Effect of recasting of Nickel-Chromium alloy on its Hardness
Jayant Palaskar D.V.Nadgir, Ila Shah

Abstract
Recasting dental casting alloy is of great advantage both economically and environmentally. When properties are considered in selection of an alloy for cast dental restorations, hardness of the casting alloy is of prime importance. Ideally hardness should be high to resist any scratches and maintenance of the smoothness during the laboratory procedures and in the oral environment. It denotes strength, stiffness, brittleness, resilience and toughness or combination of any of these qualities. Since nickel-chromium[Ni-Cr] alloys continues to be commonly used dental casting alloy, this study was designed to find out the hardness of new alloy, different percentage combinations of new alloy and once casted alloy and recasted alloy by using Vicker’s hardness test. Results show that there is no statistical difference between the hardness value of new alloy and recasted alloy.

Key Words: Recasting; Dental casting alloys; Hardness; Base metal alloys; Whitlock test

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Introduction
In our current economy it is obligatory that dentists and technicians be cost conscious about the materials they use for fixed prosthesis. Cast gold alloy is in the use since long time as restorative materials in dentistry. The alloy’s properties like resistance to tarnish and corrosion, hardness, strength, percentage elongation, castability, burnishability and capacity to take high polish have made it as an ideal restorative material. However, it has two main disadvantages, one is its high distinguishable color and the other is high cost. The preferential use of the precious metal alloy like gold alloy has almost been eliminated by the elevated cost and resulted into subsequent demand for semiprecious and nonprecious base metal alloys in dental procedures. In 1930's base metal alloys were introduced to dentistry by R. W. Eardle and C. H. Prange(1). The properties of this alloy satisfy with that of gold alloy with additional advantage of its reduced specific gravity and low cost. (2, 3) Due to this superiority over gold alloy, cobalt-chromium and Ni-Cr alloy and its alloys have become immensely popular in the field of restorative dentistry. (4) This popularity of these alloys can be gauged by the varieties of the alloys available in the market. Present demand for the base metal alloys has been resulted in substantial increase in the price of these once insignificant alloys. It is a point of commercial concern(1).

Due to nobility of the contents 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 base metal alloys, due to lack of research work and literature available. Invariably the manufacturers of base metal alloys 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(1).

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(5). It will be of definite scientific advantage if the properties of the recast alloys are studied in detail and directions given to Prosthodontist and laboratory technicians. Therefore this study has been undertaken to find out the Hardness of the new alloy, different percentage combinations of new alloy and once casted alloy and recasted alloy.

Materials and Method
Samples were casted using modified Whitlock’s method. The acrylic -wax mesh (Klett-O-flex, Renfert, Germany) of dimensions 11mm x 11mm with 100 square shaped spaces of 1mm x 1mm and filament diameter of 0.3 mm was selected. For standardization of all the samples, (Wax patterns) a putty mold was prepared using following procedure. First the sprue with 6 gauge diameter and length of 12 mm was attached to one corner of the mesh. Then two runner bars of 10 gauge diameter were attached to the adjacent sides of the mesh. This wax assembly was invested in stone plaster. After setting of the stone plaster dewaxing was done. In this prepared mold self-cured acrylic resin was poured in and a positive replica of the mesh with runner bars and sprue was obtained. An impression of this acrylic resin patterns was made by using putty consistency

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addition silicon (Reprocil DENTSPLY, USA) material and a rubber mold was obtained. This mold was used to make number of wax patterns with mesh, runner bars and sprues. By this uniform sized wax patterns were obtained for required alloy casting.

