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Post-cure depth of cure of bulk fill dental resin-composites

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ABSTRACT

Objectives. To determine the post-cure depth of cure of bulk fill resin composites through using Vickers hardness profiles (VHN).

Methods. Five bulk fill composite materials were examined: Tetric EvoCeram® Bulk Fill, X-tra base, Venus® Bulk Fill, Filtek™ Bulk Fill, SonicFill™. Three specimens of each material type were prepared in stainless steel molds which contained a slot of dimensions (15 mm × 4 mm × 2 mm), and a top plate. The molds were irradiated from one end. All specimens were stored at 37 °C for 24 h, before measurement. The Vickers hardness was measured as a function of depth of material, at 0.3 mm intervals. Data were analysed by one-way ANOVA using Tukey *post hoc* tests ($\alpha = 0.05$).

Results. The maximum VHN ranged from 37.8 to 77.4, whilst the VHN at 80% of max.VHN ranged from 30.4 to 61.9. The depth corresponding to 80% of max.VHN, ranged from 4.14 to 5.03 mm. One-way ANOVA showed statistically significant differences between materials for all parameters tested. SonicFill exhibited the highest VHN ($p < 0.001$) while Venus Bulk Fill the lowest ($p \leq 0.001$). SonicFill and Tetric EvoCeram Bulk Fill had the greatest depth of cure (5.03 and 4.47 mm, respectively) and was significant's different from X-tra base, Venus Bulk Fill and Filtek Bulk Fill ($p \leq 0.016$). Linear regression confirmed a positive regression between max.VHN and filler loading ($r^2 = 0.94$).

Significance. Bulk fill resin composites can be cured to an acceptable post-cure depth, according to the manufacturers' claims. SonicFill and Tetric EvoCeram Bulk Fill had the greatest depth of cure among the composites examined.

1. Introduction

One of the problems connected with photo-polymerized resin composites is the depth of cure limitation and the possibility of insufficient monomer conversion at depth [1]. Since photo-polymerized resin composites were introduced, the degree of conversion was acknowledged as vital to the clinical success of these materials [2]. Photo-cured resin composites polymerize only to a certain depth. This depends on the penetration of visible light through the bulk of the material [3]. It has been shown that the insufficient polymerization may lead to a decrease in the physical/mechanical [4] and biological [5] properties of resin composites.

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For sufficient polymerization, three vital characteristics are essential for the light cure unit: adequate light output, appropriate wavelength range of the light and exposure time [6]. Other factors affect the depth of cure, including resin composite type, shade and translucency, increment thickness, distance from the tip of the light cure unit, post-irradiation period [7] and size and distribution of filler particles [8].

When the cavity is large, incremental layering can be used, with approximately 2 mm thick increments. This technique is used to avoid the depth of cure limitation and to reduce polymerization shrinkage effects [9]. Insufficient polymerization may result in the degradation of the resin composite, poor physical properties and adverse biological reactions owing to the leaching of the monomeric components of the unset resin composite [9].

There are various disadvantages associated with incremental techniques, such as incorporating voids or contamination between composite layers, failures in bonding between layers, placement difficulty owing to limited access in small cavities and an extended treatment time for placement of layers and their polymerization [10].

To overcome these disadvantages "bulk fill" composites have been introduced. They have shown reduced cuspal deflection when compared with a conventional resin composite filled in an oblique incremental layering technique [11]. Also, when marginal integrity was evaluated, bulk fill composites performed well [12].

Several techniques have been employed to determine the depth of cure. The ISO standard for dental composites 4049, advocates scraping of the unset materials, immediately after irradiation, and measuring the length of the set specimen, which is then divided by two [13]. Other techniques have involved measuring the hardness of the top and bottom specimen surfaces [14], or their the degree of conversion [6]. Optical microscopy has also been used to determine the depth of cure [15], where there is a visual boundary between cured and uncured material.

The surface microhardness of resin composites has been used to evaluate indirectly the extent of polymerization, and also the efficiency of the light cure unit [16,17]. As a result of reduced light irradiance passing through resin composites, the degree of conversion decreases with increasing depth [16]. In the present study, a surface microhardness profile was used to assess the depth of cure of different bulk fill resin composites.

The aim of this study was to determine the depths of cure. This was to be achieved by consideration of the following parameters: (i) the maximum Vickers microhardness, (ii) 80% of the maximum Vickers microhardness, and (iii) the depth corresponding to 80% of the maximum Vickers hardness. The null hypotheses were that there would be no differences between materials, either in maximum Vickers hardness or in the depth of cure that could be obtained at 80% of maximum Vickers hardness for bulk fill materials.

2. Materials and methods

Five bulk fill dental-composites (Table 1) were evaluated. The acronym-codes for these materials are included in Table 1.Three specimens of each bulk fill resin composite ($n = 3$) were prepared for surface microhardness profile measurements in stainless steel molds. These contained a slot of dimensions (15 mm × 4 mm × 2 mm), and a top plate (Fig. 1). The mold was overfilled with composite, and a Mylar strip was placed on top of the material with the top plate subsequently pressed into position, followed by the scraping of the excess material from the entrance of the mold. The mold was held together in a clamp. The molds were irradiated from one end. Each specimen was photo-polymerized for 20 s using a visible light cure unit with a tip diameter 10 mm (Elipar™ S10, 3M ESPE, USA) under the standard curing mode output wavelength range 430–480 nm; output irradiance was 1200 mW/cm^2). A calibrated radiometer system (MARC, Blue-Light Analytics Inc, Halifax, NS, Canada) was used to verify the irradiance at each use of the light cure unit. All specimens were stored dry at 37 °C for 24 h prior to measurement. The top of the mold and the Mylar strip were removed and the Vickers hardness number (VHN) was measured as a function of depth of material at 0.3 mm intervals. All specimens were examined by a microhardness instrument (FM-700, Future Tech Corp., Japan). A fixed load of 300 g was applied for 15 s. Data were calculated as hardness numbers and accordingly plotted as hardness *versus* depth profiles.

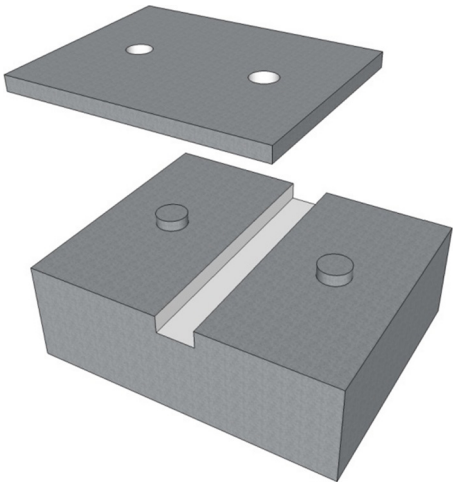

Fig. 1 – Stainless steel mold with top cover plate.

3. Statistical analysis

Univariate one-way ANOVA, Tukey *post hoc* tests (SPSS, V20, Chicago, USA) $\alpha = 0.05$, were used to analyse the significant differences of the following parameters: (1) max.VHN, (2) VHN at 80% of max.VHN and (3) depth at 80% of max.VHN (dependent variable) between different materials (independent variables). All data were subjected to Levene's test of homogeneity of variance ($\alpha = 0.05$) following the assumption of equal variances. The relationship between VHN and filler content was evaluated by linear regression.