An In Vitro Comparative Evaluation of Shear Bond Strength of Surface Treated Cobalt-Chromium Alloy, with Heat Cure Acrylic Denture Base Resin

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Abstract

This study was designed to compare and assess the shear bond strength of heat cure acrylic denture base resins with cobalt-chromium alloy, without any surface treatment to alloy and after different surface treatments such as metal primer, sandblasting, and their combination.

40 disk specimens (10mm* 2mm)were cast from cobalt chromium alloy. The group of disks were air abraded with alumina particles (110 µm) under air pressure. Modeling wax was attached on co-cr discs and flasking for heat cure resin samples were carried out after application of alloy primer on the metal-resin interface in specified groups before packing. The samples thus fabricated were subjected to shear forces under the universal testing machine until the separation took place.

All the values of bond strength (mpa) were then evaluated and analyzed for the significance level through application of various statistical tests of significance like anova and post hoc tukey's test, using spss software, version 17

The result of the study showed that the shear bond strength of the heat cure resin group treated with both sandblasting and metal primer (group hd) was highest among all with the shear bond strength value of 18.70 ± 1.2 mpa

Introduction

Heat-cure acrylic resin is the most commonly used denture base material and in the removable partial denture. Denture base resin also provides a medium to attach artificial teeth with the metal framework. The bond at the metal framework and acrylic resin interface is relatively weak. There are no adhesive forces acting between them at ionic, atomic or molecular level. Hence, denture base resins are attached to the metal framework by mechanical retention in the form of loops, mesh, beads, nail heads, undercut finish lines and struts.[1,2]

Despite the incorporation of these mechanical aids, over the period of time, functional forces often resulted in separation of the acrylic resin from the metal framework at its junction. This separation is a result of poor bond strength between metal and resin. Additionally, polymerization shrinkage takes place which may leave space between metal and resin. Differences in coefficient of thermal expansion between the metal and resin contributed to increase in microleakage, resulting in discolouration and deterioration of denture base material and also introduced potentially pathogenic microorganisms, resulting in patient's discomfort[8].long term success of the prosthesis is dependent on the bond strength of the heat cure with the metal framework. So newer methods to improve their bonding and to reduce the microleakage at the interface were studied. Sandblasting of metal framework creates the surface roughness and thereby increases the micromechanical retention[3]. The bonding of resin to dental alloys has improved significantly over the last decade . The availability of adhesive primer for base metal that is capable of chemical bonding has simplified the surface preparation of these alloys.currently, a variety of metal primers containing different functional groups like mac10 MDP, VBATDT AND MEPS are available. [4]

Hence, this study is done to evaluate and compare the effect of metal primer and sandblasting on the shear bond strength between the heat-cure denture base resin and cobalt chromium alloy.

Materials & Methodology

An in vitro study was undertaken at the Department Of Prosthodontics, Bharati Vidyapeeth Deemed University, Dental College And Hospital, Pune, Maharashtra; to evaluate and compare the effect of metal primer and sandblasting on the shear bond strength between heat cure acrylic denture base resin on cobalt chromium alloy.

A total of 40 samples of denture base resin were divided into 4 groups, based on different surface treatments to co-cr discs. Then all the samples were tested for shear bond strength between resin and Co-Cr metal discs.

Materials		Brand name	Chemical composition		Manufacturer
Metal		Co-cr alloy Adentatec	Co 50-70%,cr 10-30%, Si 0-2%		Gmbh, germany
Acrylic resin		Heat cure & Self cure	Polymethylmethacrylate resin(pmma)		Dpi, india
Metal primer		Alloy primer	Acetone ,vbatdt, mdp		Kuraray medical inc. Japan

Phase I : Preparation Of Co-Cr Alloy Discs

Figure 1 : metal mould

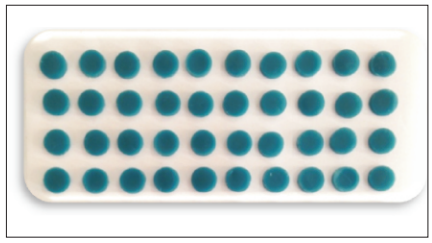
By using a specially fabricated stainless steel mould (figure 1) having an internal diameter of 10mm and height of 2mm, 40 wax patterns (Figure 2) were prepared by flowing molten inlay casting wax (m p sai, mumbai) into the mould space. Investment material (wirovest, bego, germany) was vacuum mixed in appropriate proportion in whipmixer (whipmix) according to manufacturer's instruction and the patterns were invested.

