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A 10-Year Clinical Evaluation of Resin-Bonded Fixed Dental Prostheses on Non-Prepared Teeth

Keywords

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ABSTRACT

This study evaluated the conditions of the non-invasive resin-bonded fixed dental prostheses (FDP) and patient satisfaction up to 10 years of clinical function. A total of 23 patients who required fixed prostheses in the areas of mandibular anterior and premolar, and maxillary anterior region received resin-bonded restorations between 1999-2003. In 13 patients with 14 edentulous areas were restored with an adhesive pontic (natural tooth, acrylic and porcelain). Two indirect proximal veneers using resin composite were placed in each space in 10 patients having 13 edentulous spaces. All prostheses were bonded to the proximal surface of adjacent teeth using resin cement based on 4-META/MMA-TBB. No debonding of proximal veneers but 4 pontic debonding was observed which were rebonded and remained functional until final follow up. The abutments in pontic and proximal veneer groups were free of caries and hypersensitivity. Periodontal health was improved after treatment and was maintained for 10 years except for 4 abutments that still showed some bleeding on probing. Non-invasive resin-bonded FDPs are simple, pain-free, less costly treatment procedures that could provide acceptable clinical longevity with high patient satisfaction.

INTRODUCTION

Contemporary fixed prosthodontics using acid-base cements require full or partial coverage retainers in order to gain mechanical retention and resistance. The preparation depth for abutments depends on the strength and aesthetic appearance of materials used for retainers. A thickness of at least 1-1.5 mm at the margin for a natural appearance and 1-1.5 mm at the occlusal or incisal for fracture resistance is required for metal-ceramic or all-ceramic retainers.[1-4] This means severe tooth reduction and removal of mostly impermeable enamel resulting in weakening of the tooth itself as well as violating the pulpal tissues especially in thin anterior teeth as permeable dentine is often exposed.

Clinical sequelae such as tooth-hypersensitivity, caries, prostheses detachment, gingivitis and pulpitis sometimes occur in restored teeth or abutments soon after replacement of restorative materials or fixed prostheses. The most common failure found in conventional fixed dental prosthesis is caries around the margin.[5-8] Microleakage at the tooth-cement or tooth-restoration interface is one of the major contributors to these signs and symptoms.[9,10] In fact, enamel can resist acid demineralization better than cementum and dentine, thus restorations on enamel margins survive longer than those on cementum or dentine margins.[11]

Demineralized dentine under either set acid-base cements or incomplete hybrid layer is weak in terms of mechanical strength and can be hydrolysed,[12,13] resulting in smaller size of abutments. Therefore, accuracy of prostheses has no meaning in terms of leakage prevention when the dentine abutment is continually eroded.

Adhesive resin cements being continuously developed and used for more than three decades could provide better retention and marginal seal than acid-base cements.[13-16] Currently, several techniques such as dry, wet or moist bonding and self-etching are available in the market.[13,15-17] Resin-bonded FDPs minimizes the tooth-reduction. However, clinical studies suggested that the short-term debonding (less than 5 years) and caries were the main reasons for failure of metal-ceramic type of FDPs.[18,19]

The metal framework of the FDP also compromises the natural look in the aesthetic area. Hybridization of 4-methacryloyloxyethyl trimellitate anhydride in methyl methacrylate initiated by tri-*n*-butyl borane (4-META/MMA-TBB) in the presence of poly(methylmethacrylate) (PMMA) resin into dentine and enamel using a dry bonding technique demonstrated the hybridized layer of 3-4 µm, which can resist acid demineralization and proteolytic degradation. The tensile strength of this type of resin bonding to enamel and dentin were reported to range between 15-20 MPa and 23-25 MPa, respectively.[13,15]

It was hypothesized that complete hybridization of resin into the tooth surface and the flexible properties of 4-META/MMA-TBB-PMMA resin used to attach prostheses without any tooth-reduction could resist normal functional forces in some areas of the mouth. This simple and conservative treatment might prove satisfactory for patients who refuse tooth-reduction or bone drilling for dental implants, with no harm to dental and gingival tissues. The objective of this study therefore was to evaluate the resin-bonded FDPs (either a pontic or proximal veneers) cemented to abutments using 4-META/MMA-TBB-PMMA resin with no tooth reduction, in terms of aesthetics, function, patient's satisfaction, periodontal health and caries incidence after 10 years follow up.

