SDR® Plus
Bulk Fill Flowable

Dentsply Sirona

The game changer for posterior composite restorations

By: Dr. Alan Atlas[46]

Over the past 40 years, composite resin has outpaced amalgam in clinical use extensively due to the demand for more esthetic restorations worldwide. Additionally, environmental concerns about amalgam resulted in either a decline or a ban in many countries and may eventually phase out in response to the Minamata convention.[1] However, a recent systematic review concluded composite resin posterior restorations have approximately double the failure rate of amalgam restorations.[2] Restoration fracture does not seem to be greater with composite resin restorations, but the risk of developing secondary caries is significantly higher. The major questions when evaluating the etiologies of failure are why there are more failures with composite than amalgam and what are the reasons for greater recurrent caries.

Dental manufacturers have made efforts to address these questions with improvements in filler composition, photo-initiators, and mechanical properties to improve wear and durability.[3,4] The process of photo-polymerization results in the resin monomers connecting together to make larger molecules called polymers which also join together forming a continuous network. However, the composite shrinks rapidly via this free radical process resulting in volumetric shrinkage in the range of 2-6% pending the type of composite used. When the composite is placed in a deep preparation after adhesive placement and is photo-polymerized, it has a limited ability to relax and flow creating stress within the material as well as the tooth-restoration interface that may result in debonding when the shrinkage stress is greater than the bond strength of the adhesive. Additionally, these stresses may continue and damage the restoration-adhesive interface during masticatory function.[5] The net result is a plethora of clinical complications including cuspal deflection, enamel cracking and larger marginal gap formation leading to greater bacterial colonization, secondary or recurrent caries, post operative sensitivity, pulpal inflammation and expedited failure.[6] The common hypothesis for many years was that as photo- polymerization was occurring the composite was shrinking towards the light. However, additional studies over the years postulated the direction was the result of boundary conditions or the ratio of bonded to unbonded cavity walls (C-factor) and less affected by the relation toward the light.[5,7,8]

Based on the complexities with polymerization shrinkage, different approaches to composite placement have been proposed to improve outcomes. Different light curing protocols such as soft-start, ramp cure and pulse delay have limited clinical evidence to suggest improved outcomes over the conventional light curing devices.[5] When first introduced, the first generation flowable composites were touted to suggest their low viscosity would create better adaptation to the dentin and help reduce effects of shrinkage based on their low modulus of elasticity. However, their elevated volumetric shrinkage from a low filler content and weak mechanical properties resulted in unfavorable clinical results compared to existing alternatives.[9] Several incremental placement protocols were presented to reduce the C-factor by minimizing the amount of composite in contact within the cavity walls and potentially allowing for more flow of the composite. However, pending on the protocol used, incremental filling may not reduce polymerization stress to the tooth.[10] Another disadvantage of multiple increments of 4 or more, is the increased time to do the procedure. If not using a rubber dam, the error potential increases making the procedure more technique sensitive, less efficient and less proficient.

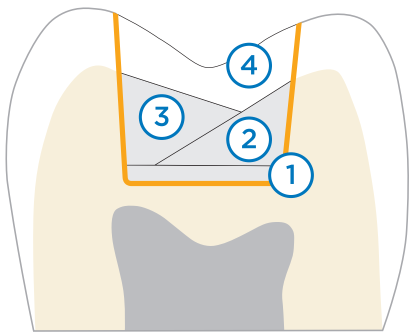

Figure 1: Illustration of a conventional layering approach for posterior composite restorations, consisting of an initial layer of flowable composite as liner (1), two triangular shaped layers of universal composite that aim at maximizing the amount of unbonded composite surface to reduce shrinkage stress build-up (2+3) and a final occlusal capping (4).

