Measuring the Shear Bound Strength on Acrylic Resin Veneer to Metal Surface of Nickel (A Comparative Study)

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Key words
Acrylic, bound strength, nickel

Abstract

The bound strength of metal resin interface of prosthesis is a key factor in determining the service ability of that prosthesis. The main objective of this study was to determine the effect of different surface treatment on the shear bond strength of Ni-Cr alloy (CB-Blando 72 alloy) and heat cured acrylic veneer resin (Vertex).

Thirty disc shaped samples from base plate wax were prepared, the diameter of disc was (8 mm x 4.5 mm). After casting the metal, the samples were cleaned, finished and polished by silicon carbide abrasive paper with grit size (600 μm) and then the profilometer was used to determine the surface roughness of samples. Then the samples were divided in to three groups, each group contain (10) samples.

The first group received no treatment and serve as control .The Second group received micro mechanical treatment using 250 μm Al_2o_3 .The third group recived micro mechanical treatment using 400 μm $Al_2o_3.$ The acrylic was prepared as a round shape (8 μm) in diameter and (2 μm) in thickness, which was placed on the metal surface treatment, the acrylic was fabricated in the same conventional way for construction veneer resin. Then all samples was tested the shear bond strength by using Instron universal testing machine .The result from this study showed that, the first group was give low shear bond strength while the second group showed that the air abrasion with 250 μm Al_2o_3 give the highest shear bond values when compared with the third group which air abrasive with 400 μm Al_2o_3.

Introduction:

Resins of methacrylate - based polymers have been used for a long time as tooth colored veneering materials on cast crown and bridges [1][2] .The low retentive force of the resin in the metal casting might lead to the loss of veneer when it is repeatedly subjected to occlusal stress [3][4]. During the last years several works were accomplished on the increase of the bond strength of resin to metals, mainly through surface treatment of metallic alloys[5]. There are several methods available for bonding resin veneers to metal.

Metal surface treatments have been classified according to factors that control the bonding between the metallic alloys and the acrylic resins, including mechanical, chemical, and combined mechanical chemical retentive bonding systems [6][7]. Under cut designs such as struts, loops, mesh work, and beads have, been incorporate into wax framework pattern before casting. These designs mechanically enhance the attachment of the resin to the cast frameworks [8].The major disadvantage of mechanical retention between the resin and metal is poor mechanical sealing which permit seepage of oral fluids between the resin-

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metal interface that leads to increased retention of microorganism and fluids, deterioration, discoloration and subsequent unfavorable results[9][8].Since 1980, methods have been reported to create a chemical bond between dental alloy and resins without the use of mechanical retention and thereby providing more space for the veneer layers, especially in limited access areas. The chemical attachment of an opaque layer to the resin metal interface limited micro leakage at the metal-resin interface that occurred because of polymerization shrinkage and mismatch of coefficient of thermal expansion between the resin and metal[10][11] .An optimum metal - resin bonding system would include a simple procedure producing maximum retention and high consistent bond strength values[11][12]. This study, metal resin shear bond strength has been evaluated by using different metal surface treatment in order to obtain better retention and prevent unfavorable results of metal-resin interface.

Materials and method:

Wax Pattern Preparation : Three sheets of modeling wax (**Degussa, Germany**) (17.5 cm in length, 9.5 cm in width and 1.5 mm in thickness) was punched with a copper ring no. 27 (8mm in diameter) as mold five points of each wax pattern could be measured by wax caliper device to check uniform thickness (4.5mm) for each pattern[13][14]

Spruing& Investing: Each 15 samples were sprued using sprue wax (Dentarum,Germany) and invested in one casting ring using (Yetl investment, Germany). The wax wire was (2.5 mm) in diameter attached to running bar of (4mm), the wax pattern was attached to the crucible former to be away from the end of the ring in about (6mm). After completion of spruing, investing wax done immediately using casting ring size (9x). The wax samples were lubricated with surface tension reducing agent (Bicosilk, Germany) (debubblizer) and left for drying[15]. Phosphate bonded investment (YetI,Germany) was mixed according to the manufactures instruction, each (100g)

of powder was mixed with (24 ml) of its special liquid without dilution, measured by using a calibrated glass measuring cylinder. The measured liquid was poured into a damp-mixing bowl followed that the powder was added. Fifteen seconds of initial hand spatulation were followed by forty five seconds of vacuum mechanical spatulation to minimize the chance of air bubbles, which could be attached to the pattern and compromise the result. A brush was used to apply the investment material gently to the wax pattern then remaining investment was poured into the ring carefully with the aid of vibrator to prevent air entrapment. Then the ring was kept a side for setting according to the investment manufacture instruction.

