The Effect of Denture Base Repair with Special Type of Acrylic O-cry1 and Different Surface Treatments on Impact Bond Strength of Acrylic Resin (Comparative Study)

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ABSTRACT
Background: the common problem in prosthodontics is a frature of the denture base and it represents an annoyance for the dentists. Therefore, the option of increasing repair strength using new reinforcement materials is of great interest to prosthodontists. The purpose of this study was to assess the effects of using a special type of acrylic O-cry1 in repair instead of heat cure acrylic resins and different surface treatments on impact bond strength using Ivomet and conventional curing methods.

Materials and Methods: One hundred thirty specimens of heat acrylic resins were constructed. There are 2 main groups according to curing methods (Ivomet and conventional method curing). For each group, there were 6 groups according to the surface treatments used (untreated, monomer, thinner, zirconium oxide, glass fiber and butt joint with monomer) as well as control group.

Results: The study showed that the control group had a higher value of impact strength than other groups which were cured by conventional method. For Ivomet curing, the butt joint with monomer and glass fiber groups improved the impact bond strength in comparison to other groups.

Conclusion: the butt joint with monomer treatment and glass fiber groups have improved the impact strength of the repaired acrylic resins when Ivomet compared with other groups. On the other hand, the use of thinner and zirconium oxide reduced the impact bond strength when using the conventional curing method. The use of Ivomet device in curing samples improved the impact strength of acrylic repaired with O-cry1.

INTRODUCTION

In dentistry, acrylic resins are widely used for fabrication of removable dentures. Such materials may be fractured when dropping. The construction of a new removable denture is time consuming and very expensive for the patients. Hence, the repair of such dentures is preferred for both dentists and patients (1,2). The type of material used, surface design, surface treatment and material reinforcement are the main factors, which affect the success of denture repair (3). The procedure of repairing dentures includes the use of repair material to join two or more fractured pieces (4). Auto-cured, heat cured and light or microwave acrylic resin have been used to repair the fractured denture (5-6). The success of denture repair depends on adhesion between fractured piece and repair material (7). Surface preparation of the sites to be joined is of paramount importance in ensuring along service life. Chemical or mechanical treatments could change the morphology or surface chemistry of the acrylic resin base material to promote better adhesion (4). Different chemical solvents such as acetone, monomer and thinner have been used to repair of light-cured acrylic resins (8). Zirconia (ZrO2) is a metal oxide and may be used to enhance the flexural strength of acrylic resin (9-11). The adding of glass fiber to repair material improves the strength of a denture base repair and may decrease the occurrence of future fracture (12-14). The aim of the study was to assess the impact of using O-cry1 in repair without surface treatments and with surface treatments on impact bond strength of repaired acrylic specimens using two curing methods.

MATERIAL AND METHODS

Grouping of specimens

In total, 130 rectangular samples of heat cured resin with dimensions (80 mmx10mmx4mm) length, width , and thickness respectively were prepared and divided according to the surface treatments and methods of activation. There were three main groups;

1. Control Group (untreated).
2. Monomer group.
3. Thinner group.
4. Zirconium oxide group.
5. Glass fiber group.
6. Butt joint with monomer group.

The study showed that the control group had a higher value of impact strength than other groups which were cured by conventional method. For Ivomet curing, the butt joint with monomer and glass fiber groups improved the impact bond strength in comparison to other groups.

Conclusion: the butt joint with monomer treatment and glass fiber groups have improved the impact strength of the repaired acrylic resins when Ivomet compared with other groups. On the other hand, the use of thinner and zirconium oxide reduced the impact bond strength when using the conventional curing method. The use of Ivomet device in curing samples improved the impact strength of acrylic repaired with O-cry1.
The first group (10 specimens) were prepared for control group (repaired with heat cure acrylic and cured by Ivomet). The second group (60 specimens) which were cured by conventional method and involved 6 groups with each group had 10 samples depending on the type of surface treatment used (untreated, monomer, thinner, zirconium oxide filler, butt joint and monomer, glass fibers). The third group (60 specimens) were cured by Ivomet and consisted of 6 groups as the second group.

**Preparation of acrylic specimens**

1. Plastic pattern preparation

A wax pattern was constructed with a dimension of (80mm x 10mm x 4mm) length, width and thickness respectively for impact strength test according to ISO 179,2000 (15) used to fabricate acrylic specimens for the impact test (Figure 1).

