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Clinical Technique/Case Report

Immediate Tooth Replacement Using Fiber-reinforced Composite and Natural Tooth Pontic

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Clinical Relevance

This case report describes a restorative procedure for immediate tooth replacement using a natural tooth pontic and fiber-reinforced composite following extraction in an area of severe localized bone loss.

SUMMARY

The loss and replacement of anterior maxillary teeth poses several challenges. In patients refusing implant surgery, when minimal tooth reduction is desired, a fiber-reinforced composite fixed-partial denture may be used as a conservative alternative to a conventional fixed-partial denture for replacement of a single missing tooth. This article describes a clinical technique and six-year follow-up. The patient presented with a missing maxillary central incisor due to localized juvenile periodontitis. The abutment teeth were clinically stable. The advantage of supragingival margins and minimal tooth structure removal made the bonded bridge with a natural tooth pontic a viable procedure for this compromised restorative situation.

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INTRODUCTION

The rehabilitation of esthetics in patients with reduced periodontal tissue support is a challenge in dentistry. Destruction of the supporting tissue can be so advanced in some teeth that extraction seems to be the only treatment option.

When extracting a maxillary anterior tooth, one of the major concerns is its immediate esthetic replacement. For esthetic reasons, delayed replacement is unacceptable. Nevertheless, immediate dental replacement in this esthetic zone is a challenge, especially when the adjacent teeth are caries free and have good esthetics. Psychologically and functionally, a provisional removable appliance is seldom acceptable. Similarly, crown preparation of adjacent intact teeth is considered by many practitioners to be radical treatment.[1] Implant supported prostheses may not be the best solution due to severe localized soft and hard tissue loss.[1] Furthermore, many patients fear the required surgery or ridge reconstruction and some consider the treatment costly. Fiber-reinforced composite fixed pros-

theses are an innovative alternative to traditional treatment. They have been increasingly studied during recent years and provide restorations with a considerable increase in strength.[2-4]

Structurally, 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 resin composites and to optimize the mechanical behavior of the material, in particular, 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 useful for fixed partial prostheses.[5] *In vitro* studies have shown that the clinical and mechanical performance of fiber resin composite (FRC) depends on several factors, including fiber direction and pretreatment.[5] Glass fibers are treated with a silane chemical coupling agent to allow dental resins to chemically adhere to the glass fiber strands. To improve the bonding of resin to polyethylene fibers, these synthetic polyethylene fibers are chemically treated with thorough surface etching, referred to as plasma treatment, which allows the resin to chemically bond to the polyethylene fibers. Without this treatment, there would be no surface wetting of resin and bonding between the two substrates.[6] Fiber composites are heterogeneous and anisotropic, meaning their properties strongly depend on the direction in which they are tested relative to their fiber orientation. For unidirectional fiber composites in which the fibers run parallel and in one direction, properties are highest in the direction parallel to the fibers and lowest in the direction perpendicular to the fibers. Multiple fiber orientations can be achieved in one of two ways: either by placing unidirectional fibers in multiple directions or by using a braided or woven fabric.[7] Another critical factor affecting the strength of fiber-reinforced composites (FRCs) is adhesion between the fibers and the resin matrix.[8] Without adequate adhesion, the fiber acts as an inclusion in the resin matrix, which actually weakens the composite.[9-10] Also, void volume content between the fibers decreases the flexural properties of FRCs.[9]

A higher volume fraction of fibers in the resin matrix improves the mechanical properties.[11-12] However, in dental applications, fiber fractions are generally limited.[7-8] This is due to the fact that fibers should be covered with a layer of unfilled polymer or with a layer of particulate filler composite.[13] In order to optimize the mechanical properties in dental applications with a relatively low quantity of fibers, the position and orientation of fibers should maximize the stress transfer from matrix to fibers.[8]

