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Original Research

Evaluation and comparison of fracture resistance of two low-viscosity bulk-fill resin-based restorative materials

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ABSTRACT:
Objectives: This study tested the fracture resistance of two different bulk-fill composite restorations and compared them to a conventional composite. **Methods and Materials:** Flowable and high viscosity bulk-fill composites (SDR, SonicFill) and a nanohybrid resin composite (Filtek Z350 XT) were used. Standardized class II cavities were prepared on extracted premolars,and different restoration protocols were used. In protocol 1 (control), restoration was applied using a layering technique; in protocol 2 (SDR), restoration was applied in bulk with a capping layer; in protocol 3 (SonicFill), restoration was applied in bulk without a capping layer. After thermocycling, the restorations were subjected to the fracture resistance test using a universal testing machine. **Results:** Statistical analysis was carried out using one-way ANOVA at a significance level of $\alpha = 0.05$. Fracture resistance of premolars restored with SDR (68.95), SonicFill (70.61) and Filtek Z350 XT (67.55) did not show significant difference ($p = 0.72$). Adhesive failures were more often observed in all the groups. **Conclusion:** The new low-viscosity bulk-fill composite restorations seem to have adequate fracture resistance.
Key words: SDR, SonicFill, Bulkfill, fracture resistance

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INTRODUCTION

Composite resin restorative materials have undergone many types of research and advancements to overcome the shortcomings like polymerization shrinkage, microleakage, and technique sensitivity, leading to the evolution of resins with better properties. Incremental layering technique has been the most widely adopted placement technique to counter polymerization shrinkage. However, it has certain drawbacks such as incorporation of voids, increased operational time, difficulty in placement of increments in small cavities, interlayer contamination, and difficulty in maintaining isolation.[1] The bulk-fill composites are a newly introduced category of direct resin-based restorative material advocated for use in posterior restorations. They can be applied and cured in a single layer of up to 4 or 5 mm, offering a faster restoration procedure.[2,3] With regard to their mechanical properties, the bulk-fill materials fall between conventional composites and flowable composites. While some bulk-fill composites require a final 2-mm increment of a conventional composite material (SDR, Dentsply, USA), other bulk-fill composites (i.e. SonicFill, Kerr Corporation, Orange, CA, USA) could be placed in the cavity without such final layer. SDR (Dentsply,Caulk,USA) bulk-fill flowable is a single component, fluoride containing, and visibly light cured radiopaque, modified urethane dimethacrylate resin composite restorative material. It has handling characteristics typical of a flowable composite but can be placed in 4 mm increments with minimal polymerization stress. SDR has a self-leveling feature that allows intimate adaptation to the prepared cavity walls.[4] Available in one universal shade, it is designed to be overlaid with a methacrylate based universal/posterior composite for replacing missing occlusal/facial enamel.

SonicFill (SonicFill, Kerr Corporation, Orange, CA, USA) is a sonic-activated material that is indicated for posterior restorations up to 5 mm depth in one step unlike the other bulk-fill flowable composites. This highly filled resin has special modifiers that react to sonic energy and rapidly flow into the cavity under sonic activation. The high depth cure is not dictated by the increase in translucency of the material like in other bulk-fill composites, yielding to better optical results.[5]

The aims of the study were to study the fracture resistance (or loads at fracture) of two different resin-based bulk-fill direct restorative materials in deep class II cavity preparations and compare with that of conventional nanohybrid resin based composite resteoerative material, Filtek Z350 XT (3M ESPE,USA).The null hypotheses were that 1) there are no significant differences in the fracture resistance between the bulk-fill materials tested, 3) there is no significant difference in fracture resistance between bulk-fill materials and nanohybrid composites.

