

Fracture Resistance of Various Bulk-fill Composite Resins in Class II MOD Cavity on Premolars: An *In Vitro* Study

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ABSTRACT

Background: Class II MOD cavity in maxillary premolar creates a specific challenge for the restoration material in terms of longevity and fracture resistance due to the anatomical shape of premolars that render them susceptible to fracture and the microleakage issue of composite restoration at the gingival margin of the proximal boxes. Bulk-fill composite was introduced to provide more strength and resistance and also to provide less polymerization shrinkage and better cure depth. With the advances in dental material science and technology, several attempts have also been made to increase the advantage of bulk-fill composite: by modifying the monomers, utilizing special restoration placement instrument, and adding fiber reinforcement to its composition, which have not been compared adequately. Hence, this study was undertaken to evaluate the effect of different bulk-fill composites in class II MOD cavities on upper premolars in terms of fracture resistance.

Materials and methods: A total of 30 sound upper premolars were divided into three groups of 10 each. Teeth were prepared in the form of class II MOD cavity and restored accordingly: group I restored with Filtek bulk-fill (3M), group II with Sonicfill bulk-fill (Kerr), and group III with EverX bulk-fill (GC). Afterward, samples were thermocycled at 5°C and 55°C for 500 cycles. Fracture resistance test was done using Torsee's Electronic System Universal Testing Machine. Data obtained were analyzed with one-way ANOVA and *post hoc* least significant difference (LSD) test to determine the difference between groups.

Results: ANOVA statistical test showed no significant differences ($p > 0.05$) in all groups. However, resin composite EverX bulk-fill (GC) has a higher fracture resistance (882.94 ± 64.41 N) compared to other groups, Sonicfill bulk-fill (Kerr) (856.48 ± 101.35 N), and Filtek bulk-fill (3M) (812.15 ± 66.89 N).

Conclusion: The use of different bulk-fill resin composites did not yield significant effects in terms of fracture resistance in the restoration of class II MOD cavity on upper premolars ($p > 0.05$). However, bulk-fill resin composite did offer advantages in clinical applications due to the simplified restoration process and reduced working time.

Keywords: Bulk-fill composite, Fracture resistance, Short fiber composite, Sonic activation.

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INTRODUCTION

Great loss of tooth structure due to cavity or trauma has been the main reason for the need for restorations. Nevertheless, in the recent years, patient expectations have moved from tooth restoration only to esthetics and maintenance of function.¹

MOD class II cavity is a cavity affecting mesial, occlusal, and distal surfaces of a tooth. One of the main problems in MOD class II composite resin restorations is microleakage at the gingival margin of proximal boxes. This is related to the absence of enamel at gingival margins, resulting in a less stable cementum–dentine substrate for bonding. The humid and organic nature of dentine makes bonding difficult and in turn will affect the adaptation integrity of the restoration materials.²

Posterior teeth, particularly maxillary premolars, have an anatomic shape that makes them more susceptible to cuspal fractures under occlusal load in the mastication process. Together, class II MOD cavity in maxillary premolar creates a specific challenge for the restoration material in terms of longevity and fracture resistance. Therefore, a restoration material for posterior teeth capable of receiving great occlusal pressure and withstanding fracture is needed.³

Polymerization shrinkage in dental composites is a well-known restoration challenge. The shrinkage could create contraction stress on cavity walls and gap formation at the tooth restoration interface. This gap would subsequently cause deformation on the surrounding tooth structure resulting in microcracks, which predispose the

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tooth to fracture.⁴ Incremental placement technique is one of the methods used to minimize the polymerization shrinkage. The main drawbacks of this were the possibility of trapping voids between layers and the time needed to place the restoration, especially in wide cavities. That is why bulk-fill composite resin materials were introduced as they make the treatment quicker by reducing the clinical steps taken.

