Original Article

Comparison of the effectiveness of Tokuyama and GC II metal primer on the bond strength of acrylic resins to Ti-6Al-7Nb

ABSTRACT

Statement of Problem: Because of the toxicity of vanadium in Ti-6Al-4V alloy, next generation of titanium alloys is proposed to focus on niobium-containing alloy, but for clinical applications, it is crucial for this alloy to bond with acrylic resins with or without the use of primers. However, literature was lacking about the effect of primers on bonding of autopolymerizing resins to Ti-6Al-7Nb.

Objectives: To evaluate the effect of different metal primers on the shear bond strength of acrylic resin to Ti-6Al-7Nb.

Materials and Methods: A total of 30 dis-shaped wax patterns (10 mm in diameter and 2 mm thickness) were prepared and casted using Ti-6Al-7Nb. After casting, the disk surfaces were finished with abrasive paper under water. Specimens were equally divided into three groups on the basis of the use of primer: metal primer (GC II metal primer) (Group 1), Universal Tokuyama primer (Group 2), no primer (Group 3). Tape of 50 μm thickness was applied on each of the specimens. Then, self-cure acrylic resin was mixed and applied on the center part of the tape, on which Bernouilles tube was placed. The tensile bond strength was measured with a universal testing machine. The data were obtained for all the specimens and analyzed using Statistical Package for Social Sciences version 17.0 at a statistically significance level of <0.05.

Results: Mean tensile force was maximum for Group 2 (28.58 ± 39.40 N) and minimum for control Group 3 (6.24 ± 10.97 N), thereby showing a significant inter-group difference ($P < 0.001$). On applying *post hoc* test (Tukey HSD), both the Group 1 and Group 2 showed a statistically significant difference as compared to control Group 3; however, the difference between two experimental groups was not statistically significant ($P > 0.05$).

Conclusions: Tokuyama primer and GC II metal primer had a significant effect on improving the bond strength between autopolymerizing denture base resin and Ti-6Al-7Nb.

Keywords: Autopolymerizing resin, bond strength, *in vitro*, primer, titanium alloy

INTRODUCTION

In removable prosthodontics, sufficient bonding is desirable between the cast metal-based partial or complete denture framework and the denture base resin. Poor chemical bonding of the metal-resin interface may result in significant clinical problems, often introducing adhesive failure and increasing microleakage of oral fluids in the finish lines, which causes an accumulation of oral debris, microorganisms, and stains.[1-3] Another significant clinical and esthetic problem associated with removable prostheses is the discoloration or staining caused by microleakage. Therefore, optimizing bond strength at the resin-metal interface of a removable partial denture (RPD) is essential for the success of the prosthesis.[4-6] The differences in the coefficient of thermal expansion between acrylic resins and alloys, and the polymerization shrinkage of acrylic resin,

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may result in separation of these materials.[7] Resin-to-metal and resin-to-denture tooth bonds are stressed by laboratory procedures during the fabrication of RPDs.[8] The use of titanium and titanium alloys for cast restorations, denture frameworks, and milled prostheses has increased substantially,[9] and several systems have been introduced increasing the bond strength between acrylic resin and RPD casting alloys.[10]

One important improvement in resin bonding techniques has been the introduction of chemical metal-resin bonding systems.[11-14] Recently, Ohkubo *et al*.[11] studied the effect of the application of metal conditioners to cast commercially pure (CP) titanium, titanium alloy (Ti-6Al-4V), and Co–Cr alloy. Semlitsch *et al*.[15] developed a titanium-aluminum alloy with the inert alloying element niobium and found the optimal composition should be Ti-6Al-7Nb. This alloy had outstanding biocompatibility,[16] good mechanical properties and corrosion resistance,[17] reliable casting properties,[12] and improved wear resistance.[13,14] Yanagida *et al*.[18] evaluated the effect of metal conditioners and a surface modification system on the bond durability between a light-activated prosthetic composite material and Ti-6Al-7Nb. In their study, the use of the primers was found to enhance bonding. Furthermore, Yanagida *et al*.[19] evaluated the adhesive performance of metal conditioners used for bonding between autopolymerizing methacrylate resins and a titanium alloy, and reported that the use of one of the three conditioners (Alloy Primer, Cesead II Opaque Primer, and Metal Prime II) in combination with autopolymerizing luting resin consisting of methyl methacrylate and tri-n-butylborane with 4-methacryloyloxyethyl trimellitate anhydride (Super-Bond C and B) is recommended for bonding to the Ti-6Al-7Nb alloy. Several adhesive primers, including Meta Fast (Sun Medical Co. Ltd., Shiga, Japan), containing 4-META monomer, and metal primer (Ivoclar Vivadent AG, Schaan, Liechtenstein), containing 10-methacryloyloxydecyl dihydrogen phosphate, have been developed and are commercially available for resin-bonded prostheses, composite-veneered prostheses, and RPDs.[11] Numerous studies have evaluated the effect of such primers on bonding acrylic resin to Ti-6Al-4V and CP-Ti. However, there is insufficient information about the effect of such primers on bonding of autopolymerizing polymethyl methacrylate (PMMA) resins to Ti-6Al-7Nb.

