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Comparative Evaluation Of Fracture Resistance Of Endodontically Treated Teeth Restored With Different Core Build-Up Materials: An Invitro Study.

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Abstract:
Aim *- The study aimed to evaluate in-vitro fracture resistance of endodontically treated teeth restored with different core build up materials.*
Method*-36 non-carious intact human maxillary premolars were collected and endodontically treated except negative control group and were randomly divided into 3 groups consisting of 12 teeth each. Group 1-negative control; Group 2-Endodontically treated teethrestored with MultiCore Flow dual core composite;Group 3- Endodontically treated teeth restored withLuxaCore Z dual cure composite containing zirconium filler particles. Fracture strength testing was performed using universal testing machine. The results were statistically analysed and fracture pattern were examined under light microscope to determine the level of fracture.*
Results*-The mean fracture resistance value (in newton) were obtained as group 1> group 2> group 3. Group 2showed higher mean fracture resistance value which was significantly higher than Group 3and the fracture occurred at the level of enamel and dentin.*
Conclusion*-A dual cure composite can be used as a direct core build-up material that can effectively resist heavy occlusal force against fracture and may reinforce the remaining tooth structure in endodontically treated teeth.*

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I. Introduction

Long term success of an endodontically treated tooth depends on the integrity and durability of the post-endodontic material used. Fracture resistance of endodontically treated teeth is less as compared to vital teeth and are more prone to fracture under occlusal load because of changes in strength and modulus of elasticity[(1)]. Therefore, intracoronal strengthening of teeth may be necessary to prevent fracture, particularly in posterior teeth in which stresses generated by occlusal forces can lead to fracture of unprotected cusp[(3)]. The prognosis of final coronal restoration depends on type of core reconstruction and the material used.

Nowadays, many resin composites specifically designed for core build-up are available with increased filler content for higher strength and to enhance easy manipulation[(2)]. These materials differ from each other with regard to the amount and type of filler, viscosity, curing mode and build up technique and their physical properties were investigated in various aspects [(16,17,18,19)]. Introduction of nano-particles as filler has allowed improvements in the filler loads reaching nearly 80% in contemporary composites.They provide improved compressive and flexural strength and thus are being used as posterior restorative composites. Dual-cure composites have been developed as core build-up materials that help in overcoming the limitations of extended chair-side time, reduced inter-layer strength, increased inter-facial porosity and depth of cure[(4)].

MultiCore and LuxaCore which are dual cure composite resins have gained attention recently as restorative materials and are recommended to be used in high stress bearing areas. MultiCore is a fluoride containing radio-opaque composite consisting of inorganic fillers like barium glass, ytterbium trifluoride, Ba-Al-fluorosilicate glass highly dispersed in silicon dioxide. LuxaCore-Z consists of 70% Zirconium as inorganic filler.

These materials have been used for onlays and core build up with posts, there have been very few studies so far to evaluate their effect on the fracture resistance of teeth when used solely as a core build up material in endodontically treated teeth[(5,6)]. Hence this study was conducted to compare the fracture resistance of endodontically treated teeth restored solely with MultiCore and LuxaCore Z in comparison.

II. Material And Method

For the study, 36noncarious, intact human maxillary premolars of similar dimensions (verified using a digital caliper), devoid of pulpal aberrations, freshly extractedfor orthodontic reasons were selected for the study. The teeth were cleaned and stored in physiological saline at 4^0C for 3 days. They were randomly assigned to 3 groups of 12 teeth each.

Group 1 was the negative control (NC);the teeth were intact and were not subjected to cavity preparation or root canal treatment.

Mesio-occluso-distal (MOD)cavities were prepared in the remaining 24 teeth using a straight fissure bur and a high speed airotor handpiece with water coolant[(1)](Figure 1,2 and 3). The intercuspal distance and buccopalatal dimensions were recorded.

Endodontic access cavities were then prepared using round bur (Mani, Utsunomiya,Japan). The working length was determined using a size 15 K-file(Mani) and set as the initial apical file. All the canals were instrumented with K- files to an apical size of 40 using a step back technique. Irrigation was performed with 5.25 % sodium hypochlorite between each file usage during cleaning and shaping and finally with normal saline. The canals were dried using paper points and obturated by cold lateral condensation with ISO standardized 2% gutta-percha and zinc oxide eugenol rootcanal sealer. The gutta-percha was removed below the levelofCEJ (Cemento-enamel junction),and the canal orifices were sealed with Xtra-cem Glass Ionomer Cement.

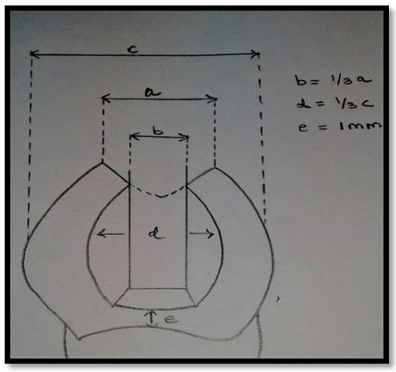

FIGURE-1 **FIGURE -2** **FIGURE-3**

Figure 1-MOD cavites(b)with one third the intercuspal distance for the buccolingual width of the occlusal isthmus (a). The buccopalatal width of the approximal preparation (d) was one third of the buccolingual width of the crown (c). The facial lingual walls of the occlusal segment were kept parallel to each other. The depth of the preparation (e) was kept 1mm coronal to the level of CEJ**. Figure 2&3-** images of sample prepared.

