ORIGINAL ARTICLE

EFFECT OF COBALT-CHROMIUM ALLOY RE-USE IN DENTISTRY ON ITS CASTABILITY VALUE

Mehreen Imran, Muhammad Raza, Muhammad Sartaj Khan, Yousaf Hayat
Prosthodontics Department, Peshawar Dental College, Peshawar-Pakistan

Background: Re-use of dental casting alloy is a routine practice, which is carried out with the motive to conserve resources. There have been studies on the re-use of alloys but a controversy exists as to the proportioning ratio of fresh to used alloy and the number of time an alloy can be recast. The objective of the study was to measure the effect of addition of 50% by weight used alloy to the fresh Cobalt-Chromium alloy on the castability. **Methods:** In the present in-vitro experimental study A total of 20 specimens were cast by flame centrifuge, using modified Whitlock's method. The total sample size was divided into four groups of five specimens each. Group 1 was the control group with 100% fresh alloy cast once. In group 2, 3 and 4, a 50% by weight cut off of previous castings were mixed to the fresh alloy. The re-used alloy for the group 2 and 3 was further aged or exposed to flame casting separately. The number of completely cast segments were counted and castability value was calculated according to the Whitlock's formula. **Result:** There was no significant difference of castability value among the entire tested group (p=0.085). **Conclusion:** Within the limitations of the present study, it is recommended that commercial Co-Cr-Mo alloy can be re-used six times without affecting its castability, when 50% fresh alloy is added on each re-use.

Keywords: Castability; Cobalt; Chromium; Alloy
J Ayub Med Coll Abbottabad 2017;29(2):270–4

INTRODUCTION

Casting had been unveiled to dental care about 1890.[1] It is an ancient procedure employed for forming solid materials like inlay on-lay, overhead, fixed partial dentures as well as removable partial dentures by molten metal or alloy into a pre-shaped mould.[2,3] The actual success of this course of action will depend on the ability of the alloy to flow as well as complete the actual preformed mould.[4] Hence the most important property for an alloy selected for casting is its Castability or flow and mould fill rate at its molten temperature.[5,6]

Cobalt Chromium alloy, belong to the class of super alloys. In dentistry, they are most commonly used for fabrication of casting partial dentures[7,8] because this alloy is easy to cast, having good polish ability[9], high ultimate tensile and fatigue strength (700–850 MPa) combine with a sufficient elongation (6–10%) at fracture[10]. Over the year's demand for the chromium based metal alloy has resulted in a substantial increase in their price.[11]

Casting procedure in dentistry requires more alloy than needed to produce a restoration. The surplus metal separated from the casting like the crucible former and sprue area is known as "button".[12] Re-use of such alloy has been recommended for both economic and environmental reasons.[13] Studies conducted on the re-use of Chromium alloys, all agree on the fact that mixing fresh alloy to the re-use state can maintain its integrity.[5,6] However controversies exist regarding the number of times the base metal alloy can be re-used.[14–17]

In the present study re-use of surplus alloys were considered to be validated in accordance to the most common casting method. This study was conducted to determine whether the mixing of re-use alloy (50% by weight) with the fresh alloy (50% by weight) would affect its foremost property like castability (flow value) when cast through flame centrifuge casting method.

MATERIAL AND METHODS

In this "*In-vitro*" experimental study, a total of twenty specimens were prepared at metal ceramic laboratory, Sardar Begum Dental College and Hospital, Peshawar. All the specimens were cast using flame centrifuge casting method. In order to calculate the Castability Value, Whitlocks method was used. The original Whitlock pattern required a 10×10 square piece of 18-gauge polyester sieve clothe composed of 100 squares and supported by 10-gauge wax sprue former along two adjacent edges (Figure-1).[18]

For the purpose of this study a master pattern was made using square retention grid wax pattern (Wachs-Gitterretention, Bego Germany) of 100 squares, i.e., each box of 2.5×2.5×0.8 mm was used. Two runner bars (wax wire for sprue Bego, Germany) made of 2.5mm sprue former, supported the pattern wax on both sides, making an internal 90° angle. The total length of each side of the wax grid and the runner bar was approximately 25 mm. The whole assembly was attached to the rubber crucible former size no.3 by a 10 mm long and 4 mm diameter round sprue former wax (Figure-2). The master pattern was invested in phosphate bonded investment (wilavest, Bego, Germany) and Wax burn out was carried out as per instruction of manufacturer.

