JOURNAL OF APPLIED ORAL SCIENCE

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J Appl Oral Sci *2004; 12(2):113-6*

EFFECT OF A METAL PRIMER ON THE BOND STRENGTH OF THE RESIN-METAL INTERFACE

EFEITO DE UM PRIMER PARA METAIS SOBRE A FORÇA DE UNIÃO DA INTERFACE METAL-RESINA

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Received: July 12, 2003 - Return for modification: October15, 2003 - Accepted: December 12, 2003

ABSTRACT

To evaluate the effect of different surface treatments on shear bond strength between a metallic alloy (Co-Cr-Mo - Remanium CD) and a resin cement (Rely X™) and to evaluate the mode of fracture after testing, forty couples of metallic-alloy disks were melted, regularized, polished, submitted to four thermal cycles (Vacuum, 960ºC, 8 minutes) and randomly separated into four groups. Each group received a different type of treatment: Group PSP: Polished with sandpaper 600; Group PCP: Polished with sandpaper 600 and application of the metal primer Alloy Primer (Kuraray); Group JSP: Sandblasted with 100µm aluminum oxide; Group JCP: Sandblasted with 100mm aluminum oxide and treated with a metal Primer. The groups were cemented and stored in distilled water at 37ºC for 36 hours and submitted to the shear bond strength test. The mean and standard deviation (in Kgf/cm^2) obtained for each group was: PSP 4.0/0.4; PCP 88.9/33.6; JSP 163.2/27.6; JCP 144.5/54.0. After the statistical analysis the authors concluded that: the highest values were obtained for the sandblasted groups (JSP, JCP), regardless of the primer application; the Alloy Primer increased the retention between the Rely X cement and the polished surface of the Co-Cr-Mo alloy, yet its bond strength was not greater than that obtained with sandblasting; all specimens showed adhesive failures in the tested interface.

UNITERMS: Resin cement; Metallic alloy; Surface treatment; Shear bond strength.

RESUMO

Para avaliar o efeito de diferentes tratamentos superficiais sobre a resistência ao cisalhamento da união entre uma liga metálica (Co-Cr-Mo - Remanium CD) e um cimento resinoso (Rely X™) e analisar o tipo de fratura durante a separação dos espécimes, quarenta pares de discos metálicos foram fundidos, regularizados e polidos, submetidos a quatro ciclos térmicos (vácuo, 960ºC, 8 minutos) e divididos aleatoriamente em quatro grupos. Cada grupo recebeu um tipo de tratamento: Grupo PSP: Polimento com lixa d'água Nº 600; Grupo PCP: Polimento com lixa 600 e aplicação do condicionador metálico Alloy Primer (Kuraray); Grupo JSP: Jato de óxido de alumínio de 100µm, e Grupo JCP: Jato de óxido de alumínio de 100mm, e aplicação do Alloy Primer. Os grupos foram cimentados e armazenados em água destilada a 37ºC por 36 horas e submetidos ao ensaio de resistência ao cisalhamento. A média e o desvio padrão (em kgf/cm^2) obtidos para cada grupo foram: PSP 4,0/0,4; PCP 88,9/33,6; JSP 163,2/27,6; JCP 144,5/54,0. Após a análise estatística os autores concluíram que: os maiores valores foram produzidos pelos grupos jateados (JSP, JCP), independentemente da aplicação do primer; o Alloy Primer aumentou a retentividade entre o cimento Rely X e a superfície polida da liga de Co-Cr-Mo, entretanto sua força de união não superou a alcançada através do jateamento; todos os espécimes apresentaram falha adesiva na interface testada.

UNITERMOS: Cimento resinoso; Liga metálica; Tratamento superficial; Resistência ao cisalhamento.

INTRODUCTION

During the last years several works were accomplished on the increase of the bond strength of resins to metals, mainly through surface treatment of metallic alloys. Nowadays, several chemical systems of adhesion for metallic alloys have been introduced in the market, most containing an acid monomer able to adhere either to the metal or to the enamel[8].

Several alloys can be used for the development of adhesive bridges with quite satisfactory clinical behavior, since they are treated appropriately. The types of surface treatments applied to metals can vary according to its composition and pattern of granulation. Due to its high elasticity module in relation to gold, basic metal alloys like Ni-Cr are favorite for making of adhesive bridges[2], being the most utilized and presenting the best results in tests[9]; however, they are contraindicated for use in patients sensitive to nickel[6], main component of this alloy. Co-Cr-Mo can substitute these alloys, apparently without affecting the durability or the clinical behavior of the restorations[5].

