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Bonding of a Gingival Shade Composite to a Denture Base Resin using a Chemically Activated 4-Meta Resin

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Abstract - *The purpose of the present study was to determine an effective surface preparation for the bonding of a gingival shade composite resin to a denture base resin. The flat surfaces of a heat-processed denture base resin were prepared in various ways. A highly filled gingival shade composite resin was applied and polymerized. Shear testing was performed in a universal testing machine, and the maximum fracture load values were determined. The application of chemically activated 4-META resin using the brush-dip technique was an effective surface preparation for the bonding of a gingival shade composite resin to a denture base resin.*

KEY WORDS: bonding, chemically activated 4-META resin, denture base resin, gingival shade composite resin, surface preparation

INTRODUCTION

The characterization of denture base resin is of interest in the field of Prosthodontics. Pound created a characterized denture by sifting colored polymers into the denture base resin[1]. The construction method of a custom-shaded denture base using visible-light-cured resin was reported[2]. Recently a highly filled light-polymerized gingival shade composite resin designed to provide shades similar to those in the natural gingiva has been commercialized. This material can serve as an effective substitute for brittle porcelain gingiva[3, 4] and can be used for a combined fixed partial denture and removable gingiva[5]. It has also been used in an alternative technique to fabricate a customized screw-retained infrastructure to replace lost soft tissue and bone[6]. This gingival shade composite resin offers unlimited possibilities, not only for the characterization of acrylic denture bases, but also for embedding the yoke of a magnetic attachment into the denture base in place of using an autopolymerizing acrylic resin[7].

It is assumed that highly filled composite resin does not easily bond to a denture base resin. Therefore, the effect of surface preparation on the bonding of a highly filled gingival shade composite resin to a denture base resin was evaluated in a previous study. The results of a study by Shimizu *et al*[8] showed that the tribochemical silica coating and application of dichloromethane after the silane coupling agent were effective surface preparations, within the limitations of the study. However, the bond durability of these preparations may be insufficient. The purpose of the present study was to improve the bond strength of a highly filled gingival shade composite resin to a denture base resin by determining the most effective surface preparation.

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MATERIALS AND METHODS

A total of 120 block specimens (10.0 x 10.0 x 3.0 mm) of heat-processed denture base resin (Acron clear) were prepared. A conventional laboratory procedure was used to mix and pack the resin in gypsum moulds for denture processing according to the manufacturer's instructions. After processing, each block was embedded in an autopolymerizing resin with an acryl ring, and the surfaces of the denture base resin were abraded under running water with up to 400-grit silicon carbide paper. The abraded flat surfaces of the specimens were prepared in one of seven ways (Table 1). In Groups 2, 6 and 7, 4-META/MMA-TBB resin (Super-Bond C&B ivory) was used. In Group 3, a tribochemical silica coating was applied using the Rocatec system. In Group 4, a primer (Signum connector) was applied and polymerized with a light-polymerizing unit (Twinkle L II) for 180 sec. In Group 5, dichloromethane was left on the surface for 5 sec[9], and a silane coupling agent (Clearfil ceramic primer) was kept wet. The subsequent procedures after each preparation in Groups 5-7 were done as quickly as possible.

Sticky masking tape with a 6.0 mm diameter hole was placed on the bonding surface of each specimen, and a Teflon ring with a circular hole (5.0 mm inner diameter, 6.0 mm outer diameter) was placed in the hole on the masking tape to hold it in place and define the bonding area. A gingival shade composite resin (Meta color Prime art accessory color paste Gum, RS1) was applied inside the Teflon ring and then polymerized with the same light-polymerizing unit for 180 sec. After the polymerization process was completed, the masking tape and Teflon ring were gently removed (Fig. 1).

All the specimens were immersed in distilled water at 37°C for 24 hours. Seventy specimens (seven sets of ten specimens) were tested for a 24-hour maximum fracture load without thermocycling. Ten specimens each from Groups 3-7 (five sets of ten specimens) were placed in a thermocycling apparatus (Thermal Shock Tester TTS 1) and cycled in water between 5°C and 55°C for 10,000 cycles with a dwell time of one min at each temperature.

