

Survival of resin-bonded fixed partial dentures made from a silver-palladium-copper-gold alloy

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Purpose: The purpose of this study was to evaluate the clinical performance of resin-bonded fixed partial dentures (RBFDPs) made from a silver-palladium-copper-gold alloy.

Materials and Methods: The retention of 81 RBFDPs inserted during the 1987 to 2002 using a thione primer as the metal conditioner (Metaltite or V-Primer) and an adhesive resin (Super-Bond C&B) was clinically evaluated. Two levels of survival were defined: (1) complete survival (no debonding) and (2) functional survival (including loss of retention on one occasion with rebonding of the original RBFDP). All data were obtained from clinical examinations, and missing data were censored at the date of the last available information. Mean survival periods were determined using the Kaplan-Meier procedure.

Results: Of the 81 RBFDPs, five restorations failed, one of which could be rebonded. The observation duration and corresponding survival ratio for complete survival were 165 months and 43.9%, and those for functional survival were 178 months and 87.7%, respectively.

Conclusion: The results indicate that Super-Bond resin combined with noble metal conditioners is a clinically reliable system for longevity of RBFDPs. (Int Chin J Dent 2006; 6: 53-59.)

Key Words: clinical evaluation, primer, resin-bonded fixed partial denture, thione.

Introduction

To conserve tooth structure, the minimal preparation required for resin-bonded fixed partial dentures (RBFDPs) is clinically advantageous because of there infrequently being damage caused after the loss. RBFDPs bonded to enamel and dentin after minimal tooth preparation are an alternative to conventional fixed partial dentures (FPDs) during replacement of missing teeth.¹⁻⁵ Nevertheless, Dunne and Millar reported the high failure rate of RBFDPs in comparison with conventional FPDs.⁶ RBFDP stability basically depends on the adhesive bonding of a resin-based luting agent to a metal framework, and on the bond strength between the cement and tooth. However, RBFDP failure is reportedly influenced by various other factors such as tooth preparation resistance to displacement forces,^{7,8} preparation design,⁹⁻¹³ location,¹³⁻¹⁹ and the gender of the patient.²⁰ Due to these numerous influential factors, the prognosis and success rates of RBFDPs remain unclear.

The type of dental metal alloy selected for RBFDPs is also thought to be important for prognosis, since bond strengths between the resin and the metal alloy are known to vary in accordance with alloy type.²¹ Hansson and Bergstrom evaluated the longevity of RBFDPs and indicated that the bond strength between resin and high gold alloys was too low to resist fatigue fractures.²² The type of resinous luting agent selected also has an effect on RBFDP prognosis.²³

A silver-palladium-copper-gold alloy is one type of metal alloy that can be used for RBFDPs.^{24,25} The purpose of the present study was to collect long-term survival data of RBFDPs made from a silver-palladium-copper-gold alloy inserted using a resinous agent under controlled clinical conditions by evaluation of the retention of the framework.

Materials and Methods

Patients

One hundred and ten RBFDPs were inserted by three prosthodontic specialists at the Nagasaki University Hospital of Dentistry (Nagasaki, Japan) in 99 patients between 1987 and 2002. The patients inserted with an RBFDP had presented one or two missing teeth and two or three intact abutment teeth with good periodontal support. All abutment teeth were caries-free or exhibited only minimal lesions that would not interfere with bonding. Enamel surfaces were suitable for etching and tooth alignment was acceptable. Attempts were made to trace all patients for evaluation of bonding between RBFDP and teeth.

The inclusion criterion for participation in the study was the presence of stable occlusal relations. Although a total of 79 patients were available for clinical reexaminations in our hospital, two were excluded from this study because of unstable occlusal relations, while the other 20 could not be recalled. As a result, since all data were to be obtained from just clinical examinations to avoid overlooking an RBFDP failure, a total of only 77 patients (43 female and 34 male) between 18 and 70 years old with 81 RBFDPs were evaluated. The distribution of RBFDPs according to the age of the patients at the time of placement of the restoration is shown in Table 1. Of the 81 RBFDPs, a total of 33 restorations were anterior and 48 posterior (anterior: 24 maxillary and 9 mandibular; posterior: 23 maxillary and 25 mandibular). Sixty-four restorations were performed for one missing tooth and 17 for two. Fifty-nine restorations were cemented to two abutment teeth and 22 onto three.

