Two-Year Clinical Trial of Resin-Bonded Fixed Partial Dentures Incorporating Novel Attachments

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Purpose: This controlled clinical trial evaluated the clinical performance of a new resin-bonded fixed partial denture (FPD) system and compared the clinical performance with that of conventional FPDs. ***Materials and Methods:*** Resin-bonded FPDs replaced 12 single anterior and 9 premolar missing teeth in 20 healthy patients. Conventional three-unit FPDs (metal-ceramic crowns or complete cast-metal crowns) replaced 10 single anterior and 10 single posterior missing teeth in 20 age-matched controls. Retention, marginal integrity, periodontal condition of the FPDs, esthetics and hygiene of pontics, and secondary caries were clinically evaluated immediately, 1 month, and 2 years after cementation. ***Results:*** After 2 years, no failure was observed in the resin-bonded or conventional FPDs because of debonding from the abutment teeth. All clinical results evaluated for both groups were satisfactory or acceptable. No secondary caries was found in either group. Fisher's exact test and/or continuity-corrected chi-square test showed no significant differences of satisfactory rates between the resin-bonded and conventional FPDs for all variables evaluated. ***Conclusion:*** Short-term clinical results indicate that resin-bonded FPDs may be used as fixed prostheses to replace lost single anterior or premolar teeth with minimum preparation of abutment teeth. This restoration did not adversely influence pulpal or periodontal health. However, a 2-year clinical trial for a new FPD can only provide preliminary data, and longer term observations are clearly necessary. *Int J Prosthodont 2005;18:225–231.*

Missing teeth may be replaced with dental implants, conventional fixed partial dentures (FPD), and resin-bonded FPDs. A laudable prosthodontic goal is the placement of FPDs with minimum preparation of the abutment teeth. Resin-bonded FPDs incorporating metal wings were developed over the past 20 years.[1–3] However, debonding of prostheses is a commonly noticed failure mode. Debonding is due to insufficient adhesive strength arising from the lack of adequate adhesive techniques and materials, and to insufficiently strong mechanical retention.[4–7] The development of improved adhesive materials and techniques has again made resin-bonded FPDs a real treatment option.[8–10] Research has also shown that the retention rate of resin-bonded FPDs may be increased by modifying the preparation of the abutment teeth and improving mechanical retention,[11,12] and by using a more biomechanical material, glass fiber–reinforced resin composite.[13,14] Also, the degree of patient satisfaction with this new generation of resin-bonded FPDs appears to be high.[15] Although resin-bonded FPDs now feature improved mechanical retention with a sufficient chemical bond between the prosthesis and the abutment teeth, debonding remains the primary reason for failure.

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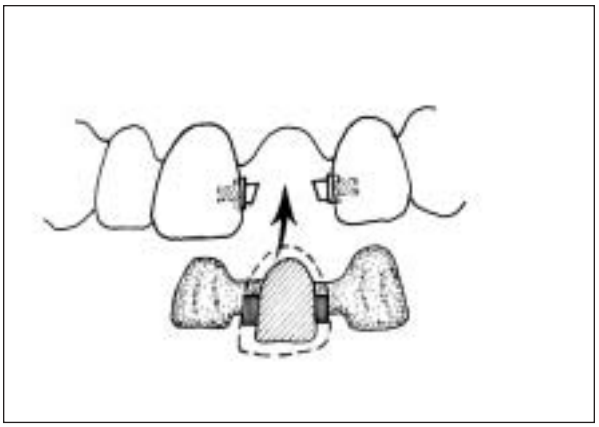


Fig 1 Principle of resin-bonded FPDs.

