ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 6, Issue – 1, January - 2023, Page No. : 279 - 284

Assessment of Fracture Resistance of Endodontically Treated Teeth Restored With Different Varieties of Direct Composites – An In Vitro Study

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Citation of this Article: Karishma Pathak, Nida Mehmood, "Assessment of Fracture Resistance of Endodontically Treated Teeth Restored With Different Varieties of Direct Composites – An In Vitro Study", IJDSIR- January - 2023, Volume –6, Issue - 1, P. No. 279 – 284.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aim: This study was conducted to assess the susceptibility to fracture of root canal treated teeth restored with different types of composites after endodontic therapy.

Materials and methods: Forty sound human mandibular premolar teeth, extracted for various reasons, were selected. For experimental purposes, they were further divided into four groups (n = 10). Groups I: the negative control (no preparation done). In all the other teeth, mesio-occluso-distal (MOD) cavities were prepared, and then root canal preparation was done and restored with the respective composite resins. Group II: condensable bulk fill composite, group III: fibre-reinforced composite, and group VI: conventional resin based composite. Corresponding adhesive systems for respective restorative resins were used. Specimens were kept in distilled water for 24 hours at 37°C to elude desiccation. The specimens were subjected to compressive loads until they fractured to calculate fracture toughness.

Statistical analysis was performed using analysis of variance (ANOVA) and post hoc Tukey's test.

Results: Statistically significant results were observed among all groups. The highest and lowest values were noted with groups I and II respectively (p = 0.05).

Conclusion: The resistance to fracture in root canal treated teeth with everX Posterior, fibre-reinforced bulk fill composite was the highest amongst all the restoratives used.

Keywords: Bulk fill composites, Endodontically treated teeth (ETT), Fracture resistance, Resin based composites.

Introduction

It has been well documented that endodontically treated teeth (ETT) show compromised biomechanical properties compared with vital teeth.[1] Endodontically treated teeth are weakened due to decreased or altered

tooth structure attributed to caries and previous restorations, fracture or trauma, endodontic access and instrumentation which leads to reduced moisture. The loss of moisture content in dentin and susceptibility to fracture in root canal treated teeth is controversial in recent literature.[2] During access cavity preparations and cleaning & shaping of the root canals, anatomic structures like the occlusal marginal ridges are compromised which renders the tooth fragile.[3] Residual amount of dentin (coronal and radicular) decides the success or prognosis of the endodontically treated teeth. Therefore, effective rehabilitation of an endodontically treated teeth with enormous loss of tooth structure is of utmost challenge for operators.[4] Various direct and indirect methods of restoring endodontically treated teeth can be inlays, onlays, crowns, post-retained restorations, amalgam restorations, gold restorations, and lastly resin based composite restorations. Resin based composite restorations are advantageous over the other above mentioned procedures because of their need for minimal tooth preparation. Also they are cost-effective[5] and single appointment procedures. A wide variety of composite resin materials are found in the market. Hence, it is mandatory to find out which variety of composite will lead to better survival of the endodontically treated teeth rendering successful outcome. Biggest drawbacks of resin based composite is polymerization shrinkage. Incremental layering technique of conventional composites has been advocated to overcome polymerization shrinkage.[6,7] The incremental layering technique suggests placement of composite resins in thickness of 2 mm, which is significantly time consuming with an added risk of contamination between layers, and also incorporation of voids in the restoration.[8,9] Thus newer materials with altered chemistry of the polymers, and increased depth of cure were adopted thereby counteracting the polymerization shrinkage, which has led to the novel idea of low shrinkage composites.[10] Single 4 mm thickness of composite resin can be placed in one or two layers and cured directly leading to a bulk filling method which reduces the procedural time remarkably.[11-13] Esthetics and bulk fill composite restorations go hand in hand. Both opaque and translucent shades are available in bulk fill composites which make the restoration mimic the natural tooth structure and it can rival all ceramic restorations. Bulk fill materials are present in unidoses, syringes, or tubes. Based on their filler content and incorporation of fibres, the bulk-fill composites are divided into several types. Since the number of studies about the fracture resistance of endodontically treated teeth restored with condensable bulk-fill resin composites, fibre-reinforced and conventional resin based composites are limited.[14] The current study aimed to assess the fracture resistance of endodontically treated teeth restored with bulk fill, fibre-reinforced, and nanohybrid composites. The null hypothesis was that there would be no statistically significant differences in the fracture resistance of endodontically treated teeth when restored with different variety of composites.[15]

