Comparative Evaluation of Fracture Resistance of Endodontically Treated Mandibular First Molar Restored with Fibre Reinforced Composite, Nanohybrid Composite and Bulkfill Composite – An In-vitro Study

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Abstract

Aim: The present in vitro study was conducted with an aim to compare the fracture resistance of endodontically treated mandibular first molar restored with Fibre reinforced composite, Nanohybrid composite and Bulkfill composite.

Materials and Methods: 100 Two rooted mandibular first molar was divided into 5 groups. Group 1 (N=20) was left intact. Endodontic treatment was done in remaining 4 groups. Group 2 (N=20) was positive control group (prepared and unfilled). In Group 3 (N=20) post endodontic restoration was done with bulkfill composite, In Group 4 (N=20) with nanohybrid composite, In Group 5 (N=20) with fibre reinforced composite. The specimens in all five groups were subjected to fracture resistance using Universal Testing machine.

Results: There was a statistically highly significant difference seen for the values between the groups with highest values in group 1 followed by group 5, 3, 4 and least with group 2.

Conclusion: Endodontically treated teeth restored with fibre reinforced composite shows highest fracture resistance.

INTRODUCTION

Teeth are more likely to fracture after endodontic therapy than before therapy[1]. The restoration of endodontically-treated teeth has always been a challenge[2]. The reason most often cited for this finding has been the dehydration and loss of dentin after the endodontic procedures and the removal of important anatomic structures such as cusps, ridges, and the arched roof of the pulp chamber, all of which provide much of the necessary support for the natural tooth[3].

Restoration of root canal treated teeth with a permanent, definitive, post endodontic material is a final step for successful root canal treatment[3]. An optimal final restoration for endodontically treated teeth maintains aesthetics, function, prevent the fracture of remaining tooth structure, and also prevents micro leakage[4].It is important to determine that the recent materials are successful to ensure the fracture resistance in endodontically treated teeth[5].

Nanocomposite were introduced with lower shrinkage by replacing triethylene glycol dimethacrylate (TEGDMA) with polyeythlene glycol dimethacrylate (PEGDMA) relative to the conventional and microhybrid composites. They consist of agglomerated nano-sized particles and nanoclusters with a filler loading of 82% by weight and surface modified zirconia/silica exhibiting excellent esthetics, high compressive, diameteral tensile and flexural strength[6].

Bulk fill composites were introduced as posterior restoratives that allows larger increments upto 4 mm to be polymerized[6].

Recently E-glass fibre with barium glass filler, fiber reinforced composite material everX posterior has been introduced. Manufacturers claims that this short-fiber composite reinforces the restoration by preventing crack formation which is the main cause for failure of the post endodontic restoration[7].

So, the purpose of the present study was to compare the fracture resistance of endodontically treated mandibular first molar restored with Fibre reinforced composite (GC EVERX POSTERIOR), Nanocomposite (BRILLIANT™ NG, COLTENE, WHALDENT) and Bulkfill composite (TETRIC N CERAM, IVOCLAR VIVADENT).

AIM & OBJECTIVES

The main objective of this study was to compare the fracture resistance of different types of composite restorative material as post endodontic restoration and evaluate the fracture resistance of the different types of composite restorative material by using Universal testing machine.

MATERIALS AND METHODOLOGY

The endodontic file system for root canal instrumentations & the post obturation restorative material used are as follows:

- 100 Mandibular first molars,
- Ultrasonic scaler (Satellac, Acteon)
- Tweezer, straight probe, scalpel (API Germany)
- Airotor hand piece (NSK, Japan)
- #10, #15, #20 K-files (Dentsply)
- Hyflex CM (Coltene Endo)
- Endo-access Bur, Endo-Z Bur (Dentsply Maillefer, Switzerland)
- DG 16 explorer (API, Germany)
- Endobloc (Dentsply)
- Endomotor (X-smartTM Dentsply Maillefer, Switzerland)
- 3% Sodium hypochlorite (Neelkanth orthodent p ltd.)
- 0.9% Normal Saline (Denis chem lab ltd.)
- EDTA gel (RC help prime dental)
- AH plus Sealer (Dentsply)
- Absorbent paper points (Meta Biomed Co. Ltd., Korea)
- Gutta-Percha Cones (Dentsply Maillefer)
- Composite filling instrument (Coltene , whaldent)
- Fibre reinforced composite (GC everx posterior)
- Nanohybrid composite (Brilliant tm ng, Coltene Whaldent)
- Bulkfill composite (Tetric N Ceram, Ivoclar Vivadent)
- LED curing light (Bestodent)
- Addition silicone impression material (Light body)
- Stainless steel mould (metal), Cold cure acrylic resin (Coltene)
- Modeling wax (Y-dents)
- Universal Testing Machine (Instron)

