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An In Vitro Analysis of Fracture Strength of Various Bulk Fill Flow able Composite Resins

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Abstract
An in vitro analysis of fracture strength of various bulk fill flowable composite resins
The use of resin composites in restoring extensive cavities reinforces dental stiffness. Ihe adhesive nature of composites binds the cusps and decreases their flexion, which is the main cause of fracture. The biomechanical preparation of the root canals in extracted human maxillary premolars was done. Afterobturation, all samples were subjected to standardized mesio-occluso-distal (MOD) cavities preparation.All experimental specimens were randomly divided into four groups (n = 20) and restored with different flowable composite resins: Surefil SDR flow (Dentsply, York, PA, USA), TetricEvo flow bulk fill (lvoclarvivadent), Filtek bulk fill (3M ESPE) &X-tra base (voco).After finishing the restoration, a groove 3 mm wide and 1 mm deep was prepared on the occlusal surface of the restorations between the cusp tips from a buccal to lingual direction. The fracture strength was determined by Universal testing machine.Highest fracture strength was obtained by Surefillbulkfill composite resin. Inserting a ribbon fiber in composite restorations in root-filled premolar teeth increased fracture strength.

Key words: *Bulkfill, Resin fibre, Fracture strength*

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I. Introduction

The restoration of endodontically treated teeth is an important aspect of dental practice that involves a range of treatment options of variable complexity. Root canal treatment should not be considered complete until the final coronal restoration has been placed. Endodontically treated teeth are weak because of loss of tooth structure caused by caries, access cavity preparation and instrumentation of the root canal. The likelihood of survival of a pulpless tooth is directly related to the quantity and quality of the remaining dental tissue. Resin‑based restorations replace the tooth's rigidity which is lost during cavity preparation and provide splinting of cusps. This can increase the fracture resistance of non‑vital teeth.[1]

The true breakthrough in the restoration of endodontically treated teeth has been the introduction of adhesive bonding, propelled by the development of efficient dentinal adhesives. Adhesion has been demonstrated to be either micro‑mechanical, due to the penetration of the bonding resin inside the microscopic and submicroscopic surface imperfections of the enamel & dentin and chemical, due to the partial dentin demineralization that leave a substantial amount of hydroxyapatite crystals around the collagen fibrils. The ability of the adhesive resin to infiltrate enamel and dentin is related to the surface wettability and it depends on the amount of surface free energy of dental substrate, which is directly proportional to the level of mineralization and indirectly proportional to the percentage of organic tissue.[2,3]

Restorations with composite resins are considered the material of choice in restorative dentistry because of the increasing demand for high‑quality esthetic results in everyday practice. With high‑viscosity composite resin, it is difficult to obtain perfect adaptation to the internal cavity surface and proper marginal seal of the cavity. One possible solution to the weaker seal on dentin is the use of more adaptable flowable resins on enamel‑free margins.[4]

Direct composite restorations in the posterior dentition have become an indispensable element of modern dentistry. The performance of these restoration, even in the masticatory load-bearing posterior region, has been conclusively proven in many clinical studies.[5]This procedure is usually carried out in an elaborate layering technique. This time-consuming procedure requires an economically sensible fee, corresponding to the effort involved. Aside from the possibilies that highly aesthetic composites offer in the application of polychromatic multiple-layer techniques, there is also a great market demand for the most simple and quick and therefore economical composite-based materials for posterior teeth. These products are offered in the category of bulk-fill composite.[6]

Flowable composite resins are widely used in clinical practice and are the most common resin materials that are recommended for restoring these lesions instead of conventional resin composites. Bulk Fill flowable resins with improved mechanical and chemical characteristics have recently been introduced.[3]Flowable resin composites are low‑viscosity materials with the reduced percentage of inorganic filler particles (44‑55% in volume) and higher amount of resinous components. Consequently, the polymerization process leads to an important volumetric contraction, but with minimal stress contraction. According to Hooke's Law, stress is determined by volumetric shrinkage and the elastic modulus of the material.[1]Flowable composites, with their low elastic modulus compete with stress development, potentially helping to maintain the marginal seal of the restoration. Moreover, flowable composites are readily workable and adaptable to cavity walls and their use can reduce marginal defects in restorations. These materials have good aesthetic properties.[4]

