REVIEW ARTICLE

International Journal of Dental Materials (ISSN: 2582-2209 (Online))
DOI: http://dx.doi.org/10.37983/IJDM.2026.8205

Smart Dentin Replacement Plus (SDR+): Composition, Polymerization Behaviour, Mechanical Properties, and Clinical Evidence: A Narrative Review

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Article History
Received: 26th April 2026
Accepted: 14th June 2026
Published: 24th June 2026

Abstract

Smart Dentin Replacement Plus (SDR+) is a bulk-fill flowable composite designed for use as a dentin replacement material in posterior restorations. This narrative review aimed to summarise the composition, polymerisation behaviour, mechanical properties, clinical applications, and the available scientific evidence for SDR+. A literature search was conducted using PubMed, Scopus, and Google Scholar to identify relevant in vitro studies, clinical trials, and review articles on SDR+ and bulk-fill resin composites. SDR+ is based on a modified urethane dimethacrylate (UDMA) resin system that incorporates stress-modulating polymerisation technology. Available evidence suggests that SDR+ demonstrates reduced polymerization shrinkage stress, adequate depth of cure up to 4 mm, and satisfactory mechanical properties for use as a dentin replacement material. Clinical studies have reported favourable marginal adaptation, low postoperative sensitivity, and clinical performance comparable to conventional incremental composite techniques. In addition, optimised resin–filler balance improves handling characteristics and radiopacity without altering the material's fundamental stress-reducing mechanism. Within the limitations of currently available evidence, SDR+ appears to be a reliable and simplified alternative to incremental composite placement techniques in posterior restorations. However, further long-term clinical studies are required to confirm its durability and long-term clinical success.

Keywords: Bulk-fill composite, Dentin replacement, Polymerization shrinkage stress, Posterior restorations.

Cite this article as: Karale AG, Mathur M. Smart Dentin Replacement Plus (SDR+): Composition, Polymerization Behaviour, Mechanical Properties, and Clinical Evidence: A Narrative Review. **Int J Dent Mater. 2026;8(2):66-72.**

1. Introduction

The evolution of resin composite materials has been driven by the demand for restorations that combine esthetics, durability, and biological compatibility with simplified clinical protocols. Conventional resin composites, although capable of producing highly esthetic and functional restorations, are associated with inherent limitations such as polymerization shrinkage, shrinkage stress development, limited depth of cure, and technique sensitivity [1]. These limitations have traditionally been addressed through incremental placement techniques, which aim to reduce polymerization stress and ensure adequate curing. However, incremental layering increases chairside time, complexity, and the risk of void incorporation or contamination between layers [2].

Bulk-fill resin composites were introduced to overcome these challenges by enabling placement in thicker increments without compromising polymerization quality or mechanical performance [2]. Modifications to resin chemistry, filler composition, translucency, and photoinitiator systems have enabled bulk-fill materials to achieve greater depth of cure and reduced polymerisation stress compared with conventional composites [3]. Smart Dentin Replacement Plus (SDR+) is a low-viscosity, bulk-fill, flowable composite designed primarily for dentin replacement. It is intended to be placed in a single increment and subsequently covered with a conventional composite resin to restore occlusal anatomy and wear resistance [4]. The material incorporates a stress-modulating resin technology that alters polymerization kinetics, thereby reducing shrinkage stress development at the tooth–restoration interface. Since its introduction, SDR+ has gained widespread clinical acceptance, particularly in posterior restorations [5].

Despite its increasing clinical use, the available evidence regarding its composition, mechanical performance, polymerization behaviour, and long-term clinical effectiveness remains dispersed across laboratory investigations, clinical studies, and review articles. Therefore, this narrative review aimed to comprehensively evaluate the composition, polymerization behaviour, mechanical and physical properties, clinical applications, and available scientific evidence related to SDR+, while highlighting its advantages, limitations, and potential role in contemporary restorative dentistry.

2. Composition and material characteristics

The composition of SDR+ composite is presented in Table 1. SDR+ is based on a modified urethane dimethacrylate (UDMA) resin matrix that incorporates a proprietary polymerization modulator [3]. This modulator is chemically integrated into the resin backbone and is designed to control the rate of polymer network formation during curing. Unlike conventional flowable composites, which rely primarily on filler loading to reduce shrinkage, SDR+ modifies polymerization kinetics to achieve stress reduction [6].