MATERIALS AND METHODS

PATIENTS

A total of 23 partially dentate patients who required fixed prostheses in the areas of mandibular anterior and premolar and maxillary anterior region agreed to participate in this study between 1999-2003. Signed informed consent was obtained from each patient. Six patients were wearing removable partial dentures (*Figure 1*a-c) and two patients had aesthetic concerns due to loosening of metal-supported resin-bonded FDPs (*Figure 2*a-c). The other four patients needed immediate replacements after tooth extraction. Severe periodontal disease with a mobility level of 3 was the reason for teeth extraction (*Figure 3*a-c). Prior to taking part in the study four patients with edentulous areas had worn removable partial dentures (*Figure 4*). The other seven patients had no experience of wearing a denture but requested tooth replacement. Thirteen patients requiring 14 FDPs were assigned for an adhesive pontic for each area. The other ten patients with ten edentulous areas and three edentulous spaces (3-5 mm) were selected for replacement with two proximal laminate veneers in each edentulous area. Indication for assignment to either pontic or veneer group depended mainly on the aesthetic requirements and the size of the gap. Distribution of the patients according to the number, age and sex, as well as the number of edentulous areas/spaces and the replacement location in each group are summarized in Table 1.

Figure 1a-c: A female patient with a removable denture a) labial, b) palatal views replacing maxillary lateral incisor, c) after orthodontic treatment.

Table 1. Distribution of the patients according to gender, age, number and location of edentulous areas/spaces in each treatment group.

Group	No. of patients	Gender		Age (years)	Number of edentulous areas/spaces		
		Male	Female		Maxillary anterior	Mandibular anterior	Mandibular premolar
Pontic	13	7	6	16-49	8	2	4
Proximal veneer	10	4	6	15-50	2	3	8

Figure 2a-c: A female patient with debonded resin-bonded porcelain fused to metal FDP a) labial, b) palatal views, and c) the remnant of resin cement on the abutments after removal of the FDP.

Figure 3a-c: A male patient with mobility grade 3 of maxillary left central incisor due to habitual object biting a) labial, b) lateral, c) palatal views.

Figure 4: A female patient with missing maxillary left canine and used to wear removable denture.

CLINICAL PROCEDURES AND EVALUATION

All patients were questioned on the history of the existing denture or edentulous space. Assessment of all abutments was made considering caries, mobility, periodontal pockets, bleeding on probing and tooth color prior to treatment. In the pontic group, three kinds of pontics namely, a stock acrylic (polymethyl-methacrylate, PMMA) tooth, a porcelain veneer bonded with resin composite, and the extracted tooth of the patients were used. For the indirect technique, impressions were made using irreversible hydrocolloid (Jeltrate[a]) and models poured with type 3 dental stone (Quickstone[b]) to make working models from both maxilla and mandible. For pontics replacing the mandibular premolars, stock acrylic teeth was used as a pontic as there was less aesthetic concern and treatment could be achieved in one visit. On the other hand, direct method was preferred for anterior tooth replacement, using stock acrylic tooth (Major Dent[c]), when the size and colour matched those of the abutments and the colour could be modified using direct veneering of the pontic with photo-polymerized resin composite *(Figure 5a-c)*. An indirectly fabricated porcelain laminate was bonded with bulk resin composite to form the customized pontic tooth that fitted the edentulous ridge and proximal sides of the abutments *(Figure 6a-c)*. Local anesthesia was needed for tooth extraction where the extracted tooth was used as adhesive pontic. In this method, the extracted tooth was sectioned at the root surface, 2-3 mm away from the cemento-enamel junction (CEJ), pulpal tissue was removed from the chamber and root canal that was subsequently cleaned and filled with resin composite *(Figure 7a-b)*. The size and contour of the abutments compared to the pontic could be modified using resin composite *(Figure 7c)*. Each pontic was then adjusted to passively fit in the edentulous area with adequate aesthetics and occlusion. All surfaces of the pontic were polished except the proximal areas to which the resin adhesive cement would adhere.

