Reconstruction of Devital Teeth Using Direct Fiber-reinforced Composite Resins: A Case Report

Simone Deliperi[a]/David N. Bardwell[b]/Carlo Coiana[c]

Summary: Nonrestored devitalized teeth are structurally compromised and represent one of the greatest challenges for the clinician. Restoration of endodontically treated teeth has been associated with the use of posts. Various post materials and designs have been introduced over the years; however, motivated by the desire to conserve the remaining sound tooth structure and thanks to properties of modern adhesive systems, clinicians have re-evaluated the dogma of traditional restorative dentistry and seek alternative methods to build up devitalized teeth. The use of direct Ultra High Molecular Weight Polyethylene (UHMWPE) fiber-reinforced post systems is becoming popular among clinicians because enlargement of the root canal space is not required and the risk of root perforation eliminated. This article presents an experimental clinical technique to reconstruct severely damaged endodontically treated posterior teeth using direct fiber reinforced post systems. Particular attention is paid to the incremental and curing techniques adopted to build up the restoration. The problems that clinicians can encounter in bonding to teeth that have undergone endodontic treatment are also analyzed. Questions that have yet to be answered by scientific research are presented.

Key words: adhesive system, composite resin, Class II restoration, devital teeth, post and core.

Earlier than 15 years ago, the restoration of devital teeth was automatically associated with a combination of prefabricated or custom-made metallic post and cores and full crowns.[38] In this way, a considerable amount of coronal and radicular sound tooth structure was sacrificed with increasing risk of root perforation or fracture.[16,41] Moreover, patients had to accept treatment which was costly in terms of both time and money.[43] The continuous development of total-etch adhesive systems[45,47-49] and the improvement of physical and mechanical properties of resin bonded composite (RBC)[22,23] were responsible for a complete revolution in restorative dentistry. Adhesive restorations allow clinicians to create minimally invasive preparations, thus conserving sound tooth structure. The increased predictability of RBC has encouraged clinicians to progressively abandon amalgam.[3] Patient demands for esthetic restorations and their increasing desire to save remaining sound tooth structure are pushing dentists to stretch clinical indications for direct RBC restorations.[6,28] This situation may be further influenced by patients' inability to afford the ideal indirect restoration in large posterior and anterior defects. As a consequence, clinical indications for anterior and posterior RBC restorations are progressively expanding; practitioners are looking for new material and techniques to further enhance the clinical performance of direct RBC when placed in severely destroyed vital or nonvital teeth.[6,28]

Tooth-colored fiber posts were introduced in the 1990s and have several advantages over conventional metal posts.[35] They are esthetic, bond to tooth structure, have a modulus of elasticity similar to that of dentin but still require dentin preparation to fit into the canal.

Lately, fiber reinforcement systems have been introduced in the attempt to increase RBC durability and damage tolerance.[12,19,46] Ultra High Molecular Weight Polyethylene (UHMWPE) fiber reinforcement systems are gaining popularity and have various clinical applications (Table 1). Being bondable reinforcement fibers, they can be used to build up endodontic post and cores, as they adapt to the root canal walls without requiring additional

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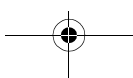
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Table 1 Clinical indications of bondable reinforcement ribbon fibers

Clinical indications
Endodontic post and core
Periodontal splinting
Orthodontic retainers
Provisional metal-free bridges
Treatment of split-tooth syndrome

Fig 1 Preoperative view of tooth 15 with fracture of the palatal wall.

enlargement of the root canal after endodontic treatment. These woven fibers have a modulus of elasticity similar to that of dentin and are supposed to create a monoblock dentin-post-core system able to better distribute forces along the root.[32] Recently, improved UHMWPE fiber systems have been introduced onto the market. They have greater strength properties than conventional UHMWPE fibers because of unidirectional fibers with braided filaments inserted between them.[26]

Increased interest and attention have also been devoted to contemporary light-curing techniques as a possible method for controlling stress.[7,13,18,25,44] The advantages of using a combination of pulse and progressive curing techniques to counteract polymerization shrinkage have been previously reported.[6,8] However, clinicians may prefer using a conventional curing method to save time, although this may increase the possibility of RBC postoperative sensitivity and reduced longevity. This trend is also influenced by manufacturers resisting the use of alternative modes of polymerization in their light-curing systems. Clinicians cannot program their curing lights for mode of polymerization and may be constrained by curing intensity and time provided by manufacturers.

