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Evaluation of the Bond Strength of Ceramic to Nickel- Chromium Alloy with various proportions of Recast Alloy - An Invitro Study.

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Abstract: Aim: *The purpose of this study was to evaluate the bond strength and point of failure between ceramic and Nickel-Chromium alloys with various proportions of fresh and recast alloy.*
Materials and method: *Fresh and once recast nickel-chromium alloy were used in various proportions and divided into 5 groups, group A, B, C, D, E with 100%, 75%, 50%, 25% and 0% of fresh alloy respectively with 10 specimens in each group. All the metal specimens were veneered with VMK 95 ceramic and were then subjected to three point bend test and SEM analysis.*
Results: *The values were statistically analyzed using One-way ANOVA and Bonferroni test. One-way ANOVA analysis showed a statistically significant difference ($p < 0.001$) in metal ceramic bond strength which decreased as the percentage of once recast Nickel-Chromium alloy increased. There was no statistically significant differences between Groups A, B and C but Group D and E showed statistically significant differences when compared with group A. SEM analysis showed, majority of the failure occurred at the metal-ceramic interface.*
Conclusion: *When more than 50% fresh alloy was used in the casting procedure, the bond strength was found to be superior to that when less than 50% of fresh alloy was used. Upto 50% of once recast alloy does not have significant effect on the metal-ceramic bond strength.*
Keywords*: Base metal alloys; porcelain; bond strength; metal-ceramic; recasting.*

I. Introduction

Metal ceramic restorations are continuing as the most commonly used esthetic material for fixed dental prosthesis. Ceramic-metal restorations possess the beauty of porcelain and the strength of a metal substructure [1]. Increased cost of precious metal alloy has resulted in subsequent demand for semiprecious and non precious base metal alloys like chrome-cobalt and nickel chromium alloys in dental casting procedures.

In current scenario, the demand of these base metal alloys has resulted in substantial increase of their cost to a point of commercial concern. Hence, today it has become utmost important that dentists and technicians be cost conscious about the materials they use for fixed prosthesis. After casting, the sprue former, runner bar and buttons are usually discarded as scrap. It would be economically advisable to reuse alloys in combination with fresh alloy.

Effect of recasting of base metal alloy is still controversial, as recasting reduces the mechanical properties like tensile strength, yield strength and modulus of elasticity [2,3]. Studies conducted by *Nelson et al* [4] and *Hesby et al* [5] concluded that recasting the base-metal alloys had no effects on the physical properties and *Presswoood* [6] reported that after six subsequent castings, no significant changes in alloy composition was found. Even though studies have shown that alloy can be reused, but the effect on its bond strength with ceramic is not well documented. The purpose of this study was to evaluate the bond strength between ceramic and Nickel-Chromium alloys with various proportions of fresh and recast alloy and to evaluate the point of bond failure by using SEM analysis.

II. Materials and Method

In this study, casting was done using fresh and single cast scrap alloy of various proportions by weight. Samples were divided into 5 groups of 10 each based on the proportion of fresh and recast alloy (Table 1).

Metal specimens were prepared according to ISO 9693[7] specifications ($25.0\times3.0 \times 0.5$ mm). Patterns were cut from the casting wax sheets of 0.5mm thickness and length of 25mm and width of 3mm. The sprued wax patterns were then attached to the crucible former incorporating 3-4 patterns in each casting ring (fig 1). All the patterns were invested using phosphate bonded investment (Bellasun, Bego, Germany) according to manufacturer's instructions. Nickel-Chromium alloy (Bellabond Plus, Bego, Germany) was selected as casting alloy. Fresh alloy and various proportions of once recast alloy was used for casting as shown in Table 1. Casting was done by using induction casting machine (Fornax, Bego, Germany). After devesting, castings were retrieved and routine finishing procedures were followed. The metal specimens were then sand blasted with alumina particles (110µ size) at $2kg/cm^2$ pressure.

VMK 95 ceramic (VITA Zahnfabrik H. Rauter GmbH & Co. Germany) opaque and body ceramic were used for veneering the castings. Ceramic build up was done as per the dimensions of 8mm in length, 3mm in width and 1mm thick at the centre of metal strip (Fig 2). These specimens were then subjected to three point bending test in universal testing machine as per the ISO 9693 [7] and DIN draft 13,927 [8] testing procedures. Specimens were supported by fixtures that were placed at 20mm distance and ceramic part facing downwards. The minimum load at which the bond failure occurred was recorded in Newtons and bond strength was calculated using the formula (Table 2):

$$\sum = 3PI / 2bd^2$$

[Where P equals maximum force (N), I equals distance between the supports (mm), b equals width of the specimen (mm), d equals thickness of specimen (mm), and ∑ equals bond strength (MPa)]

After bond strength evaluation all specimens were subjected to SEM evaluation (fig 3). All the procedures were done in standard conditions and according to manufacturer's instructions.

