Evaluation of effect of recasting of nickel-chromium alloy on its castability using different investment materials: An in vitro study

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ABSTRACT

Context: Castability has been found to be affected by many aspects of the entire casting system. Very few references in dental literature are available regarding recasting of the base metal alloys.

Aims: To evaluate and compare the castability of fresh and reused nickel-chromium alloy and to evaluate the effect of two brands of investment materials on castability of nickel-chromium alloy.

Subjects and Methods: For the experimental purpose of evaluation of the effect of recasting of nickel-chromium alloy on its castability, different percentages of new and casted alloy (Nickel-chromium alloy—(Wirolloy NB, Type 4 (Ni-67%; Cr-25%; Mo-5%; Si-1.5%; Mn, Nb, B, C each <1%)) and two commercial brands of investment materials namely, Deguvest Impact (Degudent; Dentsply Germany) and Bellavest SH (Degudent; Dentsply Germany) was used to obtain 30 samples. Castability value was obtained using Whitlock’s formula. Student t-test and one way ANOVA using SPSS 20.0 software was done.

Results: The results of this study confirm earlier works that demonstrate that there is no significant difference in castability values of new and recast alloys. In addition, it also demonstrated, there was no difference in castability using Deguvest Impact and Bellavest SH investment materials.

Conclusions: Within the limitations of the study, it was concluded that there was no significant difference found in castability of different percentage combinations of new and once casted alloy using two investment materials. The addition of new alloy during recasting to maintain the castability of nickel-chromium alloy may therefore not be required.

Key words: Base metal alloys, dental casting alloys, recasting, Whitlock’s castability test

In our current economy, it is obligatory that dentists and technicians be cost conscious about the materials they use in fixed prosthesis.[1] The preferential use of precious metal alloy like gold alloy which was in use as a restorative material for a long time has almost been eliminated by the elevated cost and resulted into subsequent demand for semi- and non-precious base metal alloys in dental procedures.[1]

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Castability has been found to be affected by many aspects of the entire casting system. Alloy composition, density, surface tension, new or reused metal, investment brand, mold temperature, the casting machine, the position of the pattern in the mold, the surface ratio, and sprue attachment design all play a role in castability.

Determining an appropriate method to measure the castability of dental alloys is difficult when dealing with different casting equipment (torch, electric, and induction) and alloys that vary markedly in composition and physical properties. The problem is compounded by the fact that the test methodology and test monitors (specimen configurations) differ widely in different castability testing. Despite the absence of a recognized classification system, at least, three types of castability tests exist. These categories are sufficiently distinct to warrant identification as abstract tests (nondental patterns), simulation tests (patterns of idealized dental restorations), and replica tests (patterns of dental restorations).

Because of the nobility of the contents of the gold alloys, it has been possible to recast the material repeatedly 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 with or without adding new alloy.

Very few references in dental literature are available regarding recasting of the base metal alloys. A 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. It will be of definite scientific advantage if the properties of the recast alloys are studied in detail, and directions were given to prosthodentist and laboratory technicians.

The aim of the study was to investigate, evaluate, and compare the castability of six different nickel-chromium alloy combinations using two different investment materials.

**SUBJECTS AND METHODS**

The two commercially available brands of investment material and six different combinations of Nickel-chromium alloy used in the study are listed in Table 1.

**Specimen preparation**

The wax mesh (Wachsgitter-Retentionen, BEGO, Germany) of dimensions 10 mm × 10 mm with 16 square-shaped spaces was used. For standardization of all the samples, this wax assembly was invested in stone plaster and dewaxed. Heat cure acrylic resin (Trevalon; DPI, Mumbai, India) was packed, cured, and a positive replica of the mesh was obtained. An impression of this acrylic resin pattern was made with putty consistency vinyl polysiloxane (Reprosil; Dentsply Caulk, Milford, USA) and a mold was obtained [Figure 1b]. Uniform sized wax patterns were obtained for casting from this mold space.

**Investing, burn out and casting**

A standard 2 mm diameter sprue (Wachsdraht; Renfert, Germany) of length 10 mm with reservoir was attached to each wax patterns which were placed on sprue former [Figure 2a and b]. Asbestos-lined casting ring of 40 mm internal diameter was placed over the sprue former. Investing was performed for respective groups under vacuum mixing (Dentaurem Airvac) following the manufacturer’s instructions. After 60 min of bench set, wax burnout was done at 250°C for 1 h followed by 850°C for 1 h and then cast in induction casting machine (SmartCast; Aseg Galloni, Italy) using nickel-chromium alloy (Wirolloy NB). After cooling at room temperature, sprues were sectioned, and samples were sandblasted using Easyblast (BEGO, Germany). The above procedure was repeated for all castings [Figure 3] in all combinations of alloy using the different investment materials. The sprue buttons of castings from Group 1 were cut into different portions so as to mix it with new alloy by weight (using digital weighing machine: Essae) in proper proportions for Group 2.