The bulkfillflowable composite resin possess a lower modulus of elasticity, as well as lower levels of polymerization stress in comparison to traditional flowable composite, without compromising on depth of cure. The material is marketed as a resin composite for bulk application in direct composite resin restorations. Bulk-fill composites are more translucent than other restorations, which allow the light to get to much deeper layers. The content of photoinitiators of polymerization and stress inhibitors determines the optimal marginal seal of these composites.

The development of fiber‑reinforced composite (FRC) technology has led to substantial improvement in the flexural strength, toughness and rigidity of dental resin composites. Fiber-reinforced composite technology has increased the use of composite resin materials in extensive preparations.[5,6] There are a wide variety of commercial fibers available in market, among them is "Leno-woven polyethylene ribbon" fibers, using this fiber along with composites increases tensile strength, elastic modulus and fracture toughness of restorations. The tensile and compressive strength of composite restorations used with woven polyethylene fibers is more as compared to non-fiber restorations. The use of fiber in the deepest part of composite restorations that contained particular fillers increases fracture strength of restoration.

The formation of an elastic layer under a composite restoration using a fiber ribbon under composite increases the fracture strength of endodontically treated teeth.Reinforcing composites with polyethylene fibres and glass fibres has successfully provided superior results. However, there are no studies comparing the use of everstickfibre with different bulkfillflowable composite restorations. So this study isconducted to evaluate the fracture resistance of endodontically treated premolars withmesio-occluso-distal (MOD) cavities restored with various types of bulkfillflowable composite reinforced with resin fibre.

II. Material &Method

A total of 90 freshly extracted human maxillary premolars will be selected, cleaned and stored in physiologic normal saline.Endodontic access cavity will be prepared with the help of diamond bur in a high speed airotor hand piece and the pulp tissue will be removed. A size 15 K file will be introduced in the canal and intraoral periapical X-ray will be carried out to determine the working length. The biomechanical preparation of the root canals will be done. After irrigation with sodium hypochloride, canals will be dried with absorbent points and obturated with guttapercha. After obturation, all samples will be subjected to standardized mesio-occluso-distal (MOD) cavities preparation. The floor of the MOD was placed on the pulp chamber floor of the samples. All the samples were divided into groups.

Control group: The control group consists of 10 teeth which are not restored by any restorative material coronally after MOD cavities preparation.

The remaining 80 specimens will be randomly divided into four groups (n = 20) and restored with different flowable composite resins:

Groups I Surefil SDR flow (Dentsply, York, PA, USA)
Group II TetricEvo flow bulk fill (lvoclarvivadent)
Group III Filtek bulk fill (3M ESPE)
Groups IV X-tra base (voco)

The adhesive system will be applied in all the samples according to the manufacturers instructions. All samples will be restored using bulk technique and subsequently polymerized. After finishing the restoration, a groove 3 mm wide and 1 mm deep was prepared on the occlusal surface of the restorations between the cusp tips from a buccal to lingual direction with a high speed bur under water coolant. The end of the grooves was on the occlusal one-third of the buccal or lingual walls of the teeth. The grooves were rinsed and dried. 2 mm wide polyethylene ribbon fiber was saturated with adhesive resin and placed into the groove and restored. After 24 h, the restorations will be finished with fine‑grit diamond bur and polished.The prepared samples were subjected to thermocyclingin water baths for 500 times between 5 and 55 degrees with a dwell time of 30 seconds in each bath and a transfer time of 30 seconds to simulate the oral conditions. The teeth will be then mounted in selfcuring polymethyl methacrylate resin. After the completion of restoration, all the samples will be stored at 37°C in 100% humidity for 24 h. The specimens will be then placed into a Universal testing machine (Instron). A stainless steel bar is affixed to the upper stage of the Instron. The upper stage was positioned so that the bar was centered over the teeth until the bar just contacted the occlusal surface of the restoration. A vertical compressive force was applied and the force necessary to fracture each tooth was recorded as Newtons.The same procedure was followed for all the remaining samples. Data was collected, tabulated and sent for statistical analysis.