![Figure 1. Wax pattern](image)

2. Investing procedure

A lower part of the flask was coated with a Vaseline. According to manufacturer instructions (the ratio of powder to water was 100g/25ml), the mixed dental stone was placed into lower part and the wax pattern was placed in the stone mixture (16). After final set of dental stone, the surface of the stone was coated with separating medium and left to dry (figure 2). The upper half of the flask was painted with separating medium, then mounted on the top of the lower portion. Under vibration the upper half of the flask was filled with freshly mixed stone. The dental stone was allowed to set for one hour. After final set of dental stone, the boil out procedure was carried out for 5 minutes to eliminate the wax pattern. The upper and lower halves were separated and a detergent was used to eliminate the wax residua to leaving spaces to be occupied by acrylic materials.

![Figure 2. Specimens positioned within the mould](image)

3. Proportioning and mixing of the acrylic

The acrylic resin was manipulated and mixed according to manufacture instructions. Packing process was then performed while the acrylic was in the dough stage, as recommended by ADA Specification No.12, 1999 (17). The 2 parts of flask were put in contact under hydraulic press. The flask was then mounted onto clamp; transferred to water bath for curing. After completing the curing, the flask was allowed to cool at room temperature before deflasking. The acrylic samples were then removed from the stone mould. All the specimens were carefully removed from the mould after deflasking and were finished and polished (17). All the specimens were stored in distilled water at 37 C for 48 hours before fracture (17-18).

**Repair procedure**

The samples were fractured by using a metal holding device. Each sample was positioned in a central groove, and cut with a fissure bur (figure 3). The space of 3 mm was created between two halves as demonstrated in the figure 4 (19-20).

![Figure 3: Fracture of the specimens](image)

![Figure 4: Specimens after the fracture](image)
The control group was repaired with heat cured resin using pressure pot (Ivomet) for 30 minutes at 40°C (21). Similar steps of finishing and polishing of acrylic specimens were followed for repairing specimens. Acrylic samples were then stored in the distilled water at 37°C for 48 hours before testing.

**Samples repaired using conventional method**

The untreated group was repaired with O_cryl without any surface treatments. The thinner group was repaired with using a thinner (Iraq) with O_acryl (8).

The butt joint with monomer group was repaired by placement the pieces from stainless steel in the gap and painted with a monomer for 180 seconds before repairing with O_cry (figure 4) (22). The glass fiber group was repaired using a glass fiber (China), with O_cry1 (figure 5) (22). The monomer group was repaired with monomer for three minutes (1). Zirconium oxide (ZrO2) group was repaired by the addition of ZrO2 filler concentration of 3% (0.3 g) to the powder (9.7 g) and mixed with monomer (4.4 ml) (23, 11).

Figure 4. Specimens repaired by butt joint treatment

Figure 5. Specimens repaired with glass fiber treatment

Similar steps of finishing and polishing of acrylic specimens were followed for repaired specimens. The samples were kept in distilled water for 48 hours.

**Acrylic samples repaired with Ivomet**

Similar steps were conducted for repairing acrylic samples, which were cured by Ivomet (figure 6) (19). Similar steps of finishing and polishing of acrylic specimens were followed for repaired specimens. The repaired specimens were stored in the distilled water at 37°C for 48 hours before testing.
Impact strength test

The impact strength test was performed according to IS 179 with impact testing device (figure 7). All specimens were supported horizontally at each end and struck by free swinging pendulum of two joules. The impact strength values were calculated in kilojoules per square meter (KJ/ M2) using the following formula:

\[
\text{Impact strength} = \frac{E}{BD} \times 10 \quad \text{(ISO, 2000)}
\]

where E: is the impact absorbed energy in joules. B represents width of the specimens. D represents the thickness of the specimens.

RESULTS

1. Samples repaired by Ivomet

Samples data were analyzed using SPSS v 20. All values of mean and standard deviation are listed in the Table 1.
Table 1: Mean and standard deviation of all groups for Ivomet curing

