Four-Year Clinical Evaluation of GFRC-RBFPDs as Periodontal Splints to Replace Lost Anterior Teeth

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Purpose: The aim of this study was to evaluate the clinical performance of glass fiber-reinforced composite-based resin-bonded fixed partial dentures (GFRC-RBFPDs) as periodontal splints for periodontal support-reduced anterior partially edentulous dentition and for replacing lost teeth.
Materials and Methods: A total of 39 subjects were enrolled who required fixed restorations for lost mandibular anterior teeth where the adjacent teeth offered severely reduced periodontal support. GFRC-RBFPDs were cemented to replace the lost teeth and to stabilize the adjacent teeth. The survival rates were recorded, and the periodontal condition (bone height, bleeding index, and probing depth) was evaluated at 1, 2, 3, and 4 years after the restorations. The results were statistically analyzed with single-factor variance analysis and chi-square tests ($\alpha = .05$).
Results: The complete survival rate was 89.7%, and the functional survival rate was 92.3% at the fourth year. The main reason for failure was fracture of the connector of the GFRC-RBFPDs. In 21.7% of adjacent teeth, the bone height decreased; in the other 78.3%, it increased from 1 year after the restoration to the end of the observation period and the heights were statistically different from the initial values. The periodontal condition of the adjacent teeth was improved after the restoration. ***Conclusions:*** This 4-year clinical evaluation indicated that GFRC-RBFPDs may be useful as fixed prostheses to replace one to three lost anterior teeth with damaged periodontal support in adjacent teeth. *Int J Prosthodont 2016;29:522–527. doi: 10.11607/ijp.4845*

Requests for a fixed restoration of lost mandibular anterior teeth are sometimes problematic for dentists. There is often an alveolar defect in the edentulous area as well as periodontal disease of the adjacent teeth, making both implants and fixed partial denture (FPD) restorations difficult. For these situations, the main treatment strategy involves controlling the deteriorated periodontal condition of the adjacent remaining teeth, replacing the lost teeth, and providing easy follow-up management after restoration. Glass fiber-reinforced composite splints have proven useful for stabilizing mobile teeth, which also clinically improves the periodontal condition.[1] Glass fiber-reinforced composite-based resin-bonded fixed partial dentures (GFRC-RBFPDs) have an acceptable survival rate of 85.6% when used to replace a single lost anterior tooth.[2,3] GFRC-RBFPDs could be offered to patients as a minimally invasive, inexpensive alternative to a fixed restoration with an acceptable esthetic result. Until now, however, GFRC-RBFPDs have been used as temporary restorations[4] or retainers after orthodontic treatment.[5] Moreover, there is insufficient clinical research on the outcome of using GFRC-RBFPDs to replace lost teeth while simultaneously stabilizing adjacent teeth with periodontal disease. This study evaluated the clinical performance of GFRC-RBFPDs as a fixed anterior prosthesis and periodontal splint for anterior partial edentulism with reduced periodontal support. They were cemented to the enamel of adjacent teeth using 4-META/MMA-TBB resin cement, which is safer and has sufficient adhesive strength.[6,7] This study analyzed the 4-year survival and periodontal condition of the adjacent teeth.