Table 1. Distribution of RBFDPs according to patient age at the time of placement.

Age (year-old)	<20	21-30	31-40	41-50	51-60	61-70
Number of RBFDPs	3	11	12	13	15	23
%	3.9	14.3	15.6	16.9	19.5	29.9

Clinical and laboratory protocol

Considering that splinting of abutments increases their resistance to the force on the teeth and the supporting structure, Ante's law^{27,28} and the principle of Duchange²⁹ were adopted as clinical guidelines to determine the number and selection of abutments involved in the fabrication of the RBFDP in the current study. Tooth preparation was carried out without a groove according to the method of Tanaka et al.²⁶ All preparations had supragingival finishing lines.

All RBFDPs were fabricated after a heavy-body/light-body impression (Exaflex or Exafine, G-C Corp., Tokyo, Japan). The alloy used was a silver-palladium-copper-gold alloy (Castwell M.C. 12, G-C Corp.). This Castwell alloy is categorized into an age-hardenable silver-based casting alloy consisting of 46% Ag, 20% Cu, 20% Pd, and 12% Au. According to the manufacturer, the alloy is applicable to inlays, single restorations, and fixed partial dentures without porcelain fusing. For aesthetic purposes, pontics were veneered either with a hybrid composite (Cesead II, Kuraray Medical Inc., Tokyo, Japan), or with a microfilled composite (Axis, G-C Corp.), since the alloy cannot be fused directly to ceramics. RBFDP framework fabrication was performed in the same laboratory.

The inner surfaces to be bonded were airborne-particle abraded for 15 s with 50-70 μ m alumina (Hi-Aluminas, Shofu Inc., Kyoto, Japan) using an air-borne particle abrader (CL-FSG94, Heraeus Kulzer Inc., Armonk, NY, USA), and primed with a noble metal alloy conditioner (Metalbite, Tokuyama Dental Corp., Tokyo, Japan; or

V-Primer, Sun Medical Co., Ltd., Moriyama, Japan). Metaltite primer contains 6-methacryloyloxyhexyl 2-thiouracil-5-carboxylate (MTU-6) in ethanol, whereas V-Primer material contains 6-(4-vinylbenzyl-*n*-propyl) amino-1,3,5-triazine-2,4-dithiol or -2,4-dithione tautomer (VTD) in acetone. The V-Primer material is a pioneering metal priming agent for noble alloys; hence, the material has been used for all of the FPDs with a service period of 10 years or more. However, Metaltite material with improved bonding performance was later released, and so the V-Primer material was replaced with Metaltite in the current study. Either primer can be used for seating conventional FPDs, although the luting agent should be limited to resin-based materials.

The enamel surfaces of the abutment teeth were polished with a brush and fluoride-free pumice, etched with an etching gel of 37-65% phosphoric acid for 30 s, and rinsed with water. The luting material used for the RBFDPs was a tri-*n*-butylborane (TBB)-initiated self-curing resin (Super-Bond C&B, Sun Medical Co., Ltd.), which contains methyl methacrylate (MMA), poly(methyl methacrylate) (PMMA), and 4-methacryloxyethyl trimellitate anhydride (4-META) as the carboxylic functional monomer.

Restorations were inserted under relatively dry conditions using cotton rolls. All patients were given oral hygiene instructions with special emphasis on cleaning proximal surfaces with an interdental brush and dental floss. Patients were recalled at 6-month intervals for oral hygiene and RBFDP evaluations. RBFDP was not examined for pontic fracture but just for debonding of the framework, since the number of veneered pontics was less than half of all the RBFDPs. Framework debonding was determined by probing the interface between the retainer casting and the tooth with an explorer tip. Restorations that exhibited debonding but no major defects were rebonded.

