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Polymerization stress – Is it clinically meaningful?

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ABSTRACT

Objectives. The objective of this article is to discuss the evidence for polymerization shrinkage and shrinkage stress of dental composite restoratives in terms of its potential relevance to the clinical situation

Methods. Articles relating to the issue of polymerization contraction stress generation in dental composite materials, and the factors that influence it, were reviewed and included. Particular attention was paid to evidence derived from clinical studies. Articles were identified through PubMed and through the bibliographies of other articles.

Results. There is extensive evidence for the presence of polymerization contraction stress in dental composites, as well as evidence for its deleterious effects, which include marginal leakage, gap formation, cuspal deflection, tooth cracking, reduced bond strength and lowered mechanical properties of the restorative. There is little, if any, direct evidence for the clinical effect of these contraction stresses. No study has directly established a link between these stresses and enhanced postoperative sensitivity or recurrent caries, for example. However, the concern over these stresses and the manner in which they influence the placement of current composite materials demonstrates that they are considered to be very important.

Conclusion. Though no direct evidence exists to prove that the generation of contraction stress in dental composite restorations causes reduced clinical longevity, the indirect evidence from numerous in vitro studies and the concern over controlling their effects proves that they are clinically relevant.

1. Introduction

Dental composites are the most frequently used direct restorative materials and have become the first choice of a majority of practitioners world-wide for the restoration of posterior teeth [1]. The primary reason for this ascent from its introduction to dentistry approximately 50 years ago is mostly related to esthetics. The importance of the ability to replace lost or damaged tooth structure in a convenient and cost effective manner, and with an excellent esthetic outcome, cannot be overstated. In addition, the ability to use adhesive dentistry to provide restoration resistance and retention form allows for a minimal intervention approach, providing another significant advantage by conserving tooth structure [2]. However, the longevity of composite restorations, as well as the durability of the composite material itself as a tooth replacement, is often questioned. Many believe that the most serious issue with dental composites is the fact that the polymerization reaction is accompanied by a volumetric shrinkage that generates stress within the material and leads to compromised adhesion to the tooth and a poor seal of the restoration.

Clinical studies vary widely in terms of the success rate for composite restorations, and proponents and detractors

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alike often use essentially the same data to support their opinions. Recent efforts by the National Institute for Dental and Craniofacial Research of the National Institutes of Health in the U.S. have targeted the development of new dental composite restoratives with enhanced service life, specifically requesting that new materials double the longevity of current materials. To justify these initiatives, NIDCR documents point to an average lifetime of 6–7 years for dental composite restorations [3]. While it is important to note that reviews show that many clinical studies report much greater longevity for these materials [4], there is significant evidence for this relatively short lifespan for composites [5,6]. Further, even with evidence that composites may have similar service life as dental amalgam, composite failure due to caries is typically higher than for amalgam [7]. The longevity of both composite and amalgam is reduced in patients with high caries risk status [4,5], but the effect is more significant for composites [8]. An extensive review of clinical studies in which dental composite and amalgam have been directly compared shows that while one retrospective, single-practice study reported improved longevity for composite vs. amalgam, the preponderance of clinical evidence demonstrates the overall enhanced longevity of amalgam restorations (Table 1). This conclusion is supported by a recent Cochrane review in which the odds ratio for failure of composite over amalgam was nearly 2:1, with the increased risk for composite being due to secondary caries; admittedly the evidence was considered weak due to the limited number of acceptable studies [18]. Thus, the general consensus is that dental composite restorations do not last as long as the profession desires, or perhaps even consider acceptable. The latter statement accounts for the fact that some dentists still hesitate to embrace this material for routine direct restoration of posterior teeth in their practice.

The question that then becomes of critical importance is why do dental composite restorations not demonstrate greater longevity? To address this question, it is important to clarify the reasons for replacement and failure of these materials. There is a distinction between these two terms, and this has been clarified for dentistry many years ago. It is likely that many restorations that may still be serviceable are replaced, and for a variety of reasons, perhaps even because it is difficult to determine their true quality [19]. For example, decay around restorations is often difficult to confirm without removal of the existing restoration to visualize the actual state of the tooth. Stained margins, gaps at margins, fractured margins, and other obvious deficiencies, possibly with or without the presence of symptoms, may leave the dentist with a dilemma about the need for immediate treatment to prevent greater problems at a later date [20]. In any case, these conditions are most likely related to a deterioration of the restoration with time. But the existence of a deficiency at the time of placement cannot be ruled out either. What is known is that the primary reason for replacement of dental composite restorations, even in recent studies, is caries associated with the restoration [5,11,12]. Whether this is a recurrence of the original caries or a new caries lesion formed specifically due to the presence of the restoration (i.e. secondary caries) may be a matter of discussion and debate. Composites also fail due to chipping or fracture of the material, fracture of the tooth, discoloration,

Table 1 – Clinical studies comparing the longevity of posterior composites and amalgams.

Study	Year	Study type	Setting	# Restorations	Duration	Outcome	Statistical difference
Bogacki [9]	2002	Retrospective	Private	300, 753	7	Comp 16.4% risk vs. am/year	Yes
Van Nieuwenhuysen [10]	2003	Prospective	Dental school	772 am, 115 comp, 89 crowns	18	Comp: 7.8 years, am 12.8 years, crowns: 14.6 years	Yes
Opdam [7]	2007	Retrospective	Private	912 am, 1955 comp	10	AFR: am: 2.1%, comp: 1.8%	No
Opdam [8]	2010	Retrospective	Private	1202 am, 747 comp	12	AFR: am: 2.4%, comp: 1.7%	Yes
Soncini [11]	2007	RCT	Teens (Portugal)	1262	5	AFR: am: 2.2%, comp: 2.9%	No
Bernardo [12]	2007	RCT	Teens (USA)	1748	7	AFR: am: 0.8%, comp: 2.7%	Yes
Simecek [13]	2009	Retrospective	Military	2780	3	Comp 64% risk vs. am/3 year	Yes
Sunnegårdh-Grönberg [5]	2009	X-sectional	Public health	3140	N/A	Comp: 6 years am 16 years	Yes
Overton [14]	2012	X-sectional	Dental school	1619 am, 2318 comp	1 (early failures)	am: 0.35%, comp: 3.6%	Yes
Kopperud [6]	2012	Prospective	Public health	184 am, 3286 comp	4.6	am: 1.6%, comp: 2.9%	Yes
Rho [15]	2013	Retrospective	Dental school	131 am, 138 comp	N/A	Comp: 5 years, am 8.7 years	Yes
McCracken [16]	2013	Prospective-observational, non-random, volunteer	PBRN	6218	2	Overall AFR: 3.1%	No
Laccabue [17]	2014	Retrospective	Military	565 am, 485 comp	N/A Avg 2.8 years	AFR: am: 2.4%, comp: 1.7%	No