Comparing Shear Bond Strength of Ceramic and Dentin towards Three Different Luting Cements for All Ceramic Restorations- An In-Vitro Study

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** Index Terms - Resin cements, bonding, all ceramics, shear bond strength, bond failure.**

I. INTRODUCTION

Bonding between a fixed prosthesis and the supporting prepared tooth structure is provided by dental luting cements. The ideal property of luting cement includes fracture resistance, low solubility, and colour stability, adhesive bond to tooth structure, adequate working and setting time. Charles Land in 1886 developed the first all ceramic crowns which was popular as the porcelain jacket crown. For many decades it was the most aesthetic full veneer restoration dentistry had to offer. The clinical performance of all ceramic restorations is mainly influenced by the shape of tooth preparation and surface treatment of crown and abutment, type of luting agents and the adhesion between tooth structure and restorative material. However ceramic restorations are very brittle which results in debonding and fracture of the restoration. This can be compensated by increasing the bond strength with tooth structure.

While bonding ceramic to tooth structure, two different interfaces need to be considered: the dentin/cement interface and the ceramic/cement interface. If the adhesive seal in the above interfaces fails, it results in micro leakage jeopardizing the clinical performance and longevity of the restorations, leading to staining, recurrent caries, adverse pulpal response and postoperative sensitivity and finally the debonding of the restoration. There are several variety of cements, each with advantages and disadvantages. Nevertheless, it is necessary to choose the right material from the various cements available for the long term service of the restoration. Hence the comparison of the bonding ability of different luting cements to ceramic and dentin is thus deemed necessary.

The aim, purpose and objective of this study was,
1. Evaluate and compare the shear bond strength of three different luting cements to ceramic and dentin on the universal testing machine.
2. Evaluate the mode of bond failure by scanning electron microscopy.

II. MATERIALS AND METHODS

IPS Empress 2 [Ivoclar vivadent, Germany] Ceramic disc specimens of 3mm diameter and width of about 2mm were fabricated. Intact, Non carious, human maxillary premolars extracted were collected and stored. The teeth were then sectioned at cement-enamel junction with diamond disc at 90 degrees to long axis of the tooth and 2mm coronally to obtain tooth disc specimen of thickness 2mm with sufficient area of dentin. Plastic mounting plates (approximately 40mm X 4mm) with machined screw fittings were fabricated. Each pair has upper and lower plates. Upper plate has a bevelled area of 15mm in diameter and a hole of 3mm in diameter which will hold the ceramic disc specimen. The lower plate has a depth of about 8mm in diameter which holds the tooth specimen. The ceramic disc specimens were embedded in the upper plastic plate and the tooth specimens embedded in lower plate with auto polymerizing acrylic resin (Cast don, Dreve). To standardize the cement thickness, a Mylar strip was interposed between the specimens. Thirty disc specimens of all ceramic and dentin were fabricated and randomly divided into three groups of 10 each named as Group A, B and C.

GROUP A – LUTING WITH Glass ionomer cement

Surface of tooth specimen was treated with conditioning paste (proxayt paste, IvoclarVivadent, liechtenstien). Then ceramic and tooth specimen were luted with Type I GIC cement (Ketac cem glassionomer cement, 3M ESPE, USA)

GROUP B – LUTING WITH CALIBRA

Surface of the tooth specimen was etched with 37%phosphoric acid (Scotchbond, 3M ESPE, USA) for 15 seconds, rinsed for 10 seconds and gently air dried. Dentin bonding agent (Adper Single bond, 3 M ESPE,USA) was applied and light polymerized for ten seconds. Surface of ceramic specimen was etched with 9% hydrofluoric acid (Ultradent Porcelian Etch) for twenty seconds followed by silane.
application (Monobond S, Ivoclar Vivadent, Liechtenstein) and then luted with Calibra luting cement (Dentsply, USA) and plates were clamped with machined screws and light cured for twenty seconds.

GROUP C - LUTING WITH PANAVIA F2.0
Surface of the tooth specimen was etched with 37% phosphoric acid (Scotchbond, 3M ESPE, USA) for 15 seconds, rinsed for 10 seconds and gently air dried. Dentin bonding agent (Adper Single bond, 3M ESPE, USA) was applied and light polymerized for 10 seconds. Surface of ceramic specimen was etched with 9% hydrofluoric acid (Ultradent Porcelain Etch) for twenty seconds followed by silane application (Monobond S, Ivoclar Vivadent, Liechtenstein) and then luted with Panavia f 2.0 luting cement (Kuraray, USA) and light cured for twenty seconds.

