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ORIGINAL ARTICLE

Impact of dietary solvents on flexural properties of bulk-fill composites

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KEYWORDS

Composites;
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Abstract *Objective:* This study investigated the effect of dietary solvents on flexural strength and modulus of bulk-fill composites.

Materials and methods: One conventional composite (Filtek Z350 [FZ]), two bulk-fill composites (Filtek Bulk-fill [FB] and Tetric N Ceram [TN]) and a bulk-fill giomer (Beautifil-Bulk Restorative [BB]) were evaluated. Specimens (12 × 2 × 2 mm) were fabricated using customized stainless steel molds. Specimens were light-cured, removed from their molds, finished, measured and randomly divided into six groups. The groups (n = 10) were conditioned in the following mediums for 7 days at 37 °C: air (control), artificial saliva (SAGF), distilled water, 0.02 N citric acid, heptane, 50% ethanol–water solution. After conditioning, the specimens were rinsed, blotted dry, measured and subjected to flexural testing using a universal testing machine. Representative SEM images of the intact surfaces were obtained to appraise the degradation mechanism by dietary solvents. Data was subjected to statistical analysis using ANOVA/Tukey's tests at significance level $p < 0.05$.

Results: Significant differences in flexural properties were observed between materials and conditioning mediums. The highest flexural properties were usually obtained with conditioning in air (control) or heptane. Exposure to aqueous solutions generally reduced flexural properties of bulk-fill composites.

Conclusion: The effect of dietary solvents on flexural properties of bulk-fill composites was material and medium dependent.

1. Introduction

Dental composite technology had progressed significantly over the past decade (Leprince et al., 2013; Shah and Stansbury, 2014). Despite this, polymerization shrinkage and depth of cure remain a clinical challenge (Deliperi and Bardwell, 2002; Jang et al., 2015; Park et al., 2008). The incremental layering technique had traditionally been used to reduce polymerization shrinkage stresses and to facilitate curing light

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penetration. Besides being time-consuming to perform, air entrapment, contamination and bond failure can also occur between layers (Jang et al., 2015; Park et al., 2008). Bulk-fill composites were introduced to overcome the need for composite layering and adapting procedures. They allow for the placement of materials in 4–5 mm increments without increasing shrinkage and compromising cure (Jang et al., 2015). The latter is achieved by means of novel resins, special modulators, unique fillers and filler control (Fleming et al., 2008; Lassila et al., 2012; Yap et al., 2016). The mechanical properties of bulk-fill composites have been the subject of some disagreement. While some authors have reported lower mechanical properties than conventional highly-filled composites, others have stated otherwise (El Gezawi et al., 2016; Ilie et al., 2013; Leprince et al., 2014).

Composite restorations are subjected to both physical and chemical degradation intra-orally. In addition to dissolution and softening of the resin matrix, filler damage and debonding can also occur ensuing in decreased restoration durability and longevity (Drummond, 2008; Wu et al., 1984). Food simulating liquids (FSLs) are usually used to mimic dietary solvents. They are often used for accelerated aging and testing of dental composites (Krishnan and Yamuna, 1998; Vouvoudi and Sideridou, 2012). Commonly employed FSLs include those listed in the Food and Drug Administration (USA) guidelines (Food and Drug Administration, 1976). Heptane imitates greasy foods like vegetable oils, butter and fatty meats, while citric acid and ethanol solutions mimic certain vegetables, fruits, candies, beverages including alcohol and syrups. Distilled water and artificial saliva are used to replicate the wet oral environment presented by water and saliva (Akova et al., 2006; Vouvoudi and Sideridou, 2012; Yap et al., 2005, 2000b).

FSLs have been found to affect the strength of dental composites in in-vitro studies. Whilst conditioning in ethanol generally weakens dental composites (Krishnan and Yamuna, 1998; Yesilyurt et al., 2009), exposure to heptane was equivocal with authors reporting both increased and decreased strength (Akova et al., 2006; Yap et al., 2000b). These studies were all conducted on conventional materials and few, if any, had determined the impact of food substances on the strength of bulk-fill composites. The latter is clinical meaningful as bulk-fill composites may behave differently from their conventional counterparts considering the variances in filler and resin technology.

The aim of this study was to determine the effect of dietary solvents on flexural strength and modulus of bulk-fill composites. The performance of these materials after conditioning in the various dietary solvents was also compared. The null hypotheses were as follows: (a) Flexural properties of bulk-fill composites are not affected by dietary solvents and (b) Irrespective of conditioning mediums, no significant disparity in flexural properties exists between bulk-fill materials.

2. Materials and methods

2.1. Materials and specimen preparation

The materials evaluated and their technical profiles are presented in Table 1. They included a conventional composite (Filtek Z350 [FZ]), two bulk-fill composites (Filtek Bulk-Fill [FB] and Tetric N ceram Bulk-Fill [TN]) and a bulk-fill giomer (Beautifil Bulk-fill Restorative [BB]). The conventional composite served as a comparison for the bulk-fill materials.

Sixty beam-shaped specimens ($12 \times 2 \times 2$ mm) of each material were fabricated using customized stainless steel molds. The composites were placed in one increment and excess material was removed by compressing the molds between two mylar strips with glass slides. The top surface of the composite specimens were light polymerized with two overlapping irradiation of 10 s each using a LED curing light (Demi Plus, Kerr, CA, USA) with a wave length of 450–470 nm and irradiance of 1330 mW/cm^2. The glass slides were removed and the composite specimens were light cured for another 10 s. The mylar strips were subsequently discarded and the composite beams were removed from their molds. Any minor material excess or 'fins' were gently removed by fine polishing discs (Sof-Lex, 3M ESPE, USA). The composite specimens were examined for the presence of voids or cracks and any defective specimens were replaced. The final dimensions of the specimens and the parallelism between their opposite surfaces were verified with a digital caliper (Mitutoyo Corporation, Kawaski, Japan).

2.2. Storage mediums and time

The composite specimens were then randomly divided into six groups (n = 10) and conditioned in the following mediums for 7 days at 37 °C: air (control), artificial saliva (SAGF), distilled water, 0.02 N citric acid, heptane, 50% ethanol-water solution. Specimens were kept in sealed containers to minimize evaporation. Composition of artificial saliva (SAGF) used is shown in Table 2 (Gal et al., 2001). The pH of the artificial saliva was adjusted to 6.8 to take after natural saliva when it is released from the salivary ducts (Vouvoudi and Sideridou, 2012).

2.3. Flexural testing

A three point bending test setup was used to assess the flexural properties of the composites after conditioning in the various mediums. Specimens were rinsed, blotted dry and measured prior to testing. Measurements were taken at two places for length, width and height, and the average of both values was taken to calculate the flexural strength and flexural modulus. The composite specimens were loaded in a universal testing machine (UTM) (Shimadzu Corporation, Kyoto, Japan) with a load cell of 5 KN and crosshead speed of 0.5 mm/min until fracture occurred. Flexural strength, σ, in Megapascals (MPa) was calculated using the following equation:

$$\sigma = \frac{3PL}{2BH^2} \quad (1)$$

where

P is the maximum load, in newtons, exerted on the specimens;

L is the distance, in millimeters, between the supports (10 mm);

B is the width, in millimeters, of the specimens measured prior to testing;

H is the height, in millimeters, of the specimens measured prior to testing.

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