The success of an adhesive bridge does not depend only on the union between the metal and the resin, but also on proper dental reduction, which supplies retention and stability to the metallic structure and compatibility with the bite forces to which the prosthesis will be submitted[9]. However, prosthesis presenting a structure deficiently elaborated or fragile will be prone to failure; therefore, an appropriate treatment plan and the bond between their components and the tooth to be restored are fundamental.

The literature shows that several doubts still remain concerning the bonding in adhesive bridges and the best treatment to be applied to the metallic surface, in this case, to the Co-Cr-Mo alloys, due to the lack of studies regarding its union to the resin cements and several materials for esthetic facets in prosthesis.

The present work aimed at evaluating the effect of different surface treatments applied in a Co-Cr-Mo alloy on the shear bond strength of the union between the metallic alloy and a resin cement, and to analyze the type of fracture occurring during separation of the specimens.

MATERIAL AND METHODS

Materials

For accomplishment of this study, a Co-Cr-Mo alloy (Remanium CD / Dentaurum), a metal primer (Alloy Primer / Kuraray), a resin cement (Rely X™ / 3M) and 100μm aluminum oxide were used. The main characteristics of the materials employed are described in the following Table 1.

Methods

Forty pairs of Co-Cr-Mo alloy disks were melted, being half constituted by a disk of 10mm and half of 12mm of diameter, both with 2mm of thickness. Those disks present loops in one of the faces to facilitate the handling of the specimens. Two cemented disks of different diameters represented a specimen.

After casting, the metallic disks were cleaned with blasting with aluminum oxide, regularized and polished with sandpaper 600, in order to eliminate possible variations in surface texture.

All metallic disks obtained were submitted to 4 thermal cycles, under vacuum, at 960ºC to simulate firing of the porcelain, with consequent formation of a superficial oxide film. Afterwards, the disks were washed in running water and in distilled water in an ultrasonic device for 2 minutes.

The disks with 12-mm diameter were fastened in a base of epoxy resin to allow adaptation to the shear device; afterwards, the specimens were randomly divided in four groups with ten specimens. Each group received a type of treatment in the surface to be cemented, as follows:

Group PSP (Polished without primer): Polished with sandpaper 600 (Control group).

Group PCP (Polished with primer): Polished with sandpaper 600 and surface oxidation, with application of the conditioning agent for metals Alloy Primer (Kuraray - Japan).

Group JSP (Sandblasted without primer): Sandblasted with 100μm aluminum oxide to 75lb of pressure, at a distance of 5cm, in right angle for 1 minute and cleaned for 2 minutes with distilled water in ultrasonic device.

Group JCP (Sandblasted with primer): Sandblasted with 100μm aluminum oxide to 75lb of pressure, at a distance of

TABLE 1- Specifications of the alloy, primer and cement employed

Material	Manufacturer	Composition	Batch
Remanium ® CD /	Dentaurum	Co-Cr-Mo	918444
Alloy Primer	Kuraray Medical inc.Japan	(MDP) (VBATDT) Acetone	104AJ 10 / 2003
Rely X™ resin Cement	3M Dental Products USA.	(Bis-GMA) (TEGDMA) Zirconium / silica - 1,5μm	CGCG 02 / 2004

(MDP) 10 – methacryloyloxydecyl dihydrogen phosphate

(VBATDT) 6 – (4-vinylbenzyl-n-propyl) amino-1,3,5-triazine-2,4-dithione

5cm, in right angle for 1 minute and cleaned for 2 minutes with distilled water in ultrasound device, followed by Alloy Primer application.

All groups were cemented with the resinous cement Rely X™ / 3M, under a load of 5Kg for 10 minutes, allowing the removal of excess cements and the marginal light-curing for 40 seconds in four positions. After this, they were stored in distilled water at 37ºC, protected from light during 36 hours, and then submitted to the tests of shear bond strength (SBS).

The specimens were adapted to the shear device through the base of the disk of larger diameter at the testing machine, through a metallic string contouring the border of the smaller disk. The force was applied until bond failure between the disks. The shear bond strength tests were conducted in a universal testing machine (Emic-Mem 2000) at a constant speed of 0.5mm/min, with cell load of 500kgf. The values in Kgf/cm^2 were obtained through the equation: R = F/A. Were: R = (Kgf/cm^2); F = rupture force (kgf); A = bonding area ($0.785cm^2$).

Thereafter the surfaces of the disks were submitted to analysis in a stereoscopic magnifying glass to evaluate the type of failure and the final aspect of the metallic surface. Failure was classified as adhesive, if the failure occurred at the resin-metal interface; cohesive, when the resin cement was fractured; and mixed, a combination of adhesive and cohesive in resin cement.

RESULTS

The two-way analysis of variance (ANOVA) revealed a significant effect for the *Sandblasting* factor in any tested condition. The *Primer* factor presented a positive effect only on the polished surface, without significant effect on the Sandblasted specimens; there was no interaction between the two tested factors.