Hence, the purpose of this study was to compare the effectiveness of Tokuyama primer and GC II primer on tensile bond strength of autopolymerizing PMMA resins to Ti-6Al-7Nb.

MATERIALS AND METHODS

A total of 30 disk-shaped wax patterns (10 mm in diameter and 2 mm thickness) were prepared and casted using a titanium alloy (Ti-6Al-7Nb), according to the manufacturer's instructions. After casting, the disk surfaces were finished with 600-grit SiC abrasive paper (CarbiMet; Buehler Ltd., Lake Bluff, Ill) under water. To each titanium disc, nuts were fixed with araldite (fixing material), and they were sandblasted with 50 μm particle sized sand at 2.5 bar pressure. After sandblasting, all specimens were steam-cleaned and kept in temperature bath for at 37°C for 24 h. The discs were then removed from temperature bath and tape of 50 μm thickness (bearing central hole) was applied on all the specimens. The specimens were now ready for testing [Figure 1], and equally divided into three groups with ten titanium plates in each group: Group 1 with GC II metal primer, Group 2 with Universal Tokuyama primer, Group 3 with no primer which acts as control group.

The metal primer (GC Corporation Ltd., Tokyo, Japan) was applied with the applicator tip on all the 10 specimens of Group 1. Then, self-cure acrylic resin (UNIFAST III; GC Corp., Tokyo, Japan) was mixed in ratio 1 g powder/0.5 ml liquid and applied on the center part of the tape, on which Bernouilles tube was placed. It was cured at room temperature (23 ± 1°C; humidity 50–60%) and after keeping undisturbed for about 10–15 min, all the specimens with the attached tubes as shown in Figure 2, was placed in hot air oven at 37°C for 24 h. The universal primer (Tokuyama Dental Corp., Japan) was applied over all the specimens of Group 2 and similar procedure was performed as described for Group 1. Same procedure was performed for Group 3 specimens, but without applying any primer over the disc surface.

The tensile bond strength was measured with a universal testing machine (TSTM 02500; Elista, Istanbul, Turkey), using a crosshead speed of 0.5 mm/min [Figure 3]. The data were obtained for all the specimens, and it was analyzed using Statistical Package for Social Sciences version 17.0 (SPSS Inc., Chicago, IL). Intergroup comparison was done using analysis of variance followed by Tukey HSD test as the *post hoc* assessment tool. The confidence level of the study was kept at 95%, hence a $P < 0.05$ indicated a statistically significant difference.

RESULTS

Graph 1 summarizes the means and standard deviations of the tensile force of the three groups. The results indicate that the mean tensile force was maximum for Universal Tokuyama primer (28.58 ± 39.40 N) and minimum for control group (6.24 ± 10.97 N), thereby showing a significant intergroup difference ($F = 41.966$; $P < 0.001$). On applying *post hoc* test (Tukey HSD), GC II metal primer and Universal

