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Original Article

Evaluation and Assessment of Bonding of Heat Cure Acrylic Resin to Cobalt-Chromium Alloy; Old Ideas Employing Newer Concepts – An Original Study

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ABSTRACT

Background and Aim: In removable prosthodontics, partial dentures are commonly fabricated with acrylic resin and metal framework. These are well suited for such frameworks because of their mechanical properties, biocompatibility and corrosion resistance. This study aimed to evaluate the status of the bonding strength between acrylic resin and partial denture casting alloys along with their clinical applicability that can best retain the said prosthesis with minimal failure. **Materials & Methods:** Pioneer workers and their contributions were compiled using popular search engines, scholarly search bibliographic databases and textbooks were searched until May 2018 using MeSH (Medical Subject Headings; PubMed) based keywords such as “Acrylic Resins”, “Chromium Alloys”, “Denture Bases”, “Surface Properties”. The search was limited to original researches, reviews, systematic researches and meta-analyses in various dental journals published over the last 38 years in English language only. A total of 95 articles were identified however after examining the titles and abstracts, this number was finally condensed to 44 articles. **Statistical Analysis & Results:** All the studied data were complied and sent for statistical analysis using statistical software Statistical Package for the Social Sciences version 21. The resultant data was subjected to relevant statistical tests to obtain p values, mean, standard deviation, chi- square test, standard error and 95% CI. **Conclusion:** Our study results clearly show that till date none of the study has explained the exact bonding and its longevity on the prosthesis. Hence the need of our is to have some long term authentic studies which could define the exact role of various surface treatments and bonding techniques to build more comprehensive understanding in this perspective.

Key words: Acrylic Resins, Chromium Alloys, Denture Bases, Surface Properties

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INTRODUCTION

In removable prosthodontics, durability of removable partial denture is dependent on strong adhesion between the metal framework and acrylic resin.[1] Any incongruity of chemical bond between PMMA and base metal alloy directly affects the metal-resin interface however; a microscopic space exists between the metal framework and the resin denture base.[2] Weak adhesion and lack of a chemical bond cause separation of denture base from framework.[3-4] Discrepancies in the coefficient of thermal expansion among these components may promote this space, leading ultimately to microleakage of salivary substitutes.[5] Furthermore, microleakage in the area of internal and external finishing lines results in discolouration, deterioration of denture base material and introduction of potentially pathogenic microorganisms that may be harbored within the crevice and contribute to an adverse soft tissue response. In removable prosthodontics, partial dentures are commonly fabricated with acrylic resin and metal framework. Base metals, such as cobalt-chromium (Co-Cr alloy), nickel – chromium alloy (Ni-Cr alloy) and commercially pure titanium (CP Ti) are commonly used for RPDs that contain metal frameworks, bars, or clasps. These are well suited for such frameworks because of their mechanical properties, biocompatibility and corrosion resistance.[6] Literature search has very well revealed that heat polymerized acrylic resin PMMA is normally used as a denture base resin for removable prostheses. Therefore, the bonding between the metal components and the denture base resin plays an important role in the longevity of the prosthesis. Unadventurously, denture base acrylic resin is attached to the metal framework by three types of retentive aids: mechanical, chemical or combination of both. Any kind of failure of the resin at the interface is a common source of dilemma when forces exceed the capacity of the retentive mechanisms. Removable partial prostheses are subjected to variations in temperature during oral function; this factor may lead to microleakage. Shrinkage of acrylic resin volume also has been associated with worsening at the interface between metal alloys and acrylic resins, fluid percolation, and the deterioration of contact between the metal alloys and the acrylic resin.[7] Substantial bonding between the metal framework & denture resin is also important; especially in situations such as limited inter ridge space, short span edentulous area and where excessive functional forces are anticipated. Livaditis described the micromechanical retention for resin-alloy systems in which electrochemical and chemical etching procedures were used.[8] Yasuda reported that the adhesive resins containing 4-META adhered strongly to the oxidized Ni-Cr alloy as well as to the resin.[9] Additionally, Tanaka et al introduced a 4-META preparation and described its effectiveness in adhesion to treated dental alloys.[10] Bonding of resin to dental alloys has significantly improved over last decade and various bonding methods and techniques for base metal alloys have been developed, such as electrolytic etching, chemical etchants and silica coating etc. The functional monomers contained in each adhesive primer have an affinity with the layer of chromium oxide created on cast Co-Cr alloy surface.[11] The bonding system of an adhesive primer containing functional monomer is considered a technique that facilitates chemical adhesion. Chemical bonding is more desirable than mechanical retention when resin is incorporated.[12] Even though many bonding systems for base metals including new priming agents have been developed for dental prosthesis, systematic literature search explore only limited and little information with this perspective. Keeping this fact in mind, authors aimed to evaluate the past and present status of the bonding strength between acrylic resin and partial denture casting alloys along with their clinical applicability that can best retain the said prosthesis with minimal failure.

