

Semi-Split Bulk Filling Technique in Large Occlusal Bulk-Fill Resin Composite Restorations

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Abstract

When composite resin hardens by light curing, it shrinks and undergoes deformation which occurs in one region more than other regions within the composite bulk. This behaviour is mainly related to variations in bonding to enamel and dentin of surrounding cavity walls. Bonding to surrounding cavity walls creates restrained shrinkage which develops tensile stresses within the composite bulk. The developed tensile stresses act against the tensile strength of the composite resin, and may cause cracks in enamel or composite, as well as residual strain at the adhesive interface, forming marginal and internal gaps.

Using the bulk filling technique, a bulk of 4 mm increment of bulk-fill resin composite is placed in a deep Class I cavity. Within the composite bulk, shrinkage displacement occurs axially in the top region more than in the bottom region, resulting in debonding and gap formation at the pulpal floor. This gap is associated with persistent postoperative sensitivity and consequent pain.

The semi-split bulk filling technique is proposed as a modification of the bulk filling technique used for placing bulk-fill resin composites in large occlusal cavities. It aims at diminishing the shrinkage stresses within the composite bulk and minimizing the incidence of pulpal floor gap formation and the consequent postoperative sensitivity and pain.

Keywords

Bulk filling; Bulk fill resin composite; Debonding; Diagonal gap; Displacement; Polymerization shrinkage; Postoperative sensitivity; Pulpal floor gap; Semi split bulk; Stress reduction

Introduction

In the past decade, bulk-fill resin composites have been introduced in the dental market as a new concept for restoring posterior teeth [1-3]. They became popular among dentists who prefer simpler clinical procedures with reduced working time [4,5]. Bulk-fill resin composites were claimed by manufacturers to have a depth of cure of up to 4-5mm. The increased depth of cure is achieved by using more efficient photo initiators [6], or by using fillers and monomers with similar refractive index [7]. Another group of bulk-fill resin composite was claimed by manufacturers to have a reduced shrinkage stress, as compared to that of the conventional composites placed incrementally. The stress reduction is achieved by additions in the organic matrix of low-shrink monomers, higher molecular weight monomers, or stress-relieving additives [1].

Polymerization shrinkage is an undesired property of dental composites which causes a discrepancy in dimensions when the restoration hardens. This affects the interface and results in residual strains at the adhesive interface, or marginal/internal gap formation [5,6]. The polymerization shrinkage stress is a complex phenomenon as it depends on several factors. Among which are the boundary conditions, the amount of material, and the polymerization reaction. They all play essential roles in stress development and/or transmission to tooth structures [8,9].

Within a large occlusal composite restoration placed as in bulk of 4 mm increment using the bulk filling technique, a greater shrinkage strain or displacement takes place in the top composite region, where it undergoes more axial displacement than the bottom composite [7,10]. Additionally, the top composite displacement exerts an upward pull on the bottom composite region resulting in its debonding from the pulpal floor, and formation of pulpal floor gap beneath the composite restoration [5,6,11].

Several studies found that bulk-fill resin insertion technique resulted in higher rates of post-operative sensitivity compared to conventional resins. This sensitivity was attributed to the formation of pulpal floor gap in bulk-fill resin composite occlusal restorations. The dentinal fluid in the gap undergoes contraction or expansion with cold or hot stimuli, resulting in sudden movement of the fluid in dentinal tubules and causes pain [1,12-14]. The objective of this paper is to propose the semi-split bulk filling technique, as a modification of the bulk filling technique which is used for placing bulk-fill resin composites in large occlusal cavities. The proposed technique aims to reduce the shrinkage stresses

generated due to the polymerization of bulk-fill resin composites, as well as to minimize the incidence of gap formation at pulpal floor, and consequent postoperative sensitivity and pain.