Figure 5a-c: The female patient in Figures 1a-c after treatment with adhesively bonded pontics using acrylic stock teeth a) labial, b) palatal (arrowed = space after orthodontic treatment), c) labial view.

Figure 6a-c: The female patient in Figures 2a-c after treatment with adhesively bonded pontic at the upper left central incisor using porcelain veneer bonded with resin-composite from a) labial, b) palatal, c) frontal views.

Figure 7a-c: The male patient in Figures 3a-c after a) tooth extraction, b) extracted tooth used as adhesive pontic, c) resin-composite fillings (arrowed) to modify the space.

In the proximal veneer group, an indirect technique was used to fabricate the resin composite laminate veneers. After tooth-color selection, impressions were made from maxilla and mandible using irreversible hydrocolloid and poured in type 3 dental stone to obtain the working models. Two indirect proximal laminate veneers were fabricated for each area using either microfilled hybrid resin composite (Z 100[d]) or organic-filled resin composite (Metafil[e]) depending on the colour match.

They were then photo-polymerized on both inner and outer surfaces for 60 s each side. Two veneers were placed in each area with different paths of insertion. The veneer with the mesio-distal path was cemented first followed by either the labio-lingual or occluso-gingival path veneer *(Figures 8a-b)*. When present, photo-polymerized resin-composite was directly filled to smoothen the undercut areas of the cemented veneers *(Figure 8d)*.

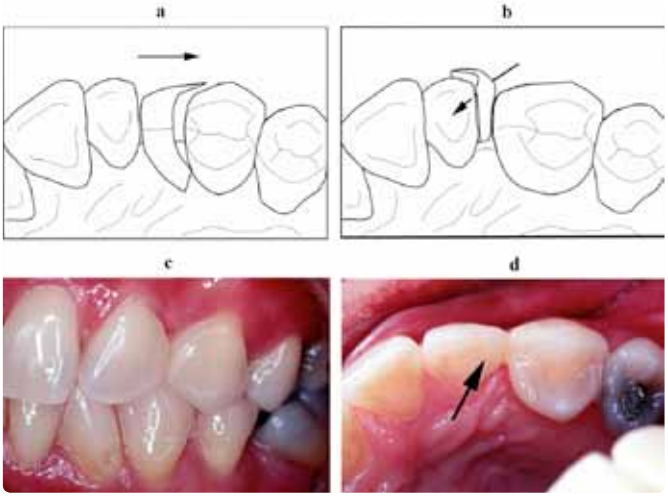

Figure 8a-d: Schematic drawings demonstrating the insertion path of 2 proximal veneers a) mesio-distal, b) labio-lingual. The female patient in Figure 4 after treatment with adhesively bonded proximal veneers using resin-composite laminates c) labial, d) palatal views (arrowed = directly applied photo-polymerized resin composite).

The bonding agent and resin cement used in this study was 4-META/MMA-TBB resin and PMMA clear powder (Super-Bond C&Bf or C&B METABONDg) which was manipulated employing a brush-dip technique according to the manufacturer's instructions. The placement of the veneers and pontics were achieved by positioning the pontic from lingual freehand and/or using sticky wax (Vivastick) for positioning the veneers during cementation.

All patients were instructed not to chew on the prostheses for at least 2-3 hours or for 24 hours if possible. Oral hygiene maintenance under the pontic area and proximal surfaces of the abutments using dental floss or super-floss were demonstrated to the patients.