MATERIALS & METHODS

Performing any genuine and extended biomedical search without using internet is almost impracticable in the present time. Internet provides a variety of internet-based tools that support the retrieval of biomedical information. Some of the renowned internet based popular search engines, scholarly search bibliographic databases and textbooks were searched until May 2018 using MeSH (Medical Subject Headings) based keywords such as “Acrylic Resins”, “Chromium Alloys”, “Denture Bases”, “Surface Properties”. The search was limited to original researches, reviews, systematic researches and meta-analyses in various dental journals published over the last 38 years in English language only. A total of 95 articles were identified however after examining the titles and abstracts, this number was finally condensed to 44 articles. The searched data were divided into eight groups according to their year. Group I was having searches of 1980-1985 and group VIII was having the search results of year 2016 onwards. We have decided to conduct this study on this basis since they are exceptionally useful to obtain detailed information clinical opinions and decision makings. They are also competent of saving time and money while analyzing the data at individual levels. In addition, they also give a broader range of data with better clarification and understanding. To ensure entirely comfortable data search, the study was performed in an anxiety free atmosphere. It was done to ensure fair outcome those may possibly be seen if attempted arbitrarily. Results thus obtained was tabulated and subjected to basic statistical analysis. P value less than 0.05 was considered significant ($p < 0.05$).

STATISTICAL ANALYSIS AND RESULTS

All the studied parameters and records were assembled and sent for statistical analysis using statistical software Statistical Package for the Social Sciences version 21 (IBM Inc., Armonk, New York, USA). The resultant data was subjected to relevant statistical tests to obtain p values, mean, standard deviation, chi- square test, standard error and 95% CI. The searched data were divided into eight groups according to their year. P value less than 0.05 was considered significant ($p < 0.05$). For the ease of study and interpretations, the available pioneer works were divided into eight Groups. Each and every group was studied and analyzed meticulously to draw significant inferences. Group I was having searches of 1980-1985 and group VIII was having the search results of year 2016 onwards. Group I had 4 pioneer workers and the p value was not significant with Chi Square Test (Pearson $\chi 2$) value 0.04. Group II had 8 pioneer workers and the p value was significant with Chi Square Test (Pearson $\chi 2$) value 0.25. Group III had 5 pioneer workers and the p value was not significant with

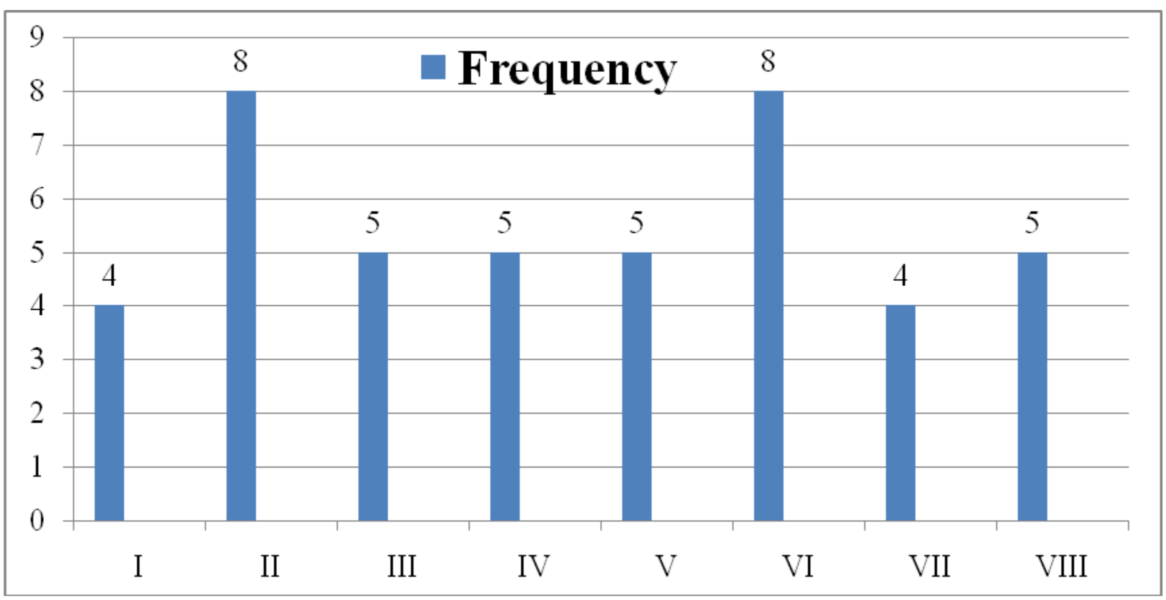
Chi Square Test (Pearson $\chi 2$) value 0.14. Group IV had 5 pioneer workers and the p value was not significant with Chi Square Test (Pearson $\chi 2$) value 0.21. Group V had 5 pioneer workers and the p value was not significant with Chi Square Test (Pearson $\chi 2$) value 0.88. Group VI had 8 pioneer workers and the p value was not significant with Chi Square Test (Pearson $\chi 2$) value 0.34. Group VII had 4 pioneer workers and the p value was not significant with Chi Square Test (Pearson $\chi 2$) value 0.02. Group VIII had 5 pioneer workers and the p value was not significant with Chi Square Test (Pearson $\chi 2$) value 0.01 (Table 1 and Graph 1-3).