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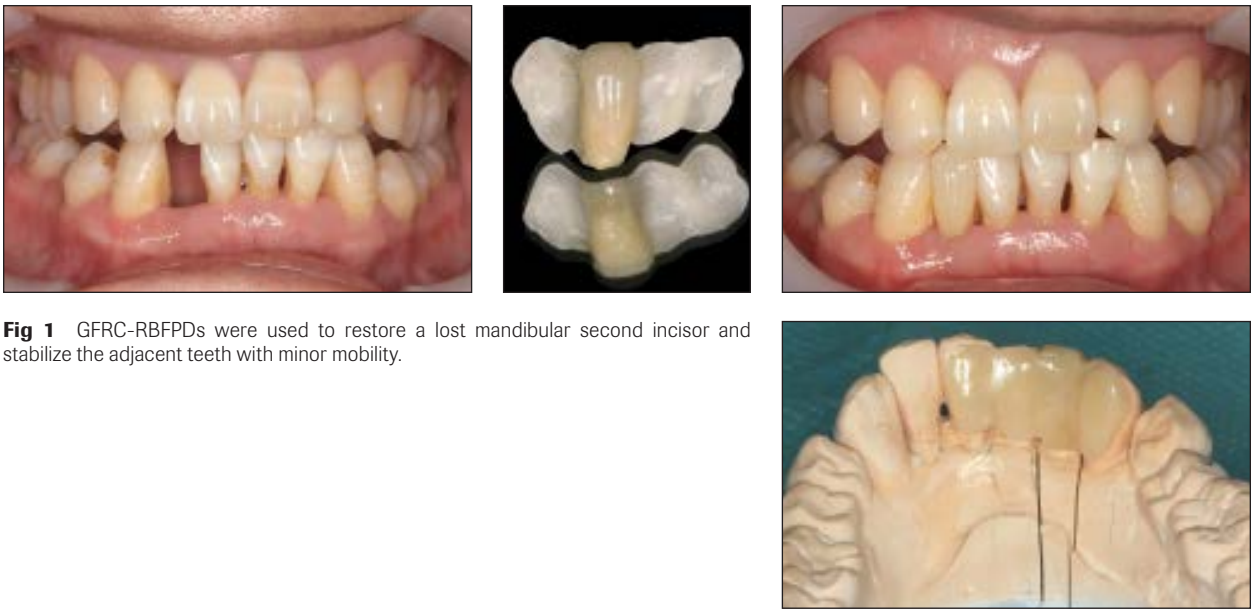

Fig 1 GFRC-RBFPDs were used to restore a lost mandibular second incisor and stabilize the adjacent teeth with minor mobility.

Materials and Methods

Subject Samples

The study enrolled 39 patients (23 men, 16 women; average age 45 years, range 25–79 years) who required fixed restorations for lost mandibular anterior teeth in the Prosthodontics Department of the School of Stomatology, Peking University, in 2010 and 2011. Of the subjects, 3 had lost three teeth, 13 had lost two teeth, and 23 had lost a single tooth.

The inclusion criteria were as follows: mandibular anterior partial edentulism with one to three lost teeth, periodontal support of adjacent abutments markedly reduced on one or both sides, free of acute or progressive inflammation, bone height around the adjacent abutments not less than one-third of the root length on radiographic examination and abutment mobility less than Class II by forceps examination, length of the clinical crown of the adjacent abutment teeth exceeding 5 mm, normal arrangement of the adjacent teeth with shallow vertical and horizontal overlap of bite, not suitable for implant replacement and crown-retained fixed partial prosthesis restoration, prior completion of thorough basic periodontal treatment, at least three pairs of posterior teeth on one side of the dental arch without a distal free-end removable denture, and the patient's agreement to regular recall and required maintenance after the restoration.

Subjects were excluded if they had a chronic systemic disease such as diabetes or hematologic disease, had progressive periodontal disease of the adjacent teeth, had a severe oral parafunctional habit such as bruxism, could not understand the advantages and disadvantages of RBFPDs, could not be followed regularly, or could not maintain good oral hygiene.

The clinic research protocol was approved by the Medical Ethics Committee of Peking University (PKUSSNCT-08B08, 2008). Subjects were enrolled once they provided written informed consent.

Clinical Procedures

The adjacent abutment teeth were prepared only by cutting off the axial undercuts of the mesial adjacent and lingual surface, stopping at the enamel layer, with no need to form a chamfer or shoulder-type finishing line. Working models were poured after final impressions were taken using polyether impression material (Impregum Penta Soft, 3M ESPE). The GFRC-RBFPDs were fabricated using E-fiberglass (everStick C&B, GC) as a framework and covering it with indirect composite resin (Ceramage, Shofu). The wing retainers of the frameworks were placed along the lingual surfaces of the adjacent teeth and extended for an extra tooth if the adjacent tooth was mobile. The pontics were built up in layers with Ceramage and light cured in a light box (Solidilite, Shofu) according to the manufacturer's instructions. The wing retainers and connector were > 1 mm in thickness, and the connector was at least 4 mm high axially. The lower margin of the wing retainers stopped 1 mm above the gingival margin, and the pontic and wing retainers were adjusted to eliminate any occlusal interference. The GFRC-RBFPDs were cemented to the adjacent teeth using 4-META/MMA-TBB resin cement (Superbond C&B, Sun Medical) (Fig 1).

