

# Functional and Aesthetic Guidelines for Stress-Reduced Direct Posterior Composite Restorations

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## Clinical Relevance

A step-by-step “stress-reducing direct composite” technique is recommended to reduce postoperative sensitivity and improve the clinical performance of composite restorations.

## SUMMARY

Amalgam has been used in the restoration of structurally compromised posterior teeth for many years. When placing large amalgam restorations, replacement of weak cusps with restorative material is recommended to prevent tooth fracture. This recommendation can be modified with new guidelines using modern adhesive techniques. Semidirect and indirect inlay/onlay composite restorations have progressively replaced amalgam restorations over the past 20 years. Lately, single visit direct resin-bonded composite (RBC) restorations have also been used as a viable alternative to conventional indirect restorations. This paper is intended to introduce a step-by-step proto-

col for the direct restoration of structurally compromised posterior teeth using RBCs with stress-reducing protocols.

## INTRODUCTION

The most recent American Dental Association (ADA) statement on resin-bonded composites (RBCs) endorses the use of posterior composites in 1) small and moderately sized restorations, 2) conservative tooth preparations, and 3) areas where esthetics are important.<sup>1</sup> These include Classes I and II, replacement of failed restorations, and primary caries. Teeth needing either larger or cusp replacement restorations are usually treatment planned for both indirect laboratory-fabricated composite resin and ceramic inlay/onlay restorations. A meta-analysis of studies conducted in the 1990s reported an annual failure rate of 2.2% for direct posterior composite restorations, 2.9% for resin composite inlays, and 1.9% for ceramic restorations.<sup>2</sup> As the basic chemistry of indirect RBCs remains similar to that of the direct materials, differences in mechanical proper-

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DOI: 10.2341/11-082-T

ties are minimal and not expected to be clinically significant.<sup>3</sup> Despite the ADA recommendation, dentists are stretching the clinical indications for direct RBC restorations.<sup>4,5</sup> Brunthaler and others<sup>6</sup> found a linear correlation between the size of the restoration and the observation period and the failure rate; conversely, Brackett and others<sup>7</sup> reported no difference in the clinical performance of medium-size vs large direct RBCs.

RBCs have been used to restore posterior teeth since the 1970s<sup>8</sup> and have been researched extensively in the last 40 years; the drawbacks of composite resin are well known. Concerns still exist with regard to composite wear,<sup>9</sup> less-than-ideal bonding to dentin,<sup>10</sup> stress from polymerization shrinkage,<sup>11</sup> and technique sensitivity.<sup>12</sup>

In fairness, one must realize that the evolution of both composite materials, adhesive, and light-curing systems has advanced rapidly over the last two decades. However, both researchers and clinicians have been waiting for further material technology improvement from the manufacturer side; conversely, they have not focused enough on the development of a step-by-step protocol to improve the clinical performance of RBC restorations.

As matter of fact, many factors contribute to the achievement of clinical success with direct posterior RBC restorations: 1) analysis of the occlusion, 2) complete excavation of dental caries and proper cavity preparation, 3) analysis of residual tooth structure, 4) proper selection and application of the dentin bonding System, 5) control of polymerization stresses by using appropriate layering and curing techniques, and 6) occlusal force equilibration. The goal of this paper is to provide esthetic and functional guidelines for the restoration of structurally compromised posterior teeth using a “stress-reducing direct composite” (SRDC) technique.

## MATERIALS AND METHODS

### Step-by-Step Protocol Through Case Presentation

A 27-year-old female patient presented with a failing restoration in a lower molar tooth replacing both the distal marginal ridge and a facial cusp (#36). The patient's tooth was restored with a direct composite resin 1 year earlier (Figure 1).

*Step 1: Analysis of the Occlusion*—Preoperative occlusal analysis showed concentration of the occlusal load on the residual facial wall of tooth #36 and an absence of an upper molar palatal centric stop (Figure 2). Wear facets are notable on the remaining

facial cusps in the area of the remaining occlusal contacts (Figure 1), upper left molar, and premolar teeth did not present any restoration. Because of the unbalanced occlusion, a fracture of the remaining wall can occur under mastication. After completing the analysis of occlusion and presenting a treatment plan to the patient for both a direct and indirect restoration, an SRDC restoration was planned on tooth #36.