Materials and Methods

Forty sound human mandibular premolars extracted for various purposes were gathered for the study. Any calculus and soft tissue deposits were removed from the teeth by hand scaling. The samples were stored in distilled water at 37°C for up to 1 month until use. Using a new diamond bur class II, MOD cavities were prepared in such a way that the gingival floor was located 1.0 mm above the cementoenamel junction. Standard cavity preparation protocols were followed and the same were verified using a divider.

Access cavities were prepared using a high-speed hand piece. Working length determination was done using a size 10 K file (Dentsply Maillefer, Ballaigues, Switzerland). Canals were instrumented to the working length, enlarging the apex to F3, using ProTaper Universal rotary file (Dentsply Maillefer), in conjunction with 2 mL of 5.25% sodium hypochlorite between each file. Prepared root canals were irrigated with 5 mL of 17% ethylenediaminetetraacetic acid, followed by 5 mL of normal saline. The root canals were then dried using paper points and filled with ProTaper F3 gutta percha and AH Plus (Dentsply DeTrey, Konstanz, Germany) epoxy resin-based root canal sealer by single cone obturation technique. Samples were stored in 100% humidity for 7 days to allow the sealer to set. The canal orifices were then sealed with a thin layer of resin-modified glass ionomer cement. A universal metal matrix band/retainer (Tofflemire, Dentsply Sirona, Pennsylvania, United States) was placed around each prepared tooth. The teeth were divided into four groups of 10 teeth each, as follows:

Group I: Negative control, includes natural teeth without any cavity preparation.

Group II: Condensable bulk fill composite (Filtek Bulk Fill, 3M ESPE). Corresponding total etch dentin bonding system was used for adhesive procedures as per manufacturer's instructions. Composite resin was placed using incremental technique.

Group III: Fibre-reinforced bulk fill composite (ever X Posterior, GC Corp). A one-step self-etch adhesive, G-aenial Bond (GC Corp, Tokyo, Japan), was used as adhesive system. Fibre-reinforced composite (ever X posterior, GC Corp) measuring approximately 4 mm in thickness was placed and the resin composite was cured for 40 seconds.

Group VI: Conventional resin-based composite (Filtek Z 250, 3M ESPE). Adper Single Bond Universal Adhesive (3M ESPE) was applied according to the manufacturer's instructions. Composite resin was placed using incremental technique. The materials for the restorative procedures are listed in Table 1.

Table 1: Material used in the study

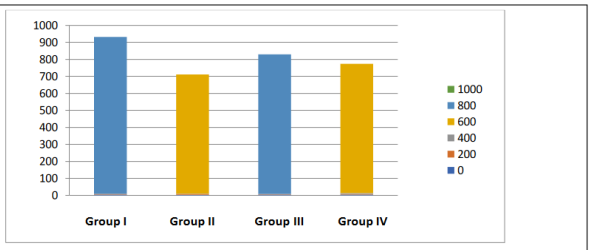
Product name	Type	Manufacturer	Composition
Filtel Bulk Fill	Condensable bulk fill composite	3M ESPE, St. Paul, MN, USA	DDDM, UDMA, Ytterbium Fluoride, benzotrial, titanium dioxide, 76.4% by wt of filler load
Ever X Posterior	Fibre-reinforced bulk fill composite	GC Corporation, Tokyo, Japan	Bis-GMA, TEGDMA, PMMA, hybrid filler and E-glass fibers, 74% by wt. of filler load
Filtek Z 250	Conventional resin based Composite	3M ESPE, St. Paul, MN, USA	Inorganic fillers, bis-GMA, UDMA, bis-EMA, procrylat resins, 70% by wt. of filler load

