

Effect of Different Layering Techniques on Shear Bond Strength of Microhybrid and BulkFill Nanohybrid Composite Resin: An *in vitro* Study

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ABSTRACT

Aim: To compare the shear bond strength of microhybrid and BulkFill composite, when they are placed under three different incremental curing techniques: gingival-occlusal layering (horizontal), wedge-shaped layering (oblique), and bulk technique.

Materials and methods: A flat dentinal surface of 60 teeth was prepared by removing 1.5 to 2.0 mm of their occlusal surfaces with the help of single-sided diamond disk for testing. These samples were randomly divided into two groups of 30 samples each: group I for microhybrid composite (Filtek Z250, 3M ESPE, St. Paul, Minnesota, USA) and group II for BulkFill Filtek composite resin (3M ESPE, St. Paul, Minnesota, USA). The two groups were further divided into three subgroups based on the layering techniques (group I—bulk technique, group II—horizontal layering, and group III—oblique layering techniques). These specimens were loaded in a universal testing machine at a speed of 0.5 mm/minute till failure for determining the shear bond strength. The modes of failures of each group were observed under a scanning electron microscope (SEM), and analysis of variance (ANOVA) and t-value calculation analysis was applied.

Results: The statistical analysis showed that there was significant difference between BulkFill and microhybrid composite and also between different layering techniques ($p < 0.05$).

Conclusion: The highest shear bond strength was observed for BulkFill when compared with microhybrid composite resin. The BulkFill bulk technique has the highest bond strength followed by BulkFill oblique layering and microhybrid oblique layering techniques.

Clinical significance: BulkFill composites might be the material of choice for restoring cavities where procedural time is of concern, especially in pediatric, geriatric, and apprehensive patients where the treatment time should ideally be kept short.

Keywords: Bond strength, Composites, Layering techniques.

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INTRODUCTION

Since its advent as a restorative material, composite resins have played a pivotal role in the advancement of esthetic and conservative dentistry. They are one of the most commonly used in comparison with previously used materials due to various advantages.¹ However, at times, composite resins may have a limited lifespan as a result of lack of adhesion to enamel/dentin due to stresses caused by polymerization shrinkage.²

Composites are generally composed of resin-based organic matrix, nonorganic filler particles, and silane bonding agent. A three-dimensional network, which is predominantly filled with filler particles is formed when organic matrix bonds into polymers. The filler particles impart strength to the three-dimensional network. Apart from the mentioned components, composites also contain polymerization initiators, various additives, stabilizers, inhibitors, and pigments which enhance the overall quality of the material.³

Therefore, the success of the composite resin restoration depends on the appropriate polymerization of the resin component, which is established when monomers get converted into polymers, along with the volumetric reduction of the material.⁴ It is a well-known fact that the volume occupied by the polymers are less compared with monomers and it leads to what is known as “polymerization shrinkage.”⁵ During the polymerization process, the weak Van der Waals forces are converted into covalent bonds; as a result, the distance between the monomer chains is reduced.⁶ The viscosity of the resin material also gradually increases during the conversion; as a result, the material loses its flowing ability. This is known as “vitrification.”⁴ The material also loses its fluidity which is referred to as “gel point.”⁵ Due to these changes, the polymerized material loses its ability to flow and relieve stresses. Now there is an increase in the elastic property of the material, hence any restraints on the polymerization shrinkage (e.g., by the bonding between restoration and tooth structure) will create residual shrinkage stresses.^{5,7-9}

In spite of various developments in composite resin restorations in recent times, its drawback related to polymerization shrinkage still causes a clinical issue.

Usually, dental composites exhibit a volumetric shrinkage between 1 and 6%, based on the formulation and curing conditions.^{10,11} Resin cements might also show a comparatively similar or higher polymerization shrinkage values.^{5,12}

As a result, shrinkage stresses are formed which can lead to debonding along the restoration/tooth interface or at the restoration margins. This in turn results in formation of internal and marginal gaps, microcracking of either or both the restorative material and tooth structure.^{5,9}

In other words, polymerization shrinkage stresses compromise the strength of the restorations.

The incremental curing technique is one of the various methods advocated to overcome this issue with composite resins.¹³ The different incremental techniques used are faciolingual layering (vertical), gingival-occlusal layering (horizontal), three-site technique, wedge-shaped layering (oblique), successive cusp build-up technique, bulk technique, and centripetal build-up.^{13,14}

The incremental curing technique has a positive impact on the strength of the composite resin restorations. But, it had other drawbacks, such as increased time taken to complete the restoration due to difficulty in placement of multiple increments; poor execution of placing multiple layers increases the chances of polymerization shrinkage and marginal leakage due to it being a technique-sensitive procedure.¹⁵ To tackle these drawbacks, a new type of composite known as "BulkFill composites" was introduced. These composites are indicated for insertion in a maximum 4 mm bulk due to their high reactivity to light curing.¹³ Therefore, in this study, we wanted to compare the shear bond strength of microhybrid and BulkFill composite, when they are placed under three different incremental curing techniques: gingival-occlusal layering (horizontal), wedge-shaped layering (oblique), and bulk technique (without any increments). Also, under SEM, we wanted to determine whether the modes of failure of these restorations are adhesive, cohesive, or mixed.

