Effect of the Thickness of Opaque Layer Coating on Strength of Metal-resin Bonding in Repairing PFM

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To observe the effect of the thickness of opaque layer coating on strength of metal-resin bonding, by comparing the metal-resin bonding strength of specimens with different opaque specimen thickness. Methods: two metal crown materials: cobalt-chromium alloy, gold alloy. Each material was produced to the same unified specimen. Then divided into three groups: no pre-opaque layer group, thin opaque layer group, thick opaque layer group. Each set had six test specimens. Using three-point flexure test method to test the initial crack pressure, the effect of different opaque layers thickness on the metal-resin bonding strength were compared. Descriptive statistics were used SPSS10.0 software package. Use SNK variance to test. RESULTS: No significant differences on bonding strength between the metal crowns. Thin opaque layer group metal - resin bonding strength was significantly greater than the thick opaque layer group’s (P <0.05); The bonding strength of the two groups’ specimens which coated opaque layer are greater than not coated opaque layer groups’, the differences was significant(P <0.05).Conclusion: Coating a thin opaque layer can increase metal-resin bonding strength, the opaque porcelain layer thickness should be controlled in order to increase the metal - resin bonding strength, in the clinical operation of PFM filling porcelain.

Keyword: Three-point Flexure; Metal-resin Bonding Interface; Binding Strength

1. Introduction

The PFM application has nearly 50 years of history. With dental materials and processing technology continues to progress, porcelain fused to metal technology has been considerable developed. As bonding strength of porcelain and alloys continues to improve, PFM can withstand greater force, but also in line with the aesthetic requirements, therefore PFM were welcomed to clinical repair. However, in clinical work, clinicians and patients were troubled by the problem of the PFM’s issue that porcelain cracking. In most cases, we choose to remove the original restoration and replace a new one. But in some cases, for example, such as poor abutments, difficult to remove the prosthesis, seriously affecting the appearance, we can only use ceramic repairing materials to repair the part cracked off.

Materials used to patch is typically a high-strength resin, it is important to improve the bonding strength between resin and metal crown restoration. Means normally used include metal grinding and sandblasting, metal surface treatment agent, etching, silane coupling agent, the use of an adhesive agent, can improve the metal-resin
bonding strength. In clinical porcelain repair case, the position again collapse porcelain usually located between the opaque porcelain layer and the metal cover, the opaque porcelain layer, between the opaque layer and the resin layer. Therefore, the opaque layer has a significant impact on the metal-resin bonding strength.

This study intends to apply three-point flexure mechanical test methods for analysis to the combining strength of different opaque layer thickness of the specimen, observing the impact of different opaque porcelain layer thickness on bonding strength, to provide guidance for clinical porcelain repair.

2. Materials and Methods

2.1 Laboratory equipment

LRX Plus mechanical testing machine (Easy Test, EZ20, Loyd Instrument LTD, UK)
Dental cobalt-chromium alloy (Shofu, Japan)
Dental gold alloys (Shofu, Japan)
Ceramic Repair (Ivoclar Vivadent, Liechtenstein)

2.2 Specimen production

2.2.1 Grouping: two metal crown materials
Cobalt-chromium alloy, gold alloy. Each material was produced to the same unified specimen. Then divided into three groups: no pre-opaque layer group, thin opaque layer group, thick opaque layer group. Each set had six test specimens. A total of 36 specimens.

2.2.2 Metal part of the production
According ISO9693 standard, metallic specimen size is $25.0 \times 3.0 \times 0.5 \text{mm}^3$, conventional embedding, casting, sandblasting, cleaning.

2.2.3 Opaque layer coating
According to ceramic material instruction require to etch, coat coupling agent, coat opaque layer. In thick opaque layer group, most porcelain color cover the entire metal base, thickness of about 0.15~0.2mm. In thin opaque porcelain layer group, porcelain color slightly to cover the entire metal base, thickness of about 0.05~0.15 mm.

2.2.4 Coating the surface layer resin
The thickness of resin layer is $8.0 \times 3.0 \times 1.0 \text{mm}^3$. 

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2.3 Load

In the LRX Plus mechanical testing machine, with a three-point flexure test to measure the loading force of metal-resin separation. Both ends of the specimen are placed on a support, span of 20mm, resin facing down. The indenter which surface radius is 1.0 mm loaded on the midpoint of the opposite surfaces of the metal resin, the loading speed is 1.0 mm/min, to observe and record the load value of the resin cracking.

Record every specimen damage critical force value $F_{\text{fail}}$. Finally, calculate the metal-resin bonding strength of the pressure $\tau_b = k \cdot F_{\text{fail}}$. (Coefficient $k$ is the product of the test piece thickness and the Young’s modulus of the metal)

2.4 Statistical analysis

Due to consistent specimen thickness, specimens are made of the same material, suppose $k$ is measured. SPSS10.0 software package used for statistical description of the experimental data $F_{\text{fail}}$. Useing Student-Newman-Keuls method to make a pairwise comparison for the sample mean.

3. Results

Different metals, different opaque layer thickness destructive critical values in Table 1

<table>
<thead>
<tr>
<th></th>
<th>No pre-opaque layer group</th>
<th>Thin opaque layer group</th>
<th>Thick opaque layer group</th>
</tr>
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<tbody>
<tr>
<td>Cobalt-chromium alloy</td>
<td>7.12±2.47</td>
<td>15.43±3.78</td>
<td>12.79±2.99</td>
</tr>
<tr>
<td>Gold alloy</td>
<td>8.02±3.52</td>
<td>14.97±4.01</td>
<td>12.06±3.14</td>
</tr>
</tbody>
</table>

No significant differences on bonding strength between the metal crowns. Thin opaque layer group metal - resin bonding strength was significantly greater than the thick opaque layer group’s ($P <0.05$); The bonding strength of the two groups’ specimens which coated opaque layer are greater than not coated opaque layer groups’, the differences was significant ($P <0.05$).

4. Discussion

In the experiment, the value of every specimen metal-resin critical burst pressure ($F_{\text{fail}}$) were calculated by formula of the bonding strength of metal-resin($\tau_b = k \cdot F_{\text{fail}}$). When the metal sample thickness of 05.mm, the Young’s modulus of the metal used is 216, K is 3.6. [5] As can be seen from Table 1, the metal-resin bonding strength is
small, which is far below the relevant findings about metal porcelain bonding strength. [6, 7, 8] Therefore, the use of porcelain repairing materials to repair collapse, its intensity is much lower than the metal-porcelain bonding strength of original restorations. From the metal-resin bonding strength value point of view, the value is difficult to meet the needs of normal chewing function, especially in the anterior region, for that case that must be able to dismantle and re-repair we should try to remove the original restoration and re-repair it. For that never been able to dismantle, it must be described in detail to the patient that the porcelain repair can only meet appearance requirements, unable to meet the functional requirements; when adjusting the occlusion, to make the porcelain repair area and teeth of opposite jaw without contact, avoiding functional contacting leading to the collapse of porcelain again.

The results of this study suggest that, during the porcelain repair, we need to coat thin opaque layer, the thinner the better, to avoid masking coating thicker layer, otherwise it will reduce the binding force between metal and resin.

References