The Proposed Technique

In the semi-split bulk filling technique, a diagonal gap (1.5 mm wide) is created vertically into the 4mm composite bulk inserted in a large occlusal bonded cavity. This gap extends for a depth of 2 mm, prior to light polymerization, using a Teflon-coated plastic filling instrument in push stroke. This gap splits the top composite 2 mm region into two equal segments. The segmented composite bulk is then light cured. The diagonal gap is then filled with the same bulk-fill resin composite and light cured.

Discussion

The shrinkage stresses generated in bulk-fill resin composites exert tension on the bonding adhesive and surrounding tooth structure during the polymerization process. If this tension exceeds the adhesive bond, or the strength of either the composite or tooth, it can cause interfacial debonding, resulting in internal/marginal gaps. Comparing the incremental vs. the bulk filling techniques, the bulk filling technique was reported to produce more interfacial debonding [15-17].

In the bulk filling technique, the shrinkage stress occurs during light polymerization within a bulk of 4mm increment of bulk-fill resin composite inserted into a large occlusal cavity (Figure 1a). The magnitude and direction of shrinkage stress varies between the top and bottom composite regions [7,10]. The polymerizing bulk-fill resin composites undergo shrinkage displacement in both axial and lateral dimensions, with less displacement occurring laterally than axially.

The axial displacement in the top 2 mm composite region occurs in downward direction, whereas it takes place in upward direction in the bottom 2 mm composite region [18,19]. Additionally, the top composite displacement exerts an upward pull on the bottom composite region strong enough to result in its debonding from the pulpal floor, and formation of pulpal floor gap beneath the composite restoration [20-22], (Figure 1b.)

The strength of the upward pulling is augmented by bonding the composite in the top region to enamel and dentin of surrounding cavity walls, as compared to bonding to dentin only in the bottom region. Moreover, the upward pull is boosted by the position of the light tip closer to the occlusal outer area of the cavity, leading to its faster polymerization than that at the cavity floor [22,23] and subsequently resulting in immobilization of the resin matrix in the top composite sooner than in the bottom composite [24-26]. It is noteworthy to mention that scattered areas of bonding and gaps could coexist within the same restoration [27].

