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Opinion Article

Exploiting the Viscoelastic Stress Relaxation Window of Bulk-Fill Resin Composites: A Conceptual Hypothesis Based on a Semi-Split Delayed Gap Closure Strategy

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ABSTRACT

This manuscript proposes and biologically rationalizes a novel conceptual hypothesis; "the Semi-Split Delayed Gap Closure (SS-DGC) technique" suggesting that temporary internal segmentation and delayed structural consolidation of bulk-fill resin composites can significantly reduce polymerization shrinkage stress by exploiting the viscoelastic stress relaxation window during early polymerization. This hypothesis introduces a temporary, non-interfacial semi-split diagonal gap within a bulk-fill composite mass, combined with low-irradiance primary curing and delayed gap closure. It reduces effective constraint, delays elastic modulus development, and allows internal stress redistribution prior to final polymerization, thereby reducing interfacial stress concentration. This hypothesis, if validated, may provide a new paradigm for polymerization stress management that preserves the clinical efficiency of bulk-fill resin composites while improving marginal integrity and restoration longevity.

Keywords: Bulk-fill resin composites, Viscoelastic stress relaxation, Polymerization shrinkage stress, Stress relaxation window, Delayed gap closure, Marginal adaptation.

1. Introduction

Although significant progress has been made in resin composite formulations, polymerization shrinkage stress continues to be a major factor affecting the durability of direct posterior restorations (1-3). Bulk-fill resin composites were developed to streamline clinical procedures and shorten chairside time by allowing placement in thicker layers while still ensuring sufficient depth of cure (4,5). Nevertheless, available evidence suggests that shrinkage stress is diminished, but not completely eliminated, particularly in cavities with high configuration factors (C-factor) (6-8).

The development of polymerization stress is a complex and dynamic phenomenon influenced not only by volumetric contraction, but also by the time-dependent viscoelastic behavior of the material during curing. Strategies including incremental placement, soft-start polymerization, and pulse-delay curing have been proposed to modulate these factors; however, such approaches may increase procedural complexity or compromise clinical efficiency (10-12).

The present manuscript advances a conceptual hypothesis based on the semi-split delayed gap closure (SS-DGC) strategy. It postulates that polymerization stress in bulk-fill composites might be further mitigated by temporarily reducing internal constraint within the material mass and intentionally utilizing the viscoelastic stress-relaxation phase prior to final network stabilization.

1.1 Polymerization Stress and Viscoelasticity

Polymerization stress occurs as a resin composite changes from a soft, moldable state into a hard, interconnected network. Before gelation, contraction can be partially accommodated through viscous flow. Following gelation, the progressive increase in elastic modulus restricts flow, resulting in the conversion of shrinkage strain into interfacial stress (9,13).

Bulk-fill composites are formulated with stress-modifying monomers, polymerization modulators, and in some cases reduced filler content to extend the pre-gel phase and attenuate stress development (5,14). However, in restorations characterized by a high bonded surface area, even limited volumetric contraction may produce stresses of potential clinical significance (6,15).

Importantly, resin composites may continue to demonstrate measurable viscoelastic stress relaxation for several minutes following light activation, particularly under conditions of reduced polymerization rate and moderated early stiffness development (16,17). This time-dependent response may represent a clinically underexplored opportunity for stress modulation.

2. Conceptual Hypothesis

2.1 Central Hypothesis

It is hypothesized that polymerization shrinkage stress in bulk-fill resin composites could potentially be reduced by temporarily introducing a non-interfacial internal discontinuity (semi-split diagonal gap) within the composite mass and postponing its closure. Such an approach may permit stress relaxation to occur before final polymer network consolidation.

2.2 Mechanistic Assumptions

The proposed hypothesis is founded on the following theoretical assumptions (18–21):

1. Temporary Internal Segmentation May Reduce Constraint: The diagonal gap may function as a transient “free surface,” allowing the material to contract toward the discontinuity rather than transmitting contraction forces exclusively to cavity walls. Introducing a semi-split diagonal gap could decrease internal constraint within the composite mass without disrupting the bonded interface, thereby potentially lowering early-stage stress development. A proposed gap depth of approximately 2 mm would theoretically preserve the integrity of the underlying composite layer while relieving tensile stress in the occlusal portion, where configuration factor (C-factor) effects are expected to be greatest.

2. Low-Irradiance Primary Cure May Preserve Viscoelastic Flow: Reduced light intensity may delay rapid elastic modulus development, thereby extending the time interval during which viscoelastic stress relaxation can occur.

3. Delayed Gap Closure May Facilitate Stress Redistribution: Maintaining the gap for approximately 5 minutes during the early post-gel phase could allow internal molecular rearrangement and redistribution of shrinkage strain prior to final structural consolidation.

4. Final Gap Closure May Restore Structural Continuity: Subsequent filling of the gap followed by higher-intensity curing would be expected to complete polymerization while minimizing reintroduction of early-stage stress concentration.

