Quest Journals
Journal of Medical and Dental Science Research
Volume 3~ Issue 9 (2016) pp: 07-12
ISSN(Online) : 2394-076X ISSN (Print):2394-0751
www.questjournals.org

Research Paper

Evaluation of The Shear Bond Strength of Laser Sintered Alloy, Cast Base Metal Alloys And Titanium Containing Alloy (Tilite) to Porcelain –A Comparative in-Vitro Study.

Dr. Gursahiba Sahni[1], Dr.Vijaysinh More[2]
[1]Post Graduate Student, [2]Professor
Department of Prosthodontics, Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune, Maharashtra

Received; 30 September 2016 Accepted; 15October 2016; © The author(s) 2016. Published with open access at **www.questjournals.org**

ABSTRACT: *A total of 80 samples were fabricated. Among these 80 samples, 20 were obtained from laser sintering machine (Group I), 40 were obtained using conventional casting alloys and were subdivided into Group II (A) – Ni-Cr alloy and Group II(B) – Co-Cr alloy. Remaining 20 samples were fabricated using titanium containing alloy (Tilite) – Group III. Porcelain build-up of 2 mm was then completed on all the 80 samples. Bond strength was then evaluated for all the samples using universal testing machine at a crosshead speed of 3 mm/min. Statistical analysis was completed using ANOVA test and Tukey's test for pair wise comparison . Results: The groups presented with the following mean shear bond strengths (±SD) in MPa: Group I, 33.1±7.1; Group II (A), 27.3±12; Group II (B), 32.1±6.5; Group III, 31.1±11.2 Conclusions: No significant difference was obtained in the shear bond strengths of all the alloys but laser sintered alloy showed higher bond strengths as compared to the other alloys.*

Keywords:*Laser Sintered Alloy, Tilite ,Shear Bond Strength.*

I. INTRODUCTION

Modern dentistry has led to the development of metal-free restorations. But, metal ceramic restorations are still used widely since these restorations have good clinical performance and low cost.[1]

For success of metal ceramic restorations, bond strength between metal and ceramic is of prime importance. Thus, research for newer materials and checking their bond strength with porcelain would lead to development in metal ceramic restorations. Thus recently alloys introduced for metal ceramic restorations are laser sintered alloys (Co-Cr) and titanium containing alloys (Tilite).

Metal laser sintering involves melting and laminating a metal powder with a laser on the basis of modelled CAD data. This technology has the advantage of shortening the production process, reducing the number of working hours and less material is wasted than in the cutting method using a milling device, because lamination is carried out only on the necessary part.[2]

Many studies have been conducted to compare the shear bond strengths of conventional casting alloys to porcelain, but very few studies have been conducted with newer alloys. Thus, this study was designed to compare the shear bond strengths of laser sintered alloy, cast base metal alloys and titanium containing alloy (Tilite) to porcelain.

II. MATERIALS AND METHODS

For obtaining the wax patterns for this study, a metal die was fabricated to obtain 60 samples. Wax patterns were fabricated according to ISO specification 9693.The wax patterns had a circular base of diameter 5mm, height 2mm and a cylinder on it of 4mm height and 4mm diameter. (Fig.1 & 2)

Fig.1: Metal die

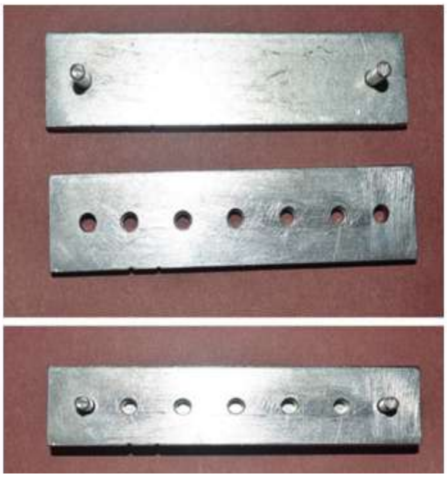
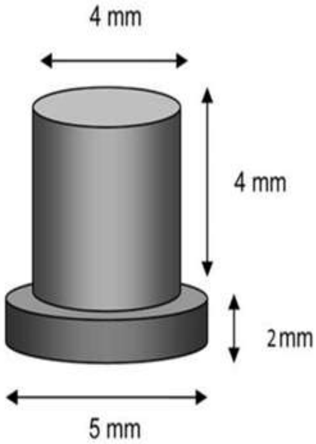


