

Fiber-reinforced Composite Fixed Partial Denture to Restore Missing Posterior Teeth: A Case Report

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Abstract

In patients refusing implant surgery for psychological reasons, when minimal tooth reduction is desired, a fiber-reinforced composite inlay fixed partial denture (IFPD) can be used to replace missing teeth. In comparison to other restorative systems this conservative approach carries a lower risk of pulp exposure and/or periodontal inflammation, maintaining the health of supporting tissues. The purpose of this case report is to describe the clinical procedure for fabricating an IFPD with a pre-impregnated glass fiber system and a hybrid composite. Fiber-reinforced composite, in combination with adhesive techniques, appears promising for an IFPD. Further clinical investigation will be required to provide additional information on this technique.

Keywords: Adhesive dentistry, fiber-reinforced composite, glass fibers, metal-free restorations, Vectris system

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Introduction

Various therapeutic solutions can be used to replace a single missing tooth. For many years, metal-ceramic fixed partial dentures (FPDs) have been the treatment of choice for this purpose.¹ However, the metallic framework is less than esthetically pleasing, the metal margins of metal-ceramic FPDs may be visible, frequently making it preferable to locate the finishing line subgingivally. Moreover, to provide the FPDs with retention and stability, aggressive tooth reduction is necessary during preparation of abutment teeth with a higher risk for pulp exposure.²

The development of implant-supported restorations led to a more conservative approach to single-tooth replacement. However, some patients reject this therapeutic option either because of the higher cost or for fear of surgery. Systemic problems may also contraindicate surgery. In these situations a metal-free inlay fixed partial denture (IFPD) may be an alternative to metal-ceramic FPDs.

All-ceramic IFPDs are frequently used to replace missing teeth. Because of their poor flexural strength, they are only recommended as single units and only as far back as the first premolar.^{3,4} Over the last few years, the development of fiber-reinforced composites (FRC) has offered the dental profession the possibility of fabricating adhesive, esthetic, and metal-free tooth replacements even in the case of molar teeth.⁵

Structurally, the fiber-reinforced composite is made up of two components: the fibers and the resin matrix. The resin matrix serves as carrier, protector, and load-splicing medium around the fibers. To improve the mechanical properties of composite resins and to optimize the mechanical behavior of the material, specifically-oriented filler materials, such as glass fibers, aramid fibers, carbon/graphite fibers, and ultra high molecular weight polyethylene fibers (UHMWPE), have been proposed. Polyethylene and glass fibers are the materials most frequently used for FPDs. *In vitro* studies have shown the clinical and mechanical performance of FRC depends on several factors, including fiber direction and pretreatment. Unidirectional fibers are anisotropic with high strength in one direction, while bidirectional fibers give so-called orthotropic properties to the

material in one plane and random-oriented fibers give isotropic properties.⁶ In order to reinforce the restoration in multiple directions woven fibers and meshes have been proposed.⁷ Resin-pre-impregnated and non-impregnated fibers are available on the market. Pretreatment of fibers with a silane coupling agent appears to minimize shrinkage on polymerization and reduce cracks and pockets, ensuring reliable adhesion between fibers and resin matrix.⁸

Both all-ceramic and fiber-reinforced composite restorations offer a good esthetic and mechanical result; however, in comparison to all-ceramic restorations *in vitro* studies indicate FRC possesses better fracture resistance and marginal adaptation.^{9,10} A significant advantage of composite prosthetic solutions over other restorative materials is they may be repaired intraorally without the risk of modifying esthetic or mechanical performance.¹¹ Moreover, the use of adhesive procedures for luting IFPD requires a minimally invasive preparation with supragingival margins. This conservative approach allows for a low risk of pulp exposure and periodontal inflammation, improving the health of supporting tissues.¹²

In this clinical report an extremely innovative conservative prosthetic solution, employing pre-impregnated glass fibers and composite resin, is described.

Case Report

A fiber-reinforced composite inlay fixed partial denture (FRCIFPD) was used for a single tooth replacement in a patient refusing surgery for psychological reasons. The FRCIFPD was made of pre-impregnated glass fibers (Vectris Pontic/Vectris Frame, Ivoclar Vivadent Inc., Schaan, Liechtenstein) embedded in a resin matrix (Enamel Plus HFO, Micerium Spa., Avegno, Italy). The glass fibers were used to make a framework structure which was divided into two parts: the inner part, consisting of parallel fibers, called the "pontic" and the external part, consisting of fibers aligned at 90°, called the "frame." To reproduce the morphology of natural teeth, the framework structure was then covered with Enamel Plus HFO.