*Step 2: Complete Excavation of Dental Caries and Proper Cavity Preparation*—A rubber dam was placed, and the existing restoration was removed using # 2 and #4 round burs (Brasseler, Savannah, GA, USA). The cavity was prepared in a very conservative manner, just removing the decayed dental tissue and trying to preserve the remaining sound tooth structure according to the basic guidelines for direct adhesive preparations. A caries indicator (Sable Seek, Ultradent Products, South Jordan, UT, USA) was applied to the dentin; stained nonmineralized and denatured dental tissues were removed with a spoon excavator. Residual enamel sharp angles and unsupported prisms were smoothed using the SD and SB partially diamond-tipped ultrasonic tips (EMS, Nyon, Switzerland); the SB instrument was also used to smooth sharp angles located within the dentin (Figure 3). No bevels were placed on either the occlusal or the gingival margins.

*Step 3: Analysis of Residual Tooth Structure*—Once the preparation was completed, it was determined that the facial-lingual occlusal extension (isthmus) was greater than two-thirds the intercuspal distance, the proximal extension was greater than half the distance to the line angle, and the facial-distal cusp was missing. However, the thickness of the residual walls greater than 3 mm and the mesiodistal extension almost half the distance to the marginal ridges were considered sufficient to give enough support to an SRDC restoration.

*Step 4: Proper Selection and Application of the Dentin Bonding System*—A circular matrix (Omni-Matrix, Ultradent Products) was placed around tooth #36 and interproximal matrix adaptation secured by only tightening it; perfect adaptation to the gingival margin was achieved without using any dental wedge. The use of dental wedges in teeth having cervical margins below the gingival level may create a step on the restoration because the matrix is pushed onto the cavity in an attempt to achieve its adaptation to the cervical area. Both the bonding and the marginal adaptation to the cervical area may be compromised. The tooth was etched for 15 seconds using a 35% phosphoric acid (UltraEtch,

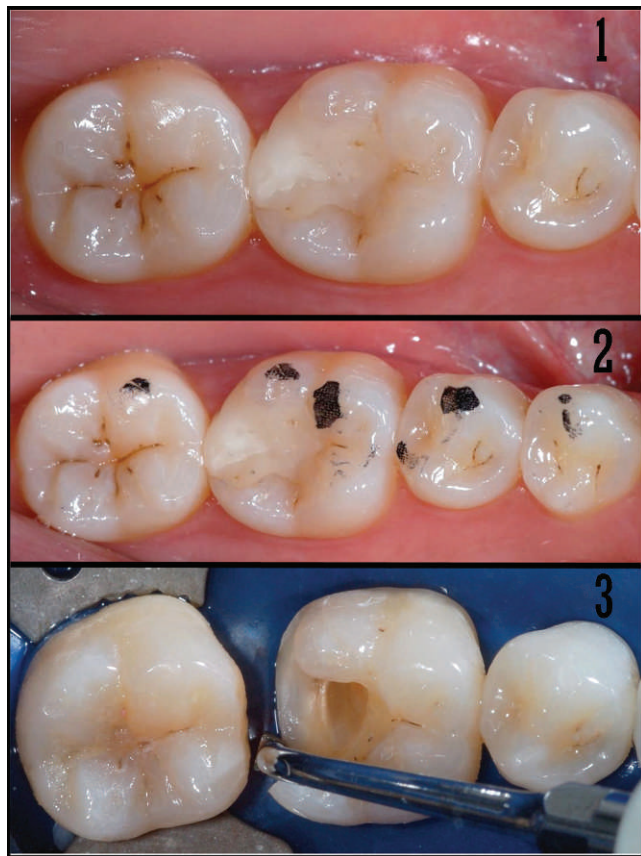


Figure 1. Preoperative view of tooth #36 showing an incongruous tooth-colored restoration

Figure 2. Before starting anesthesia, occlusion was checked, and centric stops were recorded

Figure 3. Cavity preparation was completed using partially diamond tipped ultrasonic tips

Ultradent Products; Figure 4). The etchant was removed and the cavity rinsed with water spray for 30 seconds, being careful to maintain a moist surface. The cavity was disinfected with a 2% chlorhexidine antibacterial solution (Consepsis, Ultradent Products; Figure 5). A fifth-generation 40% filled ethanol-based adhesive system (PQ1, Ultradent Products) was placed in the preparation, gently air thinned, and light cured for 20 seconds using an LED curing light (UltraLume V, Ultradent Products; Figure 6).