Table 1: YEAR WISE DISTRIBUTION OF PIONEER WORKS (GROUP I TO VIII) WITH RELATED STATISTICAL INFERENCES

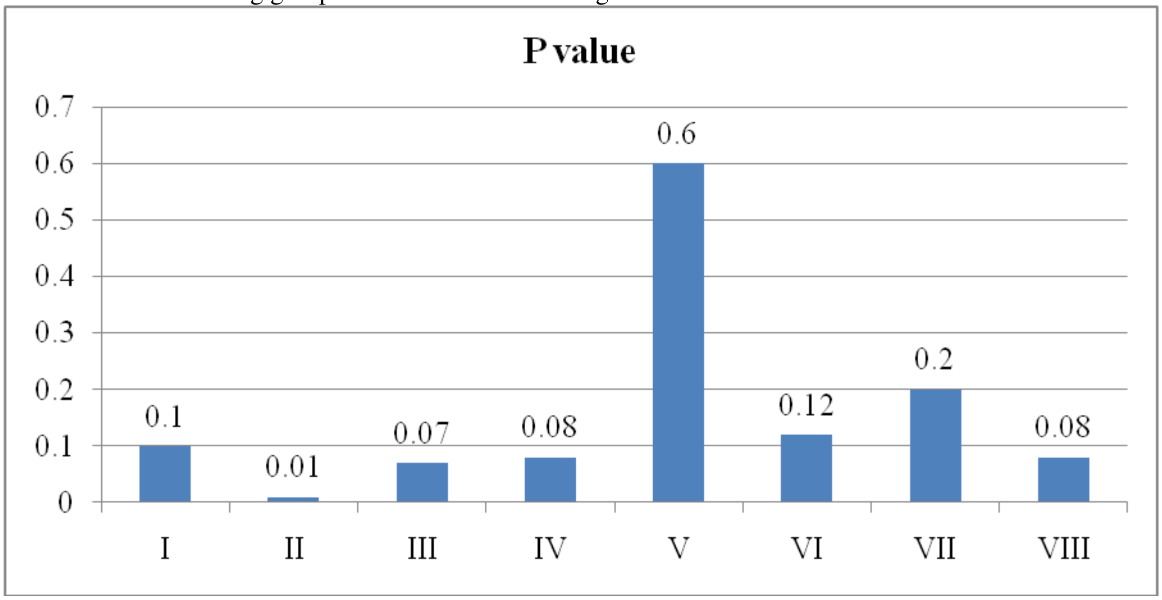
Group	Year Range	Frequency	Standard Deviation	Standard Error	Chi Square Test (Pearson $\chi 2$)	P value	Std. Deviation
I	1980-1985	4	0.447	0.017	0.04	0.10	2.233
II	1986-1990	8	0.794	0.022	0.25	0.01*	1.432
III	1991-1995	5	1243	0.454	0.14	0.07	0.764
IV	1996-2000	5	1.882	0.500	0.21	0.08	2.233
V	2001-2005	5	1.632	0.558	0.88	0.60	1.432
VI	2006-2010	8	1.044	0.370	0.34	0.12	1.667
VII	2011-2015	4	1.877	0.058	0.02	0.20	1.000
VIII	2016-Till Date	5	1.558	0.457	0.01	0.08	1.404

***p<0.05 Significant**

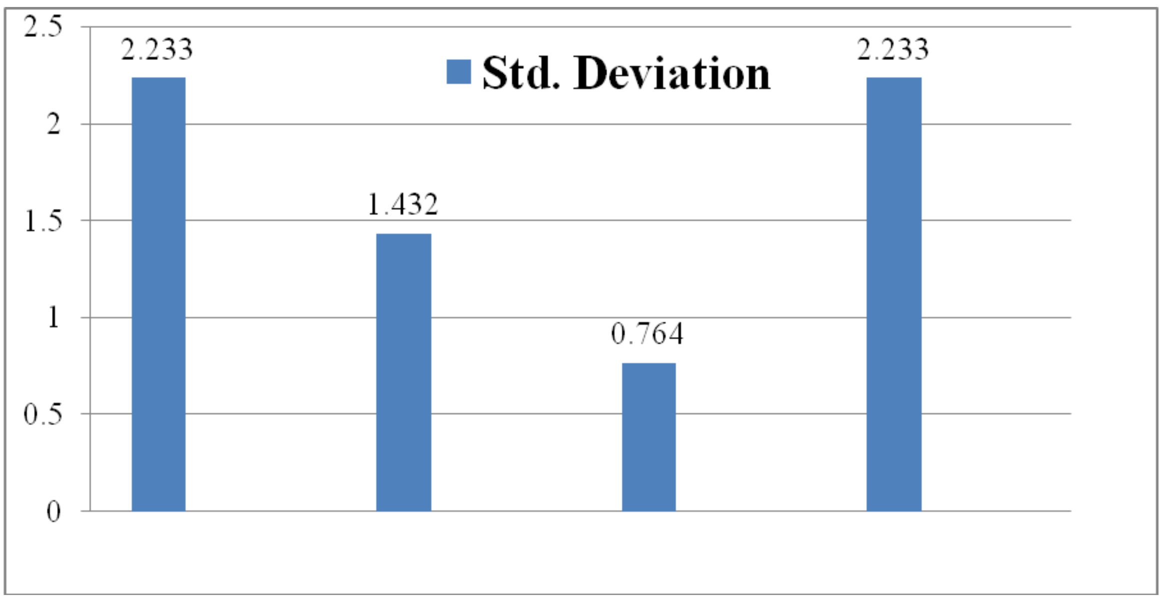
Graph 1: Frequency table showing group wise distribution of literature exploration



