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Review Article

Three-Step Diagonal Gap Concept: A Shift in Semi-Split Bulk Filling Technique for Mitigating Shrinkage Stress and Marginal Gaps in Direct Bulk-Fill Resin Composite Restorations – An Overview

Khamis A Hassan[*1], Salwa E Khier[2]

[1]Professor and Senior Consultant of Restorative Dentistry, Global Dental Centre, Vancouver, British Columbia, Canada

[2]Professor and Senior Consultant of Dental Materials, Global Dental Centre, Vancouver, British Columbia, Canada

***Corresponding Author:**

Khamis Hassan, Professor and senior consultant of restorative dentistry, Global dental centre, Vancouver, BC, Canada.

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Abstract

The bulk-fill resin composites have several advantages, which include reduced chair time, better handling, and good mechanical properties and durability. However, these materials undergo shrinkage upon curing and polymerization. The generated stresses could lead to adhesive failures, microleakage, and secondary caries. The bulk-fill resin composites are routinely placed in prepared occlusal cavities using the bulk filling technique. This technique results in issues such as debonding, internal and marginal gap formation, and microleakage, as well as secondary caries, and post-operative sensitivity. A three-step diagonal gap concept is presented in the current paper as a shift in the original semi-split bulk filling technique for managing polymerization shrinkage stresses and marginal gaps in direct occlusal bulk-fill resin composite restorations.

Introduction

Resin composites are widely used in restorative dentistry for direct restoration of carious cavities and defects in teeth. These materials are composed of a resin matrix and filler particles [1,2]. The bulk-fill resin composites are a new class of materials that offer a more efficient way to restore deep cavities and save the chair time as they can be placed in a bulk of 4-5 mm [3]. Upon curing, these materials undergo polymerization shrinkage [4,5]. This shrinkage generates stresses that cause issues at the tooth-restoration interface; such as debonding, internal and marginal gap formation, and cuspal deflection, resulting in microleakage, secondary caries, and postoperative sensitivity as well as persistent pain [6-10].

The objective of this paper is to provide an overview of the three-step diagonal gap concept within the semi-split bulk filling technique, applied for direct placement of bulk-fill resin composites in deep occlusal cavities. In general, restoration of cavity preparation with composite resins starts by applying an adhesive system to all cavity walls and curing it. When using the traditional bulk filling

technique for restoring a deep occlusal cavity single mass (4 mm thickness) of bulk-fill resin composite is placed over the adhesive to fill the cavity, and is cured [3], as illustrated in Figure 1A**.** Whereas, when using the semi-split bulk filling technique for restoring a similar cavity preparation, a single mass of similar thickness of bulk-fill resin composite is placed over the adhesive to fill the cavity, but it is not cured at this stage, then, the three-step diagonal gap concept is followed to complete the restoration [11,12], as illustrated in Figure 1B.

The three-step diagonal gap concept constitutes an integral part of the semi-split bulk filling technique. It consists of the following three steps, as illustrated in Figure 2: (1) Gap creation in uncured composite and initial curing, (2) Gap closure delay for 5 minutes, and (3) Gap closure with same composite and final curing [11,12].

Following the application of adhesive system and curing it, a single mass of bulk fill resin composite is placed to fill the cavity, ***but*** not cured, (Figure 2A). Then, the three-step diagonal gap concept of the original semi-split bulk filling technique is followed to modify the composite mass, as illustrated in Figure 2B-2D, and presented in Table 1.

The rationale of the 3-step diagonal gap approach is to manage polymerization shrinkage stress effectively. The gap in this approach serves as a critical stress-relief mechanism, allowing the composite to shrink independently on either side during polymerization. By allowing each composite segment to independent shrink, the material deforms outward toward the bonded cavity walls, rather than pulling away from the adhesive interface. This reduces the overall stress concentration at the adhesive interface reducing, helping prevention of issues like marginal gaps, microleakage, and bond failure, as well as cuspal deflection. This approach improves marginal sealing, preserves tooth/restoration integrity, and helps prevent postoperative sensitivity, microleakage, secondary caries and persistent tooth pain. Excessive shrinkage stress in deep or large cavities can cause cracks in enamel or even pull cusps inward resulting in cuspal deflection [11,12].

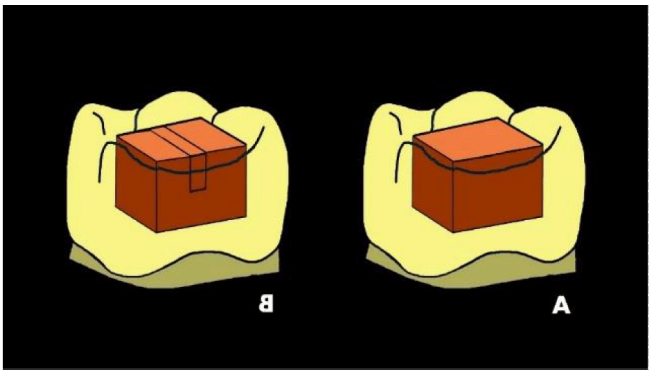

Figure 1: A large occlusal cavity preparation in a molar tooth restored utilizing: (A) the traditional bulk filling technique, and (B) the semi-split bulk filling technique, using the three-step diagonal gap concept.