A new resin-bonded FPD system (Crownless Bridge Works, CBS International BV/Crownless Bridge Works) was codeveloped in the Netherlands and Germany. This system is a new version developed from a universal dental anchorage system,[16] and it involves the two attachment matrices inserted and bonded to small pin preparations at the mesial and distal proximal surfaces of the two abutment teeth. The pontic is then inserted and cemented to the abutment teeth through the attachment patrices (Fig 1). Metal wings of the pontic unit are cemented to the lingual surfaces of the abutment teeth, which can enhance FPD retention. The matrices are placed into a 1.65-mm-deep hole in the tooth structure, but the preparation represents less trauma compared with the abutment preparation for metal-ceramic crowns.[17] This resin-bonded FPD can be fixed with one attachment at each side, or with an attachment at one side and a complete crown at the other side where the abutment tooth is damaged extensively (so-called conventional and resin-bonded hybrid FPD). This new technique combines mechanical retention with chemical adhesion and keeps the preparation of abutment teeth to a minimum.

To date, however, there have been no controlled clinical trials of this system, although reports on earlier designs exist.[18] It was the aim of this study to evaluate, in a controlled clinical trial according to well-defined criteria after 2 years, this system for replacing single anterior or premolar missing teeth.

Materials and Methods

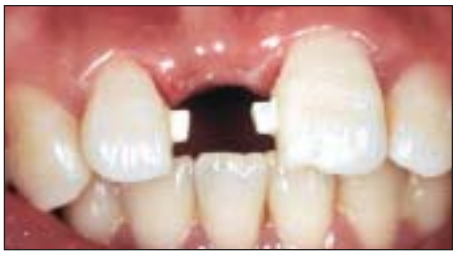
Patients

Twenty physically healthy patients with a mean age of 39 years (range 19 to 64 years) who signed an informed consent form were voluntarily recruited into the resin-bonded FPDs group. These 20 patients had a total of 21 single missing teeth, 12 anterior and 9 premolar. The 20 age-matched control patients who were voluntarily recruited into the three-unit conventional FPD group had a total of 20 single missing teeth, 10 anterior and 10 posterior. The recruitment was performed according to patient choice after a complete explanation of the two FPDs. The inclusion criteria for all patients were adequate occlusogingival clearance in the edentulous area; both or one intact abutment teeth; normal contour, position, and occlusion of the abutment teeth; and no endodontic or periodontic involvement of the abutment teeth.

Conventional and Resin-Bonded FPDs

The resin-bonded FPD instruments consist of a specially made air-engine handpiece, diamond burs, Ti-6Al-4V titanium and zirconium oxide retentive matrix attachments in different sizes (2.0-mm- and 1.6-mm-high attachments for application in posterior and anterior teeth, respectively, and 1.8-mm-high attachment for universal application), patrix acrylic resin patterns, and other accessories. An autopolymerizing adhesive resin luting system (Superbond C&B, Sun Medical) was used to cement the matrices on the teeth and the pontics onto the matrices. For the control group, the conventional FPDs were cemented to the abutments with glass-ionomer luting agent (Shofu).

The abutment teeth and edentulous areas were completely examined prior to treatment. Radiographs were taken to ensure that there was adequate tooth structure (more than 2.5 mm) to insert the matrices without damaging the dental pulp. Titanium matrices and zirconium oxide matrices 1.8 mm in height (type 2) were selected for posterior and anterior teeth, respectively, after their position and direction were determined using diagnostic casts. A small round bur (No. 001-009, Crownless Bridge Works) was used to make shallow depressions on the mesial and distal proximal surfaces of the two abutment teeth. A microengine handpiece (CBW Channel Prep, Crownless Bridge Works) and microdiamond burs (No. 2012 and 2003, Crownless Bridge Works) were used to prepare the abutment teeth using air-water cooling. The preparation was cylindrically shaped, 1.25 mm in diameter and 1.65 mm deep. The lingual surfaces of the abutment teeth were minimally prepared to eliminate undercuts. After the preparations were cleaned and dried, the preparation walls and the attachments were treated with an enamel surface treatment agent (Red Activator of the Superbond C&B system), rinsed with water, and dried, and the matrices were bonded into the pin holes (Fig 2). Special attention was paid to ensure that the two matrices were parallel to



