Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 10, Issue, 02, pp.65024-65027, February, 2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

COMPARISON AND EVALUATION OF THE MECHANICAL PROPERTIES OF CASTED, RECASTED AND COMBINATION OF COBALT-CHROMIUM ALLOY: AN IN - VITRO STUDY

*Amitha, G. L., Brijesh Shetty, Pranav V. Mody, Manoj Kumar, A. D. and Ashwini, H. V.

Department of Prosthodontics, K. V. G Dental College and Hospitals, Kurunjibagh, Sulia 574327

ARTICLE INFO

Article History:
Received 30th November, 2017
Received in revised form
23rd December, 2017
Accepted 06th January, 2018
Published online 18th February, 2018

Key words:

Recasting,
Cobalt- Chromium,
Mechanical properties.

ABSTRACT

Introduction: Currently due to the increase in price of Cobalt-Chromium and Nickel-Chromium alloys and its allies owing to increase in demand, complete or partial recasting have become a necessity for economic reasons and to avoid the exploitation of natural resources.

Methodology: A total of 30 specimens of Cobalt-Chromium alloy were fabricated and divided into 3 groups of 10 specimens each for determining the effect of recasting on hardness, tensile strength and modulus of elasticity using Universal Testing Machine and Vickers Hardness testing. Statistical analysis was done using ANOVA and POST HOC TUKEY TEST.

Result: The results revealed that there is significant difference in the mechanical properties of Cobalt-Chromium alloys. ($p=0.0001$)

In case of tensile strength and modulus of elasticity and hardness, ANOVA exhibited a difference in mean among Group I, II & III which is significant.

Conclusion: There is significant difference in the mechanical properties of Cobalt-Chromium alloys, indicating that there is deterioration of properties when the content of reused alloy is 50% or more. But taking the environmental and economic factors into consideration, addition of less than 50% reused alloy to new alloy is acceptable clinically.

Citation: Amitha, G. L., Brijesh Shetty, Pranav V. Mody, Manoj Kumar, A. D. and Ashwini, H. V. 2018. "Comparison and evaluation of the mechanical properties of casted, recasted and combination of cobalt-chromium alloy: An in - vitro study", *International Journal of Current Research*, 10, (02), 65024-65027.

INTRODUCTION

Dental alloys have been considered to be of paramount importance in the field of fixed partial prosthodontics (Baren, 1985). The preferential use of the precious metal alloy has almost been eliminated by its high cost, its high distinguishable colour and subsequently resulted in high demand for non-precious base metal alloys (Taggart, 1907). But because of the nobility of the contents of gold alloys, it is possible to recast the material again and again without losing any required properties (Baren, 1983). However same cannot be said about base metal alloys. Remelting previously cast metal is a routine procedure that dental laboratories use to decrease the cost of fixed prosthesis (Palaskar *et al.,* 2010). The reuse of melted alloys in dental laboratories remains a controversial topic in dental practice (Ucar *et al.,* 2009). For economic reasons and to avoid the exploitation of natural resources high noble, noble and base metal alloys from casting surplus are commonly re-used either in part or completely by melting and re-casting (Corey *et al.,* 2015). The excellent mechanical properties of base metal alloy like lower density, hardness, tensile strength and low cost make the use of base metal alloys attractive (Peraire *et al.,* 2007). Thus, Ni-Cr and Co-Cr alloys became a substitute for high noble alloy for dental cast restorations. To further decreases costs, previously used base metal alloy may be combined with new metal to produce restoration with minimum cost for the dental laboratory (Kuet, 2012). Opinions concerning mechanical properties after recasting are extremely divided. The process of recasting Ni-Cr base metal alloy can decrease or even result in loss of base elements such as Fe, In, Sn and Zn which may affect the mechanical properties of alloy (Al-Ali, 2007). The impurities from previous melted button and sprues may result in changes in the properties of reused dental alloys (Ayad, 2002). However, some studies have found no changes in mechanical properties of recasted alloys (Reddy *et al.,* 2011; Bajoghli *et al.,* 2013). According to Bauer et al, the scrap produced in dentistry is extremely pure due to the fact that this metal is melted in controlled industrial conditions (Hang *et al.,* 1980). Anusavice (Bauer *et al.,* 2010) have proposed that 50% new metal can be added to previously melted alloys. The basis of this guidelines is that some essential secondary elements present in small quantities in the original alloy may be lost through evaporation or oxidation (Anusavice, 11th edition). Very few references in dental literature are available regarding recasting of Co-Cr base metal alloy. The aim of the study is to evaluate the hardness, tensile strength and modulus of

