Prosthodontics

SHEAR BOND STRENGTH OF DENTURE REPAIR WITH AUTOPOLYMERIZING ACRYLIC RESIN INFLUENCED BY THREE SURFACE TREATMENTS

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ABSTRACT

The repaired denture base material fractures at the interface of base and repair material. This study evaluated the effect of different chemical treatment of the surfaces on the shear bond strength of conventional heat-cured resin repaired with autopolymerized acrylic resin. The specimens were divided into four groups, 30 specimens each according to surface treatment by chemical etchants Group 1 served as control and had no surface treatment. The remaining 3 experimental groups, the specimens were in acetone (Group 2) for 30 seconds, in methylene chloride (Group 3) for 30 seconds and monomer methyl methacrylate (Group 4) for 180 seconds. Autopolymerizing acrylic resin was placed on the treated surface using a Teflon ring. The shear bond strength (MPa) of specimens was measured after 24 hours of storage in distilled water at 37°C. One way analysis of variance and Tukey HSD tests were performed to determine significant differences (p<.05). The three chemical etchants increased the shear bond strength compared to the control (p<.001). Methyl methacrylate monomer showed the highest shear bond strength compared to methylene chloride and acetone. Methylene and acetone showed no significant differences in shear bond strength.

Key words: Denture repair, denture fracture, Acrylic resin, autopolymerization, surface treatment

INTRODUCTION

Acrylic resin dentures are susceptible to fracture after a period of clinical use. The ratio of upper denture to lower denture fractures is about 2:1 with the most common causes of fracture to be poor fit and lack of balanced occlusion. Denture fracture is also related to the following reasons: midline fracture caused by flexural failures, deep notch at the labial frenum, excessive relief at the torus regions, placing the maxillary posterior teeth labial to the crest of the ridge and accidental dropping. Several materials have been used to repair fractured acrylic resin denture bases, including auto-polymerized, heat polymerized, visible light-polymerized, and microwave-polymerized acrylic resins. However, autopolymerizing acrylic resin remains the most popular material of choice for the repair of dentures. Although the ultimate goal is to restore the original strength of the denture and to prevent repeated fracture, the repaired dentures with self-cured acrylic resin show approximately 80% transverse strength of the original strength. The dentures repaired with autopolymerized acrylic resin often fracture at the junction of old and new repaired material rather than within the repaired material. This finding indicates that the interface of the old denture and new repaired material is the area of stress concentration and finally fracture. The phenomenon of adhesion between the old and new denture repair material plays an important role, therefore, surface preparation of the sites to be joined is essential to improve repair strength and reduce stress concentration.

Mechanical and chemical surface modifications of denture base resin materials have been reported to improved bond strength. Mechanical surface preparation include round contour of repair surface with burs and roughened with air borned – particles plasma and laser treatments. Etching the fractured surface of specimen promote penetration and diffusion of monomer of autopolymerizing acrylic resins into the denture base resins. Chemical treatment of fractured parts consists of wetting the surfaces with methy methacrylate, Chloroform acetone and Methylene chloride. Shen et al investigated the effect of etching the surface of specimens with chloroform on repair strength. The result of this study indicated that treating the fractured surface of acrylic denture base with chloroform for five seconds and joining by
autopolymerizing acrylic resin improved the transverse strength compared with the unetched specimens. In one study the transverse strength of repaired specimens of denture acrylic resin with autopolymerizing acrylic resin was evaluated following the wetting with polymethyl methacrylate (MMA) for varying length of time ranging from 30, 60 and 180 seconds. It was found that wetting the repaired surfaces for longer period of time (180 seconds) increased transverse strength significantly. According to Shen et al, although wetting the repaired surface longer than 30 seconds produced significantly more smoother and develop deep pits, the transverse bond strength did not increase significantly. Sarac et al used monomer (MMA), acetone and methylene chloride to etch the heat cured acrylic resin specimens for 30 seconds. Their results indicated that methylene chloride treatment produced statistically the same shear bond strength values as acetone treatment but greater than monomer (MMA). Rached et al reported the transverse bond strength of repaired heat cure acrylic resin specimens following the wetting of surface with monomer (MMA), acetone for 30 seconds. They found that surfaces treated with acetone showed the highest bond strength compared with monomer (MMA).

