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Effect of Different Metal Bonding Agents on Shear Bond Strength of Ceramic to Direct Metal Laser Sintering

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Abstract

Introduction: laser sinter Cobalt Chromium metal replacing traditional casting processes of dental alloys for metal ceramic restorations, appropriate bonding of ceramic to metal is an important factor for long survival time. Twenty laser sinter cubic metal 10 mm for each sides was fabricated by software designing and CAD\CAM direct metal laser sintering technique. The twenty cubics were classified according to the type of metal to ceramic bonding agents into two groups (n=10), Ceram bond apply for group A and Crea alloy bond for group B. Samples fabricated using custom made silicon index was used to act as standardized mold for metal bond application and porcelain buildup. Instron with chisel indenter and special holding device were involve to measure the strength of bond for ceramic to laser sinter metal. The mean shear bond load of group A (688.8N) was significantly higher than that of group B (303.2N). Application of Ceram bond to metal laser sinter produces more bond strength when compare to usage of Crea bond material.

Key words: Ceramic laser, Bonding.

Introduction:

Metal ceramic crown and bridge still consider as gold stander because of history of success, low marginal gap when comparing with all ceramic restoration. Base metal dental alloys are widely used because of their low density, low cost and mechanical properties [1,2]. Now a day, Nickel chromium alloy less use as metal substructure for fixed prosthodontic because of increasing affair from the risk of nickel (Ni) that may cause allergic reaction and toxicity of beryllium (Be) [3,4] .Therefore nickel chromium alloys can be replace by cobalt chromium alloys to overcame the problem of nickel chromium alloys [5,7]. Laser Sintering is replacing traditional casting processes, with several advantages: low cost, accurate fit, reduced marginal adjustments and no casting defects [8]. One of the factors that affected bond between metal and porcelain was appropriate oxidation of metal surface [9- 11]. In spite of the oxide layer was already present on base metal alloys, more oxide layers were formed on metal surface during porcelain firing which lead to defect in bonding by initiation of fracture in thick oxide layer [12, 13]. Several attempts were employed to overcome this problem which are changing in alloys composition and metal surface treatment including air abrasion [14,15] firing temperature of opaque layer [16], degasification [17] and usage of metal bonding agents [18]. However, the effectiveness of metal bonding agents to laser sinter Co-Cr alloys is yet unknown .This study was done to estimate the effect of different metal bonding materials on ceramic bond strength to Co - Cr metal laser sinter.

Materials and methods:

Materials involved in present study are : Selective laser metal sinter , Ceram bond (bredent , Germany) , Crea alloy bond (Creation willi geller , Germany) , feldspathic porcelain (VITA Zahnfabrik, Germany) used as porcelain veneering and silicon rubber base putty impression (Zhermach , Italy). Fabrication of laser

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metal sintering was divided into two phases: software designing (CAD) and metal laser sintering by additive technique (CAM). The software phase include: designing cubic figure with dimension 10 mm for each sides as shown in Fig. (1) using Free CAD program, the designed cubic figure must save as .stl file, to accommodate laser sinter machine software. The .stl file was send via E-mail to direct metal laser sinter center in Ankara- turkey. After that the designed cubic figure was laser sinter by additive technique. Sample grouping: after the metal cubic was complete, it divided into two groups each group consist of ten sample (n = 10). Ceram bond was applied to one group (Group A) and Crea alloy bond was used for other group (Group B).The same porcelain type was used for all group.

Sample construction:

A silicon putty index was done to standardize the porcelain build up for all samples[20].Silicone index was fabricated by building up composite in rectangle shape with dimension 3 * 3 * 10 mm. On the middle surface of cubic metal then composite curing. The composite was place to create space in silicone index to be fill with porcelain. Putty impression material was mixed then applied over the composite and metal covering all cubic metal sides except the bottom Fig. (2). After setting the silicon was cut using surgical blade into two part Fig. (3) .The two piece of silicone were separated and composite material was removed Fig. (4).

One of cubic metal was place in silicon index, the two piece of index reassembly and secure using elastic to avoid separation then metal bond was place over the expose area after that separate the index and place metal cubic in ceramic furnace, Ivoclar Vivadent Programat EP 3010 Firing and Pressing Furnace. When metal bond firing cycle complete , wait until it cool then reinsert it in silicone index and porcelain was mixed and condense using brush into index until fill the space completely Fig. (5,6) . Finally reinserted into porcelain furnace for firing. The rest of sample was processed with the same producer, ten of sample use Ceram bond and other ten Crea bond was used.

Test method:

Universal testing machine was used to measure the shear bond strength, special holding device was employed to hold the samples during test , which consist of two flat separated part that specimen hold between them and secure by four screw Fig. (7). Chisel type indenter fixed to Instron with cross head speed 1mm/min. Adjustment for sample position was applied until the indenter must touch the cubic metal so that force applied to junction between metal and ceramic Fig. (8). Load that cause porcelain separation was record for all specimens.

Results:

Shear bond value between laser sinter metal and ceramic veneering was compare among the group. The mean of Ceram bond group was 688.8 newton, while Crea bond was 303.2 newton Table (1). One way ANOVA was done Table (2), and statical result show that Ceram bond group was highly significant difference from Crea bond group. Table show value of standerd deviation, mean, maximum and minimum of shear bond strength.

