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COMPARATIVE EVALUATION OF FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH RESTORED WITH SHORT FIBER REINFORCED COMPOSITE AND TRADITIONAL COMPOSITE MATERIAL: AN IN-VITRO STUDY

Dental Science

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ABSTRACT

Aim: To evaluate the fracture resistance of endodontically treated teeth restored with two different composite core build-up materials. **Material and Methodology:** 45 human mandibular premolars extracted for orthodontic reasons and selected for the study were endodontically treated (except Group 1) and were randomly divided into 3 groups of 15 samples each. The Control group consisted of Group 1: comprised of no endodontic treatment. The experimental group received composite restorations after endodontic treatment as follows; Group 2: Nanohybrid composite (Filtek Z350, ESPE) and Group 3: Short fiber reinforced composite (EverX Posterior, GC). Fracture resistance was measured under the universal testing machine under crosshead speed of 1 mm/min. Data analysis was done by ANOVA test and post hoc tukey's test, where $p \leq 0.05$ was considered to be statistically significant **Results:** As per ANOVA, Group 1 showed the highest mean fracture resistance followed by Group 3 and Group 2. Post hoc analysis demonstrated that statistical significant difference was noted between Group 3 against Group 2. **Conclusion:** Fiber reinforced composite showed highest resistance to fracture compared with nanohybrid composite, which was comparable to that of intact teeth.

KEYWORDS

Nanocomposite, Short Fiber Reinforced Composite, Fracture Resistance

INTRODUCTION

Dental caries, the most prevalent oral disease leading to the loss of tooth structure is a process of tooth structure decay that initiates from the enamel and progresses into the dentine. One of the regular treatments for dental caries is restoration[1]. With dental caries approaching the pulp, the tooth has to undergo root canal treatment which results in loss of water content and anatomic structures. Hence, susceptibility to fracture is more in endodontically treated teeth than vital teeth[2]. Of many reasons for endodontic failure, the most detrimental may be tooth fracture as it often results in extraction[3]. A core build-up material, a restoration placed in a root canal treated tooth not only helps to restore the bulk of the coronal portion through placement of an indirect extra coronal restoration but also intends to re-establish its fracture resistance when subjected to occlusal load[4].

Traditionally, core build up materials like amalgam, glass ionomer cement (GIC), resin modified glass ionomer cements and traditional adhesive resins were used to restore the endodontically treated teeth[5]. According to a study conducted by Mincik J et al.[6], GIC showed comparable mechanical strength to composite resin, but the strength of GIC deteriorates after 2 years and hence it cannot be used as a permanent core build-up material. These limitations have led to the development of better composite resins with improved mechanical properties and thus, composite resin has been set as the gold standard for core build-up material[7].

The nanocomposite materials are manufactured by combining nanomeric particles and nanoclusters in a conventional resin matrix. The essence of nanotechnology is in the development and use of materials and devices at the level of atoms and molecules with sizes ranging from 0.1 to 100 nano-meters. Nano filled and nanohybrid composites were more recently introduced in an endeavour to provide a material presenting high initial polishing combined with superior polish and gloss retention[8].

EverX posterior is a short glass fiber reinforced composite. It is composed of randomly oriented short glass fiber fillers made of a combination of barium glass and silanated E-glass fibers and is claimed to provide an isotropic reinforcement effect in multiple direction instead of one or two directions[9]. These short fibers prevent and arrest crack propagation, thereby avoiding catastrophic failure[10].

Thus, the aim of this study was to evaluate the fracture resistance of nanohybrid composite and short fiber reinforced composite material in endodontically treated mandibular premolars.

MATERIALS AND METHODOLOGY:

45 sound single-rooted human mandibular premolars extracted for orthodontic purpose were included in this study. All soft tissue remnants on root surface were cleaned and debris were removed. All the specimens were stored in normal saline at 4°C for 3 days. The specimens were divided into 3 groups of 15 teeth each. Group 1 was Control group on which no cavity preparation or endodontic treatment was performed.