Fig.2: Dimensions of sample



Thus, 20 samples each were made for groups II (A): Ni-Cr alloy, II (B): Co-Cr alloy, III: titanium containing alloy (Tilite).

The wax patterns obtained were sprued with the help of a 12 gauge sprue wax with a reservoir at a 45-degree angle to the middle portion of the cylindrical part of the wax pattern .Each crucible former had 10 wax patterns and they were invested using phosphate bonded investment material (Bellasun,Bego).

All castings were carried out using induction casting machine .Ni-Cr ceramic alloy (Meta Cast V) and Co-Cr ceramic alloy (Wirobond C) was used for casting.

The wax patterns as described previously were made and sent to Glaze Dental Laboratories, Mumbai for the casting of the Tilite samples.

For laser sintered alloy, the samples were digitally made using the Lava Designing Software 7 at Dental Ceramists Pvt. Ltd. Mumbai .These samples were then attached with supports. The samples were then transferred to the EOSINT M270 machine, which is a laser sintering machine that lays down 20 micrometer of powdered SP2 alloy (i.e. Co,Cr,Mo and W based alloy) and sinters it with the help of the laser and then the platform moves down and again a layer of the above mentioned powder is laid down and the process continues till the entire sample is prepared. (Fig.3)

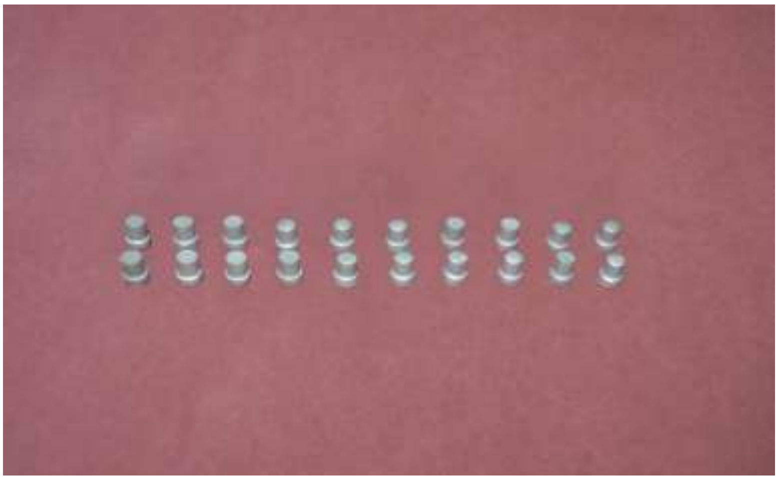


Fig.3: Samplesobtained using laser sintering

All the samples were then sandblasted at 6 atm air pressure using 100 micrometer Al_2O_3 particles for 10 seconds at 10 cm distance at 45 degree angulation. Then they were cleaned using steam water spray for 6 seconds, followed by immersion in ethyl acetate for 15 mins and then allowed to dry with absorbent paper towels. [3,4]

After the treatment of all the samples, the oxidation step is carried out for all the samples according to the manufacturer's instructions for each alloy. Sandblasting after oxidation step is carried out only for two groups i.e. Co-Cr alloy and laser sintered alloy.

Then a thin wash of a layer of opaquer (IPS Classic Opaquer) is applied over the bonding surface with the help of the flat ended ceramic brush. The samples are then placed on the ceramic tray and then placed in the furnace at 980 degree celsius and the parameters are set in the furnace according to the ceramic manufacturer's instructions.