Chairside tooth replacement is an excellent application for fiber-reinforced composite (FRC) technology. Previous attempts at chairside tooth replacement involved the use of pontics derived from extracted teeth,[14-15] acrylic resin denture teeth with or without lingual wire reinforcements[16-17] and resin composite.[18-19] A chairside FRC prosthesis offers a fast, minimally invasive approach for tooth replacement that combines all of the benefits of the FRC material for an esthetic, functional and potentially durable result. A denture tooth or a natural tooth (in the case of extraction of a periodontally-involved incisor) can be used as a pontic.[7]

Selection criteria for this tooth replacement approach includes:

- A patient who desires an immediate, minimally invasive approach.
- A patient who requires an extraction in an esthetic area and desires an immediate replacement.
- Abutment teeth with a questionable long-term prognosis.
- A non-bruxing patient.
- Cost considerations.[7]

Chauhan M treated 21 patients over six years using a natural tooth pontic in a fiber-reinforced composite fixed-partial denture. Two patients had the natural tooth pontic debond. This was attributed to unresolved parafunctional habits.[20] Auplish G described the immediate replacement of a lateral incisor using fiber-reinforced composite with the natural tooth as the pontic.[21]

The current article describes a clinical case in which an FRC bridge was fabricated using the natural tooth as a pontic for immediate replacement of a central permanent incisor following extraction.

CASE REPORT

A 19-year old man with severe bone loss of the maxillary right central incisor, associated with juvenile periodontitis, was referred to the Restorative Department. No labial soft tissue recession was observed in spite of a deep pocket being present (Figure 1). Extraction of the tooth was indicated due to progressive bone loss and probable further damage to the adjacent teeth. Significant gingival and papillary recession following tooth extraction was predicted. The patient was unwilling to loose his tooth and was concerned about esthetics immediately after extraction.

The occlusion demonstrated a deep overbite and no signs and symptoms of parafunctional habits, such as grinding and clenching of the teeth, were observed. Deep caries in the left central incisor was diagnosed but the right lateral incisor was caries-free. Mobility or esthetic problems on abutment teeth were not observed.

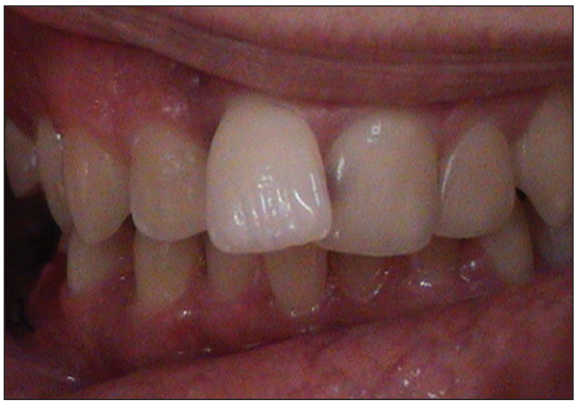

Figure 1. *Preoperative view.*

A fixed-partial denture was not indicated because of the required extensive tooth preparation and probable damage to pulp tissue. The patient was not willing to use a removable partial denture. An implant supported prosthesis could not be placed due to severe vertical bone loss and undetermined prognosis of periodontal disease and economic aspects. Therefore, an immediate chairside fiber-reinforced composite bridge using a natural tooth pontic was the treatment of choice.

