Evaluation of macrohardness of recasted Cobalt–chromium alloy

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ABSTRACT

Aims: To study the effect of recasting on the macrohardness of cobalt chromium (Co–Cr) alloy, and to evaluate the effect of finishing and polishing on it. Materials and methods: Two brand of Co–Cr alloys were used, divided into three groups, the specimens of the first group were casted from new materials, the second were casted from previously casted material without the addition of any new material (100% recast), the third were casted by combination 50% new material and 50% used material. Half of the specimens just finished and the other half were finished and polished, hardness for all of them were measured. Results: Showed that recasting, both 100% and 50%, significantly increase the macrohardness of Co–Cr alloys and no significant effect of finishing and polishing on it. Conclusion: Recasting may affect properties of Co–Cr alloy and new material should be used rather than recasted material.

Key words: Recasting, Macrohardness, Cobalt–chromium, Polishing.

INTRODUCTION

For decades gold has been used in dental practice to fabricate cast dental prostheses. In an attempt to reduce the expense of these restorations, gold alloys could be recast. Overtime, for economic reasons, base metal alloys have become widely used as cast materials in dental practice. Thus, nickel–chromium (Ni–Cr) and Cobalt–chromium (Co–Cr) alloys became a substitute for high noble alloy for dental cast restorations. To further decrease costs, previously used base metal alloy may be combined with new metal to produce restoration with minimum cost for the dental laboratory.3

It is expected that difficulties will occur during the finishing and polishing of base metal alloys because of their high hardness. High macrohardness of some alloys has been associated previously with greater abrasion resistance and time required to polish restorations. Such alloys would be difficult to finish. Various techniques have been used to assess the burnishability of casting alloy. These techniques rely on simulations of a clinical burnishability procedure. Other investigators have calculated an index on the basis of macrohardness and percentage elongation. Macrohardness has been used to indicate potential abrasion resistance and strength properties. Although a proper testing method may be difficult to develop, it would be useful if dental alloys could be classified according to their abrasion resistance.2

Harcourt (3) studied the effect of remelting of Co–Cr on their physical and chemical properties. The material was chemically analyzed before first melting and after one, six, nine and thirteen remelt, their results showed remelting causes alterations in the chemical composition of the alloy which causes decrease in the fluidity and ease of melting.

Nelson et al., (4) demonstrated no remarkable degenerative change in Ni–Cr alloy after recasting for 10 generations and combining used metal with new metal and recasting 100 times demonstrated no remarkable degenerative changes in physical properties, microstructure or clinical characteristics, but strict adherence to clean techniques was essential to minimize contamination and inclusions that adversely affect physical properties.

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Hong et al.,(5) showed that the repeated remelting of four generation of palladium silver alloys introduce an alteration of the chemical composition and/or microstructure.

Sheffick (6) concluded that Co–Cr and Ni–Cr behaved inferiorly than the Gold type III with inconsistent behavior in the chemical compositions with remelting procedures concluding that the first remelting of these alloys should be accomplished with the addition of 50% by weight new alloy to improve the cast ability and the percentage of the elemental constituents of these alloys.

Khamis and Seddik (7) studied the effect of recasting, up to four times, Ni–Cr and Co–Cr commercial dental alloys on their corrosion behavior and concluded that the corrosion resistance of alloy containing cobalt and molybdenum was not affected by successive melting and recasting.

Mosleh et al.,(8) evaluated the effect of recasting on the castability and results revealed that castability value for Ni–Cr alloy were not significantly affected.

Kaneko et al.,(9) concluded that the influence of finishing on the corrosion resistance of precious metal alloys was less significant than that of base metal alloys.

Ponnanna et al.,(10) evaluated and compared the polished surface and loss of weight of removable partial denture casting following different finishing and polishing techniques, and concluded that the loss of weight due to metal loss show concern and it can be avoided by judicious sandblasting and application of proper grit of abrasive agent.

Al–Hiyasat and Darmani(11) concluded that the reuse of base metal alloys at 50% and 100% as recast alloys significantly increased the cytotoxicity of base metal alloys investigated in their study (2 Ni–Cr, a Ni–Cr with Cu, a Co–Cr, and a Cu–base). This was related to the type and amount of elements released from these alloys. Further more, the amount of element released increased in proportion with the percentage of the recast alloys used.

