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Fiber-reinforced Resin Coating for Endocrown Preparations: A Technical Report

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Clinical Relevance

The presented clinical technique using fiber-reinforced composite as a resin-coating layer was developed for adhesive endocrown restorations. This may reduce the risk of catastrophic fractures and thus improve the success rate of this type of restoration on nonvital teeth.

SUMMARY

Coronal rehabilitation of endodontically treated posterior teeth is still a controversial issue. Although the use of classical crowns supported by radicular metal posts remains widespread in dentistry, their invasiveness has been largely criticized. New materials and therapeutic options based entirely on adhesion are available nowadays, from direct composite resins to indirect endocrowns. They allow for a more conservative, faster, and less expensive dental treatment. However, the absence of a metal or high-strength ceramic substructure as in full-crown restorations can expose this kind of restoration to a higher risk of irreversible fracture in case of crack propagation. The aim of this case report is to present a technique to reinforce the cavity of an endodontically treated tooth by incorporating a fiber-reinforced composite (FRC) layer into the resin coating of the tooth preparation, before the final impressions of the cavity. This technique allows the use of FRCs in combination with any kind of restorative material for an adhesive overlay/endocrown.

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INTRODUCTION

The tendency of endodontically treated teeth (ETT) to fracture is still a highly debated issue.[1] The biomechanics of an ETT are principally altered by the tissue loss due to prior pathologies (caries, fracture, cavity excavation), endodontic treatment (access cavity, root canal shaping), and invasive

Figure 1. *Initial view of the endodontically treated first maxillary molar after the removing of the provisional restoration.*

Figure 2. *Isolation of the cavity.*

restorative procedures (post placement, crown fabrication).[2] All of these factors may contribute to a consistent elimination of coronal and radicular tissues, which increases the fragility and thus the fracture risk of an ETT.[3] Recently, the restoration of ETT with adhesive techniques has been advocated both in the root and in the crown to prevent further loss of sound tissues as adhesion ensures sufficient material retention without the need for aggressive macroretentive preparation.[4–6] In particular, the use of bonded overlays, such as endocrowns, for the coronal restoration of an ETT is becoming more common than classic full-crown restorations. The reason for this change of paradigm is to achieve a more conservative approach, which preserves tooth tissues and allows reintervention in case of failure. Furthermore, endocrowns eliminate many technical steps during the fabrication, such as post cementation, core buildup, temporary crown, and potential crown lengthening, which increase treatment time and costs. Several *in vitro* studies and some *in vivo* trials have confirmed the validity of this adhesive approach, especially for molars.[4,7–12]

However, even with conservative overlays/endocrowns, drastic failures—below the cementoenamel junction (CEJ)—are possible, and they have been reported.[12–14] In case of crack propagation, the absence of a metal or high-strength ceramic substructure as in full crowns can expose this type of restoration to higher risk. To improve toughness, leucite and lithium-disilicate reinforced ceramics have been proposed.[15,16] As an alternative to ceramics, composite resins have been suggested because of their superior stress-absorbing properties and high degree of toughness.[8,10] In some *in vitro* studies, fiber-reinforced composites (FRCs) have been also employed to reinforce this kind of cusp-replacing restoration.[15,17,18] Beside improving the strength of the restoration, results of these studies demonstrate that the incorporation of glass fibers into composite resin materials usually leads to more favorable fracture patterns—above the CEJ—because the fiber layer acts as a stress breaker and stops the crack propagation. For classic lab-made indirect composite restorations, FRCs are commonly incorporated during the laboratory fabrication into the base of the work piece.[15,19] Unfortunately, this technique is not possible when the composite restoration is milled from a CAD/CAM block or with any kind of ceramic material. The aim of this case report is to present a technique that will allow the reinforcement of the cavity of an ETT, as opposed to the restoration.

Before taking the final impressions of the cavity, the FRC layer is incorporated on the surface of the tooth preparation. This technique allows for the use of FRCs in combination with any kind of restorative material for an adhesive overlay/endocrown.

