Review Article

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# Recasting of Dental Casting Alloys

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## ABSTRACT

**Background**: Dental casting alloys have found wide spread usage in restorative dentistry due to their desirable physical, biological and economical properties. The recasting of previously casted alloy is a routine procedure in dental laboratories. The advantages of recasting include decreased overall cost, to prevent wastage of natural resources and environmental protection. Cast gold alloy is in use since long time as restorative material in dentistry, later subsequent demand for semi-precious and non-precious base metal alloys has increased. This lead to increase in the demand for base metal alloys which resulted in a substantial increase in the cost of these once insignificant alloys. In our current economy, it is obligatory that dentists and technicians be cost conscious about the materials they use, and this lead to increased recasting of the alloys. So, one should know about the properties of the recasted alloys without compromising the properties.

**Keywords:** Recasting, remelted alloys, dental alloys, dental casting alloys, noble alloys, base metal alloys, biocompatibility, marginal gap, fixed partial dentures.

## INTRODUCTION

Dental casting alloys have found wide spread usage in restorative dentistry owing to their physical, biological and economical properties. In our current economy, it is obligatory that dentists and technicians be cost conscious about the materials they use, and this lead to increased recasting of the alloys. The recasting of previously casted alloy either in part or complete, is a routine procedure in dental laboratories in order to reduce the per unit cost of restorations.

Cast gold alloy is in use since long time as restorative material in dentistry. Properties like tarnish and corrosion resistance, hardness, strength, percentage elongation, castability, burnishability and capacity to take high polish made it as an ideal restorative material. However use of this precious metal alloy has almost been eliminated by two disadvantages: highly distinguishable color and high cost which resulted into subsequent demand for semi-precious and non-precious base metal alloys. [1,2]

Base metal alloys were introduced to dentistry by Eardle and Prange in 1930s as an indirect restorative material. They are used extensively in dentistry now-a-days for variety of appliances and instruments. Cast cobalt - chromium, nickel - chromium has been used for many years for fabricating removable partial denture framework and crowns and bridges and has replaced gold alloys. [3] The properties of the base metal alloys satisfy with that of gold alloy with additional advantage of its reduced specific gravity and low cost. Due to this superiority over gold alloys, cobalt - chromium and nickel alloys have become popular in restorative dentistry. At present demand for base metal alloys has resulted in a substantial increase in the cost of these once insignificant alloys. [1,2]

In 1930s & 40s the cost of these base metal alloys was affordably low, so the sprues and buttons

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remained after castings were discarded. Good cast restorations requires certain optimum properties, these properties should remain constant not only during various laboratory procedures but also in oral environment. Therefore recasting should not be done at the expense of the properties of the alloys. [4]

Due to the 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. The same cannot be said about the base metal alloys due to lack of research work and literature available. Though the manufacturer instructs to use alloy once, it will be of great advantage both economically and environmentally to recycle / recast the alloy. [5]

Advantages of recasting includes: first reason is decreased overall cost, second is to prevent wastage of natural resources and third reason is environmental protection: recycling provides environmental benefits in terms of energy conservation, decreased waste volume ratio. [6-11] The recasting procedure can be performed in a single step by mixing the sprue and casting surplus. It can also be conducted in multiple steps, where the recast and as received alloys are mixed in different proportions. [6]

The reuse of melted alloys in dental laboratories remains a controversial topic in dental practice. Impurities from previously melted alloy may result in changes in the properties of reused alloy. Some studies have reported that recasting of noble and predominantly base metal alloys cause a dramatic change in composition and properties like: corrosion, cytotoxicity resistance, hardness, yield strength, bonding with porcelain and color. [10, 12-18] However, some studies have found no changes in mechanical properties. [19,20]