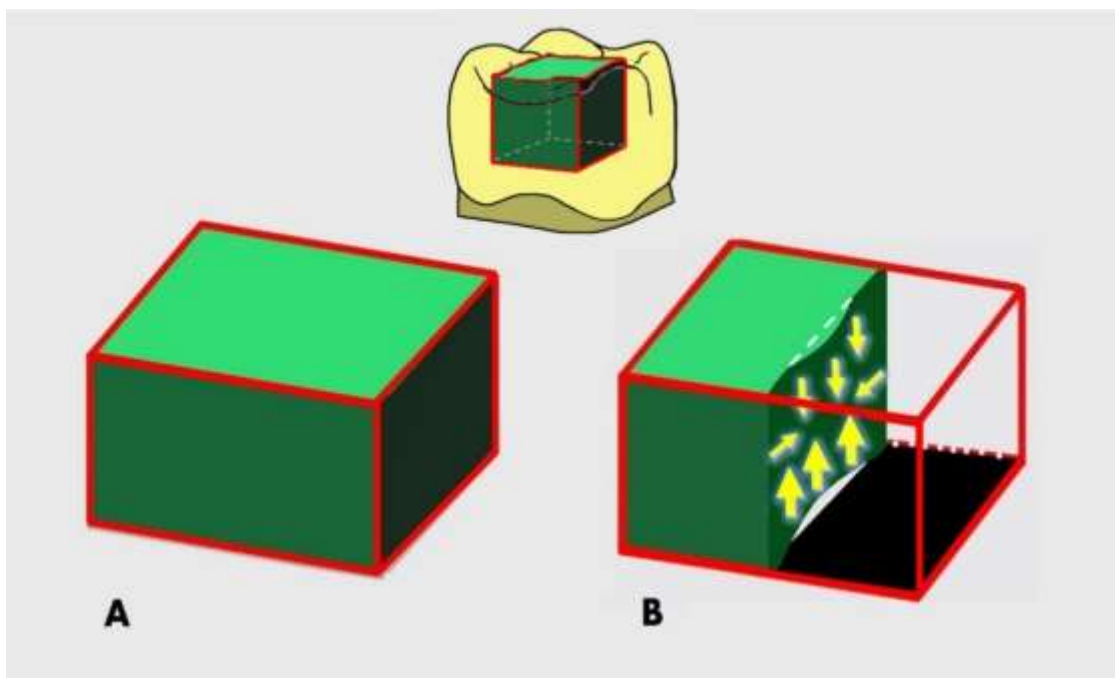


Figure 1: The bulk filling technique for placing a single composite bulk. **(a)** A large occlusal bulk-fill resin composite restoration. **(b)** A sectional view, illustrating more axial than lateral shrinkage displacement and more upward axial displacement along with gap formation at pulpal floor.

It is well understood that bulk-fill resin composites were introduced in the dental market for their easy placement in cavity preparations as one piece using the bulk filling technique which saves much of the chair side time. However, this technique is reported to cause more axial than lateral shrinkage displacement in the top composite region and to generate more axial stresses which result in debonding at the pulpal floor and gap formation, leading to persistent postoperative sensitivity and pain [1,5-7,10-14]. As a solution, the semi-split bulk filling technique is proposed for modifying the bulk filling technique by using an additional step which needs a little extra chair side time.

The proposed technique is based on creating a diagonal gap into a bulk of 4 mm increment of bulk-fill resin composite, prior to light curing. This gap is 1.5 mm wide and extends for a depth of 2 mm in the top composite region splitting it into two equal segments (Figure 2a). The rationale for the proposed technique is that the created diagonal gap would enable, through its adhesion-free surfaces, each composite segment to undergo more lateral than axial shrinkage displacement, in contrast to the more lateral than axial shrinkage displacement which occurs in composite bulk when using bulk fill technique.

The outward displacement is expected to exert a lateral pull on each composite segment in opposite direction away from the gap center and towards the bonded cavity walls. The outward displacement of each segment in opposite direction is anticipated to greatly relieve the polymerization shrinkage stress and preserve the marginal and internal gap formation in cavity walls resulting in volume reduction of each segment and diagonal gap widening (Figure 2b).

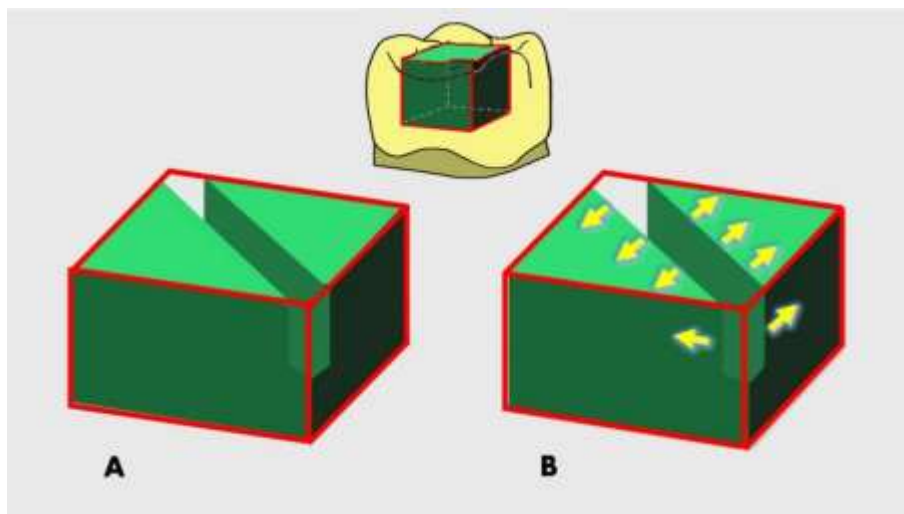


Figure 2: The proposed semi-split bulk filling technique using a single composite bulk; (a) Prior to light curing, a 2 mm deep diagonal gap created in composite bulk; (b) Upon light curing, each composite segment undergoes lateral shrinkage displacement from the gap center outwards, resulting in volume reduction of each segment and diagonal gap widening.