Burn out Step &Casting: The burn out step was carried out according to the manufactures recommendation for temperatures and timing. The casting ring was kept in electrical furnace at room temperature with crucible former opening side down ward, to facilitate evacuation of the molten wax after heating [15]. The ring was then heated gradually to (200°c) and was kept at this temperature for (30 minutes). After that temperature was elevated gradually to the final level (950°C) and was kept at that degree for (60 minutes), then a new metal of CB - Blando 72 was used for each casting, which is beryllium -free nickel chromium alloy; the alloy was selected because of its availability and broad usage. Manual driven broken arm centrifuged casting machine was prepared to be ready for casting. All the casting were made with the same casting pressure and to achieve that the machine was wound for four turns[16].After casting, the ring was left for bench cooling to room temperature, and then the sample were removed from the muffle, cleaned from the carbondum, sand blast with 250 μm aluminum oxide to remove any remaining investment and the oxide layer which covers the sample due to casting, then the sprues would be sectioned by the carbondum disc mounted on laboratory hand piece. Each individual sample *was* checked**,** for incomplete casting, any nodules and any surface irregularity, sample with major defects were discarded and replaced with new one, minor defect

such as small nodules at the edge of the disc, were removed by stone bur.

Finishing and Polishing of the Samples: The samples were finished to their final dimensions and any irregularities after casting were removed from the cast specimen with stone bur and they were gradually polished on the flat surfaces with silicon carbide paper (600 grit) manually for 50 second at 10 cm distance in straight line on a flat table [17]. All the finishing steps were done under running water to overcome heat generation, then evaluation of the surface polishing was performed by making profilometric records with the surface roughness instrument. Profilometric parameter (Ra) (Taylsuref, England) was selected for this study samples, which gave a roughness between (0.09-0.13 μm) were used and any sample with higher roughness was re- polished and their roughness was reevaluated again. The samples thickness was calibrated with a metal caliper device (Dentarum, Germany). Fig. (1).

Metal Surface Treatments of the Tested Group: Group **(1)**: The sample of these groups received no treatment and serve as control groups. **Group (2):** The samples were treated with 250 μm Al_2o_3. **Group (3)**: Each samples in these groups was treated by abrasive with 400 μm aluminum oxide abrasive at air pressure of (60 psi) for (15 second) at a distance (10 mm) [18]. The sample was fixed in especially designed fixture (a holder) placed inside the sandblast machine at (10mm) distance away from the nozzle, the nozzle was kept perpendicular to the metal surface (ruler was to standardize the distance between the nozzle and the sample). The samples then placed in distilled water in an ultrasonic cleaner for 10 minutes and then dried, stored dry until they were bonded [19][20].

Acrylic Packing:

A - Opaque Layer: The surface of the metal to be veneered was coated with opaque (vertex, Holland) (liquid-powder mixing ratio about 2:1 by volume). Thin layer of opaque were applied, let it to dry for approximately (15 minutes) before added body acrylic facing according to

manufactures instruction .The thickness of the opaque layer was measured with metal caliper device and scored (0.5 mm) [13] Fig. (2).

B - Body Acrylic Facing : To correct the pressure, size and shape of acrylic veneer used copper ring (8mm in diameter x2mm in high).The inner surface of the ring coated or painted by separating medium and correct with sample by used stick tap with specimens before added the dentin [13][14]. The mixing of the dentin was done in the mixing jars for a sample (10) to (15) drops of liquid were put into the mixing jar and dentin powder was added until all the liquid has been absorbed (liquid - powder mixing ratio approximately 1:3 by volume). Stir briefly and vigorously an agate or glass spatula (the mixing time about 1 minute). Close Jar and allow to ripen. The dough is ready for use when it no longer sticks to the spatula. Applied dentin to the whole object to be veneered, which has been covered with opaque, and adapted the dentin with spatula moistened with liquid. Mix incisal dough. Mixing ratio approximately 1:2 by volume (i.e thinner than for dentin), stir dough thoroughly, do not allow to ripen (in contrast to dentine), apply with spatula and spread. The total thickness of acrylic about (8mm in diameter and 2mm in high [13].

C – Polymerization : After modeling of acrylic facing was completed, the polymerization or curing the acrylic was done in the ivomat(vertex , Holland) which was filled by water and then cure the acrylic facing for (lOmin.) at (120°C), (6 bar) pressure (according to manufacturer's instruction) .

