ISSN 2236-8035
Archives of Oral Research, v. 7, n. 2, p. 177-182, May/Aug. 2011

Shear bond strength of porcelain veneer with fresh and recasting Ni-Cr alloy: a comparative *in vitro* study

Resistência de união ao cisalhamento entre porcelana de recobrimento e liga de Ni-Cr nova e refundida: estudo in vitro *comparativo*

Santosh Kumar Rajalbandi[a], Vinaya Kumar[b], Suresh Sajjan[c]

[a] M.D.S. assistant professor, Department of Prosthodontics, Navodaya Dental College and Hospital, Raichur, Karanataka - India, e-mail: drsrajalbandi@gmail.com
[b] M.D.S. professor, Department of Prosthodontics, College of Dental Science, Davangere, Karanataka - India.
[c] M.D.S. professor, Department of Prosthodontics, Vishnu Dental College, Bhimavaram, Andhra Pradesh - India.

Abstract

Introduction: Dental alloys are routinely subjected to multiple casting procedures. Repeated casting of the same alloys may cause loss of trace elements (such as Sn, Si, Mn, etc.) that are essential for the metal ceramic bond. A common practice is to include a proportion of new metal with the previously cast metal that is thought to replenish the lost elements. **Objective**: The study was done to evaluate the effect of variation in percentage of recasted Ni-Cr alloy used and to compare the effects with the shear bond strength of porcelain to the fresh ingot Ni-Cr alloy. **Materials and methods**: Uniform patterns were fabricated, invested and casting was done in five different combinations of fresh and recast alloy. A hundred percent fresh alloy; 25% recast with 75% fresh alloy; 50% recast and 50% fresh alloy; 75% recast and 25% fresh alloy; 100% recast alloys. After uniform porcelain application and firing, the specimens were subjected to shear bond test using a universal testing machine. Data were statistically analyzed using Duncans's multiple comparison test. **Results**: The results showed that the mean shear bond strength of the 100% fresh alloy was maximum and 100% recast alloy was least among the groups tested. The mean shear bond strength of castings obtained from 100% fresh, 25% recast, and 50% recast alloy were similar to each other and showed statistically significant difference when compared to the 100% recast group. Seventy five percent recast group did not show statistically significant difference with 100% recast alloy.

Conclusion: It can be concluded that minimum of 50% fresh alloy for casting is a safe margin for recasting Ni-Cr alloy. s.

Keywords: Porcelain. Bond. Dental alloy. Fresh. Recasting.

Resumo

***Introdução**: Ligas dentárias são rotineiramente submetidas a procedimentos de fundição múltipla. Fundições repetidas da mesma liga podem causar perda de elementos-traço, tais como Sn, Si e Mn, os quais são essenciais para a união entre metal e cerâmica. Uma prática comum é a de incluir uma proporção de liga nova com o metal anteriormente fundido visando repor esses elementos perdidos. **Objetivo**: O presente estudo avaliou o efeito da variação da porcentagem de liga de Ni-Cr refundida na resistência de união ao cisalhamento com porcelana, comparado a liga de Ni-Cr nova. **Materials e métodos**: Padrões uniformes foram confeccionados, incluídos e fundidos sob cinco diferentes combinações de liga nova e refundida: 100% liga nova; 25% liga refundida + 75% liga nova; 50% liga refundida + 50% liga nova; 75% liga refundida + 25% liga nova; 100% liga refundida. Após a aplicação uniforme da porcelana e sua posterior cocção, as amostras foram submetidas ao teste de cisalhamento utilizando uma máquina universal de ensaios. Os dados foram analisados estatisticamente através do teste de comparações múltiplas de Duncan. **Resultados**: Os resultados mostraram que a maior resistência de união ao cisalhamento para a liga 100% nova, e a menor resistência para a liga 100% refundida. A resistência de união ao cisalhamento das fundições com 100% de liga nova, 25% e 50% de liga refundida foi similar e estatisticamente diferente do grupo com 100% de liga refundida. O grupo com 75% de liga refundida não mostrou diferença estatisticamente significante com o grupo de liga 100% refundida. **Conclusão**: Pode-se concluir que o mínimo de 50% de liga nova para a fundição é uma margem de segurança para a refundição de ligas de Ni-Cr.*

***Palavras-chave**: Porcelana. União. Liga dental. Nova. Refundição.*

Introduction

The Development of “Taggarts” technique of casting by lost wax process into the Dentistry gave an impetus to use alloyed metals as a restoration (1). Most of the dental laboratories commonly use the sprue and button from a previous casting as a part of the melt for the new casting (2, 3). This practice is especially detrimental with ceramometal alloys, which contain trace elements essential for bonding to porcelain. Repeated casting of these alloys may cause sufficient quantities of these elements to be lost so as to affect the bond between the metal and the porcelain (4-6). Studies have shown that recasting the used alloy up to 25% did not show any deleterious effects on the bond strength of porcelain (2). A combination of cast alloy with 50% new alloy produced the highest bond strength values. Further use of pooled alloy with an unknown casting history was not recommended since reduced bond strength were observed in their study (6). Among all the base metal alloys systems, the most popular are Ni-Cr alloy (1). The properties of fresh and used alloys are not well understood and also there is sparse experimental justification for the amount of fresh and used Ni-Cr alloy to be composed for casting in porcelain fused to metal restorations. The objective of this study was to evaluate the effect of recasting Ni-Cr alloy on the metal ceramic shear bond strength.