The purpose of this article is to provide a simplified clinical approach to reconstruct severely damaged endodontically treated posterior teeth and discuss the benefits and problematic issues related to a similar procedure.

CASE REPORT

Case Presentation

A 46-year-old female patient presented with a previously endodontically treated right maxillary premolar (15), which had been restored with a MOD amalgam restoration and suffered a fracture of the palatal cusp after a few years of clinical service (Fig 1). As the fracture line was below the CEJ, invading the biological width, it was explained to the patient that the placement of a dental implant could be indicated if an unfavorable crown-to-root ratio would result after completing crown lengthening. The patient expressed the desire to maintain tooth 15 and restore it with a direct RBC restoration, due to the

lower cost compared to an indirect restoration. If a root fracture occurred, then a dental implant would be placed. The treatment plan was accepted and an informed consent was secured.

Restorative Procedure

Once crown lengthening was completed and tissue healing was accomplished, rubber-dam was placed in order to complete isolation and expose the cavosurface gingival margins. The existing amalgam restoration was completely removed, being careful to preserve as much tooth structure as possible. Cavity preparation was completed by placing a gingival butt joint with no bevel on the axial or occlusal surface, rounding sharp angles with #2 and #4 burs (Brasseler, Savannah, GA, USA), and trying to selectively remove the superficial sclerotic dentin (Fig 2). Three to 4 mm of gutta-percha were removed from the facial and palatal canals to expose dentin and increase microretention when using enamel dentin adhesive systems (Fig 3). A circular matrix (Automatrix, Dentsply/Caulk, Milford, DE, USA) was placed around the tooth and tightened. Interproximal matrix adaptation was secured using wooden wedges. Enamel and dentin were etched for 30 s using 34% phosphoric acid (Tooth Conditioner Gel, Dentsply/Caulk) (Fig 4). The etchant was removed and the cavity was water sprayed for 30 s, being careful to maintain a moist surface. A fifth generation nanofilled acetone-based adhesive system (Prime & Bond NT, Dentsply/Caulk) was placed in the preparation, gently air thinned to evaporate solvent (Fig 5), and light cured for 20 s at 800 mW/cm^{2} from the occlusal surface using a Quartz Tungsten Halogen curing light (Spectrum 800, Dentsply/Caulk).

In order to avoid microcrack formation on the remaining facial wall, the authors used a previously described technique,[6,7] which is based on a combination of pulse and progressive curing technique. A particular composite placement technique was also selected to build up such a challenging restoration; a combination of RBC wedge shaped increments and UHMWPE fiber reinforcement system was considered of paramount importance to further reduce polymerization shrinkage, better support the RBC, reinforce the remaining tooth structure, and reduce the total composite volume.

Fig 2 Occlusal view of tooth 15 after placing rubber-dam and removing provisional restoration.

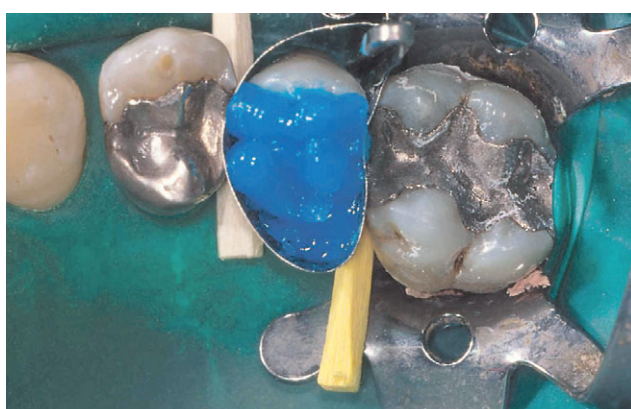**Fig 3** Three to 4 mm of gutta-percha were removed from the facial and palatal root canals.

Fig 4 A circular matrix was placed and etching was performed using 34% phosphoric acid.

Fig 5 A nanofilled acetone-based adhesive system was applied on both enamel and dentin.