There is inconsistency between the various investigations regarding the bond strength produced by methylene chloride and acetone. Furthermore, the literature does not indicate the effective application time of methylene chloride and acetone. According to Shen et al 30 seconds of etching the heat cured acrylic resin specimen is adequate. Longer etching period, the surface become more smoother and develop more pits. However, there is no significant improvement in bond strength. Furthermore Shen et al and Sarac et al have stated that since the fracture of repaired denture occurs at the junction of old and new material rather than within the material, shear bond strength should be used to evaluate debonding.

The purpose of this study was to investigate the effect of different chemical treatments of the surface on the shear bond strength of conventional heat-cured resin specimens repaired with autopolymerizing acrylic resin.

**MATERIALS AND METHODS**

Wax molds (2mm in diameter and 20mm in length) were invested in dental stone using a denture flask. The flasked molds were dewaxed in boiling water. Tin foil substitute (Al-Cote. The L.D. Caulk Co., Milford, Del) was applied to the gypsum mold while it was hot and allowed to cool to room temperature. Heat polymerizing acrylic resin (Meliodent, Heraeus Kulzer, Armonk, NY) was mixed according to manufacturer's instruction and placed under compression in 74°C water for 8 hours once processed, the flask was bench cooled and the molds were retrieved. Ninety heat polymerized acrylic resin molds were made (Fig. 1).

The surface of all acrylic resin specimens were ground flat with 600 grit silicone carbide paper (Carbinet, Buehler, Lake Bluff, Ill) to remove surface irregularities and excess material to form test surface. The specimens were then stored in water at 37°C for 7 days. After water storage, all the specimens were ultrasonically cleaned with distilled water and dried with compressed air. The acrylic resin blocks were divided into 4 groups of 30 each. Group 1 served as control and had no surface treatment. Group 2 acrylic resin blocks, the test surface was treated by immersing in chemical etchant acetone for 30 seconds. The group 3 acrylic resin blocks the test surface was immersed in methylene chloride for 30 seconds and group 4 were treated by immersing in monomer of methyl methacrylate acrylic. (Table I) for 180 seconds. To the treated surface, autopolymerizing acrylic resin was added by placing a teflon ring (8mm in diameter, 3 mm height). The autopolymerizing acrylic resin (Meliodent, Heraeus Kulzer, Armonk, NY) was mixed according to manufacturer's instructions and placed on the Teflon ring (Fig.2). Any excess of material was carefully removed from the top of the Teflon ring. The autopolymerized acrylic resin and the block assembly were placed in a pressure pot at 37°C water for 10 minutes under 2-bar pressure. The assembly was then removed from the pressure pot and stored in distilled water for 24 hours before testing.

The shear test for control and test specimens was performed in a universal testing machine (Model 8500; Instron Corp., Canton, Mass) at 1 mm/min cross head speed (Fig.3). For shear bond strength testing each specimen was securely mounted in a metal custom jig. The axis of specimen was positioned so that the shearing blade contacted the autopolymerized acrylic resin plate interface and was oriented parallel to it. The forced required to shear the ring from the heat polymerized acrylic block was recorded in Mega Pascal (MPa) units. Data were analyzed by one-way analysis of variance (ANOVA) using SPSS statistical package (SPSS 10.0; SPSS Inc, Chicago, ILL). The mean values were compared by using Tukey HSD test ($\alpha = .05$).

**RESULTS**

The mean shear strength values and standard deviations of the groups are presented in Table 2. An analysis of one-way ANOVA was used to determine for differences among the groups. The results (Table 3) indicated a statistically significant differences between...
each chemical treatment compared to the controls ($F=2.64; P < 0.001$). Further analysis with Tukey’s pairwise comparison procedure to control for multiple testing revealed that the mean change of group 3 (21.2 MPa) was significantly greater than that of group 1, (18.9 MPa) and group 2 (19.1 MPa). The percentage difference from the control for group 1, group 2 and group 3 were 11.8, 13.0 and 19.5% respectively.