III. TESTING PROTOCOL
An isotonic saline solution was prepared and all the specimens were immediately placed in it. The machined screws were removed after 1 hour. After 24 hours, the specimens of Group A, Group B and Group C were subjected for shear bond strength using Llyods universal testing machine. Shear load at failure was recorded in Newton’s and converted to stress in Megapascal. Then the fractured specimens were further evaluated for Scanning electroscopic examination. Specimens were sputter-coated with gold alloy and examined under SEM at 20kv and the specimens were viewed and photographed at original magnification (x 1000).

IV. RESULTS
The specimens were subjected to shear bond strength testing using universal testing machine (Llyods) (Table. I). Mean and standard deviation were estimated from the sample for each study group (Table. II). Mean values were compared between different study groups by using One way ANOVA followed by scheffe’s multiple range procedure. In the present study, P < 0.05 was considered as the level of significance. Scanning electron microscopic study was done on fractured specimens and mode of bond failure was analyzed. The results showed that the Mean value in Group C (16.65 ± 0.72) was significantly higher than the mean value in Group A (4.76 ± 0.37) and in Group B (14.85 ± 0.65) (P < 0.05). Further, the mean value in Group B

<table>
<thead>
<tr>
<th>NO. OF SPECIMENS</th>
<th>GROUP A (mpa)</th>
<th>GROUP B (mpa)</th>
<th>GROUP C (mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.3</td>
<td>15.11</td>
<td>16.28</td>
</tr>
<tr>
<td>2</td>
<td>4.7</td>
<td>15.46</td>
<td>17.30</td>
</tr>
<tr>
<td>3</td>
<td>4.2</td>
<td>14.18</td>
<td>15.20</td>
</tr>
<tr>
<td>4</td>
<td>5.2</td>
<td>14.58</td>
<td>16.70</td>
</tr>
<tr>
<td>5</td>
<td>4.9</td>
<td>14</td>
<td>16.40</td>
</tr>
<tr>
<td>6</td>
<td>4.6</td>
<td>14.42</td>
<td>16.48</td>
</tr>
<tr>
<td>7</td>
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<td>14</td>
<td>17.14</td>
</tr>
<tr>
<td>8</td>
<td>4.2</td>
<td>14.72</td>
<td>17.40</td>
</tr>
<tr>
<td>9</td>
<td>5.1</td>
<td>15.90</td>
<td>16.20</td>
</tr>
<tr>
<td>10</td>
<td>4.6</td>
<td>15.20</td>
<td>17.50</td>
</tr>
</tbody>
</table>

TABLE - I
Shear bond strength of three groups
TABLE II
Mean, Standard deviation and Test of significance of mean values between three groups.

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>MEAN ± S.D</th>
<th>P- VALUE *</th>
<th>SIGNIFICANT GROUPS AT FIVE PERCENT LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.76 ± 0.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>14.85±0.65</td>
<td>&lt; 0.0001</td>
<td>C VS A , B VS A</td>
</tr>
<tr>
<td>C</td>
<td>16.65±0.72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

V. DISCUSSION
The currently available most predominant highly aesthetic restorative material with optimal properties that can simulate the appearance of natural dentition is dental ceramics. Even though it has many advantages, ceramics are fragile under tensile strain. This weakness can be attributed to the presence and propagation of microflaws present on the surface of the material, making the ceramic susceptible to fracture, thereby making the cementation process very important for the clinical success of all ceramic restorations. The purpose of this study was to evaluate the shear bond strength of three different luting cements to both ceramic and dentin and then to evaluate the mode of bond failure by scanning electron microscopy. Due to its widespread popularity and usage, IPS Empress 2 is used in this study. IPS Empress 2 is a lithium disilicate, heat pressed all ceramic material. Human premolars extracted for orthodontic purpose were collected. It was then sectioned and mounted on plastic mounting plates with machined screw fittings. Mylar strips ensured uniform film thickness of 40 µm. The luting agents selected for comparative evaluation were Glass ionomer cement and two commercially available resin cements- Panavia f2.0 luting cement (Kuraray, USA) and Calibra luting cement (Dentsply, USA). Glass ionomer cements were formulated in 1976 as a dental restorative material and has been in major use for more than 30 years for increased patient acceptance. These are primarily adhesive cements containing acid soluble calcium fluoroaluminosilicate glass and aqueous solution of polyacrylic acid in a concentration of about 0-50 % 6.