The sprue pattern was attached to the crucible former and the patterns was sprayed with surface tension reducing agent (Lubrofilm - Dentaurum, Germany) and allowed it to air dry. An asbestos lined casting ring of 30 mm diameter was placed over the crucible former. Phosphate bonded investment (Castorit super -C, Dentaurum, Germany) was manipulated following the manufacturer’s instructions and pattern was invested. After 60minutes of bench set burn out was done. Wax burn out was done by keeping the casting ring in the cold furnace (Midtherm T.H. Bego Germany) and temperature was raised to 250ºC. This temperature was maintained for next one hour further temperature was raised to 950ºC and maintained at 950ºC for one hour for complete wax burn out to take place. This was transferred to the induction casting machine (Fornex 35 E.M., Bego, Germany). Then casting was done by using Ni-Cr alloy [G-Soft, Dentaurum, Germany with Chemical Composition Ni - 65% Cr - 27% Mo -5% Si - 1.5% other elements C, Mn, B - less than 1%]. After casting, ring was allowed to cool at room temperature. Then casting was obtained and it was cleaned by keeping it in concentrated hydrofluoric acid for ten minutes.

The above procedure was repeated for all castings. For this study different combinations of new alloy and once casted alloy were mixed together by weight. For the first group of castings, total new alloy was used i.e. 100% new alloy, this group was designated as group A. The buttons of these castings from group A were separated from its sprue. These buttons were cut into different portions so as to mix it with new alloy by weight in proper proportions. In this study following groups were made based on different combinations of new alloy and once casted alloy (Table 1).

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage of New alloy (by weight)</th>
<th>Percentage of once Casted alloy (by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>B</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>C</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>D</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>E</td>
<td>--</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 1 Grouping

Three samples from each group were selected randomly for the measurement of hardness. These selected samples were embedded in clear epoxy resin powder. Clear epoxy resin and formaldehyde were mixed in a ratio of 1:1 and poured into a standard mold over the samples and allowed to set. Three samples of same group were embedded in one mold (Figure 1). Same procedure was followed for other four groups. The embedded specimens were recovered and were ground flat using belt emery grinding machine. It was then further smoothened with grade ‘0’ and finished with grade ‘000’ emery paper. Care was taken to produce uniform scratch free surface and have a mirror finish. Final polishing was done on a motor driven revolving disc. The disc was covered with a velvet polishing cloth which was kept moist with slurry of various gradations of aluminium oxide powder. The specimens were cleaned with ethanol.

![Figure 1 Photographs showing embedded specimen](image)

Then the specimens were mounted on Leitz Micro hardness tester (QL/OS/001, Leitz Wetzlar, Germany) for measuring the micro hardness of the specimens on the sprue region. For the measurement of micro hardness, Vicker’s hardness test was employed (5). In this test an indenter of diamond shaped, square based pyramid was used. The angle between the faces of pyramid was 136º Vickers hardness number was calculated by measuring the distance between the diagonals of the indentation and averaged. Using this value the hardness number was obtained from a table. This procedure was followed for all the embedded specimens. These hardness measurements were carried out under the load of 500 Grams.

Results

The results are shown in the table 2 to 6.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Observation[a]</th>
<th>Observation[b]</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>213</td>
<td>210</td>
<td>211.50</td>
</tr>
<tr>
<td>2</td>
<td>207</td>
<td>213</td>
<td>210.00</td>
</tr>
<tr>
<td>3</td>
<td>216</td>
<td>204</td>
<td>210.00</td>
</tr>
<tr>
<td>Mean</td>
<td>210.50</td>
<td>0.61</td>
<td></td>
</tr>
</tbody>
</table>

Table-2 Table of observations of Micro hardness [In VPN], in GROUP A [100% new alloy]
The mean hardness value of the groups was subjected to statistical analysis using student’s test, and this is shown in table 7 and 8. There was a significant Difference present in group B & E.