Esthet-X microhybrid RBC (Dentsply/Caulk) was considered the material of choice to restore tooth 15 because of its variety of enamel shades and excellent mechanical properties. However, different microhybrid composites based on the natural layering technique[10] may also be utilized (eg, Point 4, Kerr, Orange, CA; Vit-l-escence and Amelogen, Ultradent Products, South Jordan, UT, USA). The matrix was burnished against the adjacent teeth. Tooth buildup was started using 2-mm triangular-shaped (wedge-shaped) gingivo-occlusally placed layers of amber (AE) and clear (CE) enamel shades to reconstruct the proximal and palatal surfaces. This uncured composite was condensed and sculptured against the cavosurface margins and circular matrix, and each increment was pulse cured for 3 s at 300 mW/cm^2 to avoid microcrack formation. Final polymerization of the AE and CE proximal and palatal composite walls was then completed at 300 mW/cm^2 for 40 s (Fig 6). The enamel peripheral skeleton of the restoration was built up, yielding additional spatial references to create a correct 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.[14] In this context, the application of wedge-shaped increments

of composite resin was of paramount importance, because it helped in decreasing the C-factor ratio. Dentin stratification of the facial, palatal, and proximal walls was initiated placing 2-mm wedge-shaped increments of A3 RBC at each enamel wall, avoiding any contact of fresh increments (Fig 7). Meanwhile, a UHMWPE triaxial fiber (Ribbond Triaxial, Ribbond, Seattle, WA, USA) was selected, and the dental assistant manipulated it according to manufacturer's instructions. Successive A3 increments were placed until a central area resulted for placement of a resin-impregnated fiber composite system and fabrication of a direct post and core. Each dentin increment was cured using a progressive curing technique (40 s at 300 mW/cm^2 instead of a conventional continuous irradiation mode of 20 s at 600 mW/cm^2).[6,8] Triaxial fibers were wetted with an unfilled resin (D/E resin, Bisco, Schaumburg, IL, USA) (Fig 8), excess resin was removed, and fibers were completely covered with a B1 light-cured flowable composite resin (X-Flow, Dentsply/Caulk) and placed in the central area of the restoration. UHMWPE triaxial fibers were folded and each end pushed in the two canals using a thin composite spatula. B1 flowable composite resin was used to fill any composite void, then a polymerization cycle of both the fiber-resin complex and composite resin was started. The polymerization process

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Fig 6 The peripherical enamel skeleton was built up using wedge-shaped increments of AE and CE shades.

Fig 7 Dentin stratification was started placing A3 increments of RBC and a central area was created to insert a Ribbond fiber.
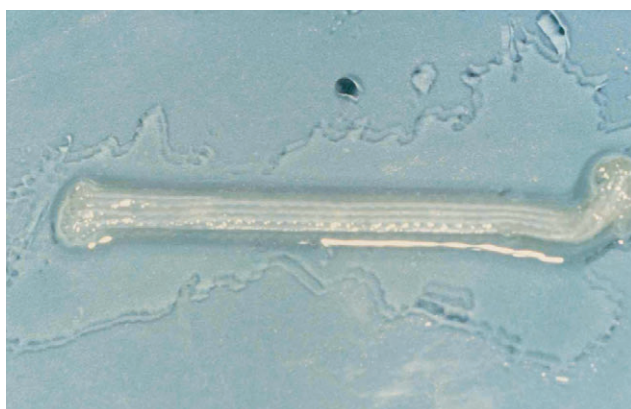

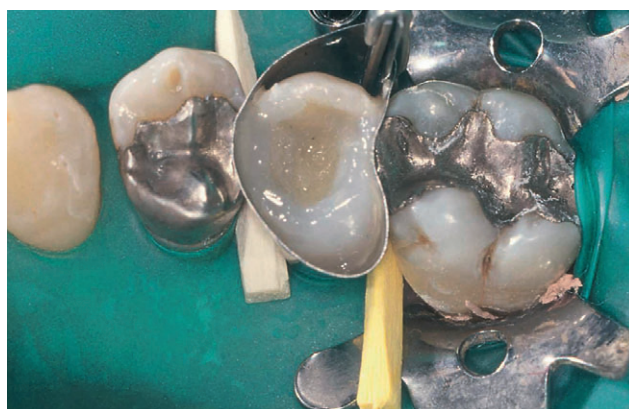**Fig 8** A piece of Ribbond ribbon was cut and wet with unfilled resin.

Fig 9 The Ribbond fiber was inserted and dentin stratification completed using B5 and B3 shades.

