A surface-retained glass fiber-reinforced bridge with a CAD/CAM-fabricated pontic

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Fixed partial dentures (FPD) fabricated from FRC (hereafter abbreviated as FRC FPDs) are nowadays considered a minimally invasive and cost-effective treatment[1,2]. They gained popularity in the early 1990's and since then have been commonly used in teeth with poor prognosis, as a substitute for removable partial dentures that replace a few missing teeth and in situations where costs are an issue[3]. Clinical experience has shown that most clinical failures are due to three main reasons: incorrect fiber orientation[4], incorrectly designed fiber framework[5,6] or inaccurate occlusal adjustment[3]. The most commonly reported reasons for FRC FPD failures are delamination and chipping of the veneering composite[2,5,7–10], dislodgement[4,8,9], and partial6 or complete debonding. Traditionally FRC FPDs have been fabricated directly (intraorally), semi-directly (chairside i.e. pre-making the fiber framework and the pontic partially extraorally)2,5,7 or indirectly (in a dental laboratory)[3,4,6,8,9,11]. Until today, CAD/CAM technology has been used only in vitro for fabricating the pontic of a simple FRC FPD[12,13]. To the authors' knowledge, this technique, has not been yet implemented clinically.

This clinical report describes the treatment of a missing maxillary left first molar with FRC FPD utilizing CAD/CAM (computer-aided design and computer-aided manufacturing) technology for designing and fabricating the pontic.

A 72-year-old female patient was referred to replace a missing maxillary left first molar, which had been extracted more than 12 years earlier due to secondary caries on the crown margins and a periodontal lesion. The maxillary left wisdom tooth had to be extracted one year prior to referral because of a periodontal-endodontic lesion. Since then, the patient started to experience decreased functional stability in the second

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Fig. 1: Intraoral photographs; a) maxillary arch; b) mandibular arch and c) lateral view.

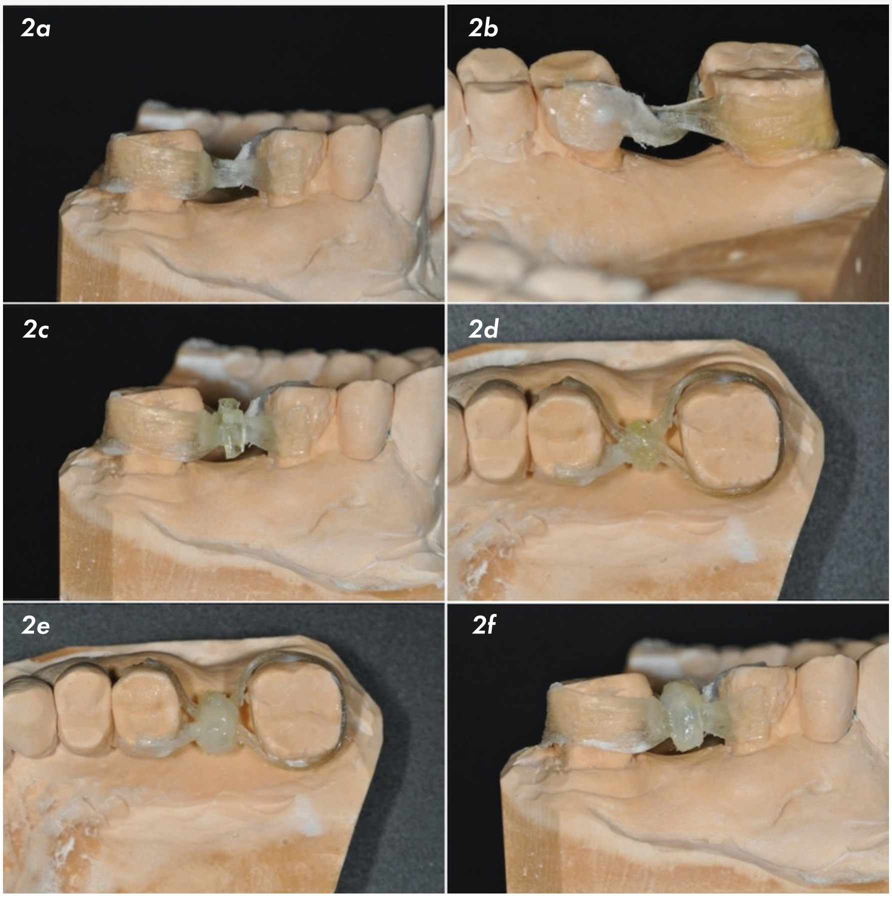

Fig 2: Fiber framework on the plaster model. Main fiber framework from different views: a) buccal and b) palatal view. Pontic additions from different views: c) buccal (perpendicularly placed everStick C&B unidirectional fiber); d) occlusal (unidirectional fiber); after e) buccal (covered with everX composite and f) occlusal (with everX).

quadrant, and wanted to close the gap and to regain masticatory function.