MATERIALS AND METHODS

Sixty freshly extracted, unerupted human third molars were collected and their root surfaces were cleaned. These

teeth were mounted in self-cure acrylic resin blocks and rinsed with distilled water. A flat dentinal surface of these teeth was prepared by removing 1.5 to 2.0 mm of their occlusal surfaces with the help of single-sided diamond disk for testing. These samples were randomly divided into two groups of 30 samples each: group I for microhybrid composite (Filtek Z250, 3M ESPE, St. Paul, Minnesota, USA) and group II for BulkFill Filtek composite resin (3M ESPE, St. Paul, Minnesota, USA). The two groups were further divided into three subgroups based on the layering techniques (group I—bulk technique, group II—horizontal layering, and group III—oblique layering techniques).

Composite resins were restored on each sample with the above-mentioned layering methods with the help of a Teflon tube which was 8 mm in diameter and 4 mm in height and they were light cured for 15 seconds using light-emitting diode.

These samples were stored in normo-saline at 37°C for 24 hours, thermocycled for 500 cycles. Shear bond testing was performed using a universal testing machine (LR50K, Lloyd Instruments Ltd, Fareham, Hants, UK) at a crosshead speed of 0.5 mm/minute. The shear bond strength values were calculated as the ratio of fracture load and bonding area, and were expressed in megapascals. After shear bond strength testing, the fractured test specimens were examined under SEM to observe the modes of failure and ANOVA and t-value calculation analysis were applied.

RESULTS

The highest shear bond strength among composites was for BulkFill when compared with microhybrid. The intergroup comparisons showed that BulkFill bulk technique has the highest bond strength followed by BulkFill oblique layering, microhybrid oblique layering, BulkFill horizontal layering, microhybrid horizontal layering, and microhybrid bulk technique representatively as shown in Table 1. The statistical analysis showed that there was significant difference between BulkFill and microhybrid composite and also between different layering techniques ($p < 0.05$). The mode of failure under SEM showed that 90% of the samples were of adhesive failures (Table 2).

Table 1: Comparison of shear bond strength among the groups by one-way ANOVA

Groups	n	Mean	Standard deviation	Degree of freedom	F-ratio	p-value
BulkFill—bulk technique	10	20.0220	2.13302	5	11.752	0.000*
BulkFill—horizontal layering	10	17.5830	1.17298			
BulkFill—oblique layering	10	18.7060	2.13429			
Microhybrid—bulk technique	10	14.0240	2.28814			
Microhybrid—horizontal layering	10	15.8290	2.14358			
Microhybrid—oblique layering	10	17.9950	1.73031			
Total	60	17.3598	2.72461			

*Significant at 5% level of significance

Table 2: Modes of failures

	<i>Adhesive</i>	<i>Cohesive</i>	<i>Mixed</i>
BulkFill—bulk technique	10	0	0
BulkFill—horizontal layering	10	0	0
BulkFill—oblique layering	8	1	1
Microhybrid—bulk technique	9	1	0
Microhybrid—horizontal layering	8	1	1
Microhybrid—oblique layering	10	0	0

DISCUSSION

Layering techniques are generally used to reduce the c-factor and polymerization stresses, which results in favorable properties. Therefore, in the present study, we wanted to evaluate whether the BulkFill composites exhibited better properties when used with different layering techniques. We anticipated better bond strength for BulkFill composites placed under layering techniques, since the bond strength depends on multiple factors, such as polymerization stress, c-factor, degree of conversion, and thickness of adhesive agent. But the results showed that BulkFill composites placed under bulk technique showed better bond strength than the layering techniques used on it. This might be due to the difference in adhesive thickness and further investigations in this regard are needed to validate this.

The shear test was considered in this study for verifying the bond strength of the composite resin materials, as it provided a better representation of the clinical forces experienced by the restoration. It also gave an easier control of the bond test area and required a less demanding specimen collection.¹⁶

The cavity configuration or c-factor is defined as the ratio of the bonded to the unbonded surface area.¹⁷ When the unpolymerized resin-based composite comes in contact with more than one wall of the prepared cavity, it increases the c-factor. This can lead to the development of shrinkage stresses which in turn lead to failure of the restoration at the weakest intersection, usually between the tooth and restorative material. This results in a number of potential problems including secondary caries, marginal staining, tooth fracture, and postoperative sensitivity.¹⁸ Previously, BulkFill resin composites demonstrated a better depth of cure, a higher degree of conversion of polymers, and lower polymerization stresses than those treated with conventional resin composites.¹⁸⁻²⁰ This might be the reason for BulkFill composites having higher bond strength compared with conventional composites.

El-Damanhoury and Platt²¹ found that BulkFill composites induced lesser shrinkage stresses than the conventional composites. In this study, the bulk filling with microhybrid composite showed least bond strength compared with other values. This might be due to the

attenuated light intensity and lower degree of conversion which prevents the complete polymerization at the bottom surface of the restoration.

CONCLUSION

Within the limitations of this study, the highest shear bond strength was observed for BulkFill composite resins. Among the layering techniques the bulk technique showed the highest bond strength.

BulkFill composite materials provide tooth-colored restorations that can be more efficient and less technique-sensitive to place than conventional composites. They might be the material of choice for restoring cavities where procedural time is of concern, especially in pediatric, geriatric, and apprehensive patients where the treatment time should ideally be kept short.¹⁸

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