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Clinical Technique/Case Report

Direct Fiber-reinforced Composite Restoration in an Endodontically-treated Molar: A Three-year Case Report

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Clinical Relevance

The proper utilization of fiber-reinforced resin composite restorations in endodontically-treated molars may preclude the use of more extensive restorative treatment, possibly delaying the need for expensive indirect restorations.

SUMMARY

The reconstruction of structurally compromised non-vital posterior teeth may represent one of the most challenging adhesive-based restorative procedures. Several factors may influence the longevity of direct fiber-reinforced resin composite restorations: endodontic procedures prior to post cementation, dentin and/or post surface treatments, selection of the appropriate post design and architecture, resin composite polymerization and layering techniques. Thus, different specialties, such as endodontics and restorative dentistry, should work as a team to improve the longevity of restorations. This article presents three-year clinical results following reconstruction of a severely damaged endodontically-treated molar using direct fiber reinforced resin composite systems.

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INTRODUCTION

Endodontically-treated teeth are weakened because of a decrease in water content and loss of dentin.[1] The decay process and/or tooth fracture may be responsible for the structural weakening of non-vital teeth; the tooth preparation required for adequate endodontic treatment may also contribute to the increased fragility.[2]

After endodontic therapy, selecting the appropriate reconstruction for each non-vital tooth should be based on the remaining hard tooth structure, the number and thickness of the residual cavity walls, the position of the tooth in the arch and the load implied. Resin bonded composite (RBC) restorations showed a strengthening effect on the tooth structure, with fracture resistance similar to that of unaltered teeth.[3-5] For many years, direct adhesive restorations have been used for anterior teeth with conservative endodontic access and intact marginal ridges.[1,6-7] Posterior non-vital teeth with an intracoronal conservative access only have also been restored with direct RBC.[4] Conversely, for many years, full coverage restorations have been indicated when the teeth are weakened by additional cavities on both the anterior and posterior area.[8-9] With the use of improved adhesive systems in the last decade, clinicians started

proposing alternative techniques to reconstruct severely damaged teeth; the main goal of the new build-up protocol is preservation and reinforcement of the remaining sound tooth structure.[2,10-11]

Although most of the coronal portion of the tooth is compromised, RBC restorations may serve to properly build-up anterior non-vital teeth by using adequate layering and curing techniques.[12] Conversely, RBC restorations are indicated in posterior teeth as long as sufficient tooth structure is preserved; more compromised teeth with missing marginal ridges and/or cusps may require placement of a post to gain additional retention of the core.[13] Lately, prefabricated tooth-colored fiber posts have been introduced and have demonstrated advantages over conventional metal posts.[14-15] They are esthetic, bond to tooth structure and have a modulus of elasticity similar to dentin. However, prefabricated tooth-colored fiber posts still require the dentin preparation to fit the canal space, thus further weakening the remaining tooth structure. Prefabricated posts are indicated for round post space; whereas, custom posts are required to closely adapt to the contours of wide root canals or oval-shaped canals.

Lately, increasing interest has also been devoted to the use of direct Ultra High Molecular Weight Polyethylene (UHMWPE) custom fiber reinforced post systems.[16-17] Being that they are bondable reinforcement fibers, UHMWPE posts adapt to the shape of the root canal; they are indicated for both round- and oval-shaped canals. Interestingly, enlargement of the root canal space is not required and the risk of root perforation is eliminated.

This article reports on the three-year longevity of direct fiber-reinforced RBC restorations in a severely damaged, non-vital molar and discusses the benefits of UHMWPE posts.

CASE REPORT

Restorative Procedure

A 20-year old female presented with an endo-treated upper molar. The restoration was delayed for two weeks after completing endodontic therapy. A rubber dam was placed and the existing temporary filling removed. Sharp angles were rounded with a #12 and #14 coarse ball-shaped bur (Brasseler, Savannah, GA, USA). No bevels were placed on the occlusal, proximal or gingival surfaces (Figure 1). Three to four millimeters of gutta-percha were removed from the mesio-buccal root canal. A sectional matrix (Composi-Tight, GDS, Spring Lake, MI, USA) was placed on the tooth and interproximal adaptation was secured using wooden wedges (Figure 2). Enamel and dentin were etched for 30 seconds using 35% phosphoric acid (UltraEtch, Ultradent Products, South Jordan, UT, USA) (Figure 3); etchant was removed, and the cavity was water

Figure 1. *Occlusal view of tooth #03 after placing rubber dam, preparing cavity and removing temporary filling.*

Figure 2. *A sectional matrix was placed after removing 3-4 mm of gutta-percha from the mesial buccal root canal.*

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

sprayed for 30 seconds, being careful to maintain a moist surface. A fifth generation 40% filled ethanol-based adhesive system (PQ1, Ultradent) was placed in the preparation, gently air-thinned to evaporate solvent and light cured for 20 seconds at 800 mW/cm^2 from the occlusal surface using an LED curing light (Ultra-Lume V-Ultradent).