**DISCUSSION**

To achieve optimum strength for repair of denture base material with autopolymerizing acrylic resin, it is essential that a good bond exists between the materials. Several investigators have suggested etch-

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**TABLE 1: MATERIALS USED IN THIS STUDY**

<table>
<thead>
<tr>
<th>Materials</th>
<th>Product</th>
<th>Code</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heat polymerized acrylic resin</td>
<td>Meliodent</td>
<td>AC</td>
<td>Heraeus Kulzer, Armonk, NY</td>
</tr>
<tr>
<td>2. Acetone</td>
<td>–</td>
<td>MC</td>
<td>E. Merk, Darmstadt, Germany</td>
</tr>
<tr>
<td>3. Methylene chloride</td>
<td>–</td>
<td>MO</td>
<td>E. Merk, Darmstadt, Germany</td>
</tr>
<tr>
<td>4. Methyl methacrylate</td>
<td>Meliodent</td>
<td>MO</td>
<td>Heraeus Kulzer, Armonk, NY</td>
</tr>
</tbody>
</table>

**TABLE 2: MEAN AND STANDARD DEVIATION (SD) SHEAR BOND STRENGTH VALUES FOR REPAIRED SPECIMENS (MPa)**

<table>
<thead>
<tr>
<th>Surface treatment</th>
<th>Mean (SD)</th>
<th>Percentage of increased strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>% AC</td>
</tr>
<tr>
<td>Group 1 Control</td>
<td>16.9 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Group 2 Acetone (AC)</td>
<td>18.9 (0.6)$^a$</td>
<td></td>
</tr>
<tr>
<td>Group 3 Methylene chloride (MC)</td>
<td>19.1 (0.9)$^a$</td>
<td>11.8</td>
</tr>
<tr>
<td>Group 4 Methyl Methacrylate (MO)</td>
<td>20.2 (0.4)$^b$</td>
<td></td>
</tr>
</tbody>
</table>

Percentage (%) of increased strength compared to control. 
Same letters indicate values that were not statistically different ($P<.05$).
ing the repair surface of denture base material with chemical etchants such as methyl methacrylate monomer, chloroform, methylene chloride and acetone to increase the bond strength. Vallittu et al\textsuperscript{2} reported that surface treatment with methylene chloride was more effective in bonding. Conversely, Nishigava et al\textsuperscript{15} reported that methylene chloride showed no significant difference compared with control specimen. The present study, however, demonstrated that methyl methacrylate monomer produced higher bond strength (19.5\%) compared with methylene chloride (13.0\%) and acetone (11.8\%) (Table 2). The result of this study is in agreement with that of Rached et al\textsuperscript{14} and Sarac et al\textsuperscript{17}. The higher bond strength by chemical etchants is attributed to the fact that they cause superficial crack propagation and numerous pits of 3 micron diameter\textsuperscript{20} in the denture base material. This change in the denture base material increases mechanical retention with the repaired acrylic resin. As regards the chemical etching period, longer than 30 seconds has not increased the bond strength\textsuperscript{9}.

Shen et al\textsuperscript{11} and Sarac et al\textsuperscript{17} have stated than since the fracture of repaired denture often occurs at the junction of old and new material rather than within these materials, the debonding should be evaluated by measuring the shear bond strength. Therefore, in the present study the specimens were evaluated by shear bond testing.

Since only the shear bond strength of one brand of heat and autopolymerized acrylic resins were limitations of this study, further investigation with different brands of acrylic resin and complex denture design with longer etching time may be investigated.

**CONCLUSIONS**

- The shear bond strength of repair material to denture base material increased with the use of chemical etchants compared with control.
- Methyl methacrylate monomer etchant produced the highest shear bond strength compared with methylene chloride and acetone chemical etchants.

**REFERENCES**


**TABLE 3: RESULTS OF ANOVA.**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>214.375</td>
<td>2</td>
<td>110.643</td>
<td>204.652</td>
<td>.001</td>
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<tr>
<td>Error</td>
<td>64.019</td>
<td>101</td>
<td>.514</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


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