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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH RESTORED WITH BULK FILL, PACKABLE AND FIBER REINFORCED COMPOSITES

[1,*]Vignesh Sundaravadivel, [2]Kandaswamy, D. and [3]Lakshmi Balaji

[1]Senior Lecturer- Department of Conservative Dentistry and Endodontics, KSR Institute of Dental Science and Research, Tiruchengode, India

[2]Professor and Head- Department of Conservative Dentistry and Endodontics, Sri Ramachandra Dental College and Hospital, Chennai, India

[3]Professor- Department of Conservative Dentistry and Endodontics, Sri Ramachandra Dental College and Hospital, Chennai, India

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ABSTRACT

Aim: To evaluate if the fracture resistance of endodontically treated mandibular molars can be improved with newer techniques and restoration than that of crown.

Materials and Methods: 55 Two rooted mandibular first molar were randomly divided into 5 groups. Group A (N=11) was left intact. Endodontic treatment was done in remaining 5 groups. In Group B (N=11) entrance filling was done with packable composite followed by tooth preparation and PFM crown placement. In Group C (N=11) entrance filling was done with GC everX Posterior Fiber Reinforced composite after Nayyar Core Technique. In Group D (N=11) entrance filling was done with GC everX Posterior Fiber Reinforced composite. In Group E (N=11) entrance filling was done with Packable Composite. The specimens in all five groups were subjected to fracture resistance using Universal Testing machine.

Results: The maximum Fracture resistance was observed in Group B and minimal fracture resistance was observed in Group E. A highly significant difference was evident on comparing the mean values of fracture resistance of different group ($p<0.01$). Inter group comparison within the different groups also revealed highly significant difference ($p<0.01$).

Conclusion: PFM crowns had the highest fracture resistance. Though literature claims that Short Fiber reinforced composites have increased fracture resistance, they could not match the fracture resistance of a crown. Nayyar core technique provided increased fracture resistance as a direct restoration.

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INTRODUCTION

Endodontic treatment has been attributed to be a foremost etiological factor for fracture of tooth (Ellis SG *et al.,* 1999; Ataly *et al*., 2016; Kishen, 2016). The major reasons for this could be due to a) loss of free water from the dentin surface and dentinal tubules, loss of water rich pulp tissue, all which can add to the decrease in mechanical integrity b) extensive loss of tooth structure, c) effect of chemicals and intracanal medicaments, c) effect of restorations and restorative procedures, d) history of recurrent pathology, e) anatomical position of the tooth, f) effect of ageing on dental tissues (Kishen, 2016; San Chong , 2016; Hargreaves and Berman, 2015).

Corresponding author: **Vignesh Sundaravadivel,**
Senior Lecturer- Department of Conservative Dentistry and Endodontics, KSR Institute of Dental Science and Research, Tiruchengode, India.

For long term success of treatment procedure, supporting the remaining dentinal structures is a crucial factor (Sandikci *et al*., 2014) .The most challenging factor for a clinician is in deciding how to implement a restorative protocol for an endodontically treated teeth with unreliable amounts of remaining tooth structure. Many different direct and indirect treatment options are available for these kinds of teeth, such as crowns (with or without post placement), onlays/inlays, and direct resin-based restorative materials (Ploumaki *et al*., 2013).

Restoration of a tooth with adhesive procedures and direct resin composites eliminates excessive loss of sound tooth structure and over preparation. As there many types of tooth-colored direct restorative materials available in the dental market, it is important to determine whether the recent materials and newer restorative technique are successful to ensure the fracture resistance in endodontically treated teeth.

Recently fiber reinforced composites (everX posterior) have been introduced which enhance the fracture resistance of restored tooth by reducing polymerization shrinkage and increasing the toughness and impact strength (Karbhari and Wang, 2007). These short fiber reinforced composites exhibited higher flexural strength, fracture toughness and a lower percentage of shrinkage when compared to several other bulk fill composite resins (Garoushi *et al*., 2013). Also, Nayyar *et al*. (1980) claimed that improvement to the fracture resistance of the core material can be done by modifying the preparation by a method called coronoradicular stabilization.

Customarily full coverage restorations (Porcelain Fused to Metal Crowns) were the choice of treatment to surmount the structural weakness of a tooth treated endodontically (Sorensen and Martinoff, 1984; McLean, 2001). These full coverage crowns show a more homogeneous distribution of biting forces during function (Hamdy, 2015). Very few studies in the literature have evaluated the fracture resistance of endodontically treated teeth restored with fiber reinforced bulk fill composites (Ataly *et al*., 2016; Yasa *et al*., 2016). Hence this study was tailored to compare the fracture resistance of endodontically treated molars restored using different restorative techniques of fiber reinforced composites to that of crown.