Endodontic access cavities for experimental group (Group 2 and 3) were prepared by using high-speed air rotor handpiece and sterile EndoAccess bur no.2 with water coolant. Pulp tissue was extirpated by using #15 K file (DENTSPLY Maillefer, Switzerland). The working length was established at the apical foramen with a 15 no. K file (Mani). Coronal pre-flaring was done with Gates Glidden drill (Mani.) no.2 and 1. Canal instrumentation was completed using ProTaper universal rotary file system with a master apical file size of F2. Irrigation was performed using sodium hypochlorite (5.25%) and normal saline. The root canals were dried with paper points and obturated using cold lateral compaction with 6% gutta percha master cone and 2% accessory points. The gutta percha was removed 1mm below the level of CEJ and the orifice were sealed with Type II GIC (GC). All cavities were etched with 37% phosphoric acid for 15s and rinsed and dried for 10s. The Group 2 and 3 received the intra coronal restoration. The composite restoration was cured in increments with LED (Coltulex, Coltene) curing unit. The materials and method of application are described in elaboration in Table 1.

All the restored specimens were finished and polished with Shofu-Lex disc. All 45 samples were then stored in normal saline at 37^{0}C for 24 hrs. The samples were mounted in 3cm x 3cm acrylic block 1mm below CEJ using auto polymerized acrylic resin.

Table 1: Materials Used in Experimental Groups and their Method of Application

Group	Material for restoration	Method of application
Group 2: nanocomposite	Filtek Z350 (ESPE)	OptiBond adhesive bonding agent was applied and gently air dried for 2sec followed by light curing with LED (Coltulex, Coltene) curing unit for 20 sec. Filtek Z350 was placed in incremental fashion and cured for 40sec

Group 3: short fiber reinforced composite	EverX Posterior (GC)	OptiBond adhesive bonding agent was applied and gently air dried for 2sec. Light cured with LED (Coltulex, Coltene) curing unit for 20 sec. EverX Posterior was placed in incremental fashion and cured for 40sec

The prepared specimens were placed on a holder slot fixed to the lower arm of the universal testing machine. A metal indenter with a 6-mm diameter fixed to the upper arm of a universal testing machine 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 1 mm/min. The force at which the tooth fractured was calculated in Newton as the fracture resistance[9].

STASTISTICALANALYSIS

Descriptive and inferential statistical analyses were carried out in the present study. The continuous measurements were presented as Mean SD. Level of significance was fixed at $p=0.05$ and any value ≤ 0.05 was considered to be statistically significant. Analysis of variance (ANOVA) was used to find the significance of study parameters between the groups. The post hoc analysis was carried out later if the values of ANOVA test were significant. The Statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data.

RESULT

The Mean ± Standard Deviation (SD) for the groups is as follows: Group 1 = 834.02 ± 98.12; Group 2 = 576.78 ± 53.61 and Group 3 = 716.93 ± 64.64. Figure 1 shows comparison of fracture resistance of endodontically treated teeth in terms of {Mean (SD)} among all the groups. There was statistical significant difference among the groups with $p < 0.001$. Group 1 showed the highest mean fracture resistance followed by Group 3 and Group 2. Post hoc analysis demonstrates that statistical significant difference was noted between Group 2 against Group 3 (Table No. 2).

Table 2: Tukey's Post Hoc Analysis

Comparison between		Mean Difference	P value
Group 1	Group 2	257.23	<0.001
	Group 3	117.08	<0.001
Group 2	Group 1	-257.23	<0.001
	Group 3	-140.14	<0.001
Group 3	Group 1	-117.08	<0.001
	Group 2	140.14	<0.001

$p < 0.05$: Statistically Significant

DISCUSSION

The structural weakening in endodontically treated teeth occurs due to loss of physical characteristics such as loss of tooth structure cusps, ridges and the arched roof of the pulp chamber. Caries, trauma, access cavity preparation and radicular preparation are the reasons mainly responsible for structural weakening. Other factors that can also result in fracture of endodontically treated teeth include iatrogenic factors like effect of chemicals and intracanal medicaments, non-iatrogenic factors like history of recurrent pathology, anatomical position of the teeth and effect of ageing on the dentinal tissues[11].

Studies have demonstrated that the preparation of endodontic access cavities decreases the strength of the teeth, because of extensive cavity preparations which critically reduces the amount of dentin and increase cuspal deflection during function[12]. However, according to Reeh ES et al.[13], endodontic procedures have only a minor effect on the tooth, reducing the relative rigidity by 5%, which is in contribution to the access preparation. The final result of endodontic treatment is based on the appropriate and timely coronal restoration of the endodontically treated tooth. Thus, the selection of the ideal restorative material is considered as key to the success of the post endodontic treatment[9].

