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Review Article

# Diagonal gap in semi-split bulk filling: crucial key to minimizing external restraint and allowing favorable unrestrained shrinkage in large posterior bulk-fill resin composite restorations

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## Abstract

When a single bulk-fill resin composite mass is placed in a large occlusal cavity using the conventional bulk filling technique, the surrounding cavity walls around the composite mass act as external restraint, resulting in restrained shrinkage. This paper addresses the diagonal gap in semi-split bulk filling as a crucial key to minimizing external restraint and allowing favorable unrestrained shrinkage in large posterior bulk-fill resin composite restorations. The unrestrained shrinkage results in minimal stress, and prevents internal debonding, marginal gap formation, and cuspal deflection, as well as enamel micro-cracking.

**Keywords:** Bulk composite; Delayed closure; Diagonal gap; Direct posterior restoration; External restraint; Occlusal cavity; Restrained shrinkage; Segment; Semi-split; Unrestrained shrinkage

## Introduction

Posterior bulk-fill resin composite restorations have gained popularity in the past few decades. Composite resin materials, in general, undergo shrinkage during polymerization, resulting in shrinkage stress generation at the composite-tooth interface.[1,2] Shrinkage is the reduction in volume of a material, while shrinkage stress is the force that results from that shrinkage. Both are outcomes of the polymerization process that occur when a resin monomer is converted into a resin polymer, and can drastically impact the success of the final restoration.[3,4] Composite resins harden when they polymerize. During polymerization, the monomer molecules within the composite material come closer together as they form covalent bonds, replacing weaker van der Waals forces, and resulting in a smaller volume or shrinkage. In general, when composite is cured, it undergoes polymerization where the monomer molecules, that occupy more space due to their looser arrangement, are converted into tightly packed polymer chains, resulting in composite volume reduction.[5]

In a prepared cavity where composite is bonded to its walls, polymerization of composite creates a highly restrained situation, where the polymerizing composite attempts to decrease its volume. Failing to reduce its volume causes complications; such as internal debonding, marginal gaps at the tooth-composite interface, post-operative sensitivity, and secondary caries, as well as potential stress on the tooth structure due to the forces generated by the shrinking material.[6] The bulk fill resin composites were introduced in the dental market in the last few decades. There has been an increased demand by dentists and dental patients for using these materials for direct restoration of posterior teeth. This is because of easy handling and placement, decreased chair-side time, improved depth of cure, and enhanced esthetic and mechanical properties.[7]

Restoration of deep posterior cavities with bulk-fill resin composites are accomplished using a single mass up to 4–5mm thick using the conventional bulk filling technique. These materials can simplify and speed up the process of restoring deep cavities. They are more translucent than conventional resins, that allows light to penetrate deeper and cure more efficiently. These materials contain chemical groups that reduce the stress caused by polymerization shrinkage.[8-10] The current paper addresses the diagonal gap in semi-split bulk filling technique as crucial key to minimizing the external restraint, and allowing favorable unrestrained shrinkage in large posterior bulk-fill resin composite restorations.

## The conventional bulk filling technique

Figure 1 illustrates the conventional bulk filling technique. Following the application and curing of the adhesive system on all prepared cavity walls and margins, the conventional bulk filling technique is used to routinely place a 4mm thick single mass of bulk fill resin composite in a large occlusal cavity, and is immediately light cured.[11]

Polymerization of the cured composite mass results in connecting (bonding) the composite with the four surrounding cavity walls and floor. This connection may hold back the polymerizing composite mass from decreasing in size, upon shrinking. It is reasonable to refer to the four surrounding cavity walls and floor as “external restraint”. It is thought that the external restraint can prevent the polymerizing composite from moving freely, and reduce its volume. This type of shrinkage is referred to as “restrained” shrinkage, which can develop tensile stress that causes non-uniform strain distributions in the composite mass and at the interface. If the tensile stress exceeds the tooth-composite interfacial bond strength, it results in movement of the polymerizing composite mass in a direction away from the adjacent cavity wall, towards the restoration center, and leads to negative clinical consequences, such as internal/marginal debonding, cuspal deflection and enamel micro-cracking. These negative consequences can lead to accelerated deterioration of composite restoration and reduce its longevity.[12,13]

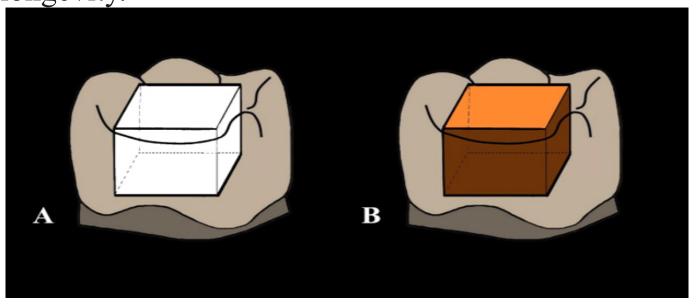


**Figure 1** The conventional bulk filling technique. A: A large occlusal cavity preparation in a mandibular molar; B: A single mass of bulk-fill resin composite, placed directly in the prepared cavity and followed immediately by light curing.