Soft and hard tissue recession following removal of an anterior tooth presents a unique restorative challenge and may lead to unesthetic, open gingival embrasures (black triangle) in a fixed prosthesis.[22] Upon evaluation of the tooth position in the bony environment, it is evident that conventional osseous architecture follows the cementoenamel junctions of the teeth only 2 mm more apical in location.[23] This osseous scallop occurs more apically on the facial and lingual aspects and coronally in the interproximal region.[22] Typically, the osseous scallop from facial to interproximal averages 3 mm in height across the maxillary anterior region.[24] The height of the gingival scallop from facial to interproximal, however, is commonly determined to be 4.5 to 5.5 mm.[22] In order to understand the process used to maintain the papilla following extraction, it is necessary to identify the etiology of the discrepancy in bone height in relation to the gingival scallop.[22] The concept of biologic width has been well described in the literature.[25-26] It has been determined that the connective tissue attachment has a mean height of 1 mm, the epithelial attachment has a mean height of 1 mm and the average sulcus is approximately 1 mm deep.[22] In the average patient, this results in 3 mm of gingival tissue above the osseous crest, which fails to explain the height of the gingival scallop from the facial to interproximal aspect, which is about 4.5 mm.[22] It appears that the presence of adjacent tooth attachment and the size of the gingival embrasure formed by these teeth is responsible for the presence and height of the papilla.[22] When a tooth is removed and a confined embrasure no longer exists, the interproximal papilla recedes to the same 3 mm level above bone as exists facially.[22] Consequently, the gingival scallop flattens to match the underlying osseous scallop, which results in compromised gingival esthetics.[22] The most effective means of recreating a papilla is to prevent its loss at the time of extraction. One solution requires the fabrication of a restoration with the same embrasure volume that existed prior to extraction; the papilla is subsequently permitted to reform.[22] The replacement should occur within hours of extraction.[22] This restoration supports the facial gingival margin and the interproximal papilla.[27] The depth of the extension into the socket and the shape of the extension are critical to the maintenance of the soft tissue profile.[22] The pontic should typically extend 2.5 mm apical to the facial free gingival margin upon extraction, which establishes the site of the pontic within 1 mm of the facial bone to prevent the facial tissue from collapsing during initial healing.[22] Along with depth, the shape of the pontic is also critical to papilla maintenance.[22] It is critical that the interproximal contour matches that of the previously extracted tooth and that the apical extension of the papilla mimics the smooth contour of the corresponding tooth. Any opening of the gingival embrasure below tissue risks an alteration in papillary height. In order to ensure papillary support through the entire buccolingual width of the papilla, the interproximal contour should also be extended palatally past the contact point.[22] The ovate pontic design is the most esthetically appealing. Its convex tissue surface resides in a soft tissue depression or hollow in the residual ridge, which makes it appear that a tooth is emerging from the gingiva. Because the tissue surface of the pontic is convex in all directions, it is accessible to dental floss; however, meticulous oral hygiene is necessary to prevent tissue inflammation resulting from the large area of tissue contact.[28] The natural tooth was prepared as an ovate pontic.

The length of the left central incisor (natural pontic) was determined by measuring the gingival level to the incisal edge plus 3 mm, so it could be extended into the alveolar socket to shape the gingivoproximal tissue level and preserve the papilla.

After anesthetizing, the tooth was extracted (Figure 2). A piece of sterile gauze was gently packed into the extraction site to prevent bleeding. The extracted tooth was immersed in normal saline, then scaled from the remaining soft tissue. The root was cut from the determined length. The root canal opening at the apical was enlarged with a straight fissure bur (Drendel+Zweiling [D&Z], Lemgo, Germany) to allow removal of the pulp tissue by filing (Figure 3). The apical end of the root was formed into an ovate pontic design with finishing diamond burs (D&Z). The canal opening was then restored with a resin composite

(Z250, 3M ESPE, St Paul, MN, USA) using an adhesive technique. A high, smooth surface area was then achieved at the apical area of the natural tooth pontic with diamond finishing instruments (D&Z) and polishing rubber points (Ivoclar-Vivadent, Schaan, Liechtenstein).