Materials and methods

Preparation of two piece mold

Shear bond testing was accomplished using a steel mold, which consisted of two parts. The upper part was a cylinder of diameter 20 mm x 20 mm height and had a through hole at center of diameter 6 mm. The lower part had a base of similar diameter as the upper part and a semi circular bar or half cylinder of diameter 6 mm x 20 mm height extending from the center of the base. It was so designed that the extended portion of the lower part fits into the space present in the upper part to create a half cylinder space of diameter 6 mm x 20 mm height. This acted as a mold space for the fabrication of wax pattern (Figure 1). Further, the same mould was used as jig for shear testing and termed as 2 piece jig.

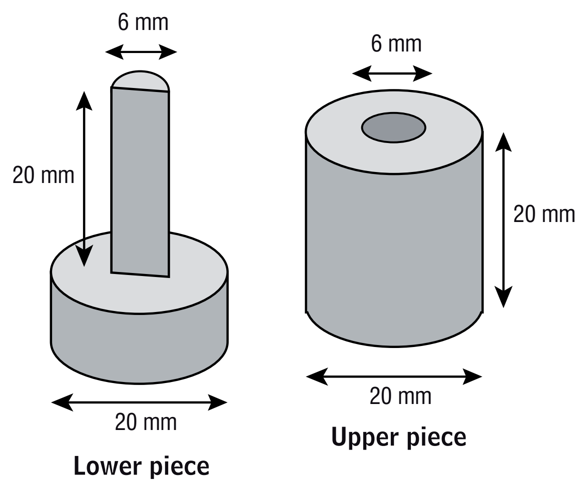

Figure 1 - Two piece mould or jig
Note: The extension of the lower piece is inserted into the cylindrical space of the upper piece, the arrangement creates the half cylindrical space for the fabrication of wax patterns and further the same space helped in shear testing.

Fabrication of the alloy specimen

The inlay pattern wax was melted in wax bath and flown into the mold. Total of 60 wax patterns for 5 groups with 12 patterns in each group of equal dimensions were obtained. Following manufacturers instruction, each group were invested separately with phosphate bonded investment material and casting was done (7). An induction casting machine was used to prevent any contamination by gas torch (8) and fresh crucible for each group was used for casting to prevent the possibility of contamination. After casting, specimens were retrieved and cleaned by sand blasting with 110 μ Al_2O_3. The separated specimens were finished using tungsten carbide bur such that these castings fit into the mold space present in two piece mould. Precisely fitting specimens were selected for the study. After air particle abrasion and ultrasonic cleaning, the sprue, runner bar and the button were used for recasting along with fresh ingot alloy to prepare specimens of the other groups by changing the alloy percentage for the respective group. Alloy groups tested were:

- Group 1: Control group - (100% fresh ingot alloy);
- Group 2: 25% recast (9.80 g) + 75% fresh ingot alloy (30.06 g);
- Group 3: 50% recast (18.35 g) + 50% fresh ingot alloy (18.13 g);
- Group 4: 75% recast (28.53 g) + 25% fresh ingot alloy (9.47 g);
- Group 5: 100% recast alloys.

Ceramic veneering

As per manufacturer instructions (Heraeus Kulzer – Metal Ceramics Manual) (7), the specimens were sand blasted with 110μ Al_2O_3 at approximately 50 Psi pressure in a sand blasting machine for 30 sec. The surface of the casting was cleaned before oxidation in a ultrasonic cleaning bath for 10 min (9).

For uniform application of the porcelain, an acrylic block was prepared, which had half cylinder shaped depression at the center that exactly received the casting. Two ridges one on either side of the depression with 1.4 mm height and 3 mm width gave the optimal ceramic thickness of 1.1 – 1.2 mm after completion of firing). The casting was placed into the depression present in the acrylic block. Glass slides covered the block on either side of the ridge in such a way that it leaves a slot of 6 mm x 3 mm x 1.4 mm (width of the casting x width of the ridge on the acrylic block x height of the ridge) into which layers of porcelain were placed and subjected to firing. The dentine material was applied and was condensed by vibration and liquid was blotted out before subjecting to firing (Figure 2). As the material shrinks after firing, the level of the porcelain became less than the level of the glass slides, and the difference was filled with enamel porcelain and were subjected to firing. Excess ceramic other then the veneered surface was trimmed off using an alpine stone and the porcelain surface was subjected to glaze firing. This completed the preparation of the specimens for one group. Similarly, the veneering of specimens of other groups was prepared. The prepared samples of all the groups were subjected to shear stress to compare the bond strength of different groups.

