Effect of recasting on the bond strength of porcelain to base metal alloys: A systematic review

Prithvi Udhayaraja¹, M. Dhanraj², Ashish R. Jain¹*¹

ABSTRACT

Background: Metal-ceramic restorations have had a high degree of success, as they integrate the esthetics of porcelain and the strength and durability of metal. Noble metal alloys are commonly used to produce the metal substructure. Aim: The aim of this study is to evaluate the effect of recasting on the bond strength of porcelain to base metal alloys. Methods: Electronic search of the PubMed-MEDLINE database was done. The reference lists of all eligible studies were also searched. The results of the searches were analyzed. The PUBMED search yielded a total of 7 articles, of which three studies met the inclusion criteria and four were excluded from the study. All the three included studies evaluated the effect of recasting on the bond strength of porcelain to base metal alloys. Results: The obtained studies showed varying levels of heterogeneity, and hence, a meta-analysis could not be performed. The tests used were the planar shear test and flexural tests to determine the bond strength of porcelain to base metal alloys. The literature has reported the following findings on porcelain bond strength with recasted alloys: (a) The first recasting of alloys reduces the bond strength of porcelain to the base metal alloys, (b) The second recasting does not differ greatly from the first recasting, and (c) a 50% recast of alloys greatly reduces its strength. Conclusion: Addition of previously used base metal dental alloy for fabricating metal ceramic restorations is not recommended as it reduces the strength of the alloy.

KEY WORDS: Alloy, Base metal, Bond strength, Casting, Porcelain, Repair

INTRODUCTION

Metal-ceramic restorations have had a high degree of success, as they integrate the esthetics of porcelain and the strength and durability of metal. Noble metal alloys are commonly used to produce the metal substructure.[1] Due to their biocompatibility, ease of casting, adequate bonding and mechanical strength, High noble and noble metal dental casting alloys are the materials of choice. However, casting alloys comprising base metals are often preferred because of their lower cost, mechanical properties, and low density.[2]

A strong bond between metal and ceramic is critical for maintaining the clinical performance of the restoration. Superior adhesion of dental porcelain to a metal substrate is created when: (1) Porcelain wets the metal surface, (2) a thin and adherent oxide layer is formed on the metal, and (3) surface irregularities are formed on the metal oxide.[3] The formation of a stable oxide layer between the two structures is important for the creation of a strong chemical bond.

Remelting the casted metal is usually done whenever there is a casting failure or as a routine procedure where dental laboratories want to decrease the unit cost of a fixed partial denture.[7] Remelting previously cast metal is a routine procedure that dental laboratories use to decrease the unit cost of a fixed partial denture. However, this process can result in a change in metal oxide composition at the dental alloy surface, which is critical for the metal ceramic bond.[8] The shear test is commonly used to evaluate the bond strength between alloys and dental ceramic.[9-13]

SEARCH STRATEGY

The PUBMED search yielded a total of 7 articles, of which three studies met the inclusion criteria and four were excluded. All the three included studies

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evaluated the effect of recasting on the bond strength of porcelain to base metal alloys.

**ELIGIBILITY CRITERIA**

Inclusion and exclusion criteria for considering studies for this review were set before the search. Studies published in English were only considered, and no publication date or publication status restrictions were applied. Literature reviews were excluded from the study.

**SCREENING AND SELECTION**

The titles and abstracts of studies identified from the searches were assessed independently by two review authors. Full copies were retrieved for those studies, which were likely to fulfill the inclusion criteria, or for which there were inadequate data in the title and abstract to make a clear decision. The full-text papers were assessed independently to identify whether or not the studies met the inclusion criteria. Conflicts concerning inclusion of a study were resolved by discussion. Studies fulfilling the inclusion criteria went through a quality assessment and data extraction, and all the irrelevant studies were excluded. The reference list searching of all the relevant studies were performed for identifying additional studies.

**DATA EXTRACTION**

Data were extracted independently by two review authors.

**DATA COLLECTION PROCESS**

Both the review authors recorded study characteristics of included studies such as sample size, knowledge of parents, and outcomes measures independently.

<table>
<thead>
<tr>
<th>Total Number of Articles</th>
<th>N = 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discarded Studies Based on Title and Abstract</td>
<td>N = 4</td>
</tr>
<tr>
<td>Full Text Articles</td>
<td>N = 3</td>
</tr>
<tr>
<td>Selected Articles</td>
<td>N = 3</td>
</tr>
</tbody>
</table>

**RISK OF BIAS**

These were categorized according to the following:

1. Low risk of bias: If all criteria were met (bias less likely to seriously alter the results).
2. Moderate risk of bias: If one or more criteria were partly met (bias that raised some equivocalness about the results).
3. High risk of bias: If one or more criteria were not met (bias that weakened acceptance of the results).

**SYNTHESIS OF DATA**

The search yielded a total of 89 articles, of which for which the title and abstract were checked. Of these 84, articles which are clearly irrelevant for this review after title search and four articles were considered for inclusion after abstract screening for this review. A total of three articles were included finally which had full-text eligibility.

**RESULTS**

A total of 89 articles were identified through the MEDLINE and PubMed searches. Abstracts were reviewed to confirm the articles met the inclusion criteria. A total of three articles were included finally and the data was extracted from these articles (Table 1). The literature has reported the following findings on porcelain bond strength with recasted alloys: The first recasting of alloys reduces the bond strength of porcelain to the base metal alloys; the second recasting does not differ greatly from the first recasting and a 50% recast of alloys greatly reduces its strength.