550c/min increase in temperature until it reached 150 c with a 90 minutes dwell (holding time). 2) 50c/min until it reached 2500c with a 90 minutes dwell. 3) 50c/minute until it reached 9500c with a 60 minutes dwell time. After reaching maximum temperature of 9500c the casting ring was casted immediately in the casting machine. The castings were sandblasted with 110 µm aluminum oxide powder (Al2o3). All the finished samples were put in ultrasonic cleaner. Thus 40 discs of co-cr alloy (figure 3) of dimension 10mm diameter and 2mm thickness were prepared.

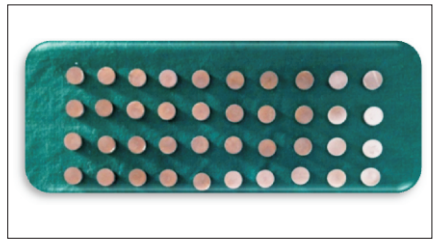
Phase II : attachment of modeling wax on co-cr discs and flasking for heat cure resin samples

Another metal mould was fabricated in such a way that it accommodated the co-cr disc (10mm diameter 2mm thickness) and above the disc the another metal mould narrowed in the diameter upto 5mm and extended 2mm above the disc. This created a space of 5mm diameter and 2mm thickness in the centre of the disc where the modeling wax was applied.

These samples were flasked by following standard procedure for flasking in a conventional denture flask base with dental plaster (kalabhai, india), five samples were flasked at a time. Then, the samples were dewaxed and were cleaned by using a steam cleaner.



40 wax patterns (Figure 2)



40 discs of co-cr alloy (figure 3)

Phase III: Surface Treatment Of Cobalt Chromium Alloy Discs

Prior to the application of heat cure acrylic resin, those four groups of alloy-resin samples = a, b, c, d were randomly formed according to the surface treatment they underwent:

Group a:10 samples consisting cobalt-chromium disc attached with heat cure denture base resin without any surface treatment

Group b:10 samples consisting cobalt-chromium disc attached with heat cure denture base resin after sandblasting procedure

Group c :10 samples consisting cobalt-chromium disc attached with heat cure denture base resin after metal primer surface pretreatment

Group d :10 samples consisting cobalt-chromium disc attached with heat cure denture base resin after combination of metal primer and sandblasting surface pretreatment.

Sandblasting

Standardized sandblasting procedure was followed for the groups which were treated with sandblasting (group b and group d of heat cure acrylic denture base resin). The samples from these groups were subjected to airborne particle abrasion with aluminum oxide (110µm hi alumina) application of Alloy Primer.

For the groups which were treated with the metal primer (group c and group d of heat cure) following procedure was followed as per manufacturer's instructions. The alloy surface of these groups were coated with a thin layer of Metal Primer (Alloy Primer Kuraray Medical Inc. Japan) (Figure 4) with the help of brush and allowed to dry. Group d which received both sandblasting and the surface treatment with the primer were first sandblasted and then metal primer was applied.

Bonded samples were retrieved carefully. The finished samples were then stored in distilled water at 370c for 24 hours.

Phase V : Preparation Of Samples For Testing

The samples were then embedded in the auto polymerizing acrylic resin blocks (DPI RR COLD CURE) to prepare them for testing.

