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Recent advances in bulkfill flowable composite resins: A review

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Abstract
The introduction of flowable composites provide expanded options for restorative dentistry. There is a growing trend among practitioners to use bulk-fill resin based composite materials because of their more simplified procedures. The main advancement of bulk-fill composite materials, namely increased depth of cure, which probably results from higher translucency, and low polymerization shrinkage stress are related to modifications in the filler content and/or organic matrix with the help of advanced technology. This article has enlighten different aspects of flowable bulkfill composite resin materials.

Keywords: Resin composite, Bulkfill, Flowable, Incremental, Polymerization

1. Introduction
Resin-based composites have been successfully used in dentistry for many years and widely replaced amalgam as a posterior restoration. There are many reasons for this relatively rapid and significant change in restorative dentistry. These includes individual patient desires for non-metal, natural-looking restorations, the less invasive nature of composite restorations, the significant improvement in composite resin material leading to increased durability and longevity.

Newer generation composites with improved properties and reduced number of steps for restoration are now the material of choice for posterior restoration. Polymerization shrinkage is reduced compared to earlier composite. Adaptability and marginal integrity of these composite is improved considerably. Resin undergoes a volumetric shrinkage of 2.6–7% during polymerization [1]. This shrinkage results in microleakage, marginal gap formation, marginal discoloration, secondary caries and cuspal deflection. The use of esthetic restorative material to prevent microleakage has been a vital concern of modern dentistry. Many esthetic restorative available products have attempted to reduce the interfacial gap between the tooth and restoration, the main pathway of microleakage.

Dental composites are expected to have mechanical properties comparable to those of tooth enamel and dentin and provide a long life of service [2]. However, several factors limit the performance of composites, especially depth of cure and degree of conversion. In spite of great advances in resin based composite technologies, an insufficient depth of cure is one of its major disadvantages. Due to insufficient depth of cure, incremental placement technique, with a maximum 2 mm thickness, was used for large composite restorations, especially class II restorations. However, the use of dental composite in an incremental placement technique, and light curing each increment individually is time consuming for the patient and the operator [3]. There is also an increased possibility of air bubble inclusion or moisture contamination between individual increments of resin composite restorations.

Recently, a new class of resin-based composite, the so called“bulk-fill” composites have been introduced with the purpose of time and thus cost savings. The unique advantage of this new material class is stated that it can be placed in a 4 mm thickness bulks to be cured in one step instead of the current incremental placement technique, without adverse effect on polymerization shrinkage, cavity adaptation or degree of conversion [4]. Furthermore, the manufacturers stated that the polymerization shrinkage of those materials is evenless than that of commonly used flowable and conventional resin-based composites.

Consequently, problems arise from polymerization shrinkage could be reduced. This new material class includes flowable and high viscosity material types.

Bulk fill composite resins are further classified into high-viscosity and low-viscosity (flowable) materials. High-viscosity bulk fill composites include greater amounts of filler particles compared to low-viscosity bulk fill composites [5]. As a result, the flowable composite resins exhibit better adaptation on the cavity walls but present greater polymerization shrinkage and lower mechanical properties. Due to their lower mechanical properties their restorations is recommended to be finished with a 2-mm capping layer of a high-viscosity bulk fill composite resin, especially when restoring areas which are submitted to occlusal stresses.

The preheated composite resins show reduced viscosity and increased polymerization efficiency. Heating composite resins prior to placement in the cavity and immediately light-curing increases monomer conversion rate and thus the duration of the irradiation period may be decreased. With increased paste temperature, free radicals and developing polymer chains become more fluid as a result of reduced paste viscosity and they react to a greater extent, leading to a more complete polymerization reaction and enhanced cross-linking [6]. The increase in the degree of polymerization of composite resins may lead to better internal adaptation to cavity walls, improved mechanical properties and increased wear resistance. The pre-heating significantly reduces shrinkage force formation of high-viscosity bulk-fill and conventional composite resins, while maintaining or increasing the degree of monomer conversion, dependent upon the specific composite material used [7].