The organic resin matrix of SDR+ includes modified UDMA, ethoxylated bisphenol A dimethacrylate (EBPADMA), and triethylene glycol dimethacrylate (TEGDMA) [4]. The inorganic filler system consists predominantly of barium- and strontium-based alumino-fluoro-silicate glass particles, which provide radiopacity and mechanical reinforcement [7].

The photoinitiator system is primarily camphorquinone-based, allowing effective polymerization with conventional light-curing units. Increased translucency of the material enhances light transmission, facilitating adequate curing at depths of up to 4 mm [3,7].

3. Difference between SDR and SDR+

Smart Dentin Replacement (SDR) and Smart Dentin Replacement Plus (SDR+) belong to the same bulk-fill flowable composite family; however, SDR+ is not merely a rebranding. It represents a refined formulation developed to improve clinical handling, esthetics, and performance while retaining the stress-modulating technology of the original SDR. The key differences between SDR and SDR+ are summarised in Table 2.

3.1 Polymerization mechanism of SDR+

SDR+ incorporates a patented polymerization modulator chemically embedded within a modified urethane dimethacrylate (UDMA)-based resin matrix. Upon light activation, free radicals generated by the camphorquinone photoinitiator system initiate monomer conversion and polymer network formation [3,5]. Unlike conventional methacrylate-based composites, the stress-modulating polymerization modulator slows the rate of cross-linking during the pre-gel phase (Figure 1).

Table 1. Composition of Smart Dentin Replacement Plus (SDR+)

Component	Description	Function	Reference(s)
Resin matrix	Modified urethane dimethacrylate (UDMA)	Stress-modulating polymer backbone	3,4
Diluent monomers	EBPADMA, TEGDMA	Improved flowability and handling	3,7
Inorganic fillers	Barium- and strontium-based alumino-fluoro-silicate glass	Mechanical reinforcement and radiopacity	4,5
Filler particle size	Wide particle size distribution (nano–micron range)	Enhanced adaptation and translucency	3
Photoinitiator system	Camphorquinone-based	Light-activated polymerization	3,7
Radiopacifier	Barium/strontium glass	Radiographic visibility	4

Table 2. Key differences between SDR and SDR+

Properties	SDR	SDR+	Clinical Relevance
Resin chemistry	Stress-modulating UDMA-based resin	Optimized stress-modulating UDMA resin	Maintains low shrinkage stress with improved handling.
Filler technology	Conventional glass fillers	Optimized filler distribution	Improved flow, adaptation, and polishability.
Translucency	Higher translucency	Balanced translucency	Better depth of cure with improved esthetics.
Shade availability	Limited (mainly universal shade)	Multiple shades	Improved shade matching and versatility.
Radiopacity	Adequate	Enhanced	Better radiographic assessment.
Handling characteristics	Good flowability	Improved viscosity control	Easier placement, reduced slumping.
Intended use	Dentin replacement	Dentin replacement (updated formulation)	Same indication with improved clinical performance.