*Step 5: Control of Polymerization Stresses by Using Appropriate Layering and Curing Techniques*—Vit-l-escence microhybrid composite resin (Ultradent Products) was used to restore the teeth. Stratification was initiated using multiple 1- to 1.5-mm triangular-shaped (wedge-shaped) increments; apico-occlusal placed layers of A4 shade were used to reconstruct the cervical third of the proximal surface. At this point, the circular matrix was

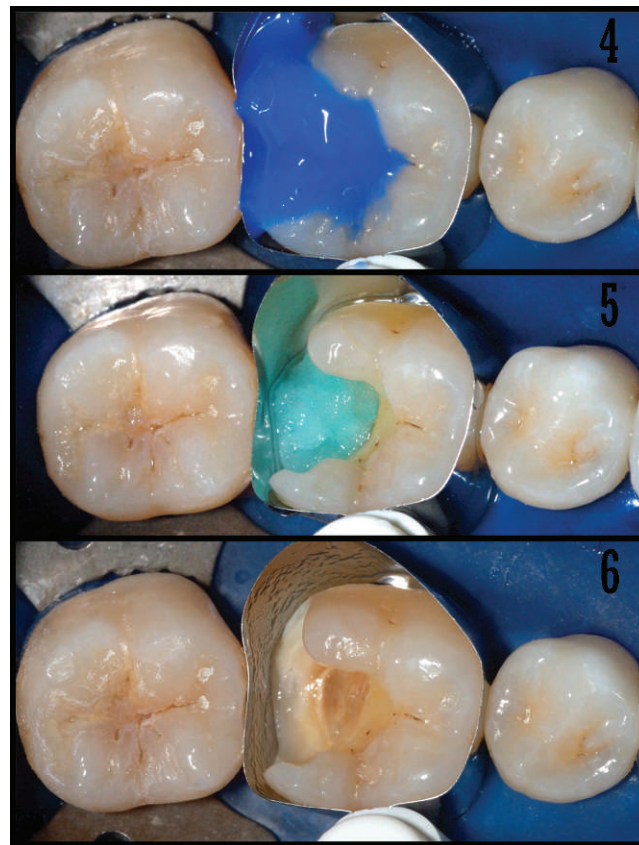


Figure 4. A circular matrix was placed and etching performed using 35% phosphoric acid

Figures 5 and 6. A 2% digluconate chlorhexidine solution was applied on dentin, followed by an ethanol-based adhesive system application on both enamel and dentin

replaced with a sectional matrix to achieve a more predictable contact point with the second molar tooth. Both the proximal surface and the external shell of the disto-lingual cusp buildups were completed using the Pearl Smoke (PS) enamel shade (Figure 7). Stratification of dentin was started by placing a 1- to 1.5-mm even layer of A3.5 flowable composite (PermaFlo, Ultradent Products) on deeper dentin (Figure 8), which was followed by the application of dentin wedge-shaped increments strategically placed to only two bonded surfaces, decreasing the cavity configuration or C-factor ratio (Figure 9). The C-factor is defined as the ratio between bonded and unbonded cavity surfaces; increasing this ratio also increases the stress from polymerization shrinkage.<sup>13</sup> For the same reason, single increments of PS enamel shade were applied to one cusp at a time (Figure 10); each cusp was cured separately, achieving the final primary and secondary occlusal morphology (Figure 11). In order to reduce stress from polymerization shrinkage, the