**DISCUSSION**

The obtained studies showed varying levels of heterogeneity, and hence, a meta-analysis could not be performed. The studies showed that the main factor in decreasing the metal-ceramic bond strength in base metal alloys is the increased thickness of the oxide layer. The tests used were the planar shear test and flexural tests to determine the bond strength of porcelain to base metal alloys. The literature has reported the following findings on porcelain bond strength with recasted alloys:

- The first recasting of alloys reduces the bond strength of porcelain to the base metal alloys.
- The second recasting does not differ greatly from the first recasting.
- A 50% recast of alloys greatly reduces its strength.

According to Atluri et al., the findings of the present study showed that there was a significant reduction in the metal-ceramic bond strength for each of the Ni-Cr (664.63N) and Co-Cr alloys (497.41N) with the addition of recast alloy to the fresh alloy. This reduction in the bond strength can be attributed to an increase in the frequency of interfacial voids as the percentage of recast metal is increased. Another possible reason for the failure of recast alloy may be the compositional change that occurs after multiple
Table 1: Studies on the effect of Recasting on the bond strength of Porcelain to Base Metal Alloys

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Journal</th>
<th>Study design</th>
<th>Study group</th>
<th>Outcome parameters</th>
<th>Intervention</th>
<th>Results</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rao et al.</td>
<td>2014</td>
<td><em>Journal of International Oral Health</em></td>
<td>In vitro one-way ANOVA</td>
<td>Group A - Ni-Cr alloy used in this prospective study was Wiron 99 Group B - The Co-Cr alloy used was Wirobond C</td>
<td>The bond strength of Ni-Cr and Co-Cr alloys with dental ceramic on repeated castings using SB test using a Custom Made Apparatus.</td>
<td>Ceramic application over recasted alloys.</td>
<td>Metal-ceramic bond strength for Ni-Cr (842.10N) and Co-Cr alloys (645.57N) was calculated. Ni-Cr reduced to 645.50N after first casting and Co-Cr reduced to 457.35N after first casting. Ni-Cr reduced to 506.28N after second casting and Co-Cr reduced to 389.30N after second casting.</td>
<td>A significant reduction in the bond strength was observed with the addition of the first recast alloy compared with the addition of second recast alloy. The addition of previously used base metal dental alloy for fabricating metal ceramic restorations is not recommended.</td>
</tr>
<tr>
<td>Madani</td>
<td>2010</td>
<td><em>Journal of Prosthodontics</em></td>
<td>In vitro three-way ANOVA</td>
<td>Group A - 0.0%, once-cast alloy Group B - 25% once-cast alloy Group C - 50% once-cast alloy Group D - 75% once-cast alloy Group E - 100% once-cast alloy</td>
<td>Bond strength of recast base metal alloys at different percentages.</td>
<td>Ceramic application over recasted alloys.</td>
<td>Adding more than 50% of recast alloy significantly decreased the bond strength of the metal ceramic.</td>
<td></td>
</tr>
<tr>
<td>Ucar</td>
<td>1999</td>
<td><em>The Journal of Prosthetic Dentistry</em></td>
<td>In vitro One-way ANOVA</td>
<td>C0 - Never cast C1 - Cast once C2 - Cast twice C3 - Cast thrice</td>
<td>The SB load between the recast alloy and dental porcelain was evaluated using two different methods: SB and 3PB tests.</td>
<td>Ceramic application over recasted alloys.</td>
<td>The mean SB load of C0 (738.0±77.1 N) was significantly higher than the load of C1 (577.8±139.4 N) (P&lt;0.003), C2 (494.8±77.6 N) (P&lt;0.001), and C3 (480.5±60.9 N) (P&lt;0.001). However, no significant difference was found between C1, C2, and C3 (P&gt;0.001). Mean peak load of specimens cast from C0 (39.8±1.79 N) was significantly higher than the mean peak load of the specimens in the other three groups (P&lt;0.001).</td>
<td>A decrease in bond was observed as the number of recastings increased.</td>
</tr>
</tbody>
</table>
castings.[14] Tucillo reported that the thickness of the adherent oxide layer formed at the metal surface might decline due to multiple castings and result in decreased bond strength.[15]

The shear test is considered by some authors as the most adequate method to measure bond between two materials.[16,17] The dominant stress in the shear bond (SB) test is shear stress, whereas in the 3-point bending (3PB) test, tensile stress predominates.

According to Madani et al., recasting the base metal alloys had a negative effect on metal-ceramic bond strength and that adding more than 50% recast alloy resulted in a significant decrease in bond strength. The formation of a strong bond between the opaque porcelain layer and the cast alloy is essential for the longevity of the metal-ceramic restoration.[18] According to several studies, the main factor in decreasing the metal-ceramic bond strength in base metal alloys is the increased thickness of the oxide layer.

According to Ucar et al., recasting of the same alloy multiple times may interfere with the compositional stability of the alloy.[21] After multiple castings, a change in minor and trace elements (aluminum, beryllium, boron, carbon, cobalt, copper, silicon, iron, tin, gallium, and zirconium) is expected.[23] This results in a decreased bond between the metal and the ceramic, since the chemical bond is affected by these elements. A significant decrease in the metal ceramic bond after the addition of recast alloy was confirmed with two different tests: The SB and 3PB tests.

CONCLUSION

Addition of previously used base metal dental alloy for fabricating metal ceramic restorations is not recommended as it reduces the strength of the alloy.

REFERENCES


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