Table 1 Clinical Assessments of the GFRC-RBFPDs up to 4 Years (n = 39)

	Time (y)				
Assessment item	0	1	2	3	4
Satisfactory esthetic result (no mismatch in color, shade, and/or translucence between restoration and adjacent tooth) (n [%])	38/39 (97)	38/39 (97)	37/39 (95)	35/39 (89)	34/37 (87)
Satisfactory marginal adaptation (no visible evidence of crevice along margin; no catch or penetration of explorer) (n [%])	39/39 (100)	38/39 (97)	36/39 (92)	37/39 (95)	36/37 (92)
Patient satisfaction rate (%)	100	100	96	93	92
Repair for margin/connector (n)	0/39	1/39	2/39	1/39	1/37
Displacement (n)	0/39	0/39	1/39	2/39	1/37
Functional survival rate (%)	100	100	100	92	92
Complete survival rate (%)	100	100	97	92	89

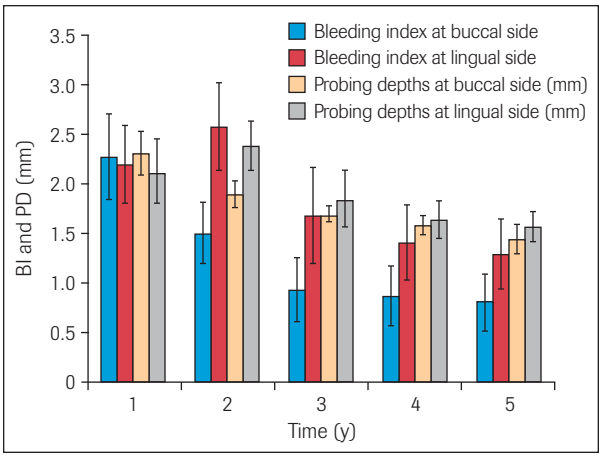

Fig 2 Bleeding index values and probing depths of the adjacent teeth.

Table 2 Mean Bleeding Indexes and Probing Depths of the Adjacent Teeth

Time	Bleeding index		Probing depth (mm)	
(y)	Buccal side	Lingual side	Buccal side	Lingual side
0	2.3 ± 0.8	2.2 ± 0.8	2.32 ± 0.5	2.12 ± 0.7
1	1.5 ± 0.6	2.6 ± 0.9	1.89 ± 0.3	2.39 ± 0.5
2	0.9 ± 0.6*	1.7 ± 1.0	1.69 ± 0.2*	1.85 ± 0.6
3	0.9 ± 0.6*	1.4 ± 0.8	1.58 ± 0.2*	1.64 ± 0.4
4	0.8 ± 0.6*	1.3 ± 0.7	1.44 ± 0.3*	1.56 ± 0.3

*Statistically significant differences between the values at follow-up times vs initial. $P < .05$.

Assessment

The clinical condition of the FPDs (mobility, marginal adaptation, esthetics, patient satisfaction) (Table 1) and periodontal condition of the adjacent teeth were assessed 1 week after cementing the GFRC-RBFPDs and then once per year for 4 years by at least two of the authors, who had calibration training and used the same standards. The criteria and evaluation standards were adapted by the authors from the California Dental Association criteria.[8,9] Survival was defined as complete if the FPD was retained in place with no mobility or displacement, with all of the clinical conditions being satisfactory; it was defined as functional if there were problems with the FPD but it remained functional after repair.

The periodontal condition of adjacent teeth was evaluated at six sites using the probing depth of the periodontal socket (PD), the modified gingival bleeding index (BI, 0–5), and the alveolar bone height measured on parallel digital apical radiographs taken using a paralleling technique with a positioning ring jig. The image magnification was calculated accordingly. The distance between the mesial alveolar crest and root apex was regarded as the mesial alveolar bone height, and that from the distal alveolar crest to the apex as the distal height. The mean mesial and distal heights were regarded as the alveolar bone height of the adjacent teeth.

Statistical Analysis

Random single-factor variance analysis and chi-square test were used to compare the values for the periodontal conditions at the initial and follow-up time points ($\alpha = .05$).