Survival was therefore evaluated at two levels: (1) complete and (2) functional survival. A restoration was recorded as having completely survived if no loss of retention was detected. Functional survival reflected survival of functioning restorations, but after loss of retention on one occasion and successful rebonding of the original restoration with the same bonding system. The baseline for assessment of both complete and functional survival was the date of insertion of the original prostheses. In cases where a RBFDP was dislodged or where one/both sides of a framework were loose or debonded from one or all abutment teeth, it was considered a failure (end-point). However, if a restoration was able to be rebonded successfully, the loosening/debonding was not considered a failure of functional survival. Other problems such as fracture of the pontic or aesthetic deterioration were not considered failures. Missing data were censored at the date of the last available information. Kaplan-Meier survival analysis³⁰ was performed with statistical software (Statview Ver. 5, SAS Institute Inc., Cary, NC and SPSS 10.0 for Windows, MapInfo Corp., Troy, NY, USA). The clinical protocol was approved by the Ethical Committee for Clinical Practice of the Nagasaki University Hospital of Medicine and Dentistry (Approval No. 23).

Results

Twenty of the 99 (20.2%) patients were declared dropouts. A review of the clinical records of these patients, who did not attend for examination, determined that they had never appeared for their recall appointment after the insertion. For a better completeness of our analysis, we sought to interview these 20 patients by telephone or mail; three patients had died and 1 had gone overseas after the treatment. One patient responded that the RBFDP for a maxillary left premolar had been clinically retentive for 15 months, and another that the RBFDP had been removed for an implant treatment at another hospital approximately two years after the initial insertion. The

remaining 14 patients could not be reached by telephone or mail; the probability being that they had moved to unknown addresses. Although the dropouts before our evaluation might result in some attrition bias, information regarding these 20 patients was excluded from our analysis as the aim of the study was in essence an explanatory trial.

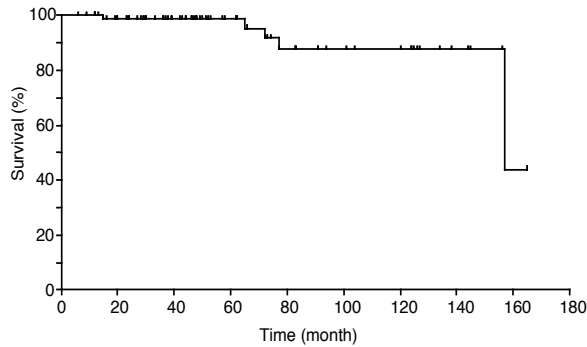


Fig. 1. Overall complete survival.

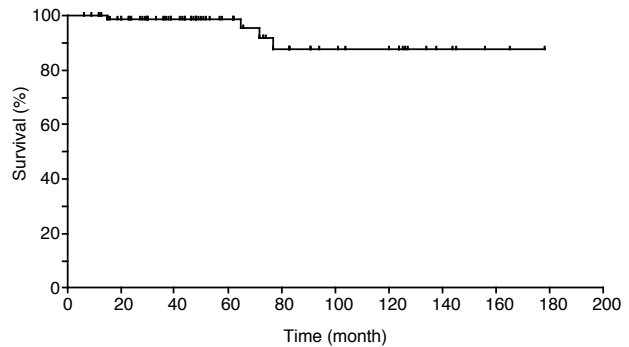


Fig. 2. Overall functional survival.

