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Clinical Technique/Case Report

Direct Cuspal-coverage Posterior Resin Composite Restorations: A Case Report

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Clinical Relevance

Adhesive restorations allow clinicians utilization of significantly more conservative tooth preparation, thus preserving and reinforcing sound tooth structure. In selected clinical cases, these advantages can be used and expanded for extensive restorations.

SUMMARY

The clinical success of direct composite restorations is the result of the correct use and performance of adhesive systems, resin composites and light curing systems. Total-etch adhesive systems and microhybrid resin composites have seen continuous improvement; various clinical techniques have been introduced to address polymerization shrinkage. Manufacturers have introduced sophisticated light-curing devices with the hope of improving performance. Direct RBCs are becoming the first choice in many clinical situations. This article presents an experimental clinical technique that outlines the reconstruction of severely damaged posterior teeth missing multiple cusps; particular attention to incremental and curing techniques is adopted to complete each restoration.

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INTRODUCTION

Single appointment direct posterior resin bonded composite (RBC) restorations should ideally be restricted to small-to-medium-size intracoronal lesions (ADA, 1998). This assumption is based on the poor wear characteristics and marginal behavior of early RBC (Roulet, 1997). The high wear rate of original direct RBC caused a loss of anatomic shape and led to the exposure of cavity margins; moreover, marginal breakdown and marked technical sensitivity resulted in compromised RBC restorations especially in the molar region.

However, present-day RBCs exhibit mechanical and physical properties superior to those of their predecessors. Wear of current direct resin composites is estimated to be around 10 µm to 15 µm per year (Leinfelder &Yarnell, 1995); amalgam wears about 10 µm per year more than occlusal enamel (Christensen, 1998).

In recent years, several laboratory-processed indirect resin composites have been introduced, having a resin composition and filler content similar to that of direct

RBCs. Chairside direct resin composite inlay/onlay restorations were also introduced in the past decade, overcoming the disadvantages of direct RBCs.

The indirect technique allows for the production of restorations in the laboratory after impressioning. Appropriate proximal contour and contact, and control of anatomic form can be easily achieved. In the direct inlay/onlay technique, the restoration is formed directly in the cavity; after an initial cure, it is removed from the cavity and post-cured in a heat and light oven. Improved mechanical and physical properties are expected compared to the direct light-cured-only composite due to the overall increase in conversion (Wendt Jr, 1987a,b). A higher stress relaxation and improved marginal adaptation is also expected. The amount of shrinkage is limited to the thin luting resin composite layer (Wendt Jr, 1991; Shortall & Baylis, 1991).

Short-term clinical evidence has shown no or low failure for direct inlay/onlays (Wendt Jr & Leinfelder, 1992; Krejci, Guntert & Lutz, 1994; van Dijken, 1994). However, Wassell and others (1995) have reported a greater number of episodes of post-operative sensitivity and a trend towards higher failure rates for direct inlays. The same findings were reported by other authors (Pallesen & Qvist, 2003). This data is influenced by the use of inferior adhesive systems; however, notable is the lower post-operatory sensitivity recorded for direct RBC.

Peutzfeldt and Asmussen (2000) reported that improved physical properties produced by post-curing are composite dependent. It was suggested that the superior mechanical strength of heat-treated resin composites was only short-lived (Ferracane & Condon, 1992; Kildal & Ruyter, 1997). This was confirmed by long-term clinical studies reporting no difference in clinical mechanical properties between direct and direct heat-treated resin composite inlay/onlay restorations (van Dijken, 2000; Wassell, Walls & McCabe, 2000; Pallesen & Qvist, 2003).

Indirect laboratory processed composites have gained increased popularity over the last decade. In the attempt to improve the wear resistance of resin composites, heat, pressure and a nitrogen atmospheric treatment may be combined to form a relatively void-free, well-polymerized resin matrix. However, the basic chemistry of indirect RBCs remain very similar to direct materials; differences in mechanical properties are minimal and are not expected to be clinically significant (Swift, 2001). Mandikos and others (2001) reported no improvement in second-generation indirect RBCs (Artglass, belleGlass, Sculpture, Targis) mechanical properties when compared to a first-generation indirect RBC (Concept).

