

## REINFORCEMENT EFFECT OF POLYETHYLENE FIBER IN ROOT-FILLED MANDIBULAR MOLAR: AN INVITRO COMPARATIVE EVALUATION OF TWO DIFFERENT TECHNIQUES OF PLACEMENT

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### ABSTRACT

Endodontic therapy, today, forms an integral part of everyday dental practice. The large number of teeth being treated endodontically makes it imperative for the dentists to provide satisfactory restoration for those teeth to remain intact within the dental arch as an integral functioning component. So this study was carried out to check the reinforcement of composite with polyethylene fibers placed in two different technique in root filled mandibular molar teeth with mesio-occluso-distal tooth preparation. Fifty freshly extracted molars were divided into five groups of ten teeth each. Group I: Intact teeth (positive control). Group II: Unrestored MOD prepared tooth (negative control). Group III: MOD tooth preparation restored with posterior composite resin. Group IV: Ribbond fiber was placed over the composite resin restoration and exposed fiber was covered with composite resin. Group V: Ribbond fiber was placed on the floor of the tooth preparation and the remaining prepared tooth was restored with composite resin restoration. The samples were subjected to compressive loading on Hounsfield tensometer until failure. The data were recorded and subjected to statistical analysis. Group-IV showed significantly higher fracture resistance than Group-V.

**KEY WORDS:** Polyethylene fibers, composite resin, MOD tooth preparation

### INTRODUCTION

Currently all endodontically treated teeth are given full cuspal coverage restorations, to increase the long term success of treatment. Though these restorations reinforce the teeth, they often require extensive tooth preparation and are expensive. Hence it is important to search for alternative methods. With recent advancement in adhesive technology and advent of new and stronger composite resin materials it is possible to create conservative, directly bonded restorations.

Strength of composite resin is increased by reinforcement with leno weave polyethylene fiber (Ribbond). These fibers possess adequate flexural modulus and flexural strength to reinforce composite restorations.

The purpose of this study is to compare the effect of unreinforced posterior composite resin restoration and polyethylene fiber reinforced composite resin restoration placed with different placement techniques in root filled

mandibular molar teeth with mesio-occluso-distal tooth preparation.

### Materials and Method

A total of fifty freshly extracted permanent molars were selected for this study. All the samples were cleaned and randomly divided into five equal groups of ten teeth each. Ten teeth were kept aside as positive control sample. Forty teeth were subjected to endodontic treatment and tooth preparation. Armamentarium and material used are given in table 1 and table 2.

Mesio-occluso-distal tooth preparation (Fig.1) was done down to the cemento-enamel junction so that the thickness of the buccal wall of the teeth measured 2mm at the buccal occlusal surface, 2.5mm at the cemento-enamel junction (CEJ), 1.5 mm at the lingual occlusal surface and 1.5 mm at the lingual CEJ. These measurements were conformed with the help of metal caliper (Fig.2).

Table .I. LIST OF ARMAMENTARIUM

ARMAMENTARIUM
1. Contra angle high speed handpiece
2. Contra angle micromotor handpiece
3. Diamond points
4. K-files (15-40)
5. Barbed broaches
6. Gates Glidden burs (No 1-3)
7. Mixing pad & spatula
8. Spreaders (15-40)
9. Excavator
10. Spirit lamp
11. Composite filling instrument
12. LED light curing apparatus
13. BP handle & blade (15 No)
14. Cotton tweezer
15. Hounsfield tensometer
16. Metal caliper.

Table. II. LIST OF MATERIALS USED IN THE STUDY

PRODUCT	MANUFACTURER
1. Sodium hypochlorite	Vishal, Dentocare Pvt Ltd.
2. Absorbent paper points	Dentsply, Maillefer.
3. .Gutta percha points	Dentsply, Maillefer.
4. AH Plus root canal sealer	Dentsply, Konstanz, Germany.
5. Etchant	Heraeus Kulzer, Germany.
6. Scotchbond Multi-Purpose Bonding System a)Primer b) Adhesive	3M, ESPE, St. Paul, Mn., USA
7. Esthet X flow	Dentsply Caulk, USA.
8. Solare P	GC corporation, Tokyo, Japan.
9. Ribbond	Ribbon Inc. Seattle, Washington, USA.