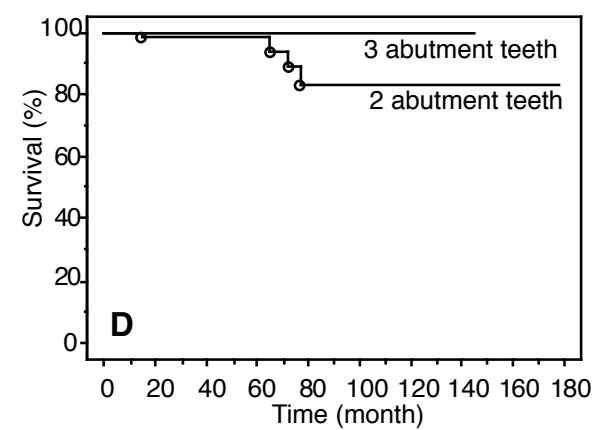
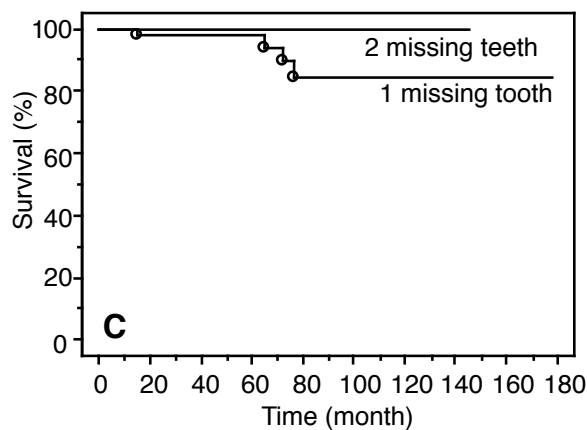
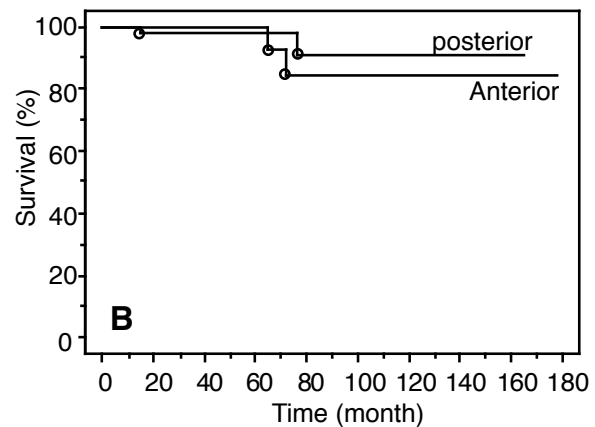
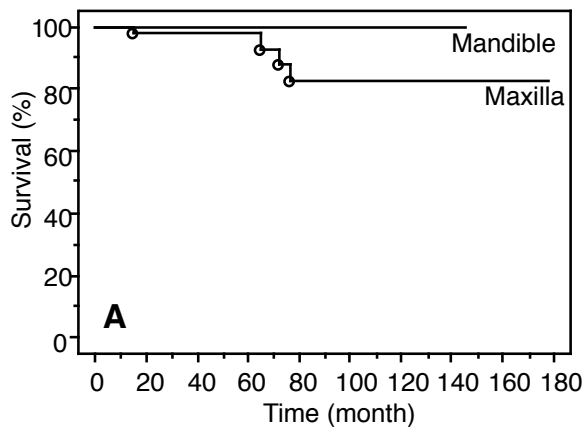


Fig. 3.

A: Functional survival in relation to the missing tooth/teeth (maxilla or mandible). Debonding number and percent censored for maxillary RBFPDs were four and 91.8%,; while those for mandibular RBFPDs were none and 100%, respectively.

B: Functional survival in relation to the location (anterior or posterior) of the missing tooth/teeth. Debonding number and percent censored for anterior RBFPDs were two and 93.8%,; while those for posterior RBFPDs were two and 95.8%, respectively.

C: Functional survival in relation to the number (one or two) of missing teeth. Debonding number and percent censored for RBFPDs for one missing tooth were four and 93.7%,; while those for RBFPDs of two missing teeth were none and 100%, respectively.

D: Functional survival in relation to the number (two or three) of abutment teeth. Debonding number and percent censored for RBFPDs of two abutment teeth were four and 93.7%,; while those for RBFPDs of three abutment teeth were none and 100%, respectively.

Among the 81 prostheses assessed, no frameworks had fractured, but debonding occurred in a total of five restorations (debonding rate: 6.2%). Of the five debonded restorations, one occurred as a result of trauma at 157 months. The RBFDP, which replaced a missing maxillary lateral incisor, was able to be rebonded since the abutment teeth exhibited no defects or aesthetic problems and periodontal supports were sufficient. Of the five debonded restorations, the remaining four could not be rebonded since secondary caries occurred in each restoration as a result of bonding failure at the tooth-resin interface. For the four RBFDPs, three new conventional FPDs and one new RBFDP were refabricated.