The aims of the study were to investigate the effect of recasting of cobalt–chromium alloy on their surface macro hardness, and to investigate the effect of finishing and polishing on surface macro hardness of cobalt–chromium.

**MATERIALS AND METHODS**

Two brand of cobalt–chromium (Re-manium, Dentaurum, Germany, and Biozil, Degussa, Germany) were used as castable alloys. Three groups from each alloy type were fabricated as follows: In the first group the specimens were casted using new alloys (as received). The second group consisted of specimens that were casted from 100% recast (once) alloys. The third group consisted of specimens that were casted from 50% weight new alloys with 50% weight recast (once) alloys. Disk–shaped specimens from each type of alloy were prepared. The thickness was 0.8 mm, which is the thickness used in the framework of the partial denture.

The disks were fabricated using a conventional lost wax technique. The processes of wax pattern, investment, burn out, and casting were performed according to the manufacturer instruction. Each group was subdivided into subgroups, the first just finished without polishing, and the second finished and polished. The process of finishing and polishing were performed in such a way to simulate the preparation of the cast metal alloys for clinical use. The specimens were airborne–particle abraded using 250–micrometer aluminum oxide to remove the investment material.

Then the sprues were cut off, and the specimens were finished using finishing stone burs in the sequence of brown, green, and pink. For each group, the first subgroup remain without polishing and the second subgroup polished using rubber polishing wheels, black followed by green wheels. Finally pumice polishing compound was used. Surface macrohardness average of the specimens was analyzed by a macrohardness–testing machine (Wolpert, Germany). The indentation of each measurement was measured by the gauge of the machine. The number of specimen for each variable was six and the number of measurements for each specimen was five, thus, thirty measurements for each variable was taken. The distribution of specimen was shown in Table (1). Analysis of variance (ANOVA) and Duncan's multiple range test were used for statistical analyses (P ≤ 0.05).
Table (1): Distribution of specimens

| Procedure      | Material | Finishing and polishing | Number of measurements |
|----------------|----------|-------------------------|------------------------|
| **First casting** | Remanium | Finished only           | 30                     |
|                | REMANIAM | Finished and polished   | 30                     |
|                | Biozil   | Finished only           | 30                     |
|                |          | Finished and polished   | 30                     |
| **100% recast** | Remanium | Finished only           | 30                     |
|                | Biozil   | Finished and polished   | 30                     |
| **50% recast** | Remanium | Finished only           | 30                     |
|                | Biozil   | Finished and polished   | 30                     |

RESULTS
The results of ANOVA (Table 2) showed a significant difference between groups. The results were illustrated more specifically in Figure (1) which showed that all specimens of 100% recast were significantly harder than the specimens of first casting; and all the specimens of 100% recast were significantly harder than the specimens of 50% recast (except for the specimens of 50% of Remanium brand alloy recast and finished only). All the specimens of 50% recast (except the specimens of 50% of Remanium brand alloy recast, finished, and polished) were significantly harder than all the specimens of first casting (except the specimens of Remanium brand alloy with first casting and finished only).

Table (2): Analysis of variance of all groups

|                      | df | Sum of squares | Mean square | F-value | P-value |
|----------------------|----|----------------|-------------|---------|---------|
| **Between groups**   | 11 | 5937.169       | 539.743     | 23.206  | 0.000*  |
| **Within groups**    | 348| 8094.075       | 23.259      |         |         |
| **Total**            | 359| 14031.244      |             |         |         |

* Significant difference existed at $P \leq 0.05$.

df: Degree of freedom.

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Within the group of first casting the specimens of polished Remanium brand alloy were significantly less harder than the rest of the specimens (Table 3 and Figure 2).

Table (3): Analysis of variance for first casting group

|          | df | Sum of squares | Mean square | F–value | P–value |
|----------|----|----------------|-------------|---------|---------|
| Between  | 3  | 638.000        | 212.667     | 4.288   | 0.007*  |
| Within   | 116| 5753.200       | 49.597      |         |         |
| Total    | 119| 6391.200       |             |         |         |

df: Degree of freedom.

* Significant difference existed at $P \leq 0.05$.