The teeth were then embedded in self-curing polymethyl methacrylate resin to a level 1mm apical to CEJ and were divided into following groups :

**Group I** : Intact teeth (No restoration).

**Group II** :Unrestored mesio-occluso-distal tooth preparation of endodontically treated molars.

**Group III** : (Experimental Group )

The prepared teeth were etched with 37% phosphoric acid for 15 seconds followed by 30 seconds rinsing with water spray. After the tooth preparation was blot dried the primer was applied followed by adhesive application and light cured for 10 seconds. The tooth preparations were then restored with a resin composite using a bulk technique and cured for 40 seconds from the occlusal surface using a light cure unit. To standardize the curing distance, the tip of the polymerization unit was applied to the occlusal surface of the teeth. ( Fig. 3 and Fig.4)

**Group IV:** (Experimental Group):

Etching, priming, bonding and composite resin placement procedures were done as described as in Group III. After finishing the restoration, a groove 3-mm wide and 1.5-mm deep was prepared on the occlusal surface of the restorations between the cusp tips, from a buccal to lingual direction, with a high speed bur under water cooling. The end of the grooves was on the occlusal one third of the buccal and lingual walls of the teeth. Flowable composite resin was added to the floor of the groove cavities, but not cured. A 3mm wide Leno Weave Ultra High Modulus (LWUHM) polyethylene ribbon fiber was first saturated with adhesive resin; the excess adhesive was removed with a hand instrument and then placed into the bed of un-cured flowable composite resin. This combination was cured for 20 seconds from the occlusal surface using the same curing unit and the exposed fiber surface was covered with a single layer composite resin and cured for 40 seconds. ( Fig.5)

**Group V:** (Experimental Group)

Etching, priming and bonding procedures were done as described as in Group III. The tooth preparation surfaces were coated with flowable composite resin. Before curing, a piece of LWUHMW polyethylene fiber (8mm long, 3-mm

wide) was prepared as described in Group IV and embedded inside the flowable composite resin from the occlusal one third of the buccal wall to the occlusal one-third of the lingual wall. After curing for 20 seconds, the prepared teeth were restored with composite as described in Group III. ( Fig 6.and Fig.7)

For 24 hours all the samples were stored in normal saline, then the mounted specimens were tested for fracture strength using Hounsfield Tensometer (Tensometer manufacture Co, England), which is a bench model of Universal Testing Machine (Fig.8). The force required to fracture the tooth was immediately recorded in kilograms on the mercury gauge. This procedure was repeated for all specimens. The recorded values were converted megapascal (MPa) and the data were subjected to statistical analysis.

### Results

The mean loads required to fracture the samples was as follows: Group I - 20.729MPa  $\pm$  1.28MPa, Group II - 3.99MPa  $\pm$  1.07MPa, Group III - 15.186MPa  $\pm$  1.65MPa, Group IV - 18.512MPa  $\pm$  1.28MPa, Group V - 16.138MPa  $\pm$  1.91MPa.

One way analysis of variance (ANOVA) indicated that mean force required to fracture the specimens of the groups are statistically significant [Table-3]. The comparison of fracture resistance between all groups by Scheffe's multiple comparison test found a statistically highly significant difference ( $p < 0.001$ ) from each other [Table.4].

### Discussion

Endodontic treatment reduces fracture resistance of the tooth. Hence the reinforcement of the endodontically treated tooth is recommended to improve its fracture resistance. With the progress in the field of direct restorative materials, composite resins have been recommended as cost effective and esthetic alternative restorations to protect weakened cusps.<sup>1,2,3</sup> One of the advancements is the reinforcement of the composite resin with polyethylene fibers [Ribbond].