It is reasonable to hypothesize that the degree of external restraint could be influenced by the size and shape of a composite restoration, as well as the stiffness of the surrounding cavity walls. It is further reasonable to assume that if the cavity walls are too rigid, they can restrict the natural shrinkage of a composite mass as it hardens, and that this could potentially cause internal stresses in the composite and at the tooth-composite interface, leading to negative clinical consequences. It is believed that the external restraint can be minimized by physically separating the opposing buccal and lingual cavity walls during polymerization, and that this separation can be achieved by a temporary cut in the uncured composite mass. This cut divides the top half of the uncured composite mass into two segments, where each segment is connected to either the buccal or the lingual wall in addition to the adjacent proximal wall. The physical composite mass segmentation provides, upon light exposure, a suitable condition for favorable unrestrained shrinkage to occur, where each composite segment is allowed to shrink and move freely. This movement occurs in an outward direction from the gap center towards the adjacent interface, resulting in better adaptation of composite to cavity walls and margins, and leading to preservation of the marginal integrity of the restoration and the restored tooth. "The temporary cut made to reduce external restraint corresponds to the "diagonal gap" in the semi-split bulk filling technique.

## The semi-split bulk filling technique

Figure 2 illustrates the semi-split bulk filling technique. In this technique, the diagonal gap constitutes an integral part, and is created intentionally in an uncured single mass of bulk-fill resin composite, using a flat bladed plastic filling hand instrument with a rounded tip, in a push stroke. This gap is 1.5mm wide and runs diagonally on the composite surface, extending into the composite mass for a depth of 2mm. The created gap divides the top half of the composite mass into two separated segments, where each segment is bonded to either the buccal or the lingual wall in addition to the adjacent proximal wall. The segmented composite is then light cured for the first time.[14–17] Then, closure of this gap is delayed for a period of 5 minutes.[18] During the delay period of gap closure, the segmented composite hardens and undergoes polymerization, where favorable unrestrained shrinkage is generated. As mentioned earlier, each polymerizing composite segment is allowed to undergo free movement from the gap center towards the adjacent cavity wall, resulting in better adaptation of composite to cavity walls and margins, and leading to preservation of marginal integrity of the restoration and the restored tooth, with absence or fewer occurrences of postoperative sensitivity and pain.[15,16] Following the 5-minute delay period, the restoration is completed by closing the gap with the same composite and curing it for the second time.[18,19]

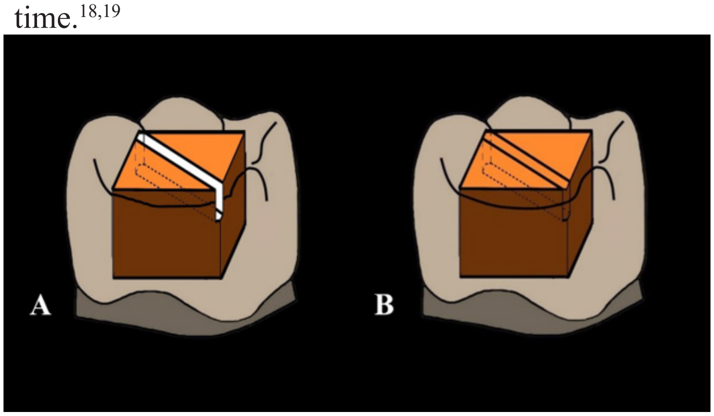


**Figure 2** The semi-split bulk filling technique. A: A created diagonal gap in un-cured single mass of bulk-fill resin composite placed in large occlusal cavity, followed by light exposure for the first. The gap is left open (unfilled) for a period of 5 minutes; B: Following the 5-minute delay period, the diagonal gap is closed (filled) with the same composite and cured for the second time.

## Conclusions

The diagonal gap in the semi-split bulk filling technique can be considered as a crucial key to minimizing external restraint, and allowing favorable unrestrained shrinkage in large posterior bulk-fill resin composite restorations.

## Acknowledgments

None.

## Conflicts of interest

Authors declare that there is no conflict of interest.

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