FIGURE 2: Duncan multiple range test for first casting group.
1: First casting–Biozil–finished only; 2: First casting–Biozil–finished and polished; 3: First casting–Remanium–finished and polished; 4: First casting–Remanium–finished only.

Within the group of 100% recast the specimens of finished only (without polishing) Remanium brand alloy significantly harder than the rest of the group (Table 4 and Figure 3).

Table (4): Analysis of variance for 100%–recast group

|          | df | Sum of squares | Mean square | F–value | P–value |
|----------|----|----------------|-------------|---------|---------|
| Between  | 3  | 361.292        | 120.431     | 19.497  | 0.000*  |
| Within   | 116| 716.500        | 6.177       |         |         |
| Total    | 119| 1077.792       |             |         |         |

df: Degree of freedom.

* Significant difference existed at $P \leq 0.05$.

Within the group of 50% recast the specimens of finished only (without polishing) Remanium brand alloy showed significantly less macrohardness, and the specimens of finished only (without polishing) Remanium brand alloy were significantly harder than the rest of the groups (Table 5 and Figure 4).

FIGURE 4: Duncan multiple range test for 50% recast group.
1: Recasting–Biozil–finished only; 2: Recasting–Biozil–finished and polished; 3: Recasting–Remanium–finished and polished; 4: Recasting–Remanium–finished only.

DISCUSSION
The finding of the this study agreed with the research hypothesis that recasting of Co–Cr alloys increase the surface macrohardness and this is an indicator that many other properties may be changed during recasting with or without the addition of new material.
Table (5): Analysis of variance for 50%–recast group

|                     | df | Sum of squares | Mean square | F–value | P–value |
|---------------------|----|----------------|-------------|---------|---------|
| Between groups      | 3  | 352.873        | 117.624     | 8.400   | 0.000*  |
| Within groups       | 116| 1624.375       | 14.003      |         |         |
| Total               | 119| 1977.248       |             |         |         |

df: Degree of freedom.
* Significant difference existed at $P \leq 0.05$.

Figure (3): Duncan multiple range test for 100%–recast group.
1: 100% recast–Biozil–finished and polished; 2: 100% recast–Remanium–finished and polished; 3: 100% recast–Biozil–finished only; 4: 100% recast–Remanium–finished only

Figure (4): Duncan multiple range test for 50%–recast group.
1: 50% recast–Biozil–finished only; 2: 50% recast–Biozil–finished and polished; 3: 50% recast–Remanium–finished and polished; 4: 50% recast–Remanium–finished only
The higher surface macrohardness of the recasted specimens may have been related to the increased percentage of carbides within the alloy which, in turn, increased as a result of the subsequent melting of Co–Cr alloys. These results agree with many studies, but disagreed with a study made by Hesby et al. (12) who evaluated the macrohardness, tensile strength, and percentage of elongation of non precious alloys after repeated use and compared the properties after first, second, third and fourth remelting without the addition of any new material, they concluded that there were no significant differences observed in the physical properties tested among four generations tested and concluded that non precious alloys can be reused for at least four generations.

In this study, it has been shown that the effect of finishing and polishing on surface macrohardness was not specific, since in some cases the polishing increase the surface micro hardness and in others decrease it. The finishing and polishing procedures in Co–Cr alloy is under concern and the concept of minimum finishing and polishing procedure is proposed because of the effect of finishing and polishing of the ultimate fit of the prosthesis. In two separated studies (13,14) it was demonstrated that there is considerable loss of removable partial denture framework metal during finishing and polishing techniques resulting in poor fit of retentive clasp arms and improper contact at the tooth–clasp interface, thus, affecting the retention and stability of the removable partial denture. In another study (15) the conclusion is that with larger component and more surface area to be polished, the tendency for mass loss is greater, also, possible structural weakening due to polishing.

The results of the current study agree with Aydin (17) who assessed the effect of finishing and polishing on cobalt chromium casting and reported that appropriate smoothing techniques are fundamental for contouring.

**CONCLUSION**

Recasting significantly increase the surface macrohardness of cobalt chromium alloy, but no specific relation between finishing and polishing (on one hand) and the surface macrohardness (on the other hand). New material should be used in casting, and if previously casted material is used, it should be mixed with new material.

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