



The Effect of Recasting on Microhardness of Cobalt/Chromium Base Metal Alloys

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Abstract

Castings made of base metals include the cobalt/chromium alloy. This alloy is frequently used in dentistry to make crowns, bridges, and partial dentures. This alloy was first promoted as a less expensive option to cast gold that had even better physical and mechanical properties and approximately comparable biocompatibility. It was better suited for long-span bridges and cast prostheses. Aim: to assess how recasting affects the cobalt/chromium base metal alloys' microhardness. Material and Methods: 42 disc-shaped specimens of cobalt/chrome alloy measuring 5 mm in diameter and 3 mm in thickness were prepared. The cast specimens were divided into three groups based on the weight of the newly and previously cast Co/Cr alloy addition: the first group was 14 specimens of (new cast) alloy; the second group was 14 specimens of (50% new cast+50% old cast) alloy; and the third group was 14 specimens of (old cast) alloy. All the specimens were subjected to measuring the microhardness property by using a digital microhardness tester. Results: Using a student t-test, it was determined that there was no significant difference in the microhardness between the two groups (new cast) and (new cast + old cast), and that there was also no significant difference between the groups (new cast + old cast) and (old cast) (P-value $p>0.05$), yet that there was a highly significant difference between the two groups (new cast) and (old cast) (P-value $P<0.01$). Conclusion: The inclusion of different ratios of fresh and recast Co/Cr alloys can affect the microhardness. Also, the recast Co/Cr metal alloy has shown excellent results for microhardness property.

Introduction:

The cobalt/chromium alloy is one of the base metal castings. In dentistry, this alloy is often used to create crowns, bridges, and partial dentures(1). The Co/Cr alloy has properties that make it a great restoration material, including resistance to tarnish and corrosion, good electrochemistry, high strength, hardness, high modulus elasticity, elongation, castability, and polishing ability(2). This alloy were initially presented as an affordable alternative to cast gold with nearly identical biocompatibility and even superior physical qualities more suited for long-span bridges and cast prosthetics(3). Precision casting has traditionally been utilized to make dental prosthetics. Another name for casting is a wax loss technique or an investment(4). The lost-wax technique is used to create dental casts. A heat-resistant investment material serving as a mould is positioned around a wax pattern imitating the final product. After that, heat is used to remove the wax. Then, a canal known as a sprue is used to inject molten metal into the mold chamber(5). Because casting processes ask for melting of more metal than is required for filling the mold, a button-like excess is removed from the casting, the extra molten metal that is left behind after casting shrinkage is used to make the button. For financial reasons, the button can be used again to fabricate a good quality casting. in order to fabricate castings that seem to be clinically acceptable(6). Although the reasons for not recycling already cast metal are not well studied and recorded, during the casting process, several significant secondary elements that were present in small quantities in the basic alloy compositions may be lost during remelting techniques through evaporation or oxidation. Recasting metals has also been shown to alter their mechanical characteristics, corrosion resistance, and biocompatibility. There are various articles available on the effects of recycling previously cast alloys on their healthcare practices. While some of these publications advocate using already-cast alloys, others argue against it(7). The

recommended methods in the literature for recasting dental alloy range from introducing old alloy to some new alloy to 50% new alloy using castings that have already melted buttons or sprues removed(8). In the absence of new alloys, alloy recasting in dentistry can change both the microstructure and the mechanical performance of the alloy(9). A common method for classifying materials and comparing the study of changes in their properties is hardness testing. The most common methods for determining hardness are abrasion, scratch, and indentation tests. However, the latter strategy has been applied the most frequently(10). Therefore, our in vitro investigation used specimens made of cobalt chromium alloy. A Vickers hardness test was applied to the specimens to measure their properties of hardness.

Materials and Methods:

Specimens' Design and Groups

42 specimens of a cobalt/chrome alloy disc shaped with a diameter of 5 mm and a thickness of 3 mm were constructed(7) Depending on the weight addition of new and old cast Co/Cr alloy, the cast specimens were split into three groups (3) as follow:

1.14 specimen of (new cast) alloy

2.14 specimen of (50% new cast+50% old cast) alloy

3.14 specimen of (old cast) alloy

Specimen Preparation

Software (Autodesk 3ds max 2022, USA) was being used to design the disc form data that is used to produce the specimens. Then the data were converted to a three-dimensional system (Asiga MAX UV, 3D printer, Sydney, Australia) and castable modeling resin was used to fabricate it. The disc-shaped specimens were made using phosphate-bonded investment material (XACT, Dentify, Germany) and cast using a Co/Cr metal alloy (Wirobond SG, BEGO, Germany), the Co/Cr alloy that was utilized has the following elemental composition: (% wt) (Co 63.9, Cr 24.7,W 5.4, Mo 5.0, Si 1.0).

