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Evaluation of macrohardness of recasted Cobalt–chromium alloy

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ABSTACT

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.

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INTRODUCTION

For decades gold has been used in dental practice to fabricate cast dental prosthesis. 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 laboratoryes.[1]

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 relay 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 alterationns 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.

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 at 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 release increased in proportion with the percentage of the recast alloys used.

The aims of the study were to investtigate 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 hardenss of cobalt –chromium.

MATERIALS AND METHODS

Two brand of cobalt–chromium (Remanium, Dentaurum, Germany, and Biozil, Degussa, Germany) were used as casting 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 ($P \leq 0.05$).

Table (1): Distribution of specimens

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

df: Degree of freedom.

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

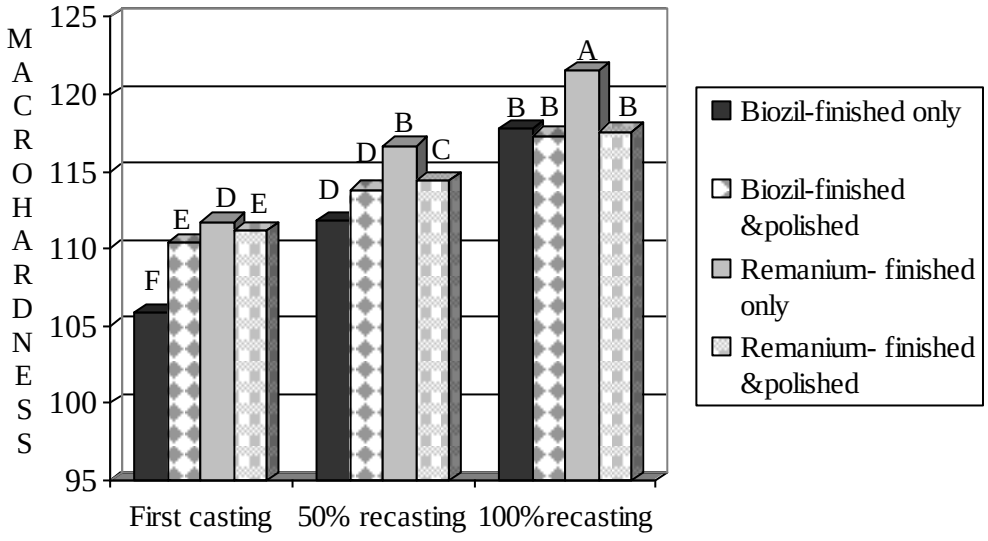

Figure (1): Duncan multiple range test for all groups

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 sequares	Mean sequare	F–value	*P*–value
Between groups	3	638.000	212.667	4.288	0.007*
Within groups	116	5753.200	49.597		
Total	119	6391.200			

df: Degree of freedom.

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

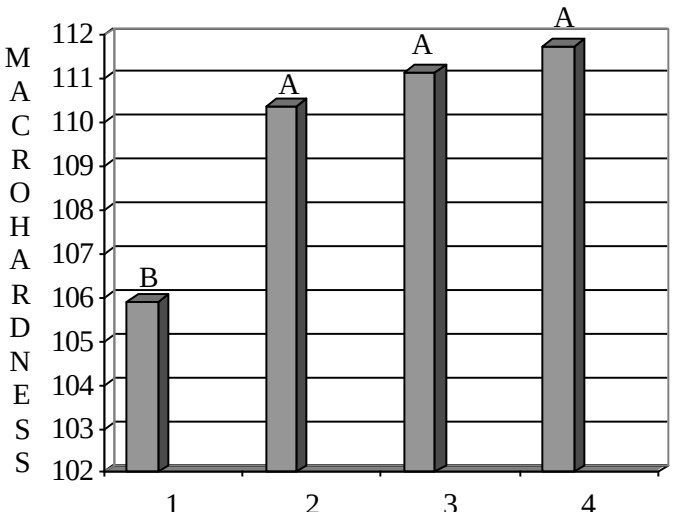

Figure (2): Duncan multiple range test for first casting group. 1: First casting–Biozil–finished only; 2: First casting–Biozil–finished and polished; 3: First casting–Remanium– finished and polished; 4: First casting–Remanium–finished only.