2.3 Proposed Semi-Split Delayed Gap Closure Model (22,23)

The proposed model involves the following conceptual sequence (Figure 1):

1. Placement of a single bulk-fill resin composite increment (4 mm thick) to fill the prepared cavity.
2. A temporary diagonal gap, around 1.5 mm in width and 2 mm in depth, is prepared in the occlusal composite with a thin Teflon-coated hand instrument. The gap traverses the occlusal surface from one corner to the opposite and splits the mass into two semi-separated segments. Crucially, the gap must not disturb the interfacial adhesive layer, followed by low-irradiance primary polymerization to stabilize the segmented masses while the gap remains open.
3. A delayed gap closure for approximately 5 minutes as a defined stress relaxation period. This "Stress Relaxation Window" allows the composite to reach its "gel point" and dissipate initial shrinkage forces.
4. Gap closure with the original composite material and high-intensity final curing over the entire restoration, including the newly filled gap.

The diagonal orientation of the gap is hypothesized to promote multidirectional stress redistribution rather than localized stress release along a single plane.

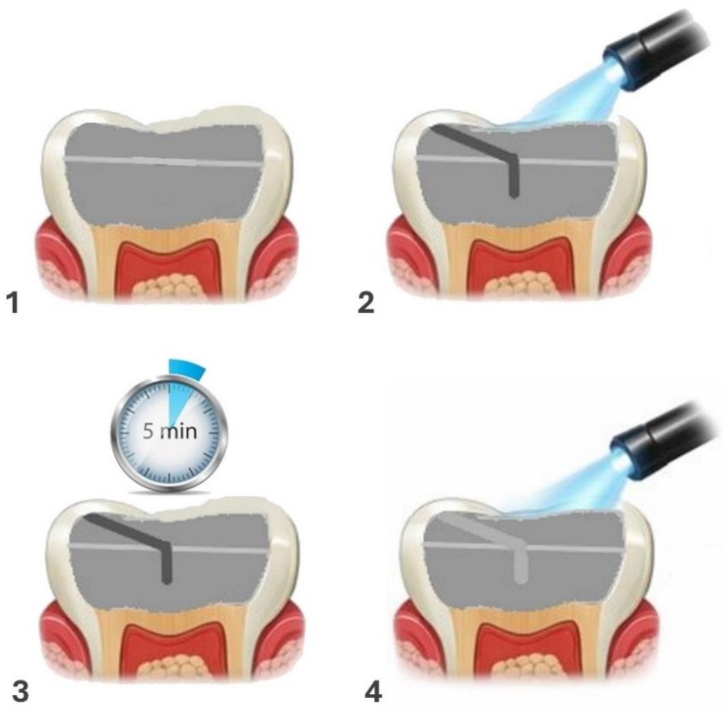

Figure 1: Semi-split delayed gap closure model. **Step 1**: Place a 4-mm thick bulk-fill resin composite in the cavity. **Step 2**: Create a temporary diagonal gap approximately 1.5 mm in width and 2 mm in depth in the occlusal portion with a thin Teflon-coated hand instrument, and perform low-intensity light curing. **Step 3**: Leave the gap unfilled for 5 minutes for stress relaxation. **Step 4**: The gap is restored with the original composite and fully polymerized with high-intensity light.

2.3.1 Testable Predictions

This hypothesis generates several testable predictions:

- Polymerization shrinkage stress measured at the adhesive interface will be lower compared with that of the conventional bulk filling curing.
- Cuspal deflection in high C-factor cavities will be reduced.
- Marginal gap formation and microleakage will be decreased.
- Degree of conversion will not be compromised when appropriate curing protocols are followed.

3. Discussion

The semi-split delayed gap closure (SS-DGC) technique represents a novel conceptual approach for mitigating polymerization shrinkage stress in bulk-fill resin composites. By introducing a temporary internal segmentation and delaying final gap closure, this strategy could exploit the viscoelastic stress relaxation window during early polymerization. Such deliberate modulation of the material’s flow and modulus development may allow internal stress redistribution before complete network consolidation, potentially reducing interfacial stress concentrations and cuspal deflection in high C-factor cavities.

It should be emphasized that the SS-DGC strategy is currently conceptual. No in vitro or clinical validation has been performed, and the anticipated mechanical and biological benefits remain speculative. These potential advantages require systematic evaluation in controlled laboratory and clinical studies.

From a clinical perspective, the SS-DGC technique could maintain the efficiency advantages of bulk-fill composites by avoiding complex incremental layering while simultaneously enhancing marginal adaptation and postoperative outcomes. If experimentally validated, this approach may provide a practical method for stress management without necessitating modifications to adhesive systems or composite formulations.

By combining mechanistic insight with clinically relevant objectives, the SS-DGC technique may offer a promising strategy for improving stress management in esthetic restorative dentistry.

