Original article:

A comparison between different luting cements on the retention of complete cast crowns - an in vitro study

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Abstract

Aim: To compare and evaluate retentive strength of 4 different commercially available luting agents (2 Older & 2 Recent) when subjected to test for tensile bond strength.

Materials & Methods: A total of 40 freshly extracted non carious human premolars teeth were mounted and prepared for full coverage crowns with 4° overall taper. Impressions recorded and castings fabricated with Ni-Cr alloy. The cements tested were Zinc phosphate cement (Harvard), Glass Ionomer Cement Fuji 1 (GC), Adhesive Resin Cement Multilink Speed (Ivoclar), Resin modified Glass ionomer cement Rely X™ Luting 2 (3M ESPE). The cemented crowns were stored in distilled water at room temperature for 24 hours prior to application of tensile load at a strain rate of 1mm/min. The loads at debonding or breaks were noted and tensile bond strength were calculated in MPa.

Analysis used: ANOVA one way test was used for analysis.

Results: The mean stress required to debonding the copings or crowns was 6.17 (± 0.39), 5.57(±0.25), 5.15(± 0.34), and 4.24 (±0.31) MPa for the Adhesive resin, Resin modified glass ionomer, Glass ionomer and Zinc phosphate cement groups, respectively.

Conclusion: The adhesive resin multilink speed cement had highest retentive strength followed by resin modified glass ionomer Rely X™ Luting 2 (3M ESPE), glass ionomer fuji 1 (GC) and zinc phosphate cement.

Key words: Freshly extracted premolars, glass-ionomer cement, adhesive resin cement, zinc phosphate cement, resin modified glass ionomer cement.

Introduction

Frequent cause of failure of crowns and bridges was reported as lack of retention. The retention of full coverage restorations is a function of tooth preparation geometry, specifically axial taper, height, surface area and surface roughness which limit the paths of displacement of the casting. However, the availability of adhesive luting cements which bond to the tooth substance and the restoration offers the possibility of increased crown retention independent of preparation geometry. Zinc phosphate cement has been used as a standard luting agent for cast restorations for many years. The retentive force of the cement measured 13% surface adhesion and 87% interlocking force when analyzed by Fusayama et al., with cylindric inlays. Poly carboxylic acid exhibits chemical adhesion to the tooth structure. It has low compressive strength, higher tensile strength. The cement has been reported to have biocompatibility with dental pulp and is best suited for cementation of single metal units in low stress areas. Glass ionomer cement adhere to the tooth structure by
formation of ionic bond as a result of chelation of carboxyl groups in the acid with the calcium or phosphate ions of enamel and dentin. Its compressive strength is higher than zinc phosphate and poly carboxylate cements. Cement failure can develop if exposed to moisture during initial setting.\(^7\)Resin modified glass ionomer cement sets by acid-base reaction These cements have greater compressive and tensile strength than zinc phosphate , poly carboxylate and some glass ionomers but less strength than resin bonding cements. It exhibits more resistance to moisture and are less soluble than glass ionomer cements.

Resin bonding cements are variation of filled BIS-GMA resin and other methacrylics. Polymerisation occurs through chemically initiated mechanisms, photo polymerisation or combination of both. Its high strength and insolubility in oral fluids makes this cement choice for cementation of all ceramic, and fibre reinforced onlays, inlays, crowns, veneers and bridges.\(^8\)The purpose of this in vitro study was to compare and evaluate retentive strengths of 4 different commercially available luting agents when subjected to tensile bond strength.

Materials and methods
A total of 40 freshly extracted non-carious human premolar teeth (fig.1) were collected. They were cleansed of debris by placing them in \(1\%\) hydrogen peroxide solution for 24 hours. Then grooves of 10 mm depth were made horizontally in radicular part of the each tooth using diamonds (SS white,TR21)then teeth were embedded in putty mold(Polyvinyl siloxane putty , Aquasil, Dentsply international, U.S.A) (20mm length & 20mm diameter) with self curing acrylic resin (DPI, Mumbai, India) (fig.2). They were placed such that cemento-enamel junction was just 1-2 mm above the acrylic surface. Then full coverage crown preparation carried by using universal tool cutter and grinding machine (Hahn &Kole,Germany)(fig.3)with over all \(4^\circ\) taper in the preparation (fig.4). The occlusal aspect was ground flat for study purposes and specimens were stored in distilled water.

