

Effect of Recasting of Nickel: Chromium Alloy on its Castability

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Abstract Castability plays an important role in selection of an alloy for cast dental restorations. This study was conducted to assess the effect of recasting of nickel–chromium alloy on its castability. Different percentage combinations of new and once casted alloy were used to produce a total of twentyfive cast samples using modified Whitlock’s method and castings obtained from new alloy were used as control group. Castability value was obtained by using Whitlock’s formula. Results were analyzed using student ‘*t*’ test. There is no statistical difference between the castability value of the new alloy and the recasted alloy (confidence level 95%). Within the limitations of the study it is concluded that the castability value will not be affected by recasting the nickel–chromium alloy. Complete castings of any metal restoration are mandatory and to know the completeness of castings of any alloy, castability test is of prime importance.

Keywords Castability · Recasting · Dental casting alloys · Whitlock’s castability test · Base metal alloys

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 colour 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 1930s a base metal alloys were introduced to dentistry by Eardle and Prange. The property of this alloy satisfies with that of gold alloy with additional advantage of its reduced specific gravity and low cost. Due to this superiority over gold alloy, cobalt, chromium and nickel alloy and its allies have become immensely popular in the field of restorative dentistry [1, 2]. This popularity of these alloys can be gauged by the varieties of the alloys available in the market. At present demand for the base metal alloys has been resulted in substantial increase in the price of these alloys, it is a point of commercial concern.

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 [3]. 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.

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

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the casted alloy [4–6]. 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 Castability value of the new and recasted alloy.

Materials and Method

Castability of the alloy was tested in this study by using modified Whitlock's method [6]. The acrylic-wax mesh (Klett-O-flex, Renfert, Germany) of dimensions 11 mm × 11 mm with 100 square shaped spaces of 1 mm × 1 mm and filament diameter of 0.3 mm was selected. Two adjacent sides of the mesh had the projections of the filaments to facilitate runner bar attachment.

For standardization of all the samples, (Wax patterns) a putty mould was prepared using following procedure. First the sprue (Dentaurum, Germany), with six gauge diameter and length of 10 mm was attached to one corner of the mesh [7]. Then two runner bars of ten gauge diameter (Dentaurum, Germany) 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 mould, 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 pattern was made by using putty consistency addition silicon (Reprocil Dentsply, USA) material and a rubber mould was obtained. This mould 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 sprued pattern was attached to the crucible former (Fig. 1) and the pattern was sprayed with surface tension reducing agent (Lubrofilm-Dentaurum, Germany) and allowed it to air dry. Then asbestos lined casting ring of 30 mm diameter was placed over the crucible former. Then phosphate bonded investment (Castorit super-C, Dentaurum, Germany) was manipulated following the manufacturer's instructions and pattern was invested. After 60 min of bench set wax 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 250°C. This temperature was maintained for next 1 h further temperature was raised to 950°C and maintained at 950°C for 1 h 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 Nickel–Chromium 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.

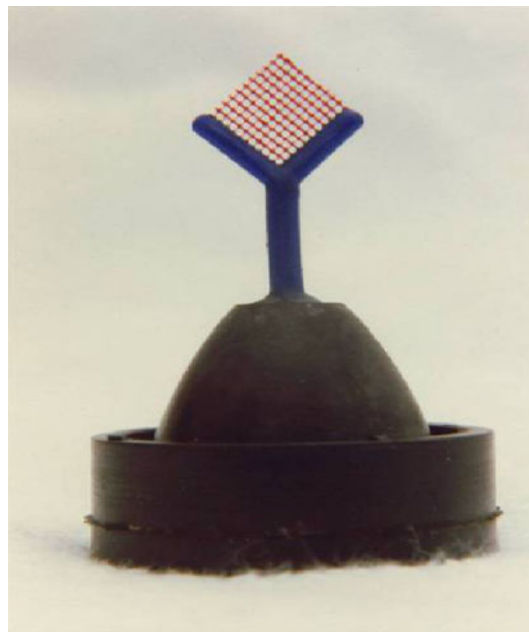


Fig. 1 Photograph showing wax pattern

Then casting was obtained and it was cleaned by keeping it in concentrated hydrofluoric acid for 10 min. Sand blasting was avoided in order to take care of delicate mesh.