The mesiodistal width of the edentulous space was 7.5 mm (Figs. 1a, b) and the occlusal plane was not disturbed (Fig. 1c). The adjacent second molar had migrated in mesial direction and the interproximal space available for the pontic approximated a premolar size. There was no increase in mobility detected in the abutment teeth.

The patient desired a fixed, non-invasive treatment solution and particularly required to completely avoid tooth preparation or surgery. Therefore, treatment solutions such as implants or metal and/or ceramic bridge constructions were not considered. Alternatively, a surface-retained FRC FPD was proposed, emphasizing that the solution was considered semi-permanent and experimental.

Laboratory procedure

The glass fiber framework was fabricated on an isolated plaster model utilizing various kinds of resin impregnated E-glass FRCs. The main FRC framework was made with unidirectional E-glass fiber bundles (everStick C&B, with ø 1.5 mm and 4000 glass fibers per bundle) and bidirectional E-glass fiber net (everStick Net, thickness 0.06 mm). The pontic area was reinforced with two short pieces of unidirectional FRC (everStick C&B) placed in inciso-gingival (axial) direction to the main fiber framework, and covered with short-fiber-reinforced composite resin (everX Posterior and everX Flow, Dentin shade) (Figs. 2a-f).

Once the framework was smoothly ground to final shape (with a handpiece micromotor and fine diamond burs of 40 grit) and cleaned with air spray, an optical impression of the fiber framework was taken. A fully anatomic pontic was virtually designed (CEREC 4.6.1 Software) (Figs. 3a-e). In order to obtain a proper design and shape of the pontic, the fabricated fiber framework was placed on the model during scanning. When the virtual model was generated, the

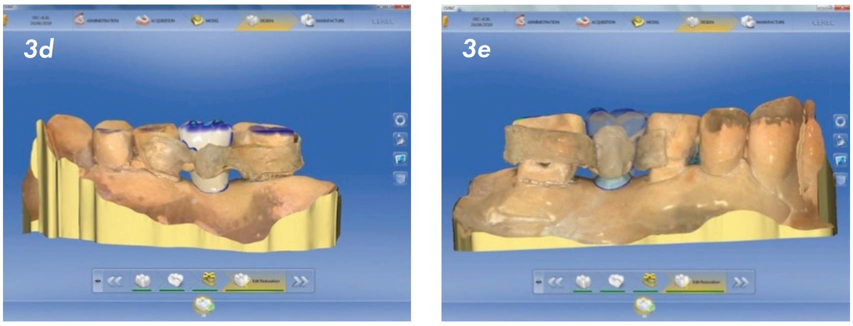

Fig 3: Representation of the digital process. Virtual model with the fiber framework in situ. a) soft tissue marking of the missing tooth; different views of the designed pontic: b) buccal, c) occlusal and d) palatal view; e) virtual material thickness evaluation.

margins of the framework and the soft tissue of the missing tooth were marked. The automatically generated pontic was then modified (in shape, size, and position) and adjusted to fit the desired material thickness (approximately 2.5 mm of overlaying material above and below the fibers). Next, it was milled from a hybrid CAD/CAM block (CERASMART 270, HT, shade A2).

Prior to bonding of the pontic to the fiber framework, both bonding surfaces were treated. The bottom surface of the CAD/CAM pontic was sandblasted with 27 µm Al_2O_3, cleaned in an ultrasonic bath with distilled water for 2 min and silanated for 60 s. A bonding agent was applied to the surface, allowed to dry and light-polymerized for 20 s. The inner surface of the smoothly ground and steam-cleaned fiber framework was also treated with the same adhesive, which was left unpolymerized (protected in a light protecting box) for a minimum of 5 min and light cured for 40 s. An injectable resin composite (G-ænial Universal Injectable, shade A2 and G-ænial Posterior, shade A2) was then used to bond the pontic to the fiber framework and light-cured for 40 s (Figs. 4a and b).