Discussion:

Many methods were described in publications to measure the bond value between metal and porcelain, including twist, shear, tension, flexural mode or the combination of flexural and twist modes. However each method had benefits and drawbacks[20]. Among these test methods, shear was consider as the best way to evaluate the bond value between two materials [8, 21, 22]. During the shear test, the materials separated as a result of shear pressure, whereas in three point bending test the two materials tend to be separate because of tensile stress [8]. Therefore, shear test was selected to be use in this study. In order to measure the shear bond value between laser sinter metal and ceramic, Instron with chisel indenter and custom made samples holding device were

used so that load predominantly concentrate on metal ceramic interface and accurate interfacial shear bond value obtained . Effect of different metal bonding materials was measured and the result show that the bond value of porcelain to laser sinter metal range from 150 – 798 newton for both group. Ceram bond was highly remarkable effect on shear bond strength when compare with Crea bond, and this may be due to ingredient of both metal bonding agent which are not announced [23].several studies show that Si-ingredient in metal bonding agents was act as absorbing excessive oxides that are formed on the alloy surface during porcelain firing[24,25]. While other metal bonding agents contained Ti-element which play important role in preventing excessive oxidation layer formation on metal surface during firing cycle[25-27] and these elements may cause the increase in porcelain-metal bond strength. Further study may need to discover the metal bonding agents ingredient used in this study that effect the bond strength using EDS analysis . There was no foregoing identical research to compare with, however Yoshito et al [23] compare the effect of metal conditioning agent on bond strength of ceramic to cobalt chromium alloy and recommended the use of metal bonding materials to increase the bond value between cobalt-chromium alloys and porcelain veneering.

Conclusions:

Within limitation of this study, application of Ceram bond to metal laser sinter was produce more bond to ceramic when compare to the usage of Crea alloys bond material.

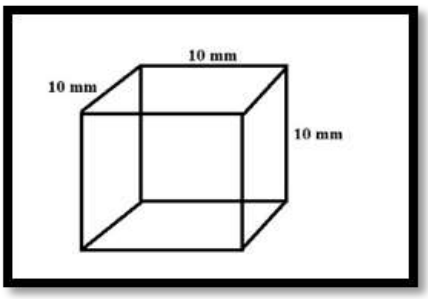

Fig.(1): Cubic dimension.

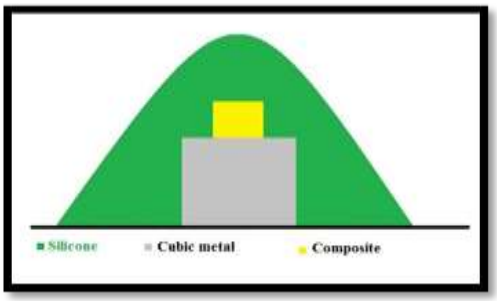

Fig.(2): Diagram show putty impression material place over cubic metal and laser sinter.

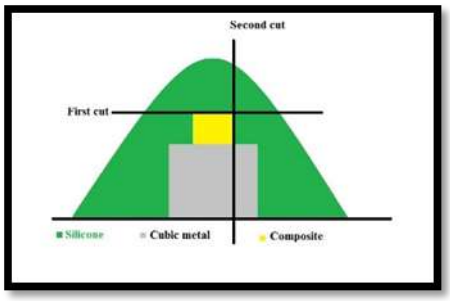

Fig.(3):Diagram of show the position of silicone cutting.

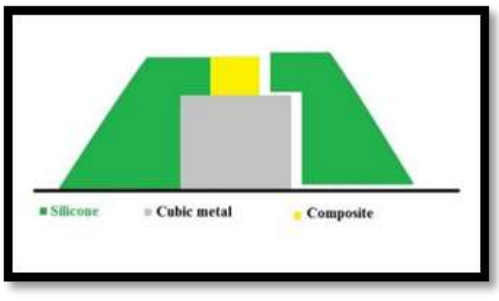

Fig.(4): Diagram represent the two piece of silicone index.

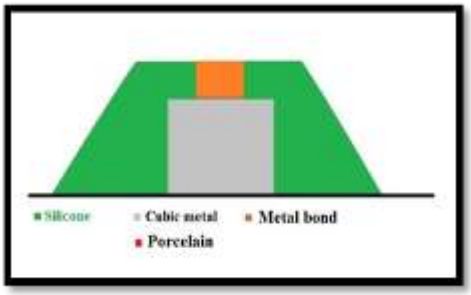

Fig.**(**5**)**: **D**iagram of application of metal bond and ceramic using silicone index**.**

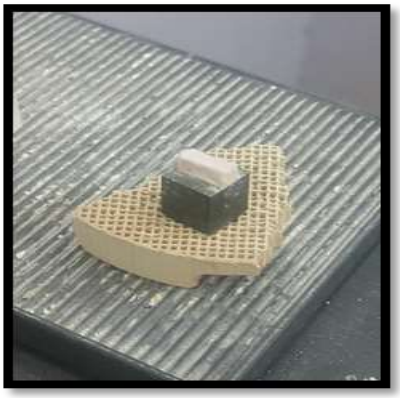

Fig**.(6)**: Cubic metal laser sinter with porcelain before firing.

Fig**.(7):** Sample in special holding device and ready for shear test.

Fig. (8): Sample in special holding device and ready for shear test.

Table (1): Mean, standard deviation, minimum and maximum shear bond strength value of both group.

Metal bond	Mean	Std. Deviation	Min	Maxi
Ceram Bond	688.80	66.203	635	798
Crea alloy bond	303.20	115.657	150	490

Table (2): Anova test between groups.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	743436.800	1	743436.800	83.723	.000
Within Groups	159835.200	18	8879.733		
Total	903272.000	19			

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