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean± Std.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>11.79±0.53</td>
<td>11.00</td>
<td>12.75</td>
</tr>
<tr>
<td>untreated</td>
<td>11.69±0.45</td>
<td>11.00</td>
<td>12.50</td>
</tr>
<tr>
<td>Monomer</td>
<td>11.93±0.58</td>
<td>11.00</td>
<td>12.75</td>
</tr>
<tr>
<td>Thiner</td>
<td>9.38±0.54</td>
<td>8.00</td>
<td>9.75</td>
</tr>
<tr>
<td>ZrO2</td>
<td>9.43±0.72</td>
<td>8.25</td>
<td>10.75</td>
</tr>
<tr>
<td>Butt joint with monomer</td>
<td>22.08±0.55</td>
<td>21.25</td>
<td>22.75</td>
</tr>
<tr>
<td>Glass fiber</td>
<td>19.53±0.72</td>
<td>18.25</td>
<td>20.75</td>
</tr>
</tbody>
</table>

The Table 1 demonstrated that the butt joint with monomer group presented the greatest value of mean impact strength. The Zirconium dioxide (ZrO2) and thinner groups had a lower mean value of impact bond strength. The glass fiber enhanced the impact strength of acrylic samples compared to other groups (untreated, monomer, and zirconium and thinner groups).

As well, the Tukey test indicated that there were significant differences between 2 groups where P< 0.05 as demonstrated in Table 2. However, no significant differences were found between these groups: control and untreated, control and monomer, untreated and monomer, thinner and zirconium dioxide groups where P >0.05.

Table 2. Tukey multiple comparison test

<table>
<thead>
<tr>
<th>Impact strength</th>
<th>Mean± Std.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>thiner</td>
<td>9.4250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZrO2</td>
<td>9.4250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>9.4250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>9.4250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>monomer</td>
<td>9.4250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass fiber</td>
<td>9.4250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butt joint</td>
<td>9.4250</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Samples repaired by conventional method.

For conventional curing method, all values of mean and standard deviation are listed in the Table 3.

Table 3: Mean and standard deviation of all groups for conventional curing

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean± Std.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>11.88±0.62</td>
<td>11.00</td>
<td>12.75</td>
</tr>
<tr>
<td>untreated</td>
<td>5.88±0.45</td>
<td>5.25</td>
<td>6.50</td>
</tr>
<tr>
<td>Monomer</td>
<td>6.08±0.64</td>
<td>5.25</td>
<td>6.75</td>
</tr>
<tr>
<td>Thiner</td>
<td>4.96±0.51</td>
<td>4.25</td>
<td>5.75</td>
</tr>
<tr>
<td>ZrO2</td>
<td>5.75±0.62</td>
<td>5.00</td>
<td>6.75</td>
</tr>
<tr>
<td>Butt joint with monomer</td>
<td>8.23±0.30</td>
<td>7.75</td>
<td>8.75</td>
</tr>
<tr>
<td>Glass fiber</td>
<td>7.08±0.41</td>
<td>18.25</td>
<td>20.75</td>
</tr>
</tbody>
</table>

The Table 3 illustrated that the greatest value of mean impact strength was with control group (11.88). On the other hand, the thinner and untreated groups had a lower value of mean impact strength. In addition, the glass fibers, butt joint, monomer and zirconium dioxide groups enhanced the impact strength of repaired acrylic. Between two groups, there were significant differences between 2 groups (P< 0.05 ) as demonstrated in Tukey test (Table 4). However, no significant differences were found between these groups( untreated and zirconium dioxide; untreated and monomer; and zirconium dioxide and monomer) ( P >0.05).
Table 4. Tukey multiple comparison test

<table>
<thead>
<tr>
<th>groups</th>
<th>N</th>
<th>Subset for alpha = 0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>thinner</td>
<td>10</td>
<td>4.9500</td>
</tr>
<tr>
<td>ZrO2</td>
<td>10</td>
<td>5.7500</td>
</tr>
<tr>
<td>untreated</td>
<td>10</td>
<td>5.8750</td>
</tr>
<tr>
<td>monomer</td>
<td>10</td>
<td>6.1750</td>
</tr>
<tr>
<td>Glas fiber</td>
<td>10</td>
<td>7.0750</td>
</tr>
<tr>
<td>Butt joint</td>
<td>10</td>
<td>8.2250</td>
</tr>
<tr>
<td>control</td>
<td>10</td>
<td>11.7880</td>
</tr>
<tr>
<td>Sig.</td>
<td>1.000</td>
<td>.473</td>
</tr>
</tbody>
</table>

Comparison between two technical method observed between the Ivomet and conventional methods (P≤0.05) as illustrated in the Figure 8.

For curing method, significant differences were observed between the Ivomet and conventional methods (P≤0.05) as illustrated in the Figure 8.