Four fresh alloy ingots of Wironit (Bego, Germany) were melt using gas oxy-flame. Centrifuge casting and investment removal was carried out according to the standard methods. Rubber cups were used for finishing and polishing.

This master casting was used for the standard mould preparation. Putty consistency of the addition Vinyl Polysiloxane impression material (Exaflex putty type O) was used for making the flexible mould. Equal scoop of both the base (blue) and catalyst (yellow) putty were hand kneaded till a streakless homogenous (green) mix. The round dough of putty was equally spread in the rectangular plastic container. The alloy casting of the pilot study was positioned in the centre of the putty and pressed down so that the putty over flowed through the squares.

Once the impression putty was set, four triangular registration grooves were carved at each side of the putty. A thin layer of oil (Johnson baby oil by Johnson and Johnsons) was applied on the set putty with the casting embedded in it. Six small escape holes (of approximately 1mm) were drilled in the other half (reciprocal) plastic container. Base and the catalyst putty were mixed till a streakless mix and loaded in the reciprocal container. This compartment was inverted on the first container, pressed down firmly and left undisturbed, under hand pressure. When set, the two compartments were separated, the metal casting was removed. A flexible rubber mould was ready for subsequent wax patterns preparation (Figure-2).

The blue in-lay wax, (Cervicalwachs, Bego Germany) was melted liquid and poured on the rubber mould. Immediately the reciprocating compartment of the mould was re-seated and hand pressed. Each time the four triangular grooves would facilitate correct re-positioning of the two compartments. Once the wax would solidify, the excess wax in the form of a wax flash could easily be lift up with a probe. The rubber mould was removed from the plastic container, and the wax pattern could easily be pried out of the mould by slow to and fro twisting of the mould.

All the patterns were examined carefully for any blow holes, cracks or thinning constrictions. The copy wax patterns were at random divided in four groups, each with five patterns (Figure-2).

On the basis of addition of re-use alloy to the fresh alloy the total sample was divided into four groups, i.e., 1, 2, 3 and 4. Each group contained 5 specimens. Group 1 had 100% fresh alloy cast once, group 2, 3 and 4 containing 50% fresh alloy added to 50% re-cast state. The re-used alloy for the group 2 and 3 was further aged or exposed to flame casting separately (Figure-2). The Castability value was calculated by a method suggested by Whitlock *et al.*[5,6] A grid with 100 square spaces will provide 220 segments. The numbers of completely cast segments were counted. In order to find out percentage castability value through a formula:[19,20]

$$Cv = \frac{\text{No. of completely cast segments}}{220} \times 100$$

Where, Cv is percent castability value. Any blow holes, voids or partial flow of alloy was considered as incomplete cast segment.

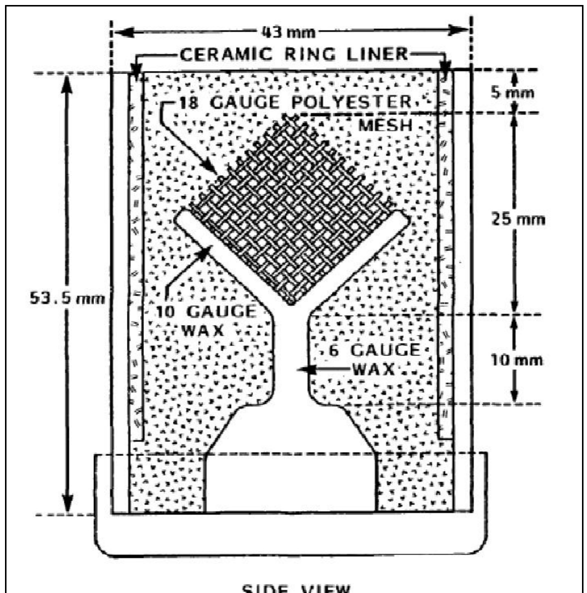
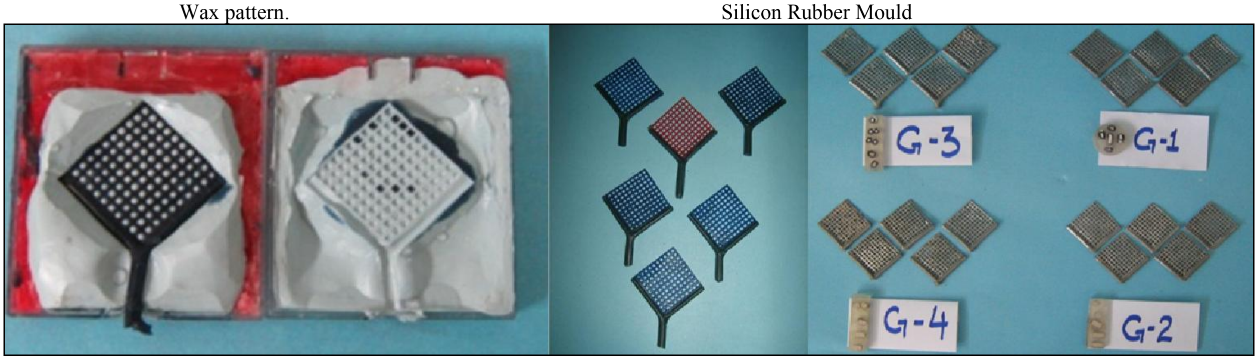