Furthermore, the created diagonal gap is expected to disable the less occurring axial displacement from gaining strength through bonding to enamel and dentin in the top composite region and exerting upward pull on the bottom composite region, preventing/minimizing its debonding away from the pulpal wall and forming a pulpal gap, in contrast to that which occurs in composite bulk when using bulk fill technique (Figure 3a). Following the light curing of the segmented composite bulk, the diagonal gap is filled with the same bulk-fill resin composite and light cured, (Figure 3b). Considering the small composite volume used for filling the diagonal gap, the generating shrinkage stress is judged to be unable to cause deleterious effects on tooth enamel, composite resin, and/or adhesive interfaces.

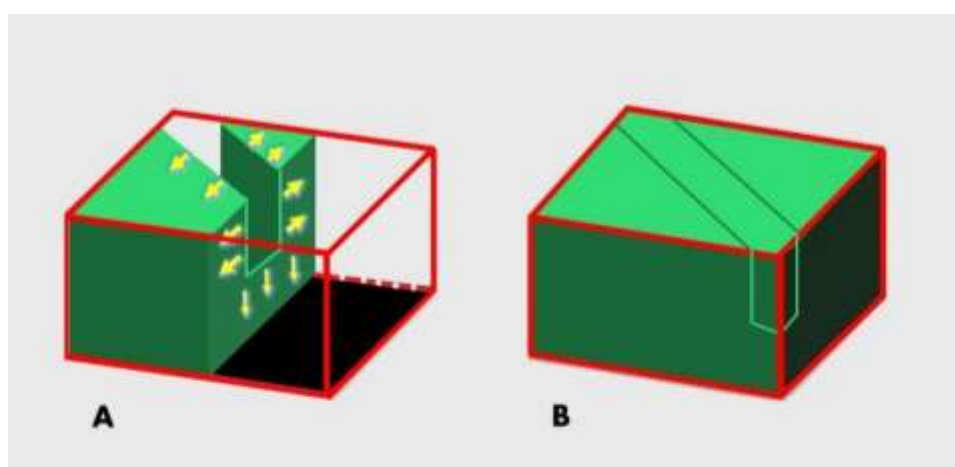


Figure 3: The proposed semi-split bulk filling technique; (a) A sectional view, illustrating more lateral than axial shrinkage displacement of the top composite, resulting in no gap formation at pulpal floor; (b) Diagonal gap filled with the same composite, and light cured.

There are variations in the number of diagonal gaps and depth between the proposed technique and the original split-increment technique. In the proposed technique, the gap extends halfway for a depth of 2 mm into the 4 mm thick composite bulk, whereas in the original split-increment technique [28], it extends into the full thickness of each of the 2 mm increments (Figure 4). In the proposed technique, the reason for not extending the gap into the full depth of 4 mm thick increment is that the diagonal splitting created in the top composite minimizes its axial displacement and greatly decreases the likelihood of exerting an upward pull on the bottom composite. As for the number of diagonal gaps, only one diagonal gap is created into the single composite bulk in the proposed technique, whereas two gaps are created in the original technique (Figure 4). The creation of two diagonal gaps in the proposed technique is considered unnecessary because of the generation of lower polymerization shrinkage stress in most bulk-fill composites, according to manufacturers, as compared to that developed in the conventional resin composites used in the original technique.

