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Review Article

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The Diagonal Gap: Characteristics, Benefits of its Delayed Closure and Effects on Large Posterior Bulk-Fill Resin Composite Restorations - A Review

Khamis A Hassan[1*] and 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 A Hassan, Professor of Restorative Dentistry, Global Dental Center, Vancouver, British Columbia, Canada.

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ABSTRACT
The semi-split-bulk filling technique provides a simplified technique for restoring large cavities in posterior teeth with bulk-fill resin composites. A diagonal gap is created temporarily into the uncured single composite mass, dividing into two separated segments, and followed by light curing for the first time. The gap is left open (or unfilled) for 5 minutes, following the first cure. During which, each segment is allowed to shrink independently, undergoing outward deformation from the gap center towards the adjacent bonded cavity walls, resulting in relief of the shrinkage stress at the adhesive interface. This improves marginal sealing, and preserves the tooth/restoration integrity. At the end of the 5-minute delay period of gap closure, the restoration is completed by closing the gap with the same composite and light curing it for the second time. This technique can be useful for dental clinicians to provide high-quality posterior composite restorations with fewer occurrences of postoperative sensitivity and pain.

Keywords: Bulk Composite, Delayed Closure, Diagonal Gap, Direct Restoration, 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].

The polymerization shrinkage stress in resin composite materials increases up to 12 hours after irradiation, and the post-curing polymerization process continues for up to 24 hours. Interfacial stress and elastic modulus of the composites demonstrated the average increases of 155% and 14%, respectively, from 30 minutes to 24 hours after irradiation [3].

Post-curing polymerization is the process by which dental composite resins continue to polymerize for up to 24 hours after initial light exposure. Post-curing polymerization can continue for hours or even days after exposure. The extent of polymerization depends on the exposure time and the time that passes after exposure. The polymerization process is most intense a few minutes after the light is applied [4].

Several factors can affect post-curing polymerization, which include exposure time, post-exposure time, and composite chemical composition, as well as composite thickness, light type used to cure composite, and distance between the light source and composite [5].

During the 5-minute period after photo-polymerization, the stress level in composite resin increases significantly, and. The stress generated can lead to clinical consequences like enamel cracks, cusp deflection, and decreased bond strength. Among the several factors that affect polymerization shrinkage stress is the delay time (i.e. waiting) for a few minutes before light activation which can reduce shrinkage stress and improve bond strength [6].

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 occurs

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when a resin monomer is converted into a resin polymer, and can drastically impact the success of the final restoration [7-9].

Shrinkage is an inevitable part of the polymerization process that occurs in composite resins. During polymerization, the simple molecules “i.e. monomers” combine to form larger, more complex molecules “i.e. polymers”, and the distance between monomers is reduced, and results in a change in density and a decrease in volume [10].

Shrinkage stress is generated when composite resins undergo polymerization shrinkage. Upon shrinkage in a cavity, the polymerized composite gets smaller and struggles to take up less space. However, being bonded to the surrounding cavity walls, the generated stress increases and puts pressure on the adhesive and surrounding tooth structure. If this pressure exceeds the adhesive bond, or the strength of either the composite or tooth, it causes several undesired clinical consequences in the final restoration/restored tooth, such as debonding that results in internal or marginal gaps, enamel cracks, and cuspal deflection, as well as microleakage, secondary caries, and postoperative sensitivity [11-13].

Restoration of deep posterior cavities with bulk-fill resin composites are accomplished using a single mass up to 4-5 mm 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 [14-17].

Restoration of deep posterior cavities with bulk-fill resin composites can be accomplished using the conventional bulk filling technique and the semi-split bulk filling technique [18-23].

The current paper provides a review on the diagonal gap that constitutes an integral part of the semi-split bulk filling technique. This paper focusses on the gap’s characteristics, benefits of its delayed closure, and effects on the large posterior bulk-fill resin composite restoration placed using this technique.

The Conventional Bulk Filling Technique

This technique is used for placing bulk-fill resin composite into a large posterior cavity [18]. Upon curing, the composite mass hardens, and undergoes polymerization, resulting in restrained shrinkage where the composite mass is prevented from moving freely and changing its volume, this restrained shrinkage is caused due to bonding of the polymerizing composite mass to the surrounding cavity walls. This results in building up of tensile stress, which results in non-uniform shrinkage strain distributed in the composite mass and at the tooth-composite interface. This developed tensile stress can form marginal gaps if it exceeds the interfacial bond strength, which can reduce the durability and longevity of the restored tooth and restoration. [24,25].

The Semi-Split Bulk Filling Technique

The use of the semi-split bulk filling technique can mitigate the restrained shrinkage and its deleterious effects that occur when using the conventional bulk filling technique for placing large posterior bulk-fill resin composite restorations.

Figure 1: Bulk-fill resin composite restoration placed in large occlusal cavity using the conventional bulk filling technique, followed by immediate light curing.

