COMMENTARY

Polymerization Stress: Does It Really Impact the Longevity of Composite Restorations?

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Vast literature is available on the topic of polymerization shrinkage stress in dental composites.[1–4] As pointed out in the article "Management of Shrinkage Stress in Direct Restorative Light-cured Composites: A Review,"[5] stresses develop because of the confinement imposed to polymerization shrinkage by the bond to cavity walls.[6] Stress development is a function of the geometry of the cavity[7] and properties inherent to the material, such as conversion and elastic modulus.[3] This has led to the development of new materials[8] and polymerization techniques[9] to minimize the possible effects of stress on the bonded interface. It is important for anyone using these materials to understand the origin, potential ramifications, and methods to cope with these stresses, as discussed in the article. But although most of the stress generation mechanisms have been elucidated, and a good correlation has been established between stress and marginal gap formation in vitro,[10,11] clinical studies have failed to demonstrate the influence of polymerization stress on the longevity of composite restorations.[12–14] Hence, the challenge remains to understand the complex reasons why dental composite restorations fail and to determine to what extent this is dependent upon polymerization stress.

The link between composite shrinkage and stress seems an obvious one because clinical studies have demonstrated that the average life span of a composite restoration is 6 years[13,15–18] and that the most common causes for failure include secondary decay and fracture, which in turn are due to the degradation of the composite material itself and the adhesive bond over time. Even though polymerization stress is a likely factor for marginal integrity breakdown, it is still not fully understood why, in some cases, even with relatively large interfacial gaps, no secondary decay is observed. Possible hypotheses include variations in the patient's dietary and hygiene habits, which in turn may regulate material degradation and bacterial colonization. Several studies have been conducted to understand the regulatory effect some of the degradation products of dental composites and dental adhesives have on the metabolic activity of cariogenic bacteria.[19,20] For example, it has been demonstrated that degradation derivatives of common dental monomers (such as bis-hydroxy-propoxyphenyl propane, ethoxylated bisphenol A, methacrylic acid, and triethylene glycol) may either stimulate or inhibit the growth of *Streptococcus mutans* and *Streptococcuss salivarius* strains.[20] A recent request for research applications was issued by the National Institutes of Health aiming at developing a new composite system with significantly improved service life, as compared with current BisGMA/TEGDMA-based materials. The need exists to develop new materials with not only reduced contraction stress, but also capable of withstanding the complex challenges in the oral environment for extended periods of time, with significantly reduced hydrolytic/enzymatic-derived degradation and desirably with antimicrobial activity.

Other than patient-derived issues (dietary and hygiene habits), the other factor to be considered in restoration longevity is the operator-derived variation in the outcomes. Placing a composite is a very technique-sensitive procedure,[21,22] in large part due to the polymerization shrinkage stress problem. This may explain why clinical studies have so far been unable to find a correlation between the stress values reported in laboratory studies and the longevity of restorations placed in vivo.[13,16–18,22] Types of clinical studies also vary: compared with randomized clinical trials, practice-based research provides a snapshot of the real-life outcomes of composite restorations, which includes

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practitioners with a broad range of skill levels, serving a broad range of population cohorts. This range of skill level brought about the need for strategies and technologies to help calibrate the performance of practitioners, but also for the development of materials whose placement is less prone to operator-derived error.

In summary, even though polymerization stress is likely a major factor determining the longevity of composite restorations, biological as well as placement technique aspects must also be considered. Research and development efforts will continue to lead dentistry in the direction of more durable and robust direct esthetic materials in the future.

REFERENCES

1. 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(10):962–70.
2. Gonçalves F, Boaro LC, Ferracane JL, et al. A comparative evaluation of polymerization stress data obtained with four different mechanical testing systems. Dent Mater 2012;28(6):680–6.
3. Pfeifer CS, Ferracane JL, Sakaguchi RL, Braga RR. Factors affecting photopolymerization stress in dental composites. J Dent Res 2008;87(11):1043–7.
4. Sakaguchi RL, Ferracane JL. Effect of light power density on development of elastic modulus of a model light-activated composite during polymerization. J Esthet Restor Dent [*et al.*], 2001. 13(2):121–30.
5. Mantri SP, Mantri SS. Management of shrinkage stresses in direct restorative light-cured composites: a review. J Esthet Restor Dent 2013 (in press).
6. Davidson CL, de Gee AJ, Feilzer A. The competition between the composite-dentin bond strength and the polymerization contraction stress. J Dent Res 1984;63(12):1396–9.
7. Feilzer AJ, De AJ, Davidson CL. Increased wall-to-wall curing contraction in thin bonded resin layers. J Dent Res 1989;68(1):48–50.
8. Cramer NB, Stansbury JW, Bowman CN. Recent advances and developments in composite dental restorative materials. J Dent Res 2011;90(4):402–16.
9. Cunha LG, Alonso RC, Pfeifer CS, et al. Modulated photoactivation methods: influence on contraction stress, degree of conversion and push-out bond strength of composite restoratives. J Dent 2007;35(4):318–24.
10. Ferracane JL, Mitchem JC. Relationship between composite contraction stress and leakage in Class V cavities. Am J Dent 2003;16(4):239–43.
11. Papadogiannis D, Kakaboura A, Palaghias G, Eliades G. Setting characteristics and cavity adaptation of low-shrinking resin composites. Dent Mater 2009;25(12):1509–16.
12. Burke FJ, Crisp RJ, James A, et al. Two year clinical evaluation of a low-shrink resin composite material in UK general dental practices. Dent Mater 2011;27(7):622–30.
13. Deliperi S, Bardwell DN, Alleman D. Clinical evaluation of stress-reducing direct composite restorations in structurally compromised molars: a 2-year report. Oper Dent 2012;37(2):109–16.
14. Van Ende A, Mine A, De Munck J, et al. Bonding of low-shrinking composites in high C-factor cavities. J Dent 2012;40(4):295–303.
15. Downer MC, Azli NA, Bedi R, et al. How long do routine dental restorations last? A systematic review. Br Dent J 1999;187(8):432–9.
16. Fagundes TC, Barata TJ, Carvalho CA, et al. Clinical evaluation of two packable posterior composites a five-year follow-up. J Am Dent Assoc 2009;140(4):447–54.
17. van Dijken JW, Lindberg A. Clinical effectiveness of a low-shrinkage resin composite: a five-year evaluation. J Adhes Dent 2009;11(2):143–8.
18. van Dijken JWV. Durability of resin composite restorations in high C-factor cavities: a 12-year follow-up. J Dent 2010;38(6):469–74.
19. Kermanshahi S, Santerre, JP, Cvitkovitch, DG, Finer, Y. Biodegradation of resin-dentin interfaces increases bacterial microleakage. J Dent Res 2010;89(9):996–1001.

 DOI 10.1111/jerd.12050

20. Khalichi P, Cvitkovitch DG, Santerre J. Effect of composite resin biodegradation products on oral streptococcal growth. Biomaterials 2004;25(24):5467–72.
21. Perdigão J, Duarte S, Gomes G. Direct resin-based composite restorations—clinical challenges. J Adhes Sci Technol 2009;23(7–8):1201–14.
22. Schneider H, Busch I, Busch M, et al. Effect of operator-specific handling on tooth-composite interface and microleakage formation. Oper Dent 2009;34(2):200–10.

 DOI 10.1111/jerd.12050