A particular composite placement technique was selected to build-up the restoration. The combination of

Figure 4. *A piece of Ribbond fiber was wetted with unfilled resin, covered with flowable composite and inserted into the mesial buccal canal.*

Figure 5. *The enamel contour of the tooth was built-up using wedge shaped increments of PA and PS shades.*

RBC wedge-shaped increments and the UHMWPE fiber-reinforcement system (Ribbond Triaxial, Ribbond, Seattle, WA, USA) was considered to be of paramount importance to further reduce polymerization shrinkage, better support the RBC, reinforce the remaining tooth structure and reduce total composite volume mass.[18-19] An UHMWPE triaxial fiber (Ribbond) was selected, and the dental assistant started to manipulate it according to the manufacturer's instructions. Triaxial fibers were wetted with an unfilled resin (Permaseal, Ultradent), excess resin was removed and the fibers were completely covered with a B1 light-cured flowable resin composite (Permaflo, Ultradent) and placed in the central area of the restoration. UHMWPE triaxial fibers were folded and each end was placed into the root canal using a thin composite spatula[13] (Figure 4). The fiber-resin complex and flowable resin composite were light cured at 800 mW/cm^2 for 120 seconds to assure complete polymerization of the fiber-resin composite complex down into the canal.

Vit-l-escence microhybrid RBC (Ultradent) was considered the material of choice for restoring the non-vital teeth, because of its variety of enamel shades and excellent mechanical properties.[11] In order to avoid micro-crack formation on the remaining facial/palatal wall, the authors used a previously described technique, based on a combination of pulse and a progressive curing technique[11,20] (Table 1).

The sectional matrix was burnished against the adjacent tooth. Tooth build-up was started using 2 mm triangular-shaped (wedge-shaped) gingivo-occlusal placed layers of amber (PA) and smoke (PS) enamel shades to reconstruct the proximal and facial surfaces. This uncured composite was condensed and sculptured against the cavosurface margins and sectional matrix; each increment was pulse cured for three seconds at 800 mW/cm^2 to avoid micro-crack formation. Final polymerization of the PA and PS composite proximal and palatal/facial walls was then completed at 800 mW/cm^2 for 20 seconds. The enamel contour of the restoration was built-up, offering more reference to creating the correct occlusal anatomy (Figure 5). As a consequence of this layering technique, an increased C-factor may result. The C-factor was defined as the ratio between the bonded and unbonded surfaces; increasing this ratio resulted in increased polymerization stresses.[21] In this context, the application of wedge-shaped increments of resin composite was of paramount importance, because it helped to decrease the C-factor ratio. Dentin stratification of the facial, palatal and proximal walls was initiated, placing 2 mm wedge-shaped increments of A3 RBC into each enamel wall, avoiding contact with fresh increments. Successive A4 and A3.5 increments were placed in the central area of the restoration surrounding the resin impregnated fiber composite system to increase the chroma, unnaturally reduced by previously using B1 flowable composite (Figure 6). Each dentin increment was cured using a progressive "curing through" technique (40 seconds at 800 mW/cm^2 through the facial and lingual walls instead of a conventional continuous irradiation mode of 20 seconds at 800

Table 1: *Recommended Photocuring Times and Intensities for Enamel, Dentin and Post&core Build-up*

Build-up	Composite Shade	Polymerization Technique	Intensity (mW/cm^2)	Time (seconds)
Proximal & Palatal Enamel	PA/PS	pulse	800 + 800	3 + 20
Ribbond post& core build-up	B1	progressive curing	800	120
Dentin	A4 to A1	progressive curing + continuous curing	800	20* + 20
Occlusal Enamel	PN/PF	pulse	800 + 800	1 + 20**

**"Curing through."*
***20 per each surface (palatal, facial and occlusal surface).*

Figure 6. *Dentin stratification was performed placing A4 to A1 shades.*

Figure 7. *The restoration was completed with the application of PF/PN shade to the final contour of the occlusal surface.*

Figure 8. *Three-year post-operative occlusal view of the final restoration.*

Figure 9. *Radiographic image of tooth #03 at the three-year recall.*

mW/cm^2 from the occlusal surface). At this point, the middle third of the dentin restoration was built-up using a combination of A2 and A1 resin composite. Enamel layers of PF or PN were applied to the final contour of the occlusal surface according to a successive cusp build-up technique. This final layer was pulse-cured for one second at 800 mW/cm^2. A waiting period of three minutes was observed to allow for stress relief; the wedges and matrix were removed, along with the rubber dam; occlusion was checked and the restoration was finished using the Ultradent Composite Finishing Kit (Figure 7). The final polymerization cycle was completed by irradiating the restored tooth through the facial, palatal and occlusal surface, respectively, for 20 seconds at 800 mW/cm^2. Final polishing was performed using Jiffy polishing cups and points (Finale, Ultradent). Figure 8 shows the clinical appearance of the fiber-reinforced composite after a three-year evaluation period; no sign of marginal discoloration or alterations of the proximal and occlusal anatomy could be detected. The three-year radiograph showed no marginal gap at the gingival cementum/dentin-resin composite interface (Figure 9).