METHODS AND MATERIALS

The case reported is an endodontically treated maxillary first molar in need of a restoration (Figure 1). A conventional indirect technique to fabricate an endocrown is accomplished by programming two appointments. During the first appointment,[20] the cavity is cut under local anesthesia. Once the cavity is properly isolated (Figure 2), an adhesive system is applied to the entire dentin and to the mesial thin subgingival portions of enamel margins and then light cured.[21] Then, an adequate amount of composite resin is applied on the dentin and into the mesial box and light cured. The goal is to fill the pulp chamber eliminating the undercuts, cover all the dentin, and relocate the cervical margins 1 mm

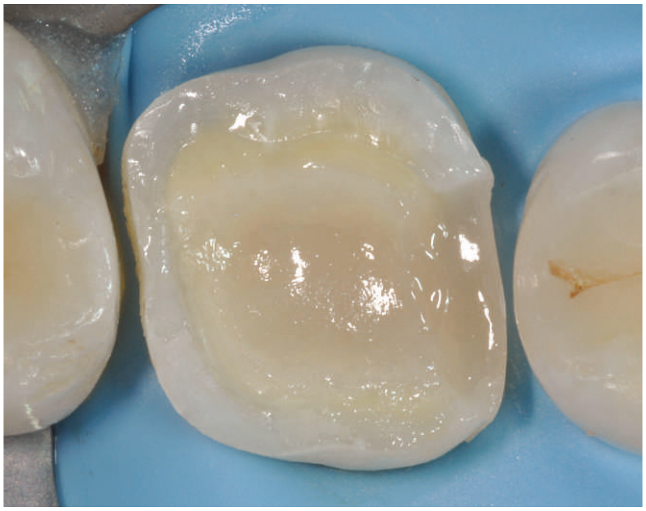

Figure 3. *The composite resin coating.*

Figure 5. *The customized transparent silicon key.*

supragingivally. For that purpose, a low shrinking nano-hybrid composite is applied (Tetric EvoCeram, Ivoclar-Vivadent AG, Schaan, Liechtenstein). Considering the thickness of the future restoration, at least 1.5 mm is recommended.[9,] Although adhesive luting does not require any particular taper of the cavity or a macro-retentive geometry, the fabrication of a concavity in the middle of the pulpal chamber will help with the positioning of the restoration during insertion (Figure 3). The next step is the insertion of the frame of resin preimpregnated bidirectional glass fibers (Dentapreg UFM, ADM A.S., Brno, Czech Republic) on top of the cavity preparation. The suitable mesiodistal length of the fiber network can be measured in the oral cavity with a periodontal probe (Figure 4). Fibers are then cut and left under light protection outside the mouth. Then, a transparent silicon key (Elite transparent, Zhermack SpA, Badia Polesine, Italy) is made to replicate the molar cavity and the occlusal part of adjacent teeth (Figure 5). A layer of about 0.5 mm of flowable composite (Tetric EvoFlow, Ivoclar-Vivadent AG), just enough to accommodate the FRCs, is spread into the cavity and left uncured. The fiber network is then inserted into the cavity over the flowable composite film, and its mesh is slightly opened (Figure 6). Thereafter, the FRC is completely adapted to the cavity with the customized silicon key and light cured (Figure 7). A second layer of flowable composite is applied over the FRC and light cured to cover all the exposed fibers (Figure 8). The enamel margins are finished with fine diamond burs (Composhape, Intensiv SA, Grancia, Switzerland) to obtain well-defined and sharp margins before the impression of the cavity (Figure 9). The

Figure 4. *The suitable length of the fiber-reinforced composite sheet is measured in the mouth with a periodontal probe.*

Figure 6. *The fiber frame embedded in a flowable resin is inserted into the cavity.*