Figure-1: Modified Whitlock's Pattern

Wax pattern. Silicon Rubber Mould



Copy wax pattern formed by in-lay wax Casted Whitlock's specimens

Figure-2: Casting Process

RESULTS

As a whole a small variability of castability values was observed. The castability value of Groups 1 and 2 was 100% with zero standard error. The group 3 castability value ranged from 95–100%. For group 4 the value ranged from 93–100%. In group 3 and 4 two samples had shown 100% castability. The lowest value of completely cast segments (206/220) amongst all the samples was in group 4. Groups 3 (fourth re-cast) showed a mean castability value (97.2%) less than the group 4 (97.6%). The overall mean castability value of all the groups throughout the experiment was 98.7%.

For the purpose of comparison of the Whitlock's castability value of Cobalt Chromium alloy of the four groups, the data was analysed by one-way ANOVA (Table-1). Overall value of the F-test was non-significant at 5% level of significance (*p*-value=0.085).

The observed Whitlock's castability value of all the groups were not affected by the alloy re-use, when it was cast up till six times. This was observed each time when fresh alloy was added to the re-use alloy by 50% weight. Thus, we fail to reject the null hypothesis.

Table-1: Mean castability values of cast Cobalt Chromium alloy in groups.

Castability Value (Cv) according to the Whitlocks Method		
Groups	Mean	*p*-value=0.085
Group-1	100	
Group-2	100	
Group-3	97.2	
Group-4	97.6	

DISCUSSION

Survival needs/ requirements efficient in addition to careful using resources. Reduce; recycle in addition to delete include the several strategies in direction of superior re-utilization connected with resources. Recasting is usually a method accomplished to re-use alloys inside the purpose to conserve metal wastage.[21]

Since 1962 studies regarding recasting of base metal alloys have been conducted by various researchers.[21–25] Properties of recast alloy have been studied by either casting the same alloy for various times or by the addition of new alloy to the recast state in different proportions. Good restoration requires certain optimum properties. These properties should remain constant not only during various laboratory procedures but also in oral environment.[19,26,27]

In the present study castability value was used for assessment of re-cast alloy. Whitlock's method was introduced for an easy, quick and quantitative assessment of castability of an alloy. A quantitative evaluation can be made which intern can make the comparison of various groups much easier. However, the Whitlock's method is not considered a reliable test for estimation of castability value of the fixed partial denture alloys.[18]

In the present study, the overall mean castability value of all the groups throughout the experiment was 98.7% (Table). Group 1 and 2 showed 100% flow rate. It can be inferred that the re-use of once cast alloy when added to 50% fresh alloy did not affect its flow rate.

Al-Khafagy, used Whitlock test to compare a locally prepared Co (62%)-Cr (30%)-Mo (5.5%) alloy with a commercially available Wirocast (Bego, Germany).[28,29] The locally prepared alloy showed higher castability value (92.42%) than the Wirocast (Cv=90.15%) but statistically this difference was not significant. Castabillity value of these both alloys after once casting was less than present study (Cv=100%). The resercher, unlike the present study, did not standardize the brand of the products during his study. Although the Cv of Al-Khafagy study was less than the Cv obtained in the present study but their conclusion based on statistical analysis support the present study null hypothesis.

