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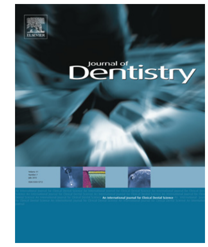

Physico-mechanical characteristics of commercially available bulk-fill composites

Q1 *Julian G. Leprince* [a,b,c,d,*], *William M. Palin* [e], *Julie Vanacker* [c], *Joseph Sabbagh* [f], *Jacques Devaux* [b,d], *Gaetane Leloup* [a,b,c,d]

[a] *School of Dentistry and Stomatology, Université catholique de Louvain, Brussels, Belgium*
[b] *Institute of Condensed Matter and Nanoscience, Bio- and Soft-Matter, Université catholique de Louvain, Louvain-la-Neuve, Belgium*
Q2 [c] *Louvain Drug Research Institute, Université catholique de Louvain, Brussels, Belgium*
[d] *CRIBIO (Center for Research and Engineering on Biomaterials), Brussels, Belgium*
[e] *Biomaterials Unit, University of Birmingham, College of Medical and Dental Sciences, School of Dentistry, St Chad's Queensway, Birmingham B4 6NN, UK*
[f] *Department of Restorative and Esthetic Dentistry, Lebanese University, Beirut, Lebanon*

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ABSTRACT

Objectives: Bulk-fill composites have emerged, arguably, as a new "class" of resin-based composites, which are claimed to enable restoration in thick layers, up to 4 mm. The objective of this work was to compare, under optimal curing conditions, the physico-mechanical properties of most currently available bulk-fill composites to those of two conventional composite materials chosen as references, one highly filled and one flowable "nano-hybrid" composite.

Methods: Tetric EvoCeram Bulk Fill (Ivoclar-Vivadent), Venus Bulk Fill (Heraeus-Kulzer), SDR (Dentsply), X-tra Fil (VOCO), X-tra Base (VOCO), Sonic Fill (Kerr), Filtek Bulk Fill (3M-Espe), Xenius (GC) were compared to the two reference materials. The materials were light-cured for 40 s in a 2 mm × 2 mm × 25 mm Teflon mould. Degree of conversion was measured by Raman spectroscopy, Elastic modulus and flexural strength were evaluated by three point bending, surface hardness using Vickers microindentation before and after 24 h ethanol storage, and filler weight content by thermogravimetric analysis. The ratio of surface hardness before and after ethanol storage was considered as an evaluation of polymer softening. Data were analyzed by one-way ANOVA and post hoc Tukey's test ($p = 0.05$).

Results: The mechanical properties of the bulk-fill composites were mostly lower compared with the conventional high viscosity material, and, at best, comparable to the conventional flowable composite. Linear correlations of the mechanical properties investigated were poor with degree of conversion ($0.09 < R < 0.41$) and good with filler content ($R > 0.8$). Softening in ethanol revealed differences in polymer network density between material types.

Significance: Given the lower mechanical properties of most bulk-fill materials compared to a highly filled nano-hybrid composite, their use for restorations under high occlusal load is subject to caution. Further, the swellingbehaviour of some of the bulk-fill materials may be a reason for concern, which highlights the critical requirement for a veneering material, not only to improve aesthetic quality of the translucent material, but to reduce the impact of degradation.

* *Corresponding author at*: Université catholique de Louvain, Ecole de médecine dentaire et de stomatologie, Centre de recherche CRIBIO, Avenue Hippocrate, 10/5721, B-1200 Brussels, Belgium. Tel.: +32 2 764 57 50; fax: +32 10 45 15 93.
E-mail address: julian.leprince@uclouvain.be (J.G. Leprince).

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1. Introduction

Due to considerable improvement since their inception, the use of photopolymerizable resin-based composite restorative materials are more frequently extended to large and deep cavities albeit with variable success.[1,2] In such cases, incremental build-up of multiple thin layers are required; first because of the limited cure depth[3,4] and second to potentially reduce the consequences of shrinkage stress,[5] although the latter theory has been refute.[6] However, layering techniques and multiple curing regimens of resin composites are time consuming. As a consequence, the composite material market is often driven by consumer demand for faster and easier procedures (sometimes at the cost of fundamental materials science principles) by reducing the curing time and/or using thicker composite layers. A modern example has seen the increasing popularity amongst dental practitioners of so-called ''bulk-fill'' materials, which are claimed to enable the restoration build-up in thick layers, up to 4 mm. This new material class includes flowable and higher viscosity paste material types.