Alginate (Zelgan plus, Dentsply Pvt Ltd, Gurgaon, India) impressions were made of each specimen, die stone (Neelkanta, Neelkanta Pvt Ltd, Jodhpur, India) was used to pour the impression and obtain the dies. The die spacer of 25 \(\mu\)m was applied on the die using Pico Fit 22 TM die spacer. Wax patterns were fabricated conventionally with the flat occlusal surface having a loop designed for testing purposes. The patterns were invested and cast in the conventional induction casting method using Ni-Cr alloy (Vera Soft, Alba dent company, Atlanta, U.S.A). The cast crown thus obtained were then sandblasted on the inside using Al oxide 50 \(\mu\)m and finished (fig.5). Then fit was checked on the corresponding specimens.

All the specimens were measured for average heights, larger and smaller diameters and total surface area was calculated using formula

\[
A = \pi S (R - r) + \pi r^2, \text{ where } S = \sqrt{(R - r)^2 + h^2}
\]

Total 40 crowns divided into four groups (A,B,C,D). Group A crowns cemented with zinc phosphate cement (Lot No.1141002, Harvard, Germany), group B crowns cemented with glass ionomer cement (Lot No.1310011, Fuji 1, GC corporation, Tokyo, Japan), group C crowns cemented with resin modified glass ionomer cement (Lot No. N56892, Rely X<sup>TM</sup> Luting 2, 3M ESPE, U.S.A), group D crowns cemented with Adhesive resin cement (Lot No. S035112, Multilink speed, Ivoclar, Germany). The luting agents were mixed as per the manufacturer’s instructions. A thin layer of luting agent was applied to the inner surface of the crown with a plastic instrument and the crown seated on its respective preparation by hand and finger pressure.
(fig.6). The excess cement removed from around the margins with a sharp probe. Then samples were stored in distilled water for 24 hours. A universal testing INSTRON machine Model 4206 (fig.7) was used to measure tensile bond strength of each sample. A tensile load was applied till cast crown debonded with cross head speed of 1 mm/min (fig.8). The load at breaks were noted and tensile bond strength in MPa were calculated using formula

\[ 1 \text{ MPa} = \frac{1 \text{ N}}{\text{mm}^2} \]  
\[ 1 \text{ kg} = 9.81 \text{ Newton (N)} \]

Results

Table 1: Retentive strengths of Ni-Cr crowns cemented with four different luting cements in MPa.

<table>
<thead>
<tr>
<th>S.no</th>
<th>Zinc phosphate</th>
<th>Glass ionomer</th>
<th>Resin modified glassionomer</th>
<th>Adhesive resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.3</td>
<td>5.3</td>
<td>5.88</td>
<td>5.92</td>
</tr>
<tr>
<td>2</td>
<td>4.42</td>
<td>5.62</td>
<td>5.76</td>
<td>6.14</td>
</tr>
<tr>
<td>3</td>
<td>4.8</td>
<td>4.78</td>
<td>5.65</td>
<td>6.83</td>
</tr>
<tr>
<td>4</td>
<td>3.85</td>
<td>4.57</td>
<td>5.76</td>
<td>6.46</td>
</tr>
<tr>
<td>5</td>
<td>4.2</td>
<td>5.12</td>
<td>5.67</td>
<td>5.46</td>
</tr>
<tr>
<td>6</td>
<td>4.1</td>
<td>5.4</td>
<td>5.12</td>
<td>6.32</td>
</tr>
<tr>
<td>7</td>
<td>3.7</td>
<td>4.9</td>
<td>5.72</td>
<td>6.11</td>
</tr>
<tr>
<td>8</td>
<td>4.3</td>
<td>5.2</td>
<td>5.36</td>
<td>5.8</td>
</tr>
<tr>
<td>9</td>
<td>4.5</td>
<td>5.56</td>
<td>5.54</td>
<td>6.2</td>
</tr>
<tr>
<td>10</td>
<td>4.2</td>
<td>5.02</td>
<td>5.22</td>
<td>6.5</td>
</tr>
<tr>
<td>Mean</td>
<td>4.23</td>
<td>5.14</td>
<td>5.56</td>
<td>6.17</td>
</tr>
<tr>
<td>SD</td>
<td>0.31</td>
<td>0.34</td>
<td>0.25</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Table 2: Mean comparison among variables.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MIN</th>
<th>MAX</th>
<th>MEAN</th>
<th>SD</th>
<th>F VALUE</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc phosphate</td>
<td>3.7</td>
<td>4.8</td>
<td>4.24</td>
<td>0.31</td>
<td>61.887</td>
<td>0.000</td>
</tr>
<tr>
<td>GIC</td>
<td>4.57</td>
<td>5.62</td>
<td>5.15</td>
<td>0.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMGIC</td>
<td>5.12</td>
<td>5.88</td>
<td>5.57</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adhesive resin</td>
<td>5.46</td>
<td>6.83</td>
<td>6.17</td>
<td>0.39</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Statistical Analysis: ANOVA one way test. Statistically significant if P<0.01
Discussion