Table 1. *Surface preparations*

Group	*Preparation*
1	no preparation
2	chemically activated 4-META resin monomer applied and allowed to dry
3	tribochemical silica coating
4	application of light-polymerized primer and prelight-polymerized
5	application of dichloromethane following the silane coupling agent
6	chemically activated 4-META resin monomer applied and left wet
7	chemically activated 4-META resin applied using the brush-dip technique

Table 2. *Fracture load values (FLV in Newtons) and failure modes of gingival shade composite bonded to denture base resin*

	Thermocycles					
	0 cycles			*10,000 cycles*		
Group	*FLV (N) Mean ± SD*	*significance*	*Failure Type (n) C / M / A*	*FLV (N) Mean ± SD*	*significance*	*Failure Type (n) C / M / A*
1	2.3± 5.6	a	0 / 0 /10			
2	173.7±28.2	b	0 / 0 /10			
3	308.8±71.8	c	0 / 5 / 5	1.8±29.0	a	0 / 0 /10
4	320.3±32.6	c	0 / 8 / 2	287.3±45.8	c	4 / 3 / 3
5	351.8±35.9	c	0 / 1 / 9	159.7±31.3	b	0 / 2 / 8
6	405.7±31.0	d, e	3 / 7 / 0	326.0±42.0	c	0 / 6 / 4
7	473.2±45.5	e, f	10 / 0 / 0	432.2±65.0	d, e, f	7 / 3 / 0

SD: standard deviation.

One-way ANOVA of results within columns at $p<0.05$ with separate letters indicate differences.

C: Cohesive failure. A: Adhesive failure at the denture base resin-highly filled composite resin interface; M: Mixture of cohesive failure and adhesive failure. Each letter corresponds to a separate specimen.

Shear testing was performed in a universal testing machine (Autograph AGS-J) to determine the maximum fracture loads at a crosshead speed of 0.5 mm/min (Fig. 2). The means and standard deviations (SD) for the maximum fracture loads (n=10) were calculated and statistically analyzed with a one-way analysis of variance (ANOVA) and the Student-Newman-Keuls post-hoc comparisons test at a significance level of $\alpha = 0.05$.

The type of bond failure was determined after shear testing when the fracture surfaces of the specimens were examined using an optical microscope (Nikon 92052) at 30X magnification. Failure was evaluated in this study as A (adhesive failure at the heat-processed denture base resin-highly filled composite resin interface), C (cohesive failure within the heat-processed denture base resin without interface separation) or M (mixture of cohesive failure and adhesive failure).

RESULTS

The statistical analysis revealed that there were significant differences in the maximum fracture load due to preparation both before and after thermocycling ($p<0.05$). Before thermocycling, the mean fracture loads of Groups 7 (application of chemically activated 4-META resin using the brush-dip technique) and 6 (application of chemically activated 4-META resin monomer without drying) were the greatest ($p<0.05$). Group 1 (no preparation) yielded the lowest fracture load ($p<0.05$). After thermocycling, Group 7 exhibited a greater mean fracture load than Group 6 ($p<0.05$). There was no significant difference between the pre- and post-thermocycled fracture loads in Group 7 ($p>0.05$), whereas the mean fracture load in Group 6 was significantly reduced by thermocycling ($p<0.05$). Table 2 summarizes the means and standard deviations (SD) of the fracture loads (N) before and after thermocycling, statistical significance and numbers of cohesive, mixed and adhesive failures.

DISCUSSION

In a previous study[8], the effect of surface preparation on the bonding of a highly filled gingival shade composite resin to a denture base resin was evaluated. It was concluded that the tribochemical silica coating and application of dichloromethane after the silane coupling agent were effective among the surface preparations tested. However, the bond durability of these treatments was presumed to be insufficient. Therefore, the aim of the present study was to determine the most effective surface preparation to enhance the bond durability between the gingival shade resin to a denture base resin.