Ceramic restorations are even more costly and require elaborate, time-consuming techniques compared to direct resin composite restorations (Liebenberg, 2001). Success depends on factors influencing the strength of a ceramic restoration, such as design of the cavity preparation, shape of the restoration and internal fit. Wear of the resin cement is a concern when placing ceramic restorations. Optimum marginal fit is mandatory for achieving longevity. A detectable wear of luting resin composite after eight months of clinical service was reported by Pallesen and van Dijken (2000). After eight years, they found clinically marked wear and minor chipping of both the enamel and ceramic inlay. Similar findings were reported by Kramer and Frankenberger (2000). This phenomenon is less relevant at the cavosurface margins of indirect resin composite inlays (Pallesen & van Dijken, 2000).

Thordrup, Isidor and Horsted-Bindslev (2001) reported no significant difference in survival between direct and indirect resin composite and ceramic inlays after five years of clinical service; although the survival rate of the different types of inlay was considered acceptable, it was comparable to the survival rate of direct RBC fillings reported in controlled clinical studies (Rasmusson & Lundin, 1995; Barnes & others, 1991). The authors questioned the cost benefits of indirect restorations as being superior to direct RBC restorations. A recent literature review reported no significant difference in the longitudinal clinical behavior of posterior direct and indirect resin composite restorations over a three-year evaluation period (Hickel & Manhart, 2001).

As a consequence, clinical indications for anterior and posterior RBC restorations are progressively expanding. Clinicians are starting to re-evaluate dogma of traditional restorative dentistry; they are looking for new materials, techniques and alternative methods to build-up direct anterior and posterior RBC restorations (Liebenberg, 2000; Krejci & others, 2003; Deliperi & Bardwell, 2004a; Deliperi, Bardwell & Coiana, 2004b).

This article provided a simplified clinical approach in the reconstruction of posterior teeth with multiple missing cusps, as well as a critical discussion of the advantages and disadvantages.

CASE REPORT

Case Presentation

A 20-year-old male patient presented with fracture of both the mesial and distal lingual cusps of a lower molar tooth (#19). The tooth was restored with a silver reinforced glass-ionomer cement eight years earlier. As the fracture line was just above the CEJ and did not invade the biological width, it was explained to the patient that the treatment plan of choice was placement of an indirect inlay/onlay restoration. Alternatively, with the marginal ridge still intact, a

Figure 1. *Pre-operative view of tooth #19 with fracture of the palatal wall and of #18 with occlusal decay.*

Figure 2. *Occlusal view after placing rubber dam and removing decay from #18.*

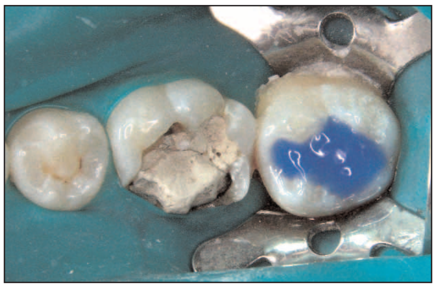

Figure 3. *Etching was performed using 35% phosphoric acid.*

Figure 4. *An ethanol-based adhesive system was applied on both enamel and dentin.*

Figure 5. *A 1-1.5-mm layer of flowable resin composite was applied on deeper dentin.*

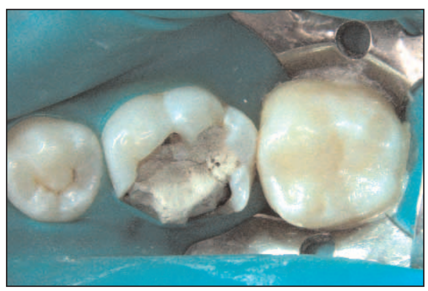

Figure 6. *Dentin and enamel stratification of #18 was completed and a correct occlusal anatomy was created.*

direct cuspal coverage restoration with resin composite could be an option. However, it was explained that the performance of this procedure was expected to be less predictable than an indirect restoration. The patient expressed the desire to restore tooth #19 with a direct RBC restoration due to cost considerations. If a fracture of both the resin composite and tooth occurs, then an indirect composite or ceramic inlay/onlay restoration will be placed. The patient exhibited decay on tooth #18 (Figure 1), which was also be restored with a direct composite restoration. A finalized treatment plan was accepted and informed consent was secured.