The diagonal gap constitutes an integral part of the semi-split bulk filling technique. This gap is a temporary cut created intentionally in the single composite mass before light curing, by using a rounded tip flat bladed plastic filling hand instrument in a push stroke. This gap is 1.5 mm wide and runs diagonally on the composite surface, extending into the composite mass for a depth of 2 mm. The created gap divides the top half of the composite mass into two separated segments, where each segment is bonded to the adjacent cavity wall only. The segmented composite is then light cured for the first time [20-23]. Closure of the diagonal gap is delayed for a period of 5 minutes, following the first light cure [26].

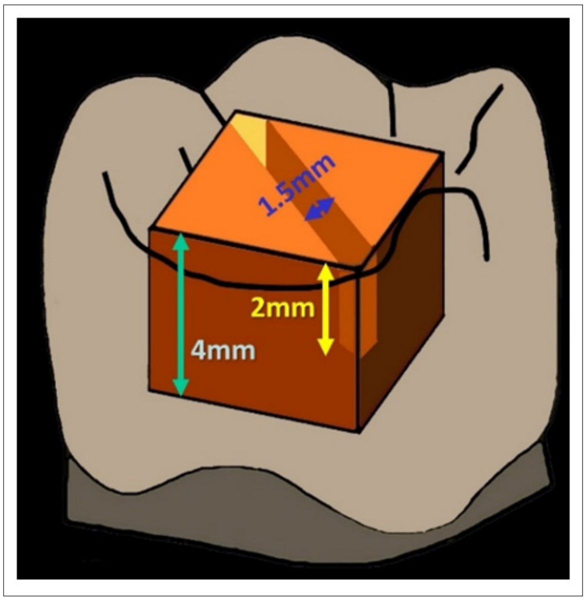

Figure 2: A diagonal gap (1.5 mm wide and 2 mm deep) divides the top half of the uncured single mass (4 mm) into two segments, followed by the first light curing. The gap is left open for 5 minutes, following this curing.

Splitting the top half of the uncured composite mass creates two segments separated by the diagonal gap. This separation allows each segment to be bonded only to the adjacent cavity wall. In the semi-split bulk filling technique, the created gap divides the top half of the composite mass into two separated segments, where each segment is bonded only to the adjacent cavity wall. Upon light curing for the first time, the segmented composite hardens and undergoes polymerization. Unrestrained shrinkage is generated, where the polymerizing composite mass is not prevented from free displacement and changing its volume, resulting in the development of unrestrained shrinkage stress. The unrestrained, free displacement allows each composite segment to freely move from the gap center towards the adjacent cavity wall. This results in better adaptation of composite to cavity walls, and leads to preservation of marginal integrity of the restoration and the restored tooth with absence or fewer occurrences of postoperative sensitivity and pain [20-22]. The restoration is completed at the end of the 5-minute delay period by closing the gap with the same composite and curing it for the second time [26].

It is worth noting that this technique was originally proposed and used for restoring deep Class I cavities with bulk-fill resin composites. It prevents internal debonding and gap formation at the deep pulpal floor, resulting in absence or fewer occurrences of postoperative sensitivity and pain [19].

Figure 3: Closure of the diagonal gap with the same bulk-fill resin composite, followed by light curing for the second time

A research study investigated the microleakage associated with large occlusal bulk-fill resin composite restoration placed using the semi-split bulk filling technique, where the diagonal gap was closed immediately after the first light curing. It is worth noting that this study reported that the marginal microleakage and microleakage on the pulpal floor were effectively reduced, as compared to the conventional bulk filling technique [27]. This implies that the immediate closure of the diagonal gap, following the light curing was effective in reducing the shrinkage stress.

Conclusions

The semi-split bulk filling technique is used for restoring posterior teeth with a 4-5 mm thick single mass of bulk-fill resin composite. The diagonal gap constitutes the core of this technique. It is a temporary cut created in the top half of uncured composite mass. The gap is left open for 5 minutes, following the first light curing to allow a significant part of shrinkage to take place without inducing harmful stress. Following a delay period of 5 minutes, the composite segments are connected by closing the gap with the same composite and curing it for the second time. The diagonal gap improves the adaptation of composite to bonded cavity walls, resulting in higher stress reduction and preservation of marginal and tooth integrity.

