Effects On The Mechanical Properties of Nickel Chromium Alloys By Their Reuse In Casting

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Abstract

Objectives

In our current economy, it is obligatory that the dentists and technicians be cost conscious about the materials they use. Therefore, it would be economically advisable to reuse them. No matter 'cost' is always an important factor in selection of alloys, but the physical, chemical and biological properties for a specific clinical situation should always be the first priority. Before a definitive recommendation can be made for repeatedly using non precious metals, carefully researched information should be available. The purpose of this study was to evaluate the effect of reusing a Ni Cr alloy on its ultimate tensile strength, yield strength and modulus of elasticity.

Method Three groups of 12 samples each were prepared. 100% new alloy was used to cast the samples of group A. Group B consisted of samples which were cast using 100% once used alloy, and Group C consisted of samples cast using 100% twice used alloy. The materials were judiciously chosen and the method employed was standardized to produce satisfactory test specimens. All tensile testing was done on a modified tensile test bar of ADA specification no. 14, which was further modified to facilitate sample alignment during investing and reduce the problems associated with castings.

Results The tensile bars were then tested for its properties of Ultimate tensile strength, yield strength (at 0.2% offset) and modulus of elasticity. The results were then subjected to standard statistical analysis.

The comparisons of means of ultimate tensile strength, yield strength, modulus of elasticity values of different groups were made using 'student t test'. It shows a significant reduction in these values if the alloy is reused.

Conclusion The practicality of recasting base metal alloys as an economy measure came under close scrutiny during the investigation.

Introduction

Conserving natural resources is a necessity to ensure that future generations will not be deprived of their share of natural resources [1]. Dental casting alloys play a prominent role in the treatment of dental diseases. This role has been changed significantly in the recent years with the improvement of all-ceramic restorations and the development of more durable resin-based composites. However, alloys still continue to be used and will likely be the principal material for years to come [2]. Proper selection and manipulation of these alloys is imperative if dental prosthesis is to perform with longevity [3-5]. For decades, gold has been used in dental practice to fabricate dental prosthesis. The interest in using gold, platinum and palladium was due to the high resistance to corrosion, tarnish and biocompatibility. But, in an economy like ours, treatment modalities should have a bearing on the socio-economic status of an individual or community as a whole. Therefore, it is obligatory that dentists and technicians be cost conscious about the materials they use for various restorations[6-7] The escalating cost of gold and other noble metals is partially responsible for the development of a new class of alloys: BASE METAL ALLOYS. The first chromium cobalt alloys were introduced for use in dentistry in 1933 by Erdle and Prange. Since they were first introduced, many new alloys have been formulated and different techniques have been used.[8-10]With the increased cost as well as popularity of non precious alloys, it will be of great advantage, both economically and environmentally to recycle or to recast them again and again with or without adding new alloy.

Very few references in dental literature are available regarding recasting of the base metal alloys. Few have tested the properties of the alloy by casting the used material and others have tested by adding new material to the casted alloy [11].

For clinicians to gain confidence in prescribing these base metal alloys by their reuse in casting, carefully researched information should be available so that different properties and limitations can be fully understood and appreciated.

Therefore this study was undertaken to evaluate the tensile strength, yield strength and modulus of elasticity of Nickel chromium alloys used repeatedly for fixed partial denture castings. These physical properties were compared between single melt alloy castings and second and third generation melt alloy castings.

Aims and objectives

The various objectives of this study can be summarized as follows:

1. To determine and compare the variation in ultimate tensile strength, yield strength, to calculate and compare the variation in modulus of elasticity of the alloy from first to third generation after recycling.
2. To evaluate, whether the addition of varying amounts of the new metal to the old, as suggested by many manufacturers is necessary or not, thus further bringing down the cost.

Material And Method

Preparation of test specimens

The alloy used was Nickel Chromium alloy(BEGO, Germany). All tensile testing was done on a modified tensile test bar. Tensile test specimens were cast in accordance with ADA specification no. 14 which requires test samples to have a diameter of 3 ± 0.1mm and a length of 15 ± 0.5mm with a minimum of 6mm at the ends to provide sufficient metal for proper attachment of specimens to the testing machine. A 2mm radius of curvature connects the bar and the step.

Compiling with these specifications a split brass mold was fabricated. Regular Type II inlay casting wax (BEGO, Germany) was melted and poured into this mold to obtain wax patterns of uniform dimensions. Horizontal method of spruing as described by Asgar was used for all tensile bar wax patterns. Four of the sprued patterns were attached to the crucible former. The patterns are then sprayed with a surface tension reducing agent (BEGO, Germany) and then allowed to dry. The casting ring with a wet asbestos free liner was then placed over the crucible former. Phosphate bonded investment (BEGO, Germany) was manipulated according to manufacturer's instructions and the patterns were invested. After 45 to 60 minutes of bench set, burn out was done. This was done by keeping the casting ring in the burnout furnace(BEGO, Germany,Miditherm) kept at initially at room temperature. The temperature was then raised to 1600° F. After the burn out procedure, the casting ring was transferred into the centrifugal electromagnetic induction casting machine(BEGO, Germany) and casting done with an adequate amount of Ni Cr alloy(BEGO, Germany). The casting ring was then bench cooled and deflasked. A sand blaster(CarlodeGiorgi, Italy) was used to remove any residue of investment material. Sprues were cut off using separating disks mounted on a high speed metal trim-mer.(Folster -alloy grinder,USA)

The above procedure was repeated for all the castings. For group A, 100% new alloy was used. The buttons, sprues and bars were melted and group B castings were made. Melting the sprues, buttons and bars of group B produced group C. Similarly, 12 castings were made for each group.