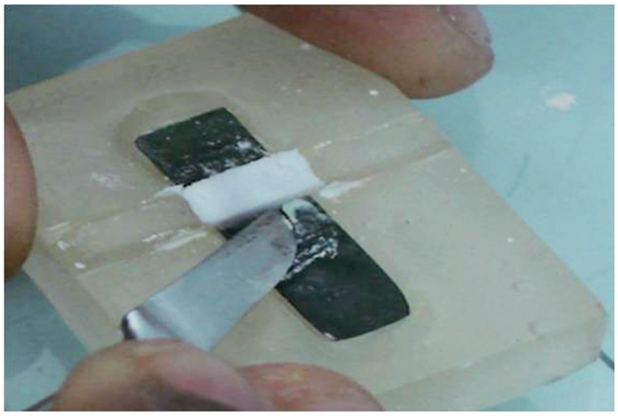

Figure 2 - Ceramic build up using acrylic block

Shear bond test

The two piece jig was mounted on to the base of a universal testing machine (Model 0195 – H5KS Series, Hounsfield, UK). The test specimens were inserted into the half cylinder space of the jig. The part of the specimen below the veneered area was inserted into the jig, the veneered part remained outside (Figure 3). The load was applied to test the bond strength at a cross head speed of 0.5 mm /min to the head of the specimen in the direction parallel to the specimen and the mold space in the jig. As the load was applied, the upper part was forced into the jig with generation of forces at the porcelain metal interface created shearing stress at the interface of the fired porcelain and the alloy. Maximum shear load at the point of failure was recorded and shear bond strength were calculated by dividing the force at which the bond failure occurred with the bonding area (10).

Figure 3 - Specimen mounted in jig for shear testing in universal testing machine

Shear bond strength = Force recorded/area (6 mm x 3 mm)

Similarly, the strength required for the bond failures for all the specimens were calculated.

Results

The results were analyzed by Duncans's multiple comparison test at a confidence level of 5% (Table 1).

Table 1 - Mean, standard deviation (SD) and pair wise comparison of groups with respect to shear bond strength (NF/ mm_2) by Duncan's multiple comparison tests procedure

Groups	Group 1	Group 2	Group 3	Group 4	Group 5
Mean (SD)	16.92 (3.60)	16.696 (4.02)	16.52 (3.22)	14.25 (1.99)	12.71 (1.45)
Group 2	0.8819	-			
Group 3	0.8056	0.9092	-		
Group 4	0.1135	0.1338	0.1407	-	
Group 5	0.0155*	0.0193*	0.0212*	0.3153	-

Note: * Significant at 5% level of significance ($p < 0.05$)
Source: Research data.

The mean shear bond strength of 100% fresh ingot alloy was maximum and the 100% re-casted alloy was the least among the groups tested. The mean shear bond strength of castings obtained from 100% fresh, 25% recast, and 50% recast alloy were not statistically significant different among each other ($p > 0.05$), but showed statistically significant difference when compared to the 100% recast group ($p < 0.05$). The 75% recast group did not show statistically significant difference with 100% recast alloy ($p > 0.05$).

Discussion

Ceramic metal restorations combine the beauty of porcelain and the strength of metal substructure. Most of the dental laboratories commonly use the sprue and button from a previous casting as a part of the melt for the new casting (2, 3). The rationale for reusing of casting alloys is based on economy, since it reduces reclaim costs and alloy inventory (11). The hardness, tensile strength and percentage of elongation of non-precious metal alloy used repeatedly for fixed partial denture castings showed no significant differences between the four generations of castings for any of the physical properties tested, indicating that the metal can be recasted for at least four generations (12). However, this practice is especially important with ceramic alloys, which contain trace elements essential for bonding to porcelain. Repeated casting of these alloys may cause loss of these elements and affect the bond between the metal and porcelain (4, 5).

The present study was designed to achieve uniform thickness of different ceramic layers with the help of acrylic block. The flat portion of the half cylinder casting provided a good surface for uniform application of the ceramic layers. Custom made two piece mould used for making uniform wax patterns and also for shear bond testing where it acted as jig. The designing of the mould helped to achieve precise fit of the specimens into the jig yet without having any frictional resistance that may alter the outcome of the results.

The obtained results showed the bond strength of group 1 was maximum and group 5 was the least. It could be due to the presence of trace elements in required proportions and have less or no contaminated alloy (4, 5). Some trace elements like Si, Sn and Mn were found to show the peak at the interface of metal to ceramic and they play a important role in the bonding of porcelain to metal (13, 14).