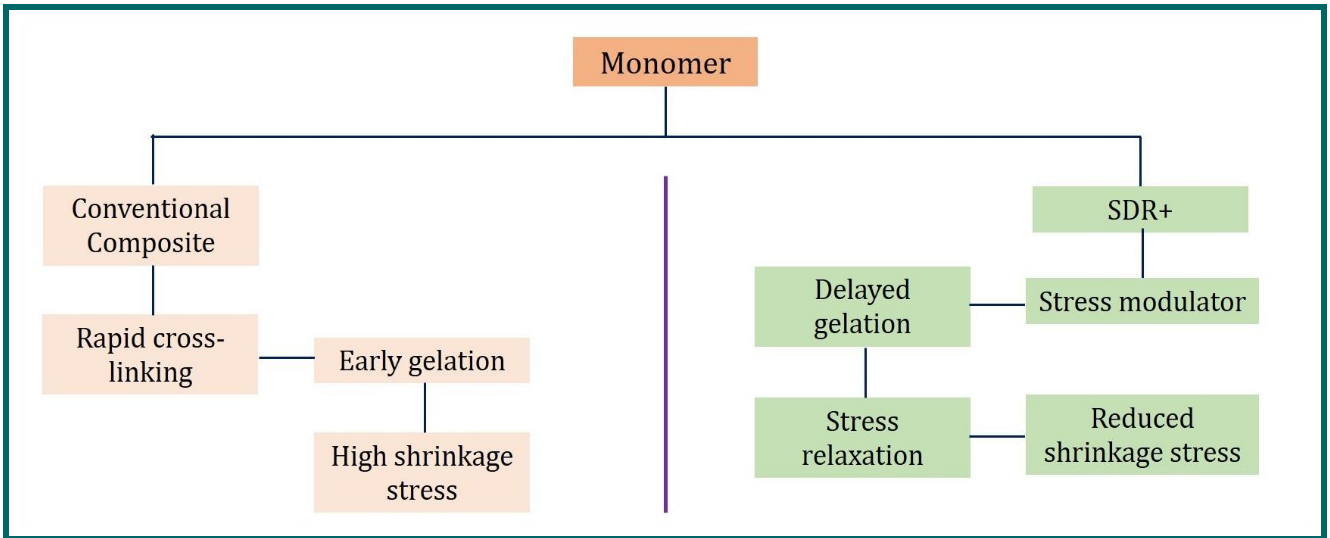

Figure 1. Comparing polymerizing pathways: Conventional vs SDR+

This delayed network formation prolongs the flowable stage of the material, allowing internal stress relaxation before the composite reaches its gel point. As a result, polymerization shrinkage stress is significantly reduced despite achieving a comparable degree of conversion. This mechanism enables SDR+ to maintain adequate depth of cure while minimizing interfacial stress, marginal gap formation, and postoperative sensitivity [3,5,8].

4. Scientific rationale for the modification

The original Smart Dentin Replacement (SDR) material was developed to address polymerization shrinkage stress through the incorporation of a stress-modulating polymerization modifier within a urethane dimethacrylate (UDMA)-based resin matrix [1]. This approach was shown to significantly reduce shrinkage stress compared with conventional flowable and packable composites [2].

Subsequent refinements leading to the development of Smart Dentin Replacement Plus (SDR+) were driven by the need to optimize clinical handling, radiopacity, and esthetic integration without altering the fundamental stress-reducing chemistry [3]. Laboratory investigations and manufacturer disclosures indicate that SDR+ incorporates an optimized resin–filler balance, including refined filler particle distribution and adjusted proportions of diluent monomers. These modifications improve viscosity control, cavity wall adaptation, and radiographic visibility while preserving polymerization kinetics similar to those of the original SDR [5].

Importantly, both SDR and SDR+ are evaluated under the framework of ISO 4049, which emphasizes performance-based criteria such as depth of cure, flexural strength, and radiopacity rather than disclosure of exact percentage composition [6]. Consequently, the evolution from SDR to SDR+ represents a formulation optimization aimed at improving clinical usability while maintaining compliance with international material standards [3].

From a clinical standpoint, the compositional refinements introduced in SDR+ translate into improved handling characteristics, enhanced radiopacity, and expanded shade availability, without compromising the low polymerization shrinkage stress that characterized the original SDR material. Improved viscosity control facilitates placement in deep and high C-factor cavities, reducing the risk of void formation and improving adaptation to cavity walls [7].

Clinical and laboratory studies evaluating bulk-fill flowable composites, including SDR+, have reported favorable marginal integrity, reduced postoperative sensitivity, and survival rates comparable to conventional incremental composite techniques when used as a dentin replacement material and covered with an occlusal composite [4,8,9]. These findings suggest that the modifications incorporated in SDR+ enhance clinical predictability while maintaining the original indication of the material [5]. It remains essential that SDR+ be used in accordance with manufacturer recommendations and covered with a conventional composite in stress-bearing areas, as its flowable nature limits its wear resistance when exposed directly to occlusal loading [8].

5. Properties of SDR+

5.1 Polymerization behaviour and shrinkage stress

Polymerization shrinkage and the associated stress remain critical challenges in adhesive dentistry. During polymerization, volumetric contraction occurs as monomer molecules are converted into a cross-linked polymer network. When contraction is constrained by adhesion to cavity walls, stresses develop at the tooth–restoration interface, potentially leading to marginal gap formation, postoperative sensitivity, and secondary caries [8]. SDR+ incorporates a stress-decreasing resin technology that modifies polymerization kinetics, particularly during the pre-gel phase. By slowing polymer network formation, the material allows stress relaxation before reaching the rigid gel phase. This mechanism differs from traditional approaches that rely on incremental placement or reduced filler loading [3,5]. Multiple *in vitro* studies have demonstrated that SDR+ exhibits significantly lower polymerization shrinkage stress compared with conventional flowable and packable composites [3,5,8]. This property is especially beneficial in cavities with a high configuration factor (C-factor), such as Class I and Class II restorations, where polymerization stress is typically highest.

