Original Article

Effect of metal type and surface treatment on shear bond strength of resin cement (*in vitro* study)

Hiba Al-Helou, Eyad Swed[1]

Departments of Fixed Prosthodontics, Faculty of Dentistry, Syrian Private University, [1]Damascus University, Damascus, Syria

Abstract

Background: Resin-bonded fixed partial dentures appeared to prevent the excessive preparation of dental tissue. Investigation of surface treatments to improve the bond of resin cements to metals may contribute to the longevity of these restorations. Due to the potential lack of ideal preparation form, the type of alloy and its surface pretreatment may have clinically relevant correlations with the retentive strength of castings to minimally retentive preparations.

Aim: The aim of this search is to study the bonding resin cement strength to different types of the metal alloy due to the surface treatment.

Purpose: Evaluate the effects of two different surface treatments on shear bond strength (SBS) between a palladium-silver alloy (Pb-Ag) and commercially pure titanium (CP Ti) cast alloy with resin luting cements.

Materials and Methods: A total of 120 cylinders having 5 mm in diameter and 4 mm in height were divided into two different main groups of metal type: 60 cylinders cast from CP Ti Grade I (Tritan - Reintitan - Germany-Dentaurum) as a base metal and 60 cylinders cast from Pb-Ag (Status-Yamakin, Japan) as a noble metal. 30 cylinders from each type were embedded in acrylic resin, and the rest were left without embedded in acrylic resin. All of the cylinders were smoothed with silicon carbide papers and sandblasting with 50-µm aluminum oxide. Specimens of each metal type were divided into two subgroups, which received one of the following luting techniques: (1) Multilink (Ivoclar Vivadent), (2) Multilink (Ivoclar Vivadent) plus metal zirconia primer (MZP). Every two cylinders from the same metal type and surface treatment were bonded to each other. All specimens were stored in distilled water at 37°C for 24 h and then thermal cycled (500 cycles, 5–55°C). After thermal cycling, the specimens were stored in 37°C distilled water for an additional 24 h before being tested in shear strength. Data (MPa) were analyzed using T-s tests to study the significance of various - means among groups and perform a comparison between each two groups of them.

Results: The T-s tests indicated significant effect of combination of the sandblasting technique (aluminum oxide particles 50 µm) with the application of primer MZP before using resin cement ($P < 0.05$) independent of the metal type used. The metal type did not significantly affect SBS for any of the compared surface pretreatments.

Conclusion: Metal primer application significantly enhanced SBS to base and a noble metal. No significant differences in shear strength were found between alloys.

Key Words: Commercially pure titanium, metal zirconia primer, palladium-silver alloy, resin cement, sandblasting

Address for correspondence:
Dr. Hiba Al-Helou, Department of Fixed Prosthodontics, Faculty of Dentistry, Syrian Private University, Damascus, Syria. E-mail: dr.hiba4a@yahoo.com
Received: 18th January, 2015, **Accepted:** 18th July, 2015

Access this article online	
Quick Response Code:	Website: www.j-ips.org
	DOI: 10.4103/0972-4052.164882

How to cite this article: Al-Helou H, Swed E. Effect of metal type and surface treatment on shear bond strength of resin cement (*in vitro* study). J Indian Prosthodont Soc 0;0:0.

INTRODUCTION

Resin-bonded fixed partial dentures (FPDs) have appeared to prevent the excessive preparation of dental tissue with complete crown and reliable restorative alternative to conventional short-span fixed dental prostheses.[1] The type of alloy used to fabricate the metal substructure of the crown may affect its retention. Base metals have higher free-surface energy and are more reactive than noble and high noble alloys and forming a thicker oxide layer.[2] These oxides provide potential locations for chemical bonding and also serve to roughen the metal surface and provide some micromechanical retention but it is difficult to achieve a passive oxide layer on noble alloy surfaces, a variety of metal surface modification techniques have been developed to improve bond strength.[3]

Prior to cementation, a variety of surface treatments are available, all purported to enhance the bond strength of the restoration to the cement. The intaglio surface can be left with a sandblasting surface,[4] or a surface that has been treated with a variety of different chemical components that supposedly enhance the bonding capacity of cement to the metal substructure: Metal primer, tin plating, and silicoating.[5,6] Sandblasting is inexpensive and may improve adhesive and cement wetting because of the mechanical removal of surface debris.[7] The different components in metal primers aid in the retention of resin to the metal surface. The compound having a phosphoric acid monomer (10-methacryloyloxydecyl dihydrogen phosphate [10-MDP]) provides enhanced retention of resin to a base metal alloy.[8,9] Surface treatments such as tin plating and silicoating although frequently studied, are not commonly used in the clinical setting because they require additional equipment and are technique sensitive.[10,11]