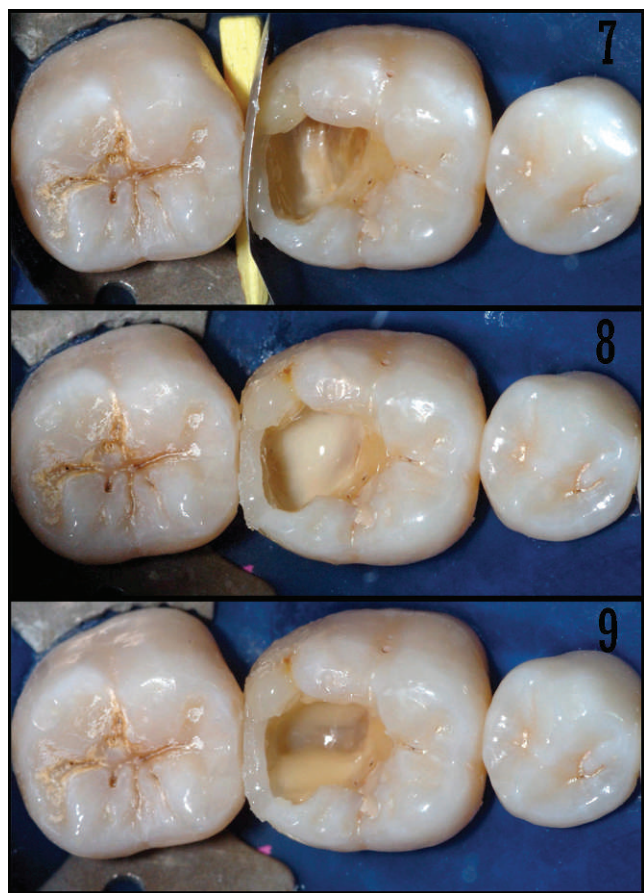


Figure 7. The circular matrix was replaced with a sectional matrix, and the peripheral enamel skeleton was built up first using a combination of dentin and enamel wedge-shaped increments

Figure 8. Dentin stratification was started placing a 1-mm layer of A3.5 flowable composite resin on deep dentin

Figure 9. Dentin stratification was performed by using wedge-shaped increments of composite dentin shades

authors utilized a previously described polymerization technique, based on a combination of pulse (enamel) and progressive (dentin) curing technique through the tooth. The pulse curing protocol is adopted for the proximal and occlusal enamel buildup polymerization; it is accomplished by using a very short curing time (1 or 2 seconds) per each increment. The progressive curing technique is used for the polymerization of the dentin increments; it is performed by placing the light tip in contact with the external cavity walls to start the polymerization through the wall (indirect polymerization) at a lower intensity. Final polymerization is then provided at a higher intensity and extended curing time. Initial occlusal and proximal adjustment of the restoration was performed using #7404 and #7902 carbide burs (Brasseler). The patient was recalled after 48 hours to complete the occlusal adjustment and perform the



Figure 10. A brown composite tint was placed at the end of dentin stratification

Figure 11. Restoration was completed with the application of PS shade to each cusp in order to develop cusp ridges and supplemental morphology

Figure 12. Result at the six-month recall

final polishing. Figure 12 shows the restoration at the six-month recall.

**Step 6: Occlusal Force Equilibration**—Occlusion was verified, avoiding excessive load on the residual facial cusp and creating a centric stop in the composite restoration at the center of the tooth-restoration complex. The centric stops located on the tooth structure and composite resin are of the same intensity; they do not differ from the ones on the adjacent premolar teeth (Figure 13). Figures 14 and 15 show the pre- and postoperative X-rays.

## DISCUSSION

When restoring a significant amount of occlusal anatomy, the patient's occlusion is a major determining factor in the success of large RBC restorations. The preoperative analysis of occlusion and the equal distribution of the load on the residual tooth structure and the restorative material, once the restoration is completed, are important to maintain the tooth-RBC complex over time.