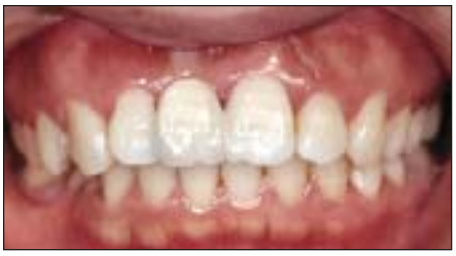
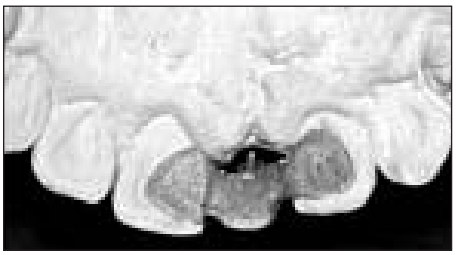


Fig 2a *(right)* Resin-bonded FPD: Maxillary right central incisor is missing, and attachments have been bonded into preparations located at proximal surfaces of mesial and distal abutment teeth.

Fig 2b *(below)* Labial view of resin-bonded FPDs cemented to abutment teeth.

Fig 2c *(below right)* Lingual view of metal frame of the resin-bonded FPDs.



each other, their lateral walls had similar paths of insertion, and the tooth structure above the attachments was thicker than 2 mm.

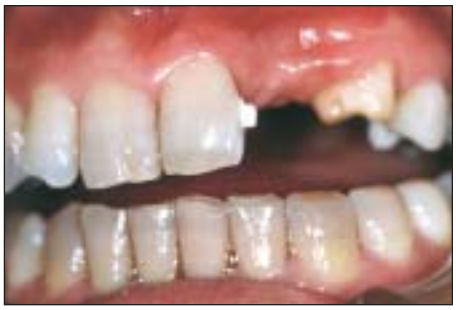
A final impression of the teeth was made using silicone impression material (Honigum, DMG) and poured with dental stone (New Fujirock, GC). The patrix acrylic resin patterns were inserted on the parts of cast that duplicated the matrices, and the framework of the pontic was waxed to include the patterns and extended to the lingual surfaces of the abutment teeth to create the lingual wings. Then, through the procedures of casting, framework trial insertion, shade selection, porcelain buildup, occlusal adjustment, and glazing,[19] the finished Ni-Co alloy metal-ceramic pontic was cemented to the matrices of attachments and the abutment teeth using Superbond C&B adhesive resin luting agent. The pontic had a ceramic occlusal surface with similar occlusal contact strength to adjacent teeth and a basal surface with a modified ridge lap. The occlusions of both FPDs were checked carefully using 12-μm-thick marking ribbons in centric relation and mandibular intercuspal position.

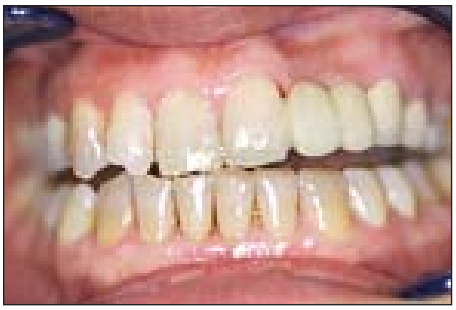
When a tooth is restored on the proximal surface of the adjacent area, it cannot be used directly as an abutment because the filling material cannot support an attachment. In situations in which one side of the abutment tooth had extensive restoration, a complete crown served as the retainer instead of as matrices (Fig 3). For these restorations, the FPD was termed a conventional and resin-bonded hybrid.

All resin-bonded FPDs were prepared without anesthetic, and the time for preparation of one pinhole was about 30 seconds. In the control group, the preparations of the abutments were performed as usual[19] and took about 25 minutes for 1 abutment tooth; local anesthetic was used for vital teeth. The distribution and type of the resin-bonded and conventional FPDs are shown in Table 1.