Results

A total of 39 subjects had 39 GFRC-RBFPDs cemented in place. The clinical conditions and survival rates are shown in Table 1 and Fig 2. From 1 year after application until the end of the observation period, chipping and fractures were found in five subjects with pontic mobility. Of these, three were repaired using resin adhesion and flowable composite resin so that the pontics remained in place. Beginning in the second year, connector fracture caused the displacement of four pontics. Two of these were changed, one to a crown-retained FPD and the other to a removable denture; two others were refabricated with thicker connectors and cemented to the teeth again. All of the subjects with displaced pontics were men.

The BI values, PDs, and alveolar bone heights of the adjacent teeth during the 4 years of follow-up are shown in Tables 2 and 3 and Fig 2. The bone height of

Table 3 Mean Changes in Alveolar Bone Heights of Adjacent Teeth (n = 74)

Time (y)	Decrease in bone height (mm) (n = 17)	Increase in bone height (mm) (n = 61)	Average change in bone height (mm) (n = 78)
0	0	0	0
1	−0.8 ± 0.5 (17)	1.2 ± 0.8 (43)	0.6 ± 1.2
2	−0.3 ± 0.2 (16)* (P = .001)	1.5 ± 0.9 (44) (P = .056)	1.0 ± 1.2* (P = .04)
3	−0.2 ± 0.2 (16)* (P < .001)	1.6 ± 1.0 (44)* (P = .038)	1.1 ± 1.2* (P = .024)
4	−0.2 ± 0.1 (13)* (P < .001)	1.8 ± 0.6 (47)* (P < .001)	1.4 ± 1.0* (P < .001)

*Statistically significant differences between the values at follow-up times vs initial.