DISCUSSION

Fiber-reinforced resin composites may be based on various fabric configurations. The types of reinforcement may consist of unidirectional fibers, UHMWPE biaxial or triaxial braided fibers and UHMWPE leno-woven fibers. The unidirectional configuration provides significant enhancement of strength and stiffness in the fiber direction, but it has poor transverse properties, resulting in the tendency toward longitudinal splitting and premature failure. Rich-resin areas may also result from architecture modification during handling.[22]

Fiber orientation of biaxially braided material may also change after cutting and embedding into the composite when adapting to tooth contours. The fibers in the ribbon spread out and separate from each other, losing the integrity of the fabric architecture. Conversely, UHMWPE leno-woven and triaxial braided fibers can be cut and embedded into dental composites with no architecture alteration; the fiber yarns maintain their orientation and do not separate from each other when closely adapted to the contours of teeth. Belli and others[23] described a toughening mechanism for the leno-woven reinforced composite in MOD cavities of endodontically-treated teeth. They supported the favorable fiber elastic modulus and the interwoven nature of the fabric, allowing for distribution of the force over a wider area, thus decreasing stress levels.

In this case report, UHMWPE triaxial braided fibers were used to build-up the restoration due to the excellent adaptation to root canal walls and the capacity for matching stiffness of the root canal. In the triaxial braid architecture, fibers are arranged in three directions: the axial yarns and the two braiding yarns are oriented at predetermined sets of angles (such as ± 30° and ± 45°).[19] Karbhari and Wang[19] reported that the use of triaxial braids increases the flexural characteristic of resin composites and provides a high level of fatigue resistance by isolating and arresting cracks. These authors also reported that the maximum flexural stress of dentin was around 60% higher than that of unreinforced resin composite; conversely, the same braided resin composite provided more than 70% enhancement in maximum stress level.

Lately, fiber-reinforced resin composites have been extensively researched in the laboratory;[18,23-24] however, clinical data on the long-term integrity of similar restorations are still missing. Although the observation time was limited to only three years and just one case report was considered, no marginal discoloration, recurrent decay, chipping or composite clefts were detected. The preliminary results of this case report and the results of a 12-month clinical trial on direct fiber-reinforced resin composites seemed to meet the expectation of laboratory studies.

When placing UHMWPE triaxial braided fibers into the root canal, clinicians should take particular care with the adhesion and curing steps. The technique used to bond the UHMWPE was described earlier.[13]

Complete polymerization of the fiber-resin composite complex down into the canal was of great concern; therefore, only 3 to 4 mm of gutta-percha were removed from the root canal. A curing cycle of 120 seconds at 800 mW/cm^2 was completed, and further light energy was provided during the core build-up and final polymerization procedure. Previous considerations, along with recent developments in LED curing light technology and increased resin composite photosensitivity, may help to achieve complete polymerization, even into the canal.[25] Lindberg and others[26] compared the depth of cure of quartz tungsten halogen (QTH) and LED curing units at different exposure times and light-tip resin-composite distance. The authors used 6 mm specimens of A3 resin composite. Despite the lower power density of the LED unit (Ultralume 2), similar depths of cure were reported for the 20 and 40 second exposure times at a 0, 3 and 6 mm distance using both QTH and LED curing units. These findings were explained by the fact that QTH power density includes spectral ranges that are not well absorbed by camphoroquinone. Yap and Soh[26] reported that new generation high-powered LED lamps may cure resin composite as effectively as conventional QTH/LED lights, with a 50% reduction in cure time. Ernst and others[8] compared the depth of cure of different QTH and LED curing units. One to five mm thick A3 resin composite samples were used, and the light-guide tip was kept 7 mm from the bottom side of the composite specimen. The authors observed that LED-curing devices are capable of curing resin composites comparable to or even better than high intensity QTH curing devices.

The use of fiber posts to restore endodontically-treated teeth has tremendously increased over the last decade; the mechanism of bonding to intraradicular dentin has been extensively researched.[27-28] However, concerns still exist regarding the bonding reliability of fiber posts to intraradicular dentin. Clinical trials reported that fiber-post restorations may fail via debonding of the posts.[29-30]

A highly unfavorable C-factor was reported within the dowel space.[31] A large area of resin cement is bonded to the tooth structure and post surface; in fact, almost no free area is available to compensate for polymerization contraction. The irrigant solution and endodontic cement used for root canal treatment may also influence post retention.[32] Many root canal sealers contain eugenol, which has been described as interfering with the polymerization process of both adhesive and resin composite systems;[33] reduced dentin wettability, along with reduced bond strength, has also been associated with the use of eugenol-containing materials.[34] Eugenol-based endodontic sealers should be allowed to set completely before post-space preparation to avoid contamination of the post space. Vano and others[35] recommended not performing post-space preparation and cementation of fiber posts immediately after root canal filling; delaying the procedure for 24 hours or a week may help to increase post retention.

CONCLUSIONS

The reconstruction of severely damaged non-vital teeth requires knowledge of both curing and adhesive techniques. Fiber-reinforced resin composite restorations allow for the utilization of conservative tooth preparation, preservation and reinforcement of sound tooth structure. Selection of the appropriate fiber-post design and architecture is paramount to achieving this goal.

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