Filtek™ Z350 (3M ESPE) is a visible light-activated radiopaque composite designed for use in anterior and posterior restorations. The resin contains bis-GMA (bisphenol A-glycidyl methacrylate), UDMA (urethane dimethacrylate), TEGDMA (tetraethyleneglycol dimethacrylate), and bis-EMA (bisphenol A-diglycidyl methacrylate ethoxylated) resins. To moderate the shrinkage, PEGDMA (polyethylene glycol dimethacrylate) has been substituted for a portion of the TEGDMA resin. The fillers are a combination of non-agglomerated/non-aggregated 20 nm silica filler, non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, and aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particles). These composites have an average cluster particle size of 0.6 to 20 microns. The inorganic filler loading is about 78.5% by weight (63.3% by volume).

Recently, the composite resins have been reinforced with short E-glass fibers and a particulate ceramic mixture to improve their mechanical properties. Composite resin reinforced with polyethylene fibers and glass fibers (Interlig Fibers) have been shown to have a better effect on the resistance and durability of endodontically treated teeth. The effectiveness of the restoration depends on the resin matrix, quantity of fibers, length, form and orientation of fibers; and the adhesion of impregnated fibers to the resin matrix[9].

Fracture resistance is a mechanical property that determines the resistance of a material to cracks when specific amount of load is applied on the restored tooth. Fracture resistance is one of the most commonly used tests for assessing the toughness of a restorative material because it determines the maximum strength and load that a restorative material can bear before any damage occurs[1].

In the current study, all the load was recorded in newtons and subjected to ANOVA and Tukey's post hoc test. Figure 1 shows Comparison of fracture resistance of endodontically treated teeth in terms of {Mean (SD)} among all the 3 groups using ANOVA test. The fracture resistance of Group 1 (control group) showed the highest mean resistance value of 834.02 N. Group 2 (Filtek Z350) showed the mean resistance value of 576.78 N. Group 3 (EverX Posterior) showed the mean resistance value of 716.93 N. In intergroup comparison, the results of tukey's post hoc test showed the highly significant values between all the groups and the significance value was $p < 0.001$.

A study by Eapen AM et al.9 had shown similar results and concluded that the short fiber reinforced composites in MOD cavities of maxillary premolars had shown statistically high fracture resistance. In the performed study the fracture resistance of nanocomposite was significantly lower than short fiber reinforced composite which was in agreement to study conducted by Kurniawati CS et al1. Oskee PA et al.14 showed that there was increased fracture resistance when glass fibers were placed on the occlusal third instead of the gingival third of the cavities. The proximity of the fiber location to the force exertion point (shortening of the working arm according to the lever principle) and maintaining the buccal and lingual cusps close to each other by occlusal surface fibers protect the natural cusps, resulting in higher fracture resistance9. Thus, this could have influenced the results of the conducted study.

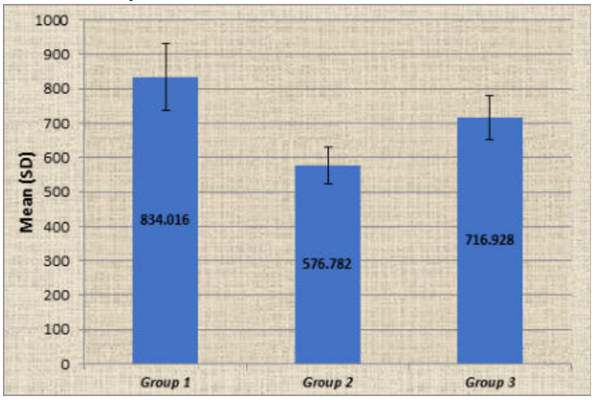

Figure 1: Comparison of fracture resistance of endodontically treated teeth in terms of {Mean (SD)} among all the 3 groups using ANOVA test

CONCLUSION

Within the limitations of this in-vitro study we could conclude that the fracture resistance is affected by the type of the composite resin material used to restore the endodontically treated teeth. Fiber reinforced composite showed highest resistance to fracture compared with nanohybrid composite when used as core build up material in endodontically treated teeth which was comparable to that of intact teeth.

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