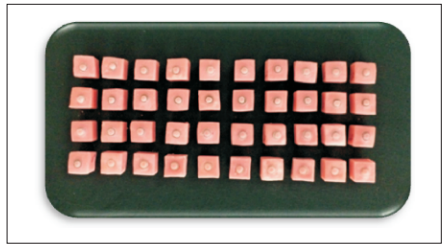
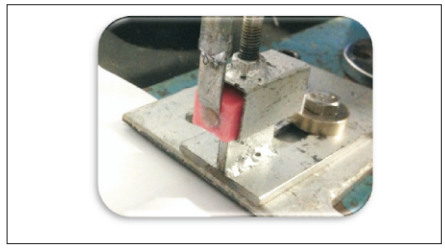


Fig 5. Bonded Samples



Bonded Samples Into Universal Testing Machine (Fig. 6)

Results

In group a each (n=10) no surface treatment was done for the alloy and this group was a control group.

Group b each (n=10) was treated with sandblasting.

Group c each (n=10) was treated with alloy primer only .

Group d each (n=10) was treated with both sandblasting and alloy primer.

S.no.	Group a	Group b	Group c	Group d
1.	2.60	9.95	13.84	17.04
2.	2.13	10.63	13.25	18.52
3.	2.32	9.78	14.75	19.54
4.	2.58	10.29	13.56	17.15
5.	3.18	9.48	15.51	18.67
6.	2.51	9.15	14.34	20.57
7.	2.82	10.15	14.68	18.35
8.	2.77	9.07	13.47	18.22
9.	2.89	8.98	15.69	19.91
10.	2.19	9.11	15.88	19.03

Table 1:shear bond strength of resin samples (in mpa)

The samples thus fabricated were subjected to shear forces under the universal testing machine (fig. 6) until the separation took place.

All the values of bond strength (mpa) were then evaluated and analyzed for the significance level through application of various statistical tests of significance like anova and post hoc tukey's test, using spss

software, version 17.

	Sum of squares	Df	Mean square	F	Sig.
Between groups	1433.648	3	477.883	723.487	.000
Within groups	23.779	36	.661		
Total	1457.427	39			

Table 2 : anova test for bonded samples

The result of the study showed that the shear bond strength of the heat cure resin group treated with both sandblasting and metal primer (group d) was highest among all with the shear bond strength value of 18.70 ± 1.2 mpa and the bond strength of control group (group a) was lowest among all with bond strength value of 2.59± 0.32 mpa.

Since there was a statistically significant difference ($p<0.05$) between the bond strength of group b (sandblasting only), group c (primer only) and group d (sandblasting and metal primer) as compared to the control group a (no surface treatment) having bond strength of 2.59± 0.32 mpa, this shows that surface treatment of metal alloy definitely improves the bonding of the metal with resin.

The bond strength of the group treated with only sandblasting (group b) was less (9.65 mpa) than group treated with primer only (group c) having bond strength of 14.49 mpa and also there was a significant statistical difference ($p<0.05$) between the groups; this shows that the metal primer provides better bonding of metal with the resin as compared to the sandblasting.

The bond strength of group treated with primer only (group c) had lower bond strength (14.49 mpa) than the group treated with both sandblasting and the primer (group d) having bond strength of 18.70 mpa. Also there was a significant statistical difference ($p<0.05$) between the groups, this shows that the surface treatment with both sandblasting and primer provides better bonding of metal with resin as compared to the use of metal primer alone.

Discussion

Cast partial denture (cpd) is widely used as a treatment modality therefore there is a constant need to improve the overall quality of the prosthesis so as to serve for a longer period of time. Majority of predictable methods for the retention of denture base resin are beads, posts, an open lattice, a mesh[18] or some other macroscopic retentive design. If there is a separation between the acrylic resin and the metal framework, especially at the finishing line, cracks or crazing may occur in the acrylic resin, leading to microleakage that is accompanied by staining. Furthermore, microleakage from the metal- PMMA interface can lead to discoloration, deterioration of the resin, and the creation of a reservoir for oral debris and micro-organisms.[5]

Chemical surface treatment with adhesive primer of metal alloys has shown to improve the bonding properties . In this study the effect of sandblasting (110µm alumina particles) and use of metal primer (alloy primer, kuraray co.) On the bond strength of heat cure acrylic denture base resin (dpi) with co-cr alloy (adentatec, gmbh, germany) has been evaluated so, that the appropriate surface treatment can be suggested while using this combination of material in the fabrication of the prosthesis.