The patients were requested to return for evaluation once a year or if any problems occurred. The details of treatment procedures according to the number of prostheses for both groups are shown in Table 2. All the clinical procedures were performed and monitored by the same operator from the Department of Prosthodontics, Faculty of Dentistry, Chulalongkorn University, Thailand. Evaluation of the treatment procedures, the patients' satisfaction before and after treatment, assessment of the prostheses and abutments after 10 years was recorded.

Table 2. Treatment procedures and methods using either an adhesive pontic or proximal veneer, and the number of edentulous areas.

Procedures	Number of edentulous space (n)		
	Pontic (n=14)		Proximal veneer (n=13)
Prostheses fabrication	9 (Direct)	5 (Indirect)	13 (Indirect)
Local anesthesia	4	0	0
Tooth-reduction	0	0	0
Gingival retraction	0	0	0
Impression with alginate	0	5	13
Chair-side time (< 1h)	9	5	13
Laboratory time (< 1h)	0	5	13
One visit treatment	9	5	5

STATISTICAL ANALYSIS

Statistical analyses were performed using the Statistical Package for the Social Sciences (version 18.0, SPSS Inc, Chicago, IL, USA). Mann-Whitney non-parametric test was used to evaluate the patient satisfaction level before and after treatment in all groups. P values less than 0.05 was considered to be statistically significant.

RESULTS

Four patients in pontic group could not come to the follow-up. Thus, 19 patients (83%) were evaluated for 10-year controls. There was no difference between the pontic and proximal veneer groups in overall procedures *(Table 2)*. The total clinical time for both groups was less than 1 hour for each edentulous area but longer time was required for laboratory work using the indirect technique.

Patient satisfaction level showed significant difference before and after treatment ($p<0.05$) *(Table 3)*. No significant difference was observed between baseline and 10-year controls in both groups in all aspects ($p>0.05$). The abutments in pontic and proximal veneer groups were free of caries and hypersensitivity. Periodontal health was improved after treatment and was maintained for 10 years except for 4 abutments (15-20%) that still showed some bleeding on probing *(Table 4)*.

Table 3. Subjective patient assessment of satisfaction level before and after treatment in each group (n=number of patients; 1=low, 2=medium, 3=high).[a,b] Different superscript letters indicate significant difference ($p<0.05$) except for the cleaning ability* ($p>0.05$).

Group	Pontic (n)									Proximal veneer (n=10)								
Questions	Before (13)[a]			After (13)[b]			10 year (9)[b]			Before[a]			After[b]			10 year[b]		
Level	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1
Aesthetics	0	2	11	13	0	0	9	0	0	0	3	7	10	0	0	10	0	0
Comfort	0	2	11	13	0	0	9	0	0	0	4	6	10	0	0	10	0	0
Self-confidence	0	2	11	13	0	0	9	0	0	0	4	6	10	0	0	10	0	0
Chewing ability	2	6	5	10	3	0	9	0	0	0	4	6	10	0	0	10	0	0
Lack of food retention	2	6	5	13	0	0	9	0	0	3	7	0	10	0	0	10	0	0
Cleaning ability*	8	3	2	9	4	0	7	2	0	6	2	2	8	2	0	8	2	0

Table 4. Assessment of abutments before treatment and 10 years after treatment (n=number of abutments).

Group	Pontic (n)		Proximal veneer (n)	
Evaluations	Before (28)	10-y treatment (20)	Before (26)	10-y treatment (26)
Caries	0	0	0	0
Mobility (> 1)	2	0	0	0
Periodontal pocket depth (> 4 mm)	2	0	0	0
Bleeding on probing	10	4	12	4
Tooth hypersensitivity	2	0	0	0
Color change	0	0	0	0

Outcome of the evaluations of the FDPs are summarized in Table 5. Prosthesis loosening in the pontic group occurred in four pontics (40%); one from distal shift of the abutment (*Figures 9a-c*), the others from accidentally during excessive biting. None of the proximal veneers were debonded. Three debonded pontics were removed using a bridge removal technique and some of the existing cement was removed from the abutment surfaces before re-cementing the original pontics using the previously mentioned method. The pontic with one debonded connector was re-cemented directly in the mouth. External stain on the materials could be removed using prophylaxy paste.

