Comparison of shear bond strength of composite, compomer and resin modified glass ionomer in primary and permanent teeth: An in vitro study

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ABSTRACT

The aim of this study was to determine the difference in shear bond strength between Composite, Compomer and Resin modified glass ionomer in primary and permanent teeth. Thirty extracted primary molars and thirty premolars were selected and buccal surfaces of all the teeth were made smooth with the help of 300 grit silicon carbide paper. These specimens were then divided into 6 groups. Restorative materials were placed on the buccal surfaces of respective specimens with the help of acrylic template. All the specimens were subjected to thermocycling and shear bond strength was tested under the Honsfield testing machine and results were recorded in megapascals (MPa). The resultant scores were tabulated and statistically analysed. It was observed that in case of primary teeth resin modified glass ionomer exhibited significantly higher shear bond strength as compared to composite and compomer, whereas on permanent teeth composite demonstrated a significantly higher shear bond strength than that of the resin modified glass ionomer and compomer, where as compomer gave poor shear bond strength in both primary and permanent teeth.

Key Words: Composite, Compomer, Resin modified glass ionomer, Shear bond strength

INTRODUCTION

Pediatric dental practice requires a restorative material that can be quickly and easily placed with a reliable adhesion to tooth structures. A dislodged filling is an inconvenience to both patient and dentist. The present day composite, compomer and resin modified glass ionomer have become popular restorative materials for primary anterior and posterior teeth. In some of the European countries composites and glass ionomer cements are the materials of choice for primary teeth, whereas composites have been used in permanent teeth because of the controversy over mercury release from silver amalgam. Another reason for the increased use of composites and glass ionomer in pediatric dentistry is the growing demand from parents to provide aesthetic restorations to their children. The first glass ionomer cement developed by Wilson and Kent was a product of an acid base reaction between basic fluoroalumino silicate glass powder and polycarboxylic acid in the presence of water. Currently, many glass ionomer products are available for restorations. They bond directly to teeth and have a potential effect of remineralization because of fluoride content. Composite resin is the most esthetic restorative material currently available for restoring anterior and posterior teeth. This material possesses superior mechanical properties and better esthetics than glass ionomer cements. However, they require bonding agents because they are usually hydrophobic and thus do not adhere well to teeth.

The disadvantages of conventional glass ionomer cements as compared to composite resins are, interior mechanical properties namely bond strength, tensile strength and fracture toughness. Due to these reasons, resin modified glass ionomer cement was designed to produce favourable physical properties similar to that of composite resin and retaining basic features of the conventional glass ionomer cement. This was achieved by incorporating water soluble resin monomers into an aqueous solution of polyacrylic acid. A new generation of glass ionomer, now available are called compomers, which are resin reinforced glass ionomer cements. They have improved properties of traditional glass ionomers and also have physical properties quite similar to composite resin.

Since composite resin, a material of choice in permanent teeth, showed high failure rate in primary teeth, it is suggested that resin-reinforced glass ionomer cements (compomer) or resin modified glass ionomer cements may become the materials of choice in primary teeth.

The purpose of this study was to determine the difference in shear bond strength between Composite, Compomer, Resin modified glass ionomer cement in primary and permanent teeth.

MATERIALS AND METHOD

The present invitro study was carried out in the Department of Pedodontics and Preventive Dentistry, Bapuji Dental College and Hospital, Davangere in association with the Department of textile, Bapuji Institute of Engineering and Technology, Davangere and Department of Oral Pathology.
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and Microbiology, Bapuji Dental College and Hospital, Davangere.

30 non carious primary molars which were extracted at the time of exfoliation with the eruption of succedaneous permanent teeth and 30 permanent premolars extracted for orthodontic reasons were selected for the study. The extracted teeth were cleaned and stored in distilled water at room temperature until further use. The buccal surfaces of extracted 30 primary molars and 30 premolars were made smooth with the help of 300 grit silicon carbide paper and cleaned with pumice and rubber cup. Then 30 primary molars were randomly divided into 3 groups of 10 teeth for each restorative material.

Group 1 : Composite (Filtek P 60, 3M Dental Products, USA)
Group 2 : Compomer (F 2000, 3M Dental Products, USA)
Group 3 : Resin modified glass ionomer (Vitremer, 3M Dental Products, USA)

The 30 premolars were randomly divided into 3 groups of 10 teeth for each restorative material.

Group 4 : Composite (Filtek P 60, 3M Dental Products, USA)
Group 5 : Compomer (F 2000, 3M Dental Products, USA)
Group 6 : Resin modified glass ionomer (Vitremer, 3M Dental Products, USA)

All the three materials were manipulated according to the manufacturer’s instructions and were placed on smoothened buccal surface of the respective group samples by using acrylic template bearing a hole measuring 3 mm diameter and 2 mm depth. The excess material was removed around the template and light cured.