<table>
<thead>
<tr>
<th>Group</th>
<th>No of observations</th>
<th>Mean ± S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>210.50±0.61</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>202.8±4.75</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>228.6±16.30</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
<td>221.3±10.61</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>214.6±3.01</td>
</tr>
</tbody>
</table>

Table 7: Statistical table showing mean and standard deviation for Micro hardness in different groups

Discussion

The dental gold alloy contains all noble metals except copper. Hence, sprues and buttons remaining after casting were used again for casting with addition of lost copper. Since 1930’s base metal alloys like Co-Cr, Ni-Cr 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, at present the cost of these base metal alloys has become very high. In spite of this, manufacturer’s give the instruction that alloy should be used only once for casting. Very few manufacturers advocate part addition of new alloy to the sprue and buttons for recasting. Apart from the cost due to environmental factors and deprivation of the resources, every material is being tried to reuse for various purposes. It is desired that the base metal alloy must also be reused for casting. Good restoration requires certain 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.

Since 1962 studies regarding recasting of base metal alloys have been conducted by various researcher’s namely Harcourt (6), Hesby (7), Hong(8, 9), Nelson(10), and Presswood (11). Mainly they have studied properties of recast alloy like tensile strength, ultimate tensile strength, percentage elongation, modulus of elasticity, mean yield strength, microstructure and micro hardness. This study was undertaken to study hardness of the recast alloy. So far the study on properties of recast alloy has been done either by casting the same alloy again and again up to thirteen generations or by studying the properties of the castings with the addition of new alloy to the recasted alloy in various proportions.

It is easy and scientific to compare the properties of the only new alloy, with various percentage combinations of new alloy and once casted alloy and with only recasted alloy. In this study Whitlock’s method (11) was followed with little modification. One modification was use of wax-acrylic mesh instead of using polyester sieve cloth. This was done due to non-availability of polyester sieve cloth of required dimensions. However, it should be noted that the filaments of wax mesh were very fine and the size was comparable to that of sieve cloth used by Whitlock. One of the properties of the restoration required is hardness. Ideally hardness should be high to resist any scratches and maintenance of the smoothness in the oral environment.

Hardness is the quality of firmness produced by cohesion of particles composing a substance, as evidence by resistance to penetration, abrasion, scratching, cutting or shaping. It denotes
strength, stiffness, brittleness, resilience, toughness or combination of these qualities. (11) Hence this property was tested in this study. The tests most frequently used in determining the hardness of dental materials are Brinell, Rockwell, Vicker and Knoop. In this study applying Vicker’s test, values were obtained by using Leitz wetzlar micro-hardness testing machine. The hardness measurements were carried out on sprue portion of the samples.

As per tables 2-6 mean micro hardness values vary from 202.83 VPN to 228.67 VPN. As per the table 7 except the comparison between group B and group E, all other comparisons of means of micro-hardness values of different groups through ‘t’ test is of no statistical significant difference. Scientific explanation cannot be given at present for statistically significant(2, 3) value of difference between group B and group E. Further study should be carried out to verify this finding.

It is to be noted that these findings are comparable and similar to the findings of Hesby (7) and Nelson(10). They studied hardness of recasted alloy and proved that statistical comparison of the first through fourth generations showed no significant differences in the hardness and also other physical properties.

Nelson(10) et al stated that results of Vicker’s hardness test exceeded the calculated minimum specification for Ni-Cr alloys. Micro-hardness values ranged from 335 VPN to 390 VPN. Although values were not consistent among generations but statistical significant difference was not there. The study conducted by Presswood(11) indicates that in each generation of the recast, 0.01% to 0.1% loss of components will be there. According to Presswood it does not(11) contribute to any change in the hardness and other properties of the alloy. Based on this study it can be advocated that subjecting the alloy for recasting will not bring any significant change in the hardness value of the alloy. It can be advocated that recasted alloy can be used at least once again. As per studies of Harcourt(6) recasting can be done up to thirteenth generation without losing any properties of the alloy. It can also be advocated that completely cleaned and deoxidized casted alloy need not be added with new alloy in any proportion. Also this finding is of great significance in view of the cost involved and maintaining the level of available resources.

Conclusion
This Study concludes that, a) the hardness will not be affected by recasting the Ni-Cr alloy, b) it is not necessary to add new alloy in any proportion to the once casted alloy to maintain the hardness value of the alloy.

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References

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