The introduction of flowable composites provides expanded options for restorative dentistry. Flowable composites are low-viscosity resin composites obtained from formulations with 20% - 25% lower filler loading and increased resin content than conventional resins. The reduced viscosity of the mixture makes their placement possible by injection syringes and limits stickiness [8]. Although the first-generation flowable composites were used only as liners due to low elastic modulus, second-generation flowables are developed for use in bulk restorations and as liner in class I and II restorations. Surefill SDR was marketed as a low-stress flowable base material that can be placed in layers up to 4mm in thickness without negatively affecting polymerization shrinkage, cavity adaptation or degree of conversion. Tetric Evo Ceram Bulk-fill was introduced to the market as a bulk-fill restorative material with the ability to place the restoration with a single increment (up to 4 mm). Nowadays a new sonic-activated bulk-fill system (Sonicfill, Kerr Corp, USA/KaVo, Germany) was introduced to the market for posterior bulk restorations. The Sonicfill system is a unique, sonic-activated bulk-fill system comprised of a specially designed hand piece and a new composite material in unidose tips. The composite is a combination of flowable and universal composites and incorporates a highly-filled proprietary resin with special modifiers that react to sonic energy [9] As sonic energy is applied to the hand piece with five different levels of flowability, the modifier causes the viscosity to drop (up to 87%), increasing the flowability of the composite. When the sonic energy is stopped, the composite returns to a more viscous, non-slumping state for carving and contouring. In addition, the manufacturer informs that increased levels of photoinitiators in the composite material allow a full 5 mm depth of cure in 20 seconds with a 550mW/cm^2 light source.

Direct posterior restorations play a significant role in dentistry. But achieving predictable and successful outcomes remains a main concern for practitioners, due to technique sensitivity and the numerous steps required for proper placement [10] In addition, several negative effects in resin-based composite restorations are frequently connected to polymerization shrinkage stress. Filling all of a tooth preparation with a composite at one time has obvious advantages for both patients and practitioners.

The bulk-fill materials can achieve a depth of cure of 6 mm. The physical and mechanical properties of dental composites are directly influenced by the degree of conversion achieved during polymerization [11]. Lower degree of conversion provides composites with an inferior mechanical properties and greater discoloration and degradation and as a result, restorations with poor wear resistance and poor color stability. In the study of Tiba *et al*. multiple bulk-fill (flowable and high viscosity) and incremental-fill resin composites were evaluated regarding depth of cure to be acceptable according to international standard4049. Three of the high viscosity bulk-fill resin composites (Sonic Fill, Kerr; Tetric Evo Ceram Bulk Fill, Ivoclar-Vivadent; Alert Condensable Composite, Pentron), one flowable bulk-fill composite (Filtek Bulk Fill Flowable Restorative, 3M ESPE), and one incremental-fill composite (Heliomoler HB, Ivoclar-Vivadent) did not achieve adequate depth of cure according to the standard. However all other materials tested either high viscosity bulk-fill resin composites (QuiXfil and x-tra fill) or flowable bulk-fill composites (SureFil SDR flow, Dentsply; Venus BulkFill, HeraeuseKulzer; x-tra base, Voco) and incremental-fill composite (Filtek Supreme Ultra Universal Restorative, 3M ESPE) attained the depth of cure claimed by the manufacturers and accepted by the standard. In another study, the depth of cure of Tetric Evo Ceram Bulk Fill (high viscosity bulk-fill composite) and x-tra base (flowable bulk-fill composite) were evaluated by FTIR spectrometer and the mentioned depth of cure values of these materials were 41.4% and 43.8%, respectively. In another work, the depth of cure of nine of the available bulk-fill (flowable and high viscosity) composites were measured and it was found a great diversity in the results with the depth of cure ranged from the lowest, 43.6%, for Filtek Bulk Fill (flowable) to the highest, 76.5% for Sonic Fill (high viscosity) [8].