All patients were still satisfied with the aesthetic appearance after 10 years and confirmed to be present for future follow-up (*Figures 9a-c, 10a-b, 11a-c, 12a-c*).

Figure 9a-c: The female patient in Figures 5a-c after 10 years and 4 months following the treatment a) labial, b) palatal (arrowed = distal shifted abutments), c) labial view.

Table 5. Assessment of resin-bonded FDPs 10 years after placement (n=number of FDPs).

Group	Pontic (n=10)			Proximal veneer (n=26)		
	None	Mild	Severe	None	Mild	Severe
Debonding	6	1 (1 connector)	3 (2 connectors)	26	0	0
Remake	10	0	0	26	0	0
Permanent staining	10	0	0	26	0	0
Discolouration	10	0	0	26	0	0

Figure 10a-b: The female patient in Figures 6a-c after 10 years and 8 months following the treatment a) labial, b) palatal view.

Figure 11a-c: The female patient in Figures 7a-c after 10 years and 1 month following the treatment a) labial, b) palatal, c) labial view.

Figure 12a-c: The female patient in Figures 8a-d after 10 years and 9 months following the treatment a) labial, b) palatal, c) labial view.

DISCUSSION

In this clinical study, 4-META/MMA-TBB-PMMA resin was used to attach the resin-bonded FDPs on the non-prepared teeth. Considering the limited number of failures over 10 years, the hypothesis could be accepted.

The patient history prior to treatment revealed that the patients concerning aesthetics had preferred to wear removable prostheses instead of FDPs as they were scared of invasive procedures such as severe tooth-reduction or implant placement that would require surgery. Resin-bonded FDPs either using an adhesive pontic or proximal veneers with no tooth reduction can be performed in one visit using either a direct or indirect technique. The combined restoring of PMMA tooth, resin composite, patient's extracted tooth or porcelain materials using 4-META/MMA-TBB resin could be performed by the dentists at the chair-side in single appointment. This pain-free treatment satisfied all the patients as no tooth reduction and gingival retraction or bone drilling were required compared to costly conventional FDP or surgical implant procedures.

Microleakage is considered one of the major reasons causing hypersensitivity, dental caries, marginal opening, debonding of the FDP and pulpal infection.[9,10] Microleakage also takes place at demineralized dentine under the restorations.[20-22] The abutments with tooth reduction in the conventional treatment procedures often exposes dentine and yields to leakage pathway. Such prepared abutments present mostly caries with or without endodontic complications over time.[5-8,23] Leakage-free resin-enamel and resin-dentine interfaces for direct and indirect restorations have been reported in previous studies.[20-22] Hybridized enamel and hybridized dentine layers prevent penetration of dye and silver nitrate solutions which could explain the lack of hypersensitivity, dental caries, marginal opening and pulpal infection in non-prepared abutments in this study.

Resin cement and bonding agent used in this study based on 4-META/MMA-TBB resin and PMMA powder provided reliable hybridization to both enamel and dentine with tensile bond strength of 15-20 MPa and 23-25 MPa, and shear bond strength of 20-25 MPa in earlier *in vitro* studies.[13,15] The tensile strength using a mini-dumbbell test of this cement at PMMA rod-cement interface was approximately 35-40 MPa,[24] while its bond strength to polymerized resin composite, porcelain or metal alloy ranged between 8 and 10 MPa.[25] These studies suggested that adhesive pontic using acrylic stock tooth or extracted tooth could resist the tensile force better than the porcelain or resin composite stock tooth with the same amount of bonding area.