Hence, this study was undertaken to determine fracture resistance of unreinforced posterior composite resin restorations and polyethylene fiber reinforced posterior composite resin restorations with two different placement techniques in root filled mandibular molar teeth with mesio-occluso-distal tooth preparation.

The comparison between Group I (20.729MPa) and Group II (3.99MPa) showed that the fracture resistance of Group II was reduced almost five times that of the teeth in Group I. This difference was statistically highly significant [Table.4]. This decrease in fracture resistance may be attributable to the loss of dentin.<sup>4,5,6,7</sup>

The comparison of fracture resistance between Group II (3.99MPa) and Group III (15.186MPa) showed that Group III had higher fracture resistance than Group II. This difference was statistically highly significant [Table.4]. The increased fracture resistance of Group III may be due to the use of posterior composite resin that splints the cusps together, decreasing cusp flexure and therefore, the fatigue within the tooth structure.<sup>3,8</sup> The results of present study are in accordance with the studies of Belli et al<sup>5,9</sup> who showed increased resistance to fracture (9.372 MPa and 9.497 MPa respectively).

A Comparison between Group III (15.186MPa) and Group IV (18.51MPa) showed higher fracture resistance for Group IV as compared to Group III. A highly significant difference was noted between these two groups [Table.4]. This result is in accordance with the finding of Belli et al<sup>9</sup>, (15.621MPa). The increased fracture resistance observed in Group IV may be due to: Low elastic modulus of the fibers (171GPa), which act as a stress absorber in the restoration.<sup>9,10</sup> The effect of leno weave, unique to Ribbond fibers provides multidirectional reinforcement to composite resin restoration that act as a crack stopping or crack deflecting component and offer resistance to shifting within the matrix.<sup>11</sup> Plasma treatment of Ribbond fibers ensures an adequate bond between the fibers and resin matrix.<sup>11,12</sup> This bonding ability might have increased the fracture strength of the tooth by keeping both the cusps together.

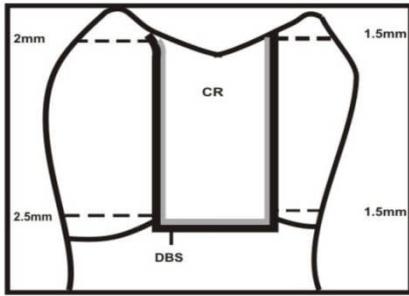
A higher fracture resistance was observed with Group V (16.738MPa) when compared with Group III (15.186MPa). The difference between these groups was highly significant [Table.4]. Similar results were obtained by Belli et al,<sup>5,9</sup> who in their two studies reported that the fracture resistance of posterior composite resin restored teeth with Ribbond fibers placed on the cavity floor, was increased (13.871MPa and 11.747MPa respectively). This increased fracture resistance can be explained by the aforementioned five reasons.



Fig. 1. Mesio-Occlusal-Distal Preparation



Fig. 2. Confirmation of the measurements with the calipers

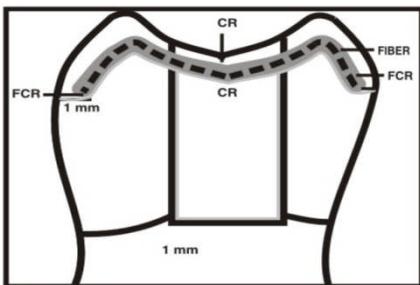


CR - COMPOSITE RESIN DBS - DENTIN BONDING SYSTEM

Fig.3. Restorative scheme for Group III teeth



Fig.4. resin composite restoration of Group III teeth

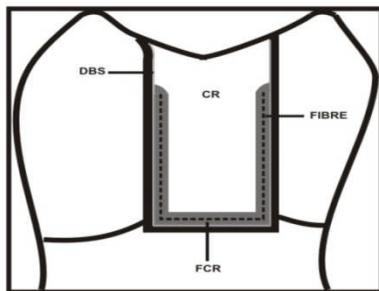


CR - COMPOSITE RESIN FCR - FLOWABLE COMPOSITE RESIN

Fig.5. Restorative scheme for Group IV teeth



Fig 6. polyethylene fiber extending from buccal wall to the lingual wall. (Group V teeth)