5.2. Mechanical and physical properties

Although SDR+ is primarily intended as a dentin replacement material, its mechanical and physical properties are critical for clinical performance [1]. Laboratory investigations have evaluated parameters including compressive strength, flexural strength, elastic modulus, wear resistance, depth of cure, and radiopacity [3,7]. The mechanical and physical properties of SDR+ are summarized in Table 3.

The compressive strength of SDR+ has been reported to range from approximately 240–300 MPa, which is comparable to that of conventional posterior resin composites and supports its use as a dentin replacement base material. Flexural strength values ranging from 110–140 MPa have also been reported, meeting ISO 4049 requirements for resin-based restorative materials [10-12]. In addition, SDR+ exhibits an elastic modulus of approximately 6–10 GPa, which is closer to that of natural dentin than highly filled packable composites, thereby allowing stress absorption and potentially reducing interfacial stress during polymerization and functional loading.

Depth of cure studies have demonstrated adequate polymerization at increment thicknesses up to 4 mm, attributed to the material's increased translucency and stress-modulating resin chemistry [3,7]. Wear resistance investigations indicate that SDR+ performs satisfactorily when used as a base or liner; however, it demonstrates lower wear resistance than highly filled packable composites when directly exposed to occlusal loading [4,6]. Consequently, SDR+ is recommended to be covered with a conventional composite in stress-bearing areas.

Radiopacity values of SDR+ have been reported to exceed that of an equivalent thickness of aluminum, fulfilling ISO 4049 requirements due to the presence of barium- and strontium-containing fillers [4]. This high radiopacity facilitates postoperative radiographic evaluation and detection of recurrent caries. The comparison of physical and mechanical properties of SDR+ with the human dentin is presented in Table 4.

6. Clinical applications of SDR+

SDR+ is primarily indicated as a bulk-fill base or liner in posterior restorations. Its flowable consistency allows excellent adaptation to cavity walls, internal line angles, and irregularities, thereby reducing the risk of void formation [5,6]. Common clinical applications include class I posterior restorations, class II restorations as a dentin replacement layer, deep cavities requiring bulk placement, endodontically treated teeth as a core build-up material, and minimally invasive restorative procedures. Clinically, SDR+ is typically placed in a single increment of up to 4 mm and light-cured according to manufacturer recommendations. A conventional nano-hybrid or packable composite is subsequently applied to restore occlusal anatomy and provide long-term wear resistance [2,6,13,14].

7. Clinical performance of SDR+

Clinical studies evaluating SDR+ have reported favorable short- and medium-term outcomes. Parameters such as marginal adaptation, postoperative sensitivity, retention, and secondary caries have demonstrated performance comparable to or better than conventional incremental composite techniques [5].

Recent systematic reviews have demonstrated that bulk-fill composite restorations exhibit clinical performance comparable to incremental layering techniques over follow-up periods ranging from 6 months to 10 years [15]. A retrospective clinical study reported favourable durability and survival rates for bulk-filled posterior restorations over a 3-year follow-up period [16]. Furthermore, recent randomized clinical trials have shown low postoperative sensitivity and acceptable marginal integrity with bulk-fill restorative materials [17,18]. Prospective clinical trials with follow-up periods ranging from 12 months to 5 years have shown high survival rates and acceptable clinical scores for posterior restorations using bulk-fill materials, including SDR+ [9].