Comparison between the means of the groups with the Tukey test determined statistical equivalence between the groups JSP and JCP, both Sandblasted. They presented significant different between themselves and the polished groups (PSP and PCP). Besides, the polished groups presented statistical difference between themselves at a significant level ($p<0.05$) (Table 2).

Type of failure

In agreement with the findings observed through analysis in a stereoscopic magnifying glass with 8x magnification, all specimens tested in this study presented adhesive failure in the resin-metal interface.

DISCUSSION

The literature presents several studies on the surface treatment of metallic alloys; these papers show that the minimal alteration on the composition of the alloy, cement or primer agent will lead to different shear bond strength (SBS) values. Even for the same type of alloy, generalizations cannot be made regarding the surface treatment, since there are many variations in the proportion of their constituent elements [7].

The specimens of the PSP group (Polished without primer) presented the lowest SBS values, and among the ten specimens, only five could be tested, because the remaining failed during handling and inserting in the shear device. The polished surface presented a low union been this type of treatment not recommended by the literature since the appearance of adhesive bridges [3, 4].

In the PCP group (Polished with primer) there was an increase of more than twenty times in the average of the values when compared to the PSP group. This shows that the primer promoted an increase in the adhesion of the cement to the polished alloy through chemical means.

According to Matsumura, et al.[8] (1997) complicated surface treatments will probably be substituted by the use of primers derived from thiol, in combination to cements with polymerization initiated by tri-n-buthyl-borane. According to Antoniadou, et al.[1] (2000), utilization of the Alloy Primer is simple, fast and effective to increase the durability and the bond strength between resins and sandblasted metallic alloys; however, this bonding depends on the composition of the alloy. In 2001, Yoshida, et al.[10]

TABLE 2- Means results (m), standard deviation (sd) (expressed in kgf/cm^2 and in MPa) and comparison for the four groups, through the Tukey test

	Kgf/cm²		MPa		comparison		
Group	m	sd	m	sd			
PSP	4.0	0.4	0.4	0.04	a		
PCP	88.9	33.6	8.7	3.3		b	
JSP	163.2	27.6	16.0	2.7			c
JCP	144.5	54.0	14.2	5.3			c

Means followed by different letters in the column indicate statistical difference at the 95% confidence level ($p<0.05$).

stated that the combined use of resin cements and an appropriate adhesive primer spares the use of complicated surface treatments during cementation of adhesive bridge, which minimizes the formation of marginal gaps and increases the clinical durability of restorations. According to these authors, the Alloy Primer containing the monomers VBATDT and MDP is effective to increase the bond strength between resins and basic alloys. MDP has an ester phosphate group that presents great chemical bonding with the surface layer of oxide of chrome formed in the surface of the cobalt-chrome, which can be highly reliable to promote better union of the cements to these alloys[11].

Despite of this, the highest mean value of SBS was obtained for the sandblasted surface, regardless of the application of the metal primer. The JSP group (sandblasted with 100ìm aluminum oxide) and the JCP group (sandblasted with 100ìm aluminum oxide, with primer application) presented the highest SBS values, without significant difference between them. However, the JCP group presented a standard deviation that was two times larger than the JSP group.

According to Yoshida, et al.[11] (1997) sandblasting with aluminum oxide on the surface of cobalt-chrome alloys favors the bonding between the chrome oxide and resin cements. Moreover, sandblasting promotes formation of surface irregularities in the metallic alloy, achieving micro-mechanical bonding when the cement flows through these irregularities.

Utilization of a primer in this surface might have partially filled out these irregularities, what would explain the highest variation in the group where it was applied. It should be emphasized that there were no statistical significant differences between them; however, there was a considerable increase in the standard deviation found.

All specimens presented adhesive failure in the interface. This happened because of the fact that bonding between cement and metal did not overcome the cohesive resistance of the cement.

Researches should be accomplished with the purpose of verifying the action of chemical, mechanical, and chemical-mechanical retention on the marginal leakage, color alteration and displacement of the esthetic facet or cement agents, searching for a smaller reduction in the remaining dental structure to receive a fixed prosthesis. This smaller reduction would allow higher preservation of the dental structures, which are better than any restorative material existing.

CONCLUSION

Based on the results achieved and after statistical analysis and discussion, it could be concluded that the best outcomes of retention were found for the sandblasted groups (JSP, JCP), regardless of the primer application.

Alloy Primer application was effective in the formation of chemical bonding between the tested resin cement and the cobalt-chrome alloy; however, this bond strength did not overcome the force of the micro-mechanical union reached by sandblasting with 100µm aluminum oxide.

All specimens presented adhesive failure at the resin-metal interface.

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