To answer this procedural risk, bulk-fill composite materials were introduced by dental manufacturers, starting in the late 1990's (e.g. Surefil® Composite by Dentsply Sirona), to expedite the extended procedure times of incremental filling techniques and curing by modifying translucencies and photoinitiators providing an enhanced depth of cure and thus allow the placement of larger increments. To manage shrinkage and stress build-up, those bulk-fill materials featured a high filler content, thereby minimizing volumetric shrinkage, and consequently require the dental practitioner to pack the material into the cavity to create the required adaptation. More recent materials of this category of packable/sculptable bulk fill composites were stated to be able to be used in up to 5 mm increments with lower polymerization shrinkage stress due to decreased filler amount or increased filler size and incorporation of stress modifiers.[11,12]

Since 2009 however, bulk-fill composites have to be subdivided into two groups based on viscosity. In addition to the high viscosity or packable/sculptable bulk-fills, low viscosity or flowable bulk-fills emerged as a new material category, with lower filler contents and weaker mechanical properties. Those materials are generally used as dentin replacements only requiring a 2-mm enamel capping layer of conventional composite.[12]

The polymerization shrinkage and polymerization shrinkage stresses of both types of bulk-fill composites have been analyzed and compared in several studies. [11,13,14,15,16,17,18,19,20,21,22,23]

What was concluded and stood out prominently from all the studies referenced was that one flowable bulk-fill chemistry had the lowest polymerization shrinkage stress **- SDR® Bulk Fill Flowable Composite**.

What is SDR® Bulk Fill Flowable Composite and why does it have the lowest polymerization shrinkage stress?

According to the manufacturer, SDR® Bulk Fill Flowable Composite in all of its varying brands around the globe (SDR® flow+, SDR® Plus, and SDR® Bulk Fill Flowable Composites) is a one-component, fluoride-containing, visible light cured, radiopaque composite. SDR® Bulk Fill Flowable Composite has handling characteristics typical of a flowable composite, however, can be placed in 4 mm increments with minimal polymerization stress. SDR® Bulk Fill Flowable Composite has a self-leveling feature that allows intimate adaptation to the prepared cavity walls.

When used as a base/liner material in Class I and II restorations, it is designed to be overlayed with a methacrylate-based universal/posterior composite for replacing missing occlusal/facial enamel. It is also suitable as a stand-alone restorative material in conservative Class I, Class III and V restorations without a separate capping being applied on top. To ensure esthetic appearance in Class III and V restorations, the shade range has been expanded to A1, A2 and A3 shades in addition to the universal shade.

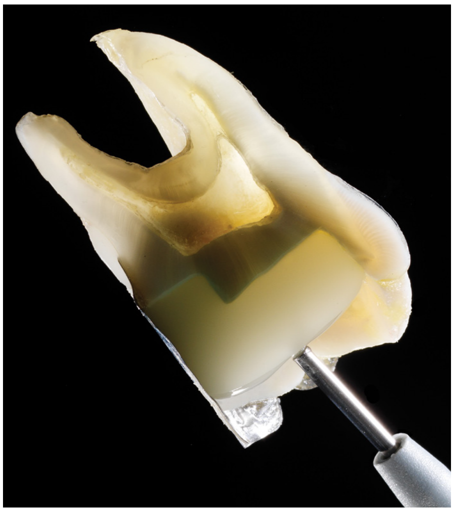

Figure 2: Application of SDR® Plus Bulk Fill Flowable Composite in a sectioned tooth, illustrating the excellent adaptation of the materials into the proximal box and to the cavity walls.

The SDR® Bulk Fill Flowable Technology exhibits a patented urethane dimethacrylate structure (UDMA) that allows for a volumetric shrinkage of only 3.5%, which puts it on the low end in overall shrinkage compared to other flowable composites. Though, lower volumetric shrinkage can contribute to overall lower polymerization stress reduction, it is the polymerization pattern and the patented and therefore unique UDMA structure that is key to stress reduction.

Compared to conventional resin systems, the SDR® Bulk Fill Flowable Composite forms large molecular structures upon polymerization that, according to the manufacturer, include a chemical moiety called "polymerization modulator". The high molecular weight and the conformational flexibility around the centered modulator impart optimized flexibility and network structure to SDR® Bulk Fill Flowable Composite. The SDR® Bulk Fill Flowable Composite Technology is able to dissipate more energy during polymerization, thereby inherently reducing the shrinkage stress.