After maintaining hemostasis, the gauze was removed. The pontic was then positioned on the extracted site and positioning indexes were marked on the pontic and adjacent teeth for achieving an accurate alignment of the pontic. A tunnel was prepared across the pontic from one proximal side to another with fissure and round burs at the predetermined level. The tooth was then rinsed to remove debris and dried. The etchant gel (Ultra-Etch, Ultradent, South Jordan, UT, USA) was applied to the prepared tunnel and slightly beyond the margin onto the proximal surface. The etchant was left undisturbed for 15 to 30 seconds (30 seconds for the enamel margin and 15 seconds when dentin was involved). After rinsing and gently air drying, excess water was removed using cotton pellets applied in the tunnel. The adhesive bonding agent (Single Bond, 3M ESPE) was applied to all the prepared tooth structure according to the manufacturer's directions. Once applied, the adhesive was polymerized for 20 seconds from each direction using a halogen light-curing unit (Optilux 70, Coltène-Whaledent, Cuyahoga Falls, OH, USA). The tooth was then put aside.

The abutment teeth were anesthetized and Class III cavities were prepared in the marked areas (Figure 4). The teeth were then isolated with cotton rolls during the remaining portion of the procedure.

Premeasured FRC material (Fiber-Braid, NSI, Dental Pty Ltd, New South Wells, Australia) was cut and immersed into the specified bonding agent (Margin Bond, Coltène-Whaledent) and flowable composite (Filtek Flow, 3M ESPE) for 15 minutes. During this time, it was protected from early polymerization by artificial and natural light. Then, it was passed gently through the tunnel with clear cotton pliers. Following this step in the procedure, a small amount of flowable composite was inserted into the tunnel and hybrid resin composite (Z250, 3M ESPE) was packed into the tunnel to fill it completely (Figure 5).

The extended FRC materials were protected with foils to prevent polymerization of the non-embedded section during light curing of the embedded segment. This procedure allowed the clinician adequate working time to properly place and embed the FRC into the two adjacent cavities.

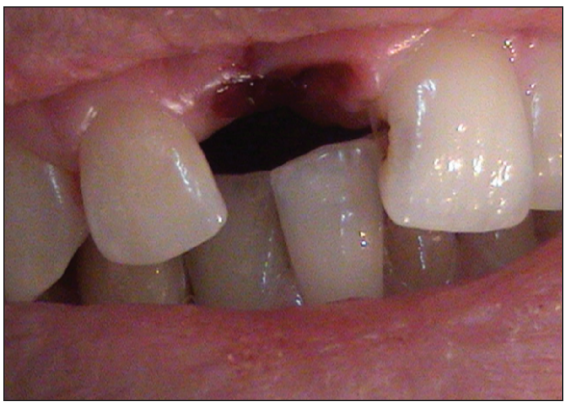

Figure 2. *Extraction site.*

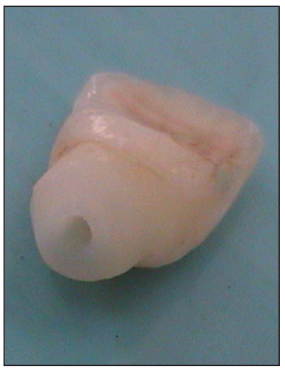

Figure 3. *Prepared tooth extraction.*

The Class III preparations on the abutment teeth were etched, rinsed and gently air-dried. The adhesive was applied and cured. The flowable and hybrid composite were placed into the prepared Class III preparations prior to placement of pontic. The pontic was then placed into the predetermined position and the extended fibers were positioned into the Class III preparation. The fibers were condensed through the resin composite with a plastic instrument and polymerized for 40 seconds from each direction. More resin composite was added to fill the Class III cavities and completely cover the fibers (Figure 6).