Systematic reviews and meta-analyses on posterior composite restorations suggest that bulk-fill techniques do not compromise clinical longevity when compared with conventional incremental pla-

Table 3. Mechanical and physical properties of SDR+

Property	Reported Characteristics	Clinical Relevance	Reference(s)
Depth of cure	Effective curing up to 4 mm	Enables bulk placement	3,7
Polymerization shrinkage stress	Significantly reduced vs conventional composites	Improved marginal integrity	3,5,8
Elastic modulus	Comparable to dentin	Stress absorption at adhesive interface	1,3
Compressive strength	Comparable to posterior composites	Functional support as dentin replacement	1,3
Wear resistance	Moderate (inferior to packable composites)	Requires occlusal capping	4,6
Radiopacity	High (meets ISO standards)	Radiographic evaluation	4

Table 4. Comparison of physical and mechanical Properties of SDR+ and human dentin

Property	SDR+	Human Dentin	Reference(s)
Compressive Strength (MPa)	240–300	230–370	3, 13
Flexural Strength (MPa)	110–140	150–212	7, 13
Elastic Modulus (GPa)	6–10	12–20	3, 7, 13
Vickers Hardness (VHN)	45–60	50–70	13
Depth of Cure (mm)	Up to 4	Not applicable	3, 7
Radiopacity	>Aluminum equivalent	Natural tooth structure	4

Table 5. Summary of clinical and laboratory studies evaluating sdr+ and bulk-fill techniques

Author (Year)	Study Design	Follow-up	Main Findings
Roggendorf *et al.* (2011)	*In vitro* marginal adaptation study	*in vitro*	SDR+ demonstrated improved marginal adaptation compared with conventionally layered composites.
Van Dijken & Pallesen (2016)	Randomized controlled clinical trial (posterior restorations)	5 years	High survival rates of bulk-fill restorations, comparable to incremental composite techniques.
Ilie & Stark (2015)	Laboratory mechanical and curing evaluation	Laboratory study	SDR+ achieved an adequate degree of cure at 4-mm thickness.
Chesterman *et al.* (2017)	Narrative review of bulk-fill composites	Review	Bulk-fill materials, including SDR+, showed favourable clinical and laboratory outcomes.
Van Ende *et al.* (2017)	Narrative literature review	Review	SDR+ demonstrated reduced polymerization shrinkage stress compared with conventional composites.

Table 6. Advantages and limitations of SDR+

Advantages	Disadvantages
• Reduced polymerization shrinkage stress [3,8]. • Simplified and time-efficient placement [2]. • Improved adaptation to cavity walls [5]. • Reduced risk of void formation and interlayer contamination.	• Requires coverage with a conventional composite in occlusal areas [4]. • Not intended as a standalone restorative material in high-stress regions. • Limited long-term clinical data beyond five years [6,9].

cement, provided materials are used according to manufacturer recommendations [2,9]. However, long-term randomized controlled trials lasting more than 5 years remain limited, highlighting the need for continued clinical evaluation (Table 5).

8. Advantages and limitations

The advantages and limitations of SDR+ are summerized in Table 6.

9. Clinical significance

Bulk-fill flowable composites have simplified posterior restorative procedures by reducing technique sensitivity and chairside time. Smart Dentin Replacement Plus (SDR+) demonstrates reduced polymerization shrinkage stress, favourable handling characteristics, and reliable depth of cure, making it a clinically effective dentin replacement material [19,20]. When used according to manufacturer recommendations and covered with an appropriate occlusal composite, SDR+ offers predictable marginal adaptation, reduced postoperative sensitivity, and satisfactory short- to medium-term clinical performance in posterior restorations [21,22].

10. Future perspectives

Ongoing research in resin composite technology continues to focus on improving bulk-fill materials with enhanced mechanical strength, wear resistance, and esthetic properties. Advances in photoinitiator systems, filler technology, and resin chemistry may allow future materials to combine simplified bulk placement with the durability of conventional restorative composites [2,14]. For materials such as SDR+, future developments may include formulations suitable for definitive restorations without the need for an occlusal capping layer. Additionally, long-term randomized clinical trials will be essential to validate their performance under functional conditions.

11. Conclusion

Smart Dentin Replacement Plus (SDR+) represents a significant advancement in bulk-fill composite technology. Its stress-modulating resin chemistry, favourable handling characteristics, and simplified placement technique address many limitations associated with conventional incremental composite restorations. Available laboratory and clinical evidence suggest that SDR+ provides reduced polymerization shrinkage stress, satisfactory mechanical properties, and favourable short- to medium-term clinical outcomes. When used as a dentin replacement material and combined with an appropriate capping composite, SDR+ is a reliable and evidence-based option for posterior restorations in contemporary restorative dentistry. Continued long-term clinical research is warranted to further establish its durability.

Conflicts of interest: The Authors declared no conflicts of interest.

Financial support: None

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