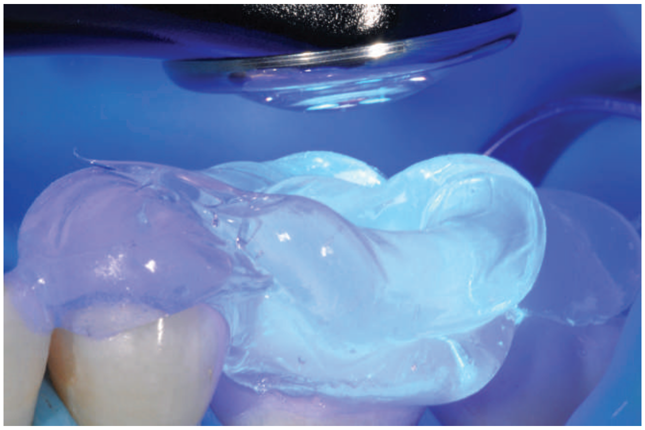

Figure 7. *The fiber-reinforced composite layer is polymerized through the transparent key with a powerful LED lamp.*

indirect restoration is then fabricated. In the case mentioned, the endocrown was milled from a CAD/CAM composite resin block (LAVA Ultimate, 3M ESPE AG, Seefeld, Germany; Figure 10). During the following appointment, the intaglio surface of the restoration and the cavity are adhesively treated, and the restoration is luted with a conventional light-cured micro-hybrid resin composite.[22]

DISCUSSION

In the past 30 years, the optimal performances achieved by modern adhesive systems and the growing emphasis on minimal invasive principles in all fields of dentistry have finally promoted adhesive strategies for ETT. Although metallic restorations and classic PFM crowns supported by radicular metal posts remain widespread, their invasiveness in the root as well as in the crown has been largely criticized, and new therapeutic options

Figure 8. *A further thin layer of flowable resin is applied on fibers to isolate and protect them.*

Figure 9. *Enamel is refurbished before the impressions.*

based on adhesion are available nowadays.[3,23–25] In the case of small to medium cavities, direct composite resins and indirect inlay/onlay restorations have almost replaced metallic restorations.[26–29] In the case of large cavities, or whenever a cuspal coverage is needed, bonded endocrowns made of ceramic or composite currently represent a valid alternative to classical full crowns to restore the esthetics and function of ETT.[4,8,10–12,15]

In the clinical case presented, the large amount of tissue lost due to pathology and to the endodontic treatment supports the use of a minimally invasive adhesive endocrown restoration instead of a full crown. This technique allows for the conservation of sound dentin and, above all, peripheral enamel, maintaining the possibility of bonding margins of the future restorations to it, which is known to have a beneficial effect on marginal stability.[30] The adhesive procedure also eliminates the need for the use of a post and a core, which would be otherwise necessary

Figure 10. *The CAD/CAM composite restoration one month after the luting.*

in a typical crown preparation. Moreover, the adhesive cavity configuration keeps all margins of the restoration away from the periodontium, which is beneficial for hygiene and periodontal health.[1,31]

Once the tooth is isolated by a rubber dam, a micro-hybrid composite resin is applied to the cavity. Regardless of its composition, resin coating aids elevating cavity margins in slightly subgingival areas as well as eliminating cavity undercuts, thus saving sound tooth structure. Besides these structural functions, the placement of this composite layer on dentin immediately after cavity preparation provides optimal cavity sealing and protection of the endodontic treatment during the temporization period.[32–34] Potential exposure to oral fluids and consequent water sorption of bonding resin are minimized as well.[35] In addition, a composite base leads to the fabrication of thinner inlays and onlays. This implies a better light penetration through the definitive restoration during light polymerization, introducing the use of light-cured luting composites above chemical or dual-cured resins for cementation. Furthermore, and especially for ETT, this composite base reinforces cavity walls during the temporary phase.[12]