***Corresponding author:** Amitha, G. L.
Department of Prosthodontics, K. V. G Dental College and Hospitals, Kurunjibagh, Sulia 574327

elasticity of the casted, recasted and combination of Co-Cr base metal alloy.

MATERIALS AND METHODS

A total of 30 specimen was fabricated and divided into 3 groups of 10 specimen each, which was tested for hardness,tensile strength and modulus of elasticity:

Group 1:100% new alloy.
Group 2: 100% recasted alloy.
Group 3: 50% new alloy & 50% recasted alloy.

Dimension of test specimen

Wax patterns of desired dimension were made from metal mould which is according to the ANSI/ADA Specification No.38 for testing of alloys used for metal/metal-ceramic restoration.

Preparation of test specimen

A. **Preparation of Wax Patterns**- Then molten wax was poured into mould space gently. Care will be taken to avoid entrapment of air bubble. After the wax cooled, the wax pattern was removed cautiously. If any distortion in the wax pattern was found, it will be discarded & a new pattern will be fabricated.
B. **Spruing of the wax patterns-**A direct technique of spruing was used. The wax patterns were sprued with 3mm diameter sprue wax.
C. **Investing and Casting the pattern-**Investing and casting was done using standard procedure (in accordance to manufactures instruction)

Retrieval of casting

The casting ring was allowed to bench cool to room temperature. Casting was divested from the refractory and sand blasted. After obtaining all the samples, they were subjected for hardness, tensile strength and modulus of elasticity test.

Measurement of Micro hardness

One end of the fractured bar would be prepared for micro hardness evaluation. Each specimen was embedded in acrylic resin. After polishing, Vickers Hardness testing was accomplished using a 136^0 diamond in a micro hardness tester.

Measurement of Tensile Strength

The equipment used for measuring the tensile strength was UNIVERSAL TESTING MACHINE with a load cell of 5 KN and a rate of 5mm/min

Measurement of Modulus of Elasticity

The equipment used for measuring the modulus of elasticity was UNIVERSAL TESTING MACHINE with a load cell of 5 KN and a rate of 5mm/min

Statistical Analysis: Results were plotted with a mean and standard deviation. The variance was analysed using ANOVA. The difference between groups was detected by POST HOC TUKEY TEST.

RESULTS

Specimens were tested for tensile strength, modulus of elasticity and hardness. Tensile strength and modulus of elasticity were assessed using Instron Universal Testing Machine, whereas hardness was assessed using Vicker's hardness tester.

Group 1: 100% Cobalt- Chromium alloy.
Group 2: 100% recasted Cobalt- Chromium alloy.
Group 3: 50% new Cobalt- Chromium alloy & 50% recasted Cobalt- Chromium alloy.

The values were subjected to statistical analysis.

Statistical analysis done using ANOVA for comparison of all groups with respect to tensile strength, modulus of elasticity and hardness. It revealed that, there was statistical significance ($p<0.0001$) Table:1

Table 1. Comparison of mean values of physical properties between different casted alloys in three studied groups

Mechanical properties	Groups N=10	Mean	Std. Deviation	95% Confidence Interval for Mean		'P' value (one way ANOVA)
				Lower Bound	Upper Bound	
Tensile strength	Group 1	11195.00	50.166	11159.11	11230.89	<0.0001
	Group 2	7565.00	363.692	7304.83	7825.17	
	Group 3	9579.00	379.604	9307.45	9850.55	
Modulus of elasticity	Group 1	6784.60	30.435	6762.83	6806.37	<0.0001
	Group 2	3782.50	181.846	3652.42	3912.58	
	Group 3	5302.60	299.137	5088.61	5516.59	
Hardness	Group 1	982.90	16.462	971.12	994.68	<0.0001
	Group 2	745.00	5.578	741.01	748.99	
	Group 3	874.50	14.532	864.10	884.90	