After this the samples are removed from the furnace and allowed to cool. After the samples cool down, 2nd layer of opaquer is applied so that all the metal is hidden by the opaquer. The temperature is 970 degree celsius and all other parameters are set as per the manufacturer's instructions .After this step, the samples are removed from the furnace and allowed to cool.

After this the body porcelain is built up using a ceramic build up die.To standardise the ceramic build–up, a die containing holes of 5 mm diameter is made to accept the base of the castings. Thus for ceramic build–up a teflon lid is placed exactly at 2 mm. To facilitate this uniform 2 mm ceramic build–up, on 4 sides of the die, supports are given at the height of 2 mm and these supports stabilize the teflon lid, thus facilitating uniform ceramic build–up. But before ceramic build-up, ceramic separator is applied so that the ceramic is not stuck on the teflon during the retrieval of the die. (Fig.4)

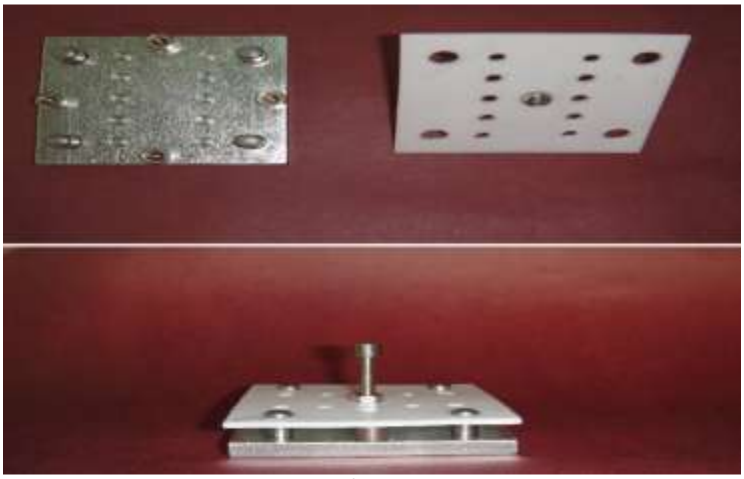


Fig.4: Metal die for ceramic build-up

With the help of the die the ceramic build–up (IPS Classic body porcelain)is completed and the samples are fired in the ceramic furnace at 920 degree celsius and the other parameters are set following the manufacturer's instructions.

After the first firing the samples are removed and allowed to cool. There is firing shrinkage seen and the samples are once again placed in the die and the build –up is done and once again the samples are placed in the furnace at 910 degree celsius and the parameters are set as per the manufacturer's instructions. (Fig.5)

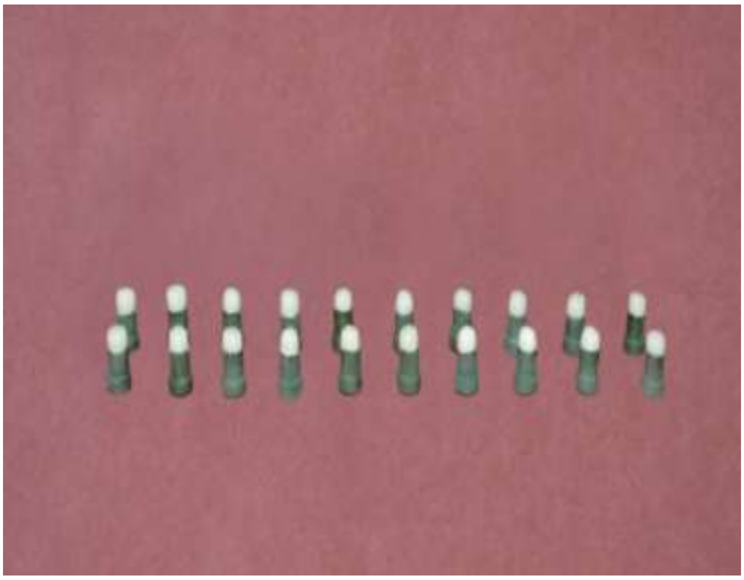


Fig.5: Final samples

After the samples are cooled, they were tested under the universal testing machine for shear bond strength between the alloy and the porcelain at the crosshead speed of 3 mm/m^2. A jig was made to stabilize the sample in the universal testing machine. (Fig.6&7).