Thereafter, a frame of resin preimpregnated bidirectional glass fibers is applied to the cavity (Dentapreg UFM, ADM A.S.). FRCs have been largely tested as materials above all in fixed partial dentures, and they have proved to have superior mechanical properties compared with conventional restorative particulate filler composite resins.[18,36,37] Their use is growing in cusp-replacing single-tooth restoration to overcome limitations in terms of fracture toughness of conventional composite restorative materials in high–load-bearing posterior areas.[15,17–19,38] The FRC layer is positioned between the tooth cavity and the restoration, in a more tensile zone.[37] In case of a classical indirect technique, this configuration is achieved by incorporating the fibers at the base of the composite overlay during the in-lab fabrication. During function, in case of a vertical crack inside the restoration, the FRC layer has the ability to slow or stop the crack propagation through underlying tissues, thus avoiding irreversible fractures. Considering the fibers' orientation, the choice of bidirectional or woven fibers seems more appropriate than unidirectional ones, as in the mouth the restoration is submitted to multidirectional chewing loads.[15,18] Although some authors consider that in single-tooth restorations, the ability of fibers to yield better failure modes is the most beneficial effect of FRC incorporation,[17] Dere and others[15] have recently found that the presence of a multidirectional FRC layer under cusp-replacing composite restorations also led to an improvement of fracture strength for endodontically treated molars.

In the specific case presented, the fiber layer is applied to the cavity before an impression is taken. The incorporation of the fiber layer is accomplished with the help of a layer of flowable composite. The same highly filled micro-hybrid composite used to seal the cavity may be the best choice from different points of view, as flowable composites exhibit high contraction stress during polymerization and may not be sufficiently resistant to deformation under load.[39,40] On the other hand, highly filled micro-hybrid composites are quite difficult to spread in a thin layer because of their high viscosity. The low viscosity of the flowable composite guarantees the diffusion of this resin into the preimpregnated fiber network and decreases the risk of void incorporation. The use of a customized transparent silicon key to push the fiber layer in place during polymerization improves the adaptation of the FRC sheet to the geometry of the cavity and limits the thickness of this intermediate layer. This aspect is of prime importance when a thin restoration is indicated.[41] Moreover, the customized key simplifies the application and the polymerization of the FRC layer compared with the use of specific metallic instruments as suggested by the manufacturer (Dentapreg Fork, ADM A.S.). Once the FRC layer is cured, further application of flowable composite over the fibers protects them from an accidental exposure during the temporary phase.[22,37]

The incorporation of the FRC layer into the tooth cavity before the impression gives the operator the choice between different restorative options. Several materials can be used to fabricate endocrowns, such as feldsphatic porcelain or reinforced glass-ceramic, hybrid composite, or CAD/CAM ceramic and composite blocks. The scientific literature is still not clear about which material is best indicated for this kind of restoration. The authors prefer hybrid composite resins, citing their stress-absorbing properties and their practical benefits such as the possibility to modify and repair the surface easily.[42] In particular, CAD/CAM resin blocks (LAVA Ultimate, 3M ESPE AG) may be used instead of classical lab-made restorations in order to avoid defects inherent in a free-hand laboratory technique and thus improving mechanical properties. The in-lab insertion of an FRC layer at the base of a milled CAD/CAM composite restoration, even if theoretically possible, would mean cutting the restoration, thus compromising its homogeneity.

CONCLUSIONS

Adhesive overlays, often called endocrowns, are increasingly used as a restorative alternative to full crowns for nonvital teeth. Their advantages are minimal invasiveness, simpler preparation, and optimal coronal seal. The risk associated with these restorations is rare but may result in a catastrophic vertical fracture of the tooth-restoration complex, often leading to the extraction of the tooth. The presented clinical technique with FRC reinforcement of the resin-coating layer was developed for use with CAD/CAM composite or ceramic restorations. It may reduce this risk of extensive fractures and thus improve the success rate of this type of restoration on nonvital teeth.

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Conflict of Interest

The authors certify that they have 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.

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