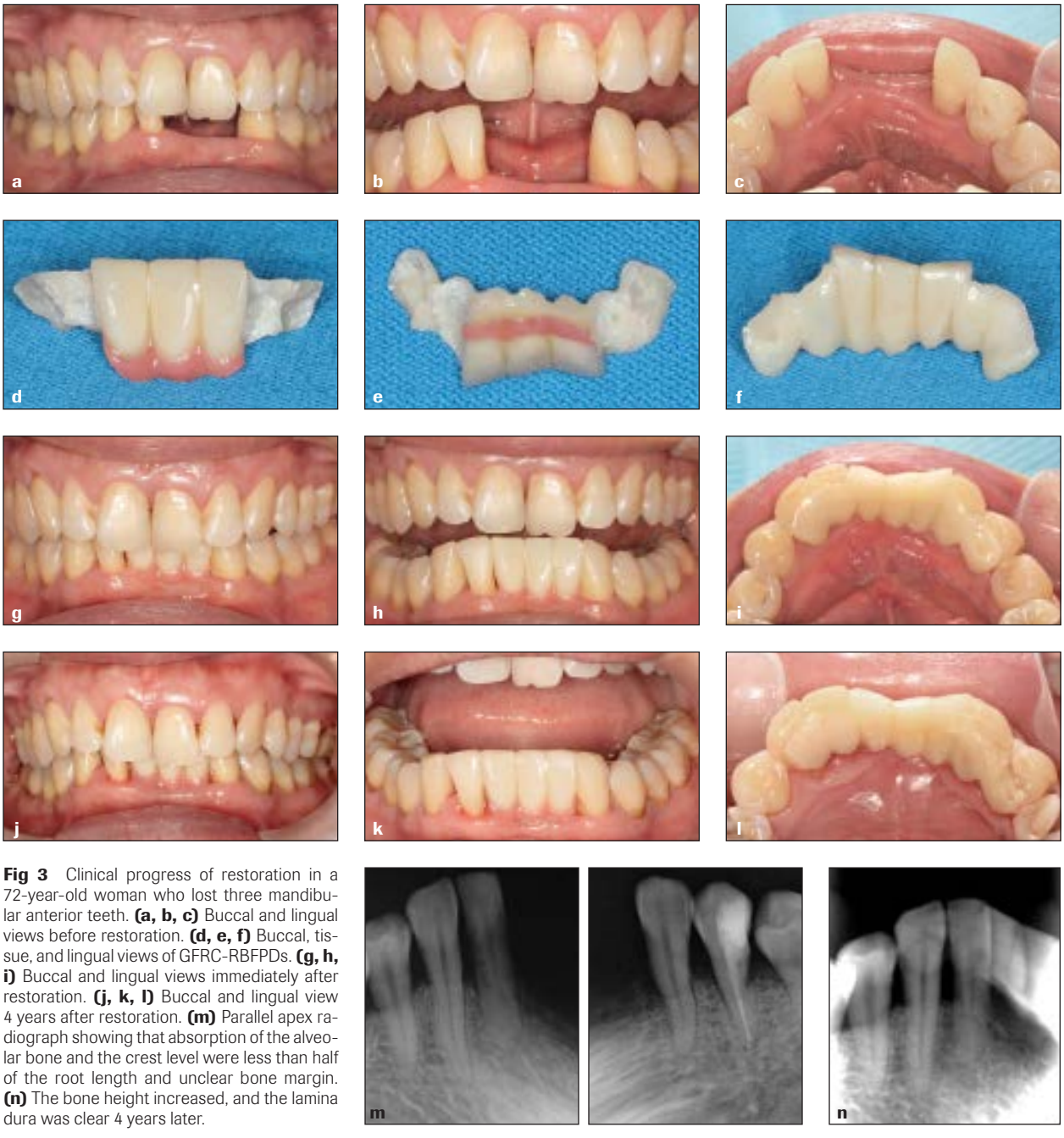

Fig 3 Clinical progress of restoration in a 72-year-old woman who lost three mandibular anterior teeth. **(a, b, c)** Buccal and lingual views before restoration. **(d, e, f)** Buccal, tissue, and lingual views of GFRC-RBFPDs. **(g, h, i)** Buccal and lingual views immediately after restoration. **(j, k, l)** Buccal and lingual view 4 years after restoration. **(m)** Parallel apex radiograph showing that absorption of the alveolar bone and the crest level were less than half of the root length and unclear bone margin. **(n)** The bone height increased, and the lamina dura was clear 4 years later.

adjacent teeth decreased in 21.7% and increased in 78.3% of cases between 1 year after the restoration and the end of follow-up. Figures 3 and 4 illustrate the clinical progress of two subjects.