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 sequares	Mean sequare	F–value	*P*–value
Between groups	3	361.292	120.431	19.497	0.000*
Within groups	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).

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.

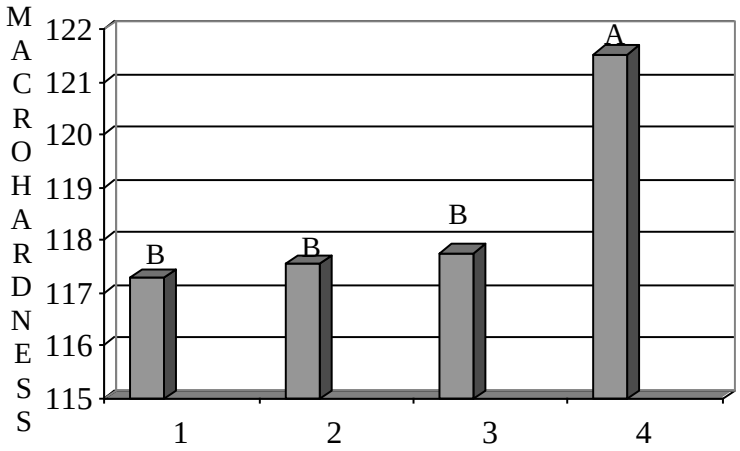

Figure (3) : Duncan multiple range test for 100% –recast group. 1: 100%recast–Biozil– finished and polished; 2: 100%recast–Remanium– finished and polished; 3: 100%recast–Biozil–finished only; 4: 100%recast–Remanium– finished only

Table (5): Analysis of variance for 50%–recast group

	df	**Sum of sequares**	**Mean sequare**	**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 $P \leq 0.05$.

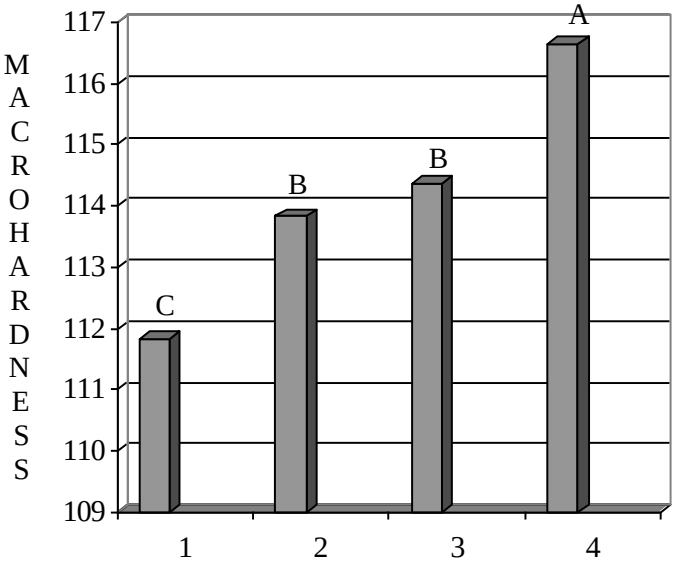

Figure (4): Duncan multiple range test for 50%–recast group. 1: 50%recast–Biozil–finished only; 2: 50%recast–Biozil–finished and polished; 3: 50%recast–Remanium–finished and polished; 4: 50%recast–Remanium–finished only

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,[3,5,6,8,11] 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 beca-use 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 Hunt *et al*.,[16] who investigate hardness and relative corrosion rates of four alloys, stainless steel, nickel titanium, cobalt chromium, and beta titanium, before and after polishing. The sample showed variations in surface finish with beta titanium having the roughest appearance and cobalt–chromium the smoothest indicated that no significant hardening occurred as a result of polishing.

The results of the this study disagreed 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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