Graph 2: P value table showing group wise status of level of significance



Graph 3: Std. Deviation values for Group I to IV



DISCUSSION

In removable prosthodontics and especially in context of removable partial dentures, acrylic resin has been a material of choice since ages. This is particularly true mainly because of its easier attachment to artificial teeth and to metal framework. However, in day to day clinical practices and in methodological studies we do see cases of failure attributed to bonding between the metal and acrylic. Most of the related studies are seems to be focused on improving the bonding either by using metal primers or doing different surface treatments on metal surface. Tanaka and associates [13] evaluated the effect of surface treatment on non precious alloys (Ni-Cr and Co-Cr alloy) for adhesion- fixed partial dentures. They used four non precious alloys. Surface treatment was completed by immersing them in an oxidizing solution. The surface of the cast metal frames was air abraded with 50 µm alumina powder, washed in neutral detergent solution for 10 minutes. They concluded that two Ni-Cr alloys for metal-ceramic crowns developed superior bonding strength and adhesive durability after sandblasting with alumina and oxidation. Sufficient bonding strength and adhesion were obtained for the Co-Cr metal ceramic crowns and metal base dentures by merely sandblasting and ultrasonic wave washing. Thereafter, Zurasky and colleagues[14] evaluated adhesion of acrylic denture resins to base metal alloys. Ni-Cr samples were cast and groups were further prepared for surface treatment of electrolytic etching and bead retention. The metal was etched by using 10% sulphuric acid with a current density of 300 milliamps for 3 minutes per meter square. Bead samples were prepared by placing six kayon synthetic resin retention beads. Tensile bond strength is determined by using Instron universal testing machine. They concluded that using electrochemical etching to obtain microscopic retention of polymethyl meth acrylate produces significantly greater tensile bond strength than those obtained with acceptable bead retention. Ferrari and co workers[15] also assessed two chemical etching solutions for nickel-chromium-beryllium alloys and a chromium-cobalt alloys. They were (A) Assure etch (solution A) and (B) a solution with 800 ml of methanol, 200 ml of 37 % HCI, and 2 ml of ferric chloride (solution B). The solutions were heated up to 70° C in a water bath during the etching process. Different etching times were selected which were 45, 60 and 75 minutes for nickel-chromium-beryllium alloys and 5, 10, 15, 20, and 30 minutes for chromium cobalt alloy respectively. The chemical etching solutions created high micro-retentive surfaces in nickel-chromium-beryllium alloy but the chromium-cobalt alloy surfaces after etching were less retentive. They concluded that the two chemical etching solutions created a highly micro-retentive surface when nickel-chromium-beryllium alloys were treated and the Co-Cr alloy revealed lesser micro-mechanical retention after surface treatment with both chemical etching systems. Kohli[16] further clarified this dilemma by evaluating the effect of three different surface treatments on the tensile bond strength of the resin bond to Ni-Cr-Be alloy. A total of one hundred and twenty samples of nickel-chromium-beryllium were prepared and bonded to each other. The etched samples were cleaned with water in an ultrasonic cleaner for 15 minutes. Group (B) samples were etched chemically with a gel etchant and group (C) samples were abraded with 50µm alumina particles for 15 seconds at a distance of approx 10 mm with 60 psi of air pressure and bonded with an adhesive resin, Panavia EX. It was concluded that chemical etching of the metal for 1 hour imparted the highest strength followed by air abraded bond samples and the tensile strength of samples etched with Assure-Etch etchant was significantly higher than that obtained with samples etched with Met-Etch etchant. The study results were similar to some extent as of Kolodney and colleagues[17] They studied to evaluate shear bond strengths of adhesive systems to a nickel-chromium-beryllium alloy. They showed Panavia as a composite resin luting agent containing phosphate monomers that bonds chemically to air-abraded base metal alloys and is particularly suited for cementing resin-bonded retainers. They actually aimed to compare prosthodontic adhesive systems that incorporated the Siiicoater system and/or Panavia. The results revealed that the surface treatment that provided considerably higher shear bond strength was the Silicoater system and a layer of unfilled resin. Results further highlighted that Panavia Opaque material was displaced peripherally during placement of overlying laboratory composite resin veneers. It was concluded that use of an unfilled resin as an intermediate layer bonded to Silicoater yielded superior shear bond strength. Sedberry and associates[18] also compared the tensile bond strength of three chemical and one electrolytic etching system for a base metal alloy. They have taken three hundred plastic Rexillium III disks which were cast and etched by the following etching systems: electrochemical, Assure-Etch, Met-Etch gel, and Etch-It gel. These processed thermo-cycled samples were loaded to failure in tension on an universal testing machine using a crosshead speed of 5mm/minute. Their study results further clarified the fact that samples etched electrochemically yielded significantly greater bond strengths than those etched chemically. May and colleagues[19] evaluated the effect of three different surface treatments on the shear bond strength of polymethyl methacrylate bonded to titatnium partial denture framework material. They took thirty rod shaped specimens of titanium which were divided into three equal groups. Lucitone CH denture resin was processed around each specimen. A Shell-Nielsen shear test was then performed at a crosshead speed of 0.5 mm/minute to determine the bond shear strength in kilograms per square centimetre. The results of this study showed that surface pre-treatment of titanium with 110µm alumina air abrasive plus silicoat silane coating significantly enhances the bond shear strength of polymethyl methacrylate more than 60% when compared with no treatment. Kourtis[1] also evaluated the bond strength of resin to metal bonding system. As a proven fact, resinous materials for the veneers of fixed prosthesis commonly require mechanical retention on metal substructures because there is no chemical adhesion. Conversely, mechanical retention does not restrict creation of a marginal gap at resin metal interface, which can cause discoloration or detachment of resinous material. Six resin to metal bonding system were tested namely silicoater, silicoater MD, Rocatec OVS, sebond and Spectra Link. Every specimen were carefully examined in bending tests after 24 hours of dry storage, after 24 hours of water storage and thermo-cycling, and after 2 months of water storage and thermo-cycling. They concluded that bonding of resin to metal substructure was stable despite prolonged wet storage and intensive thermocycling. NaBadalung[20] conducted a study to evaluate tensile bond strength of three denture base resins (Trutone, Lucitone 199 and Triad) to treated Ni-Cr-Be alloy. One hundred eighty samples of truncated cone shape were prepared and treated with three surface treatments i.e Sandblast, Acid etch and Rocatec with or without primers. After storing the bonded specimens in distilled water at 37ºC for 24 hours, the samples were de-bonded in tension in universal testing machine. They concluded that Trutone groups when primed showed the highest bond strength than non primed group. Met- Etch and Rocatec treated groups produced higher bond strengths than the sandblasted groups. Rothfuss[21] also compared the shear bond strength of composite to metal with two commercially available chemical bonding systems: a silicoating system (Silicoater) and a nitrogenous heterocycleacrylonitrile system (Kevloc). Fifty-two nickel-chromium cubes were cast and composite resin was bonded to the alloy surfaces according to manufacturer's directions. After storage at 35° C for 15 days, and thermocycling at 5° C and 55° C for 1200 cycles, the bonds were fractured in shear on a universal testing machine and concluded that mean bond strength for the silicoated sample was 10.93 MPa and for the heterocycle-acrylnitrate system 11.44 MPa. Visual inspection of the fracture surfaces revealed that failure was adhesive at the resin-to-metal surface in almost all the specimen. Yoshida[22] studied adhesive primers for bonding cobalt–chromium alloy to resin and for that, he evaluated the effect of five adhesive primers on the Shear bond strength of a self cure resin to cobalt-chromium (Co-Cr) alloy. A brass ring which was placed over the casting alloy disk surface non-primed or primed with each primer was filled with the self curing MMA-PMMA resin. The specimens immersed alternately in water baths at 4 °C and 60 °C for 1 min each for up to 50000 thermal cycles before shear mode testing at a crosshead speed of 0.5mm/min all of the primers examined, except MOBL, improved the shear bond strength between the resin and Co-Cr alloy compared with non-primed samples prior to thermocycing. Regardless of which primer was used, the shear bond strength significantly differed between thermal cycles 0 and 50000. They concluded that COP and MPII are effective primers to obtain higher bond strength between resin and Co-Cr alloy. Sharp[23] evaluated the efficiency of metal surface treatments in controlling micro-leakage of the acrylic resin-metal framework interface. They literally designed their study to determine the effects of various metal surface treatments on micro-leakage and bond strength between the metal alloy and acrylic resin used in the fabrication of a removable partial denture. A total of ninety-six nickel-chromium-beryllium alloy specimens were randomly divided into 8 groups. Air abrasion, tinplating/oxidation, and silanation were evaluated individually and in all combinations. Heat-polymerized acrylic resin was processed against all specimens before storage in distilled water at 37°C for 72 hours. Each specimen then was thermo-cycled in distilled water (3000 cycles) before immersion in sodium fluorescein dye for 24 hours. They concluded that air abrasion, alone and in conjugation with other surface treatments, resulted in a significant reduction in micro-leakage between the metal alloy and acrylic resin. Tinplating also resulted in reduction of micro-leakage although to a lesser degree than with air abrasion. Azad[24] and co-workers genuinely estimated the tensile bond strength of denture base resins to surface pre-treated cobalt chromium base metal alloys. A total of 60 tensile bar specimens were prepared and one half of the bar was cast in cobalt chromium alloy and the other half made of denture base resins attached to the alloy following surface pre-treatment. Two denture base resins and five surface pre-treatments were used which were sandblasting, acid etching, and use of metal adhesive primers and combination of above mentioned modes. The study results indicated that the bond strength in those specimens wherein a combination of sandblasting , acid etching, and priming was done as surface pre-treatment showed the maximum values as compared to other groups.