Harcourt and Cotterill advocated addition of new alloy in the proportion of at least an equal weight of old Co-Cr alloy to maintain the castability and mechanical properties of the alloy, this is also in agreement with the present study.[30]

The present study is at par with Jayant Palaskar[19], Mosleh[31], Nakhaei[32] and studies regarding the Cv of Chromium alloy (Ni-Cr) in the re-use state. In the present study, good qualities of castings were obtained through conventional flame centrifuge casting method. It was practically evident and statistically proven that Co-Cr-Mo alloy with a 50% by weight re-use alloy can intimately reproduce the given pattern till six times.

The observed minor decrease in Cv of this study was statistically insignificant and could be attributed to the repeated processing. This can cause micro structural changes like alteration in the minor elements, irregular crystal size and micro porosities resulting in small casting defects.[12]

In the dental laboratory amount of scrap alloy produced depends on the type of restoration e.g, the quantity of the scrap alloy produced during the fabrication of removable partial dentures is quite large. Thus, it seems to be more meaningful to reuse alloy for such restorations. Especially for under developed countries with limited resources, economical restrains and illiteracy, better utilization of quality materials is of ample importance. Legitimacy of such cost-efficient practices can only be established through experimental trials.

CONCLUSION

Within the limitation of this study Cobalt-Chromium-Molybdenum alloy can be re-used till six times provided a 50% fresh alloy is added to it, on each recast.

So, in order to avoid random mixing of old and fresh alloy, a simple straight forward proportioning of 50% by weight of alloy will help establish an empirical formula which can be easily managed and followed by the laboratories.

Thus, the present study proportioning method will be helpful in setting an empirical relation for recasting alloys till six times.

Since re-casting is carried out for economical and ecological reasons, further re-castings (more than six times) should be carried out till a significant difference can be noticed.

Disclaimer: It is certified that the abstract/paper has not been previously presented or published in any conference.

Conflict of interest: There is no conflict of interest regarding financial, personal, or professional that could be construed to have influenced the work.

Ethical Issue: Permission was taken from the Ethical Committee of Sardar Bagum Dental College Peshawar before research.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgments: Principal Sardar Begum Dental Collage, Prof. Dr. Shaheed Iqbal and Associate Prof. Dr Sayyed Nasir Shah (Head of Prosthetic) for their kind support and continuous encouragement.

Prof. Yaseen Iqbal (Incharge MRL University of Pehawar).

Assist. Prof. Alamzeb khan (UET Peshawar)

AUTHORS' CONTRIBUTION

MI: Chief investigator, acquisition, concept and study design, literature search, data collection and compilation and drafting. MR: Objective setting, literature search, results interpretation and proofreading. MSK: Project supervision. YH: statistical analysis

REFRENCES

1. Sweeney WT. Cristobalite for dental investment. J Am Dent Assoc 1933;20:108–19.
2. Powers JM, Sakaguchi RL. Casting and soldering procedures. In: Powers JM, Sakaguchi RL, editors. Craig's Restorative Dental Materials. 12th ed: St. Louis, Mo.: Mosby Elsevier; 2006. p.411–41.
3. Leinfelder KF. An evaluation of casting alloys used for restorative procedures. J Am Dent Assoc 1997;128(1):37–45.
4. Baltes H, Brand O, Fedder GK, Hierold C, Korvink JG, Tabata O, *et al*. Microengineering of Metals and Ceramics: Part I: Design, Tooling, and Injection Molding. Vol. 30. John Wiley & Sons; 2008.
5. Hero H, Waarli M. Effect of vacuum and Super-temperature on Mold Filling during Casting. J Dent Res 1991:99(1):55–9.