References

1. Walls AW, McCabe JF, Murray JJ. The polymerization contraction of visible-activated composite resin. J Dent. 1988. 16: 177-181.
2. Hegdahl T, Gjerdet N. Contraction stresses of composite resin filling materials. Acta Odontol Scand. 1977. 35: 191-195.
3. Yamamoto T, Hanabusa M, Momoi Y, Sakaguchi RL. Polymerization Stress of Dental Resin Composite Continues to Develop 12 Hours after Irradiation. J Esthet Restor Dent. 2014. 27: 44-54.
4. Kaviani A, Goudarzi P. Effect of Shade on Immediate and Post-Curing Polymerization Shrinkage of Composite Resin. J Iran Dent Assoc. 2022. 34: 27-35.
5. Leung RL, Fan PL, Johnston WM. Post-irradiation Polymerization of Visible Light-activated Composite Resin. J Dent Res. 1983. 62: 363-365.
6. Cunha LG, Alonso RCB, Souza Junior EJC, Neves ACE, Sobrinho LC, et al. Influence of the curing method on the post-polymerization shrinkage stress of a composite resin. J Appl Oral Sci. 2008. 16: 266-270.
7. Marovic D, Tauböck TT, Attin T, Panduric V, Tarle Z. Monomer conversion and shrinkage force kinetics of low-viscosity bulk-fill resin composites. Acta Odontol Scand. 2015. 73: 474-480.
8. Benetti AR, Havndrup-Pedersen C, Honoré D, Pedersen MK, Pallesen U. Bulk-fill resin composites: polymerization contraction, depth of cure, and gap formation. Oper Dent. 2015. 40: 190-200.
9. Nascimento AS, Lima DB, Fook MVL, Albuquerque MS, Lima EA, et al. Physicomechanical characterization and biological evaluation of bulk-fill composite resin. Braz Oral Res. 2018. 32: e107.
10. Pereira RA, Araujo PA, Castañeda-Espinosa JC, Mondelli RF. Comparative analysis of the shrinkage stress of composite resins. J Appl Oral Sci. 2008. 16: 30-34.
11. Soares CJ, Faria-E-Silva AL, Rodrigues MP, Vilela ABF, Pfeifer CS, et al. Polymerization shrinkage stress of composite resins and resin cements - What do we need to know?. Braz Oral Res. 2017. 31: e62.
12. Alomari QD, Barrieshi-Nusair K, Ali M. Effect of C-factor and LED Curing Mode on Microleakage of Class V Resin Composite Restorations. European J Dent. 2011. 5: 400-408.
13. Malhotra NMK, Acharya S. Strategies to Overcome Polymerization Shrinkage − Materials and Techniques. A Review. Dent Update. 2010. 37: 115-125.

14. Arbildo-Vega HI, Lapinska B, Panda S, Lamas-Lara C, Khan AS, et al. Clinical Effectiveness of Bulk-Fill and Conventional Resin Composite Restorations: Systematic Review and Meta-Analysis. Polymers. 2020. 12: 1786.
15. Ilie N, Bucuta S, Draenert M. Bulk-fill resin- based composites: an in vitro assessment of their mechanical performance. Oper Dent. 2013. 38: 618-625.
16. Ilie N, Fleming GJ. In vitro comparison of polymerisation kinetics and the micro-mechanical properties of low and high viscosity giomers and RBC materials. J Dent. 2015. 43: 814-822.
17. Yu P, Yap A, Wang XY. Degree of Conversion and Polymerization Shrinkage of Bulk-Fill Resin-Based Composites. Oper Dent. 2017. 42: 82-89.
18. Monteiro RV, Taguchi CMC, Machado RG, Silva SB, Bernardon JK, et al. Bulk-Fill Composite Restorations Step-by-Step Description of Clinical Restorative Techniques Case Reports. Odovtos Int J Dent Sci. 2019. 21: 23-31.
19. Hassan KA, Khier SE. Semi-split bulk filling technique in large occlusal bulk-fill resin composite restorations. J Oral Med and Dent Res. 2021. 2: 1-9.
20. Hassan KA, Khier SE. Semi-split bulk filling technique: a key to achieve occlusal bulk-fill resin composite restorations free of postoperative sensitivity and pain. J Clin Res Dent. 2021. 4: 1-3.
21. Hassan KA, Khier SE. Direct bulk-fill resin composite restorations: characterization of pulpal floor gaps in deep occlusal cavities and current restorative minimization strategies - An overview. Saudi J Oral Sciences. 2023. 10: 59-65.
22. Hassan KA, Khier SE. Gap-Modified Bulk Placement Technique For Reducing Shrinkage Stresses In Direct Occlusal Bulk Fill Resin Composite Restorations- J Oral Dent Health Res. 2023. 5: 162-166.
23. Hassan KA, Khier SE. Direct bulk-fill resin composite restorations: Characterization of pulpal floor gaps in deep occlusal cavities and current restorative minimization strategies - An overview. Saudi J Oral Sci. 2023. 10: 59-65.
24. Han SH, Park SH. Incremental and Bulk-fill Techniques With Bulk-fill Resin Composite in Different Cavity Configurations. Oper Dent. 2018. 43: 631-641.
25. Van Ende A, De Munck J, Lise DP, Van Meerbeek B. Bulk-Fill Composites: A Review of the Current Literature. J Adhes Dent. 2017.19: 95-109.
26. Hassan KA, Khier SE. Delayed Closure Of Diagonal Gap In Semi-Split Bulk Filling Technique: A Simple Innovative Modification For Maximum Reduction Of Lateral Shrinkage Stress In Direct Occlusal Bulk-Fill Resin Composite Restorations. Dentistry and Oral Health Care.
27. Patel D, Khunt A, Somani M, Kinariwala N, Joshi C, et al. Comparative evaluation of microleakage between novel semi-split and bulk filling technique using two different generations of the adhesive system: an in vitro study. NeuroQuantology. 2022. 20: 1480-1489.