Figs. 1 and 2 show the complete and functional survival curves, respectively. The observation duration and corresponding survival ratio for complete survival were 165 months and 43.9%, and those for functional survival were 178 months and 87.7%. Fig. 3 shows Kaplan-Meier functional survival curves of the RBFDPs in relation to the missing tooth/teeth, the location and the number of missing teeth and abutment teeth. Although the survival curves showed different tendencies, these factors had no statistical affect on longevity. Additional analyses could not be carried out due to the infrequency of dedonding.

Discussion

RBFDPs made from a silver-palladium-copper-gold alloy were clinically followed-up for a maximum of 178 months (14.8 years). Although positive effects of tooth preparation have been found in previous studies,^{1,9,11,12} minimal preparation without a groove²⁶ was carried out in the present study to conserve tooth structure. The debonding rate of 6.2% obtained here was lower than those observed in other studies,^{15,31} and retention of the restorations was thought to be favorable.

Hansson evaluated the longevity of resin-bonded prostheses made of a high-gold alloy, the inner surface of which was treated with air abrasion using aluminum oxide and high-temperature oxidation.³¹ The average survival period of the RBFDPs was only nine months, and therefore it was suggested that adhesion of resin-bonded prostheses must be based on mechanical retention between the TBB-initiated Super-Bond C&B material and gold alloy selected because of the low durability of bonding joints to water. Tanaka et al. afterward confirmed that the low bonding durability of Super-Bond resin joined to heated gold alloy was the result of insufficient stability to acid attack of the oxidized copper oxide layer that forms on the gold alloy surface during heating.³²

Application of metal alloy conditioners for chemical bonding would help improve the overall results. Two thione primers are reported to enhance bonding durability between dental alloys and Super-Bond C&B adhesive material,²¹ and also showed excellent bond strength for silver-palladium-copper-gold alloys.^{33,34} This high bonding durability is accurately reflected in the results of this study, as all bonding failures were the result of debonding at the tooth-resin interface. However, the bond strength of resin and dental metal alloy decreases after repetitive thermocycling, regardless of the application of the two thione primers.³² This has been reported previously for V-Primer.³⁵ Although the results of this study did not indicate the need to improve the primer, treatment of the inner surface of the retainer should be carefully selected to facilitate longevity. The development of a noble metal primer in the future should lead to a more satisfactory prognosis for RBFDPs. The importance of the type of dental alloy selected is also reflected in the current results. Restorations made from silver-palladium-copper-gold alloy might be naturally superior to those made of base metal alloys such as nickel-chromium or cobalt-chromium. Hikage et al. reported that the survival rate of silver-palladium-copper-

gold alloy was not statistically different from that of metal-ceramic gold alloys.²⁴

The effect of restoration location is reportedly significant; in general, maxillary posterior restorations have shown better retentive results than mandibular restorations.^{13-15,17,18} However, in this study, the effect of location was not significant, since the debonding rate was too low to statistically evaluate the influence on functional survival time. Similarly, no other factor was shown to statistically affect the results. Nevertheless, debonding/loosening actually occurred, and debonded/loosened RBFDPs could not always be rebonded. Partial debonding could easily be missed at a recall or subsequent examination by a dentist, probably since the debonding area could be imperceptible and the debonded/loosened RBFDP probably not detached. Generally, there is in theory a greater possibility of rebonding an RBFDP compared with a conventional FPD. Although the clinical examinations in this study could not specify the causes of the bonding failures, the results of the study still indicated the difficulty of reusing a RBFDP.

Within the limitations of this study, the minimal preparation, without any additional mechanical retention between the dental alloy and the luting agent and without additional preparation of the abutment teeth including groove or extensive preparation, was thought to be acceptable in light of the high survival rate. Additional tooth preparation is an obviously contradiction to the concept of minimal intervention. Yet, the results here showed another problem where partial debonding of the RBFDP framework might cause secondary caries that prevent rebonding (functional survival). Clinicians should pay special attention and try not to miss any barely perceptible debonding of an RBFDP when undertaking oral hygiene treatment; as well, they should be aware that the prognosis for a RBFDP depends substantially on the selection of the framework alloys, the type of primer and luting agent, and proper surface preparations of adherent surfaces. The results here also indicate that further improvements to the RBFDP bonding system are needed.

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