Case Analysis

A 62-year-old man presented missing a maxillary right first premolar (Figures 1 and 2). Diagnostic casts were made, duplicated, and mounted in a semi-adjustable articulator (Model 2240, Whip Mix Corp., Louisville, KY, USA). A wax-up was effected in order to plan preparations and to ensure a minimal reduction of tooth structure.

Preparation of Abutment Teeth

After occlusal analysis with articulating paper, the cavity preparations were made following information available in the literature concerning adequate tooth reduction for an IFPD.¹³ The cavity preparation for FRCIFPD is similar to those for inlay restorations, while following the philosophy of maximum conservation of tooth structure: the box-shaped proximal preparation was performed on abutment teeth.¹⁴ Since the retention of the prosthesis was due to adhesive luting and not to parallelism, the walls of the cavity were flared between 5° and 15°. All internal line angles were rounded and the gingival floor was prepared with a butt joint. Occlusal reduction of 2 mm was made so as to obtain a suitable placement of the fibers and composite resin.¹⁵

After sketching the cavity (Figure 3), the operating field was isolated with a rubber dam and a 35% phosphoric acid gel (Ultra-Etch, Ultradent, South Jordan, UT, USA) was applied to the prepared surfaces for 30 seconds. The teeth were then rinsed and gently dried. Scotchbond Multi-Purpose (3M ESPE Dental AG., Seefeld, Germany) was applied to the preparations following the manufacturer's instructions.

To protect the prepared tooth surfaces and to reduce restoration microleakage, a thin layer of flowable composite (Tetric Flow, Ivoclar Vivadent Inc., Schaan, Liechtenstein) was applied.¹⁶ After light-polymerization of the flowable composite for 40 seconds, the cavity margins were finished with diamond-coated finishing diamond burs (Nr. 3113R/3117, Intensiv SA., Grancia, Switzerland) (Figure 4).

Impression and Temporization

After removing the rubber dam, an impression of the prepared teeth was made using an elastomer material (Permadyne Penta H/Garant, 3M ESPE



Figure 1. Occlusal view showing missing maxillary right first premolar.



Figure 2. Preoperative facial view.

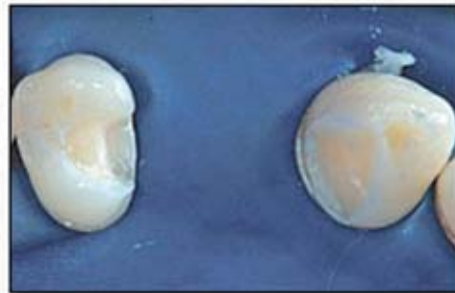


Figure 3. Proximal preparations on occlusal-distal surface of maxillary right canine and mesio-occlusal surface of maxillary right second premolar have been carried out.

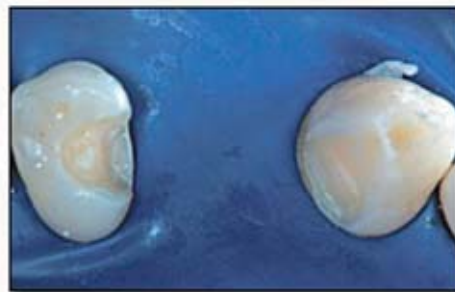


Figure 4. After protecting the prepared surfaces with flowable composite, the cavity margins have been finished with appropriate diamond burs.

Dental AG., Seefeld, Germany). The inlay cavities were provisionally restored with a light curing methacrylate material (Fermit, Ivoclar Vivadent, Inc., Schaan, Liechtenstein). Before light curing, a Vectris Pontic (Ivoclar Vivadent Inc., Schaan, Liechtenstein) fiber bar was placed across the prepared teeth, inserted into the Fermit, to act as a space maintainer.¹⁷

Prosthesis Fabrication

Die stone was poured (Figure 5) and the casts were mounted in a Model 2240 semi-adjustable WhipMix articulator. The Vectris system enables a specifically-designed individual fiber structure to be produced, depending on the framework shape required.

To maximize the fiber content, the Vectris Pontic fiber was vacuum/pressure adapted (Figure 6). The framework structure was then completed with the application of fiber with 90° alignment (Figure 7) and further adapted through a vacuum/pressure process.

Finally, the fiber framework was finished (Figure 8), wetted with a silane coupling agent (Wetting agent, Ivoclar Vivadent Inc., Schaan, Liechtenstein), and veneered with Enamel Plus HFO (Figure 9).

To improve the mechanical properties of the FRC, the IFPD (Figure 10) was post-polymerized at 90°C for 25 minutes under the vacuum/pressure process (Vectris VS1, Ivoclar Vivadent Inc., Schaan, Liechtenstein).