Bulk-fill composites offer clinical advantages of low polymerization shrinkage and high depth of curing up to 4 mm, which will lead to less work time, decreased porosity, homogenous consistency, and also reduced cost and time for the patient.⁵ Bulk-fill composites usually have higher filler percentage and a modified initiator system to ensure better curing, particularly in a deep

restoration. Several improvements have also been done to increase the advantage of bulk-fill composites: modifying the monomers, utilizing special restoration placement instrument, and adding fiber reinforcement in its composition.

Filtek™ bulk-fill composite offers enhanced mechanical properties by adding two novel monomers that, in combination, act to lower polymerization shrinkage.

Instruments that could condense the restoration material with a vibration technique using ultrasonic energy had also been developed for composite application. This sonic energy reduces the viscosity of the resin by 87% allowing adaptation in deep cavities, up to 5 mm, in a single increment.⁶

Fiber reinforcement of conventional dental composites was also introduced with the aim of enhancing their physical and mechanical properties and increasing their resistance to fracture.⁷

While the above explanation showed the attempts made to increase the advantages of bulk-fill composites, there were no studies comparing the effect of short fiber reinforced bulk-fill composites, sonic activation in bulk-fill placement, and different monomer contents in bulk-fill composites toward fracture resistance. Therefore, this study was done to observe the effect of different types of bulk-fill composites in MOD class II restoration on upper premolars toward fracture resistance.

MATERIALS AND METHODS

Sample Criteria

This study was a laboratory experiment using posttest only control group design. Study samples consisted of 30 upper first and second premolars. The selection criteria were fresh intact individual human upper premolars, and caries free without any restorations that were extracted for orthodontic or because of mobility. The exclusion criteria were premolars with caries, restoration, and crack.

METHODS

Sample Preparation

A total of 30 sound upper premolars were cleaned with a scaler and stored in saline solution. Samples were randomly divided into 3 groups of 10 teeth each according to the type of restoration material used and then mounted on gypsum blocks for preparation and restoration procedures.

Group I: Class II MOD cavity restored with Filtek Bulk-Fill (3M ESPE, USA).

Group II: Class II MOD cavity restored with Bulk-Fill SonicFill (Kerr).

Group III: Class II MOD cavity restored with everX Posterior Bulk-Fill (GC, Europe) and Filtek Bulk-Fill (3M ESPE, USA).

Outline form design of MOD (mesial occlusal distal) class II cavity was made using pencil on the tooth with the help of a caliper to get accurate measurements of cavity depth 3 mm from the pulp floor and 4 mm from the gingival floor, measured from the palatal cavosurface margin with a 1 mm axial wall. Buccal and palatal axial walls were made parallel to each other. Cavity preparation was done using fissure diamond bur on a high-speed handpiece, and preparation was initiated from the occlusal surface (Fig. 1).

Sample Restoration

After the application of tofflemire matrix system, the prepared cavities were acid etched for 15 seconds with the help of a

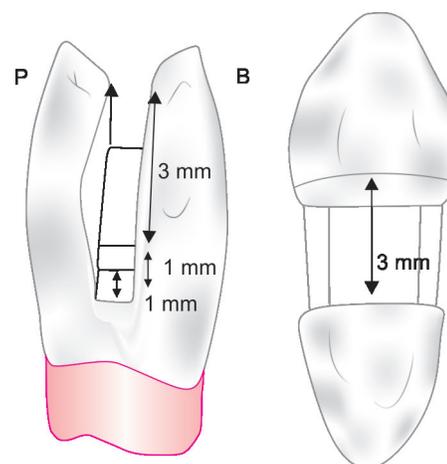


Fig. 1: MOD class II preparation design on premolar teeth⁸

microbrush and then rinsed with water and air dried. The tooth structure was maintained moist. Afterward, the prepared cavity surfaces were saturated with a bonding agent for 10 seconds using a microbrush and gently air-dried. An LED light curing unit was used for the polymerization process for 20 seconds. Bulk-fill composite according to the type of the group was then placed at 4 mm thickness, measured using a probe, and cured for 20 seconds.