There currently exists a growing trend in the use of bulk-fill materials amongst practitioners due to a more simplified procedure. However, the lack of available literature on their clinical performance promotes much in vitro research, which ranks the properties of bulk-fill materials relative to the conventional flowable and paste composite types already on the market. In the available literature, some interesting characteristics were reported for bulk-fill materials. First, the possibility of adequately light-curing these materials to greater than 4-mm thickness was confirmed by microhardness measurements for X-traFil (VOCO),[7] SDR (Dentsply),[8,9] Venus Bulk Fill (Heraeus-Kulzer),[8] Tetric EvoCeram Bulk-Fill (Ivoclar-Vivadent) and X-tra Base (VOCO),[10] and by measurements of degree of conversion for X-tra Base and SDR.[9] However, the use of such methods to assess the quality of cure in depth may lead to an overestimation of the depth of cure.[11] Specifically regarding bulk-fill composites, various depths of cure have been reported depending on the method used. The median depth of cure after 20 s cure of SDR, Venus Bulk-fill and Tetric EvoCeram Bulk-Fill was respectively 4.93, 6.08 and 3.83 mm when based on the ISO4049 method, and 2.5, 4.0 and 0.2 mm based on microhardness.[12] Similarly, the extent of cure through depth indirectly evaluated by biaxial flexure strength measurements was significantly lower (<4 mm) than when relying on degree of conversion or microhardness.[9]

SDR was also associated with low shrinkage stress and shrinkage stress rates compared with various conventional pastes and flowable composites.[9,13] Similar observations were made for Tetric EvoCeram Bulkfil, Venus Bulk Fill, X-tra Fil, and Filtek Bulk-Fill (3M-ESPE) compared with Filtek Z250 (3M-ESPE).[14] In other work, SDR levels of shrinkage stress were lower than Filtek Supreme XT and Clearfil Majesty Posterior (Kuraray), but in the same range as Venus Diamond (Heraeus-Kulzer), Filtek Silorane (3M-ESPE), an experimental ormocer from VOCO or ELS (Saremco).[15] Nevertheless, despite the reduction in shrinkage stress, the advantages in terms of marginal adaptation are unclear. X-tra Fil (VOCO) was shown to present no significant difference in the amount of cuspal deflection compared to Filtek Supreme Plus (3M-ESPE) when filling a 4 mm-deep cavity in one step.[7] Bulk-filling a 3.5 mm-deep cavity with X-tra Base and SDR was associated with significantly reduced cuspal deflection compared with a conventional composite, GrandioSO (VOCO) used in an oblique incremental filling technique, although no associated change in cervical microleakage was observed.[16] Similarly, equivalent marginal adaptation was observed when SDR was used as a base under conventional hybrid composites compared to the latter used incrementally.[17] SDR was shown to significantly improve microtensile bond strength compared to Filtek Z100 (3M-ESPE) and G-ænial Universal Flo (GC) when filling cavities of high C-factor in bulk, but no difference in bond strength was observed when an incremental filling technique was employed or when bonding to a low C-factor surface.[18]

The main advancements of bulk-fill materials, namely increased depth of cure, which probably results from higher translucency,[19] and low shrinkage stress are related to modifications in the filler content and/or the organic matrix. Ideally, these perceived improvements should not be at detriment to the mechanical properties of the material. Recent studies have reported that bulk-fill resin composites exhibited acceptable levels of creep resistance, in the range shown by conventional material types,[20,21] although some bulk materials investigated (SDR and Venus Bulk Fill) presented a significantly higher creep strain than the nanohybrid composite Filtek Supreme XT (3M-ESPE).[21] Among flowable composites (EsthetX Flow, Dentsply; Filtek Supreme Plus Flow, 3M-ESPE), SDR exhibited the lowest Vickers hardness, the highest elastic modulus and the highest creep, but all three properties were much lower than hybrid composites (Filtek Silorane, 3M-ESPE; EsthetX Plus, Dentsply; Filtek Supreme Plus, 3M-ESPE).[13] Similarly, another study raised some concerns regarding low to very low hardness and elastic modulus for some bulk-fill materials, especially SDR, Venus Bulk Fill and Filtek Bulk-Fill.[22] In other work, some improvement in elastic modulus, flexural strength and greater increase in fracture toughness were attributed to a bulk-fill material containing glass microfibers (Xenius, GC) compared with bulk-fill types.[23]

The objective of the present work was to group all the main currently available bulk-fill composites as well as a dual-cure composite in a single study (Table 1), and to compare their physico-mechanical properties under optimal curing conditions to those of two conventional composite materials chosen as references, one highly filled and one flowable nano-hybrid composite: Grandio and Grandio Flow (VOCO). The null hypothesis was that there are no differences in physico-mechanical properties between neither of the so-called bulk-fill composites, nor with two conventional composite materials chosen as controls.

2. Materials and methods

The materials used in the present investigation are presented in Table 1. They were placed in a 2 mm × 2 mm × 25 mm Teflon mould and light-cured by four 40 s overlapping irradiations on the upper sample side to ensure optimal mechanical properties. The light tip of the polywave LED light

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