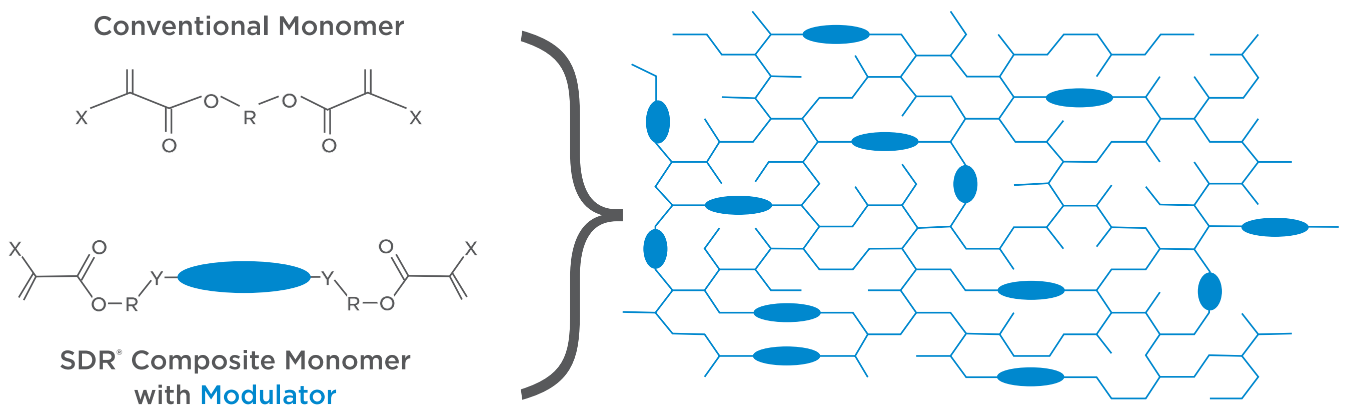

Figure 3: Illustration of the SDR® Bulk Fill Flowable Composite monomer with a molecular weight of 849 g/mol compared to 513 g/mol for conventional Bis-GMA, and the modulator component. The high molecular weight and the conformational flexibility around the centered modulator impart optimized flexibility and network structure to SDR® Bulk Fill Flowable Composite .

As a result, SDR® Bulk Fill Flowable Composite provides an approximately 20% reduction in volumetric shrinkage and almost an 80% reduction in polymerization stress compared to conventional methacrylate resins.

In comparison of the original chemistry, the resin matrix and filler paste have been modified in the currently available SDR® Bulk Fill Flowable Products (SDR® flow+ / SDR® Plus). The filler load has been increased by 2.5% pts to strengthen the material, improve its radiopacity and reduce its wear.
The previous glass filler has been partially replaced by an alternative filler which provides higher strength. The resin was also re-formulated to adjust to the overall consistency of the new filler loading and retain the flowability and self-leveling, key characteristics of SDR® Bulk Fill Flowable Composite. The patented and therefore unique characteristics of the first generation SDR® Bulk Fill Flowable Material were preserved while increasing the wear resistance to the level of standard flowable composites and the radiopacity by approximately 20% to 2.6 mm Al.

How does SDR® Bulk Fill Flowable perform in the in-vitro studies and clinical trials?

At the onset of research on SDR® Bulk Fill Flowable Composite, several studies demonstrated its ability to bond well to the cavity floor in high C-factor restorations at 4 mm increments.[24,25,26] In the direct Class 2 posterior composite restoration, the goal for the clinician is to apply materials that reduce polymerization shrinkage and shrinkage stress and work effectively on enamel, as well as in the proximal box of deep restorations where dentin and cementum become primary concerns for long-term success. Therefore, the type of composite resin used in the proximal box may play a critical role in the marginal adaptation of a Class 2 posterior composite restoration.

Using SDR® Bulk Fill Flowable Material in the open-sandwich technique for placement of a Class 2 posterior composite restoration allows a layer placed as dentin replacement extending from the gingival box floor up to 4 mm. With the remaining top or enamel layer of at least 2 mm all proximal margins exposed to the oral cavity are sealed, which is of primary concern for long-term clinical success.

For in-vitro studies, new technologies have been introduced to assess marginal adaptation of different types of composites in class 1 and 2 posterior composite restorations. Microcomputed tomography (µ-CT) allows for non-destructive evaluation of the restorative interface in two and three dimensions and can measure volumetrically in microns the marginal integrity and internal adaptation of the restorative materials studied.[8,19,27] A recent study[28] evaluated three bulk-fill composite resins, SDR® Bulk Fill Flowable, 3M™ Filtek™ One Bulk Fill† and Tetric®N-Ceram Bulk Fill† against a conventional composite resin Filtek™ Z350† in caries free and crack free human molars prepared with a MOD restoration. The teeth were thermocyled and cyclic loaded to mimic aging and stresses in the oral cavity during function. Micro-CT was performed on each sample to measure the interfacial gap at the restorative interface. The results demonstrated that SDR® Bulk Fill Flowable had the smallest gap volume of all tested composite resins. An additional in-vitro Micro-CT study[19] on Class 1 restorations concluded SDR® Bulk Fill Flowable exhibited less volumetric polymerization shrinkage compared with the other flowable groups, Permaflo™†, Filtek™ Bulk-fill flow†, and Vertise™ flow†.