Try-in and Adhesive Luting of FRCIFPD

At the time of luting, the provisional restorations were removed with a scaler and the preparations were cleaned with a finishing diamond bur (Cerinlay Set Prep, Intensiv SA., Grancia, Switzerland). The FRCIFPD was evaluated intraorally to assess marginal fit and esthetics before definitive cementing. The restoration fit was evaluated with an explorer and a silicone-based material (Fitcher, GC America, Chicago, IL, USA), while the esthetic result was evaluated visually.

The adhesive cementation of the FRCIFPD followed the recommendations proposed by Behr et al.¹⁴ The area was isolated with a rubber dam



Figure 5. Die stone used to fabricate FPDs in the laboratory.



Figure 6. Inner part of fiber framework has been realized by longitudinal glass fibers (Vectris Pontic).



Figure 7. To reinforce the Pontic framework, fibers with 90° alignment (Vectris Frame) have been applied on the longitudinal fiber structure.



Figure 8. Fiber framework has been finished and checked on the working die.

and the cavity preparations were etched with Ultra-Etch for 30 seconds. After rinsing and gentle drying, Scotchbond Multi-Purpose was applied to the preparations.

The inner surfaces of the IFPD retainers were airborne-particle abraded using 110 micron modified silica particles propelled by compressed air (Rocatec Junior, 3M ESPE Dental AG., Seefeld, Germany) and then brushed with a silane solution (Pulpdent Silane Bond Enhancer, Pulpdent Corp., Watertown, MA, USA). Scotchbond Multi-Purpose was then applied and the FRCIFPD was luted with the composite used to fabricate it: Enamel Plus HFO. Light-polymerization of the composite (60 seconds per side) enables working time to be extended and facilitates removal of excess cement.¹⁸

After checking occlusion with articulating paper, the prosthesis was finished with diamond burs (Composhape, Intensiv SA., Grancia, Switzerland) and polished with a polishing system (Enhance, Dentsply DeTrey GmbH., Konstanz, Germany) (Figures 11 and 12).

Discussion

The mechanical properties of FRC must be improved so as to reduce the risk of clinical failure due to catastrophic fracture.¹⁹ The fracture strength of FRCIFPD depends on several factors including: the elastic modulus of the supporting substructure, the preparation design, occlusal load of the span and the characteristics of the manufacturing process, and the materials used to fabricate the prosthesis.

Few studies have focused on cavity preparation for FRCIFPDs, and the principles governing standard cavity preparation have not been established. When making box preparations for an FRCIFPD, if pre-existing restorations are present, they can determine abutment shape. Otherwise, when teeth are intact, mechanical and biological aspects must be considered in choosing the preparation design: the proximal box should be as deep as possible in the gingival direction to ensure an adequate amount of FRC and to provide maximal strength in the connection area. At the same time, the margins must be located within the enamel for better long-term marginal adaptation.²⁰



Figure 9. Esthetic composite resin veneered with a layering technique.



Figure 10. Marginal fit and morphology of the prosthesis has been checked on the working die before luting.



Figure 11. After adhesive luting, the FRCIFPD offers esthetic and less invasive restoration of the missing tooth.



Figure 12. Postoperative facial view.

The manufacturing process may also influence the mechanical properties of the FPD. Several techniques have been proposed for FRCIFPD using pre-impregnated glass fibers. Some systems prefer manual adaptation of the pre-impregnated fibers. Others use glass fibers pre-impregnated with thermoplastic polymers, which form a multiphase polymer matrix with light-curing monomers. Both these procedures have been proposed with the goal of reducing the equipment needed for their manufacture. To the contrary, the Vectris system entails vacuum/pressure adaptation of the fibers in a mold with specific processing and curing equipment. This technique maximizes fiber content, decreases pockets in the framework, makes the technique more predictable,²¹ and, at the same time, provides optimal framework design, ensuring better stress distribution within the tooth/restoration complex during occlusion and clenching.¹³

In veneering the fiber structure an optimal esthetic result may be achieved thanks to the use of different shades of composite.^{22, 23} In the case reported here a hybrid fluorescent composite, available in numerous dentine and enamel shades, was used.

Conclusion

Over recent years, the desire expressed by many patients for cosmetic and metal-free restorations has led to the development of better-performance and truly aesthetic composite resins. The use of fibers as reinforcement has also provided appropriate mechanical behavior of materials used to replace missing teeth. The FRCIFPD enables the original tooth anatomy to be reproduced, together with functionality and esthetics, while preserving tooth structure. Thus, when an esthetic restoration with minimal tooth reduction is desired, the FRCIFPD may be a valid therapeutic option to replace single missing teeth.

The FRCIFPD, in combination with adhesive techniques, appears to be an effective restorative solution. However, additional studies are necessary to provide additional clinical data from which to draw further conclusions concerning this therapeutic approach.

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