The analysis of occlusion is performed at two different levels: the tooth to be restored and the opposing dentition. The tooth/teeth to be restored should be analyzed with the goal of detecting an uneven distribution of the occlusal contacts and assessing the presence of any wear facets related to both malocclusion and parafunction habits. Overload on either the restoration or the remaining tooth structure may lead to premature failure. The antagonist teeth need to be checked to assess the presence of any anatomically incongruous restoration potentially responsible for the incorrect occlusion detected in the opposing dentition; if this is the case, replacement of the restoration in the lower and upper teeth should be considered. Conversely, having a functional restoration in the antagonist dentition will not require a replacement; the material (ceramic vs composite resin) used to restore the antagonist teeth may influence the choice of the restorative material for the restoration of the opposing tooth.<sup>14</sup> Given that the wear of posterior RBCs is similar to the reported enamel wear,<sup>15</sup> the selection of RBCs is the ideal choice having either virgin teeth or teeth restored with composite resin in the opposing dentition. Conversely, the partial or complete coverage of the opposing teeth with ceramic restorations may guide the clinician to select an indirect ceramic restoration to better match the wear rate. Although ceramic is considered the most “enamel-like” material, increased wear of either opposing natural teeth<sup>16</sup> or composite resin<sup>17</sup> remains a primary concern.

The thickness of the residual cusp wall both at the base and the cusp tip is a key element in the decision to preserve or eliminate cusps. Cusp coverage with a 2-mm overlap of restorative material is recommended when cusp base thickness is less than 2 mm and occlusal margins located at the cusp tip.<sup>18</sup> This decision needs to be supported by the analysis of the remaining tooth structure, including the connection of the cusp with a marginal ridge and its thickness, and the occlusal load distribution. Removing the unsupported enamel prisms and smoothing the sharp angles on both enamel and dentin are just the first steps to achieve a reliable bond to the dental substrate. These need to be coupled with both prevention of hybrid layer degradation and final occlusal equilibration. RBC restorations rely on both macromechanical and micromechanical retention; increasing cavity size results in restorations depending more on micromechanical retention provided by a specific adhesive technique.<sup>19</sup> Adhesive systems produce bond strengths that allow clinicians to bond

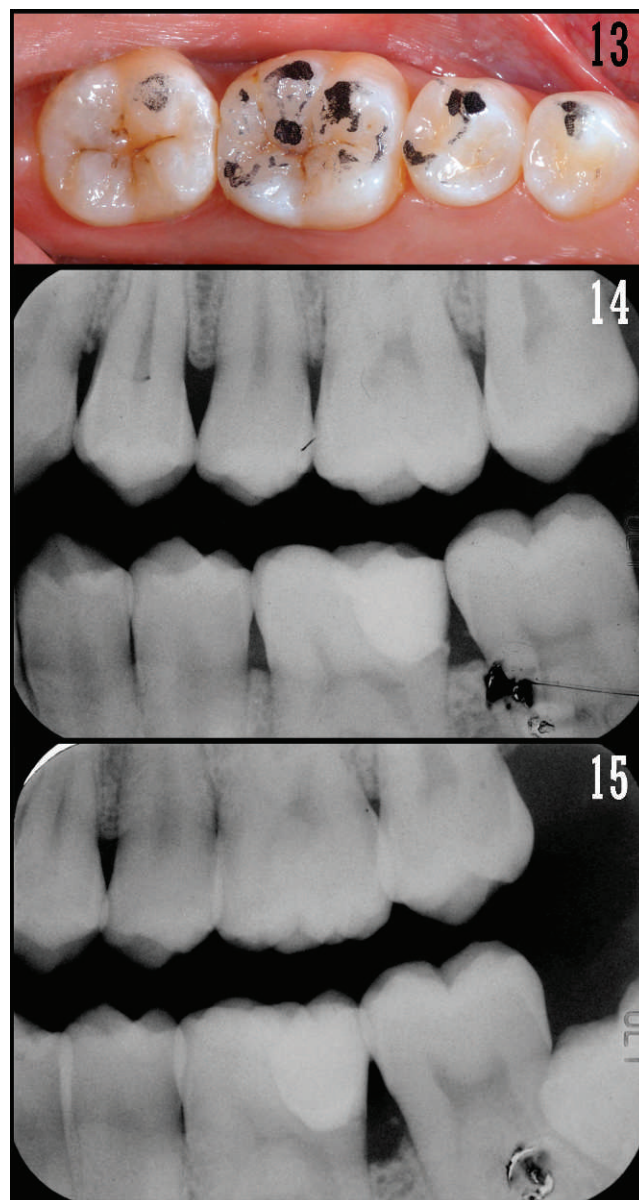


Figure 13. Occlusal view of the final restorations after occlusion checking  
Figures 14 and 15. Pre- and postoperative X-rays