Swept-Source Optical Coherence Tomography (SS-OCT) is another in-vitro technology developed to visualize how composites behave while undergoing light polymerization using real-time video display. Two studies[29,30] concluded SDR® Bulk Fill Flowable Composite had a slower polymerization rate and a delayed gel point of resin matrix increasing its flow capacity as demonstrated by a lower incidence of voids and better internal dentin adaptation at both 2 mm and 4 mm depths compared to a conventional flowable composite. Another SS-OCT study[31] demonstrated that SDR® Bulk Fill Flowable Composite had a low shrinkage stress making it ideal as an intermediate dentin replacement layer for better internal adaptation compared to other bulk-fill composites.

A biocompatibility study[32] found that only SDR® Bulk Fill Flowable and one other bulk fill composite demonstrated cell viability above 70% at a 4mm increment, whereas two standard composites, two bulk-fill pre-reacted glass ionomer composites and one other bulk-fill composite showed lower cell viability.

In studies assessing the degree of conversion and depth of cure when light curing bulk fill composites, SDR® Bulk Fill Flowable material showed significantly higher conversion degrees at the bottom and top surface than the other composites tested. Shorter curing times (10 seconds) significantly reduced the polymerization of Filtek™ Bulk Fill† and x-tra base†. SDR® Bulk Fill Flowable demonstrated high polymerization in 4 mm thick bulks reaching the conversion degree of 2 mm thick composite layers. SDR® Bulk Fill Flowable, in the manufacturer's light-curing time, cured properly in 4 mm. Higher radiant exposure of SDR® Bulk Fill Flowable had no adverse effect on its polymerization shrinkage. Flowable bulk-fill composites like SDR® Bulk Fill Flowable performed better regarding polymerization efficiency at 10 seconds compared to high viscosity bulk-fill composites like SonicFill™† that required 20 seconds.[33,34,35,36]

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Clinical trials of class 2 posterior composites published using SDR® Bulk Fill Flowable Material have been both retrospective and randomized controlled in methodology. A recent retrospective study[37] of SDR® Bulk Fill Flowable Composite used in two increments as a 4 mm dentin increment with a 2 mm enamel layer of a conventional composite versus a conventional composite used in three 2 mm increments resulted in the SDR® Bulk Fill Flowable group performing better over a 3-year period. The authors concluded the use of SDR® Bulk Fill Flowable Composite may provide a reduced procedure time for posterior composites over conventional composites and extended incremental techniques.

A recent 4-year randomized prospective split-mouth evaluation of bulk fill flowable composites in class 2 posterior composite restorations compared a conventional microhybrid composite resin Amelogen Plus†, Ultradent†) against a flowable bulk-fill and nanoparticulate composite resins (Filtek™ Bulk Fill Flow† + Filtek™ Z350XT†, 3M™/Espe†); and flowable bulk-fill and microhybrid composite resins, (SDR® Bulk Fill Flowable + TPH®3 Composite, Dentsply). The results demonstrated that the SDR® Bulk Fill Flowable/TPH®3 Composite group had better performance for wear and surface staining than the other groups.[38]

A 6-year randomized controlled study[39] evaluated a flowable resin composite bulk-fill technique in posterior restorations and compared it with a conventional 2-mm composite layering technique for Class 1 and 2 posterior composite restorations. Thirty-eight pairs of Class II restorations and 15 pairs of Class I restorations were placed in 38 adults.

In the first cavity of each pair, the flowable resin composite (SDR® Bulk Fill Flowable) was placed, in bulk increments of up to 4 mm. The occlusal aspect was finished with a layer of nanohybrid resin composite. In the second cavity of each pair, the hybrid resin composite was placed in 2-mm increments. After 6 years, 72 Class II restorations and 26 Class I restorations could be evaluated. Six failed Class II molar restorations, three in each group, were observed, resulting in a success rate of 93.9% for all restorations and an annual failure rate (AFR) of 1.0% for both groups. The main reason for failure was resin composite fracture and not secondary caries.