Yanagida[25] further evaluated the adhesive properties of metal conditioners when used for bonding between auto-polymerizing methacylic resins and a titanium alloy. A disk specimens were cast from a titanium-aluminium-niobium alloy, air abraded with alumina, and bonded with twenty four combinations of 8 metal conditioners and three polymerizing methacrylic resins. Un-primed specimens were used as controls. Shear bond strength were determined both before and after thermo-cycling (4-60° C, 20,000 cycles). They concluded that the use of one of the three conditioners (ALP, COP and MP II) in combination with the SB resin is recommended for bonding the Ti-6Al-7Nb alloy. Shimizu[26] conducted a study to evaluate the shear bond strengths of an auto-polymerizing denture base resin to cast Ti–6Al–7Nb and Co–Cr alloys using three metal conditioners. Ti–6Al–7Nb alloy and Co–Cr alloy discs were cast. The disc surfaces were air-abraded with 50 mm alumina particles and treated with three metal conditioners (Alloy Primer; Cesead II Opaque Primer; Metal Primer II). An auto-polymerizing denture base resin was applied on the discs within a hole punched in a piece of sticky tape and a Teflon ring to define the bonding area. All specimens were immersed in 37.8 degree Celsius water for 24 hours. Half of the specimens were thermo-cycled up to 20,000 cycles. The shear bond strengths were determined at a crosshead speed of 1.0 mm/min. The authors achieved significant improvements in bond strength of the auto-polymerizing denture base resin to cast Ti–6Al–7Nb alloy and Co–Cr alloy through the application of Alloy Primer, Cesead II Opaque Primer and Metal Primer II. Banerjee[2] evaluated the tensile bond strength of denture repair acrylic resins to primed base metal alloys (Ni-Cr and Co-Cr). Three different metal primers viz. Alloy Primer, UBar , MR Bond were used. One hundred and twenty eight samples were prepared, half of them were bench cured and other half was pressure pot cured. Samples were tested in Instron testing machine to evaluate the tensile bond strength. Significant differences in bond strength were observed, between combination of primer, curing methods and alloys. They concluded that primed sandblasted specimens that were pressure pot cured had significantly higher bond strengths than primed sandblasted bench cured specimens. The results of the study suggested that MRB metal primer can be used to increase bond strength of auto-polymerized repair acrylic resin to base metal alloys and curing auto-polymerized acrylic under pressure potentially increases bond strength. Kim and co-workers[27] evaluated the shear bond strengths of a heat cure denture base resin to commercially pure titanium, and a cobalt-chromium alloy using two adhesive primers (Alloy primer, MR bond). The study discs of commercially pure titanium, Ti-6Al-4V alloy and a cobalt-chromium alloy were made. A hexagonal shape wax was attached to disc to fabricate apart of resin tap apart. Samples were invested in conventional way. They concluded that Alloy primer, which contains phosphoric acid monomer, MDP, was clinically more acceptable for bonding a heat cure resin to titanium than a MR bond, which contains the carboxylic acid monomer. Bulbul and colleague[28] evaluated the effect of metal primers on the shear bond strength of acrylic resins to 3 different types of metals. In this total of 432 disk-shaped wax patterns were cast in a Ti alloy (Tritan), base metal (Co-Cr alloy, Wironit), or noble metal (Au-Ag-Pt alloy, Mainbond EH). The samples of noble alloy were airborne-particle abraded with 50-μm aluminum oxide; the other samples were airborne-particle abraded with 110-μm aluminum oxide for 10 seconds. All specimens were stored in distilled water at 37°C for 24 hours after polymerization and then thermal cycled (5000 cycles at 5-55°C with a 30-second dwell time). The samples were tested in a universal testing machine at a crosshead speed of 0.5 mm/min in shear mode. They concluded that the metal primers were associated with an increase in the adhesive bonding of acrylic resins to metal alloys. Though among metal alloys, the shear bond strength of the acrylic resin to the base metal alloy was significantly higher than the shear bond strength to the noble and titanium alloys. Lim[29] compared the shear bond strength and failure types of a polymethyl methacrylate (PMMA) denture base resin to commercially pure (CP) titanium, Ti-6Al-4V alloy, and cobalt-chromium alloy using a metal surface conditioner. The PMMA denture base resin was cured onto disks, 10 mm in diameter and 2.5-mm thick. The shear bond strength of the PMMA resin with the surface conditioner was significantly higher than that without. There was no significant difference between the types of metal. Ali[30] conducted a study to evaluate the effect of primers on the shear bond strength of two types of acrylic resin to Co-Cr partial denture alloy. Fifty Co-Cr ingot and fifty cast specimens were fabricated and embedded in resin. Their surfaces were sandblasted and primed with four primers except for the control group. 4 x 5 mm discs of self-cure and heat-cured resins were processed against the alloy and stored in distilled water for 24 hours. Specimens were de-bonded in shear using a Universal testing machine. Primed alloy specimens showed greater bond strength than the non-primed controls and heat-cured resin bonded better than the auto-polymerized resin. ZP primer demonstrated the highest bond strength regardless of type of alloy and resin. Monobond P demonstrated the lowest bond strength. The bond strength between primed specimens improved significantly compared to the control group. It was shown that primers enhanced the bond strength of acrylic resin and cast Co-Cr alloy. Kawaguchi[31] conducted a study to evaluate the effect of surface preparation on the bond strength of heat-polymerized denture base resin to commercially pure titanium and cobalt-chromium alloy. The alloy specimens were divided into five groups: 1) airborne-particle abraded with 50 μm alumina (SAND), 2) Rocatec tribochemical silica coating system (RO), 3) air-abraded followed by application of Epricord Opaque Primer (EP), 4) air-abraded followed by application of Super Bond C&B liquid (SB), 5) air-abraded followed by application of Alloy Primer (AL). Heat-polymerized denture resin was applied to the bonding area and polymerized according to the manufacturer's instructions. The halves of all specimens were thermo-cycled up to 10,000 cycles. Before thermocycling SB and AL showed significantly higher shear bond strengths than SAND, RO, EP for both metals. The shear bond strength of AL group after thermocycling was significantly higher than that of the other groups. Fonseca and colleagues[31] evaluated the efficacy of surface treatments on the shear bond strength (SBS) of resin cement to nickel-chromium (Ni Cr) alloy. Eighty cast NiCr alloy disks were divided into 8 groups, which received 1 of the different surface treatments which includes Al particles and or silane with metal primer and silica and or their combinations. The silane was RelyX Ceramic Primer and the metal primer Alloy Primer. RelyX ARC resin cement was bonded to NiCr alloy surfaces. Specimens were thermally cycled before shear mode testing. Data (MPa) were analyzed by 1-way ANOVA and the Tukey test (α=.05). Failure mode was determined with a stereomicroscope (×20). The results revealed that surface treatment was significant ($P<.001$). No significant difference was observed between silane and metal primer in the groups abraded with 50 µm and 120 µm Al particles. Particle size influenced SBS only in the groups abraded with silica-modified Al. The bonding agent did not affect SBS in the groups abraded with Al. Alloy Primer was not chemically compatible with silica-modified Al. Both mechanical (particle size) and chemical (silica/silane interaction) factors contributed to the high SBS of Rocatec with silane. Literature has evidenced marvelous work on increasing bond strength between acrylic resin and partial denture casting alloys in past by various pioneer workers. Several systems have been employed to increase the bond strength between acrylic resin and partial denture casting alloys. Some of the popular methods were silicate layer-silane coupling agents, active acrylate monomers:

polyfluormetacrylate bonding agents, tin oxide layer and bifunctional monomer (dual function group). With the exception of air abrasion, most techniques are associated with expensive equipment, technique sensitivity, and harmful chemicals. Air abrasion, however, consistently has been associated with improved bond strengths. Traditionally, denture base acrylic resin is attached to the metal framework by three types of retentive aids: mechanical, chemical or combination of both. Advantage of retentive elements weakens the acrylic resin base by creating stress and by replacing its bulk on which resin depends for strength. Failure of the resin at the interface is a common source of problems when forces exceed the capacity of the retentive mechanisms. In spite of many disadvantages of PMMA, such as polymerization shrinkage, thermal expansion & risk of de-bonding, it is one of the most popular denture base materials most often used for conventional removable and implant-supported prosthodontics.[4] Majority of predictable methods for the retention of denture base resin are beads, posts, an open lattice, a mesh, or some other macroscopic retentive design. The most commonly used acrylic retentive designs are open lattice, preformed mesh, and a metal base with bead retention. The lattice design has a high susceptibility to permanent deformation, and the open lattice design produces the greatest amount of retention for acrylic resin. External and internal finishing lines should be placed on the cast metal framework of all three types of acrylic retentive designs, wherever the acrylic resin joins the cast framework.[3,4,32,33] 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 micro leakage 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 microorganisms.[34-39] Any insufficiency of the chemical bond can directly affect the metal-resin interface. However, the difference in the coefficients of thermal expansion between the metal and the resin might create a gap at the interface, leading to micro-leakage.[40-44]