Fig 10 Restoration was completed with the application of CE shade to the final contour of the occlusal surface.

included an initial polymerization using a progressive curing technique (40 s at 300 mW/cm^2) followed by a continuous irradiation at 800 mW/cm^2 for 240 s to assure complete polymerization of the fiber-complex down into the canal. At this point, the middle third of the dentin restoration was built up using a combination of B5/DY and B3 to increase the chroma, unnaturally reduced by previ-

ously using B1 flowable composite (Fig 9). Enamel layers of CE were applied to the final contour of the occlusal surface according to a successive cusp buildup technique (Fig 10). This final layer was pulse cured for 3 s at 300 mW/cm^2. A waiting period of 3 min was observed to allow for stress relief before polymerizing at a higher intensity (30 s at 800 mW/cm^2) (Table 2).

Subsequently, wedges and matrix were removed and the final polymerization cycle was completed by irradiating the restored tooth through the facial and palatal surface for 30 s each at 800 mW/cm^2.

Rubber-dam was removed, occlusion checked and the restoration was finished using the Raptor system (Bisco). Final polishing was performed using a one-step diamond micropolisher system (Pogo, Dentsply/Caulk) (Figs 11 and 12). The same restoration was evaluated at a 2-year recall (Fig 13).

DISCUSSION

Cuspal coverage is considered fundamental to avoid cusp fracture in endodontically treated teeth.[39,40] However, a recent in vitro study reported no difference in cuspal fracture when large inlay and onlay restorations were complet-

Table 2 **Recommended photocuring times and intensities for enamel, dentin, and post-and-core buildup**

Buildup	Composite shade (Esthet-X)	Polymerization technique	Intensity (mW/cm^2)	Time (s)
Proximal and palatal enamel	AE-CE	pulse	300 + 300	3 + 40
Dentin	A3-B3-B5	progressive curing	300	40
Ribbond post-and-core buildup	B1	progressive curing + continuous curing	300 + 800	40 + 240
Occlusal enamel	AE-CE	pulse	300 + 800	3 + 30

Fig 11 Postoperative occlusal view of the final restoration.

Fig 12 Radiograph of tooth 15 following periodontal and restorative treatments.

Fig 13 Result at the 2-year recall.

ed on devital teeth, even though the restored cavity had a remaining buccal and lingual wall that was very thin.[27] Although we performed a direct inlay-onlay RBC restoration, results may be the consequence of increased reliability of dentin adhesion in the last decade.[45,47-49] It would be interesting to compare indirect and direct inlay-onlay restorations to evaluate any differences in the rate of cuspal fracture. Some laboratory studies have demonstrated that modern adhesive systems in combination with RBC can further reinforce remaining tooth structure.[2,21] It has yet to be explained to what extent this can occur for both direct and indirect resin restorations, and further biomechanical studies are required. Certainly, adhesive systems have been researched intensively and improvement has been dramatic, possibly superior to those for composite resin. Lately, the mechanism of bonding to normal and sclerotic, coronal and radicular dentin has been researched, allowing clinicians to perform more predictable composite resin restorations with quartz and carbon fiber post-supported buildups.[15,30,50] Conversely, the mechanism of bonding to endodontically treated teeth needs to be further researched. The potential benefits of adhesive dentistry in this field have not been fully explored.[5] Devital dentin is deprived of its odontoblastic process and collagen layer, so a different hybrid layer is created due to absence of resin-impregnated collagen fibrils. The influence of endodontic sealers in contact with root dentin should be evaluated, as well as the interference of conventional irrigants (sodium hypochlorite and hydrogen peroxide) on dentin permeability

and bond strength of current adhesive systems.[24,33,36] Both biomechanical and ultrastructural studies are also required to better explain the behavior of adhesive systems on this particular substrate.

This case presents an example of resin-composite longevity in the posterior region. At the 2-year recall, no marginal discoloration, recurrent decay, chipping, or composite clefts were detected. Although the observation time was limited to only 2 years and just one case report was considered, the clinical performance of Esthet-X microhybrid composite was more than acceptable. Even though the clinical technique applied still has an experimental character, the clinical performance of UHMWP fibers placed on devital premolars and molars with missing cusps is under investigation in our clinic. The results seem to be promising after 12 months of clinical service, and are comparable to those presented in this study (unpublished data). However, before recommending a similar treatment on a regular basis, a longer follow-up period is required in addition to further in vitro and clinical studies.