Dual cured cements are found to have higher hardness values when compared to chemically cured cements7. The major advantages of resin luting agents include increased bond strength when used in conjunction with silane coupling agents8,9,10., increases the fracture resistance of the tooth and the restoration itself and minimizes the microleakage due to better wettability and bonding to tooth structure 10.

In Group A (luted with GIC) – the dentin surfaces were surface treated with conditioning agent ( proxylt paste Ivoclar Vivadent,liechtensten) to remove the smear layer and surface debris. Its removal results in higher bond strength of dentin adhesives5. In Group B and C – the dentin surfaces were first acid etched with 20% phosphoric acid (Gluma etch 20 gel, Hereaus Kulzer, Germany) to remove the mineral phase and increase the porosities of the tissues resulting in the formation of resin tags which are extension of adhesion resin in to open dentinal tubules6. This is followed by the application of dentin bonding agent to fill the resin tags and form a chemical bond between resin cement and dentin5.

According to Holand et al, the main crystal phase of IPS Empress 2 glass ceramic is formed by elongated crystals of lithium disilicate. A second phase is composed of lithium orthophosphate. A glass matrix surrounds both crystalline phases. Hydrofluoric acid removes the glass matrix and the second crystalline phase creating irregularities within the lithium disilicate crystals and thereby results in increased bonding11. This is followed by silanization with Monobond S (Ivoclar Vivadent, Liechtensten). Silane coupling agents enhances the formation of chemical bond between the inorganic phase of the ceramic and the organic phase of the resin and increases the wettability of ceramic surface 6. Other methods of surface treatment of ceramics include sandblasting with 50µm aluminium oxide particles, surface roughening with coarse diamond bur, etching with 40% phosphoric acid solution 9,12. In this in vitro study, the shear bond strength of conventional glass ionomer cements and 2 commonly used resin luting cements to IPS Empress 2 all ceramic and dentin was evaluated. Shear loading was performed using universal testing machine and maximum shear load at the point of failure was recorded. Shear bond strength were calculated by dividing the force at which the bond failure occurred by the specimen bonding area 6. The results obtained were then statistically analyzed by one way analysis of variance (ANOVA). The testing was performed at a significant level of p – 0.05.

Maximum bond strength was obtained for Group C specimens followed by Group B specimens. Increased bond strength of Group C can be attributed to higher filler content of the cement compared with other cements13. Failure analysis through SEM examination revealed predominantly cohesive failures at the resin-dentin and ceramic-resin interfaces for both Group B and Group C luting cement in accordance with studies done by R.Janda(2002)14.

These resin cements form a hybrid layer which is a molecular level mixture of collagen and resin polymers. It is formed by the diffusion of monomers that have been placed on the conditioned dentinal surface and subsequently polymerized in
situ (Nakabayashi 1982)15. Bond strength of both Group A was found to be inferior to that of both Group B and Group C. Although conventional glass ionomer cements has many advantages to its merit, lower bond strength was reported when compared to resin cements. On SEM examination, Glass ionomer cements exhibited cohesive failures at cement – dentin interface. This is due to the formation of chemical bond to tooth tissue by reaction with the calcium salts in the tooth structure7. But adhesive failures were predominant at cement/ceramic interface due to lack of chemical and mechanical union between glass ionomer cement and ceramic surface. This in vitro study allowed an immediate assessment of the bond created between the cement and the restorative material. It is acceptable, to compare the measured in vitro results obtained in a controlled environment. But, these tests cannot adequately simulate clinical situations with all the detail. The compulsive and final evaluation of material performance should be determined using long term clinical studies and trials.

VI. CONCLUSION

With the limitations of this study, it has been concluded that;

1. Maximum shear bond strength values were obtained for Panavia f2.0 resin cement followed by Calibra cement. Glass ionomer cement showed least bond strength values.

2. On SEM examination, the mode of failures seen was predominantly cohesive for both Calibra and panavia f2.0 resin luting cements at resin-dentin and resin-ceramic interface suggesting improved bond strength.

3. Glass ionomer cement showed cohesive failures at dentin-cement interfaces. However, adhesive failures were predominant at cement-ceramic interface suggesting inadequate bond strength with the ceramic surface.

REFERENCES


AUTHORS

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