MATERIALS AND METHODS

Teeth Selection

55 sound non carious mandibular first molars extracted for periodontal purpose were used for this study. 0.1% thymol solution was used to store the specimens until use. An ultrasonic device was used to remove any soft tissue deposits or calculus from the teeth. The crown dimensions of the teeth were measured in millimeters my using their mesiodistal and buccolingual widths (12.5-14.5mm) and the teeth of similar shape and size were selected. Following radiographs, teeth with two mesial canals and one distal were chosen.

Endodontic treatment

Standard access cavities were prepared by means of a high-speed handpiece without involving the proximal surfaces. Pulp chamber roof was penetrated with #2 diamond round bur, and was removed using non end cutting bur. Following working length determination apical enlargement was done till 25 K file in the mesial canal and till 30 K file in the distal canal. The root canals were prepared using ProTaper rotary instruments up to master apical rotary size(F3 protaper) 30- 9% in the distal canal and 25-8% (F2 Protaper) in mesial canal, Irrigation was done using 2 ml of 5.25% sodium hypochlorite between each file. 5 ml of 17% ethylenediamine tetraacetic acid was used for rinsing the prepared root canals. 5 ml of distilled water was used for final rinse, followed by which the canals were dried using paper points. Thereafter, the roots were obturated with ProTaper F3 gutta-percha in the distal canal and Pro Taper F2 gutta percha in mesial canal and AH Plus epoxy resin based root canal sealer by single-cone technique. Excessive coronal gutta-percha was removed, and samples were stored in 100% humidity for one day at 37 degree celcius to allow the sealer to set.

Mounting of the teeth

The replication of periodontal ligament was done by using a 0.6mm thick foil which covered the root surfaces 2mm below the CEJ.

The teeth were then embedded separately in a self cured acrylic resin blocks (2.5cm×2.5cm). After initial polymerization, each tooth was removed carefully from the respective resin blocks. The foil was gently detached from the surface of the roots and light body addition silicone impression material was injected into the acrylic resin blocks in the place that was earlier occupied by the root of the tooth and foil. The teeth were then inserted again in the the resin blocks. A homogeneous silicone coat that replicated periodontal ligament was thus created taking the foil thickness (Fig 1).

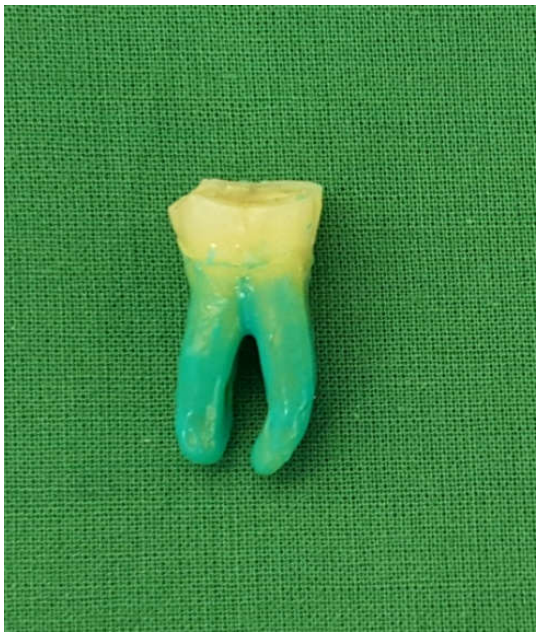

Figure 1. Replication of periodontal ligament space using addition silicone

Sample Grouping

The teeth were randomly divided into 5 groups (11 in each group) based on the technique used for restoration.

Group A: Non carious sound mandibular 1st molars. (N=11)

Group B: Acid etching was done for 15 seconds, washed off using distilled water. Entrance cavity was dried using cotton. Bonding agent was placed and light cured for 20 seconds. Packable composite was added in two increments and was cured for 40 seconds followed by finishing and polishing. The tooth was prepared to receive a PFM crown. This was accomplished with occlusal reduction of 1.5mm to 2mm, functional cusp bevel of 2mm with round end tapered diamond bur, facial reduction of 1.4mm using flat end tapered diamond bur. Proximal reduction is done with short needle diamond bur. Enough tooth structure is removed on both lingual and proximal axial walls to create a chamfer finish line. Impressions were made and the indirect restorations were processed in the laboratory. PFM crown cementation was done using Type I GIC and excess cement were removed.

Group C: From both the canals gutta percha was removed with size III gates glidden drills upto a depth of 3mm. Fiber-reinforced composite (GC everX posterior, GC Corp) measuring approximately 4 mm in thickness was placed, and enough space was left for the overlaying composite on all surfaces of the restoration. The resin composite was cured for 40 seconds following acid etching and application of bonding agent.

