracture for each sample. The fracture strength and type of fractures which were observed were analysed.



**Fig 3:** Testing of sample under Universal Testing Machine

### Assessing the type of fracture and type of failure

The type of fracture whether repairable or unrepairable was evaluated by visual examination [5]. The type of failure was assessed using Stereomicroscopy (10x). Failures were classified as:

- **Type 1:** Adhesive failure between post and luting cement
- **Type 2:** Adhesive failure between dentin and luting cement
- **Type 3:** Cohesive failure of post system
- **Type 4:** Cohesive failure of luting cement
- **Type 5:** Mixed type; combination of any two of the above-mentioned types [6].

### Statistical Analysis

Data was entered in Microsoft excel and analyzed using IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp. IBM Corp. Categorical variables were expressed as frequency (percentage) and numeric variables were expressed using mean and standard deviation. Association of type of failure and fracture mode with Group was tested using Pearson Chi-square test. To compare the mean fracture resistance across the group One-Way ANOVA test was used and post hoc analysis was done using Tukey HSD. For all these statistical interpretations,  $p < 0.05$  was considered the threshold for statistical significance.

### Results

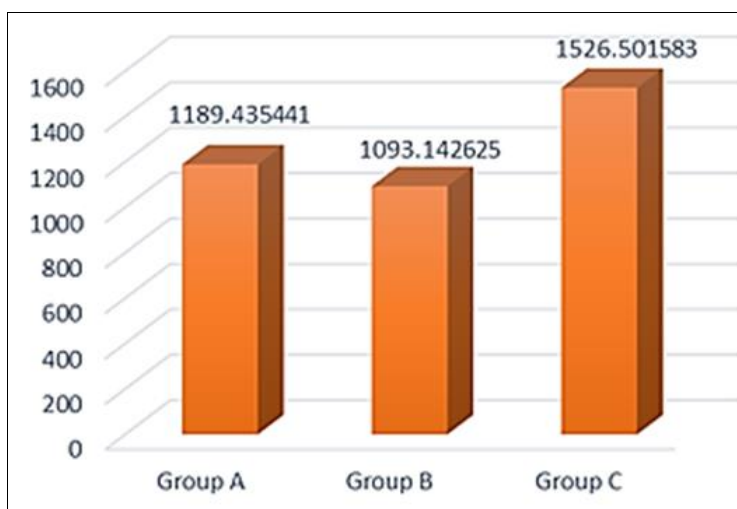
Comparison of fracture resistance between the three groups was done using one way ANOVA test. Highest fracture

resistance was shown by samples supported by horizontal fiber post (Group C) with a mean fracture resistance of 1526.50 N. (Table -1), (Graph -1). There was a stastically significant difference between mean fracture resistance among the groups ( $p \leq 0.001$ ). The fracture resistance of resin composite group (Group A) and Vertical post group (Group B) were similar. Mean fracture resistance of Group A was 1189.43 N and that of Group B was 1093.14 N.

Comparison of type of failure was assessed using Pearson Chi- square test. Group B had higher chances of Type 1 failure (Adhesive failure between post and luting cement): 36.4% compared to other groups. Group A had higher chances of Type 4 failure (Cohesive failure): 54.5% and Group C had higher chances of Type 5 failures (Mixed type; combination of any two of the above-mentioned types): 63.6%. There was statistically significant association between group and failure type ( $p = 0.009$ ). There was no statistically significant association between groups and fracture mode (repairable and unrepairable). Majority of samples from Group A and Group C underwent repairable fractures ( $p = 0.077$ ).

**Table 1:** Mean fracture resistance

Group	N	Mean	Std. Deviation	Std. Error	df	F	P value
Group A	11	1189.44	319.14	96.22	2	10.291	<0.001*
Group B	11	1093.14	210.49	63.46			
Group C	11	1526.50	141.03	42.52			



**Graph 1:** Mean fracture resistance

### Discussion

The null hypothesis of this study was rejected because there was statistically significant difference between the fracture resistance of three groups. Significant difference might be due to the difference in tooth material loss.