3.1 Clinical Relevance

If validated, this conceptual approach could:

- Preserve the efficiency advantages of bulk-fill resin composites
- Reduce reliance on complex incremental layering
- Improve marginal integrity and postoperative comfort
- Be integrated into esthetic restorative workflows without altering materials or adhesive systems

3.2 Limitations and Considerations

As a conceptual hypothesis, this model currently lacks direct experimental validation. Variables, such as optimal gap dimensions, relaxation time, composite chemistry, and curing parameters, require systematic investigation. Improper execution may compromise restoration strength or anatomy.

3.3 Future Research Directions

Future research should systematically investigate these factors using in vitro and computational methods. Future studies should focus on:

- Strain gauge and finite element stress analysis.
- Evaluation of viscoelastic behavior during delayed consolidation.
- In vitro marginal integrity and fatigue resistance.
- Controlled clinical trials assessing postoperative sensitivity and restoration longevity.

4. Conclusions

This paper proposes a theoretical framework. Deliberately exploiting the viscoelastic stress relaxation window through temporary internal segmentation and delayed gap closure may reduce polymerization shrinkage stress in bulk-fill resin composites. If validated, this approach could introduce a new paradigm for stress management in esthetic restorative dentistry.

Conflict of Interests

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References

1. Ferracane JL. Resin composite: State-of-the-art. Dent Mater. 2011;27:29-38.
2. Braga RR, Ferracane JL. Alternatives in polymerization contraction stress management. Crit Rev Oral Biol Med. 2004;15:176-184.
3. Versluis A, Tantbirojn D, Douglas WH. Do dental composites always shrink toward the light?. J Dent Res. 1998;77:1435-1445.
4. Ilie N, Hickel R. Investigations on a methacrylate-based flowable composite based on the SDR™ technology. Dent Mater. 2011;27:348-355.
5. 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.
6. Feilzer AJ, De Gee AJ, Davidson CL. Setting stress in composite resin in relation to configuration of the restoration. J Dent Res. 1987;66:1636-1639.
7. Al Sunbul H, Silikas N, Watts DC. Polymerization shrinkage kinetics and shrinkage-stress in dental resin composites. Dent Mater. 2016;32:998-1006.
8. Yu P, Xu Y-X, Liu Y-S. Polymerization shrinkage and shrinkage stress of bulk-fill and non-bulk-fill resin-based composites. J Dent Sciences. 2022;17:1212-1216.
9. Davidson CL, Feilzer AJ. Polymerization shrinkage and polymerization shrinkage stress in polymer-based restoratives. J Dent. 1997;25:435-440.
10. Mehl A, Hickel R, Kunzelmann KH. Physical properties and gap formation of light-cured composites with and without 'softstart-polymerization'. J Dent. 1997;25:321-330.
11. Kanca J 3rd, Suh BI. Pulse activation: Reducing resin-based composite contraction stresses at the enamel cavosurface margins. Am J Dent. 1999;12:107-112.
12. Watts DC, Alnazzawi A. Temperature-dependent polymerization shrinkage stress kinetics of resin composites. Dent Mater. 2014;30:654-660.
13. Watts DC, Cash AJ. Determination of polymerization shrinkage kinetics in visible light-cured materials: Methods development. Dent Mater. 1991;7:281-287.
14. Tauböck TT, Tarle Z, Marovic D, Attin T. Pre-heating of high-viscosity bulk-fill resin composites: Effects on shrinkage force and monomer conversion. J Dent. 2015;43:1358-1364.

15. Braga RR, Ballester RY, Ferracane JL. Factors involved in the development of polymerization shrinkage stress in resin composites: A systematic review. Dent Mater. 2005;21:962-970.
16. Watts DC, Marouf AS, Al-Hindi AM. Photo-polymerization shrinkage-stress kinetics in resin composites: Methods development. Dent Mater. 2003;19:1-11.
17. Alnazzawi A, Watts DC. Simultaneous determination of polymerization shrinkage, exotherm and thermal expansion coefficient for dental resin-composites. Dent Mater. 2012;28:1240-1249.
18. 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.
19. 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.
20. Hassan KA, Khier SE. Delaying diagonal gap closure in semi-split bulk filling technique: A simple innovative modification for considerable reduction of shrinkage stress in direct occlusal composite restorations. Dent Oral Health Care 2025;4:1-5.
21. Hassan KA, Khier SE. The diagonal gap: Characteristics, benefits of its delayed closure and effects on large posterior bulk-fill resin composite restorations: A review. J Stoma Dent Res. 2025;3:1-4.
22. Hassan KA, Khier SE. Dark curing and early post-irradiation stress spike in light-cured composites: overlooked phenomena compromising freshly bonded interfaces in large restorations and leading to marginal gaps and cuspal deflection. J Oral Dent Health Res. 2025;7:192-195.