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 [3–5, 8]. In this study groups were made based on different combinations of new alloy and once casted alloy as shown in Appendix Table 8. The castability was tested for all the samples from all the groups (Fig. 2). The Castability value was calculated by a method suggested by Whitlock et al. [6]. A grid with 100 square spaces will provide 220 segments. The numbers of completely cast segments were counted. In order to find out percentage castability value Hinman and Whitlock et al. suggested a formula [8].

$$C_v = \frac{\text{No. of completely cast segments}}{220} \times 100$$

where, C_v is percent castability value.

Results

The results are shown in the Tables 1, 2, 3, 4, and 5. The mean Castability value of the groups was subjected to statistical analysis using student 't' test, and this is shown



Fig. 2 Photograph showing specimens

Table 1 Tables of observations of castability values obtained through the completely cast segments, in Group A (100% new alloy)

Specimen	No. of completely cast squares	Completely cast segments	Castability value
1	99	219	99.55
2	100	220	100.00
3	100	220	100.00
4	99	219	99.55
5	97	215	97.73
Mean	99	218.60	99.36
SD	1.22	2.07	0.94

Table 2 Tables of observations of castability values obtained through the completely cast segments, in Group B (75% new alloy)

Specimen	No. of completely cast squares	Completely cast segments	Castability value
1	84	182	82.73
2	98	218	99.09
3	100	220	100.00
4	100	220	100.00
5	100	220	100.00
Mean	96.40	212	96.36
SD	6.98	16.79	7.63

in Tables 6 and 7. Graph 1 shows mean Castability value in different groups.

Discussion

The dental gold alloy contains all noble metals except copper. Sprues and buttons remaining after casting were used again for casting with addition of lost copper. Since 1930s base metal alloys like Co–Cr, Ni–Cr are in use as indirect restorative materials as they were cost effective. In

Table 3 Tables of observations of castability values obtained through the completely cast segments, in Group C (50% new alloy)

Specimen	No. of completely cast squares	Completely cast segments	Castability value
1	100	220	100.00
2	100	220	100.00
3	100	220	100.00
4	91	207	94.09
5	83	183	83.18
Mean	94.80	210	95.45
SD	7.66	16.10	7.32

Table 4 Tables of observations of castability values obtained through the completely cast segments, in Group D (25% new alloy)

Specimen	No. of completely cast squares	Completely cast segments	Castability value
1	97	216	98.18
2	100	220	100.00
3	100	220	100.00
4	91	207	94.09
5	94	214	97.27
Mean	96.40	215.40	97.90
SD	3.91	5.36	2.43

Table 5 Tables of observations of castability values obtained through the completely cast segments, in Group E (100% once casted alloy)

Specimen	No. of completely cast squares	Completely cast segments	Castability value
1	100	220	100.00
2	94	215	97.73
3	100	220	100.00
4	100	220	100.00
5	89	204	92.73
Mean	96.60	215.80	98.09
SD	4.98	6.94	3.15

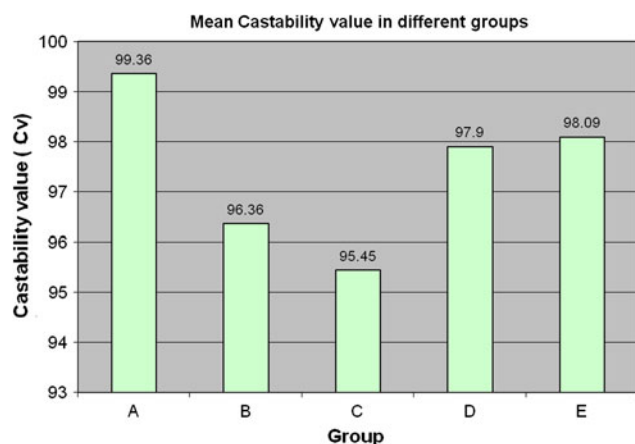
1930s and 1940s the cost of these base metal alloys was affordably low, so the sprues and buttons remaining after casting were discarded. However, at present the cost of these base metal alloys has become very high. In spite of this, manufacturer's give the instruction that alloy should be used only 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 cast restoration requires certain optimum properties, these