All the samples were stored in distilled water for 24 hours at room temperature and subjected to thermocycling in 5°C±2°C and 55°C±2°C water bath for 100 cycles with a dwell time of 30 seconds. All the samples were mounted with self cured acrylic resin (Fig 1,2,3,4). The mounted samples were subjected to shear bond strength test by using Honsfield Universal Testing machine (Fig 5), with a knife edged blade running at a cross head speed of 0.5 mm/minute.

STATISTICS

The scores were tabulated in Megapascals. The mean and standard deviation were calculated and the various group were compared by using Kruskall Wallis ANOVA and Mann - Whitney U-Test.

RESULTS

In primary teeth, resin modified glass ionomer showed highest shear bond strength of 16.75 ± 3.21 MPa which is highly significant when compared to composite (8.52 ± 1.15 MPa) and compomer (6.97 ± 1.55 MPa) with P value <0.01. When the shear bond strength of composite was compared with compomer, composite was superior with P value <0.05. [Table 1 and Graph 1]

In permanent teeth, composite showed a shear bond strength of 19.88 ± 1.89 MPa which is significantly higher than the compomer (7.55 ±1.89 MPa) and resin modified glass ionomer (17.39 ± 2.26 MPa) with P value <0.01 and <0.05 respectively. When the shear bond strength of resin modified glass ionomer was compared against compomer, the resin modified glass ionomer gave the higher values with P<0.05. [Table 2 and Graph 2]

The composite showed significantly (P<0.01) higher shear bond strength in permanent teeth as compared to primary teeth, whereas compomer and resin modified glass ionomer showed no significant (P>0.05) difference in shear bond strength between primary and permanent teeth.[Table 3 and Graph 3]

DISCUSSION

In the present invitro study, the composite showed higher mean shear bond strength in permanent teeth as compared to compomer and resin modified glass ionomer cement, whereas in primary teeth it showed significantly lesser shear bond strength compared to resin modified glass ionomer cement, but higher than compomer. These findings are in agreement with previous studies.1,4-6

Literature review about morphological and chemical aspects of the primary teeth structure may provide some insight about low bond strength in primary teeth with composite materials. Bordin-Aykroyd et al suggested that shear bond strength of a dentin adhesive depends on calcium level or total area of solid dentin available.7 As dentin approaches the pulp, calcium level decreases which subsequently leads to lower bond strength. Since primary teeth have relatively larger pulp chamber the flat surface gained must be closer to the pulp than in permanent teeth preparation. This may lower the bond strength in primary teeth.

Hirayama et al8 also revealed that peritubular dentin of the primary teeth is 2-5 times thicker than that of the permanent
Comparison of shear bond strength of restorative materials

Fig 1: Restorative material placed on buccal surfaces of primary tooth (Occlusal View)

Fig 2: Restorative material placed on buccal surfaces of primary tooth (Proximal View)

Fig 3: Restorative material placed on buccal surfaces of permanent tooth (Occlusal View)

Fig 4: Restorative material placed on buccal surfaces of permanent tooth (Proximal View)

Fig 5: Honsfield universal testing machine
### Table 1: Comparison of shear bond strength of restorative materials in primary teeth

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>NO. OF SAMPLES</th>
<th>SHEAR BOND STRENGTH (MPa)</th>
<th>DIFFERENCE BETWEEN THE MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RANGE</td>
<td>MEAN ± S.D.</td>
</tr>
<tr>
<td>Composite</td>
<td>10</td>
<td>6.64 - 9.94</td>
<td>8.52 ± 1.15</td>
</tr>
<tr>
<td>(GROUP 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compomer</td>
<td>10</td>
<td>5.24 - 9.46</td>
<td>6.97 ± 1.55</td>
</tr>
<tr>
<td>(GROUP 2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resin Modified Glass</td>
<td>10</td>
<td>11.01 - 22.11</td>
<td>16.75 ± 3.21</td>
</tr>
<tr>
<td>Ionomer (GROUP 3)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Kruskall Wallis ANOVA [ H = 21.68, P<0.001, HS]  
Mann-Whitney U-Test  
[If U < 23 P <0.05  
< 16 P<0.01] Significant
Kruskall Wallis ANOVA [ H = 22.0, P<0.001, HS]
Mann-Whitney U-Test

<table>
<thead>
<tr>
<th>RESTORATIVE MATERIALS</th>
<th>NO. OF SAMPLES</th>
<th>SHEAR BOND STRENGTH (MPa)</th>
<th>DIFFERENCE BETWEEN MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RANGE</td>
<td>MEAN ± S.D.</td>
</tr>
<tr>
<td>COMPOSITE (GROUP 4)</td>
<td>10</td>
<td>18.84 - 23.34</td>
<td>19.88 ± 1.89</td>
</tr>
<tr>
<td>COMPOMER (GROUP 5)</td>
<td>10</td>
<td>4.77 - 11.33</td>
<td>7.55 ± 1.89</td>
</tr>
<tr>
<td>RESIN MODIFIED GLASS Ionomer (GROUP 6)</td>
<td>10</td>
<td>13.56 - 19.67</td>
<td>17.39 ± 2.26</td>
</tr>
</tbody>
</table>