**Evaluation of specimens**

The castability was evaluated for all the samples from all six groups. Obtained castings were evaluated for castability using formula suggested by Whitlock et al. Grid with 16 square spaces will provide 40 segments.

Percentage castability value was calculated using formula:

\[ Cv = \frac{\text{Number of completely cast segments}}{40} \times 100 \]

(where \( Cv \) is percent castability value)

Furthermore, the number of completely filled squares was counted in each sample out of 16 square spaces. Percentage of filled squares per casting per sample was calculated using formula:

\[ Fs = \frac{\text{Number of completely filled squares}}{16} \times 100 \]

(where \( Fs \) is percentage of filled squares)
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Statistical analysis
Statistical analysis was performed by Student’s t-test and one-way ANOVA using SPSS 20.0 (IBM, USA) with P ≤ 0.05.

RESULTS
The results are presented in Tables 2-6.

The results of this study show that mean castability values ranged from 97.5% to 99.5%, and there was no significant difference (P > 0.05) between castability of fresh alloy and recast alloy using different investment materials.

DISCUSSION
Castability plays an important role in the selection of an alloy for cast dental restorations. The escalating cost of gold has contributed to the widespread use of base metal alloys for fabrication of removable partial denture frameworks. The popularity of base metal alloys is further enhanced by their resistance to corrosion, reduced weight, and generally more favorable physical properties than those of gold.

As an economic measure, excess gold (buttons and sprues) has routinely been recast in combination with new metal to produce clinically acceptable castings. Since the cost of base metal alloys was affordably low in those days, the sprues and buttons remaining after casting were discarded. However, at present, the cost of these base metal alloys has become exorbitant. Despite this, manufacturer’s instructions suggest that alloy should be used only once for casting. Few manufacturers advocate partial addition of new alloy to the sprue and buttons for recasting. Apart from the cost, every material should be recycled as far as possible to conserve resources and protect the environment.

A good cast restoration requires certain optimum properties that should remain constant not only during various laboratory procedures but also in the clinical situation.

Table 2: Castability values in percentage recorded for each group invested with the two investment materials

| Sample | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 |
|--------|---------|---------|---------|---------|---------|---------|
| Sample 1 | 100 | 97.5 | 100 | 100 | 100 | 100 |
| Sample 2 | 95 | 97.5 | 97.5 | 100 | 97.5 | 100 |
| Sample 3 | 100 | 100 | 100 | 100 | 100 | 97.5 |
| Sample 4 | 97.5 | 95 | 95 | 97.5 | 92.5 | 100 |
| Sample 5 | 92.5 | 100 | 100 | 100 | 97.5 | 97.5 |

Table 3: Completely filled squares (percentage) cast segments on casting observations (n=5)

| Filled squares in percentage | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 |
|-----------------------------|---------|---------|---------|---------|---------|---------|
| Sample 1 | 0 | 18.75 | 0 | 12.5 | 12.5 | 6.25 |
| Sample 2 | 6.25 | 6.25 | 25 | 0 | 0 | 25 |
| Sample 3 | 0 | 6.25 | 31.25 | 25 | 12.5 | 12.5 |
| Sample 4 | 6.25 | 0 | 6.25 | 6.25 | 0 | 6.25 |
| Sample 5 | 18.75 | 6.25 | 0 | 6.25 | 0 | 6.25 |

Table 4: Mean castability values of different groups

| Group number | Sample size | Mean±SD |
|--------------|-------------|---------|
| Group 1      | 5           | 98.0±2.09 |
| Group 2      | 5           | 98.0±2.09 |
| Group 3      | 5           | 98.5±2.23 |
| Group 4      | 5           | 99.5±1.11 |
| Group 5      | 5           | 97.5±3.06 |
| Group 6      | 5           | 99.0±1.36 |