The remaining parts of the cavities were restored with increments at a maximum of 2 mm in thickness using a posterior resin composite, SolareX posterior, and light-cured for 40 seconds.

Group D: Fiber-reinforced composite (GC everX posterior, GC Corp) measuring approximately 4 mm in thickness was placed, and enough space was left for the overlaying composite on all surfaces of the restoration. The resin composite was cured for 40 seconds following acid etching and application of bonding agent. The remaining parts of the cavities were restored with increments at a maximum of 2 mm in thickness using a posterior resin composite, SolareX posterior, and light-cured for 40 seconds.

Group E: Acid etching was done for 15 seconds, washed off using distilled water. Entrance cavity was dried using cotton. Bonding agent was placed and light cured for 20 seconds. Packable composite was added in increments and was cured for 40 seconds. Finishing and polishing was done.

Following preparation and restoration all specimens were stored in an incubator at 37º celcius for 24 hours, at 100 % relative humidity in deionized water before testing.

Evaluation of fracture resistance

Using a universal testing machine(computer controlled), all specimens were subjected to compressive axial loading until fracture . The crosshead speed was 0.1 mm/minute to 1mm/ minute . An 8 mm diameter steel bar was positioned at the midpoint of the occlusal surface and force was applied parallel to the long axis of the tooth and to the slopes of the cusps and not that of the restoration (Fig 2). All samples were laden until fracture whilst the highest breaking loads were recorded in Newton (N).

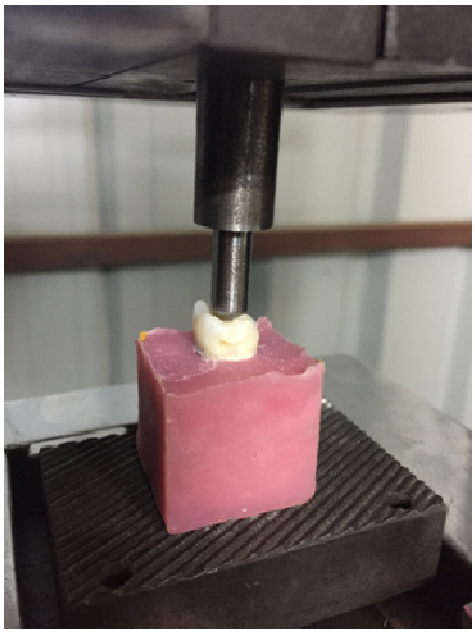

Figure 2. Evaluation of fracture resistance by using Universal Testing Machine

Statistical Analysis

To compare the mean fracture resistance of different groups Independent t test was used. For the multivariate analysis the one way ANOVA with Tukey's Post-Hoc test was used.

RESULTS

- Maximum fracture resistance was observed for Group B (endodontically treated teeth with crown) - 8514.7 N
- Least fracture resistance was observed for Group E (post endodontic restoration with Packable composite- 965.5 N)
- Order of the fracture resistance as follows
- Group B>Group A>Group C>Group D>Group E
- Among all the groups tested statistical significant difference was observed between each of them. (Table 1 and 2).

Table 1. Mean Fracture resistance of different Groups

	N	Mean	Std. Deviation	Std. Error	P value
Group A	11	5037.7	346.628	104.512	
Group B	11	8514.7	602.624	181.698	
Group C	11	3847.1	425.729	128.362	
Group D	11	1934.0	187.542	56.546	0.0005*
Group E	11	965.5	86.349	26.035	
Total	55	4059.8	2692.353	363.037	

* P<0.01 – Highly significant difference (Independent t test)

Table 2. Comparision of mean fracture resistance amongst different groups

Groups		P value
Group A	Group B	.0005*
	Group C	.0005*
	Group D	.0005*
	Group E	.0005*
Group B	Group A	.0005*
	Group C	.0005*
	Group D	.0005*
	Group E	.0005*
Group C	Group A	.0005*
	Group B	.0005*
	Group D	.0005*
	Group E	.0005*
Group D	Group A	.0005*
	Group B	.0005*
	Group C	.0005*
	Group E	.0005*
Group E	Group A	.0005*
	Group B	.0005*
	Group C	.0005*
	Group D	.0005*

* P<0.01- Highly significant difference (One way ANOVA with Tuckey's Post Hoc)

DISCUSSION

The ultimate success of endodontic treatment is reliant on the apt and well-timed coronal restoration because the conservation of the residual tooth structure subsequent to endodontic therapy is compromised (Cobankara *et al*., 2008). A proper endodontic treatment in addition to the material placed and the technique used plays a vital role in determining the prognosis. To improve the therapeutic success of teeth with major and moderate structural loss, different techniques and materials are being used (Kivanc *et al*., 2010). The standard protocol to surmount the structural weakness of endodontically treated teeth customarily is full coverage restorations (Porcelain Fused to Metal Crowns) (Sorensen and Martinoff, 1984). However to receive a crown it requires extensive tooth preparation, it also has a potentially adverse effect on periodontium and often require development of a completely new occlusal scheme (Hamdy, 2015).