Clinical performance of restorations and FPDs made of Ag-Pd alloys is overall excellent when they are seated with the currently available noble metal bonding systems.[12] Palladium-silver (Pb-Ag) system alloyed with other metals represents one of the possible material choices in prosthetics. Its corrosion properties are influenced by minority components added in order to obtain the properties required for stomatological purposes.[13]

The use of titanium and its alloys for cast restorations and FPD frameworks has increased substantially over the last years. This trend can be mainly attributed to the development of casting technology for titanium alloys, such as new casting machines and investment materials and the extensively reported advantages of titanium over other base metal alloys.[14,15] Also, excellent biocompatibility, high strength to weight ratio, low density, high corrosion resistance, and low cost compared to noble metals are attractive properties which have favored the application of titanium alloys in prosthetic restorations.[16,17]

The purpose of this study was to examine the effect of surface pretreatments on the shear bond strength (SBS) of base and noble metals to resin cement included of: Only sandblasting and sandblasting with followed by application of a metal primer solution.

MATERIALS AND METHODS

One hundred and twenty cylindrical specimens (5.0 mm in diameter and 4.0 mm thick) were divided into main groups: 60 cylinders cast from commercially pure titanium (CP Ti) Grade I (Tritan - Reintitan - Germany-Dentaurum) base metal alloy and 60 cylinders Pb-Ag (Status-Yamakin, Japan) noble metal alloy. 30 cylinders from each type of metal were embedded in a polyvinyl chloride ring, using polymethyl methacrylate acrylic resin and the rest left without embedded in acrylic resin. All specimen bonding surfaces were smoothed with silicon carbide paper and sandblasting with 50-μm aluminum oxide for 20 s at a pressure of 35 psi and a distance of 10.0 mm from the specimen surface. Each of main groups was divided into two subgroups and the bonding sites received one of the following luting techniques: (1) Multilink (Ivoclar Vivadent), (2) Multilink (Ivoclar Vivadent) plus metal zirconia primer. The primer, as a single liquid was applied, to the alloy surface with a brush for 15 s and then air dried for 5 s. Two cylinders of the same alloy and surface pretreatment were bonded to each other. During cementation, 0.5-kg weight for 10 min was placed on top of the resin cements to permit overflow of a slight excess of material and to unify the thickness of the cement.

The cements were protected against exposure to oxygen. 40 min after preparation, all specimens were stored in distilled water at 37°C for 24 h before thermal cycling between 5°C and 55°C for 1000 cycles with a 30-s dwell time. After thermal cycling, the specimens were stored in 37°C distilled water for an additional 24 h before being subjected to a shear load using a testing machine (Inston 1195, England) and a crosshead speed of 0.5 mm/min. A chisel apparatus was used to direct a parallel shearing force as closely as possible to the luting agent-metal interface and that shown in Figure 1.

Figure 1: How to apply the shear bond strength

SBS values were recorded in MPa, the mean and standard deviation was calculated, shown in Figure 2 and Table 1.

Data (MPa) were analyzed using T-s tests at a significance level of 0.05 to study the significant of various in means among groups and perform comparison between each two groups of them.

RESULTS

Effect of metal type on shear bond strength

The T-s test ($P > 0.05$) showed that, there were no statistically significant differences among groups (CP Ti and Pd-Ag) that have same of surface pretreatment [Table 2].

Effect of surface treatment on shear bond strength

The T-s test showed that there were significant differences between the groups ($P < 0.05$). The sandblasting plus metal primer group showed significantly higher SBS in comparison to sandblasting group [Table 3].

DISCUSSION

Two important interfaces affect the ultimate bonding potential for an indirect restoration to a prepared tooth between the tooth and the adhesive resin, and that between the resin and the intaglio surface. Much information is available with respect to treatment of the tooth for obtaining optimal retention. The many generations of dentin bonding agents have provided ever increasing successes in this regard.[18] However, clinicians may choose among several alloy types for the metal substructure, various surface treatments to be applied to the intaglio surface of the restoration, and must also select the most appropriate cementing agent, in the event of which the metal-to-cement bond developed becomes even more important, to maximize restoration longevity.[19]