CR - COMPOSITE RESIN FCR - FLOWABLE COMPOSITE RESIN  
DBS - DENTIN BONDING SYSTEM

Fig.7. Restorative scheme for Group V teeth

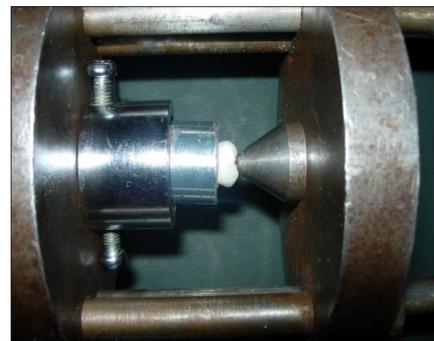


Fig 8. Measurement of Fracture strength using Hounsfield Tensometer

TABLE.III. ANOVA

	SUM OF THE SQUARES	DEGREE OF FREEDOM(df)	MEAN SQUARE	f-VALUE	p- VALUE
<b>BETWEEN GROUPS</b>	1694.2	4	423.56	194.83	0.0001*
<b>WITHIN GROUPS</b>	97.831	45	2.174		
<b>TOTAL</b>	1792.1	49			

\*p-values <0.01 is highly significant

**Application of one way analysis of variance (ANOVA) for differences within the groups.**

TABLE . IV. SCHEFFE'S COMPARISON TEST

COMPARISON OF GROUPS		F value	P value
<b>Group I</b>	Group II	644.40	0.000*
	Group III	70.66	0.000*
	Group IV	11.31	0.000*
	Group V	36.62	0.000*
<b>Group II</b>	Group III	288.28	0.000*
	Group IV	484.99	0.000*
	Group V	373.76	0.000*
<b>Group III</b>	Group IV	25.43	0.000*
	Group V	5.54	0.001*
<b>Group IV</b>	Group V	7.23	0.000*

\* p < 0.01 is highly significant

**The comparison of the fracture strength between the groups.**

A statistically significant difference was also noted between fracture resistances of Group IV (18.51MPa) and Group V (16.738MPa) [Table.4]. Group IV showed higher fracture resistance than Group V. This finding is in accordance with the finding of Belli et al<sup>9</sup> who reported increased fracture resistance of the restoration when the fibers were placed over the composite resin restoration (15.621MPa) as compared to the fracture resistance when the fibers were placed on the cavity floor (11.747MPa). The extension of the fiber ends through the occlusal one third of buccal and lingual walls allowed the fibers to keep the cusps together. This could be the reason for the increased fracture resistance of Group IV.

A highly statistically significant difference was also found between Group I when compared with Group III, Group IV and Group V [Table.4]. This was

due to failing of all reinforcement techniques to provide a fracture resistance as that of the intact tooth.

In this study, Group IV performed better than Group III and Group V. The comparison of the fracture strengths between these groups was highly significant.

#### CONCLUSION

The following inferences were drawn from the present in vitro study:

1. Reinforcement of posterior composite resin restoration with Ribbond fiber increases the fracture resistance.
2. When the posterior composite resin restoration was reinforced with the Ribbond fiber placed over the occlusal surface of the restoration from a

buccal to lingual direction (Group-IV), significantly higher fracture resistance was observed compared to the placement of Ribbond fiber on the floor of the prepared tooth (Group-V).

3. None of the reinforcement techniques exceeded the mean fracture resistance of intact teeth, but there was a clear reinforcement of all the samples by different techniques carried out to restore endodontically treated teeth, in the present study.

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