CONCLUSION

The reliability of the bond at the PMMA-to-metal interface is essential for the service longevity of prosthesis. Even if current literatures emphasis emerging trends in implant supported prosthesis and fixed partial dentures, the conventional removable partial dentures using cobalt chromium framework remain a viable treatment option especially for conditions not available to fixed replacement. So far none of the study has explained the exact bonding and its longevity on the prosthesis. Therefore the need of our is to have some long term authentic studies which could define the exact role of various surface treatments and bonding techniques to build more comprehensive understanding in this perspective. Our study results clearly showed the present scenario the bonding strength between acrylic resin and partial denture casting alloys along with their clinical applicability. Our study results could be treated as suggestive for predicting clinical outcomes for such critical situations. Nevertheless, we expect some other large scale studies to be conducted that could further set certain standard norms.

REFERENCES

1. Kourtis SG. Bond strength of resin to metal bonding systems. J Prosthet Dent 1997;78:136-45.
2. Banerjee S, Engelmeier R, Keefe K, Powers MJ. In vitro tensile bond strength of denture repair acrylic resins to primed base metal alloys using two different processing techniques. J Prosthodont 2009;18:676-83.
3. Jacobson TL, Chang JC, Keri PP, Watanabe LG. Bond strength of 4 –META acrylic resin base to Co-Cr alloy. J Prosthet Dent 1988; 60:570-6.
4. Jacobson TE, Chang CJ, Keri PP, Watanabe GL. The significance of adhesive denture base resin. Int J Prosthodont 1989;2:163-72.
5. Darbar UR, Hugget R, Harrison W. Denture fracture – a survey. Br Dent J 1994;5: 342-5.
6. Yeung AL, Lo EC, Clark RK, Chow TW. Usage and status of cobalt- chromium Removable partial dentures 5-6 years after placement. J Oral Rehab 2002;29:127-32.
7. Lamstein A, Bleckman H. Marginal sepage around acylic resin venner in gold crowns. J Prosthet Dent 1986;6:706-8.
8. Livadits GJ, Thompson VP. Etched castings: an improved retentive mechanism for resin bonded retainers. J Prosthet Dent 1982;47:52-8.
9. Yasuda N. The application of adhesive resin coating 4META in metal based prosthesis. Part I. A logical background and the basic studies on 4 META. Rev Jpn Dent 1980;450:33-9.
10. Tanaka T, Nagada K, Takeyama M. 4 META opaque resin- a new resin strongly adhesive to Ni- Cr alloy. J Dent Res 1981;60:1697-1706.
11. Ohno H, Araki Y, Sagara M. The adhesion mechanism of dental adhesive resin to the alloy relationship between Co-Cr alloy surface structure analyzed by ESCA and bonding strength of adhesive resin. Dent Mater J 1986;5:46-65.
12. Ikemura K, Kojima K, Endo T, Kadoma Y. Effect of combination of dithiooctanoate monomers and acidic adhesive monomers on adhesion to precious metals, precious metal alloys and non precious metal alloys. Dent Mater J 2011;30:469-77.
13. Tanaka T, Fujiyama E, Shimizu H, Tanaki A, Atsuta M. Surface treatment of non-precious alloys for adhesion fixed partial dentures. J Prosthet Dent 1986;55:456-62.
14. Zurasky EJ, Duke SE. Improved adhesion of denture acrylic resins to base metal alloys. J Prosthet Dent 1987;57:520-4.
15. Ferrari M, Cagidiaco CM, Borracchini A, Bertelli E. Evaluation of a chemical etching solution for Ni- Cr- Be and Co-Cr alloys. J Prosthet Dent 1989;62:576-81.
16. Kohli S, Levine AW, Grisius JR, Fenster KR. The effect of three different surface treatments on the resin bond to Ni-Cr-Be alloy. J Prosthet Dent 1990;63:4-8.
17. Kolodney H, Puckett DA, Breazeale SM, Patterson LK, Lentz LD. Shear bond strengths of prosthodontic adhesive systems