The bond strength values of group 2 and 3 were near to group 1 and did not show statistically significant difference when compared with each other. Group 4 showed lower strength values than group 1, 2 and 3, which were not statistically significant different when compared with each other. The bond strength values of group 1, 2 and 3 showed statistically significant difference when compared with group 5. The reason could be the presence of adequate trace elements required for the bond (2, 3). The bond strength values of group 4 had no statistical difference with group 5.

The decreased bond strength values of group 4 and 5 can be attributed mainly due to the loss of some of the elements required for bonding (13), or change in the thickness of the oxide layer. It is a known fact that increased oxide layer thickness decreases the bond strength (4). Studies indicated that alloys containing a high Cr content (16%-27%) and a minimum of 6% Mo exhibited a uniform oxide layer. Whereas alloys containing lower levels of Cr and Mo did not exhibit homogeneous surface oxide layer (14). During the process of recasting some of the key ingredients similar to Cr-Mo may have lost or altered that resulted in change in the properties of the oxide layer. Although the buttons and sprues may be sand blasted and cleaned, the contents of the metal oxides cannot be completely eliminated under normal laboratory conditions (4).

The results obtained in the study indicate recasting 75% of Ni-Cr alloy decreases the shear bond strength of the metal ceramic restoration. Keeping in mind the deleterious effect of 75% of alloy in the present study, we can suggest that recasting up to 50% Ni-Cr alloy is economical with simultaneous maintenance of optimum properties. However, further clinical trials are recommended to confirm the results of this study.

Conclusion

It can be concluded that 50% fresh alloy for casting is adequate for recasting Ni-Cr alloy.

References

1. Anusavice KJ, Phillips RW. Science of dental materials. 11th ed. St. Louis: W.B. Saunders; 2003.
2. Moffa JP, Lugassy AA, Guckes AD, Gettleman L. An evaluation of precious alloys for the use with porcelain veneers. Part I. Physical properties. J Prosthet Dent. 1973;30(4):424-31.
3. Rasmussen ST, Doukoudakis AA. The effect of using recast metal on the bond between porcelain and gold palladium alloy. J Prosthet Dent. 1986;55(4):447-53.
4. Hong JM, Razzoog ME, Lang BR. The effect of recasting on the oxidation layer of a palladium-silver Porcelain alloy. J Prosthet Dent. 1988;59(4):420-5.
5. Zhang K, Watanabe LG. Bond strength of ceramo metal after repeated castings and firings. J Dent Res. 1989;68:303.
6. Jochen GD, Caputo AA, Matyas J. Effect of opaque porcelain application on strength of bond to silver-palladium alloys. J Prosthet Dent. 1990;63(4):414-8.
7. Heraeus K. Metal ceramics manual. 5th ed. Philadelphia: W.B. Saunders; 2003.
8. Baran GR. The metallurgy of Ni-Cr alloys for fixed prosthodontics. J Prosthet Dent. 1983;50(5):639-49.
9. Prado RA Panzeri H, Fernandes AJ Neto, Neves FD, Silva MR, Mendonca G. Shear bond strength of dental porcelains to Ni-Cr alloys. Braz Dent J. 2005;16:202-6.
10. Piwowarczyk A, Lauer HC, Sorensen JA. In vitro shear bond strength of cementing agents to fixed prosthodontic restorative materials. J Prosthet Dent. 2004;92(3):265-73.
11. Jochen DG, Caputo AA, Matyas J. Reuse of silver-palladium ceramic metal. J Prosthet Dent. 1991;65(4):588-91.
12. Hesby DA, Kobes P, Garver DG, Pelleu GB. The physical properties of repeatedly used non- precious metal alloys. J Prosthet Dent. 1980;44(3):291-3.
13. Anusavice KJ, Ringle RD, Fairhurst CW. Adherance controlling elements in ceramic metal system II in non precious alloys. J Dent Res. 1977;56(9):1053-61.
14. Bruggers K, Corcoran C, Jeansonne EE, Sarkar NK. Role of manganese in alloy-porcelain bonding. J Prosthet Dent. 1986;55(4);453-6.
15. Anusavice KJ, Ringle RD, Fairhurst CW. Identification of fracture zones in porcelain-vereered-to-metal bond test specimens by ESCA analysis. J Prosthet Dent. 1979;42(4):417-21.
16. Roach MD Wolan JT, Parsell DE, Bumgardner JD. Use of x-ray photoelectron spectroscopy and cyclic polarization to evaluate the corrosion behavior of six nickel-chromium alloys before and after porcelain-fused-to-metal firing. J Prosthet Dent. 2000;84(6):623-33.

Received: 11/15/2010
Recebido: 15/11/2010

Approved: 06/24/2011
Aprovado: 24/06/2011