Fig.6: Universal testing machine

Fig.7: Jig used for testing the samples in universal testing machine

III. RESULTS

The groups presented with the following mean shear bond strengths (±SD) in MPa: Group I,33.1±7.1; Group II(A),27.3±12 ; Group II(B),32.1±6.5; Group III,31.1±11.2

The ANOVA test and pair wise comparison using Tukey's test showed that there was no significant difference between the shear bond strength for all the groups (P=0.580). (Table 1,2&Fig.8)

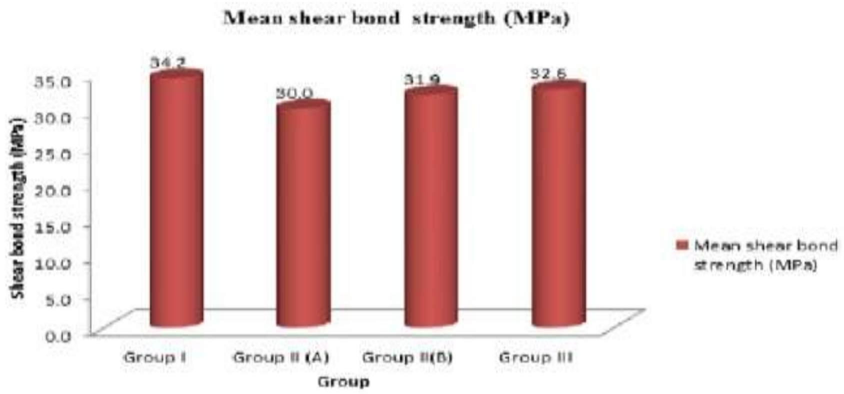


Fig.8: Bar diagram illustrating the mean shear bond strength of groups tested.

Group	Shear bond strength (MPa)					F-value	P-value
	Min	Max	Mean	SD	Median		
I	24.6	51.4	34.2	7.1	33.1	0.658	0.580
II(A)	16.0	55.7	30.0	12.0	27.3		
II(B)	20.3	41.4	31.9	6.5	32.1		
III	21.1	74.9	32.6	11.2	31.1		

Table.1: Comparison of mean shear bond strength (MPa) in groups I, II (A), II (B), III by using ANOVA test.

	I	II(A)	II(B)	III
I	-	0.514	0.875	0.955
II(A)	-	-	0.922	0.822
II(B)	-	-	-	0.995
III	-	-	-	-

Table.2: Pair wise comparison of mean shear bond strength (MPa) using Tukey's test.

IV. DISCUSSION

Metal-ceramic compatibility is an important factor in manufacturing metal-ceramic restorations. The coefficient of linear thermal expansion (CTE), thermal conductivity and the nature and strength of the bond are all factors that influence the porcelain's capacity to resist fracture during clinical use of the restoration.[5]

Studies have also reported the bond strength of ceramic to Co-Cr and Ni-Cr alloys in the range from 35 MPa to 95 MPa.[6]

Many authors [7,8] have emphasized the importance to evaluate different alloys and ceramics, using physical tests. Many tests were, thus, designed in an attempt to reproduce the complex set of forces which act on the metal-ceramic interface. Since that, there has been a great concern on the evaluation of bond strength between metal and ceramic, seeking the most ideal test to evaluate this interface, simulating the conditions observed in the oral cavity. Several tests have been used for that purpose, including shear tensions, tensile tensions, flexure tensions and torsion.[9]

Regardless of the quantity of existent test types, according to Anusavice[10], a test must fulfill two basic requirements to provide precise results: (1) the concentration of stresses must take place only along the interface. If the test produces stress concentrations outside the interface, for example, at the end of the ceramic layer or thickness alterations of this layer, the obtained results will be lower than the actual metal-ceramic bond resistance; (2) the quantity of present tensions should be zero, because if this kind of force exists, there is a possibility of ceramic fracture and "contamination" of the test resulting values.