Selection of Teeth

100 Mandibular first molars teeth extracted for periodontal purpose with approximately same size crown measured mesiodistally and faciolingually (12.5 – 14.5 mm) were used for this study.

Inclusion Criteria

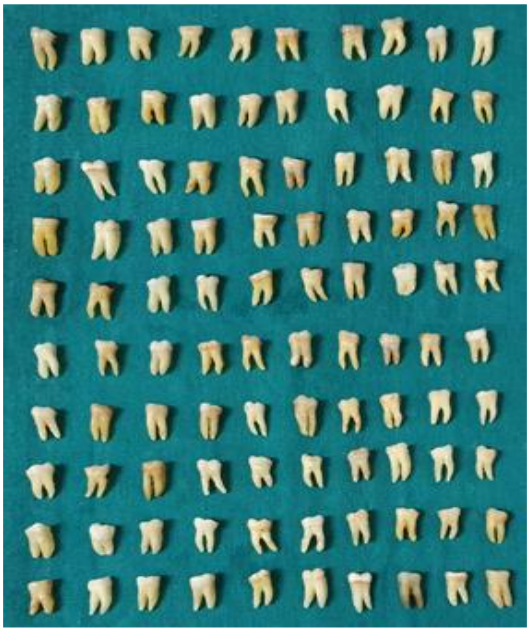
- Teeth without caries.
- Teeth without non carious cervical lesions.
- Teeth with mature apices.
- Teeth having three canals (Two mesial and one distal).
- Teeth having no signs of internal or external resorption.
- Teeth without calcifications.

Exclusion Criteria

Teeth with fracture.
Teeth with root caries.
Teeth with visible cracks.
Teeth with resorptive changes.
Teeth with immature apices.
Teeth with previous restorations or root canal treatment.

Methodology

This was a comparative experimental study, which involved 100 extracted teeth (Permanent mandibular first molars) consisting of positive and negative control groups, each with 20 samples.



Photograph of the Specimen

The selected teeth were cleaned and debride with a scalpel and ultrasonic scaler to remove remaining tissue. They were then stored in 10% neutral buffered formalin for at least two weeks and then in distilled water until they were used for testing.

INSTRUMENTATION

Standard access cavities was prepared in all four groups except in negative control group using Endo access diamond bur no.2 and Endo-z bur using high speed Airotor hand piece under air water coolant spray. A straight line access was prepared to facilitate instrumentation.

Canal patency was established with DG-16 and ISO size 10 K- hand file. Presence of canal was checked, the working length was determined by substracting 0.5 mm from the length of an inserted #10 K-file (Dentsply) with its tip visualized at the apical foramen. All four groups except negative control group were then prepared till an ISO size #20 K-hand file in distal canal and #15 K hand file in both mesial canals. Remaining preparation was done using torque and speed controlled endodontic motor (X-Smart, Dentsply maillefer) along with rotary hyflex CM file system (25/0.04 in both mesial canals and

30/0.06 in distal canal) at 500 rpm speed and 2.4 Ncm torque using a 1:16 reduction handpiece.

EDTA gel RC help (10% carbamide peroxide and 15% EDTA gel) was used during instrumentation with each file size in all the groups studied and the canals were frequently irrigated with 3% sodium hypochlorite and normal saline for complete debridement between every instrument use and final irrigation was done with 17% EDTA solution after instrumentation was completed in each group. Teeth were stored in distilled water after the instrumentation procedures to prevent dehydration.