Table 2: Comparison of shear bond strength of restorative materials in permanent teeth
Mann - Whitney U - Test * (Between tooth types)

[If calculated U < Table value Significant]

\[ U < 23 \text{ } P < 0.05 \]
\[ U < 16 \text{ } P < 0.01 \]

NS : Not Significant (P > 0.05)

Table 3: Comparison of shear bond strength of restorative materials in permanent and primary teeth

<table>
<thead>
<tr>
<th>RESTORATIVE MATERIALS</th>
<th>TOOTH TYPE</th>
<th>NO. OF SAMPLES</th>
<th>SHEAR BOND STRENGTH (MPa)</th>
<th>U-VALUE *</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>RANGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMPOSITE</td>
<td>PERMANENT</td>
<td>10</td>
<td>16.84 - 23.34</td>
<td>0</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>PRIMARY</td>
<td>10</td>
<td>6.64 - 9.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMPOSITE</td>
<td>PERMANENT</td>
<td>10</td>
<td>4.77 - 11.33</td>
<td>45</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>PRIMARY</td>
<td>10</td>
<td>5.24 - 9.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESIN MODIFIED</td>
<td>PERMANENT</td>
<td>10</td>
<td>13.56 - 19.67</td>
<td>40</td>
<td>NS</td>
</tr>
<tr>
<td>GLASS IONOMER</td>
<td>PRIMARY</td>
<td>10</td>
<td>11.01 - 22.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Comparison of shear bond strength of restorative materials in permanent and primary teeth
Comparison of shear bond strength of restorative materials

Graph 1: Shear bond strength of restorative materials in primary teeth

Graph 2: Shear bond strength of restorative materials permanent teeth
Comparison of shear bond strength of restorative materials in permanent and primary teeth.

With the thicker peritubular dentin, one may suspect that there is relatively less intertubular dentin. Since intertubular dentin is the major area where bonding occurs, primary teeth dentin provides lower bond strength with composite when compared to permanent teeth.

The resin modified glass ionomer exhibited significantly higher mean shear bond strength in primary teeth when compared to compomer and composite, whereas in case of permanent teeth, resin modified glass ionomer showed significantly lesser mean shear bond strength when compared to composite, but significantly higher shear bond strength than compomer. These findings are in agreement with previous studies.\(^1,4,5\)

The better performance of resin modified glass ionomer cement could be due to their expected dual mechanism of adhesion.\(^9,10\) For conventional glass ionomer the underlying mechanism of adhesion is thought to be based on a dynamic ion exchange process, in which the polyalkenonic acid softens and infiltrates the hydroxyapatite structure. There it is hypothesized to displace calcium and phosphate ions out of the substrate and to form an intermediate adsorption layer of calcium and aluminium phosphates and polyacrylates at the glass ionomer - hydroxyapatite interface. In case of resin modified glass ionomer cement the adhesion is probably through a combination of later mechanism and micro mechanical bonding mechanism that has been described for the resin based adhesives.

Compomer showed significantly lesser mean shear bond strength in both primary and permanent teeth when compared to composite and resin modified glass ionomer cement. These results are in agreement with previous studies.\(^1,4,5,6,11\)

Prior to placement of compomer, the PSA Prime/Adhesive should be applied to dentin without any separate acid etching of enamel or dentin. The bonding mechanism of the self etching primer is not fully clear. This PSA Prime/Adhesive contains PENTA (Dipentaery-thritolpentacrylate Phosphoric acid), by which it is claimed to form ionic bonds to the inorganic part of the tooth. This adhesive system aims to modify the smear layer and to incorporate it in the bonding process, but is definitely not acidic enough to form a distinct hybrid layer. Consequently, this smear layer modifying primer, only is very superficially interrelated with dentin without any collagen fibril exposure. Concurrently, the dentinal tubules
remained plugged by smeared debris. Erick et al found that the dentin was wetted but not penetrated with this primer system, resulting in a low bond strength. It had therefore, been proposed that etching of the enamel with phosphoric acid will improve the retention and sealing ability of the compomer. These materials rely on the chemical bond to the substrate rather than mechanical bond. Due to more resin in the material, it required an adhesive so as to create a hybrid layer that gives the material good adhesiveness to the substitutes as in composite resin. Variations in composition and chemistry among the commercial products marketed under the same group of hybrids or resin-ionomer restorative materials may directly affect their properties and clinical characteristics. They may or may not have the typical features of true glass ionomer such as chemical adhesion to tooth structures and long-term fluoride release. Therefore, they should be used carefully, following the instructions of the manufacturers because different handling methods may influence their clinical behaviour. To conclude composite had a better adhesion to permanent teeth and resin modified glass ionomer cement showed better adhesion to primary teeth. However, the results of the present study should be corroborated with further investigation to reach a definite conclusion.

REFERENCES