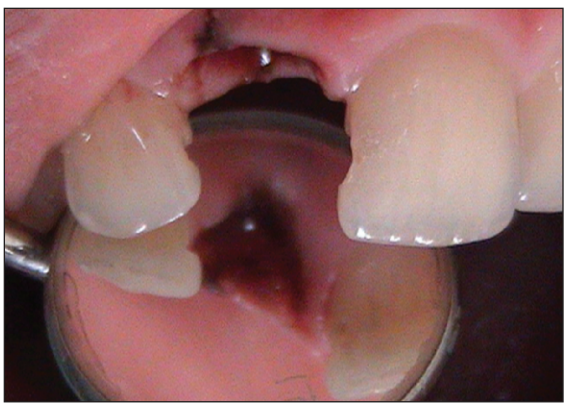

Figure 4. *Prepared adjacent teeth.*

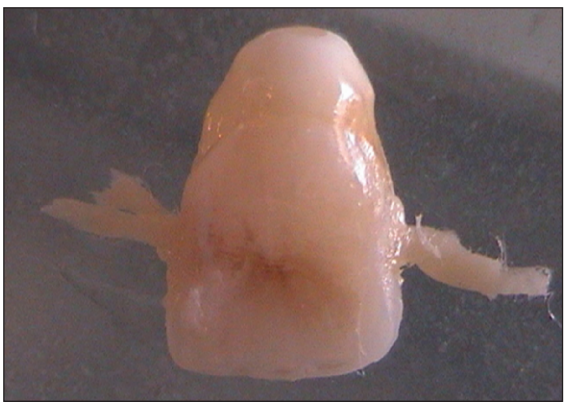

Figure 5. *Prepared pontic.*

Occlusal adjustment was then made using articulating paper and diamond finishing burs (D&Z) and surfaces polished with rubber polishing points (Ivoclar-Vivadent).