to tooth structure without the use of aggressive retentive cavity preparations. However, immediate dentin bonding may be challenged by the overlaying composite shrinkage stress; Magne and others<sup>20</sup> reported increased bond strength following immediate dentin sealing after the completion of tooth preparation for semidirect and indirect restorations. The protocol for SRDC restorations adopts a layering technique based on an enamel wall buildup first, followed by dentin stratification; this first step requires selective curing to be accomplished, allowing for initial dentin bonding maturation. Neverthe-



less, major concerns have been recently expressed regarding interfacial aging due to degradation of the hybrid layer related to water sorption, hydrolysis of the resin, and disruption of the collagen network.<sup>10</sup> Matrix metalloproteinases-2 (MMP-2) are endopeptidases present in large amounts in human dentin; MMP-2 may be involved in the degradation of the polymer matrix of the hybrid layer as well as the collagen fibrils. As a result, deterioration of the dentin-composite bond may compromise the longevity of both direct and indirect RBC restorations. Occlusal loading may contribute to this process because of the development of fatigue. Chlorhexidine was demonstrated to be effective in the inhibition of MMPs. The application of a similar inhibitory agent in the clinical bonding procedure may result in a more satisfactory performance of bonding interfaces over time.<sup>21</sup>

Stress from polymerization shrinkage is one of clinician's main concerns when placing direct RBC restorations. Postoperative sensitivity, marginal enamel fractures, premature marginal breakdown, and staining may result from the stress developed at the tooth restoration interface. Three different strategies to reduce polymerization stress have been identified<sup>9,22</sup>: 1) modification of the placement technique, 2) altered curing schemes, and 3) use of a resilient liner on dentin. Combining composite stratification with wedge-shaped increments and polymerization with a low-intensity approach is mandatory to reduce stress in the restoration. Multiple wedge-shaped increments are placed, trying to contact no more than two bonded cavity walls; the technique allows a decrease in stress from polymerization shrinkage by reducing the composite mass (per increment) and transforming the high-C-factor configuration into multiple low-C-factor configurations (maximizing the unbonded free surface to enhance stress relief). In addition to this sophisticated stratification technique, a combination of progressive and pulse curing polymerization is used on dentin and enamel, respectively, to further decrease the stress from polymerization shrinkage.<sup>22</sup> By adopting a similar soft-start curing protocol, physical and mechanical properties of composite resin may also be improved; more time is available for composite flow in the direction of the cavity walls, resulting in stress release during polymerization shrinkage and increased cross-linking. The quality of the polymer network, which is not equivalent to the degree of conversion, is influenced by the modified curing scheme. A recent research study<sup>23</sup> corroborated previous findings<sup>24,25</sup> supporting the

fact that polymerization protocols based on low intensity and increased curing time result in longer polymer chain formation; conversely, frequency of cross-linking increases using higher-intensity and short curing times, leading to multiple short polymer chains formation and reduced degree of cure.

The application of a thin layer of flowable composite (.5-1 mm) limited to the dentin floor has been suggested as an adjunctive strategy to counteract stress from polymerization shrinkage.<sup>26,27</sup> According to Hooke's law, stress depends on both shrinkage and elastic modulus; because of their low stiffness, flowable composite may deform to absorb some of the overlaying composite shrinkage strain.

## CONCLUSION

An SRDC technique is based on a detailed pre- and postoperative analysis of occlusion. A well-equilibrated occlusion may contribute to the prevention of either changes in the occlusal morphology or tooth-RBC complex failure; accurately preserving and preparing the remaining sound tooth structure, selecting strategies to prevent the degradation of the hybrid layer, and adopting specific layering and curing schemes may protect the RBC restoration from both polymerization shrinkage and occlusal loading stresses.

## Conflict of Interest Declaration

The author of this manuscript certifies that there is no proprietary, financial or other personal interest of any nature or kind in any product, service and/or company that is presented in this article.

(Accepted 25 September 2011)

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