Clinical Evaluation

Patients were clinically evaluated immediately, 1 month, and 2 years after cementation of the FPDs according to the criteria shown in Table 2. The retention, marginal integrity, periodontal health of the FPDs, esthetics and hygiene of the pontics, and secondary caries were evaluated by the same operator. The criteria were adapted by the authors from the California Dental Association criteria.[20–22] The satisfactory rate of each variable evaluated was compared between the two groups of patients by Fisher's exact test and/or continuity-corrected chi-square test ($P < .05$). The minimum expected counts were less than 1 in the variables retention, marginal integrity, and periodontal health; therefore, Fisher's exact test was used for statistical analyses. The minimum expected counts were greater than 1 but less than 5 in the other variables, so the continuity-corrected chi-square test was used. The clinical trial protocol was researched and approved by the Ethical Committee for Clinical Practice of the hospital.





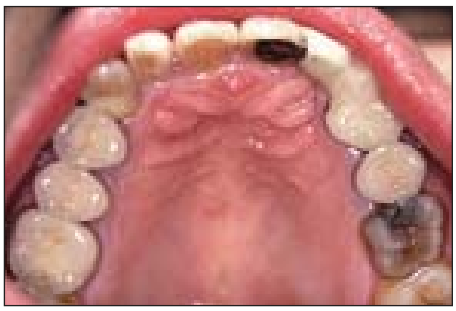


Fig 3a *(left)* Conventional and resin-bonded hybrid FPD: Maxillary left lateral incisor and canine are missing; zirconium attachment has been bonded to preparation at distal proximal surface of central incisor, and complete crown preparation has been performed on extensively damaged first premolar.

Fig 3b *(below left)* Labial view of hybrid FPDs cemented to abutment teeth.

Fig 3c *(below)* Occlusal view of hybrid FPDs cemented to abutment teeth.

Table 1 Distribution and Type of Maxillary FPDs

Type of FPD	Central incisors	Lateral incisors and canines	First premolars	Second premolars	First molars	Total
Resin bonded	9	3 (1)	4	5 (2)	0	21
Conventional	7	3	2	3	5	20

*Numbers in parentheses indicate combination conventional and resin-bonded hybrid fixed partial dentures (FPDs).

Results

Immediately after cementation, the variables evaluated for the resin-bonded FPDs were satisfactory, except for unesthetic display of the metal matrix in the interfaces of pontics and abutment teeth in three patients. In two of these patients, the matrices were placed buccally from the middle of the proximal surface; in the third patient, the matrix was placed superiorly from the contact point. The variables evaluated for the conventional FPDs were satisfactory, but esthetics was just acceptable in two patients because of the unpleasant marginal optical effects of the metal-ceramic crowns, characterized by a gray line.

One month after cementation, the retention and marginal integrity of the resin-bonded FPDs were good, and the FPDs could perform the masticatory function well. In two patients, however, the gingival papillae under the attachments were slightly red and swollen, there were small spaces between the attachments and papillae, and there was a small quantity of calculus on the cervical area of the pontics. The pontics were repolished, and interdental brushes were provided to the patients. There was no change of results in the conventional FPDs.

Two years after cementation, all resin-bonded and conventional FPDs functioned well; the retention of the FPDs was satisfactory. There was no obvious discoloration of the pontics nor any fracture or secondary caries in the two groups. The periodontal health of the resin-bonded FPDs was good, but slightly red swelling appeared in the gingiva of abutment teeth of four patients in the conventional FPD group.

For each variable evaluated, the satisfactory rate did not differ significantly (all P values $> .05$) between the resin-bonded and conventional FPD groups at the same review time (Table 3).