**DISCUSSION**

In repairing procedure, all acrylic samples, which were repaired with O-cry1 showed a lower mean value of impact strength when compared to specimens that were repaired with heat cured acrylic resin. The process of repairing a denture with auto cured resins have about 60-65% from the original strength (23). The material strength, working time of the material and its dimensional stability which achieved after and during repair are the main factors which must be taken into consideration when selecting the material repair (24-25). All acrylic samples which were repaired with O-cry1 and cured by Ivomet device showed slightly a low mean value of impact strength than control group and a high mean value than the conventional method. The reason was that the auto resin was cured under pressure in water and at 40ºC. It could have improved the fracture strength of auto acrylic resin. The chemical reaction between polymer components and the monomer could be activated by heat and produced almost complete polymerization. These results are in agreement with Intisar et al, (2015) (21). The results showed a significant improvement at (P < 0.05) in the impact strength values of all the repaired acrylic specimens treated with monomer for both the conventional and Ivomet curing techniques.
compared with control and untreated groups, this may be due because of forming interpenetrating polymer networks. These results are in accordance with Rached & Del-BelCury (2001) and disagree with Grajower & Goultschin (1984) as they stated that the process of wetting with monomer only did not increase the sample strength. The results showed that the lowest mean value of impact bond strength was with thinner treatment group in two technical methods. This demonstrated that some treatment solvent materials decrease the cohesion between old and new acrylic resin and led to a lower fatigue life value. This is in agreement with Jagger, R.G et al., (2002) and D.Jagger et al.,2003(29), where they found that monomer solvent material increase the stiffness, toughness and cohesion chemical bond of the old and new acrylic. The results showed that a lower mean value of impact strength was when using a ZrO2 nano filler treatment in two curing methods. The reduction in the strength could be of stress consequence around ZrO2 particles, which lead to crack propagation. As well, it might due to weak bond between ZrO2 particales and PMMA resins. The results were in agreement with the results of the study Areej and mohammed in (2016) that found the addition ZrO2 in acrylic repair that reduced the transverse strength of the reinforced denture. The current research indicated that the use of ZrO2 decreased the impact strength. These results disagree with a study which reported that the incorporation of nano-ZrO2 into resins improved the flexural strength of the material. The impact strength was meaningfully enhanced after using glass fibers as the presence of fibers in the resin ensure transferring of load from matrix to fiber, which also eventually arrests the crack and lead to an increase in the strength of the resin and allows the resin to tolerate the force of fracture more than the samples that had no fibers. In addition to above, the homogenous mixture of poly methylmethacrylate(PMMA) and fibers, good impregnation of fiber with monomer make a good contact of fiber with resin, and adequate quantity of fiber present in resin, all that caused an increase in the acrylic strength. Also, this might due to the nature of the resin and fibers which are inorganic. This agreed with Ali (2005) and disagreed with Polyzois et al., (2001) who recorded a reduction in the tensile strength of the acrylic samples when reinforced with the glass fibers. These results agreed with Hanna et al., (2010) study. The butt joint group presented the highest mean value than all groups. The use of mechanical treatment (i.e. grinding with burs, airborne particle, retention grooves and sandblasting) increases the surface area, and mechanical retention to increase Vander Waal force of attraction. As monomer is not an efficient solvent for polymethyl methacrylate, painting or immersing the surface will not adequately dislodge the debris, and create particle free surface for bonding. The treatment with chemicals, therefore, is required as metal pieces have the ability to support to acrylic materials and give higher tendency and ability with to stand the higher strength regardless the type of substances used for repair. The present study was similar to a study which carried out by Golbidi and Mousavi (2010). Furthermore, the results showed that all groups which were cured by ivometh device had a higher mean value of impact strength when compared with conventional method. The increase of temperature to 40°C had a significant impact on the mechanical properties of auto acrylic resin. However, the increase in temperature to 80°C had no much positive effect. Therefore, polymerization under pressure and hot-water bath leading to samples with better properties for auto acrylic resins. The present study concluded that the specimens which were repaired with heat-cured acrylic have a higher mean value of impact bond strength than the specimens which were repaired with O-cry1 by two technical methods. The specimens, which repaired with surface treatments showed a higher bond strength except the thinner and zirconium oxide nano filler when compared with the control group by Ivomet curing. On the other hand, all surface treatments cured in conventional method showed that a lower bond strength than control group. All the specimens repaired with Ivomet curing showed a high impact strength than those cured in conventional method.

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