Dental luting agents provide a link between the restoration and prepared tooth, bonding them together through some form of surface attachment, which may be mechanical, micro-mechanical, chemical or combination. Long-term clinical success of fixed prosthodontic and cast restorations is influenced by many factors, preparation design, oral hygiene/microflora, mechanical forces, and restorative materials being some of them. However, key factor to success is the choice of a proper luting agent and the cementation procedure. Many studies have been carried out comparing the retention of cast restorations with different cements. However, it can be concluded that no cement emerges as clearly superior to another in these tests due to conflicting results. This may have occurred due to variations in test parameters, testing conditions and application of statistical tests which assume normal distributions where they did not exist, together with small numbers of test specimens.

According to statistical analysis of this study there was a difference between the retention of 4 different luting agents. Zinc phosphate cement (Harvard cement) had the least adhesive strength compared to the other three luting cements (4.23 MPa). Zinc phosphate is a non adhesive cement with limited mechanical properties, exhibits no adhesion on the molecular level. It holds the restoration in place by engaging small irregularities on the surfaces of both tooth and restoration. The glass-ionomer cement provided significantly better retentive strength values than the zinc phosphate cement. Lesser values than resin modified glass ionomer and adhesive resin cements. Glass ionomers, possesses some molecular adhesive capabilities molecular adhesion involves physical forces (Bipolar, Van der Walls) and chemical bonds (Ionic, Covalent) between the molecules of two different substances although this is limited by their relatively low cohesive strength. They still depend primarily on nearly parallel walls in the preparation to retain restoration.

Statistical analysis reveals that Rely X™ Luting 2 resin modified Glass ionomer cement had mean tensile bond strength (5.56 MPa) that is marginally more than Fuji 1 Glass Ionomer Cement (5.24 MPa). This signifies that the adhesive potentials of resin modified glass ionomer cement is greater than glass ionomer cement. Resin modified glass ionomer is more reliable on long term basis because of its superior mechanical properties than glass ionomer/fuji 1. Adhesive resin cement Multilink speed showed the
maximum retentive strength among all adhesive luting cements (Mean bond strength of 6.17 MPa). This high bond strength of adhesive resin cement is attributed to micro sandblasting of metal surface and micromechanical bonding of cement to tooth and restorative surface. Adhesive resin cement also has better mechanical properties such as high compressive strength and fracture toughness which makes it more reliable. This in vitro study using extracted human teeth allowed accurate preparations with 4° overall taper to compare the retentive strength of 4 different luting agents when subjected to tensile bond strength. At the end of study it was observed that resin cement multilink speed had highest retentive strength followed by rely X™ luting 2 (3M ESPE) resin modified GIC, GIC fuji 1 (GC) and zinc phosphate (Harvard) cement had the least tensile bond strength. Limitation of this study was that data collected from which in vitro study ranks low on the hierarchy of evidence based treatment decision model.

**Conclusion**

From this study following important observations are made

1. Ni-Cr cast crowns cemented using recent luting cement Multilink speed Adhesive Resin Cement showed the maximum retentive strength among all luting cements.

2. Statistical analysis reveals that Rely X™ Luting 2 resin modified Glass ionomer cement had mean tensile bond strength that is more than Fuji 1 Glass Ionomer Cement and Harvard Zinc phosphate cement.

3. According to Statistical analysis Harvard Zinc phosphate cement had the least retentive strength compared to other three luting cements.

Fig.1- Extracted non-carious premolar teeth were stored in distilled water.

Fig.2- Tooth embedded in the centre of acrylic base.

Fig.3- Hahn & Kole, Germany, universal tool cutter and grinding machine.

Fig.4 - Prepared tooth.
Fig. 5- Wax pattern & Ni-Cr alloy cast crown.

Fig. 6- Seating of crown with finger pressure.

Fig. 7- Universal testing INSTRON machine Model 4206

Fig. 8- Debonded Ni-Cr crown.

References