For the first group an electrical burnout furnace was used for burnout, and an induction casting equipment was used for casting. All of the steps were carried out in accordance with the manufacturer's instructions, which called for cooling at room temperature, divesting, and 250 μ m aluminum oxide particles for sandblasting under 3 bar pressure with a 20 mm gap and a 45° angle between the specimens' surface and the nozzle(11). The recasting was carried out using a cylindrical wax pattern to simplify the casting process(12). The second group of specimens was created by combining 50 % of Co/Cr alloy that had just been received from manufacture with 50 % of Co/Cr alloy that had previously been once recasted from the cylindrical pattern, the third group was completely made from Co/Cr alloy once recasted from the cylindrical pattern. The same approach used to process group one was applied to the other two groups.

Hardness Test Procedure

Due to the study's small specimen size, the Vickers hardness number (VHN) was computed for all Co/Cr specimens. (HVS microhardness tester, LARYEE, China) was used, fig.(1). A diamond indenter designed like a right pyramid with a square base and an angle of 136 degrees between the opposing sides has been used to indent specimens as part of the Vickers hardness test. Under a microscope: 15 seconds of 500 grams of force(7). The specimens' surfaces' diagonals of the indentation left there after the force was eliminated are recorded, and their average is calculated. Digital computations are being used to identify the area of the sloping surface of the indentation.

Results:

The statistical analysis for the current study was performed using the SPSS statistical software. Basic statistical techniques such as descriptive and inferential statistics (student t-test) were used to

evaluate and analyze the data. The descriptive statistics of the three studied groups of Co/Cr alloy (new cast), (new cast + old cast), and (old cast), which include minimum, maximum, mean, and standard deviation, respectively, as shown in Table (1) and Fig. (2), with the old cast group having the highest mean value. For the microhardness comparison between two groups (new cast) and (new cast + old cast) using student t-test revealed that there was no significant difference (P-value $p > 0.05$), and for the comparison between (new cast + old cast) and (old cast) groups also, there was no significant difference (P-value $p > 0.05$), whereas there was a highly significant difference between (new cast) and (old cast) with (P-value $P < 0.01$) as shown in Table (2).

Discussion:

Hardness increased following the initial recasting processe(7). The processes of remelting and resolidification are involved in recasting, and the resultant grain size may differ from the original. The resulting grain size depends on the number of nuclei for grain formation when the melting temperature and casting circumstances are the same(13). Typically, the impurities can help with grain nucleation and reduce grain size, which results in a rise in microhardness with each recast, In addition to an increase in impurity concentration, the recasting sequence's disappearance and appearance of various phases also may contributed to the microhardness rise(14). Analyses by Kaiser help explain the variability in the micro hardness values found in our experimental study. Thus, according to Kaiser, the standard indentation tests produce results that are representative of the alloy's entire matrix. The size of elements in an alloy system, such as grains, carbon at grain boundaries, intergranular matrix, or micro holes brought on by alloy contraction, is extremely varied. The depth of the feature (such as grains)

may be exceeded by the indenter, minimizing the hardness(15).

100%) new and recast cobalt/chromium base metal alloys.

Conclusion:

In the perspective of this study's limits: -
1-For the purpose of manufacturing fixed prostheses, recast cobalt/chromium base metal alloy shows favorable results in terms of measured microhardness property.
2-The microhardness can be modified by the addition of various ratios of (50%,

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Fig. (1): HVS microhardness tester

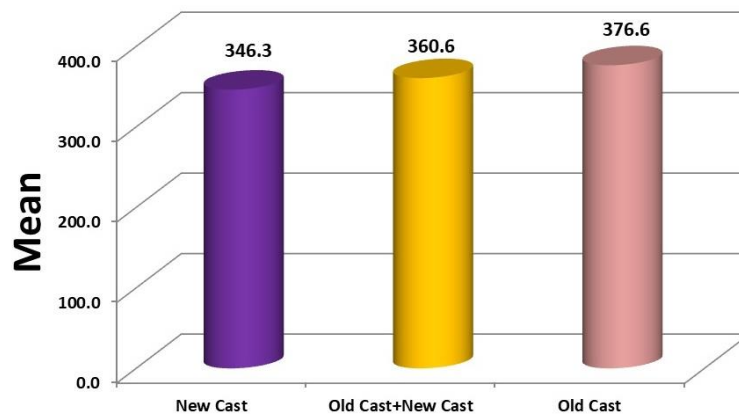


Fig. (2): Mean value of (new cast), (new cast + old cast) and (old cast)

Table (1): Descriptive statistics of studied groups

Groups	N	Range		Mean± SD.
		Min.	Maxi.	
New Cast	14	312.5	378.9	346.26±25.65
New Cast + Old Cast	14	318.3	398.3	360.57±27.89
Old Cast	14	350.5	399.3	376.56±17.34

Table (2): Comparison between the different studied groups

Groups	t-Test	P-Value	C.S
New Cast * New Cast + Old Cast	1.700	P=.113	P>0.05 (NS)
New Cast + Old Cast * Old Cast	1.784	P=.098	P>0.05 (NS)
New Cast * Old Cast	3.833	P=.002	P<0.01 (HS)

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