Clinical procedure

Preceding cementation, abutments were cleaned with pumice and then isolated using rubber dam. All surfaces were cleaned by sandblasting with 27 µm Al_2O_3, etched with 35% phosphoric acid, rinsed and air-dried. A metal primer and a one-component universal adhesive (G-Premio BOND) were applied to the sandblasted gold inlay surfaces and all bonding teeth surfaces, respectively, following the manufacturer's instructions and left unpolymerized. The FRC FPD cementation surfaces were also treated with an adhesive for 5 minutes (shielded from light) and light cured for 40 s from each side. A preheated resin composite

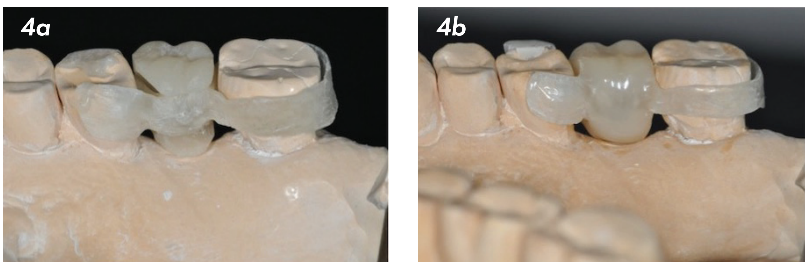

Fig 4: Creation of the FRC FPD. The milled pontic was a) fitted and b) bonded to the fiber framework.

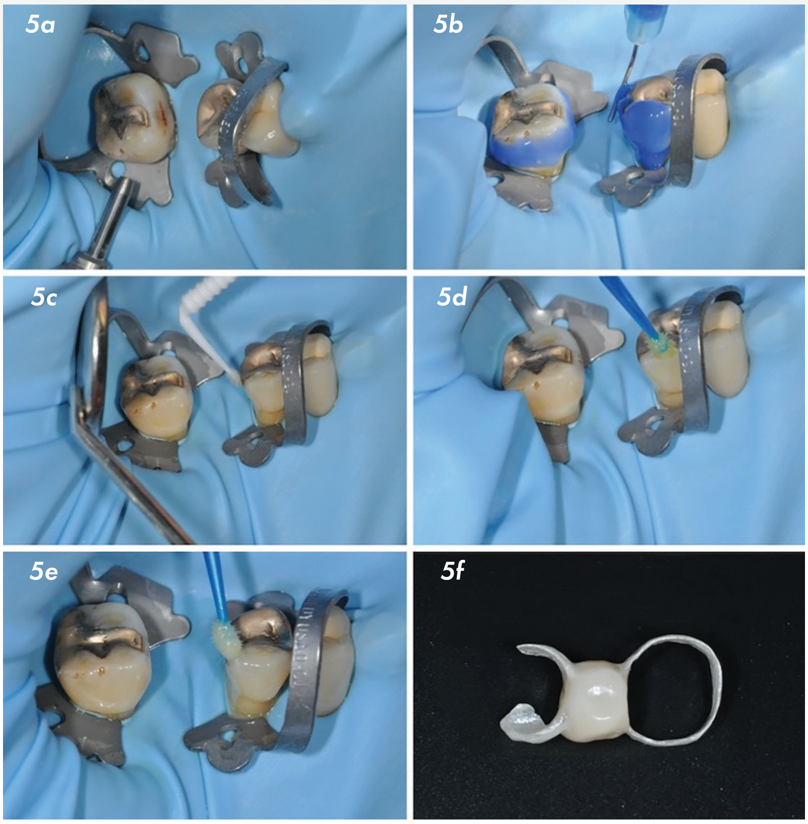

Fig. 5: Clinical cementation steps. a) sandblasting; b) etching with phosphoric acid; c) application of metal primer to gold restorations; d) application of primer to the tooth; e) application of resin adhesive to all surfaces and f) the adhesively treated fiber framework.

(G-ænial Posterior, shade A2) was used for luting the FRC FPD. After excess removal, all surfaces were light-cured for 40 s each, followed by occlusion adjustment and polishing (Figs. 5a-f).

The patient was examined at baseline (Figs. 6a-c), after 3 months (Figs. 7a and b) and 12 months (Figs. 8a and b). No signs of debonding, surface staining of the bridge or wear were observed. However, marginal discoloration was observed at the 3 and 12 month controls, and surface lustre was slightly lost after 12 months of service.

Subjectively, the patient expressed satisfaction with the FCR FPD and adaptation to the additional volume of material (loop and wings) was not difficult. At the one-year recall, the construction was still well accepted and not perceived as a foreign object. The patient was instructed and motivated to maintain oral hygiene. In addition, it was planned to include her into a six to nine months re-call program. This way, failures could be detected and repaired in an early stage. Due to COVID-19 related restrictions, the last follow-up appointments could not take place in the hospital; hence, the patient was interviewed by phone. The patient reported that the FRC FPD was still in place and without subjective problems. The device had been in function for 28 months at the time of the latest follow-up interview. The FRC FPD design in the present patient case did not involve preparation of any cavities or undercuts. The retention was mainly achieved utilizing natural retentive features (tooth undercuts and pits) and by the fiber framework design (wings, loop). Because the construction is mainly surface-retained, debonding is likely to occur at some point[3,8–10].