The 24 teeth then received resin as coronal restorations according to the allotted groups,
Group 2- Endodontically treated teeth restored with MultiCore Flow
Group 3- Endodontically treated teeth restored with LuxaCore Z
The restorative procedures are as follows-

Material	Type	Composition	Method of application
MultiCore Flow (IvoclarVivadent, Schaan, Liechtenstein)	Self-cured core build-up composite with light-cured option	Monomer matrix: Dimethacrylate (Base:28.1wt%, catalyst:28.4 wt%) Inorganic fillers: Barium glass,Ba-Al-flurosilicate glass and highly dispersed silicon dioxide (base:54.9 wt% catalyst : 54.4 wt%). Ytterbium trifluoride (base:16.4 wt%, catalyst:16.2 wt%) Additional contents: Catalysts, stabilizers and pigments (base: 0.6 wt%, catalyst: 1 wt%)	1.The prepared cavity were etched for 15 seconds, rinsed for 10seconds, and dried with cotton pellet. 2.bonding agent applied, air dried and light cured for 30 seconds 3.MultiCore Flow was mixed and injected into the prepared cavities upto the occlusal level through the automix tips provided and was light cured for 40 seconds.
LuxaCore Z-Dual Automix (DMG, Hamburg, Germany)	Dual-cured core build-up composite	Bis-GMA-based dental resins (28%),inorganic fillers (70%),additivespigments,catalyst(2%)	1.The prepared cavity were etched for 15 seconds, rinsed for 10seconds, and dried with cotton pellet. 2.bonding agent applied, air dried and light cured for 30 seconds 3. LuxaCore Z dual cure was mixed and injected into the prepared cavities upto the occlusal level through the automix tips provided and was light cured for 40 seconds.

A thin metal matrix band(0.001")held by a tofflemire retainer was placed around each tooth before restoration. All teeth were restored using an incremental technique and cured with light curing unit at a power intensity of 1000 mW/cm^2 (RTA MiniS, Guilin Woodpecker).

After the procedure,the matrix bands were removed and the restorations were contoured,finished and polished with a series of abrasive disks. The teeth were stored in distilled water for 24 hours at 37^{0}C before being subjected to fracture testing. The roots of the teeth were mounted in self cure acrylic resin upto the level of 1mm apical to the CEJ.

The prepared specimens were placed on a holder slot that was fixed to the lower arm of the universal testing machine. A metal indenter with a 6mm diameter was set to deliver increasing loads until fracture occurred. The load was

applied to the occlusal inclines of the buccal and lingual cusps vertically along the long axis of the tooth at a crosshead speed of 1mm/min. The force required to fracture each toot was recorded in newtons.

III. Data And Statistical Analysis

Data were explored for normality using Komogorov-Smirnov Z test which showed that data were normally distributed. The confidence level was 95%. The sample size was derived using GPower 3.0.10 software. The mean fracture resistance values were stastistically analysed using 1-way ANOVA test and intergroup comparison was performed using the post hoc Tukey test. The data provide a statistically significant difference that can be clinically correlated.

IV. Results

The mean fracture resistance values and standard deviation of the groups are given in the Figure4. Mean fracture resistance of group 1 was 852.416 N,group 2 was 773.833 N and group 3 was 465.166 N and standard deviation of group 1 was43.808,group 2 was 78.485 and group 3 was 40.183. Fracture resistance of group 1 was statistically significant than group 2 (p=0.005) and statistically highly significant than group 3 (p=0.001). Fracture resistance of group 2 was statistically highly significant than (p=0.001) than group 3. The levels of fracture are shown in table 1. In all group 1(NC) fracture occurred at the level of enamel, in group 2 (MCF) it occurred at the level of enamel and dentin and in group 3 (LCZ) fracture occurred involving dentin at or below CEJ.

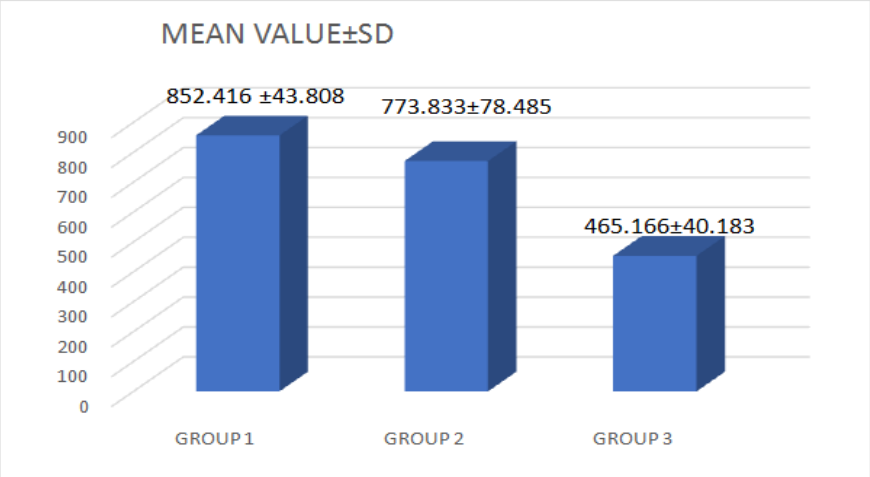

FIGURE 4-graphical presentation of mean fracture resistance and standard deviation