Before thermocycling, the failure load for the specimens treated with chemically activated 4-META resin monomer

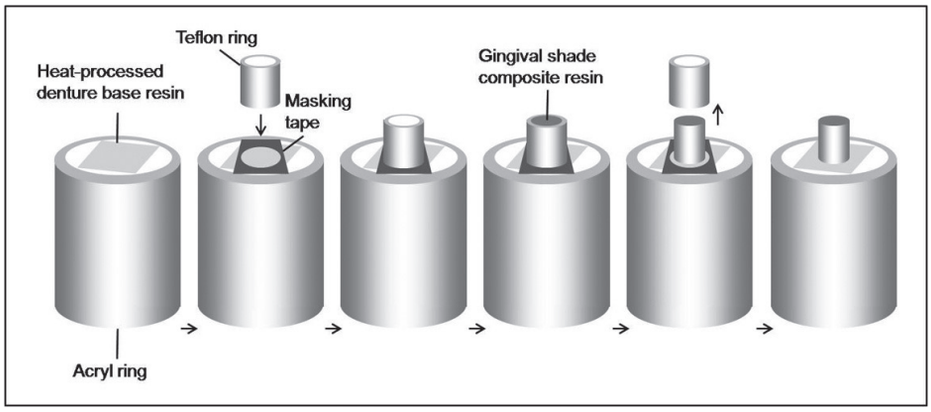

Figure 1. *Illustration showing the preparation steps of test specimens.*

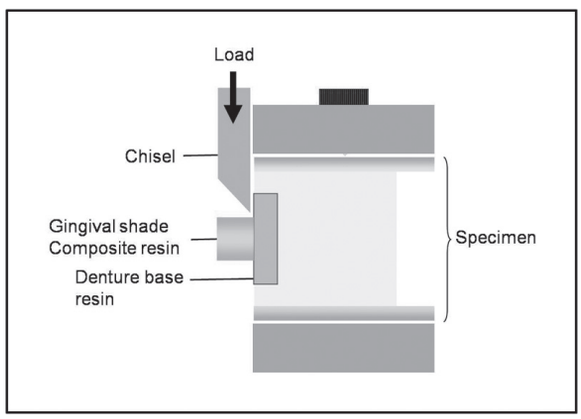

Figure 2. *Illustrations showing shear testing.*

using the brush-dip technique without drying was significantly higher than that with application of the same resin with drying. This finding indicated that a crucial factor for bonding a highly filled gingival shade composite resin to a denture base resin may not be the functional monomer 4-META as a chemical component, but may be the surface tension or another property of the resin itself. There were no significant differences in the values between before and after thermocycling for the specimens treated with 4-META resin only using the brush-dip technique. Therefore, the application of 4-META resin followed by the prompt addition and polymerization of a gingival shade composite resin is recommended in the clinical situation.

The combined use of dichloromethane and a silane coupling agent may create the synergistic effect of morphologically changing the denture base resin and coupling the gingival shade composite resin to the filler particles. However, the coefficients of the gingival shade composite resin to a denture base resin in Group 5 were 53.5% for pre-thermocycling and 26.9% for post-thermocycling. The mode of failure in Group 5 clearly supported the results of the fracture load values.

The effect of applying light-polymerizing primer and prelight polymerization may be due to the presence of residual monomer on the surface of the denture base resin. However, this procedure was inferior to the above-mentioned preparations. In this study, it was difficult to explain why there were four specimens undergoing cohesive failure after thermocycling in Group 4.

CONCLUSION

Within the limitations of the present study, the application of chemically activated 4-META resin using the brush-dip technique and the prompt subsequent procedures was effective at bonding the gingival shade composite resin to a denture base resin.

MANUFACTURERS' DETAILS

- Acron clear, GC Corp., Tokyo, Japan
- Super-Bond C&B ivory, Sun Medical Co., Ltd., Moriyama, Japan
- Rocatec™ junior coating unit, 3M ESPE AG, Seefeld, Germany
- Signum connector, Heraeus Kulzer GmbH, Wehrheim, Germany
- Twinkle L II, Toho Dental Product Co., Ltd, Saitama, Japan
- Dichloromethane, Wako Pure Chemical Industries Ltd., Osaka, Japan
- Clearfil ceramic primer, Kuraray Medical Inc., Tokyo, Japan

- Meta color Prime art accessory color paste Gum, Sun Medical Co Ltd., Moriyama, Japan
- Thermal Shock Tester TTS 1, Thomas Kagaku Co., Ltd., Tokyo, Japan
- Autograph AGS-J, Shimadzu Corp., Kyoto, Japan
- STATISTICA for Windows Version 5.5, StatSoft Inc., Tulsa, OK, USA
- Nikon 92052, Nikon Corp., Tokyo, Japan

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