However, the main advantages of the presented solution are:

1. its complete reversibility, offering the opportunity for diverse treatment options in the future;
2. tooth substance preservation, which makes the biological cost very low and
3. the possibility for an easy intraoral repair or re-bonding due to the semi-IPN network, which supports the functional survival.

The uniqueness of FRC FPDs lies in the individual (custom) fabrication of the fiber framework. The main fiber framework construction was made of fully impregnated uni- and bidirectional E-glass FRCs, whereas short fibers were used to give an anatomical shape of the fiber framework in the pontic zone. It has to be emphasized that all fibers used (everStick, everStick Net, everX Posterior and everX Flow) have the same matrix composition. This is the multiphase polymer matrix, known as semi-interpenetrating polymer network (semi-IPN), due to which reliable bond to the veneering composite and to the luting cement could be developed [3,14,15].

The pontic in this clinical case was virtually designed using digital technology. The use of a digital technique was found to be beneficial for evaluating the material thickness, and optimizing the anatomy and shape of the overlaying structure around the fibers. Compared to direct composites, hybrid ceramic CAD/ CAM block have better mechanical properties[16], which might also decrease the incidence of chipping and delamination within the veneering material. Furthermore, standardizing the fabrication quality will

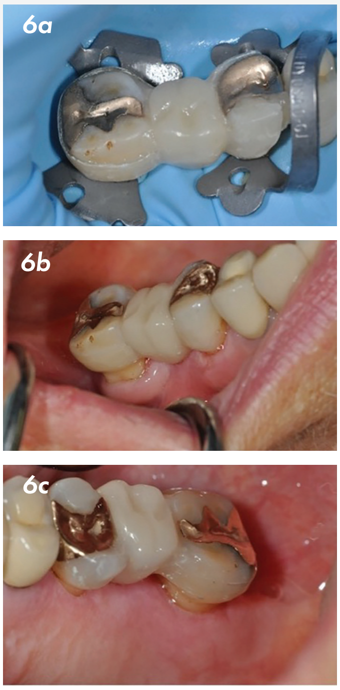

Fig. 6: Clinical images at baseline. a) freshly cemented FRC FPD; b) buccal and c) palatal view.

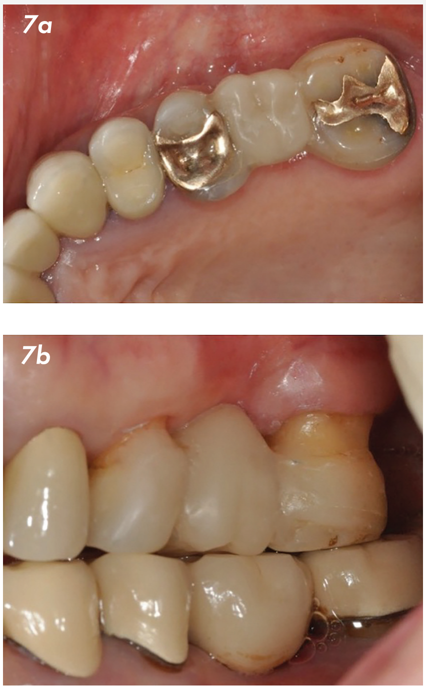

Fig. 7: Clinical images at follow-up after 3-months. a) occlusal and b) buccal view.

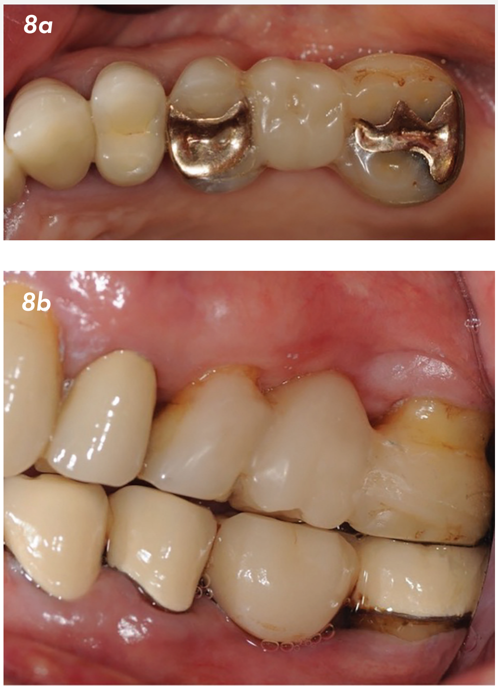

Fig. 8: Clinical images at follow-up after 12-months. a) occlusal and b) buccal view.

minimize operator-related flaws, such as air entrapment.

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