According to Yue *et al.*, loss of structural integrity is a major cause for fracture in endodontically treated teeth. Tooth type, thickness of canal wall and transverse geometry, root canal preparation instruments and preparation techniques, and the master apical file size might lead to tooth fracture [7].

In our study, MOD cavity was prepared to simulate the extensive tooth structure loss associated with root canal treated teeth restored using posts. According to studies, teeth with MOD cavities are more susceptible to fracture. Loss of one marginal ridge makes teeth 46% weaker while loss of both marginal ridges decrease the strength by 63% [8].

Adhesive restoration aids in uniform distribution of stresses along the axis of the tooth [9]. The composite restorations that bond directly to dentin enhance the durability of unsupported tooth structures. But polymerisation shrinkage of composite resin may lead to cuspal deflection which can be minimised by incremental layering techniques.

An endodontically treated tooth can be reinforced with horizontal fiber glass posts, running from the buccal to the lingual wall. A study by Grandini *et al.* [10]. Reported that restoration of endodontically treated teeth with fiber posts and resin composites is a treatment option that in the short-term conserves remaining tooth structure.

In this study, there was a statistically significant difference between the fracture resistance of the three groups. The horizontal post group showed the highest fracture resistance. Scotti *et al.* [11] and Salameh *et al.* [12] showed that compared

to a direct composite restoration, fiber reinforced composite significantly increased fracture resistance. The buccolingual direction delivered better results. In another *in vitro* study, Karzoun *et al.* [13] showed two times increase in fracture resistance by using single glass fiber post in the buccolingual direction. Bromberg *et al.* [14] studied fracture resistance of endodontically treated molars. Results showed 60 percent more fracture resistance in samples supported by two horizontal fiber posts as compared to those with composite restoration alone. Beltrao *et al.* [15] and Favero *et al.* [16] had similar results. Single horizontal post in the molars achieved significantly higher fracture resistance according to Beltrao *et al.*

The type of fracture was assessed using visual examination. The samples were mounted in acrylic blocks to a level 2 mm apical to the CEJ, mimicking the simulated bone level. All fractures above the simulated bone level was considered repairable while those below was considered as unreparable. Majority of samples in group A and group C showed repairable fractures while those of group B showed

unrepairable fractures.

Fracture patterns were assessed in various studies. According to Mergulhao *et al.* [17], eighty percent of samples reinforced with horizontal fiber post showed repairable fracture while those samples with composite restoration alone showed majority of unreparable fractures extending below the CEJ. There was variations in the reference level considered to assess fracture type. Mergulhao *et al.* [17] and Scotti *et al.* [11] considered CEJ as the reference level to as fracture while Karzoun *et al.* [13] in his study used cervical third of root. Bromberg *et al.* [14], Beltrao *et al.* [15], and Favero *et al.* [16] assessed involvement of pulpal floor as the reference.

There was statistically significant association between group and failure type. Group B (vertical post group) had higher chances of Type 1 failure (adhesive failure between post and luting cement) compared to other groups. Group A (Composite group) had higher chances of Type 4 failure (cohesive failure of luting cement) and Group C (horizontal post group) had higher chances of Type 5 failures (mixed type). (Fig -4).



**Fig 4:** Samples after fracture testing (Group A, B, C respectively)

## Conclusion

Horizontal post placement is a more economic option for short term reinforcement of endodontically treated teeth. This will also act as a reinforced core build up for the full coverage restoration placement. Compared to vertical posts, horizontal posts provide less hindrance to teeth requiring retreatment as well. Results from this study favors horizontal post placement as it gives better reinforcement to an endodontically treated teeth compared to vertical post.

One of the limitations of this study is assessment using static load. Thermocycling and dynamic fatigue loading if used will provide more reliable results that can be related to the oral conditions and masticatory forces. Also further studies on molar teeth need to be carried out as they have different morphology and are subjected to more occlusal loads.

## Conflict of Interest

Not available

## Financial Support

Not available

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