D - Finishing and Polishing the Samples : In the first removed the copper ring from the sample, then the acrylic was finished by carbide bur to remove the excessive amount of acrylic then stone bur used to standardize the thickness of the facing followed by sand paper used for smoothing. The final thickness of acrylic was checked by a Vernier. The polishing was done with bristle brush and wet pumice using dental lathe polishing machine at speed (30.000 rpm) finally used universal polishing paste with cotton buff brush mounted on the polishing machine at the

same speed. The final shape of each group as show in Fig. (3).

Shear Bond Strength Testing: Shear bond strengths were tested with zwick - instron universal testing machine (England), using the chisel shaped rod with a cross head speed of 0.5mm/min [7].The tested specimens were placed in the lower member (Jaw) of the testing machine so that the chisel rod was positioned at 90° at the interface between the edge of the metal and the resin. The specimens secured tightly in place to ensure that the specimens were always be kept at 90° in the vertical plan [21] Fig (4).

The specimens were then stressed to failure. The force of bond failure was recorded in Newton which has been divided by the surface of bonded area to obtain the shear bonded strength calculated in MPa:

(SBS= F/SA = MPa) [11][22].

Statistical Analysis:

The statistical methods were used in order to analyze and assess the result, included: **Descriptive Statistics** (statistical tables, mean of value, standard deviation, minimum and maximum reading and graphical presentation by /Bar –charts/). **Inferential Statistics: These** were used in order to accept or reject the statistical hypotheses, they include Student test (t-test) for comparison between groups.

Results:

- **Shear bound strength result :**

Mean values, standard deviation, maximum and minimum values are presented in table (1) for shear bond strength. The highest mean value of shear was in 250 μm Al_2o_3 (4.0260). While the lowest mean value of shear bonding strength was in control group (1.7800).

In table (2) showed student t. test. The high significant difference at P < 0.01 between control group and 250 μm Al_2o_3, and between 250 μm Al_2o_3 and 400 μm Al_2o_3.

Discussion:

The result of present study showed that, the control group was low bond strength values when comparing with other groups, as shown in table (1). This is due to the fact that resinous materials for the veneer of fixed prostheses commonly require mechanical retention on the metal substructure because there is no chemical adhesion, and the potential for separation of the resin from the metal is also influence by the difference in thermal expansion coefficients of the resin and metal Pesun Mazurat (1998), Kourtiz (1997). This study agrees with Hero et al., (1987), who said that "on polished specimens, no bonding was achieved, because silicon oxide particles were not embedded in the surface of the alloy. Also agree with Mukai et al; (1995) they found that the low shear bond strength values in polishing group when used the resin with two types of alloy (Ni-Cr and Ag-Pd) comparison with other group treated by 37um $Al_2 0_3$ and 250um $Al_2 0_3$ air abrasion. This was also supported by de Freitas and Francisconi (2004), they found that the specimens of the polish group presented the lowest SBS values compared with other group (polished with primer, sandblasted without primer, and sandblasted with primer) between the rely x-cement and polished surface of the Co-Cr -Mo alloy. This was agree with Mansour (2006) who study the measuring and comparing the shear bond strength of acrylic veneer to Ni- CR alloy after different metal surface treatment , when found the low shear bond strength on un treatment metal surface . On the other hand the results obtained in present study disagree with those obtained by Al-Alawi (2005), he found that the no surface treatment showed the best treatment for Cpti were bonded with chemically cured resin comparison with other treatment (air abrasion with aluminum oxide, acid etch by mixture of 50% HNO3 and 50% HCL and combination of air abrasion + acid etching. One of the easy methods of enhancing bond strength is roughening the surface by air abrasion.

In group 2 and 3, the results showed that air abrasion raised the mean bond strength values higher than that of the control group .This improvement in the SBS may be due to the fact that the process of air abrasion cleaning the alloy surface area, remove unfavorable contamination, produced suitable and uniform micro