A study by Walczak M et al, found that at least 50% of brand new alloy must be used and the remaining part of alloy may be casted once or twice and he also stated that recasting procedure may reduce the costs of Co-Cr-Mo-W castings. They may be used safely in dentistry. [21] The microstructure of castings containing re-melted material is similar to microstructure of new castings. The addition of 50% new alloy to previously melted buttons or sprues is recommended for recasting noble metal ceramic restorations. [15,16,18,19] Reisbick and Brantley reported a significant decrease in yield strength after 3 recastings of type III gold alloy. [22] Peraire et al showed that 7 generations could be used with no addition of new alloy. Other studies reported that on the basis of evaluation of various physical properties, at least 4 generations of alloys can be reused. [18]

Metal ceramic restorations have been commonly used in dental applications to combine the esthetics of porcelain with the durability of the metal. Mc Lean reported that properties of oxide layer of base metal surfaces can influence the bond strength between metal and porcelain. Several studies showed that some essential elements which are present in small quantities in the original alloy such as Cu, Zn may be lost through evaporation or oxidation during first casting. The proportional decrease in these elements can decrease the adherence of porcelain. So, addition of 50% new alloy to previously melted alloy is recommended for recasting noble metal ceramic restorations. [23] Ucar et al concluded that sufficient bond strength between porcelain and metal structure is an important factor determining the durability of metal ceramic restorations. The bond strength will be decreased with increase in number of recastings. He suggested not using previously casted alloys to avoid potential reduction of bond strength between metal and porcelain. [24]

The prosthetic scrap encompass the residuals generated in casting process e.g. originating from the runners, casting cones and improperly completed melts are frequently used as a part of recasting procedure. [25] The state of load occurring in oral cavity in course of mastication process is diversified and cause various level of stress concentration in hard tooth tissues and in dental fillings which may result in damage of denture fasteners or in-ceramic phase separation from prosthetic apparatus with permanent porcelain veneers. [21,26]

The addition of 50% recast material to a brand new alloy is allowed by greater part of dental alloys manufacturers. Some manufacturers established the condition that the addition of so called scrap can be recasted only once and must wholly originate from the same batch. However, the use of additions in the form of repeatedly remelted materials is not allowed by other alloy manufacturers and information regarding potential use of post-production scrap is not yet published. [21] In the opinion of Bauer et al. the scrap produced in dentistry is extremely pure due to the fact that the metal is melted in controlled conditions without necessity to apply any chemical process used in industrial conditions. [17]

**Effect of recasting on the properties of the alloys:-**

**Biocompatibility:** Is the capability of existing in harmony with the surrounding biologic environment GPT – 8

The biocompatibility of cast metallic restorations is primarily determined by the amount and nature of released cations. The biological effects of these metal ions are significantly different. Although contradictory data have been documented, many investigators have reported that Cu, Ni, and Be have pronounced cytotoxic potency. There is also evidence from *in vitro* investigations that various metallic elements like Ni, Co and Cr can modulate the immune response. Local and systemic allergic reactions to many metals have been observed, with Ni being the most frequent allergenic element. The *in vivo* effects of these metals on the immune response are yet unknown. Additionally, various other factors could contribute to biological interactions of metallic restorations, such as physicochemical surface parameters (atomic ratio of noble to non-noble metals *etc.*), phase formation, wear and quality of the manufacturing process.

There is no evidence to suggest that metal dental restorations increase the mutagenic and carcinogenic risk in humans. Except for laboratory technicians, there is no indication that metal dental materials are an occupational hazard for dental personnel. These laboratory technicians have a higher risk for fibrotic lung diseases due to dust from metals and abrasives, only if there is insufficient exhaust and ventilation in dental laboratories. The importance of these factors still remains unclear, since very scarce information from *in vivo* studies are available. [27]