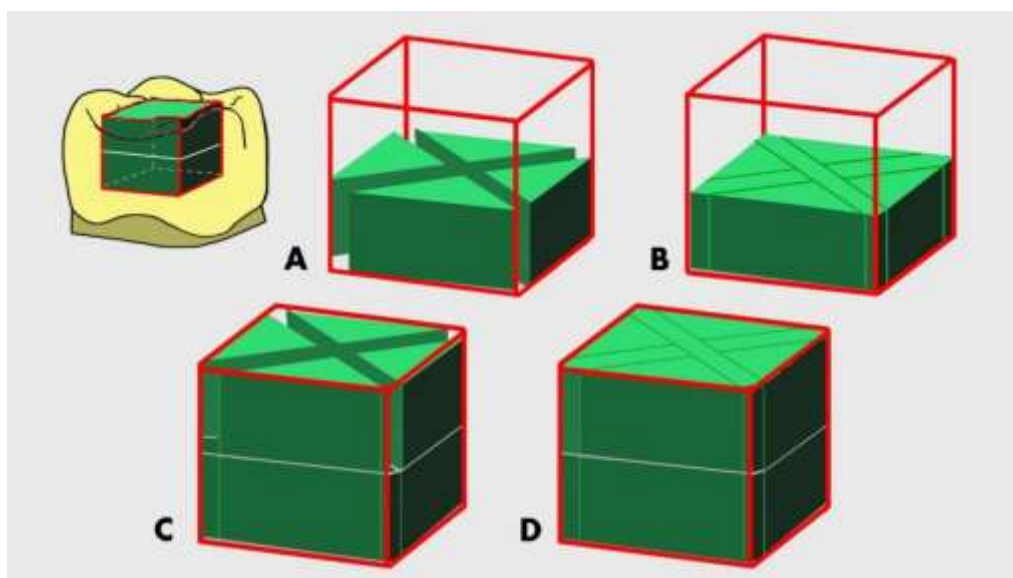


Figure 4: The original split-increment technique using two increments of conventional composite resin; (a) Prior to light curing, two diagonal gaps are created in first composite increment, and light cured; (b) Diagonal gaps filled using the same composite resin, and light cured; (c and d) Diagonal gaps in the second increment created and filled, as in the first increment.

Several studies reported that bulk-fill resin composites resulted in higher rates of postoperative sensitivity as compared to conventional composite resins and was attributed to pulpal gap formation beneath the composite restoration [15,29,30]. The pulpal gap formation is attributed to postoperative sensitivity which fills with dentinal fluid. This fluid undergoes contraction or expansion by cold or hot stimuli, resulting in its sudden movement in the dentinal tubules makes which makes postoperative sensitivity persistent and causes pain [29]. It has also been reported that bulk-fill flowable composites also resulted in gap formation over the internal walls of the restored cavities [30].

The restorative techniques, along with some other factors were reported to affect the shrinkage stress

generation, debonding, and postoperative tooth sensitivity, as well as microleakage, and secondary caries [1]. The original split-increment technique, as compared to the oblique layering technique, significantly minimized microleakage in Class V silorane-based resin composite restorations [31]. Also, it had the least microleakage at occlusal and gingival margins in Class II composite restorations, followed by centripetal and oblique techniques [32]. Moreover, the original technique exhibited lower degrees of microleakage at the occlusal and gingival margins of Class V, as compared to the oblique and occlusogingival incremental techniques. Furthermore, both techniques of the split-increment and the one using fiber inserts in gingival increment showed significantly lower microleakage at gingival margins in Class II restored with a nanocomposite resin, when compared to bulk insertion, oblique, centripetal, and flowable composite techniques [34].

Based on the results of the research studies conducted on the original split-increment technique, it is expected that the proposed semi-split bulk filling technique would be able to minimize the shrinkage stress and decrease the incidence of pulpal gap formation beneath the large occlusal bulk-fill resin composite restorations. A research study is currently underway to investigate the effect the proposed technique on reducing shrinkage stresses and pulpal gap formation in large occlusal bulk-fill resin composite restorations.

Summary

The use of the proposed semi-split bulk filling technique for restoring large occlusal bulk-fill resin composite restorations can minimize shrinkage stress and prevent or decrease the incidence of pulpal gap formation beneath the restoration. This would consequently result in fewer occurrences of persistent postoperative sensitivity and pain.

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