However, in this study no difference was observed in terms of pontic debonding among the three types of pontics. The patient's reports revelaed that the cause of failures were not normal functional forces but habitual excessive biting, accidental biting on a fruit seed and chewing sticky candy. After re-cementation, awareness of patients on excessive biting and avoiding sticky chewy food could eliminate this problem. In the patient who previously had orthodontic treatment, seven months after replacement the right lateral pontic, debonding was observed as the distal abutment moved 0.5 mm into the remaining distal space *(Figures 5b*) while the left lateral pontic was still intact. Re-cementing was easily perfomed by minimal grinding of the existing cement on the abutment teeth and fixing the adjusted pontic in place with the same resin cement. No further loosening on this re-cemented adhesive pontic occurred until the final observation *(Figure 9a-c*). This implied that closing all the adjacent space could stabilize the abutments as well as the adhesive pontic and prevent debonding of the resin-bonded FDP as the high movement of abutments could increase the chance of debonding in orthodontically treated patients.

Masticatory forces vary at different locations in the dental arch. The mean maximal bite force in the anterior and premolar regions ranges between 45 and 550 N which is considered to be less than in the molar region (500-874 N).[26,27] The functional force at a tooth-cement-prosthesis interface is composed of compressive, tensile and shear stresses. Thus, in order to prevent debonding, the bond strength between prostheses and abutments should exceed the functional force. Although no standard measurements were made from bonding surfaces, the surface area where the FDP was bonded ranged between 15 to 30mm^2, which may be considered sufficient to withstand normal function in the anterior and mandibular premolar regions.

None of the resin-bonded FDPs were remade over 10 years since no fracture of either the pontic or proximal laminates were observed. The cement used in this study could increase the fracture strength of porcelain laminate 2 to 3 times when bonded to dentine and enamel, respectively.[28] The compressive strength of resin composite used in this study varied between 90 and 200 MPa. In this context, based on the results of this study, it can be stated that 0.5-3mm thick resin composite proximal veneers bonded to non-prepared abutments have sufficient strength to resist fracture from functional forces in the anterior and mandibular premolar regions. The colour of the FDPs was still considered satisfactory by the patients after 10 years. External stain was not different between natural dentition and pontics supporting previous observations.[29]

In this study, no metal or fiber reinforcement (FRC) were employed for the resin bonded FDPs. The majority of the similar studies on fiber reinforced composite FDPs presented a survival rate of ≥ 72% after 2 to 5 years.[29] Recently, more favourable results are reported with cantilever design.[30,31] In one recent study, 97.7% survival rate was reported with indirect FRC FDPs up to 7 years with a mean observation time of 58 months.[32] The question remains to be answered in future clinical studies whether such reinforcement is needed for attachment of pontics on the abutment teeth.

One limitation of this study is the drop-out of 4 patients in this small sample size, heterogeneity of the studied parameters and that pontics were selected based on patient requirements which may also consist some level of bias. Yet, clinical observations after 10 years could give some insights for better-designed clinical trials in the future. Patients are being followed up for longer observation durations.

CONCLUSIONS

Fixed prosthodontics without tissue removal and using a pontic and proximal laminate veneers cemented to tooth abutments using 4-META/MMA-TBB-PMMA resin could be considered as a predictable alternative in restoring edentulous area in anterior and mandibular premolar region up to 10 years. All patients were satisfied with this pain-free treatment procedure, function, aesthetics and comfort. No caries or hypersensitivity on the restored teeth or abutments was discovered at the 10-year evaluations. The results of this clinical study support that a leakage-free hybrid layer could provide long-term function of resin-bonded FDPs restoring missing teeth.

MANUFACTURERS' DETAILS

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[d] Z100, 3M ESPE, MN, USA

[e] Metafil, Sun Medical, Shiga, Japan

[f] Super-Bond C&B, Sun Medical, Shiga, Japan

[g] C&B METABOND, Parkell, NY, USA

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DISCLOSURE

The authors declare that they have no conflict of interest.

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