

Bond strength of denture base resin to castable Fe-Pt magnets

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Purpose: The purpose of this study was to evaluate the bond strengths of denture base resin to a magnetic Fe-Pt alloy using four adhesive metal primers.

Materials and Methods: Disk patterns (7.5 mm diameter, 2.0 mm thick) were cast from a custom-made Fe-Pt ingot (Fe-69.4wt%Pt-0.6wt%Nb) in a high-frequency centrifugal casting machine. Aging at 600°C was performed for five hours to obtain hard magnetic properties. After the adhesive surfaces were sandblasted with 50 µm Al₂O₃, they were primed with Metal Primer II (MP), Meta Fast Bonding Liner (BL), New Meta Color INFIS Opaque Primer (IN), or Epricord Opaque Primer (EP). Denture base resin (Palapress Vario) was then polymerized according to the manufacturer's instructions. After the specimens were immersed in 37°C water for 24 hours (Baseline, TC0), the shear bond strengths (n=7) were measured at a crosshead speed of 0.5 mm/minute after 10,000 thermal cycles (TC 10,000 at 4°C to 60°C). The data were statistically analyzed by ANOVA/Scheffé's test ($\alpha=0.05$).

Results: MP and EP had significantly higher bond strengths ($p<0.05$) than BL and IN at TC0. Thermal cycling significantly ($p<0.05$) reduced the bond strengths using all the primers tested. However, the bond strength of EP was slightly less after thermal cycling than for the other three primers (MP, BL, IN).

Conclusion: The results of this in vitro study indicate that EP provides superior long-term bond strength when a cast Fe-Pt magnet is embedded in denture base resin. (Int Chin J Dent 2005; 5: 39-42.)

Clinical Significance: The use of Epricord Opaque Primer is recommended to obtain long-term clinical reliability when the denture base resin is bonded to cast Fe-Pt magnet.

Key Words: cast Fe-Pt magnet, denture base resin, metal primer, bond strength.

Introduction

Dental magnetic attachments are frequently used to retain dental and maxillofacial prostheses^{1,2} because of their excellent attractive force. Most commercial dental magnetic attachments utilize rare-earth Fe₁₄Nd₂B magnets, which is the strongest type of magnet with excellent magnetic properties (hard magnetic properties) such as high maximum energy product and high coercive force (strength of magnet).³⁻⁵ Since the corrosion resistance of Fe₁₄Nd₂B magnets is very low, they must be covered with a corrosion-resistant magnetic stainless steel yoke cap.⁶ Recently, castable Fe-Pt magnetic attachments with high corrosion resistance were developed^{7,8} and clinically applied in sectional or collapsible removable dentures for patients with microstomia.^{9,10} These reports indicated favorable results because of the custom-cast magnetic attachments made for individual patients. In these cases, the Fe-Pt magnet or keeper was embedded in the denture base resin without a metal primer. Although primers had the potential to enhance long-term clinical reliability, there was a little information about them. Ohkubo et al.¹¹ investigated the bond strengths of laboratory prosthetic composite to magnetic Fe-Pt alloy using several metal primers. They reported that primers containing 10-methacryloxydecyl dihydrogen phosphate (MDP) and methacryloyloxyalkyl thiophosphate derivative (MEPS) were effective at obtaining high bond strength and durability.

To ensure reliable prostheses without adhesive failure and microleakage, it is important to obtain a strong bond between the denture base resin and the Fe-Pt magnetic alloys. This study examined the shear bond strength

of a denture base resin to cast custom-made Fe-Pt magnets using several metal primers.

Materials and Methods

The materials used in this study are listed in Table 1. Plastic disk-shaped patterns (7.5 mm diameter, 2 mm thick) were prepared for casting a custom-made Fe-Pt magnetic alloy. The disk patterns were invested in mold rings with a magnesia-based investment material (Titavest CB, Morita, Japan). The burn-out procedure was accomplished according to the manufacturer's instructions, and the patterns were then cast from a custom-made Fe-Pt ingot (Fe-69.4wt%Pt-0.6wt%Nb) in a high-frequency centrifugal casting machine (Eagle; Jelenko, Armonk, NY, USA). After casting, the disks were vacuum-sealed in quartz-glass tubes and heat-treated at 1,325°C for 45 minutes, and then quenched in ice water. Aging at 600°C was subsequently performed for 5 hours to obtain hard magnetic properties. Then the surfaces of the cast Fe-Pt alloy disks were polished with up to No. 400 SiC abrasive paper under water.

Table 1. Materials used.

Material/Trade name	Code	Manufacturer	Code	Composition
Magnetic Fe-Pt alloy		Custom-made Ishifuku Metal Industry, Tokyo, Japan Nilaco, Tokyo, Japan Hirano-Seizaemon, Tokyo, Japan		Fe-69.4wt%Pt-0.6wt%Nb Pt: 99.5% pure Fe: 99.99% pure Nb: 99.9% pure
Denture base resin Palapress Vario		Heraeus Kulzer, Inc. Hanau, Germany		Poly(methyl methacrylate)
Primer				
Metal Primer II		GC, Tokyo, Japan	MP	MEPS
Meta Fast Bonding Liner		Sun Medical, Moriyama, Japan	BL	4-META
New Meta Color INFIS Opaque Primer		Sun Medical	IN	VTD
Epicord Opaque Primer		Kuraray, Osaka, Japan	EP	MDP

MEPS, Methacryloyloxyalkyl thiophosphate derivative; 4-META, 4-methacryloxyethyl trimellitate anhydride; VTD, 6-(4-vinylbenzyl-*n*-propyl) amino-1,3,5-triazine-2,4-dithiol; MDP, 10-methacryloxydecyl dihydrogen phosphate.