The type of alloy used in this study was co-cr alloy (adentatec, gmbh, germany). It was chosen for fabrication of alloy samples because it is the most commonly used alloy and shows good material properties like better strength, ease of castability, good thermal conductivity and good corrosion resistance. Among the various denture base resins used, polymethyl-methacrylate (pmma) resins have been used more commonly so in this study pmma based denture base resin (dpi, india) was used. Also acrylic resin[6], with its high load and displacement at yield, make it the material of choice for veneering the more flexible saddle areas of partial dentures.

The sandblasting alone was done for group b. Many studies have been done to investigate the effect of sandblasting on the bond strength of resin with the metal alloys and it has shown to have a positive effect. Takaya ishii et al. reported that the alumina air abrasion enhances the bond strength of resin with the metal and the roughness produced is depend on the composition of alloy and also reported that there is remarkable improvement in the shear bond strength between the resin-alloy after sandblasting.

The metal primer used in this study was alloy primer (Kuraray Japan Co.) Which is a VBATDT MDP based metal primer.

In this study the primer used was alloy primer which had principle ingredients: acetone, mdp [10,-methacrylic-decyl dihydrogen phosphate] and vbatdt [6-(4-vinylbenzine-n-prophyl-1,3,5-trizine-4-dithone)] a thione-thiol tautomer.

The coupling mechanism of this primer is by (i) mdp has a phosphate ester group that presents great chemical bonding with the surface layer of oxide of chrome formed at the surface of co-cr alloy subsequently primary bond formation and (ii) copolymerization of vinyl groups with the methacrylate-based resin monomer.[23,24]

Mean bond strength value of group a (with no surface treatment) was 2.59 ± 0.32 mpa which was lowest among the groups, group b (with only sandblasting) had bond strength of 9.65 mpa which was higher than group a but less than group c and d. Group c (with only metal primer) had bond strength of 14.49 mpa and group d (with sandblasting and metal primer) had bond strength of 18.70 mpa. Group d had highest value among the groups. The bond strength values were in the following order group a < group b < group c < group d.

It was evident that the group d significantly differed from group a , group b and group c in resin groups. Thus it shows that sandblasting along with primer application significantly improved the bond strength as compared to no surface treatment or sandblasting alone or metal primer alone. Also the application of metal primer alone resulted in higher bond strength than sandblasting alone.

Conclusion

This study was designed to compare and asssess the shear bond strength of heat cure acrylic denture base resins with cobalt-chromium alloy, without any surface treatment to alloy and after different surface treatments such as metal primer, sandblasting, and their combination.

Based on the results, within the limitations of the study, inference can be drawn that :

1. The shear bond strength of surface treated with both sandblasting and metal primer (group d) was highest among all heat cure resin samples with the shear bond strength value of 18.70 mpa .
2. Group c (primer only) showed 2nd highest shear bond strengths with mean value of 14.49.
3. Group b (sandblasting only) showed next higher shear bond strength with mean value of 9.65 mpa.
4. The shear bond strength of control group i.e. Without any surface treatment (group a as control group) was lowest among all heat cure samples with the shear bond strength value of 2.59 mpa.

Summary

The study was undertaken to evaluate the effect of different surface treatment, like sandblasting and adhesive metal primers, on the shear bond strength of co-cr alloy with heat cure acrylic denture base resin. The purpose behind the study was that the bonding between the denture base acrylic resin and the metal alloy is critical for the success of the removable partial denture. Earlier macro-mechanical means of retention were used to provide the retention but due to absence of chemical bonding there was problem of separation and microleakage, which resulted in poor prognosis of the prostheses.

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