V. Discussion

The strength of core materials is one of the important properties in obtaining a longterm success of restoration, especially when the remaining tooth structure is limited[20]. In this study, stress wasplaced on the core material that demands a higher strength material to resist a fracture load.

Composite materials are generally composed of organic polymer matrix, a compound of Bis-GMA and filler particles[2].Despite of advancements in material sciences and with the concepts of minimally invasive procedures composite restorations are not commonly used for extensive restorations or in high stress bearing areas because of their relatively high brittleness low fracture toughness and formation of microcrack in the tooth structure caused by polymerization shrinkage[7]. Hence composite resins are reinforced with microglass fibres, whiskers, and particulate ceramic fillers to improve their mechanical properties[8,9].

Composite resin reinforced with polyethylene fibres and glass fibres have shown better effect on the resistance and durability of endodontically treated teeth [10]. It can be stated that the effectiveness of fibre reinforcementdepends on many factor including the resin used the quantity,length,form and the adhesion and impregnation of the fibre to the resin matrix[11,12].Our study compared the recently introduced MultiCore Flow (MCF) with natural tooth and LuxaCore Z(LCZ).MCF and LCZ are dual curing composite with fluoride filler and zirconium dioxide fillers respectively that have low consistency which allows mixing and application in the root canal space. According to manufacturer'sinformation higher filler content is seen with MCF (base 71.3 wt%, catalyst 70.6 wt%), followed by LCZ (70 wt%).Itwas noted that the results of fracture resistance load had the same trend with the filler content in the core material.

Maxillary premolar teeth were used in this study as during mastication the anatomic shape of premolars creates tendency for the separation of cusps[1]. Post placement in these teeth is not recommended as they have a delicate root morphology[12]. Siso et al[13] reported that an unrestored tooth with MOD preparation leads to significant reduction in the tooth strength (50%) because of loss of the marginal ridges compared to that of an unaltered premolar tooth. Therefore in this study, the MOD cavity was prepared, and each preparation was proportional to the tooth dimensions in order to simulate the worst clinical situation.

Bruke and Watts [14] proved that when the cylindric intender makes contact with the tooth, it acts as a wedge between the buccal and the lingual cusps and decreases the mean fracture resistance values while promoting more catastrophic types of fracture. In this study the force was applied on the cuspal inclines vertically because it was found to be appropriate to simulate the clinical intraoral conditions.

In this study group 1 (NC) showed highest resistance to fracture (852.416 ± 43.808), whereasgroup 2 (MCF) showed a value (773.833±78.485) comparable with that of group 1 and least fracture resistance was observed with group 3 (LCZ) with the value of (465.166±40.183) proving the deleterious effect of loss of vital tooth structure because of MOD and access cavity preparation.

Among the experimental groups, group 1(NC) was significantly better thangroup 2 (MCF) and group 3(LCZ) and also group 2 (MCF) was significantly better than group 3 (LCZ)stating that group 2 is a better core build up material as compared to group 3. It has strength nearly comparable although to a lesser extent to that of a natural tooth with future scope of modification in the composition of material to yield a material with improved properties.

It can also be stated that there is direct correlation between the level of fractures and the reinforcement effect of the material to the tooth, in this study in addition to fracture resistance level of fracture are also evaluated. Fracture that occur at the level of enamel and dentin can be considered as favourable because they can be easily repaired without any additional reinforcement[(15)],but when it is extended up to the level of or below the CEJ,it requires more complex restorative procedures or even may even lead to the loss of tooth. In group 1 fracture modes were all at the level of enamel. In group 2 fracture modes were in dentin and enamel correlating to the fact that loss of tooth structure certainly affects the fracture resistance of the tooth and in group 3 fractur modes were at the level of dentin or CEJ, with lower fracture resistance values indicating its less reinforcing effect.

Table 1-Levels of fractures in various Groups(n=12)

Level of fractures	Group 1 (NC)	Group 2 (MCF)	Group 3(LCZ)
Enamel	12	7	-
Dentin	-	5	4
At CEJ or below CEJ	-	-	8

VI. Conclusion

Based on the results of this in vitro study this study emphasizes that using MCF could provide better reinforcing effect in endodontically treated teeth and may also result in a better compound without delamination under high stress. MCF can be recommended to be used as a direct core build up material in high stress bearing areas, replacing the current invasive methods.Within the limitations of this in vitro study,MCF resin in a MOD cavity increased the fracture resistance of endodontically treated premolars significantly.

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The authors deny any conflicts of interest related to this study.

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