Finishing and Polishing

Specimens were finished using fine finishing diamond bur to remove excess composites and then polished with a silicone bur.

Water Storage and Thermocycling

All the restored specimens were freed from the gypsum blocks and then stored in a container filled with saline solution for 24 hours and thermocycled for 500 cycles at 5°C and 55°C with a dwell time of 20 seconds and a transfer time of 5 seconds.¹

Sample Fixation and Pressure Test

Self-cured acrylic resin in a cylinder mold was used to fix each tooth up to 2.0 mm below the cemento-enamel junction. Afterward, the samples were subjected to compressive load at a cross-head speed of 1 mm/minute using Torsor's Electronic System Universal Testing Machine. Compressive loading was applied using a custom-made metal zig placed in the center of the tooth. The force required to cause fracture was recorded in kgf and converted to Newton (N), and the mean was calculated for each group.

Data Analysis

Data obtained were statistically analyzed using one-way ANOVA with a confidence level of 95% and a significance level of $\alpha = 0.05$ to examine if there were differences between groups. *Post hoc* LSD test was done to determine the significance level in each group.

RESULT

Both Figure 2 and Table 1 show that group III (everX bulk-fill (GC)) had the highest mean value of fracture resistance at 882.94 ± 64.41 N, followed by group II (Sonicfill bulk-fill (Kerr)) at 856.48 ± 101.35 N and group I (Filtek bulk-fill (3M ESPE)) at 812.15 ± 66.89 N.

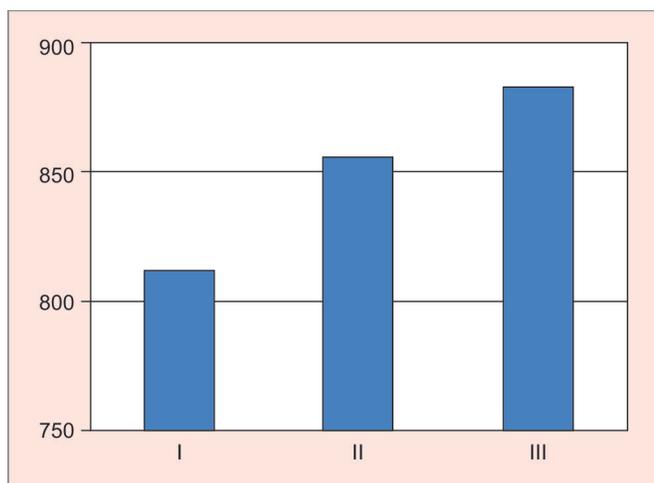


Fig. 2: Mean value of the fracture resistance of bulk-fill composites

Table 1: The ANOVA results of mean value \pm standard deviation of fracture resistance in groups I to III

Group	Fracture resistance (Newton) $x \pm SD$	p value
I. Bulk-fill composite resin restoration with AUDMA and AFM monomers	812.15 \pm 66.89	0.151
II. Sonic activated bulk-fill composite resin restoration	854.48 \pm 101.35	
III. Short fiber reinforced bulk-fill composite resin restoration	882.94 \pm 64.41	

DISCUSSION

This study is in agreement with Vahid et al. who investigated the fracture resistances of bulk-fill composites in class II MOD cavity on upper first premolar teeth. His result showed that Ever X composite (GC) had the highest fracture resistance compared to other bulk-fill composites.

The highest fracture resistance value of Ever X bulk-fill (GC) in our study might be due to the combination of resin matrix, short e-glass fiber filler, and an organic filler in its composition. The short fiber composite resin has also proved to control the polymerization shrinkage stress by fiber orientation, and thus, marginal microleakage was reduced. This is supported by Aboueiil et al., who found that fibers in composite could stop the crack propagation through the material. He also discovered that the fiber reinforced composite samples remained attached, even after the failure of the sample and formation of crack line.⁷