Bis-GMA: Bisphenol A Glycidyl Methacrylate; UDMA: Urethane Dimethacrylate; TEGDMA: Triethylene Glycol Dimethacrylate; PMMA: Poly Methyl Methacrylate; Bis EMA: Ethoxylated Bisphenol A Glycol Dimethacrylate; Wt: Weight

Finishing was achieved under air/water spray using diamond finishing burs (SS White) at high speeds. Subsequently, polishing was completed with Shofu Mini Polishing Kit. The specimens were stored in distilled water at 37°C for 24 hours. The root surfaces were filled with a thin coat of polyvinyl siloxane impression material to simulate the periodontal ligament and the teeth were stabilized in a block of self-cure acrylic resin. Fracture resistance was evaluated in a Universal Testing machine, Instron (ADMET, Enkay enterprises, New Delhi). Fracture resistance was evaluated by placing an occlusal load perpendicular to the long axis of the tooth. The load was applied until fracture occurred and was recorded in Newtons (N). Mean and standard deviations were determined for each group, and data were statistically analyzed with ANOVA followed by the post hoc Tukey's test. Statistical analysis was performed using SPSS software at the significance level of 5%

Results

The mean fracture resistance values (N) and the standard deviations for each group are presented in Table 2. The graphical representation of the same is depicted in Graph 1.



Graph 1: Fracture Resistance Graph

The negative control (901.3 N) showed higher fracture resistance and the condensable bulk fill composite resin lowest

Table 2: Mean fracture resistance values (N) and the standard deviations for each group

Groups	n	Mean	Std Dev
Group I (Negative control)	10	901.320	5.0460
Group II Bulk Fill condensable	10	697.000	8.3675
Group III Fibre-Reinforced composite	10	851.933	9.7842
Group IV Conventional resin composite	10	731.208	8.3149

Discussion

In this experimental study, significant differences were recorded in fracture resistance of different direct composite restoratives, thus rejecting the null hypothesis. The fracture resistance of tooth is reduced when sound tooth structure is compromised due to various reasons such as removal of caries, cavity preparations and trauma.[2] Previously it was considered that placement of posts was beneficial to the compromised tooth structure, but it is seen that post preparation can notably weaken the root as there is loss of radicular dentin in the process. Ultimately leads to root fracture leading to treatment failure. Hence, selection of the post endodontic restorative material is the key to successful outcome, as the material properties of direct restorations influence the fracture toughness.[17,18] So, in this study, fracture resistance was taken as a criterion for judgement. Higher filler content plays a significant increase in the depth of cure of the bulk fill composites. It also decreases the volume of resin matrix for polymerization[19] and also increases hardness.[20] Altogether it would reduce polymerization shrinkage.[21] Fracture of the restoration mainly depends on the composition and filler content of resin composites and their elastic modulus.[21] In the study negative control group showed highest fracture resistance which is consistent with the studies conducted earlier [22,23] reporting that restored teeth had significantly lower resistance to fracture. Among the tested groups, fibre-reinforced bulk fill composites showed the highest fracture resistance. A study conducted by Garoushi et al[24] explains that the mere insertion of fibres does not enhance the fracture resistance properties, but its length and diameter play a vital role. The fibre length and diameter of everX Posterior using stereomicroscope and scanning electron microscope showed that they have a diameter of 16 µm and a wide range of fibre length, with the average lying between 1 and 2 mm, thus exceeding the fibre length required.[24] Because of the fibre length and the critical direction of the fibres, they showed highest fracture resistance among the tested groups of this study. Also, in the present study, the mean fracture resistance values of teeth restored with everX Posterior fibre-reinforced resin were significantly different from those of teeth restored with other restorative materials.

Conclusion

Within the limitations of this study, the fracture resistance of teeth restored with everX Posterior, fibre-reinforced bulk-fill composite was the highest. But

compared with the intact teeth, the restored teeth had a lower fracture resistance.

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