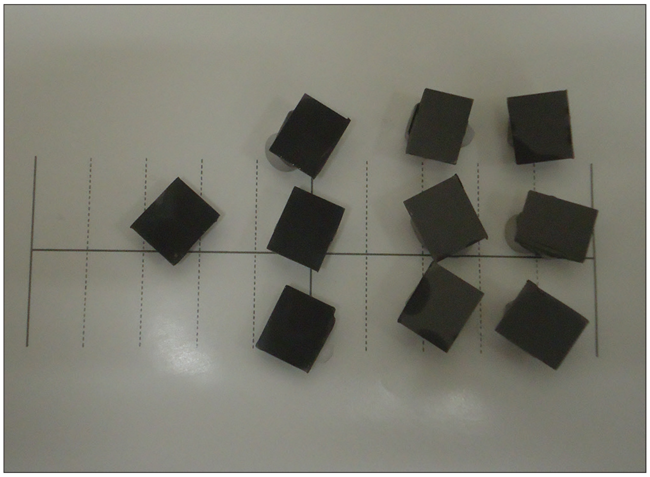


Figure 1: Titanium specimens used in the study

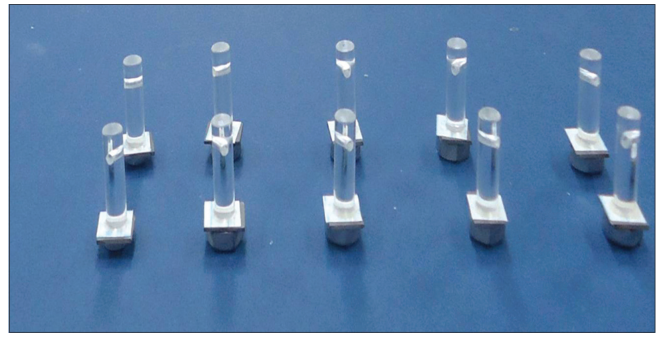


Figure 2: Specimens with the attached bernouilles tubes ready for testing

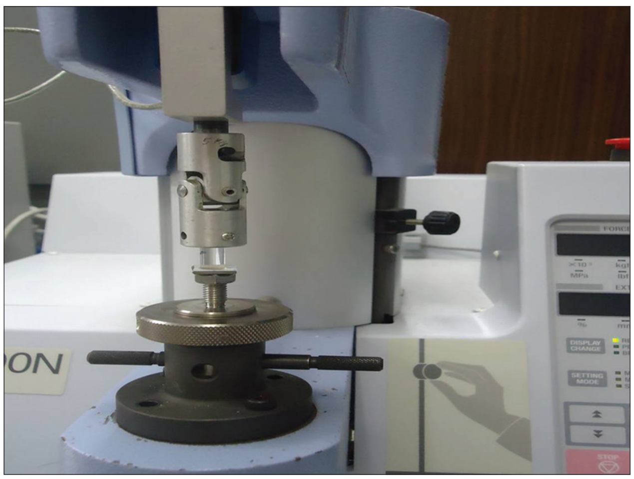
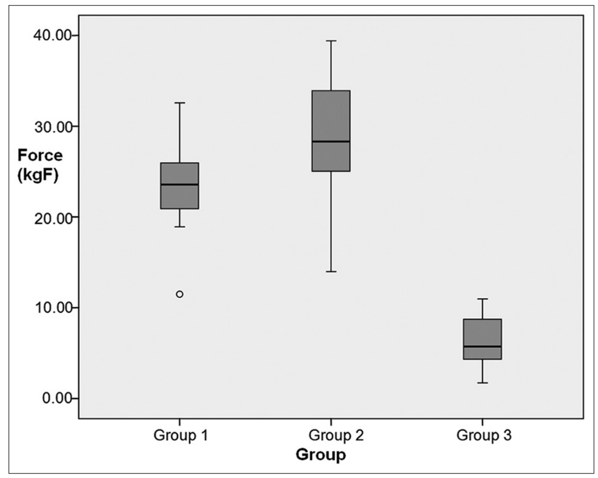


Figure 3: Universal testing machine used in the study



Graph 1: Graphical view of tensile force in different groups. Group 1 - GC primer II; Group 2 - Tokuyama primer; Group 3 - No primer (control)

Tokuyama primer showed a statistically significant difference as compared to control group. However, the difference between two GC II metal primer and Universal Tokuyama primer was not significant statistically ($P > 0.05$).

DISCUSSION

The current study evaluated the effect of GC Primer II and Tokuyama Primer on tensile bond strengths between an autopolymerizing PMMA resin to Ti-6Al-7Nb.

As there are serious concerns on the toxicity of vanadium in Ti-6Al-4V alloy, so the next generation of titanium alloys is proposed to focus on niobium-containing alloy.[20] However, the superior biological[20] and mechanical[21] properties of Ti-6Al-7Nb do not warrant their extensive application in dentistry unless this alloy can be used as an alternative to Ti-6Al-4V or CP-Ti. For practical applications of Ti-6Al-7Nb in prosthodontics, it is crucial for this alloy to bond with acrylic resins with or without the use of primers.

In our study, airborne-particle abrasion was employed to create surface roughness by cleaning the surface of metal oxides and other substances, to increase the mechanical and chemical bond strength between metal and acrylic resin.[9] As the choice of a chemical bonding system for prosthodontic applications depends on factors such as expense, availability, time requirements, and the shelf life of the perishable components.[22] However, a control group (Group 3) was also formed in the present study to check whether the need of primer to bond titanium alloy to acrylic resin could be eliminated. However, it was found that bond strength in this group was approximately four times less than the primer treated groups (Group 1 and 2) as shown in Graph 1.

Numerous studies have established that application of primers significantly improve the bond strength of the acrylic resin to the cast metals, Ti-6Al-4 V, CP-Ti, composites, and ceramics.[8-10,23-32] However, the comparative evaluations of bond strength between acrylic resin and Ti-6Al-7Nb with the use of Tokuyama primer and GC II metal primer have never been documented. In the present study, the tensile bond strength of Ti-6Al-7Nb to acrylic resins was significantly ($P < 0.001$) improved by primer application compared to control group [Graph 1]. The mean tensile force was maximum for Group 2 (28.58 ± 39.40 N) and minimum for control Group 3 (6.24 ± 10.97 N), thereby showing a statistically significant intergroup difference ($F = 41.966$; $P < 0.001$) Therefore, both Tokuyama primer and GC II metal primer had a statistically significant effect on improving the bond between the autopolymerizing denture base resin and Ti-6Al-7Nb, which can make this alloy feasible for use in removable prosthodontics.

However, as tensile bond strength is not the only factor that may influence the durability of resin-metal bonds, so careful interpretation in the clinical application of these results is suggested, as the design of the present study, did not consider factors existing in the oral environment, such as dynamic fatigue loading and pH changes. The efficacy of the tested systems in providing reliable bond strength needs to be confirmed by long-term clinical studies.

CONCLUSIONS

Within the limitation of this *in vitro* study, it can be concluded that both Tokuyama primer and GC II metal primer had a statistically significant effect on improving the bond strength between autopolymerizing denture base resin and Ti-6Al-7Nb, which can make this alloy feasible for the use in removable prosthodontics as a safe alternative to Ti-6Al-4V.

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Conflicts of interest

There are no conflicts of interest.

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