III. Result

The frequencies of fracture strength scores obtained from the experimental groups are presented in Table 1.

Groups	Mean	SD
Group I	1652.67	234.42
Group II	515.04	101.61
Group III	984.07	153.56
Group IV	995.61	203.13

Table 1: Fracture resistance of all the groups

The arithmetic mean & standard deviations were calculated for intra & inter group comparisons. The One way Anovaanalysis of variance Test was applied to find the significant difference among the four groups.
At 5% level of significance (i.e. $P< .05$), the One way Anova analysis of variance revealed significant differences among the four groups ($P> 0.05$).
Resin-based composite restorations bonded with TetricEvoflowbulkfill showed least fracture strength and the highest fracture strength values were displayed bySurefillbulkfill composite resin.

IV. Discussion

Improvement in resin composites have increased their usefulness as restorative materials; however, polymerization shrinkage continues to remain one of the primary deficiencies of composite restorations.Polymerization shrinkage causes contraction stress within the restoration that leads to micro-leakage, as well as stress within the surrounding tooth structure.

In this study, fracture resistance of various composite resins was checked. It is the simplest to perform but it is a destructive test that may not always simulate in vivo conditions because the forces required to fracture specimens in vitro may not occur in the oral cavity.

The fracture resistance of endodontically treated maxillary premolars was assessed, the anatomic shape of which creates a tendency toward separation of their cusps during mastication. In addition, loss of tooth structure during endodontic access and cavity preparation procedures makes these teeth even more prone to fracture.[7]

Endodontic access to the pulp chamber destroys the structural integrity provided by the coronal dentin of the pulpal ceiling, allowing greater flexion of the tooth under function. The general effect of MOD intracoronal cavity preparations is the creation of long cusps. Thus, the restorative material used must not only replace the lost tooth structure but also increase the fracture resistance of the tooth and promote effective marginal sealing.[8,9]

Restorations that enhance structural integrity would be expected to increase the prognosis of endodontically treated teeth which are exposed to heavy masticatory loading forces. However, there is no consensus regarding the preferred type of final restoration for endodontically treated posterior teeth. In the past decade, improved restorative adhesive bonding technique and materials have led some authors to suggest that endodontically treated teeth can be restored in a more conservative manner than was previously considered appropriate. Numerous materials have been used as substitutes for natural dental tissues.[10,11]

For these reasons, adhesive materials have been considered useful for tooth reinforcement. The use of resin composites in restoring extensive cavities reinforces dental stiffness. It has been suggested that the adhesive nature of composites binds the cusps and decreases their flexion, which is the main cause of fracture. Adhesive restorations efficiently transmit and distribute functional stresses across the bonding interface to the tooth and reinforce weakened tooth structure. It has been found that maxillary premolars when restored with bonded composite resins were approximately100% stronger than unrestored premolars.

However, separate studies have proposed that significant differences exist in fracture resistance between intact and restored premolars with resin composite and dentin bonding agent, with intact teeth being superior. These differences in results could reflect the variation in type and size of teeth, preparation design, experimental material, loading speed, direction of load and thermocycling.[12,13]

The bulkfillflowable composite resin possess a lower modulus of elasticity, as well as lower levels of polymerization stress in comparison to traditional flowable composite, without compromising on depth of cure. The material is marketed as a resin composite for bulk application in direct composite resin restorations.

EverStick NET is a woven, continuous bidirectional glass fiber sheet impregnated with bis-GMA and PMMA. The thickness of a single fiber is 6 μm. Several researchers have investigated the effect of fibre reinforced composite on the fracture resistance of endodontically treated teeth through different methods. It has been reported that the fracture resistance of molar teeth may increase if the insertion of a piece of polyethylene fiber into the cavity in the gingival and occlusal third method is used. Another study showed that a ribbon of glass fiber in the occlusal third of the restoration was an effective method to increase fracture resistance.[14]

The rapid development of dental materials, and the time needed for in vivo and in vitro studies has meant that the effects of bulk fill composite resin reinforced by resin fibre on fracture strength have not received sufficient attention. Therefore, this study aimed to investigate the effect of a new-generation bulkfillflowable composite resin on the fracture strength in composite restorations. The null hypothesis of the study was that fracture strength would not be affected by types of flowable composite.