III. Results

The values were statistically analyzed using One-way ANOVA and Bonferroni tests. Table 3 shows the mean values and standard deviation of bond strength of various groups. One-way ANOVA analysis (Table 4) showed a statistically significant difference ($p < 0.001$) in metal ceramic bond strength as the percentage of once recast Ni-Cr alloy increased. Group A was taken as the control group with which the remaining groups were compared statistically using Bonferroni test (Table 5). There was no statistically significant difference in bond strength between groups A, B and C but group D and E showed statistically significant differences when compared with group A. All the specimens were subjected to SEM analysis to evaluate the point of bond failure. Majority of the failure occurred at the metal-ceramic interface (Table 6). In all specimens of Group D and Group E the point of bond failure was at the metal-ceramic interface, whereas in specimens of group A, B and C few specimens fractured at the interface as well as within the ceramic.

IV. Discussion

The results of current study showed that recasting of Nickel-Chromium alloys had a negative effect on the bond strength of metal ceramic depending upon the proportions. As the amount of recast alloy was increased, the bond strength decreased. Bond strength decreased significantly, when more than 50% of recast alloy was used.

One of the main requirement of good bonding is the wettability of metal surface with porcelain during sintering [9,10,11] and studies have shown that clinically acceptable bond strength is achieved mainly by chemical bonding [12,13,14]. A continuous electronic structure is formed from the metal to porcelain through the oxide layer, forming a chemical bond between metal and porcelain [15,16]. Mechanical interlocking increases the bond strength as documented by McLean [17] and Philips [18].

The results of SEM analysis in this study showed that majority of bond failure occurred at the porcelain-metal interface. Many studies documented in literature suggest that decrease in metal-ceramic bond strength is mainly due to change in the oxide layer at the interface either due to increase or decrease in the thickness of oxide layer [2,4,19,20].

In current study, results showed best bond strength value with group A, and group B and C showed similar bond strength values whereas group D and E showed comparatively inferior bond strength. Decrease in bond strength may be due to increased percentage of recast metal which can contribute to increased frequency of interfacial voids, excessive oxidation, loss of elements and change in physical properties of alloy, change in grain structure or incorporation of impurities etc. Further studies are required to evaluate the surface characteristics at the interface, change in composition of alloy and characteristics of oxide layer.

V. Conclusion

This study was done to evaluate the bond strength between ceramic and Nickel-Chromium alloys with various proportions of fresh and single recast alloy and to evaluate the point of failure. Bond strength was found to decrease as the proportion of recast alloy increased. When more than 50% fresh alloy was used in the casting procedure, the bond strength was found to be superior to that when less than 50% of fresh alloy was used. Majority of the bond failure occurred at the metal-ceramic interface. Metal-ceramic interface is shown to be the weakest link.

Tables and figures

Table 1
Combination of fresh and recast alloy

GROUPS	% Of fresh Alloy By Weight	% Of Once Reused Alloy By Weight
Group A	100	0
Group B	75	25
Group C	50	50
Group D	25	75
Group E	0	100

Table 2
Bond strength of the specimens of each group

Sl No	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**
1	27.15	26.23	27.16	23.48	21.15
2	26.38	28.52	23.12	22.64	20.83
3	27.64	26.18	26.52	27.14	19.05
4	22.54	32.54	22.03	25.79	21.63
5	27.79	27.65	26.32	24.35	20.05
6	26.52	21.24	24.71	23.68	28.63
7	33.16	23.12	24.62	22.71	22.15
8	28.42	27.34	28.01	20.18	21.47
9	27.36	28.12	25.83	23.54	21.82
10	28.23	24.32	29.14	22.93	20.59

Table 3
Mean values and standard deviation of bond strength of various groups

Groups	N	Mean	Standard deviation
Group A	10	27.5190	2.5921
Group B	10	26.5260	3.1486
Group C	10	25.7460	2.1762
Group D	10	23.6440	1.8783
Group E	10	21.7370	2.5889

Table 4
One-way ANOVA Analysis

	Df	**F**	**Sig.**
Between Groups	4	8.588	.000 (P<0.001)
Within Groups	45	-	-

Table 5
Comparison of group "A" with remaining groups Bonferroni Test

Group	**Group**	**Sig**
A	B	1.000
	C	1.000
	D	0.012
	E	0.000

Table 6
SEM analysis for point of debonding or bond failure

Point of failure	Group A	Group B	Group C	Group D	Group E
Ceramic	2	2	1	0	0
Metal	0	0	0	0	0
Metal-Ceramic interface	8	8	9	10	10
Total	10	10	10	10	10
Percentage of bond failure at Metal-Ceramic interface	80%	80%	90%	100%	100%