Restorative Procedure

A rubber dam was placed, and the cavity on tooth #18 was first prepared in a very conservative manner, removing caries with a #245 bur (Shofu Dental Corporation, San Marcos, CA, USA) and rounding sharp angles with a #2 and #4 bur (Shofu Dental Corporation) without beveling of the occlusal or gingival surfaces (Figure 2). The cavity preparation was disinfected using a 2% chlorexidine antibacterial solution (Consepsis-Ultradent Products, South Jordan, UT, USA). Tooth #18 was etched for 15 seconds using a 35% phosphoric acid (UltraEtch, Ultradent Products) (Figure 3); the etchant was removed and the cavity was water sprayed for 30 seconds, carefully maintaining a moist surface. A fifth generation, 40% filled ethanol based adhesive system (PQ1, Ultradent Products) was placed in the preparation. The bonding agent was gently air thinned until its milky appearance disappeared. It was light cured for 20 seconds at the occlusal and lingual aspects using a Quartz Tungsten Halogen (QTH) curing light (VIP Light, BISCO, Inc, Schaumburg, IL, USA) Figure 4. Dentin stratification was initiated with a 1-mm to 1.5-mm layer of flowable composite (PermaFlo-Ultradent Products) on deep dentin (Figure 5); dentin wedge shaped increments of Vitalescence microhybrid resin composite (Ultradent Products) were strategically placed on single surfaces only, decreasing the C-factor ratio (Deliperi & Bardwell, 2002; Deliperi, Bardwell & Congiu, 2003a). Enamel layers of Pearl Frost (PF) were applied to the final contour of the occlusal surface of tooth #18 utilizing a successive cusp build-up technique (Figure 6).

The existing restoration on tooth #19 was removed, and the cavity was prepared with the same criteria described in tooth #18, preserving as much enamel as possible at the gingival margin (Figure 7). A circular matrix (Automatrix-Dentsply/Caulk, Mildford, DE, USA) was placed around the tooth and tightened. Etching and bonding steps were followed using the same materials and techniques described for tooth #18 (Figures 8 and 9).

Vitalescence microhybrid resin composite (Ultradent Product) was also used to restore tooth #19. Vit-l-escence was selected as the material of choice in restoring tooth #19. However, several microhybrid compos-

Figure 7. *Occlusal view of #19 after removing the old restoration and decay.*

Figure 8. *A circular matrix was placed and etching and bonding were performed as per #18.*

Figure 9. *A circular matrix was placed and etching and bonding were performed as per #18.*

Figure 10. *The peripherical enamel skeleton was built-up using wedge-shaped increments of PS and PF shades; dentin stratification was started placing a 1-mm layer of A2 flowable resin composite.*

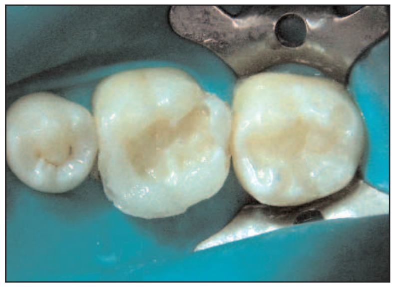

Figure 11. *Dentin stratification was completed by using wedge-shaped increments of dentin shades.*

Figure 12. *Restoration was completed with the application of PF shade to the final contour of the occlusal surface.*

Table 1: *Photocuring Times and Intensities Used to Polymerize Enamel and Dentin Build Up*

Build up location	**Composite shade**		**Intensity** (mW/cm^2)	**Time** (seconds)
	(Vitalescence)	Polymerization technique		
Lingual Enamel	PS/PF	pulse	200 + 300	3 + 40
Dentin	A3.5 -A3-A2- A1	progressive curing	300	40
Occlusal Enamel	PF	pulse	200 + 600	3 + 10 (occlusal) 10 (facial) 10 (palatal)

ites, utilizing a natural layering technique (Dietschi, 2001), may also be used (Point 4, Kerr, Orange, CA, USA; Amelogen, Ultradent Products; Esthet-X Dentsply/Caulk). Stratification using multiple 1-mm to 1.5-mm triangular-shaped (wedge shaped), apico-occlusal-placed layers of Pearl Smoke (PS) and Pearl Frost (PF) shades were placed to strategically reconstruct the gingival and occlusal enamel external shell of each cusp (Figure 10). This uncured composite was condensed and sculptured against the cavosurface margin and circular matrix, and each increment was pulse-cured for 3 seconds at 300 mW/cm^2 to avoid microcrack formation. The enamel peripheral skeleton of the restoration was built-up, highlighting spacial references for more accurate occlusal anatomy. An increased C-factor resulted as a consequence of this layering technique. The C-factor was defined as the ratio between bonded and unbonded surfaces; increasing this ratio resulted in increased polymerization stresses (Feilzer, de Gee & Davidson, 1987). In this context, the application of wedge-shaped increments of resin composite was of paramount importance, resulting in a final total decreased C-factor ratio. At this point, stratification of dentin was started by placing a 1-mm to 1.5-mm even layer of A2 flowable composite (PermaFlo-Ultradent Products) on deeper dentin