Table 2 Clinical Evaluation Criteria

Criterion	Satisfactory	Acceptable	Unacceptable
Retention of FPDs*	FPD is stable, without any movement	FPD is stable but shows a little movement	One or both sides of pontic is loose or debonded from abutment
Marginal integrity of FPDs	No visible evidence of crevice along margin; no catch or penetration of explorer	Visible evidence of crevice and/or catch of explorer; no penetration of explorer	Visible evidence of crevice and penetration of explorer
Periodontal health of FPDs	Mucosa under pontic and gingiva around abutment show no inflammation; color and contour are clinically healthy	Gingiva and mucosa show slight red swelling	Gingiva and mucosa show obvious red swelling
Esthetics of pontics or crowns	No mismatch in color, shade, and/or translucence between restoration and adjacent tooth	Mismatch between restoration and tooth structure within normal range of tooth color, shade, and/or translucence	Esthetically displeasing color, shade, and/or translucence
Hygiene of crowns	Pontic surfaces are clean and show no calculus	Small quantity of calculus on surfaces of pontic	Obvious dental calculus on surfaces of pontic
Secondary caries	No caries present (no discoloration; no catch or penetration of explorer on surface of enamel around prosthesis)	—	Caries present (discoloration and catch or penetration of explorer on surface of enamel around prosthesis)

*FPDs, fixed partial dentures.

Table 3 Results of Clinical Evaluation of Resin-Bonded and Conventional FPDs*

	Immediately after cementation		1 mo after cementation		2 y after cementation	
Criterion/score	Resin bonded	Conventional	Resin bonded	Conventional	Resin bonded	Conventional
Retention of FPDs						
Satisfactory	22	20	22	20	22	20
Acceptable	0	0	0	0	0	0
Unacceptable	0	0	0	0	0	0
Marginal integrity of FPDs						
Satisfactory	22	19	22	19	21	19
Acceptable	0	1	0	1	1	1
Unacceptable	0	0	0	0	0	0
Periodontal health of FPDs						
Satisfactory	22	20	20	20	22	16
Acceptable	0	0	2	0	0	4
Unacceptable	0	0	0	0	0	0
Esthetics of pontics or crowns						
Satisfactory	19	18	19	18	19	18
Acceptable	3	2	3	2	3	2
Unacceptable	0	0	0	0	0	0
Hygiene of crowns						
Satisfactory	22	20	19	20	20	18
Acceptable	0	0	3	0	2	2
Unacceptable	0	0	0	0	0	0
Secondary caries						
Acceptable	22	20	22	20	22	20
Unacceptable	0	0	0	0	0	0

*The satisfactory rate of each variable at the same review time between the two types of fixed partial dentures (FPDs) was analyzed and did not differ significantly.

Discussion

The resin-bonded FPD combines the principles of mechanical retention and chemical adhesive retention. In addition to being cemented to the abutment teeth by the metal wing-like retainers, the patrices of the pontic are inserted into the matrices of attachments that have been prebonded to the proximal surfaces of the abutments; this can theoretically enhance the mechanical retention structure and therefore increase the longitudinal retention effect of the FPDs. If the resin-bonded FPD fails after application, it can be rebonded

to the abutment teeth as long as the attachment matrices remain in place and stable. Thus, the resin-bonded FPDs provide a semireversible way to replace missing teeth. In this crownless resin-bonded FPD system, without a crown margin on the abutment, there is little possibility of influencing the natural appearance and periodontal tissue of the abutment teeth. Thus, the resin-bonded FPD presents an alternative method for fixed partial prosthetics.

Using the resin-bonded FPD system to replace 21 teeth in 20 patients, no failure was observed after 2 years. There was no significant difference between the resin-bonded and conventional FPDs in the variables evaluated. Moreover, the resin-bonded FPDs were prepared with minimum reduction of abutment teeth. None of the patients required anesthetic during the preparation of abutment teeth, and there was no incidence of postsensitivity reaction of the dental pulp. There was no secondary caries, and the periodontal health and hygiene of the pontic could be kept in good condition.