to Nickel-Chromium-Beryllium alloy. Quintessence Int 1992;23:65-9.
18. Sedberrry D, Burgess J, Schwartz R. Tensile bond strength of three chemical and one electrolytic etching systems for a base metal alloy. J Prosthet Dent 1992;66:606-10.
19. May BK, Russell MM, Razzoog EM, Lang RB. The shear bond strength of polymethyl methacrylate bonded to titanium partial denture framework material. J Prosthet Dent 1993;70:410-3.
20. NaBadalung P, Powers M, Connelly E. Comparison of bond strength of three denture base resin to treated nickel-chromium-beryllium alloy. J Prosthet Dent 1998;80:354-61.
21. Rothfuss L, Hokett DS, Hondrum SO, Elrod CW. Resin to metal bond strength using two commercial systems. J Prosthet Dent 1998;79:270-3.
22. Yoshida K, Kamada K, Atsuta M. Adhesive primers for bonding Co-Cr alloy to resin. J Oral Rehab 1999;26:475-8.
23. Sharp B, Morton D, Clark EA. Effectiveness of metal surface treatment in controlling microleakage of the acrylic resin-metal framework interface. J Prosthet Dent 2000;84:617-22.
24. Azad MA, Shetty P, Bhat S, Joseph M. Comparative evaluation of Tensile bond strength of denture base resins to surface pretreated cobalt chromium base metal alloys-an in nitro study. Int J Dent Res 2001;12:159-65.
25. Yanagida H,Taira Y, Shimoe S, Atsuta M, Yoneyama T, Matsumura H. Adhesive bonding of Titanium-Aluminium-Niobium alloy with nine surface preparations and three self curing resins . Eur J Oral Sci 2003;111:170-4.
26. Shimizu H, Kurtz SK, Tachii Y, Takahashi Y. Use of metal conditioners to improve bond strength of autopolymerizing denture base resin to cast Ti-6Al-7Nb and Co-Cr . J Dent 2006;34:117-22.
27. Kim S, Vang M, Yang H, Park S, Lim H . Effect of adhesive primers on bonding strength of heat cure denture base resin to cast Titanium and Cobalt- Chromium alloy. J Adv Prosthodont 2009;1:44-6.
28. Bulbul M, Kesim B. The effect of primer on shear bond strength of acrylic resins to different types of metals. J Prosthet Dent 2010; 103:303-08.
29. Lim HP, Kim SS, Yang HS, Vang MS. Shear bond strength and failure types of polymethyl methacrylate denture base resin and titanium treated with surface conditioner. Int J Prosthodont 2010;23:246-8.
30. Ali M. Effect of primers on shear bond strength of two types of acrylic resin to Co-Cr partial denture alloy. Pak Oral Dent J 2011;31:464-9.
31. Kawaguchi T, Shimizu H, Lassila VJ, Vallittu PK, Takahashi Y. Effect of surface preparation on the bond strength of heat polymerized denture base resin to commercially pure titanium and cobalt chromium alloy. Dent Mater J 2011;30: 143-50.
32. Fonseca RG, Martins SB, de Oliveira Abi-Rached F, Dos Santos 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.
33. Dunny A, King E. Minor connector design for anterior acrylic resin bases. A prelimnary study. J Prosthet Dent 1985;34:496-502.
34. Ikeda T, Wakabayashi N, Ona M, Ohyama T. Effects of polymerization shrinkage on the interfacial stress at resin metal joint in denture base: A non linear FE stress analysis. Dent Mater 2006;22:413-9.
35. Barclay CW, Spence D, Larid WR, Marquis PM, Blunt L. Micromechanical versus chemical bonding between Co-Cr alloys and methacrylate resins. J Biomed Mater Res 2007;81:351-7.
36. Suzuki T, Takahashi H, Arksornnukit M, Oda N, Hirano S. Bonding properties of heat polymerized denture base resin to Ti-6Al-7Nb. Dent Mater J 2005;24:530-5.
37. Mukai M, Fukui H, Hasegawa J. Relationship between sandblasting and composite resin alloy bond strength by a silica coating. J Prosthet Dent 1995;74:151-5.
38. Yanagida H, Matsumura H, Taira Y, Atsuta M, Shimoe S. Adhesive bonding of composite material to cast Titanium with varying surface preparations. J Oral Rehab 2002;29:121-6.
39. Mair L, Padipatvuthikul P. Variables related to materials and preparing for bond strength testing irrespective of the test protocol. Dent Mater 2010;26:17-23.
40. Rahim HA, Erol FB. The Effect of Different Metal Primers on Shear Bond Strength Between Heat Cure Acrylic Resin and Different Metal Alloys after Thermocycling. EC Dent Sci 2018; 17:1417-30.
41. Nagarajan MK, Sangili N, Vijitha D. Effect of Metal Primer On The Shear Bond Strength of Poly Methyl Methacrylate Heat Cured Denture Base Resin to Cast Titanium and Cobalt-Chromium Alloys: An In-Vitro Study. Acta Biomedica Scientia 2017;4(2):85-91.
42. Nishigawa G. Various Effects of Sandblasting of Dental Restorative Materials. Plos One 2016;11:1-5.
43. Rosenstiel SF. Contemporary Fixed Prosthodontics". Fifth Edition: st. Louis, Missuri 63043. by Elsevier Inc (2016).
44. Al Jabbari YS, Zinelis S, Al Taweel SM, Nagy WW. The Effect of Artificial Aging on The Bond Strength of Heat-activated Acrylic Resin to Surface-treated Nickel-chromium-beryllium Alloy. Open Dent J 2016;30:124-30.

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