Table 2. Posthoc comparison of mean values of physical properties in between groups among different casted alloys

Mechanical properties	Group	Group	Mean Difference	Std. Error	'P' Value
Tensile strength	1	2	3630.000*	136.354	<0.01
	1	3	1616.000*	136.354	<0.01
	2	3	-2014.000*	136.354	<0.01
Modulus of elasticity	1	2	3002.100*	90.729	<0.01
	1	3	1482.000*	90.729	<0.01
	2	3	-1520.100*	90.729	<0.01
Hardness	1	2	237.900*	5.850	<0.01
	1	3	108.400*	5.850	<0.01
	2	3	-129.500*	5.850	<0.01

* The mean difference is significant at the 0.05 level.

Statistical analysis done using POST HOC TUKEY TEST for comparison of all groups with respect to tensile strength, modulus of elasticity and hardness. It revealed that, there was statistical significance ($p<0.01$) Table: 2

DISCUSSION

The casting procedure is complex, involving various stages, each of which may affect the dimensions and therefore the accuracy of the final casting, which has to withstand the rigors of the oral environment. The dimensional accuracy of the casting depends not only on the method employed but also on the various method involved in its fabrication. Strict adherence to certain fundamental principles is necessary to produce accurate castings. Introduction of new materials and techniques in order to improve the quality of these restorations warrants a constant monitoring of the whole process to ensure success. Apart from copper, the dental gold alloys contain all noble metals. Hence, sprues and buttons remaining after casting were used again for casting with addition of copper lost during the casting process. Since 1930's base metal alloys like Cobalt-Chromium, Nickel-Chromium is in use as indirect restorative materials as they were cost effective. In 1930's and 1940's the cost of these base metal alloys were affordably low so the sprues and buttons remaining after casting were discarded. However, the cost of the base metal alloys has escalated. Manufacturers insist that these alloys should be used only once for casting. Very few manufacturers advocate part addition of new alloy to sprue and buttons for recasting. Apart, from the cost, the burden of the waste on the environment and depletion of natural resources are factors high in promoting "GREEN" dentistry by recycling once cast alloy. The fabrication of the cast metal restoration should process optimum properties. These properties should remain constant not only during various laboratory procedures but also in oral environment. Therefore it is very clear that recasting should not be done at the expense of the properties of the alloy. Presswood (1983) in his study reported a 0.01% to 0.1% loss of component metals with each generation of the recast.

According to Presswood, recasting does not contribute to any change in the hardness and other properties of the alloy. Based on the study, he concluded that subjecting the alloy for recasting will not bring any significant change in the hardness value of the alloy. He advocated that recasted alloy can be at least use once again. As per studies of Harcourt (1965) recasting can be done up to thirteenth generation without losing any physical properties of alloy. He also advocated that completely cleaned and deoxidized cast alloy need not to be added with new alloy in any proportion, and concluded that this finding is of great significance in view of the cost involved and maintaining the level of available natural resources. Harcourt (1965) studied the effect of remelting of Cobalt-Chromium on their physical and chemical properties. The material was chemically analysed 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. Sheffick (1993) concluded that Cobalt-Chromium and Nickel-Chromium behaved inferiorly than the Gold type III alloys with inconsistent behaviour 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 of the new alloy to improve the castability and the percentage of the elemental constituents of these alloys.