The investigators were able to replicate those results in a 5-year randomized controlled study[45] that followed a similar protocol with 38 pairs of Class I and 62 pairs of Class II restorations (first restoration with 4 mm SDR® Bulk Fill Flowable Composite + nano-hybrid resin, second restoration with nano-hybrid resin composite in 2 mm increments) placed in 86 patients.

After 5 years, 68 Class I and 115 Class II restorations could be evaluated. Ten restorations failed with four in the SDR® Bulk Fill Flowable Composite and six in the control group due to tooth fracture and secondary caries, resulting in a success rate of 94.5% for all restorations and an annual failure rate (AFR) of 1.1% for the SDR® Bulk Fill Flowable group and 1.3% for the control group.

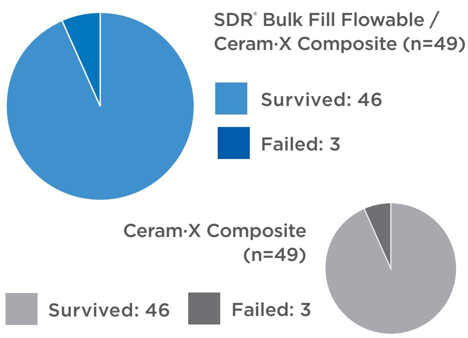

Figure 4: 6-year survival rates of Class I and II restorations filled with SDR® Plus Bulk Fill Flowable and capped with a universal composite (Ceram•X® Nano Ceramic Restorative by Dentsply Sirona) in comparison to layered restorations in the same patients, using a universal composite (Ceram•X® Nano Ceramic Restorative by Dentsply Sirona).[39]

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Conclusion

Developed in 2009, flowable bulk fill composites with SDR® Bulk Fill Flowable Composite technology became the first composite resin that allowed 4mm bulk placement in flowable nature. Now, over 13 years later, SDR® Bulk Fill Flowable Composite has established itself as the most important development in composite resin technology and biggest game changer for posterior composite restorations. The success of a class 2 composite resin is dependent upon placing a material in the most constricted area of the restoration, the gingival box. Placement of SDR® Bulk Fill Flowable Composite not only seals that gingival margin better than conventional and other bulk fill composites but in combination with only 1-2 increments of the enamel top layer with a nano-hybrid composite can expedite the technique and oral environment sensitive procedure compared to traditional multiple small increment protocols.[40]

Glass Ionomers and Resin Modified Glass Ionomers used either as dentin replacements or as total bulk fill restorations have failed to demonstrate success in the clinical trials according to a recent systematic review and meta-analysis.[41] Current resin composites are not designed to release substantial quantities of calcium, phosphorus and fluoride that could be applicable for bioactivity of dentin and enamel. Furthermore, there is insufficient scientific evidence for using products that claim bio-remineralization of the restoration interface based on company sponsored in-vitro studies.[42] Recent independent clinical trials for these dental materials have not produced assuring outcomes.[43,44]

Many materials have tried to imitate the SDR® Bulk Fill Flowable Composite but no other dental material has been studied as extensively or ever duplicated the successful clinical results of over a hundred million restorations produced using SDR® Bulk Fill Flowable Composite technology. In-vitro studies and clinical trials have clearly demonstrated that no other material available to dentists all over the world is better than SDR® Bulk Fill Flowable Composite as the true bulk fill dentin replacement material for every composite restoration.

About the Author[46]

Dr. Alan Atlas maintains a full-time private practice dedicated to esthetic and comprehensive restorative dentistry located in Philadelphia, Pennsylvania. Dr. Atlas received his D.M.D degree from the University of Pennsylvania School of Dental Medicine and currently holds a dual appointment as Clinical Professor in the Department of Endodontics and the Department of Preventive/Restorative Sciences. He is Director of Restorative Microscopy at Penn Dental Medicine teaching student's precision restorative dentistry utilizing the dental microscope with digital technologies. Dr. Atlas is an internationally recognized lecturer and researcher whose unique academic and private practice perspective is focused on applying scientific based protocols to general and advanced clinical dentistry. His presentations span worldwide including Japan, Africa, Australia, Middle East, China, South Korea, Europe and all major meetings in the United States.

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46. Dr. Atlas has been compensated for writing this article.

ML1C0053Bb (6/22/23)