Metal primer application significantly increased hear bond strength to base and noble metal, it was due to the components of the metal primer solution used (adhesive compounds and MDP (10-methacryloyloxydecyl dihydrogen phosphate) which effectively improved the bond strength of resin cement to base and noble alloys, the primer contain phosphoric acid can react with the metal oxides, creating the necessary metal-phosphate bonds to promote bonding. This might be a possible explanation for their high bond strength, these results are similar to those reported by other investigators who evaluated the effect of metal type and surface treatment on bonding to resin cement, there is a studying found significant differences between metal alloy types for any of the surface treatments evaluated.[20] However, other studies reported higher bond strength for metal alloys as the nobility of the alloy decreased.[21] The addition of three additives, Sn, Ga, and In, in palladium- silver (Pb-Ag) noble metal alloy increased the initial bond strength of adhesive cement to these alloys. The positive effects of the three additives could be due to the formation of a suitable oxide layer for strong bonding.[22] The primer contain phosphoric acid which can react with the metal oxides, creating the necessary metal-phosphate bonds to promote bonding. This might be a possible explanation for their high bond strength.[23] The authors suggested that airborne-particle abrasion with 50-µm Al_2O_3 particles resulted in improved microtopography and possibly better wettability and penetration of the primers into the microirregularities of the surface.[24] And adhesion of resin to a substrate depends on both micromechanical interlocking and physicochemical bonding.[25] The former can be obtained by sandblasting with aluminum oxide, whereas the latter is achieved by functional monomers contained in resin-based materials or metal primers.[26]

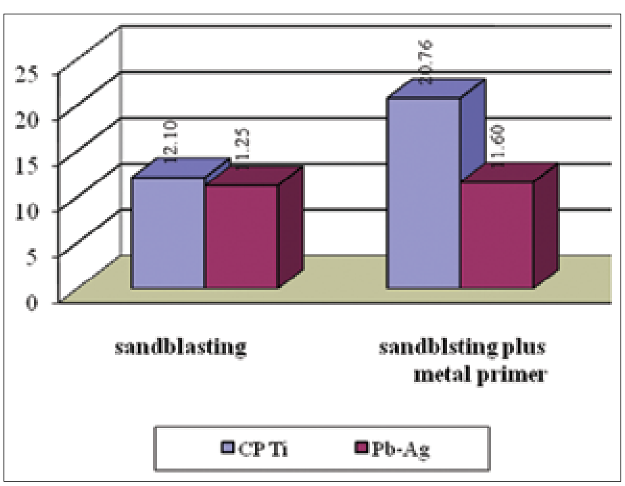

Figure 2: Mean shear bond strength values (MPa) for all groups

Table 1: Mean and SD of SBS values (MPa) for all groups

Metal type	Surface pretreatment	*n*	Mean	SD
Base metal	Sandblasting	15	12.10	2.90
CP Ti	Sandblasting plus metal primer	15	20.76	5.41
Noble metal	Sandblasting	15	11.25	3.55
Pb-Ag	Sandblasting plus metal primer	15	18.50	2.43

CP Ti: Commercially pure titanium, Pb-Ag: Palladium-silver alloy, SBS: Shear bond strength, SD: Standard deviation

Table 2: Comparison of different metal type on SBS

Surface pretreatment	Degrees of freedom	*t*	*P*
Sandblasting	28	0.718	0.479
Sandblasting plus metal primer	28	1.479	0.150

SBS: Shear bond strength

Table 3: Comparison of different surface treatment on SBS

Metal type	Degrees of freedom	*t*	*P*
Base metal	28	5.467	0.000
CP Ti			
Noble metal	28	6.519	0.000
Pb-Ag			

CP Ti: Commercially pure titanium, Pb-Ag: Palladium-silver alloy, SBS: Shear bond strength

Some authors found that Shear bond strengths (SBS) to high noble alloys were not increased by primers.[27,28] Variations in the results reported by other authors might be caused by metal alloys and methodological differences among the studies, including the surface treatment specimen and the specific resin cement used.

CONCLUSION

Within the limitations of the present study, the following conclusions were drawn:

1. Metal primer application significantly enhanced SBS to base and noble metal alloys, compared to sandblasting pretreatments
2. When base and noble alloys were compared for each surface pretreatment, there were no significant differences in SBS between the alloys for any of the metal pretreatments evaluated.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Dündar M, Ozcan M, Cömlekoglu ME, Güngör MA. A preliminary report on short-term clinical outcomes of three-unit resin-bonded fixed prostheses using two adhesive cements and surface conditioning combinations. Int J Prosthodont 2010;23:353-60.
2. Naylor WP. Introduction to Metal Ceramic Technology. 2nd ed., Vol. 3. Chicago: Quintessence Publishing Co., Inc.; 2009. p. 33-59.
3. John FM, Angus WG. Applied Dental Materials. 9th ed., Vol. 23. London: Blackwell Publishing Ltd.; 2008. p. 238-40.
4. Denizoglu S, Hanyaloglu CS, Aksakal B. Tensile bond strength of composite luting cements to metal alloys after various surface treatments. Indian J Dent Res 2009;20:174-9.
5. Parsa RZ, Goldstein GR, Barrack GM, LeGeros RZ. An *in vitro* comparison of tensile bond strengths of noble and base metal alloys to enamel. J Prosthet Dent 2003;90:175-83.
6. Antoniadou M, Kern M, Strub JR. Effect of a new metal primer on the bond strength between a resin cement and two high-noble alloys. J Prosthet Dent 2000;84:554-60.
7. Gurbuz A, Inan O, Kaplan R, Ozturk AN. Effect of airborne-particle abrasion on retentive strength in overtapered fixed prosthodontic restorations. Quintessence Int 2008;39:e134-8.
8. Watanabe I, Hotta M, Watanabe E, Atsuta M, Okabe T. Shear bond strengths of laboratory-cured prosthetic composite to primed metal surfaces. Am J Dent 2003;16:401-3.
9. Taira Y, Yanagida H, Matsumura H, Atsuta M. Effects of a metal etchant and two primers on resin bonding durability to titanium. Eur J Oral Sci 2004;112:95-100.
10. Imbery TA, Burgess JO, Naylor WP. Tensile strength of three resin cements following two alloy surface treatments. Int J Prosthodont 1992;5:59-67.
11. Petrie CS, Eick JD, Williams K, Spencer P. A comparison of 3 alloy surface treatments for resin-bonded prostheses. J Prosthodont 2001;10:217-23.
12. Matsumura H, Shimizu H, Tanoue N, Koizumi H. Current bonding systems for resin-bonded restorations and fixed partial dentures made of silver-palladium-copper-gold alloy. Jpn Dent Sci Rev 2010;34:56-61.
13. Joska L, Poddana M, Leitner J. Corrosion behavior of palladium-silver-copper alloys in model saliva. Dent Mater 2008;24:1009-16.
14. Yanagida H, Taira Y, Shimoe S, Atsuta M, Yoneyama T, Matsumura H. Adhesive bonding of titanium-aluminum-niobium alloy with nine surface preparations and three self-curing resins. Eur J Oral Sci 2003;111:170-4.
15. Eichmiller FC, Gaithersburg MD. Titanium applications in dentistry. J Am Dent Assoc 2003;134:347-9.
16. Lijimaa D, Yoneyama T, Doib H, Hamanakab H, Kurosaki N. Wear properties of Ti and Ti-6Al-4V castings for dental prostheses. J Biomater 2003;24:519-24.
17. Ohkubo C, Hanatani S, Hosoi T. Present status of titanium removable dentures – A review of the literature. J Oral Rehabil 2008;35:706-14.
18. Aggstaller H, Beuer F, Edelhoff D, Rammelsberg P, Gernet W. Long-term clinical performance of resin-bonded fixed partial dentures with retentive preparation geometry in anterior and posterior areas. J Adhes Dent 2008;10:301-6.
19. Browning WD, Nelson SK, Cibirka R, Myers ML. Comparison of luting cements for minimally retentive crown preparations. Quintessence Int 2002;33:95-100.
20. Osman SA, McCabe JF, Walls AW. Bonding of adhesive resin luting agents to metal and amalgam. Eur J Prosthodont Restor Dent 2008;16:171-6.
21. Sarafianou A, Seimenis I, Papadopoulos T. Effectiveness of different adhesive primers on the bond strength between an indirect composite resin and a base metal alloy. J Prosthet Dent 2008;99:377-87.
22. Kern M, Thompson VP. Sandblasting and silica-coating of dental alloys: Volume loss, morphology and changes in the surface composition. Dent Mater 1993;9:151-61.
23. Abreu A, Loza MA, Elias A, Mukhopadhyay S, Looney S, Rueggeberg FA. Tensile bond strength of an adhesive resin cement to different alloys having various surface treatments. J Prosthet Dent 2009;101:107-18.
24. Di Francescantonio M, de Oliveira MT, Garcia RN, Romanini JC, da Silva NR, Giannini M. Bond strength of resin cements to Co-Cr and Ni-Cr metal alloys using adhesive primers. J Prosthodont 2010;19:125-9.
25. Sen D, Nayir E, Pamuk S. Comparison of the tensile bond strength of high-noble, noble, and base metal alloys bonded to enamel. J Prosthet Dent 2000;84:561-6.
26. Goto S, Churnjitapirom P, Miyagawa Y, Ogura H. Effect of additive metals, Sn, Ga, and In in Ag-Pd-Au-Cu alloys on initial bond strength of 4-META adhesive cement to these alloys. Dent Mater J 2008;27:678-86.
27. Minami H, Murahara S, Suzuki S, Tanaka T. Effects of metal primers on the bonding of an adhesive resin cement to noble metal ceramic alloys after thermal cycling. J Prosthet Dent 2011;106:378-85.
28. Fonseca RG, Rached FB, Cruz CA. Effect of different airborne-particle abrasion/bonding agent combinations on the bond strength of a resin cement to a base metal alloy. J Prosthet Dent 2012;108:316-23.