Table 6 Statistical table showing mean and standard deviation for castability in different groups

Group	Sample size	Mean ± SD
A	5	99.36 ± 0.94
B	5	96.36 ± 7.63
C	5	95.45 ± 7.32
D	5	97.90 ± 2.43
E	5	98.09 ± 3.15

Table 7 Comparison of means of castability values of different groups through “t” test

Between groups	‘t’ value	Df	‘p’ value	Significant
A and B	0.859	4	0.05	No
A and C	1.361	4	0.05	No
A and D	1.414	4	0.05	No
A and E	1.203	4	0.05	No
B and C	0.164	4	0.05	No
B and D	−0.420	4	0.05	No
B and E	−0.420	4	0.05	No
C and D	−0.837	4	0.05	No
C and E	−1.201	4	0.05	No
D and E	−0.103	4	0.05	No



Graph 1 Mean castability value in different groups

properties should remain constant not only during various laboratory procedures but also in the 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 researchers’ namely Harcourt, Nelson, and Presswood, Hesby, Hong [3–5, 8, 9]. Mainly they have studied properties of recast alloy like tensile strength, ultimate tensile strength, percentage elongation, modulus of elasticity, mean yield strength, microstructure and microhardness. As per the review of

literature it is to be noted that a few studies have been carried out on castability of the recastable base metal alloy. Therefore this study was undertaken to study castability 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. The groups of different combinations of alloy used in this study were shown in the Table 8 in appendix.

Ideal indirect restoration requires accurate reproduction of the wax pattern. This accuracy has so far been studied by applying castability values. Whether it is a new alloy or recasted alloy with or without addition of new alloy has to have high castability values. Hence this property was tested in this study. This castability value of various alloys and casting technique have been studied by various methods [10], However, it has been found that Whitlock’s method is easy and no special equipment is needed to assess the castability [6]. It is so because it simply involves the counting of the number of completely casted segments divided by total number of segments of the polyester sieve cloth. Whitlock’s method uses a mesh monitor of polyester sieve cloth of 18 gauge thickness of dimension 20 mm × 20 mm, with 100 square shaped spaces. This mesh monitor attached with ten gauge runner bars to the two adjacent sides of the mesh and the sprue of six gauge diameter and 10 mm length attached at the junction of two runner bars.

In this study Whitlock’s method was followed with little modification. One modification done 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.

As per Tables 1, 2, 3, 4, 5 and Graph 1, mean castability values vary between 95.45 and 99.36%. As per Table 7 the comparison of means of castability values of different groups through ‘t’ test. There is no statistical significant difference. It means that castability basically depends on the flow of the molten alloy. Though the contents of the alloy are subjected for reheating, probably they are not affected; hence flow of the molten alloy remains same. This is a very significant finding for advocating recasting of the alloy.

It can be advocated that subjecting the alloy for recasting will not bring any significant change in the castability of the alloy. Based on this study it can be

advocated that recasted alloy can be used at least once again. As per studies of Harcourt [3], 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. Various investigations have evaluated the effect of repeated use of alloys on their characteristics, however these studies showed different results. For example the comparison of Hesby et al. and Mosleh et al. studies with Issac and Bhat and Mickovic's studies reveals contradictory results about the effect of recasting on physical characteristics of base metal alloys [8, 11–13].

The results of this study are in agreement with studies by Nakhaei et al. and Mosleh et al. that recasting will not affect the castability of Nickel–chromium alloy [11, 13]. Further studies can be carried out to confirm effect of recasting of nickel–chromium alloy on its physical properties and cytotoxicity.

Conclusion

1. The castability value will not be affected by recasting the Nickel–Chromium alloy.
2. It is not necessary to add new alloy in any proportion to the once casted alloy to maintain the castability value of the alloy.
3. In this study only till second generation of the recasted alloy has been studied. It is suggested to recast the alloy for number of generations and study its effect on the properties of the alloy.

Appendix

See Table 8.

Table 8 Percentage combination of alloy used in the study for recasting

Groups	Percentage of new alloy by weight	Percentage of once casted alloy by weight
A	100	0
B	75	25
C	50	50
D	25	75
E	0	100

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