METHODOLOGY

Sixty intact maxillary premolars were collected after extraction and stored in 0.05% thymol solution at a temperature of 4˚C. The teeth were examined under a light microscope at 10 X magnification to ensure that they were free of defects and fracture lines. The bucco-lingual dimension and crown length of the teeth at the interproximal areas were measured with a digital micrometer gauge and only teeth within a size range of less than 1 mm were selected. Standardized class II occluso-distal cavities were prepared by one operator under copious saline irrigation. For standardization, the dimensions were confirmed using a periodontal probe and a digital micrometer with an accuracy level of up to 0.05 mm. The bucco-lingual width and occlusal width of the preparation was 2 mm each; the distal box extended 6 mm gingivally, ending in dentin right below the cemento-enamel junction with a width of 3.5 mm at the marginal ridge; and the width of the gingival seat was 1 mm. The preparation was done using round-ended straight fissure carbide burs (Mani, Japan). Each bur was replaced after four preparations.

Restoration Protocol

The teeth were randomly divided into 3 groups (n=20) and restored by one operator. The restorative materials were placed with their respective bonding agents according to the manufacturers' instructions

Group C (control): Twenty cavities were incrementally filled with Single Bond Universal/Filtek Z350 XT nanohybrid composite. Acid etching was done for 15 s; rinse and dry using cotton pellet and gentle blotting. Single bond universal adhesive was applied and rubbed for 20 s. Gentle air drying was done for for 5 s and light cured for 10 s. Filtek Z350 XT composite was placed in a horizontal incremental technique with 2-mm layer thickness. Each layer was cured for 20 seconds.

Group SD (SDR): Twenty cavities were bulk-filled in 4-mm increments using Prime&Bond NT/SureFil SDR, with the addition of a 2-mm capping layer using the Filtek Z350 XT composite without bonding agent. The protocol was: Acid etching for 15 s; rinse and dry using cotton pellet and gentle blotting.Apply a generous amount of the adhesive and keep surface wet for 20 s. Gentle air drying for 5 s. Light cure for 10 s. The 4mm SDR layer was cured for 20 seconds, and the second 2mm capping layer of nanohybrid composite was cured for 10 seconds.

Group SF (SonicFill): The remaining 20 samples were restored with SonicFill. The specimen's cavity were etched with 37% phosphoric acid for 15 s followed by cleaning with gentle water spray for 10 s. Optibond Solo Plus (Kerr, Orange CA, USA) was applied to etched dentin surface according to manufacturer's instructions. The adhesive was cured for 20 s. After completion of bonding protocol as in Group I, the dispensing rate of SonicFill composite was set and the tip was placed at the bottom of cavity floor. The cavity was filled in a steady, continuous stream, withdrawing the tip as the cavity got restored and then cured for 20 s from the occlusal surface.

A LED light-curing unit was used (Bluephase N, Ivoclar Vivadent AG, Schaan, Liechtenstein). The light-guide tip was placed touching tooth cusps, and kept 2 mm from the marginal ridge. Analysis and

measurement of the irradiance values (1200 mW/cm2), spectrum emission, and total energy delivered for each specimen were performed with the use of an intensimeter. After restoring the teeth, excess material was removed, and finishing and polishing were done using diamond composite finishing burs (Diatech, Coltene,USA), Soflex polishing discs (3M ESPE, St Paul, MN, USA), a scalpel, and a number 12 blade.
The samples were stored in moist conditions for 24 h at 37°C and then subjected to thermocycling of 500 cycles with the temperature changing from 5°C to 55°C, dwell time of 15 s, and an interval time of 10 s each. After the thermo-cycling, the teeth were embedded into a plastic ring 2.5 cm in diameter and 3 cm in length. An autopolymerizing resin (Hiflex RR, Prevest Denpro, India) was used up to 3 mm below the cemento-enamel junction in order to be able to fit the specimens into the jig of the universal testing machine. A small flat area in the middle of the restoration's marginal ridge that was used as the point for force loading. A universal testing machine (HEICO, New Delhi,India) with a smooth, 0.5-mm tipped, round-ended stainless-steel rod attached to its upper member was used to fracture the specimens. They were subjected to a compressive axial loading with a crosshead speed of 1 mm/min. The failure loads of the restorations were determined and recorded in newtons (N). The fracture mode of each specimen was evaluated under a stereo-microscope (Kyowa Getner, Japan) at 3X magnification. It was classified into three groups: cohesive fracture of tooth structure, cohesive fracture of the filling material, and mixed fracture of both tooth structure and the filling material.

