The influence of tooth surface roughness on retention of complete cast crowns using glass ionomer cement

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ABSTRACT

Background: The purpose of this in-vitro study was to evaluate the effect of tooth surface roughness on retention of complete cast crowns cemented with glass ionomer cement.

Materials and Methods: Forty sound human maxillary first premolars were used in this study. Each tooth was embedded in individual acrylic block. Then the teeth received complete cast crown preparation with diamond burs (group I), diamond burs and treated with air flow (group II), tungsten carbide burs (group III), and tungsten carbide burs with air flow treatment (group IV). Complete cast crowns were fabricated for all teeth and cemented with glass ionomer cement. The cemented crowns were stored in normal saline solution for 24 hours, and then separated in tension by the use of an Instron testing machine.

Results: The results showed that crowns cemented on teeth prepared with carbide burs and air-flow treatment exhibited the highest mean tensile stresses followed by crowns cemented on teeth prepared with carbide burs only, then crowns cemented on teeth prepared by diamond burs and air-flow treatment, while crowns cemented on teeth prepared with diamonds bur only exhibited the lowest mean tensile stresses.

Conclusions: Glass ionomer cement provided greater retention for cast crowns on smooth than on rough surfaces.

Key words: Surface roughness, Cast crown, Glass ionomer cement.

INTRODUCTION

Numerous factors may influence the retention of castings cemented on abutment teeth (1). The retention of artificial crowns varied not only due to the mechanical properties of luting medium but also due to the design of the preparation and the restoration. With regard to preparation, its geometric configuration, convergence angle, and surface area are important (2). Previous studies (3,4) have investigated many variables, but the influence of surface topography was the least understood. It is apparent that both increasing surface area and better wetting improve a bond. However ideal surface roughness is necessary to create optimal wetting because of capillary pressure, but it should not be so excessively rough that air is trapped between the luting cement and dentin (4). The objective of the luting cement is to affix the casting to the preparation and to seal the gap between them, so it is an adjunct to retention and not the sole source (5). Among the various types of luting cements for fixed prosthesis, glass ionomer cement considered as one of the most widely used (6). Because of its cariostatic potential (7), adhesive properties (8), and low in-vivo disintegration (9), glass ionomer cement has advantages over other types of luting cements.

MATERIALS AND METHODS

Forty sound human maxillary first premolars recently extracted due to orthodontic purposes, of comparable length, age and size were collected and stored in normal saline solution till they received complete crown preparation.

The roots of the teeth were notched from buccal and lingual sides, and then embedded in individual acrylic blocks to about 2 mm below the cemento-enamel junction. A standardized preparation was obtained using high speed hand piece adapted to dental surveyor in such a way that the long axis of the bur was parallel to that of the tooth. For each tooth sample the occlusal surface was reduced to the depth of the central groove, and then each sample prepared with axial length of 4 mm and total axial taper of 5 degrees using diamond or carbide burs according to their groups. A shoulder finishing line was prepared in the facial, lingual and interproximal surfaces of each tooth. A new rotary instrument was used for each sample with a continuous water jet to simulate a clinical tooth preparation (4).

Samples were randomly divided into four groups of ten each:

Group I: teeth prepared with diamond fissure burs, and their cast crowns cemented using glass ionomer cement.

Group II: teeth prepared with diamond fissure burs, then each surface of the tooth treated with air-powder polishing device, and their cast crowns cemented using glass ionomer cement.

Group III: teeth prepared with tungsten carbide fissure burs, and their cast crowns cemented using glass ionomer cement.

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Group IV: teeth prepared with tungsten carbide fissure burs, then each surface of the tooth treated with air-powder polishing device, and their cast crown cemented using glass ionomer cement.

The air-powder polishing device was used to apply a spray of air and sodium bicarbonate powder. The time was 10 seconds for each surface of the tooth to simulate actual clinical application. To estimate the axial surface area of each preparation, strips of aluminum foil were cut 4 mm wide to correspond with the length of the prepared walls, and then adapted to each prepared samples and cut at the area where the two ends overlapped. The surface area of each preparation was calculated in the following manner:

\[ S_2 = S_1 \times \frac{W_2}{W_1} \]

where:
- \( S_1 \) = Known surface area strip.
- \( W_1 \) = Weight of known surface area strip.
- \( W_2 \) = Weight of the foil strip for each sample.
- \( S_2 \) = Surface area of \( W_2 \).

The weight of the foil strip for each sample was measured by a sensitive scale. Wax patterns were made directly on the prepared teeth using type II blue inlay wax with ring like attachment added to the occlusal surface. Each wax patterns were invested with a phosphate bonded investment material and the casting procedure was performed using silver palladium alloy.