Application of a fiber layer in a restorative material increases the load-bearing capacity of the restoration and prevents crack propagation from the restoration to the tooth. The elastic modulus of UHMWPE fiber was previously shown to be 1397 MPa. However, in clinical conditions, UHMWPE fiber Ribbond is used in combination with flowable resin and an adhesive resin, resulting in the elastic modulus increasing to 23.6 GPa. The higher modulus of elasticity and lower flexural modulus of the polyethylene fibre are believed to have a modifying effect on the interfacial stresses developed along the etched enamel/resin boundary.[15] Embedding an LWUHM polyethylene fiber into a bed of flowable resin under an extensive composite restoration increases both the fracture strength in root-filled premolars with MOD cavities and the micro tensile bond strength to dentin. The development of FRC technology has increased the use of composite resin materials in extensive preparations. The results of this study support the idea that in endodontically treated maxillary premolars, when minimal dentin structure connects the buccal and the lingual walls of preparation, a method that could reinforce the tooth should be used. The ability to predictably restore an endodontically treated tooth to its original strength and fracture resistance without placement of a full coverage restoration could provide potential periodontal health and is economic to patients.

In this study, the results showed that the difference in mean force required to fracture the teeth in Group 1 (Surefill SDR flow), Group 2 (TetricEvoflowbulkfill), Group 3 (Fitekbulkfill) & Group 4 (X-tra base) were statistically significant.

In the current study, we examined the fracture strength of different types of bulkfillflowable composite resins. The highest fracture strength was obtained by Surefillbulkfillflowable composite resin. This can be explained by the lower stress due to low elastic modulus and lower wettability of bulkfillflowable composite. The flowable composites can be readily inserted into small cavities and are expected to adapt better to the internal cavity wall than other restorative composites, which are more viscous. These features of flowable composites can account for our findings of their superior behavior. Bulk-fill composite materials evaluated in the present study seem to meet satisfactorily the requirements of this type of materials in terms of fracture strength. Bulk-fill composites are more translucent than other restorations, which allow the light to get to much deeper layers.[6]The content of photoinitiators of polymerization and stress inhibitors determines the optimal fracture strength of these composites. It has been reported that the degree of fluidity when applying the composite material influences the marginal adaptation; increased fluidity of the composite makes it adhere better to the walls of the cavity.[7] Moreover the chemistry of the bulkfillflowable composite resin affects the polymerization shrinkage leading to difference in fracture strength. These results were in contrary to the previous study. Leprince et al (2014) showed that the mechanical properties of the bulk-fill composite were lower compared with the conventional high viscosity material and the flowable composite resins.[3] EL-Safty (2012) observed lower mechanical properties with bulkfillflowable composite resin than conventional nano-hybrid composite. It has been reported that the bulk-fill composite are not perfect substitute for conventional composites.[8]Alshali RZ (2015) observed comparable mechanical properties of bulkfill composite resin with conventional composite resin.[4]It was alsoobserved that the bulk-fillflowable base composite provided satisfactory bond strengths regardless of filling technique and cavity depth as compared to conventional composite. Llie et al (2013) observed the highest flexural strength with x-tra base and lowest flexural strength with filtek bulk fill flowable composite resin.[15]

Thus, the type of material employed are the key parameters to be considered when restoring a tooth.

Within the limitation of this in vitro study, the following can be concluded:

- The fracture strength of bulkfill composite resin was influenced by the type of flowable composite resin.
- Highest fracture strength was obtained by Surefillbulkfill composite resin. Inserting a ribbon fiber in composite restorations in root-filled premolar teeth increased fracture strength.

However, long term clinical studies are required to determine the success rate of the different bulkfillflowable composite resins.

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