Due to the nobility of the gold alloys, it has been possible to recast the material again and again without losing any of its required properties. However same cannot be said about the base metal alloys, due to lack of research work and literature available. Invariably the manufacturers of base metal alloy instruct to use the alloy only once. Therefore, it will be of great advantage, both economically and environmentally to recycle or to recast the alloy again and again with or without adding new alloy. The aim of the study was to investigate the effect of recasting Cobalt- Chromium alloy on their tensile strength, modulus of elasticity and hardness. A tensile stress is caused by a load that tends to stretch or elongate a body. A tensile stress is always accompanied by tensile strain. Because most dental materials are quite brittle, they are highly susceptible to crack initiation in the presence of surface flaws when subjected to tensile stress. In the present study, physical specifications for tensile strength were standardized, the dimensions of which were similar to those suggested by Moffa *et al.* In the present study, the values of tensile strength exceed the calculated minimum specification for Cobalt- Chromium alloys. The tensile strength values ranged from 7120 to 11190 N Although the values were not consistent among the groups tested there was suggestion of changes in the property of the alloy samples that would indicate a deterioration of the metal as statistical significant difference was there. Modulus of elasticity or Young's modulus describes the relative stiffness or rigidity of a material. Although the stiffness of a dental prosthesis can increase by increasing its thickness, the elastic modulus does not change. The elastic modulus has a constant value that describes a material's relative stiffness.

Since the elastic modulus of a material is constant, it is unaffected by the amount of elastic or plastic stress that is induced in the material. It is independent of the ductility of the material since it is measured in the linear region of the stress-strain plot, and it is not a measure of its plasticity or strength. In the present study, the value of modulus of elasticity exceeds the calculated minimum specification for Cobalt-Chromium alloys. The modulus of elasticity values ranged from 3560 to 6782 N/mm^2. Although the values were not consistent among the groups tested, there was suggestion of changes in the property of the alloy samples that would indicate a deterioration of the metal as statistical significant difference was there. Hardness is the resistance to permanent surface indentation or penetration. It denotes strength, stiffness, brittleness, resilience, toughness or combination of these qualities (Ayad and Ayad, 2010). Vickers hardness test was used in this study to measure hardness. In this method, 136 degree diamond pyramid-shaped indenter is forced into the material with a definite load application. The indenter produces a square indentation, the diagonals of which are measured. Loads are varied from 1- 120kg. In the present study, the values of hardness exceeded the calculated minimum specification for Cobalt-Chromium alloys. The hardness values ranged from 740 to 1007 VHN. However, unlike the studies by Hesby (1980), Nelson (1986) and Presswood (1983), there was suggestion of changes in the hardness of the alloy samples that would indicate a deterioration of the metal as statistical significant difference was there.

Limitations of the study

A limitation of the study is the exclusion of effect of recasting on the biocompatibility of Cobalt-Chromium alloy. Studies by

Al-Hyasat and Darmani (2005) demonstrated that both the cytotoxicity and elemental release of alloys were influenced by recasting. Studies by Pervin *et al.,* 2014 concluded that recasting Nickel-Chromium alloy with 65% surplus metal addition significantly increase the cytotoxic activity. Another limitation of the study is the lack of application to in-vivo condition. The effect of recasting on the alteration of chemical composition of the recast alloys was not studied. Therefore even though some physical properties remained unchanged, further studies to evaluate biocompatibility should be conducted both in in-vitro and in-vivo before use of these recast Cobalt-Chromium alloys can be advocated for clinical use.

Conclusion

The results show that there is significant difference in the tensile strength, modulus of elasticity and hardness of Cobalt-Chromium alloys. In case of tensile strength, modulus of elasticity and hardness, ANOVA exhibited a difference in mean among Group I, II and III which is significant. In the perspective of this study, addition of reused alloy less than 50% was found to be clinically acceptable. However, significant statistical difference was seen between Group I, II and III, indicating that there is deterioration of properties when the content of recasted alloy is 50% or more. So it is advisable to use new alloy for casting. But taking the environmental and economic factors into consideration, addition of less than 50% recasted alloy to new alloy is acceptable clinically.

REFERENCES

Al-Ali, A.A. 2007. Evaluation of Macrohardness of Recasted Cobalt-Chromium Alloy. *Al-Rafidain Dent J.,* 7(1):111-117.

Al-Hiyasat A S, Darmani H. 2005. The effects of recasting on the cytotoxicity of base metal alloys. *J Prosthet Dent.,* 93:158-163.