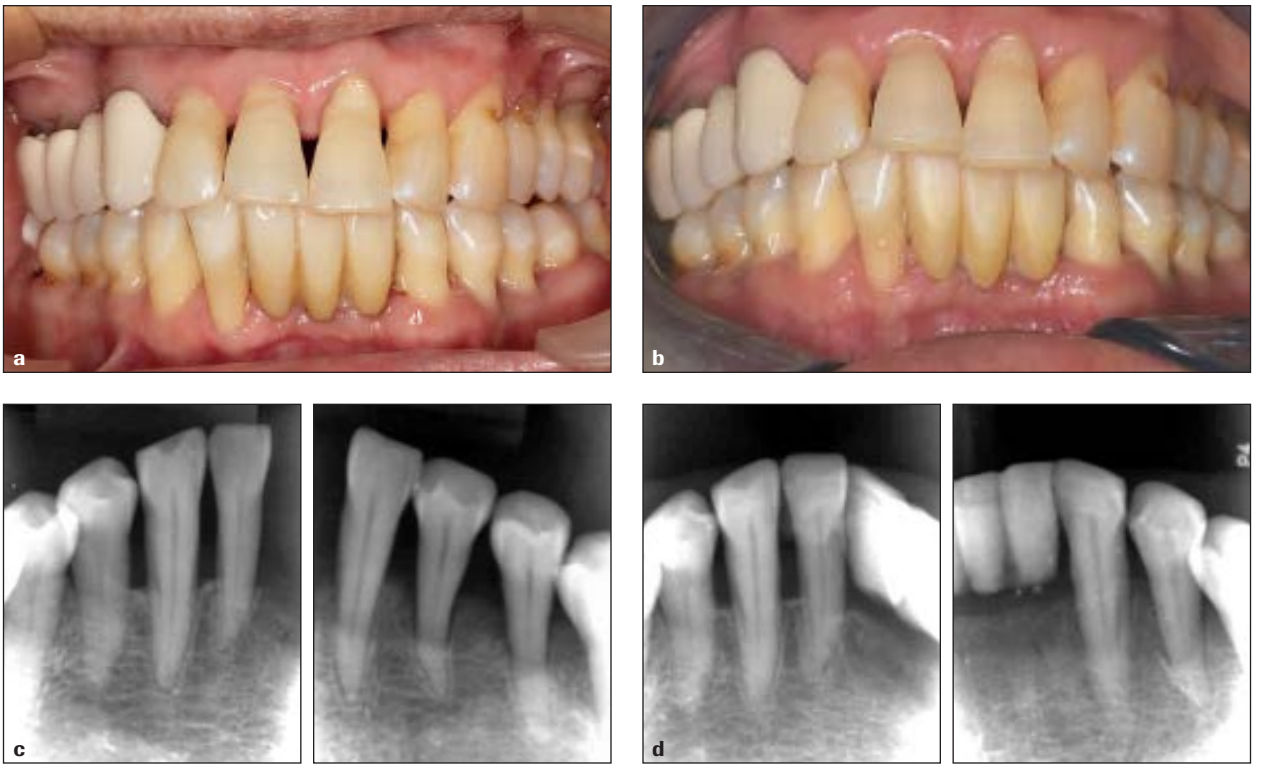

Fig 4 Clinical condition **(a, b)** and parallel apex radiographs **(c, d)** of a subject who lost three anterior teeth before and 4 years after restoration. The radiographs show a clearer alveolar lamina dura after 4 years than initially.

Discussion

Although resin-bonded restorations with glass fiber-reinforced composite materials have various clinical uses, insufficient clinical data have been available to support their use as relatively long-term prostheses. In addition, there are no design standards for the morphology and strength of GFRC-RBFPDs for laboratory fabrication. Currently, the application of RBFPDs is limited by a lack of confirmation of the long-term durability of adhesion and by shortcomings in the esthetics and stability of composite-based RBFPDs. This 4-year clinical study evaluated GFRC-RBFPDs as minimally invasive FPDs and periodontal splints for replacing lost mandibular anterior teeth with reduced periodontal support from the adjacent teeth. Using 4-META/MMA-TBB resin cement, the clinical outcome and functional survival rate were found to be acceptable over 4 years, and subject satisfaction was quite high. All the displaced GFRC-RBFPDs were in men who either ate hard food or had squarish faces with relative strong muscle forces.[10] No woman had a connector fracture or debonding between the composite wing retainers of the GFRC-RBFPDs and tooth structure, demonstrating that the adhesion strength was sufficient for clinical use.

Most of the failures involved connector fracture, suggesting that the thickness and strength of the connectors are important. This is consistent with research describing localized high stress concentrations around the connectors under all loading conditions.[11] FPDs made of GFRC materials veneered with particulate filler composite had fracture strengths ranging from 893 ± 459 to 1326 ± 391 N, which was strong enough to resist chewing loads in another experiment, although the specimens in that study were > 2 mm thick.[12] In most situations, the wing retainers were placed on the lingual side, so the thickness of the wing retainer and connector should be designed with sufficient strength while avoiding a feeling of excessive bulk. Therefore, the retainers used in this study were around 1 mm thick.

One disadvantage of composite-based RBFPDs is their relatively poor esthetic appearance, including lower polishing and shade-expressing ability, compared with all-ceramic RBFPDs. However, the economic advantages, adhesion capabilities, and possibility of direct repair in the mouth make them a reasonable alternative as FPDs.

Patients' periodontal conditions generally improved, based on the decreased BI and PD on the buccal side of adjacent teeth and the increased alveolar bone

height. The reason for the increase in bone height may be due to bone infill following repair where the structure of the bone was present but not visible on the radiograph or the bone was very thin. In addition, the visible lamina dura of the alveolar bone after restoration makes the measurement of bone height easier and clearer. This indicated that GFRC-RBFPDs are effective at maintaining periodontally questionable teeth. However, the periodontal condition on the lingual side did not improve, which might be related to the small distance between the lower margin of the wing retainers and the gingival margin and to poor oral hygiene.

Conclusions

In conclusion, this 4-year clinical study found that GFRC-RBFPDs gave relatively satisfactory results and improved periodontal condition when used as periodontal splints and fixed prostheses to replace missing mandibular anterior teeth.

Acknowledgments

The authors reported no conflicts of interest related to this study.

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