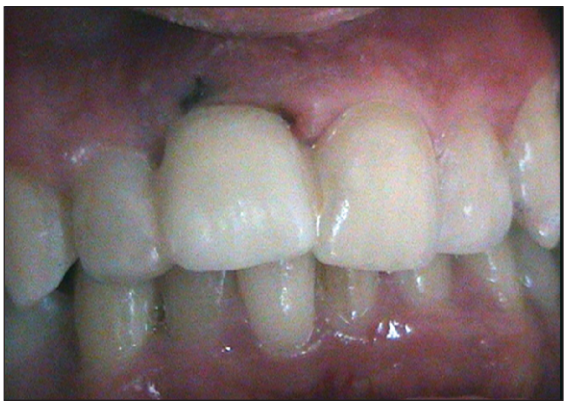

Figure 6. *Immediate final restoration.*

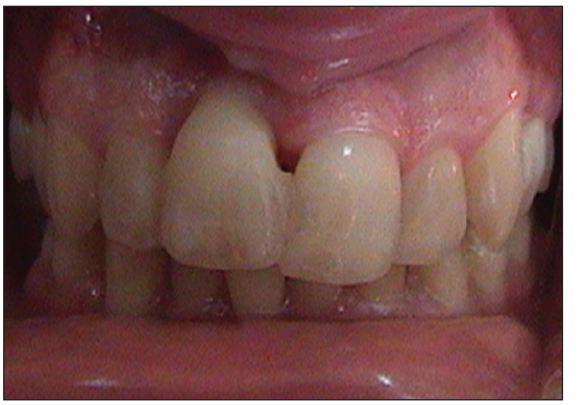

Figure 7. *One-year follow-up restoration.*

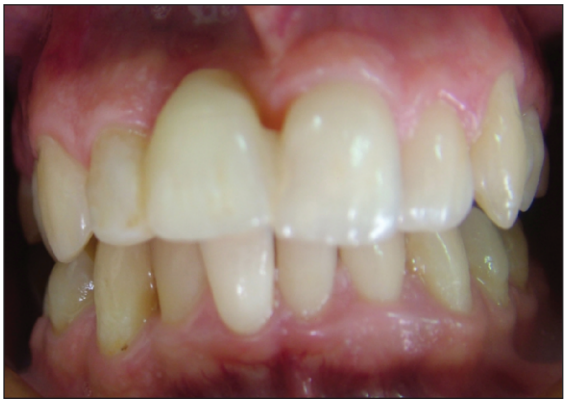

Figure 8. *Six-year follow-up restoration.*

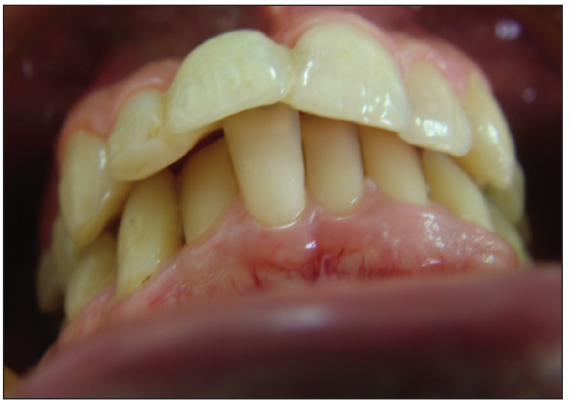

Figure 9. *Palatal view.*

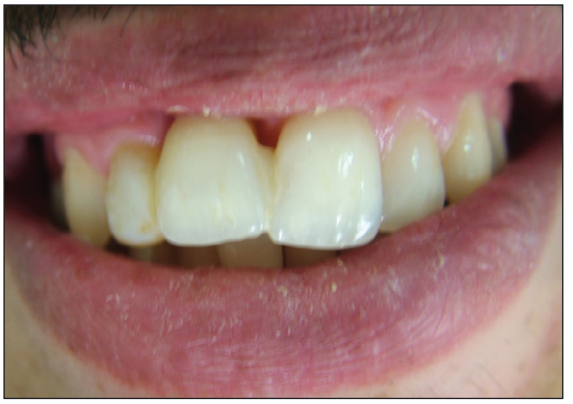

Figure 10. *Frontal view.*

The patient was instructed to keep his restoration clean and free from plaque (Figure 7). The six year follow-up showed no adverse effects or failure, except for some gingival recession, which was expected (Figures 8-10).

DISCUSSION

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.[29] However, the metallic framework is less than esthetically pleasing. Moreover, to provide the FPD with retention and stability, aggressive tooth reduction is necessary during the preparation of abutment teeth with a high risk of pulp exposure.[30]

The development of implant-supported restorations led to a more conservative approach to a 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.

Resin-bonded fixed-partial dentures (FPDs) with metal frameworks are considered to be a practical and conservative approach, but no documentation of long-term success, especially for the replacement of posterior teeth, could be identified.[31-32] The most common type of failure with resin-bonded FPDs is debonding of the cast metal framework from the luting cement; however, debonding of the luting cement from the enamel surface has also been reported.[33-34] Teeth have some degree of mobility under function, which causes repeated tensile and compressive stresses at the interface between the metal framework and the composite luting cement. Repeated stress can predispose fatigue failures of the adhesive joint. By selecting a material that has a lower modulus of elasticity than that of cast metal alloy, stress at the interface can be diminished.[35] A group of materials whose modulus of elasticity can be tailored to specific needs is fiber-reinforced composite (FRC).

Few reports on the successful use of FRC restorations in peer-reviewed literature include clinical reports[36-37] and a study with short-term follow-up.[38] The primary type of failures identified were either bulk fracture at the connector or the pontic area, debonding of the veneering composite or fiber exposure.

FRC restorations are expected to withstand masticatory forces. Different testing methods and difficulty in measuring masticatory forces result in a wide range of force values. Stress applied during mastication may range between 441N and 981N, 245N and 491N, 147N and 368N and 98N and 270N in molars, premolars and canine and incisor regions, respectively.[39] A restoration should be able to withstand stress to approximately 500N in the premolar region and 500N to 900N in the molar region.[39]

In dental applications, such as fixed prostheses, splints and posts, FRC are usually subjected to flexure or bending in clinical service.[7] While clinical performance is the final determinant of success, flexure is still the most widely reported mechanical property.[7]