A recent clinical study reported excellent clinical performance of direct RBC restorations used to reconstruct endodontically bleached teeth in extensive anterior restorations after a 2-year evaluation period.[9] A combination of progressive and pulse-curing technique was also adopted in the former study. The curing technique could have influenced the clinical performance of direct RBC restorations, because efforts were concentrated to delay the gel point in the attempt to give composite particles more time to flow in the direction of cavity walls, thus relieving stress from polymerization shrinkage. 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 because of increased stiffness of RBC.

It was demonstrated that a pulse-curing technique can reduce stress development at the cavosurface margins, avoiding the formation of microcracks.[8,25,44] 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.[20,34] Furthermore, lower light intensity and longer curing time has demonstrated an improvement in marginal adaptation while maintaining the excellent physical properties of composite resin.[31,37] The progressive curing technique used to polymerize dentinal increments may be critical in transmitting lower stress at the cavosurface margins.

It has become clear in recent literature reviews that posts do not strengthen endodontically treated teeth, and their use is justified only for retention of the coronal restoration.[4,43] Post preparation may be responsible for the destruction of sound tooth structure, and tooth perforation may also occur during this procedure. Some authors find that teeth with remaining coronal structure may not require the cementation of a post if adhesive restorations are used.[9,17,27] However, this assumption needs to be confirmed by further laboratory and longitudinal clinical studies. A similar procedure cannot be routinely recommended, due to the distinction between anterior and posterior tooth thickness and number of remaining cavity walls after tooth preparation.

UHMWPE fibers may represent a good compromise in terms of sound radicular tooth structure preservation and increased strength and retention of the composite build-up. However, the post-and-core buildup using woven fibers may be a technique-sensitive procedure. Manufacturers recommend the use of a combination of a visible-light-curing (VLC) unfilled resin, self- or dual-curing adhesive system and resin cement to assure complete polymerization of the post-and-core system. This same technique has been described in some recent clinical reports.[12,19,46] The use of dual or self-curing adhesive systems and resin cement may be responsible for some chemical incompatibility with the light-cured unfilled resin which is used to wet the ribbon fiber; then clinicians may not have enough time to insert and mold the fibers into the canal when building up a post. This procedure is based on the empirical assumption that the unfilled resin is used just to moisten the fibers; with the resin being very thin, the dual-curing flowable composite would cause its polymerization (Rudo DN, personal communication). The use of a dual or self-curing unfilled resin to wet the polyethylene fiber may be recommended, but it may render the procedure more technique sensitive.

Conversely, we used a VLC unfilled resin, a VLC adhesive system, and flowable composite to bond the polyethylene fibers to the tooth structure and composite resin core. To assure complete polymerization, a polymerization cycle of 240 s at 800 mW/cm^2 was completed, and further light energy was provided during the core buildup and final polymerization procedure. A lower total energy may be used to assure polymerization of the polyethylene fibers, but further research needs to be conducted on this subject. The introduction of composite resin with lower polymerization shrinkage and increased photosensitivity along with improved LED curing lights may dramatically reduce this curing time.[11,42] The long curing time used to build up the restoration may not be acceptable for most general practitioners, but dentist should keep in mind that considerable effort is needed to adapt the use of current direct resin composite to such challenging clinical situations. Single-appointment direct RBC restorations should ideally be restricted to small to medium-sized intracoronal lesions.[1] Alternatively, large multisurface defects can best be restored with indirect laboratory-processed restorations.[29] However, the higher cost of indirect restorations, patients' desire to maintain remaining sound tooth structure, and unfavorable anatomical conditions may render the direct restoration the first choice in many clinical situations.

CONCLUSION

The clinical case presented may be considered challenging even for experts in esthetic dentistry. Further in vitro and clinical studies are required before recommending

such treatment on a regular basis. However, continuous improvement of adhesive systems, composite resin, and curing techniques may make the use of direct RBC in reconstructing severely damaged teeth commonplace in the near future. The demand for indirect restorations may be reduced, and costs for both patient and dentist may be dramatically cut while saving remaining sound tooth structure.

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Clinical relevance: Success of direct composite resin restorations is influenced by selection of materials and techniques. The dentist should also keep in mind that the diligence and skill of clinicians play a very important role particularly when reconstructing severely damaged teeth.