**Cytotoxicity:** The property of being able to cause damage to or death of cells.

Casting alloys should be biologically inert, and the release of metallic elements from the alloys is a health hazard for the patients. [28] Base metal alloys are susceptible to various types of corrosion depending on their composition and oral environment.[29] An important consequence of element release is the cytotoxicity of adjacent tissues in cell cultures. [30,31] The cytotoxicity of cast alloys depends on their composition and element release, which may be affected by recasting.[32] As said before dental casting alloys should be biologically inert, and the release of metallic elements from dental casting alloys is a potential health hazard for dental patients. [28] Co-Cr alloys are more negatively affected by recasting than Ni-Cr alloys.[11] The Cu content of an alloy remarkably increases its cytotoxicity. [6,29] In the clinical setting, recasting base metal alloys may increase their potential cytotoxic effects. Therefore, the use of this procedure in dental practice may adversely affect the soft tissues adjacent to a restoration. For these reasons, 2 studies have suggested that base metals alloys should not be recasted.[28,33]

A study by Reddy et al analyzed the living cells and percentage of cell viability and reported that cytotoxicity increased. The addition of recast alloy increased the cytotoxic effects of Co-Cr, Ni-Cr, and Au-Pt alloys. [8] Extract solutions from the recast alloy group were more cytotoxic than control cultures. The high Cr content seems to protect against corrosion. Although 50% surplus metal addition seems to be acceptable, according to the author, clinicians should remain cautious, particularly when treating patients with known sensitivity to Ni and Pt. [15]

**Color:** The quality of an object or substance with respect to light reflected or transmitted by it. Color is usually determined visually by measurement of hue, saturation and luminous reflectance of the reflected light. Color is an important determinant of the esthetic appearance of metal ceramic restorations. [34,35] Yilmaz et al used a spectroradiometer to study the influence of recasting on the color of opaque porcelain. He compared the color of opaque porcelain applied on recasted alloys with different proportions (50% and

100%). The different proportions of recasted alloys had similar effects on the color of opaque porcelain but lack of control group was a limitation. [36]

**Castability:** The ability of molten metal to be able to wet the investment mold material very well and flow into the most intricate regions of the mold without any appreciable interaction with the investment and without forming porosity within the surface or subsurface regions.

Castability plays an important role in selecting an alloy. Base metal alloys are difficult to cast. The castability value (obtained by the Whitlock formula) [37] of Ni-Cr and Co-Cr alloys are not affected by recasting. [38] In a study by Palaskar et al, the results showed that the castability value of base metal alloys was not affected by recasting. But in this study only the second generation of the recasted alloy was used. [39]

**Porosities:** The state or quality of having minute pores, openings or interstices.

Porosities in dental casting alloy can alter physical and mechanical properties of the metal which in turn may lead to failure of the prostheses. Most frequently observed defect present on the surface of gold-based alloys is alloy porosity, which may be caused by two phenomena. The first phenomenon is appearance of the shrinkage porosity induced by the volume decrease during liquid to solid transition, while the second one is the so-called gas porosity which appears as round shiny pores scattered on the alloy surface and in the bulk. These defects cannot be removed either by grinding or polishing, because of the possible exposure of other subsurface pores. [40]

In the early days of dental casting, presence of shrinkage porosity defects near the sprue attachment points was common. Results of numerous investigations demonstrated that it was caused by solidification of the melt in the sprue, cutting off the supply of the melt to the main casting while it was still undergoing solidification and contraction. This could be avoided by the selection of appropriate melting temperature as well as by suitable design and dimensions of the sprue. Nevertheless, even with sprues of good design, it was found that localized shrinkage porosity still persisted in some castings near to their surfaces. [41]