Figure 13. *Post-operative occlusal view of the final restorations.*

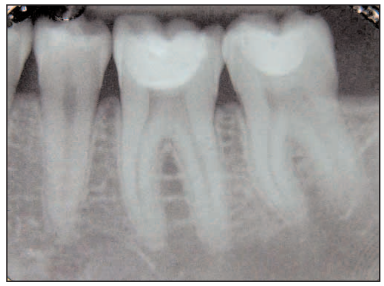

Figure 14. *Radiograph of #18 and #19 following restorative treatment.*

Figure 15. *Results at the one-year recall.*

(Figure 10). Final polymerization of both the flowable composite and the PS-PF composite lingual cusp wall was then completed at 300 mW/cm^2 for 40 seconds. Dentin stratification was completed by the application of dentin wedge-shaped increments strategically placed at single surfaces as previously described for tooth #18 (Figure 11). Each dentin increment was cured using a progressive curing technique (40 seconds at 300 mW/cm^2 instead of a conventional, continuous irradiation mode of 20 seconds at 600 mW/cm^2).

As most of the occlusal surface was missing, particular attention was paid in creating appropriate and correct anatomy, using proximal and facial surfaces as spacial references. Each cusp was built-up separately, and enamel layers of Pearl Frost were applied to the final contour on the occlusal enamel surface with a successive cusp build-up technique (Figure 12). To minimize microcrack formation on the remaining wall and reduce stress from polymerization shrinkage, a previously described polymerization technique based on a combination of pulse and progressive curing technique was used (Deliperi & Bardwell, 2002; Deliperi & others 2003a) Table 1.

The rubber dam was removed, occlusion checked and the restoration finished using the Ultradent Composite Finishing Kit (Ultradent Product). Polishing was performed using impregnated silicon rubber cups and points, while final polishing was performed using diamond and silicon carbide impregnated cups, points and brushes (Finale Polishing System, Ultradent Products) Figure 13. This same restoration was evaluated at a one-year recall (Figures 14 and 15).

DISCUSSION

Polymerization shrinkage is a major concern when placing direct posterior composite restorations. If the mass of resin composite to be polymerized is large, polymerization shrinkage is more difficult to control.

Traditionally, amalgam has been the material of choice in the restoration of direct cuspal-coverage of posterior teeth. Smales and Hawthorne (1996) found a 66.7% survival rate after 10 years and a 47.8% survival rate after 15 years for large cusp-covered amalgam restorations; Plasmans, Creugers and Mulder (1998) observed a retention rate of 88% after 8 years for similar restorations and reported a higher failure rate for patients older than age 30. McDaniel and others (2000) reported the results of a survey which revealed that the leading cause of failure among cuspal-coverage amalgam restorations was tooth fracture. They assumed the main reason for failure was a too conservative tooth preparation; they recommended replacing weak cusps with restorative material when placing large amalgam restorations. Alternatively, a catastrophic failure of the tooth can occur, resulting in its non-restorability.

Conversely, alternative methods reconstructing severely destroyed molars and premolars with tooth-colored restorations have become available. The operative procedure is more complex and time consuming and comes with a higher cost (Liebenberg, 2000, 2001).

The increased predictability of direct RBC has encouraged clinicians to progressively abandon amalgam over the last decade (Christensen, 1998). This is the result of three different phenomena: 1- continuous development of total-etch adhesive systems (Van Meerbeek & others, 1994, 1998, 2001; Swift Jr & others, 2001) and the improvement of resin bonded composite (RBC) physical and mechanical properties (Hickel, Manhart & García-Godoy, 2000; Hickel & Manhart, 2001); 2- patient demand for aesthetic restorations; 3- patients' desire to save remaining sound tooth structure, and their inability to afford indirect restorations in large posterior and anterior situations. In the final analysis, dentists have pushed the limit of clinical indications for direct RBC restorations (Liebenberg, 2000; Deliperi & Bardwell, 2004a).