6. Carreiro Ada F, Ribeiro RF, Mattos Mda G, Rodrigues RC. Evaluation of the castability of a Co-Cr-Mo-W alloy varying the investing technique. Braz Dent J 2005;16(1):50–5.
7. Antony K. Wear-resistant cobalt-base alloys. J Met 1983;35(2):52–60.
8. Kelly JR, Rose TC. Nonprecious alloys for use in fixed prosthodontics: A literature review. J Prosthet Dent 1983;49(3):363–70.
9. Slokar LJ, Matkovic T, Matkovic P. Microstructure and hardness of Co-Cr-Ti alloys for dental castings. Metalurgija 2004;43(4):273–7.
10. Bertrand C, Poulon-Quintin A. Proposals for optimization of laser welding in prosthetic dentistry. J Prosthodont 2010;19:69–76..
11. Ucar Y, Akova T, Akyil M S, Brantley WA. Internal Fit Evaluation of Crowns Prepared Using a New Dental Crown Fabrication Technique. Laser-Sintered Co-Cr Crown. J Prosthet Dent 2009;102(4):253–9.
12. Khuraif AA, Ramamoorthi M. Fatigue behaviour of Recasted Removable partial denture alloys. Int J Dent Clin 2011;3(4):20–2.
13. Utilization of non-ferrous scrap. [Internet]. [cited 2013 Apr 22]. Available from: http://nzic.org.nz/ChemProcesses/metals/8C.pdf
14. Brantley WA. Wrought alloys. In: Anusavice KJ, Phillips RW, editors. Phillips' science of dental materials. 11th ed. St. Louis, Mo: Saunders; 2003. p.621–53.
15. Yannikakis SA, Zissis AJ, Polyzois GL. Removable partial denture repairs: A survey. Quintessence Dent Technol 2000;23:184–190
16. McCabe JF, Walls AWG. Base Metal Casting Alloys. In:, editors. Applied Dental Materials 8th edition, Oxford (UK), Blackwell Science; 1998. p.63–8.
17. Glekin J, Dixon H. Unravelling India, Part 3: Demography [Internet]. [cited 2012 Jan]. Available from: http://blogs.reuters.com/breakingviews/2012/01/20/unravelling-india-part-3-demography/
18. Naylor WP, Moore BK, Phillips RW, Goodacre CJ, Munoz CA. Comparison of two tests to determine the castability of dental alloys. Int J Prosthodont 1990;3(5):413–52.
19. Palaskar J, Nadgir DV, Shah I. Effect of Recasting of Nickel: Chromium Alloy on its Castability. J Indian Prosthodont Soc 2010;10(3):160–4.
20. Whitlock RP, Hinman RW, Eden GT, Tesk JA, Dickson G, Parry EE. A practical test to evaluate the castability of dental alloys. J Dent Res 1981;60:404–404.
21. Khamis E, Seddik M. Corrosion evaluation of recasting non–precious dental alloys. Int Dent J 1995;45(3):209–17.
22. Presswood RG. The castability of alloys for small castings. J Prosthet Dent 1983;50(1):36–9.
23. Dern WM, Hinman RW, Hesby RA, Pelleu GB Jr. Effect of a two-step ringless investment technique on alloy castability. J Prosthet Dent 1985;53(6):874–6.
24. Hong JM, Razzoog ME, Lang BR. The effect of recasting on the oxidation layer of a palladium-silver porcelain alloy. J Prosthet Dent1988;59(4):420–5.
25. Nelson DR, Palik JF, Morris HF, Comella MC. Recasting a nickel-chromium alloy. J Prosthet Dent 1986;55(1):122–7.
26. Palaskar J, Nadgir DV, Shah I. Effect of recasting of nickel–chromium alloy on its porosity. Contemp Clin Dent 2010;1(4):237–42.
27. Palaskar JN. Effect of recasting of Nickel-chromium alloy on its Hardness. Int J Dent Clin 2010; 2(4):8–11.
28. Al-Khafagy MT. Evaluation of some properties of prepared dental base-metal alloys. Ph.D thesis. Coll Dent Univ Baghdad 2003.
29. Al-Hueaizi AF, Al-Khafaji AM. The effect of recasting on the castability of the prepared Co-Cr dental base-metal casting alloys. J Baghdad Coll Dent 2017;19(1):24–27.
30. Harcourt H. The remelting of cobalt-chromium alloys. Brit Dent J 1962;112:198–204.
31. Mosleh I, Abdul-Gabbar F, Farghaly A. Castability evaluation and effect of recasting of ceramo-metal alloys. Egypt Dent J 1995;41(4):1357–62.
32. Nakhaei MR, Ghanbarzadeh J, Gokharian R. The effect of recast base metal alloys on crown's marginal accuracy. J Med Sci 2008;8:599–602.

Received: 15 July, 2016	Revised: 19 December, 2016	Accepted: 29 December, 2016

Address for Correspondence:
Mehreen Zia, Prosthodontics Department, Peshawar Dental College, Peshawar-Pakistan
Cell: +92 333 998 5955
Email: hmraza77@yahoo.com