Obturation

Root canals in all four groups were dried with absorbent paper points and obturated with a master Guttapercha cone of 25/0.04 in mesial canals and 30/0.06 in distal canal using single cone obturation technique with AH plus sealer. Samples were stored in 100% humidity for one day at 37 degree celcius to allow the sealer to set. Then group allocation was done depending on the post endodontic restorative material used containing 20 samples in each group.

Post Endodontic Restoration

After completion of obturation of all four groups, samples were divided into 5 groups-

Group1: Negative control (unprepared and unfilled),

Group2: Positive control group (prepared and unfilled),

Group3: Post endodontic restoration was done with bulkfill (Tetric N ceram) composite,

Group4: Post endodontic restoration was done with nanohybrid composite (Brilliant Ng),

Group5: Post endodontic restoration was done with fibre reinforced composite (GC EverX posterior) and coronal 2mm portion was restored with universal Brilliant Ng Composite.

In samples of group 4 and 5 the dentin surface of access cavities was washed and air dried for 10 sec, then a layer of adhesive One coat 7.0 (Coltene, whaldent) was applied using micro-brush and gently scrubbed For 10 sec and then light cured for 20 sec using curing light and in group 2 , no Adhesive was applied. In group 3 etching of access cavities was done with 37% phosphoric acid for 20 seconds, then washed and air dried for 10 seconds, then a layer of adhesive tetric n bond (ivoclar vivadent) was applied using applicator tip and light cured for 20 sec. The access cavity of each group was then restored with different post endodontic restorative material.

Mounting of Teeth

All the teeth were then mounted vertically, positioned in Centre, in a standardized cylindrical custom made Stainless Steel mould (25mm x 25mm) with coronal portion of the tooth exposed above cemento-enamel junction (CEJ). the replication of periodontal ligament will be done by covered the root surfaces 2mm below the CEJ with wax to obtain a 0.2 to 0.3 mm-thick layer before embedding the roots into acrylic resin. After initial polymerization each tooth will be removed carefully from the respective resin blocks. the wax will gently detached from the surface of the roots and light body addition silicone impression material will be injected into the acrylic resin blocks in the place that will earlier occupied by the root of the tooth and wax. The teeth will then be inserted again in the resin blocks. A homogenous silicone coat that replicated periodontal ligament will thus create taking the wax thickness.

The prepared samples were then kept wet in cotton-gauge pad at room temperature to prevent dehydration before testing.

Measurement of Fracture Load

All the samples were mounted in a Universal Testing Machine. The Stainless Steel rings (acrylic block) were placed on the lower plate of the machine. Mounted ring was vertically aligned in the testing machine one at a time. The tip was cantered and Samples were subjected to axial compression load applied parallel to the long axis of the tooth and a slowly increasing vertical force was exerted (1mm/min) until the samples fracture under load. The fracture moment was determined when a sudden drop in force occurred that was observed on testing machine display. The maximum force required to fracture each specimen was recorded in newtons. The data was tabulated and statistically analyzed to compare the resistance of five groups.

Sample Placed under Universal Testing Machine

RESULTS

The force required to fracture the specimens were recorded as the fracture strength. The load at fracture was recorded in Newton.

Statistical Procedures

Data obtained was compiled on a MS Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States).

- Data was subjected to statistical analysis using Statistical package for social sciences (SPSS v 26.0, IBM).
- Descriptive statistics like Mean & SD for numerical data has been depicted.
  Normality of numerical data was checked using Shapiro-Wilk test & was found that the data followed a normal curve; hence parametric tests have been used for comparisons.
- Inter group comparison (2 groups) was done using t test.

For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

Table 1: Descriptive Statistics showing the mean standard deviation of all the five groups.