According to the literature, there is no test that can be considered as ideal for the evaluation of the shear bond strength between metal and ceramics. There are many tests that have been used frequently with the ceramic applied around metallic patterns in a semi-circle shape, or applied over a flat metal surface, in order to avoid tensions on ceramic.

The circular-planar interface shear test, which provides easy fabrication and standardization of the specimens that are submitted to the tests. Furthermore, the matrix used in the fabrication of the specimens provides the execution only of shear strength tests. According to the requirements described by the authors, this type of test is highly reliable, because it is based on minimal experimental variables and least residual stresses at metal-ceramic interface.[9]

With the same test type, Chong et al obtained shear bond strength values of 30MPa using Ni-Cr alloys. Other authors, using the same test type, just with small methodology alterations, obtained results varying from 15MPa to 60MPa.[9,11]

Various tests have been designed and selected by researchers to evaluate metal-ceramic bond strength and the minimal value recommended by the ISO standard 9693 for metal-ceramic dental restorative systems is 25 MPa for 3-point bending test. However, it can be affirmed that this value is related more to the flexure strength of the metallic substrate than to the metal-ceramic bond strength causing difficulty when comparing different metallic substrates.[5]

Statistical analysis of the results obtained in the study were evaluated using ANOVA test and pairwise comparison was done using Tukey's test. The mean maximum load in Group I showed the maximum value (429.9 N) and the minimum value (377.7 N) was obtained for Group II(A).Also the comparison of the mean shear bond strength in Group I showed the maximum value (34.2 MPa) and the minimum value (30.0 MPa) was obtained for Group II(A).

In this study, the bond strengths showed no statistically significant difference, but it is estimated that the Group I showed higher bond strengths than the other groups because the gap caused by the additive manufacturing method widened the surface area.

Furthermore, according to Gu and Shen, the balling phenomenon occurs during layer-by-layer lamination during laser sintering. The balls formed at this time can be expected to increase the bond strength with the ceramic by increasing the surface area and by causing undercut. The balling phenomenon, which occurs typically in SLS, results in the combination of only a part of the center of a spherical particle with the nearby material .This phenomenon is affected by both the laser power and the scan speed.

The studies performed by Korkmaz and Asar, indicated that the bond strength between a Co-Cr alloy and a ceramic was 41.46-85.16 MPa, while Nieva et al reported values of 57.11-63.81 MPa. These values are similar to or slightly higher than that reported in this study. Moreover, the results reported in this study are significantly higher than the minimum bond strength (25 MPa) between the metal and the ceramic specified in ISO 9693. Hence, it may be possible to use SLS to produce metal-ceramic restorations.[2]

Bonding strength of Tilite (Ni-Cr-Ti) group is higher than that of groups II (A) and II (B). It means titanium in Tilite (Ni-Cr-Ti) advanced bonding strength because all other elements are same in both the alloys. In study of Yilmaz et al., they found that adherence strength of titanium is larger than that of Ni-Cr alloy oxides. In this study, the alloy containing Ti showed higher bonding strength compared to the alloy without the Ti. It is well consistent with the results of Yilmaz's research[12]. Therefore, the samples casted with alloy containing Ti is good to bond between metal and porcelain due to Ti oxide formation for sintering.[13]

De Melo, Travassos and Neisser (2005), they evaluated the shear bond strengths between a porcelain system and NiCr and CoCr alloys, the results were 58.5 MPa and 63.4 MPa respectively, with no significant difference in the shear bond strength values for the metal-ceramic specimens tested. These results are in consistent with the results of the present study.