In order to overcome these drawbacks, there claims a question for choosing the post endodontic restorations alternative to crown without disturbing the tooth and its supporting structures. Of late, short fiber reinforced bulk fill composites (everX Posterior) were introduced as a restorative material , which is a combination of a resin matrix, randomly orientated E-glass fibers and inorganic particulate fillers that and improves toughness of the polymer matrix and also gives superior bonding properties (McLean, 2001). So the null hypothesis is that if the fracture resistance of this SFR composite was found to be matching that of the PFM crown then there will be shift in the treatment modality where all root canal treated tooth will not always require a crown. It has been claimed by Nayyar *et al*. (1980) that improvement to the fracture resistance of the core material can be done by modifying the preparation by a technique known as corono-radicular stabilization. In this method, a retentive core is created by preparing coronal 2 to 4 mm of root canal from the orifice and faintly undercutting the pulp chamber. The core material is placed into the prepared space creating the core and the radicular material a solitary unit. This probably could provide the advantage of restoring an endodontically treated tooth to its actual strength without placing a full coverage restoration which could offer possible periodontal benefits and also be cost-effective to the patients (Yashwanth *et al*., 2012). Hence the aim of the present study was to evaluate the fracture resistance of endodontically treated mandibular molars with coronal restoration of a short fiber reinforced composite materials using nayyar core technique, bulk fill composites and packable composites.

There was a significant difference in the mean fracture resistance between all the 5 groups in the present study with a P value of 0.0005. Intergroup comparison also revealed highly significant results with P value of 0.0005. In the present study, endodontically treated teeth with full coverage PFM crown had the highest fracture resistance (8514.7N) followed by Nayyar core technique (3847.1N) everX posterior (1934N), Packable composites (965.5N). Our results were in par with studies conducted by several other authors. The highest fracture resistance in full coverage crowns could be attributed to the fact that these materials show a more homogeneous distribution of biting forces during function (Hamdy, 2015) and also it protects the teeth against irreversible fractures (Bitter *et al*., 2010). In Nayyar Core Group the fracture resistance (3847.1N) was significantly higher than the everX posterior group (1934N). This could be attributed to the fact that the composite injected into the coronal and radicular region of the tooth in the corono radicular technique will act as a single unit14 and in addition with the increased toughness, impact strength and high flexural strength of short fiber reinforced composite mentioned before have contributed to the increase in fracture resistance in this group (Lastumaki *et al*., 2003; Garoushi *et al*., 2012). When the mode of fracture patterns were observed in the short fiber reinforced composite groups, it was noted that in 16 out of 22 samples the fracture occurred on the tooth surface and not on the restoration. This again adds on to the literature evidence that in SFR composites crack propagation is arrested and redirected. The results of this study further revealed that endodontically treated teeth with coronal restoration of a packable composite had the least fracture resistance amongst all the groups. This could be due to the absence of fibres that promotes stress distribution in these composites and causes dissipation of occlusal forces to the entire length of composite (Abouelleil *et al*., 2015).

The main limitation of the study is that it is *in vitro*. The clinical situation is different in its force, angulation and surrounding supporting structure. Thus from the results of this study it has been inferred that, PFM crowns have the highest fracture resistance . Though literature claims that Short Fiber reinforced composites have increased fracture resistance, they could not match the fracture resistance of a crown. Nayyar core technique provided increased fracture resistance as a direct restoration. Improved fracture resistance can be expected if we include nayyar core technique along with crown as post endodontic restoration. Future in vitro studies are required to justify the results of the present study.

Conclusion

Within the limitations of the study, it is concluded that

- There was highly statistically significant difference found between all the groups.
- Group B (Endodontically treated teeth with PFM crowns) exhibited highest fracture resistance and the least was found in Group E (packable composite alone).
- Promising results are observed between Group C and Group D where fracture resistance of Group C (Post endodontic restoration with short fiber reinforced composite by using corono radicular technique) had increased fracture resistance when compared to Group D (post endodontic coronal restoration with short fiber reinforced composite).
- Materials tested in this study couldn't replace the fracture resistance of the crown.

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