After casting, the obtained cast crowns were cleaned and fitted on their respective prepared teeth, and the crown margins adapted to the finishing line without any gap. The cast crowns of all groups were cemented with glass ionomer cement. To reduce variables, the cementation procedure was performed by the same investigator and a static load of 9 Kg was used to hold each crown for about 10 minutes on their tooth until the cement was completely set. After the cementation procedure was completed, the cemented samples were stored in normal saline solution for 24 hours.

The samples were adapted to the lower jaw of a tensile testing machine (Instron 1122). A specially designed hook was held by the upper jaw of the machine and was fitted to the ring like attachment of each crown. A continuously increasing tensile force was applied with the long axis of the tooth at a crosshead speed of 5mm/min until the crown separated from the prepared tooth. The data obtained were statistically evaluated using one way analysis of variance (ANOVA) test and student t-test.

RESULTS

The amount of forces required to separate the cemented castings from their teeth were recorded by Newton. Each reading was multiplied by 0.225 in order to be converted into a pound. Then each pound reading was divided by the surface area (square inch) of its specimen in order to be converted into psi (pound per square inch). The mean and standard deviations of the four groups are presented in table (1).

Statistical analysis of data by using analysis of variance “ANOVA” test revealed that there is a statistically very highly significant difference (P<0.001) between the mean stresses among the four groups, as shown in table (2). The source of this statistically significant difference was investigated by further analysis of data to examine the differences between groups using the student t-test, as shown in table (3).

The results showed that crowns cemented on teeth prepared with carbide burs and air-flow treatment (group IV) exhibited the highest mean tensile stresses followed by crowns cemented on teeth prepared with carbide burs only (group III), then crowns cemented on teeth prepared by diamond burs with air-flow treatment (group II), while crowns cemented on teeth prepared with diamond burs only (group I) exhibited the lowest mean tensile stresses.

Table 1: Descriptive statistics of tensile stresses (in psi) for the four groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>373</td>
<td>447</td>
<td>516</td>
<td>598</td>
</tr>
<tr>
<td>S.D.</td>
<td>24.2</td>
<td>19.8</td>
<td>19.6</td>
<td>24.3</td>
</tr>
<tr>
<td>Min.</td>
<td>345</td>
<td>417</td>
<td>495</td>
<td>560</td>
</tr>
<tr>
<td>Max.</td>
<td>402</td>
<td>476</td>
<td>556</td>
<td>637</td>
</tr>
</tbody>
</table>

Table 2: Analysis of Variance (ANOVA) test for the four groups.

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Degree of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F.Value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>27709</td>
<td>9236.3</td>
<td>8.832</td>
<td>Very High Significant</td>
</tr>
<tr>
<td>Within Groups</td>
<td>36</td>
<td>376471</td>
<td>10457.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>379210</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Student t-test comparison between groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>t-value</th>
<th>Significance (at confidence level 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I and II</td>
<td>7.466</td>
<td>V.H.S</td>
</tr>
<tr>
<td>I and III</td>
<td>14.480</td>
<td>V.H.S</td>
</tr>
<tr>
<td>I and IV</td>
<td>20.683</td>
<td>V.H.S</td>
</tr>
<tr>
<td>II and III</td>
<td>7.819</td>
<td>V.H.S</td>
</tr>
<tr>
<td>II and IV</td>
<td>15.201</td>
<td>V.H.S</td>
</tr>
<tr>
<td>III and IV</td>
<td>8.289</td>
<td>V.H.S</td>
</tr>
</tbody>
</table>

*degree of freedom = 18  V.H.S. = very highly significant.

DISCUSSION

This study proves that the type of bur used to finish tooth preparation is essential in achieving a suitable retention for complete cast crown. The diamond burs used in this study produced surfaces with greater roughness than those prepared with tungsten carbide burs, and that roughness is directly proportional to the diamond grain size (5). But the surface roughness prepared with tungsten carbide burs is smoother and dependent on the number of flutes and manufacturer, so the more the flutes are, the smoother surface is produced.

The use of air-flow polishing device produced smoother surfaces because dentin is readily removed by this air abrasive cleaning device which will remove surface irregularities, any traces of smear layer, and make the surface smoother.

Under the conditions of this study, the results demonstrated that retention with glass ionomer cement on smoother surfaces is greater than on rough surfaces. This may be due to the fact that the retention of glass ionomer cement is mainly achieved in part by mechanical retention and in part by chemical chelating (13). The interaction between acid and apatite would produce ionized carboxyl groups, which could form strong-ionic bond with the surface calcium within enamel and dentin (14). And that need complete wet and spread of cement on the prepared tooth surface. So on rough surfaces there might be incomplete penetration of the cement into surface irregularities and no intimate contact between cement and the whole tooth surface. The intimate contact may appear at the tips of the irregularities which constitute small part of the total surface area. This means that few adhesive bonds will form between the tooth surface and the cement. When the surfaces become smoother the irregularities decrease and the possibility of intimate contact between the tooth surface and the cement increases.

REFERENCE

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