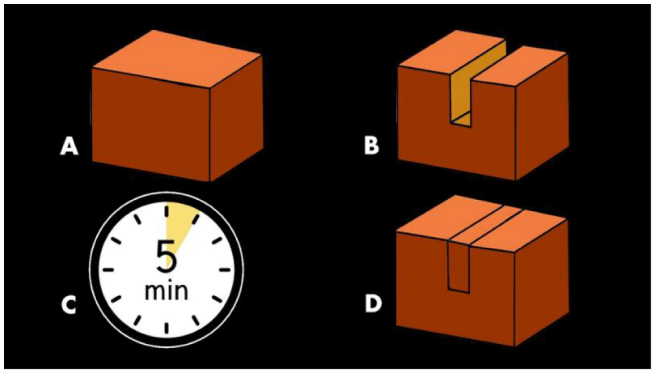

Figure 2: Close-up view of a large occlusal composite restoration made using the semi-split bulk filling technique, and following the three-step diagonal gap concept. (A) The uncured composite mass. (B) The gap created in uncured composite, followed by initial curing. (C) Delay of gap closure for 5 minutes. (D) The gap closed the with same composite, followed by final curing.

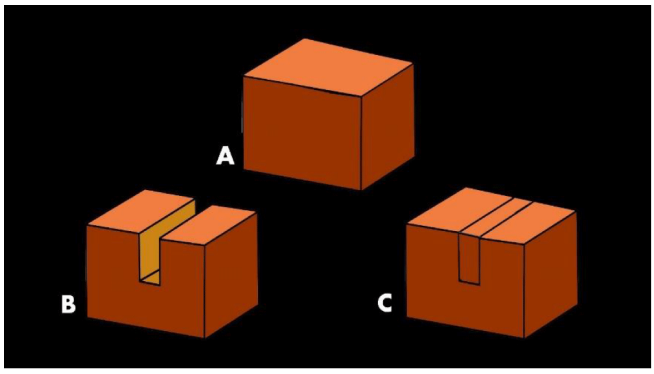

Figure 3: Close-up view of a large occlusal composite restoration made using the two-step diagonal gap of the original semi-split bulk filling technique. (A) The uncured composite mass. (B) The gap created in uncured composite, followed by initial curing. (C) The gap immediately closed with same composite, which is followed immediately by final curing. No waiting periods.

It is essential to note that the original semi-split bulk filling technique consists of only the following two steps: (1) Gap creation in uncured composite and initial curing, and (2) Immediately, the gap is closed with same composite, and light curing for 20-40 seconds is performed. In the original technique, there is no waiting for 5 minutes, as illustrated in Figure 3. The immediate gap closure offers quicker results at the expense of possible challenges with polymerization. It could result in more shrinkage stress within the composite mass during the curing process, and

Table 1: Description and purpose of each of the three steps of the diagonal gap concept within the semi-split bulk filling technique.

Step	Description	Purpose
Step 1. Diagonal Gap Creation & Initial Curing (Figure 2B)	- Use Teflon-coated, flat-bladed plastic filling hand instrument in a push stroke to intentionally create a 1.5 mm wide gap by removing material from the uncured composite mass. - Gap runs along a diagonal of restoration surface, and extends only halfway through the 4 mm thickness of the composite mass, (i.e. for 2 mm depth). - This way, gap does not fully divide the composite mass into two separate segments; instead, the bottom half remains connected. - Cure initially for 10-20 seconds.	Controls shrinkage stress by separating the composite into two triangular shaped segments. Generates shrinkage stresses in a controlled manner, reducing internal stress buildup.
Step 2. Delayed Gap Closure (Figure 2C)	Wait 5 minutes before sealing the gap.	Allows for more independent shrinkage and stress dissipation, preventing debonding, marginal gap formation and cuspal deflection.
Step 3. Gap Closure & Final Curing (Figure 2D)	Fill the gap with more of the same composite and cure finally for 20-40 seconds.	Ensures complete polymerization, improving restoration strength and stability.

lead to potential issues with polymerization shrinkage and stress, which could affect the longevity of the restoration [13-16].

Conclusion

The current paper addresses the common problems associated with bulk-fill resin composite restorations by using a controlled three-step diagonal gap approach as an integral part of the semi-split bulk filling technique for managing shrinkage stress and improving the durability of the restoration. This approach helps to create a more stable, long-lasting bond between the restoration and the tooth, resulting in fewer complications such as debonding, marginal gaps, postoperative sensitivity, and secondary caries.

Acknowledgments

None.

Conflicts of Interest

None.

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