The adhesive surfaces were sandblasted with 50 μm Al_2O_3 for 10 s at an emission pressure of 0.28 MPa with the nozzle positioned approximately 10 mm away from the surface of the metal adherend. After the bonding surfaces were air-abraded, they were primed with one of four primers: Metal Primer II (MP), Meta Fast Bonding Liner (BL), New Meta Color INFIS Opaque Primer (IN), or Epicord Opaque Primer (EP) (Table 1). The bonding area was defined by placing a piece of double-stick tape with a 4.8 mm diameter hole on the bonding surface of each cast disc and then positioning a Teflon ring (2 mm thick) with a circular hole (6 mm in diameter) over the tape. Autopolymerizing PMMA resin (Palapress Vario, Heraeus Kulzer, Inc.) was poured inside the Teflon ring. Polymerization was performed according to the manufacturer's instructions, namely, in a pressure-curing unit (Palamat, Heraeus Kulzer, Inc.) at 55°C and 200 kPa for 15 minutes. After removing the Teflon ring, all specimens were stored in water at 37°C for 24 hours (Baseline, TC0); they then underwent 10,000 thermal cycles (TC10,000) in water between 4°C and 60°C with a 1-minute dwell time. As a control, non-primed specimens were fabricated in the same manner. The shear bond strengths were measured on a screw-driven mechanical testing machine (Model 5565, Instron Corp., Canton, MA, USA) at a crosshead speed of 0.5 mm/minute. The means and standard deviations of shear bond strength ($n=7$) were calculated and statistically analyzed by ANOVA and the Scheffé's test at a significance level of $\alpha=0.05$.

Results

Table 2 shows the shear bond strength results. MP and EP had significantly higher bond strengths ($p < 0.05$) than BL and IN at TC0. IN had the lowest bond strength among the other three primers, and there were no significant differences ($p > 0.05$) in bond strengths at TC0 without a primer (control). Thermal cycling significantly ($p < 0.05$) reduced the bond strengths using all the primers tested. However, the EP-primed specimens had higher durability (only 16% decrease) after thermal cycling than did the other three primers (MP, BL, IN).

Table 2. Mean shear bond strengths (MPa) of denture base resin to primed Fe-Pt magnet surfaces.

Primer (Functional monomer)	TC 0 (Baseline)			TC 10,000 (Thermocycled)			Decrease (%)
	Mean	SD	Grouping	Mean	SD	Grouping	
Control (No treatment)	4.1	0.8	c	1.1	1.0	c	74
MP (MEPS)	17.6	0.8	a	10.4	2.2	b	41
BL (4-META)	10.8	3.1	b	1.7	0.9	c	84
IN (VTD)	4.3	0.9	c	0.8	0.5	c	81
EP (MDP)	16.6	1.6	a	13.9	2.2	a	16

SD, One standard deviation. Similar lowercase letters indicate statistically equivalent values (Scheffé's test, $p > 0.05$). MP, Metal Primer II; BL, Meta Fast Bonding Liner; IN, New Meta Color INFIS Opaque Primer; EP, Epricord Opaque Primer; TC, Thermal cycles.

Discussion

To investigate the bond strength and durability of denture base resin bonded to cast Fe-Pt magnetic alloy, this study evaluated four metal primers with individual functional monomers (Table 1) purported by each manufacturer to react with precious and/or nonprecious metals. The Fe-Pt magnet used in the present study contains a large amount of precious Pt (69.4 %) and nonprecious Fe (30%). The bond strength and durability of denture base resin bonded to cast Fe-Pt magnetic alloy was greater when MP and EP primers were used, and EP in particular had the greatest durability (16% decrease). MP contains MEPS, which was intended for bonding to both precious and nonprecious metals. EP contains MDP and was developed for bonding to nonprecious metals. Our results were in agreement with a previous study by Ohkubo et al.¹¹ who reported that the MDP- and MEPS-containing primers were effective at promoting high bond strength and durability of a prosthetic composite bonded to Fe-Pt magnetic alloy. These primers might be effective at increasing the bond strength of denture base resin to Fe-Pt alloy surfaces partially covered with iron oxides. Although BL contains 4-META, which was also intended for bonding to nonprecious metals, the bond strength and durability of specimens primed with BL were not as good as those primed with EP (MDP) primer. Therefore, a MDP-containing primer is more clinically reliable than a 4-META-containing primer when they are applied to a cast Fe-Pt magnet before the denture base resin is bonded to the alloy. The bond strength of the specimens primed with IN was the lowest at both baseline (TC0) and 10,000 thermocycles (TC 10,000). The IN used in this study contains an adhesive monomer of VTD, which is claimed by the manufacturer to react with the gold in precious metal alloys such as Type IV gold alloy and gold/silver/palladium alloys. Since IN was not an effective primer for the Fe-Pt magnets, which contain a large amount of precious metal (69.4% Pt), the difference in the elemental composition of the alloy (gold/silver/palladium vs. platinum) may be one reason for the low bond strength of the denture base resin to the Fe-Pt alloy.

Conclusion

Of the metal primers employed in this study, Epricord Opaque Primer produced the greatest bond strength both pre- and post-thermocycling of a denture base resin to cast Fe-Pt magnetic alloy.

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