In a study by Maksimović et al, change of the alloy properties due to the casting conditions modification is above all indicated with the linear increase of alloy microhardness with the increase of casting cycle number. Namely, the change of alloy microhardness with the number of recasting cycles follows the ascending order 160 MPa → 179 MPa →194 MPa and after the eighth recast sequence it is observed that the microhardness is increased more than 20 % in regard to its value determined after the first one. Further, the linear contractions of at least 1.25 % can be expected during the liquid to solid transition of the dental noble alloys, [42] which in turn influences the alloy porosity occurrence. Two types of porosity may be distinguished, *i.e.* the presence of shrinkage porosity is dominant after first recasting sequence, while in the other samples the presence of gas porosity is clearly revealed. Porosity varies from 0.4 % to 0.9 %**.** The increase of gas porosity is mainly connected with the reduction of zinc content in the alloy. It is well known that during multiple melting and casting comes to reduction in the content of the zinc and copper. Zinc acts as an oxygen scavenger during melting to minimize the oxidation of the other elements in the alloy. Zinc prevents oxygen from forming gas porosity in the casting. [43] The grain growth with recasting was also detected in this study. [44]

**Marginal Fit:** The fit of a casting can be defined best in terms of the “misfit” measured at various points between the casting surface and the tooth. Measurements between the castings and the tooth can be made from points along the internal surface, at the margin, or on the external surface of the casting.

The perpendicular measurement from the internal surface of the casting to the axial wall of the preparation is called the internal gap, and the same measurement at the margin is called the marginal gap. Such marginal gap in the casting determines the fit of the casting on the tooth/teeth. [45]

Marginal fit is an important aspect of fixed restorations because marginal opening leads to marginal leakage which in turn leads to more plaque accumulation and bone loss, recurrent caries and periodontal disease. [13,28,46]

Ayad evaluated the effects of 3 different casting protocols on the marginal accuracy of a high noble alloy. Statistically but not clinically significant differences were found in marginal accuracy, with a marginal discrepancy of less than 25 mm for all casting conditions. [8]

A recent study evaluated the cervical fit and internal fit of complete metal crowns that were cast and recast with Pa-Ag alloy for 3 different marginal configurations. [33] The authors concluded that as-received alloys produced significantly better marginal fit and internal adaptation than recast alloys, concluding that the recasting procedure should not be used. Three studies in which the authors measured the marginal gap with a stereomicroscope were reviewed, although the conclusions were not the same.

Ayad in another study [8] and Lopes et al [33] concluded that recasting could be performed without restrictions, whereas Bajoghli et al stated the opposite, although the latter study was limited by the small sample size (5 specimens). [47] Harcourt stated that excessive remelting of alloys leads to some changes in their composition and physical properties. This in turn decreases the fluidity of the alloy. He suggested that the alloy to be reused should be mixed with new alloy in 1:1 proportion. [48] According to Anusavice 50% of new metal can be added to previously melted alloy. After casting the surface of alloys is contaminated with investment materials, metal oxides like Al.

Bauer et al reported that the introduction of impurities in the recasting process may lead to changes in the mechanical properties of Ti after recasting. [17] Some authors proposed various surface treatment procedures before recasting to eliminate contamination. [48]

Some authors recommend that noble metal alloys can be air-borne particle abraded from 2mm distance for 1 min by $Al_2 0_3$ at 300Kpa pressure and base metal alloys at 600Kpa pressure. [13,17,50] Bauer et al reported that previously cast alloys can be air-borne particle abraded with alumina and immersed in a chemical solution with a mixture of $H_2SO_4$, HF, and $HNO_3$. [17] Hong et al introduced ultrasonic cleaning with distilled water. [13] Lin et al proposed immersion in aqua regia for 15 minutes for Co-Cr alloys, Immersion in 65% $HNO_3$ and 40%HF for Ti alloys. Airborne particle abrasion with glass beads for Au-Pt alloys. [51]

## CONCLUSION

Recasting of dental alloys is practiced worldwide mainly due to economic reason and to prevent wastage of natural resources and environmental protection. Very few references in dental literature are available regarding recasting of alloys. Few have tested the properties of the alloy by casting the used material and others have tested by adding new material to the previously melted alloy. It will be of definite advantage if the properties of the recast alloys are studied in detail and directions given to Prosthodontist and technicians without compromising the optimum properties of the alloy.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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