Table 5: Student’s t-test of the mean castability values

| t       | df | Mean difference | 95% CI of the difference |
|---------|----|----------------|--------------------------|
|         |    |                | Lower                   | Upper                   |
| Group 1 | 104.766 | 4 | 98.00 | 95.4029 | 100.5971 |
| Group 2 | 104.766 | 4 | 98.00 | 95.4029 | 100.5971 |
| Group 3 | 98.500  | 4 | 98.50 | 95.7236 | 101.2764 |
| Group 4 | 199.000 | 4 | 99.50 | 98.1118 | 100.8882 |
| Group 5 | 71.204  | 4 | 97.50 | 93.6982 | 101.3018 |
| Group 6 | 161.666 | 4 | 99.00 | 97.2998 | 100.7002 |

CI=Confidence interval
The results also suggest that castability basically depends on the flow of the molten alloy. It is presumed that the flow of the metal alloy remains the same because the alloy is not affected despite its contents being subjected to reheating. This is a very significant finding to advocate recasting of the alloy. Hence, it can be concluded that recasting can be done for Wirolloy NB without adding new alloy before each recasting. It can also be advocated that completely cleaned and deoxidized casted alloy need not be added with new alloy in any proportion. This finding is of great significance in view of the cost involved and maintaining the level of available natural resources. The results of this study are in agreement with those studies done by Palaskar et al. [4] Nakhaei et al. [10] and Mosleh et al. [11] who suggest that recasting will not affect the castability of nickel-chromium alloy.

The results also show the presence of completely filled squares on casting, as shown in Table 6, which shows overfilling of mold by molten metal. Occurrence of voids was seen to a greater extent in Deguvest Impact investment material as compared to Bellavest SH; however, the difference was not statistically significant. Hence, both the investment materials may be used for recasting of nickel-chromium alloys.

The difference between numbers of filled squares could be because of various reasons. One possible cause of completely filled squares might be an inadequate flow of investment material through wax mesh patterns resulting in voids formation during investing. Furthermore, it could be caused by the excess flow of molten metal through the mold at high pressure. Although for the purpose of standardization, the same operator carried out the investing and casting technique, this discrepancy could be attributed to intra-operator errors during the study.

CONCLUSION

Within the limitations of the study, it was concluded that:
1. There was no significant difference in castability among the three groups of alloys, i.e. 100% fresh alloy, 50% fresh and 50% recast alloy, and 100% recast alloy
2. There is no need of adding new alloy during recasting to maintain the castability of nickel chromium alloy
3. There was no significant difference found in castability of nickel-chromium alloys using two investment materials Deguvest Impact and Bellavest SH.

Table 6: One-way analysis of variance test of the mean castability values

| Group | Sum of squares | df | Mean square | F | Significant |
|-------|----------------|----|-------------|---|-------------|
| Group 1 | Between groups | 234.375 | 2 | 117.188 | 0.857 | 0.475 |
| Between groups | Within groups | 156.226 | 2 | 78.113 | 0.543 | 0.368 |
| Total | Total | 390.601 | 4 | 0.368 | 0.840 |
| Group 2 | Between groups | 89.844 | 2 | 44.922 | 0.920 | 0.521 |
| Within groups | Total | 97.656 | 2 | 48.828 | 0.857 | 0.368 |
| Total | Total | 187.500 | 4 | 0.521 | 0.920 |
| Group 3 | Between groups | 246.094 | 2 | 123.047 | 0.434 | 0.697 |
| Within groups | Total | 566.406 | 2 | 283.203 | 0.434 | 0.697 |
| Total | Total | 812.500 | 4 | 0.697 | 0.434 |
| Group 4 | Between groups | 339.844 | 2 | 169.922 | 30.480 | 0.223 |
| Within groups | Total | 97.656 | 2 | 48.828 | 0.223 | 0.368 |
| Total | Total | 437.500 | 4 | 0.368 | 0.223 |
| Group 5 | Between groups | 156.250 | 2 | 78.125 | 0.368 | 0.757 |
| Within groups | Total | 224.546 | 2 | 112.273 | 0.368 | 0.757 |
| Total | Total | 156.250 | 4 | 0.757 | 0.368 |
| Group 6 | Between groups | 164.063 | 2 | 82.031 | 0.840 | 0.543 |
| Within groups | Total | 195.313 | 2 | 97.656 | 0.543 | 0.368 |
| Total | Total | 359.375 | 4 | 0.543 | 0.368 |

The results also show the presence of completely filled squares on casting, as shown in Table 6, which shows overfilling of mold by molten metal. Occurrence of voids was seen to a greater extent in Deguvest Impact investment material as compared to Bellavest SH; however, the difference was not statistically significant. Hence, both the investment materials may be used for recasting of nickel-chromium alloys.
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Conflicts of interest
There are no conflicts of interest.

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