Sonicfill (Kerr) is a fast and reliable new technique for posterior restoration which does not require any additional capping layer. The manufacturer stated that as sonic energy is applied through the handpiece, the modifier causes the viscosity to drop (up to 87%), increasing the flowability of the composite, enabling quick placement, and precise adaptation to the cavity walls.⁹ Sonicfill resin has a shrinkage of only 1.6%. Low polymerization shrinkage minimizes gap formation and the risk of cracking that could cause fracture.¹⁰ Ibarra et al. found that the sonic activation technique lowers the viscosity of the material to allow for easy adaptation to the cavity walls without creating air bubbles.¹¹

Filtek bulk-fill (3M ESPE) contains two novel methacrylate monomers. One is high molecular weight aromatic urethane dimethacrylate (AUDMA) which decreases the number of reactive groups in the resin. This helps to decrease volumetric shrinkage and thus reduces the polymerization stress. The second monomer is addition fragmentation monomer (AFM), which contains a third reactive site that may cleave through the fragmentation process during polymerization. This process provides relaxation mechanism for the developing network and subsequent stress relief.

Descriptive results showed that the fiber reinforced bulk-fill composite has a higher value of fracture resistance compared to other bulk-fill composites. However, one-way ANOVA analysis did not show a significant difference between groups. This might be due to a number of reasons explained below, which comprised also the limitations of this study. But Farahanny et al. found that the maxillary premolar teeth that had been endodontically treated with final restoration resin composite bulk-fill had high fracture resistance.¹²

Difficulties in looking for study samples of recently extracted upper premolar teeth were also of influence when measuring fracture resistance because tooth that has been extracted quite a while would undergo structural changes. Inorganic materials such as calcium hydroxyapatite and organic materials such as collagen start to deteriorate after the tooth was extracted. These structural changes will affect the chemical bonding between teeth and composite.¹³

Jefferson et al. carried out a fracture endurance study in premolars by controlling the shape and variation of sampled teeth. The teeth were observed under a microscope to confirm that the samples were cavity- and crack-free. In our study, cusp variation, position, and the size of upper premolars were not controlled. Samples were not examined under a microscope, and hence, the possibility of microcrack that was there before was not controlled.¹⁴

In this study, the age of the subjects where the samples were acquired was not controlled. Noronha et al. found that fracture resistance in upper premolar teeth from young (18–21) subjects was 77.5 kgf, while in >60-year-old subjects it was about 128.9 kgf. This might be due to the difference in enamel rods alignment, which was perpendicular in young age, while in elderly, it was tilted. This difference might influence the result of fracture resistance.¹⁵

Fahad in his study of fracture resistance on weakened premolars said that the root surface of the teeth should be covered with aluminum foil up to 2 mm below the cemento-enamel junction to simulate the periodontal issue.⁸ Similarly, Franca et al. also dipped the root surface into melted wax to a depth of 2 mm below cemento-enamel junction (CEJ) to produce the average thickness of the periodontal ligament.¹⁶ In our study, this simulation of periodontal tissue using wax or foil was not performed, which might contribute to the difference in results.

Pressure test process in this study utilized the Torsee's Universal Testing Machine, but the limitation of this machine was that it did not simulate an adequate clinical oral cavity condition and dynamic loading. In this study, Torsee's Universal Testing Machine only provided one-way load on one point, which means it did not simulate the actual force occurring in the mastication process.^{1,17}

Thermocycling process was done for 500 cycles, which was assumed to be equal to 20–25 days usage in the oral cavity. Nevertheless, the result of the study did not show significant differences; therefore, further *in vivo* investigation is recommended.

CONCLUSION

In this study, there were no differences in fracture resistances of MOD class II restoration using different bulk-fill composites. However, bulk-fill composites clearly have advantages over regular composites on clinical application because they simplify the restoration process and save the working time. Bulk-fill composites also reduced polymerization shrinkage and better material adaptation, which in turn will increase restoration longevity.

CLINICAL SIGNIFICANCE

In this study, the use of different bulk-fill composites did not offer significant advantages in terms of fracture resistance in MOD class II restoration on upper premolars.

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