Based on hardness results of bulk-fill resin composites, as a material class, the authors classify this material as between the flowable resin composites and the hybrid resin composites. The results of a previous study on hardness of bulk-fill materials (Tetric Evo Ceram Bulk Fill and x-tra base) confirmed that both materials enable at least 4 mm thick increments to be cured in one step. The x-tra base, although being a low viscosity bulk-fill material, showed a higher VHN than that of Tetric Evo Ceram Bulk Fill, a high viscosity bulk-fill material. Knoop hardness ratio of several bulk-fill versus incremental-fill resin composites was assessed and stated that all bulk-fill composites tested, except Alert Condensable Composite exhibited adequate hardness ratio that is comparable to that of the conventional incremental-fill composites [6]. The surface hardness of some of bulk-fill composite materials was significantly decreased after ethanol storage, which raises distress about long-term stability of these materials. There is a good correlation between the hardness and degree of conversion.

On the contrary, no correlation was found between depth of cure and microhardness of several resin composites. In addition, it is found that polymers with the same depth of cure displayed different hardness numbers.

Table 1: Properties of various bulkfill flowable composite

Materials	Composite Type	Depth of Cure	Needs Enamel Replacement Layer	Needs low viscosity liner
SureFil SDR Flow (Dentsply/Caulk)	Flowable	4mm	Yes	No
X-tra Base (Voco)	Flowable	4mm	Yes	No
Venus Bulk Flow (Heraeus Kulzer)	Flowable	4mm	Yes	No
Filtek Flow Bulk Fil (3M/Espe)	Flowable	4mm	Yes	No
TetricEvoCeram Bulk Fill (IvoclarVivadent)	Highly filled composite	4mm	No	Yes
X-tra Fill (Voco)	Highly filled composite	4mm	No	Yes
SonicFill (Kerr)	Highly filled composite	5mm	No	No

Currently, there is a growing trend among practitioners to use bulk-fill resin based composite materials because of their more simplified procedures. Manufacturers mentioned that the main advancement of bulk-fill composite materials, namely increased depth of cure, which probably results from higher translucency, and low polymerization shrinkage stress are related to modifications in the filler content and/or organic matrix with the help of advanced technology [5].

Adequate polymerization all over composite resin restorations is one of the main important factors influencing their clinical success. The degree of conversion is an important tool to estimate the physical, mechanical and biological properties of composite resin restorations. Higher degree of polymerization is an essential factor for obtaining superior physical and mechanical properties. Inadequate polymerization might lead to marginal microleakage, discoloration and decreased bonding strength of resin composite restorations. A lower degree of conversion might, also cause increase in the amount of released unreacted monomer, leading to less biocompatible restorations.[8] In addition, uncured functional groups can act as plasticizers, producing restorations with inferior mechanical properties. Furthermore, oxidation and hydrolytic degradation caused by monomer trapped in the restoration might result in discoloration and accelerated wear.

In short, these new bulk-fill products reduce the need for multiple layers when placing posterior composite restorations. In addition, flowable base materials (e.g. SureFill SDR Flow, Dentsply, Filtek Bulk Fill Flowable, 3M/ESPE) as well as a highly-filled composite that is vibrated into the cavity (i.e. SonicFill, Kerr), allow excellent adaptation to cavity walls [4]. This, in turn, results in fewer voids when compared to traditional layered materials and techniques. These advanced materials have required modifications in resin chemistry and in the case of SonicFill the addition of sonic energy technology to address depth of cure and shrinkage stress [6]. They have also necessitated a re-examination of the science of light curing, polymerization kinetics and shrinkage stress, especially considering the higher output of today's curing lights.

All of these newer bulk fill composite resin materials are too new to have long-term clinical trial data; however, they are proving popular with dentists and they continue to grow in the market place. Given the number of posterior composites dentists place in practice, this growth would seem unlikely if these new posterior composite materials and technologies weren't performing successfully.

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