The experimental fiber-reinforced denture resins of the 1960s had properties only marginally superior to those of the resins themselves, and some reports even showed decreased strength with reinforcement due to poor adhesive between the fibers and the matrix.[40] As fiber contents were increased and the overall quality of the dental fiber composite improved, their flexural strengths became sufficient for application, such as frameworks for fixed prostheses.[7] The early thermoplastic-based dental fiber composites had a flexural strength of 200 to 500 MPa.[41] The earliest prosthodontic framework fiber composites used for implant-supported prosthesis approached flexural strength values of approximately 250 MPa.[42] Contemporary methods of glass-fiber reinforcement of denture resins produce strengths of 265 MPa,[43-44] and the reinforcement of dental resins with high-strength polyethylene fibers can achieve values of approximately 200 MPa.[45] Typical flexure strength values for commercial laboratory-processed fiber-reinforced composite ranges from approximately 300 MPa to 1000 MPa, depending on the test specimen preparation and geometry.[46-47] Table 1 summarizes the flexural properties of some FRC products. The fiber type and architecture of these products are described.[7]

Although reinforced composite materials seem to provide excellent esthetics, some authors do not recommend composite materials for permanent restoration[48-49] because of unstable esthetics, increased wear[50] and liability to plaque accumulation.[51] In the current study, the risk of discoloration, loss of superfacial gloss and increased wear was diminished due to use of natural tooth as a pontic.

When making box preparations for a fiber-reinforced composite fixed partial denture, if teeth are intact, mechanical and biologic aspects must be considered when 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.[52] In addition, the possibility of extending the bonding surface of FPD even to the labial/buccal surface of the abutment without causing esthetic problems seems to offer new possibilities in FPD treatment.[38] In this case report, immediate replacement of the maxillary central incisors associated with severe bone loss using fiber-reinforced composite with a natural tooth pontic addressed esthetics, patient comfort and psychological acceptance.

A six-year follow-up demonstrated good clinical success. Complications, such as postoperative sensitivity, caries, debonding and fracture at the connector area and discoloration, were not observed. Also, there was

Table 1: *Classification and Flexural Strength of Fiber-reinforced Composite Dental Product*

Product	Company	Fiber Type	Fiber Architecture	Flexural Strength	
Pre-impregnated laboratory products				Elastic Limit	Ultimate
Fiber Kor	Jeneric/Pentron	Glass	Uni-directional	471	539
Vectris Pontic	Ivoclar	Class	Uni-directional	510	614
Pre-impregnated/ chairside product	Jeneric/Pentron	Glass	Uni-directional	469	617
Split-it			Weave	170	220
Impregnated-required/chairside products					
Connect	Kerr	polyethylene	Braid	50	222
Glas Span	Glas Span	Glass	Braid	266	321
Ribbond	Ribbond	Polyethylene	Lenoweave	56	206

no high plaque accumulation, and gingival inflammation and bleeding was not observed during clinical evaluation. It should be mentioned that the patient strictly observed the oral hygiene instructions, and polishing of the restored surfaces was performed during periodic recall visits. The abutment teeth were conserved, keeping the technique relatively reversible, and the procedure could be completed chairside, thereby avoiding laboratory costs. However, efforts in preserving the gingival papilla by immediately placing an ovate pontic in the extraction area was not achieved likely due to preexisting periodontitis.

CONCLUSIONS

In recent years, the desire expressed by many patients for cosmetic and metal-free restoration has led to the development of better performance and truly esthetic resin composites. The use of fibers as reinforcement has also provided appropriate mechanical behavior in materials used to replace missing teeth.

The described technique using a patient's natural tooth as a pontic in a resin composite-reinforced fiber framework is a conservative, esthetic and cost-effective method for the replacement of incisors. This technique enables the original tooth anatomy to be replaced, together with functionality and esthetics, while preserving tooth structure. The fiber-reinforced composite fixed partial denture, in combination with adhesive techniques, appears to be an effective restorative solution. However, additional studies are necessary to provide more clinical data from which to draw further conclusions regarding this therapeutic approach.

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