Testing method employed

Tensile bars thus obtained were tested for tensile strength for each specimen by means of a Universal Testing Machine (Llyod make). The cross head speed of the machine set at a rate of 0.1cm/ minute. Offsets of 0.2% were used as arbitrary values to calculate the yield strength. The ratio of stress to strain for each specimen, from the slope of the straight line portion of the tensile curve yields modulus of elasticity. The validity of the results were tested using descriptive type of statistics, SPSS (Statistical package for social sciences) 19th version. Anova single factor test was used to validate the statistically significant difference within the groups.

(table 1)

Represen-tation Of Mean, S.d. And P Values For Tensile Strength, Yield Strength And Modlus Of Elasticity For Group A, B And C.

S.no	Types of Strengths	Mean+-s.d.			P Value
		Group A	Group B	Group C	Within Groups
1	Tensile Strength	560+-9.11	532+-7.23	471+-4.78	P<.05(sig.)
2	Yield Strength	367+-4.49	346+-4.97	297+-4.97	P<.05(sig.)
3	Modulus of Elasticity	161958 +-1069	107804 +-473	80790+-265	P<.05(sig.)

Discussion

Recasting is a technique carried out to reuse cast nickel chromium alloys in the motive to conserve alloy wastage [12]. The practicality of recasting base metal alloys as an economy measure came under close scrutiny during the investigation. The casting procedures for all the groups on this investigation was carried within a limited span of time so as to avoid any variations in equipment settings and function, as well as various materials used. Since 1962, many studies regarding recasting of base metal alloys have been conducted by various researchers, namely Harcourt[13] ,Presswood[11] ,Hesby[14] .They mainly studied properties of recast alloy like tensile strength, ultimate tensile strength, percentage elongation, modulus of elasticity, mean yield strength, microstructure, and micro hardness . In another study[7,] the physical properties of a non precious metal alloy (Ticon) used repeatedly were evaluated. Physical properties like tensile strength, hardness and percentage of elongation were compared between single metal alloy castings and second, third and fourth generation melt alloy castings. No significant differences were observed in the physical properties tested among any of the four generations of castings. This finding indicates that the metal can be reused for at least four generations contrary to the results of the study conducted.

One more study [15] was performed to evaluate the effect of recasting on the physical properties and clinical characteristics of a nickel chromium alloy (Ticonium). Excess metal was combined with new metal for subsequent casting in an appropriate amount to maintain, n approximate 50/50 ratio. This study extended to ten generations. The results showed that the mean value of all generations exceeded the minimum ADA specification with regard to all the properties evaluated. Combining excess used metal with new metal and recasting 100 times demonstrated no remarkable degenerative changes in physical properties, microstructure or clinical characteristics. Their microstructure showed a large amount of contamination, porosity and inclusions, which increased with each generation. They suggested that the remelting of base metal alloys introduce the opportunity to alter chemical composition and physical properties.

From the results of the current study, it can be seen that there is a significant decrease in the evaluated physical properties from the Group A specimens to Group C specimens. The fabrication of the alloy specimens was performed in a way to simulate the technique used to produce dental cast restorations in dental laboratories. Finally, although a small sample size was used in the current study, significant differences were found between the different groups. Hence, it is advocated that the Ni-Cr alloy should not be reused, without addition of new alloy. Even the manufacturer's suggest that the alloy can be reused should be subjected to further investigation. Future studies also are needed to evaluate other physical properties not included in this study, like the grain size, carbide spacing, and coefficient of expansion. Also, the properties of reusing a Ni Cr alloy with addition of new metal need to be further studied to arrive at a conclusion. The findings of this study may be summarized as follows:

1. The values of ultimate tensile strength, yield strength, modulus of elasticity showed a remarkable degenerative change after recasting as we move from first through third generation, the degeneration being more pronounced in Group C compared to Group B.
2. According to the statistical analysis, it is advised not to reuse Nickel Chromium alloys, without the addition of new alloy.

   Although the degenerative changes seen in the properties are statistically significant, their clinical significance needs to be investigated further. It is also suggested that further investigation is needed to evaluate other physical properties not evaluated in this study. These properties include the percent elongation, grain size, carbide spacing, and coefficient of expansion. The bond strength of porcelain to metal after repeated castings should also be evaluated. An alteration in either of them may set a degenerative trend in physical properties.

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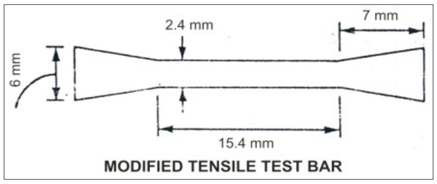

MODIFIED TENSILE TEST BAR