In considering a resin-bonded FPD to replace a missing tooth, some technical problems should be considered. First, debonding of a resin-bonded FPD may be caused by incorrect application of the adhesive resin luting agent, incomplete separation from the wetting agent, too small a metal lingual wing, and/or too strong an occlusal load. Thus, the adhesion procedure should strictly follow the manufacturer's recommendations, and adequate isolation from the oral fluid should be obtained. In addition, the metal wings should be spread as wide as possible to fit the lingual surfaces of the abutment teeth to increase the adhesion area; the occlusal contacts should be checked to avoid overloading the pontic. Another technical problem might be the position of the matrices, which will influence the esthetics of the pontic and health of the gingival tissue beneath the attachments. If the position is too low, there may be a wide cervical portion of the pontic; if it is too high, there may be a space between the attachment and gingival papilla. The matrix should be positioned just at the proximal contact point and just lingual to the middle of the tooth in the buccolingual direction to avoid display of the metal color of the attachment. Moreover, to obtain a similar path of insertion for the pontic, the lateral walls of the matrices should be carefully confirmed to be parallel while they are bonded.

As only a few molar situations were included in this trial, it is not known if the resin-bonded FPD system is as effective in the replacement of molar areas as in anterior and premolar areas. Moreover, it needs to be emphasized that this report is limited to early clinical findings and continued follow-up needs to occur.

Conclusion

Within the limits of this study, there was no statistically significant difference between the resin-bonded and conventional FPDs in the variables evaluated (all P values $> .05$). Resin-bonded FPDs may be used to replace single anterior or premolar missing teeth with little influence on the health of the dental pulp and periodontal tissue, at least up to 2 years. However, as this study was only a 2-year clinical trial, it can provide only preliminary data. A longer observation period is necessary if compelling conclusions are to be drawn from this technique.

Acknowledgment

The authors would like to thank Professor I. Naert of the University of Leuven, Belgium, for his kind suggestions concerning this research.

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Thermo-hydrolytic stability of core foundation and restorative composites

This in vitro study evaluated the influence of thermo-hydrolytic stress on the flexural strength and flexural modulus of core foundation composite resins. The filler percentage was also evaluated. Nine composite resins (Coreflo, DC Core, Photocore, APX, Litefil II A, Surefil, TPH Spectrum, Z100, and Z250) were fabricated following ISO Standard 4049. A total of 216 specimens were fabricated. Flexural strength and flexural modulus were determined on the composite resins before and after storage in boiling water for 24 hours. The filler content in the composites was determined by incineration. Filler content of the tested composite resins ranged from 66.6% to 81.8%. Significant differences in both flexural strength and flexural modulus existed among the materials. After boiling, Coreflo, DC Core, Z100, and Z250 showed a significant decrease in flexural strength, but Surefil showed a significant increase in flexural modulus. The authors concluded that composite resins were affected differently by thermo-hydrolytic stress. Stability of the composite resins varied among brands and this may affect the long-term function of core foundations.

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Vertical marginal discrepancy of ceramic copings with different ceramic materials, finish lines, and luting agents: An in vitro evaluation

This article evaluated the pre- and post-cementation vertical marginal discrepancy of 2 different crown preparation finish lines, 3 all-ceramic coping manufacturing techniques (Procera, Empress 2, and InCeram), and 3 luting agents (zinc phosphate, resin-modified glass ionomer, and resin composite cements). Two standard stainless-steel molars were prepared for crowns with chamfer and rounded-shoulder finish lines. Each tooth was duplicated to fabricate 90 ceramic copings. They were divided into 18 groups. Ten copings were used for each finish line/coping material/luting agent combination. The distance between 2 predetermined points was measured before and after crown cementation. The results showed that Procera copings demonstrated the lowest mean values of pre- and post-cementation marginal discrepancy (25 and 44 μm), followed by Empress 2 (68 and 110 μm), and InCeram Alumina copings (57 and 117 μm). Finish lines and luting agents demonstrated insignificant effects. The result of this study would be more interesting if there was a control group using conventional metal copings.

Quintas AF, Oliveira F, Bottino MA. *J Prosthet Dent* 2004;92:250–257. **References:** 52. **Reprints:** Dr Adriana F. Quintas, Rua Dr. Alceu C. Rodrigues 247, #101 São Paulo 04544 000, Brazil—*Ansgar C. Cheng, Singapore*