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retention .Each of these factors has been shown to increase the wettability of the metal surface and bonding surface area Mukai et al; (1995).,Chung and Hwang; (1997).,Rubo et al;(2001).   The present study agree with Dixon et al; (1994)**,** who found that higher shear bond strength values with air abrasion of Ni-Cr alloy with 50 μm **AI_2O_3.**The results also agree with those obtained by Wiltshire (1986), Pintocelho et al et al., (1995), Pesun and Mazurat; (1998) who found that air abrasion increased surface area, expanded the energy, and also heightened activity of the alloy surface area, thus results in increased bond strength. Also agree with May et al, (2000), they reported that the experimental group demonstrated a mean bond strength 3.7 time greater than the control group (significant p=0.0001, ANOVA) pretreatment with 110 micron aluminum air abrasion significantly enhanced the bond strength of heat cured metal bonding polymethacrylat to titanium .These results are in agreement with Mukai et al; (1995), who found that the surface treatment of the metal by sandblasting with Al_2O_3 particles (37-250 μrn) has improved the effectiveness of the surface area of the metal and increased the resin -metal bond strength. The resin alloy bond strengths improved remarkably after sandblasting. Also agree with Wataube et al., (1999), they reported that sandblasting restoration, with 250 μm aluminum (Al_2O_3), has the potential to remove significant amount of substances and could effect on the bonding of the prostheses. Similar results obtained by Sharp et al., (2000), when they evaluated the effectiveness of the metal surface treatment in controlling micro leakage of the acrylic resin -metal interface, and found significant reduction in micro leakage, which means significant improvement of the bond strength. This result was in agreement with that obtained by Blixt et al, (2000), who reported that Al_2O_3 increased the reaction on the metal surface with the resin and created micromechanical retention that increased the bond strength. Previous studies reported that the alumina not only affected the micromechanical roughness of the surface but it left alumina particle embedded in the surface and ultra-sonic cleaning result in only minor removal of the embedded alumina, which effect on bond strength .However , the results of the present study disagree with those obtained by Shell and Nielsen (1962), on the bond between gold alloy and porcelain after surface roughening of the alloy, the micromechanical retention causes weakening of the bond , and they said that air and dirt can be entrapped in the crevices , which can also lave unbounded areas .The results of the present study are not consistent with the results obtained by Shue et al., (1987)**,** who said that "air abrasion of the metal by itself is not recommended as a retentive system because of retention inconsistency. Disagree with the results of the present study, as they found no improved retention of acrylic resin bonded to titanium framework after air abrasion May et al (1993) .Also this study disagree with Al-Alawi (2005), he found that the a i r abrasion gave the low shear bond strength than no surface treatment for Cpti were bonded with chemically cured resin. In comparison between the effect of air abrasion with different grain Size (1, 2, 3) groups, the results showed that the better SBS obtained by 250 μm and finally by 400 μm this is may be due to that air abrasion with 250 μm Al_2O_3 provided a metal resin bonded with lower resin film thickness and Triolo and Kelsey (1995), mentioned that when a thin film is created between two materials, that makes the system stronger than bulk properties of adhesive. Or may be due to the surface treated with 250 μm aluminum oxide less effected of ultrasonic cleaned and surface containing a significant amount of Al_2O_3, which effects bond strength and gave best bond**.**

Conclusion:

The highly mean value of 250 μm grain size of aluminum oxide (Al_2O_3) give best retention were found for sand blast treated when compared with 400 μm grain size of aluminum oxide (Al_2O_3). Statistically high significant difference in shear bond strength was obtained groups with different grain size of aluminum oxide (Al_2O_3).

Fig (1) measuring the sample thickness

Fig. (2) The samples with opaque layer and ring

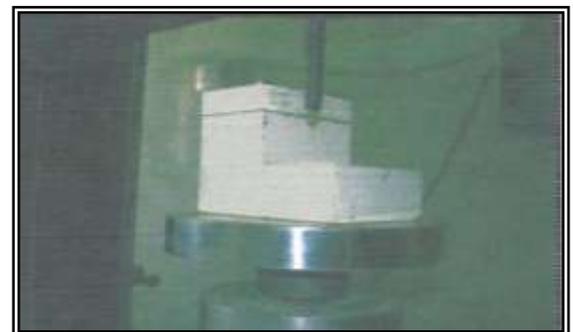Fig (3) The final shape of each group be for test

Fig. (4): Specimens under shear bond strength test

Table (1) mean value, slandered deviation, maximum and minimum values for each group :

Studied groups	Group control	250 + μm group Al_2o_3	400 + μm group Al_2o_3
N	10	10	10
Mean	1.7800	4.0260	2.7440
Std. Deviation	.2694	.3424	.3137
Minimum	1.42	3.50	2.19
Maximum	2.18	4.48	3.13

Table (2): student t. test for group of shear bond strength.

Groups		p-value	C.S
Control group	250 μm Al_2o_3	P< 0.01	HS
Control group	400 μm Al_2o_3	P< 0.01	HS
250 μm Al_2o_3	400 μm Al_2o_3	P< 0.01	HS

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