Fig 1
Sprued wax pattern

Fig 2
Metal-Ceramic Specimen

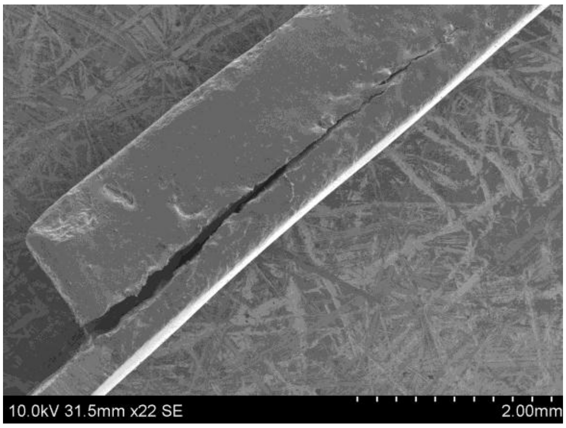

Fig 3
SEM analysis showing Point of bond failure at the metal ceramic interface

References:

[1]. Lubovich RP, Goodkind RJ. Bond strength studies of precious, semiprecious, and nonprecious ceramic-metal alloys with two porcelains. J Prosthet Dent 1977 Mar;37(3):288-99.
[2]. Issac L, Bhat S. Effect of re-using nickel-chromium alloy on its ultimate tensile strength, yield strength and modulus of elasticity. Indian J Dent Res 1998;9:13-17.
[3]. Harcourt HJ, Riddihoug M and Osborne J. The properties of nickel-chromium alloys containing boron and silicon. Br Dent J 1970;12(9):419.
[4]. Nelson DR, Palik JF, Morris HF and Comella MC. Recasting a nickel-chromium alloy. J Prosthet Dent 1986 Nov;55(1):122-27.
[5]. Hesby DA, Kobes P, Garver DG, Pelleu GB. Physical properties of a repeatedly used nonprecious metal alloy. J Prosthet Dent 1980 Sep;44(3):291-93.
[6]. Presswood RG. The castability of alloys for small castings. J Prosthet Dent 1983 July;50(1):36-39.
[7]. International Organization for Standardization: ISO9693:Metal-ceramic dental restorative systems. Geneva, ISO, 1999, pp. 1-14.
[8]. German Standard Institution, DIN 13927 Metal-ceramic system. Berlin, Beuth, 1990, pp. 1-18.
[9]. Mc Lean JW. The metal ceramic restoration. Dent Clin North Am 1983;27:747-61.
[10]. Craig RG: Restorative Dental Materials (ed7). St. Louis, CV Mosby Co,1985, pp,454-55.
[11]. King BW, Trippp HP, Duckworth WH. Nature of adherence of porcelain enamels to metals. J Am Ceram Soc 1959;42:504-25.
[12]. Riley EJ. Ceramo-metal restoration-state of the science. Dent Clin North Am 1977;21:669-82.
[13]. Derand T. Residual stress in metal-ceramic crowns. J Oral Rehabil 1981;8:69-74.

[14]. Kelly M, Asgar K, OBrein WJ. Tensile strength determination of the interface between porcelain fused to gold. J Biomed Mater Res 1969;3:403-8.
[15]. Borm MP, Pask JA. Role of “adherence oxides” in the development of chemical bonding at glass metal interfaces. J Am Ceram Soc 1966;49:1-6.
[16]. Pask JA, Fulrath RM. Fundamentals of glass to metal bonding VIII. J Am Ceram Soc 1962;45:592-6.
[17]. McLean JW: The Science and Art of Dental Ceramics, Vol 1.The nature of dental ceramics and their clinical use. Chicago: Quintessence, 1979, pp,63-71.
[18]. Philips RW: Skinner’s Science of Dental Materials (8^{th}ed), Philadelphia; WB Saunders, 1982, pp, 25,523-24.
[19]. Nikellis I, Levi A, Zinelis S. The effect of soldering on metal-ceramic bond strength of a Ni-Cr base alloy. J Prosthet Dent 2005 Nov;94(5):435-9.
[20]. Ucar Y, Aksahin Z, Kurtoglu C. Metal ceramic bond after multiple castings of base metal alloy. J Prosthet Dent 2009 Sep;102(3):165-71.