STATISTICAL ANALYSIS

The statistical analysis was done using SPSS version 22.0 for Windows (IBM, Chicago, IL, USA). One-way ANOVA was carried out to compare the control with the bulk-fill groups prepared according to the manufacturers' instructions. The level of significance was set at a = 0.05 for all tests.

RESULTS

The mean fracture loads and failure modes of the different groups are presented in Table 1 and Table 2 respectively. Fracture resistance three tested materials did not show significant difference among them. Adhesive failures were more often observed in experimental groups.

Group	Mean (N)	Standard Deviation	Standard Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Min	Max	P value
Z350 XT (C)	67.55	15.66	3.25	60.93	74.2	42.59	83.91	>0.05
SDR (SD)	68.95	2.59	0.91	58.04	79.86	65.30	72.61	
SonicFill (SF)	70.61	4.19	1.48	59.70	81.52	61.35	74.05	

TABLE 1: Mean fracture loads of different experimental groups

Group	Failure modes (%)		
	Adhesive	Cohesive	Mixed
Z350 XT (C)	60	0	40
SDR (SD)	80	0	20
SonicFill (SF)	82	0	18

TABLE 2: Modes of failures in percentages

DISCUSSION

This study aimed to evaluate and compare the load-bearing capacity of Class II tooth preparations restored with sonic-activated bulk-fill SonicFill, SDR and 3M Filtek Z350 XT nanohybrid composites. Based on the results of this study, since fracture resistance did not show significant difference between the experimental groups, the null hypothesis could be accepted. Bulk-filling technique of composite placement was not accepted until recently, with the advent of new group of bulk-filling posterior composites. These allow up to 4 mm increments to be placed and cured in a single increment. This may be due to the improvements in monomer chemistry (matrix and initiator) and filler characteristics of these materials.[6,7]

In the present study, high fracture resistance values were displayed by both the incrementally placed nanohybrid and bulk-fillcomposites. No statistically significant difference ($P > 0.05$) was observed between the three groups. In accordance with the present study, Rauber *et al* observed that there was no difference with reference to fatigue resistance when the bulk-fill resin placed in a single increment was compared to restorations placed incrementally.[8] Furthermore, the results of this study are consistent with the study by Rosatto *et al* that concluded that the bulk-fill technique has been shown to provide lower cuspal strain, shrinkage stress, and higher fracture resistance.[10]Incremental layering technique has been the standard of care for placement of dental composites. It aids reduction in polymerization shrinkage and associated stress as well as overcomes the inability to light-cure composite beyond a certain depth.[10] Bulk-fill technique is highly desired in daily dental practice due to decreased number of restorative incremental steps.[11] The reported properties of bulk-fill composites such as decreased polymerization shrinkage[12], improved self-levelling ability[13], reduced cuspal deflection[14] and optimal bond strength[11] are certain advantages of this material. Manufacturers eliminated the disadvantages such as shrinkage stress by modifying the composition through polymerization kinetics. Slower polymerization is employed in bulkfill materials as a basic strategy to decrease the polymerization shrinkage.[15] In an earlier study, teeth restored with bulk-fill composites presented higher fracture resistance where no sonic activation was practised.[9] In this study, a sonic-activated bulk-fill material was used presenting similar fracture resistance results compared to those of other materials. SDR has the lowest filler content (47% by volume) of the bulk-fill materials tested in this study, which may cause the lower fracture resistance values. But in this study, the SDR was capped with a layer of nanaohybrid composite, thus reaching values comparable to that of 3M Filtek Z350 XT. Bulk-fill composites may be able to substitute the time-consuming incremental placement technique. However, directions of forces that are peculiar to individuals' oral environment and occlusion affect in vivo fracture resistance of restored teeth. Hence, further long-term clinical studies are required for bulk-filled composites to replace the gold standard incremental placement technique.

CONCLUSION

Within the limitation of this in vitro study, it can be concluded that the novel bulk-fill composites like SDR and SonicFill displayed fracture resistance values similar to incrementally placed nanocomposite.

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