When compared to similar amalgam restorations, placement of a direct RBC restoration takes 2.5 times longer due to the complex sequence included in incremental techniques (Roulet, 1997).

In the clinical case presented in this study, particular attention was paid to both the layering and curing technique. The build-up was simplified in transforming the multi-surface to a Class I cavity. The enamel peripheral skeleton of the restoration was build-up first, giving

Table 2: *Direct vs Indirect Cuspal Coverage Restorations*	
Advantages	**Disadvantages**
• Overall reduced chair-time	• Increased chair-time (per session)
• Lower cost (no impression materials and lab cost)	• Increased skill of dentist
• Sound tooth structure is preserved	• No long-term clinical data
• No wear of luting agent	• Increased wear may be expected in patients with parafunction
• Chemical bond of adhesive system to resin composite	

more spacial reference to creating adequate anatomy. Following the outline of the occlusal surface, it was possible to achieve a restoration free from marginal excess and a smooth surface. Adjustment of the occlusion is usually minimal or unnecessary; this allows the clinician to save time and minimize composite wear (Deliperi & Bardwell, 2002; Ferreira, Lopes & Baratieri, 2004). When preparations are overfilled and polymerized, more time is required. The generation of heat and the formation of microfissures can lead to increased marginal breakdown (Hoelscher & others, 1998; Liebenberg, 2001) and increased susceptibility to wear (Ratanapridakul, Leinfelder & Thomas, 1989; Hondrum & Fenández, 1997).

With regard to curing technique, a combination of progressive and pulse curing was adopted. Resin composite goes from a pre-gel state (early setting) to a post-gel state (final setting) during polymerization; once the gel point is achieved, flow cannot occur from the resultant increased stiffness of the RBC. The curing technique could have influenced the clinical performance of the direct RBC restoration, with efforts concentrated on delaying the gel point. The attempt to give composite particles more time to flow in the direction of cavity walls allows stress relief from polymerization shrinkage.

It was demonstrated that a pulse curing technique can reduce stress development at the cavosurface margins, avoiding the formation of microcracks (Kanca & Suh, 1999; Suh, 1999; Deliperi, Bardwell & Papathanasiou, 2003b). If a conventional, continuous, fast-curing technique is adopted, the bonding interface may remain intact, but microcracks may develop just outside the cavosurface margins due to the stress of polymerization shrinkage (Han, Okamoto & Iwaku, 1990; Prati & others, 1992). Furthermore, lower light intensity and longer curing time has demonstrated an improvement in marginal adaptation while maintaining the excellent physical properties of resin composite (Miyazaki & others, 1996; Sakaguchi & Berge, 1998). The progressive curing technique used to polymerize dentinal increments may be critical in transmitting lower stress at the cavosurface margins.

At the one year recall, no marginal discoloration, recurrent decay, chipping or composite clefting was detected. Although the observation time was limited to only one year and just one case report was considered, the clinical performance of Vitalescence microhybrid composite was more than acceptable. Even though the clinical technique applied still has an experimental character presently, the clinical performance of direct RBC placed in molars with missing cusps is under investigation. Results seem promising after 12 months of clinical service (unpublished data). Patients enrolled in this study were selected through a precise inclusion and exclusion criteria. Patients with parafunctional habits are not ideal candidates for similar treatments. Occlusion should be carefully analyzed and balanced both in static and dynamic relation; the enamel-dentin thickness of both the fractured and remaining cusps should be considered. The distinction between vital and non-vital teeth may contribute to the long-term success or failure of the final restoration. The advantages and disadvantages of direct and indirect restorations for cuspal coverage are summarized in Table 2. As a consequence, before recommending similar treatment, more longitudinal data should be gathered in subsequent in vitro and clinical studies.

CONCLUSIONS

Steady improvement of adhesive systems, resin composite and light curing technology may render the use of direct RBCs in reconstructing severely damaged teeth commonplace. The demand for indirect restorations may decrease, with reduced cost for both patient and dentist. The preservation of sound tooth structure and the one visit option can certainly render the aforementioned treatment acceptable.

Further investigation and controlled clinical trials are necessary before a fail safe recommendation can be given.

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