Anusavice K J. Phillips Science of Dental Materials, 11th edition.

Ayad M F, Ayad G M. 2010. Corrosion behavior of as-received and previously cast type III gold alloy. *J Prosthet Dent.,* 19; 194-9.

Ayad, M.F. 2002. Compositional Stability and marginal accuracy of complete cast crowns made with as received and recast type 3 gold alloy. *J Prosthet Dent.,* 87;162-166.

Bajoghli F, Nosouhian S, Badrian H, Goroohi H, Saberian, 2013. A- Effect of base

Baren G R. 1985. Selection criteria for base metal alloys for use with porcelains. *Dent Clin North A.M.,* 29:779-787.

Baren, G. 1983. The mechanical metallurgy of Ni-Cralloys for fixed prosthodontics. *J Prosthet Dent.,* 50(5):639-650.

Bauer J, Celle S, Pinto MM, Coste JF, Reis A, Loguercio A.D. 2010. The use of recycled metal in dentistry: Evaluation of mechanical properties of titanium waste recasting; resources, *Conservation and Recycling,* 54; 1312-1316.

Corey V., Corne P, Demarch P, 2015. Fleutot S- Influence of recasting on the quality of dental alloys: A systematic review. *J Prosthet Dent.,* 114(2), 205-211.

Hang, J.M., Rezzoog ME, Long BR. 1980. The eefect of recasting on the oxidation layer of Palladium – Silver Porcelain Alloy. *J Prosthet Denta.,* 59; 420-425.

Harcourt H J, Cotterill W F. 1965. Induction melting of Cobalt-chromium alloys; a comparison with flame melting. *Br Dent J.,* 20;118:323-9

Hesby D, Kobes P, Graver D and Pelleu G. 1980. Physical properties of a repeatedly used nonprecious metal alloy:- JPD., 44(3); 291-293.

Kuet- Ts- Evaluation of physical properties and casting accuracy of Chrome- Cobalt alloys with different casting systems and investments. *Journal of Physical Science,* 2012; 23(2); 91-102.

metal alloys after recasting on marginal integrity of castable crowns. *J Contemp Dent Pract.,* 14; 255-258.

Moffa J P,Lugassy A A, Guckes A D, Gettleman L. An evaluation of non-precious alloys for use with porcelain venners. Part-I: Physical properties. JPD 30:424, 19.

Nelson D R, Palik J F, Morris H F, Comella M C. Recasting a nickel-chromium alloy. *J Prosthet Dent.,* 55(1):122-7

Palaskar J, Nedgir Dv, Shah I. 2010. Effect of recasting Nickel Chromium alloy on its castability. *The journal of Indian Prosthodontic Society,* 10(3); 160-164.

Peraire M., Martinez-Gomez J, Anglada J m, Bizar J, Salsench J, Gil F J. 2007. Effects of recasting on the chemical composition, microstructure, micro hardness and ion release of 3 dental casting alloys and titanium. *Int J Prostho Dent.,* 20; 286-288.

Pervin, 2012. Influence of recasting different types of dental alloys on gingival fibroblast cytotoxicity. *J Prosthet Dent.,* 107; 24-33.

Presswood R G, 1983. Multiple recast of nickel-chromium beryllium alloy. *J Prosthet Dent.,* 50; 198-9.

Reddy NR, Abraham AP, Murgesan K. 2011. An invitro analysis of elemental release and cytotoxicity of recast nickel-chromium dental casting alloys. *J Indian Prosthodont Soc.,* 11; 106-112.

Sheffick, L. N. 1993. The effect of remelting and casting procedures on castability and chemical composition of dental alloys.MSc thesis. College of Dentistry. University of Baghdad.

Taggart W H. 1907. A new and accurate method of making gold inlays; *Dent Cosmos,* 49: 1117.

Ucar Y, Aksahin Zafer, Kurtoglu C. 2009. Metal ceramic bond after multiple castings of base metal alloy. *J Prosthet Dent.,* 102; 165-17.

****