Group	N	Mean force (newtons)	Std. Deviation
1	20	1938.104500	94.1514798
2	20	1119.367500	106.3338031
3	20	1382.669000	95.3570845
4	20	1366.251000	91.4260319
5	20	1795.425500	72.8133185

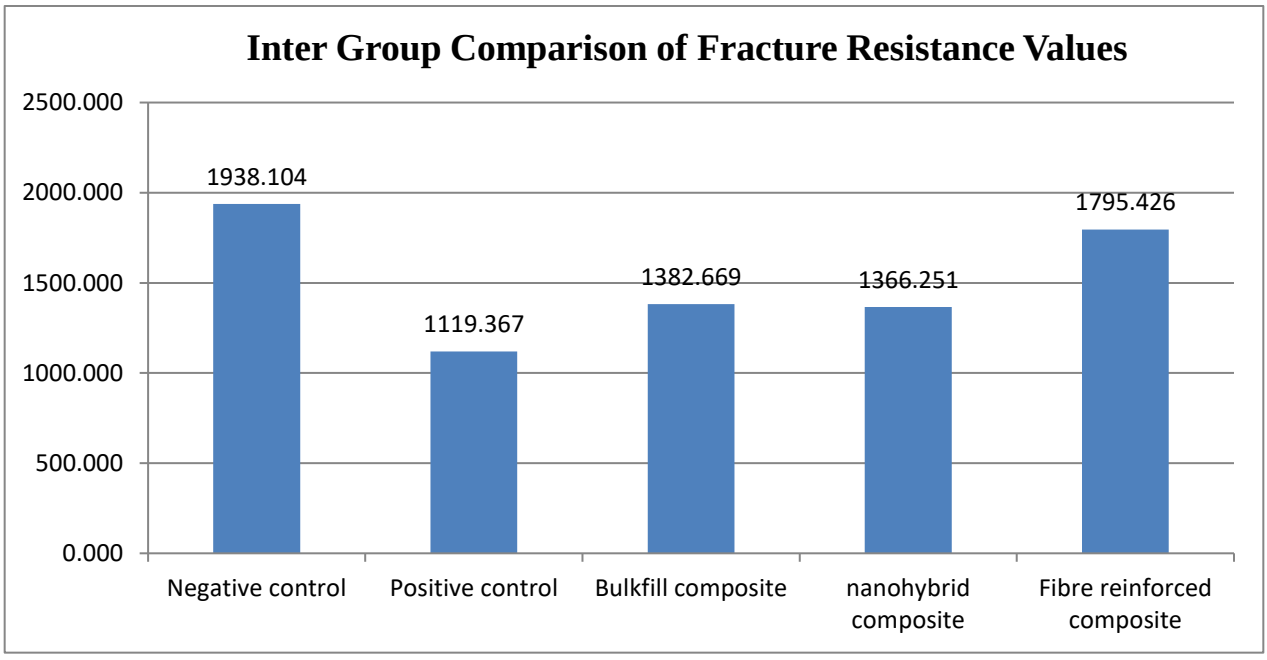
Table 2: Inter group comparison of fracture resistance values between each pair of groups

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p value	95% Confidence Interval	
						Lower Bound	Upper Bound
Negative Control	1	2	818.7370000	29.3001198	.000**	872.257335	1035.216665
	1	3	555.4355000	29.3001198	.000**	473.955835	636.915165
	1	4	571.8535000	29.3001198	.000**	490.373835	653.333165
	1	5	142.6790000	29.3001198	.000**	61.199335	224.158665
	2	3	-2.6330150	29.3001198	.000**	-479.781165	-316.821835
	2	4	-2.4688350	29.3001198	.000**	-463.363165	-300.403835
	2	5	-6.7605800	29.3001198	.000**	-892.537665	-729.578335
	3	4	16.4180000	29.3001198	.980#	-65.061665	97.897665
	3	5	-4.1275650	29.3001198	.000**	-494.236165	-331.276835
	4	5	-4.2917450	29.3001198	.000**	-510.654165	-347.694835

There was a statistically highly significant difference seen for the values between the following pairs of groups ($p<0.01$)

Group 1 vs 2, 1 vs 3, 1 vs 4, 1 vs 5, 2 vs 3, 2 vs 4, 2 vs 5, 3 vs 5 and 4 vs 5.

Except for group 3 vs 4 where there was a statistically non significant difference seen for the values ($p>0.05$).



DISCUSSION

The main purpose of endodontic treatment is to clean the root canal system, eliminate the toxins and infected content in the canal[8]. An endodontic procedure included access cavity preparation by removal of sound tooth structure followed by root canal preparation that further remove the root canal dentin which severely affects the strength and integrity of the tooth[9].