But according to TolgaAkova et al (2008), who conducted a similar study have found that the mean shear bond strength was highest for the cast Ni–Cr metal–ceramic specimens (81.6±14.6MPa), the bond strength was not significantly different ($P > 0.05$) from that for the cast Co–Cr metal–ceramic specimens (72.9±14.3MPa) and the laser-sintered Co–Cr metal–ceramic specimens (67.0±14.9MPa).[3]

V. CONCLUSION

From the above conducted study, it was clear that laser sintered alloy and Tilite (Titanium containing alloy) can be used for crown and bridge restorations in prosthodontics, since their mean shear bond strength is greater than 25 MPa. On comparison of mean shear bond strength of all the groups, laser sintered alloy showed the highest mean shear bond strength value. But there is no statistically significant difference between the values of all the groups.

ACKNOWLEDGEMENTS

Dental Ceramist Laboratory, Mumbai
Glaze Dental Laboratory, Mumbai
Praj Metallurgical Laboratory, Pune

REFERENCES

[1]. Deepak K, Ahila SC, Muthukumar B, Vasanthkumar M. Comparative evaluation of effect of laser on shear bond strength of ceramic bonded with two base metal alloys: An in-vitro study Ind J Dent Res. 2013;24(5):610-615.
[2]. Eun-Jeong Bae, Ji-Hwan Kim, Woong-Chul Kim, Hae-Young Kim. Bond and fracture strength of metal-ceramic restorations formed by selective laser sintering .J AdvProsthodont 2014;6:266-271
[3]. TolgaAkova, YurdanurUcara, AlperTukayb,Mehmet CudiBalkayac, William A. Brantleyd.Comparison of the bond strength of laser-sinteredand cast base metal dental alloys to porcelain. Dent Mater 2008;24:1400–1404.
[4]. Renata Marques de Melo, Alessandro Caldas Travassos, and Maximiliano PieroNeisser. Shear bond strengths of a ceramic system to alternative metal alloys. J Prosthet Dent 2005; 93:64-69.
[5]. Stella CrosaraLopes,Valeria Oliveira Pagnano, Joao Manuel Domingos de Almeida Rollo, Monica Barbosa Leal, Osvaldo Luiz Bezzon. Correlation between metal –ceramic bond strength and coefficient of linear thermal expansion difference. J App Oral Sci.2009;17(2):122-128.
[6]. Renato Morales Joias, Rubens Nisie Tango, Jose Eduardo Junho de Araujo, Maria Amelia Junho de Araujo, Guilherme de Siqueira Ferreira Anzaloni Saavedra, *et al*., Shear bond strength of a ceramic to Co-Cr alloys. J Prosthet Dent 2008;99(1): 54-59.
[7]. IhabA.Hammad, Yousef F.Talic.Designs of bond strength tests for metal –ceramic complexes:Review of literature. J Prosthet Dent 1996;75: 602-608.
[8]. Dr. PreetiGoel, Dr. SoumitraGhosh,Dr.Jayanta Bhattacharya ,Dr.Samiran Das, Dr.SayanMajudar.Comapritive evaluation of metal –ceramic bond strength using two different specimen designs: An in-vitro Study. RUJODS 2012; 1(2):1-6.
[9]. JulianoMilczewskyScolaro, AccacioLins Do Valle. Bonding ceramic to metal: A comparison using shear tests. Rev Fob 2002;10(1):57-62.
[10]. Anusavice KJ, Dehoff PH, Fairhurst CW.Comparative evaluation of ceramic – metal bond tests using finite element stress analysis. J Dent Res 1980;59(3):608-613.
[11]. M.P.Chong and D.R.Beech,C.Chem. A simple shear test to evaluate the bond strength of ceramic fused to metal. Aust Dent J 1980;25:357-61.
[12]. H.Yilmaz,C.Dincer.Comparison of the bond compatibility of titanium and NiCr alloy to dental porcelain . J Dent1999;27:215-222.
[13]. J. S. Park, H. S. Kim, H. S. L. Kim, M. K. Son and H.C. Choe. Interfacial Bonding and Fracture Phenomena between Porcelain and Metal Coping. Pro Eng 2011;10: 1567–1572.