There are few factors which can influence the result of the fracture resistance studies. These include the tooth mounting method, type of load application device and crosshead speed. During fracture strength testing, point of contact between the loading bar and occlusal surface of teeth may differ and this might cause a large standard deviation of the results[10].

The present study examined the fracture resistance of endodontically treated molars as literature shows that posterior teeth are more prone to fracture.

Mandibular first molars are considered for the study but there can be variation which cannot be controlled hence we have standardized the procedure by making uniform access cavity keeping the dimension of the cavity equal in all the groups (by measuring the teeth mesiodistally and buccolingually as much as possible).

Natural teeth were used in this study to simulate clinical conditions. The teeth were embedded in acrylic resin to mimic the position of the root in the bone & light body addition silicone impression material was used to simulate periodontal ligament & to provide cushioning effect as in clinical scenario.

Selected teeth were cleaned to remove remaining tissue and make debris free with the help of scalpel and ultrasonic scaler and were then stored in 10% neutral buffered formalin for at least two weeks and then in distilled water until further use. This was done in accordance with the previous study done by **Patsandra PS Lam et al[11]** and ISO recommendation ISO/TS11405 for storage medium of extracted teeth. Also distilled water was used as storage medium to keep the teeth, as this medium causes smallest changes in dentin over time as investigated by **Strawn et al[12].**

Major drawback of the posterior composite restorations commonly encountered in the dental practice is the fracture within the body or at the margins of the restorations[13]. Flexural strength and modulus of elasticity are the parameters used to evaluate the elasticity and degradation of the materials under stress[14].

In this study, five groups were taken in which different composite resin restorative materials were placed in three groups and two group was taken as control (positive and negative). Negative Control Group i.e. unaltered tooth showed the maximum fracture resistance and Positive control group (prepared and unfilled) showed the least fracture resistance among all the groups. Among the restored groups, maximum fracture resistance was seen in group 5 i.e. fibre reinforced composite. Whereas there is insignificant difference was observed between group 3 i.e. bulkfill composite and group 4 i.e. nanohybrid composite. Difference seen is due to the physical and mechanical properties of the materials.

Intact teeth presented the highest mean fracture load due to the presence of the palatal and buccal cusps with intact mesial and distal marginal ridges which form a continuous circle of dental structure, reinforcing the tooth[15].

The result showed that there was maximum fracture resistance Among the restored groups in group 5 in which restoration was done using fibre reinforced composite, This is because of the higher modulus of elasticity and lower flexural modulus of the glass fibers are believed to have a modifying effect on the interfacial stresses developed along the etched enamel/resin boundary[6]. The short fibres of fibre reinforced composite will make it a perfect sub-structure to reinforce any composite restoration in large size cavities. Fibres will also prevent and stop crack propagation through the filling, which is considered to be the main cause of composite failures[16].

Bulkfill composite contains ivocerin which is more reactive than conventional initiators and allows larger increments upto 4 mm to be polymerized. These polymerization boosters fill the gaps between the traditional initiators and the glass fillers which relieves shrinkage strain[17]. A special patented filler which is partially functionalised by silanes, acts as a unique shrinkage stress reliever in bulkfill composite. Due to its lower elastic modulus, glass filler is flexible like a microscopic spring and thus reduces the shrinkage stresses developed[18].

Nanohybrid composite contain pre-polymerised particle filling, in addition to high nanometric particle content, produce optimum consistency for

manipulation and modelling along with a noticeable decrease in shrinkage and easily achievable high gloss surfaces. due to its revolutionary matrix with Optimized Light Refractive Index (OLRI), increases the ability to mimic natural tooth colour[19].

CONCLUSION

Under the limitations of the present study, it can be concluded that, the fracture resistance of endodontically treated teeth restored with fibre reinforced composite were significantly superior to the teeth restored with bulkfill and nanohybrid composite.

Conclusion drawn from this study is that attempts to reduce fracture susceptibility of the endodontically treated teeth are limited clinically, because many factors interact in influencing fracture susceptibility. So, to reduce fracture susceptibility, one should keep the tooth preparation as conservative as possible.

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