Effect of conventional and microwave curve on bond strength between denture base resin and acrylic teeth with different surface treatments
R.S. Gugwad, Sharanbasappa Nagaral

Abstract
Aims: To determine tensile bond strength between denture base and acrylic teeth cured by conventional and microwave energy methods. Materials and Method: Ninety test specimens were fabricated from aluminum rod. It had dimension of 75 mm length 7.5 mm diameter at tooth end and 12mm dia at holding end for a length of 7.5 mm. Specimens were divided into 6 groups of 15 specimens each depending on surface treatment and curing method followed. Group A, B and C was cured by conventional method and Group D, E & F were cured by microwave energy. In Group B & E monomer was applied on ridge lap surface of the denture teeth and in Group C and F the ridge lap surface of denture teeth were sandblasted. Tensile bond strength was tested in a digital display U.T.M. (Universal Testing Machine). Results: The mean bond strength of 6 groups differ significantly F=9.36 P<0.001. The coefficient of variation is not statistically significant with each other groups. Conclusion: Conventionally cured specimens with sandblasting of ridge lap surface of the denture tooth showed less bond strength than the microwave cured specimens with same surface treatment.
Key Words: Tensile Bond Strength; Conventional Curing; Microwave Curing; Surface Treatments; Microwave Energy; Ridge Lap Surface; Sand Blasting.

Introduction
The loss of teeth is a matter of great concern for majority of people and their replacement by artificial substitutes such as dentures, is vital to normal life. Acrylic resin polymers were first introduced as denture base materials in 1937(1). Poly Methyl Methacrylate (PMMA) has been the most commonly used resin to make removable complete and partial dentures. Their use is widely accepted due to simple technique, easy manipulation good esthetic results and consistency in properties exhibited. However, it has some short comings like lack of strength, abrasion resistance, lack of dimensional stability, crazing, color instability, liability of causing tissue irritation and sensitivity.

Acrylic teeth are the most popular artificial teeth for denture, constructions(2). They have advantages, such as chemical bond with acrylic denture base, high fracture resistance; can be easily ground and polished and minimal abraction of opposite dentition. But certainly it has some disadvantages. Recent research shows that 30% of denture repairs are attributed to bond failure between acrylic-teeth and denture base resin(3). Failure of the tooth denture bond may be caused by excessive stress or by fatigue, extent of co-polymerization of the acrylic denture base, faulty boil out technique and in discriminate use of separating medium. In the continuous search of improved method to process Poly methyl methacrylate various techniques have been developed like processing with dry heat, steam, infrared rays visible light activation, electric heating etc. A recent addition to this list is microwave curing.

Conventionally used heat cured acrylic resins are polymerized by addition reaction initiated by benzoyl peroxide with application of external heat. Conventionally, electricity or gas is used to heat water bath for polymerization of acrylic resin. Medium or long cured cycles of more than 7 hours are preferred to produce resin with less residual monomer and optimal mechanical properties without reducing dimensional accuracy(4). A large quantity of gas or electricity is consumed in the process thus increasing the relative cost of the denture. This method of curing is laborious, messy and a lot of time is required to get satisfactorily cured resin. A study was conducted to study Effect of conventional and microwave curve on bond strength between denture base resin and acrylic teeth with different surface treatments.

Materials and Method
A standard metal die simulating test specimen dimension was prepared. 90 wax cylinders of test specimen dimensions attached to cross linked acrylic teeth were duplicated using two halved die stone mold of standard metal die. 90 specimens were divided into 6
groups of 15 specimens each depending on surface treatment and curing method followed. Group A, B and C was cured by conventional method and Group D, E & F were cured by microwave energy. In Group B & E monomer was applied on ridge lap surface of the denture teeth and in Group C and F the ridge lap surface of denture teeth were sandblasted. Tensile bond strength was tested in a digital display U.T.M. (Universal Testing Machine).

A. Designing of test specimen: A test specimen was fabricated from aluminum rod. It had dimension of 75 mm length 7.5 mm diameter at tooth end and 12mm dia at holding end for a length of 7.5 mm as shown in figure. This was a modification of test specimen prepared in resin according to ADA SP No. 15 for acrylic teeth. It was a cylindrical rod of 7.5 mm diameter and 7.5 mm long with acrylic teeth attached to one end. For these specimens external threading (1 mm depths and 20 mm length) was made so as to grip the specimen in holding device of universal testing machine. Disadvantage of this specimen design was they fractured at threaded and unthreaded junction in PMMA where there was decrease in diameter of specimen instead of deboning at actual tooth PMMA junction. So for this reason above said modification in the dimension of the test specimen was made.

B. Wax Pattern replication of specimens: Two halve die stone mold metal die was prepared. Orientation groves were made on the closing surface of the mold for proper assembly approximation of the two halves. Modeling wax (Hindustan dental products, Hyderabad India) was melted in a steel jar was poured in the die stone mold and the melted was appropriated. The wax was allowed to cool for five minutes and the mold opened. This methods permitted uniform replication was patterns. Thus total no. of 90 specimens were made and were stored in room temperature

C. Tooth Selection: Trans molded, 10% cross-linked acrylic resin teeth, and lower right first molar of same mold and size were selected.

D. Cleaning of denture teeth: All acrylic teeth were held in klip-klap and thoroughly washed with hot household detergent solution (2-table spoon Nirma Powder in 1L of water) followed by flushing with a clean hot water for 2 mins. Then they are dried with a clean gauze piece.

E. Sand Blasting of Ridge Lap Surface of Denture Teeth: The ridge lap surface of acrylic denture of teeth was sand blasted with 15 aluminum oxide powder, at controlled distance of 52 mm and for 30 seconds. Sand blasting was done for 15 teeth which were going to be cured by conventional method and other 15 teeth to be cured by microwave cure. Thus total no. of 30 acrylic denture teeth were sand blasted. After sand blasting they were kept undisturbed till their attachment with the wax pattern specimen was done with different surface treatment (Table 1).

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Surface Treatment</th>
<th>Curing method</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td>None</td>
<td>WB</td>
<td>G.C.acron</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>Monomer</td>
<td>WB</td>
<td>G.C.acron</td>
</tr>
<tr>
<td>C</td>
<td>15</td>
<td>Sand blasting</td>
<td>WB</td>
<td>G.C.acron</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>None</td>
<td>MW</td>
<td>G.C.Acron MC</td>
</tr>
<tr>
<td>E</td>
<td>15</td>
<td>Monomer</td>
<td>MW</td>
<td>G.C.Acron MC</td>
</tr>
<tr>
<td>F</td>
<td>15</td>
<td>Sand blasting</td>
<td>MW</td>
<td>G.C.Acron MC</td>
</tr>
</tbody>
</table>

Table 1- Grouping by surface treatment method

F. Attachment of acrylic denture tooth to the wax pattern specimen: The thoroughly cleaned denture tooth which was free from surface debris, oil, secretions of skin was attached to the wax pattern specimen at 7.5 mm diameter end by using undercut blocking wax after attachment of the tooth to the specimen they were kept undisturbed and were ready for flasking.

G. Denture base Materials selection: Acron, heat activated denture base resin material and Acron MC, microwave curing acrylic denture base resin material were selected because they are commercially available resins for both heat curing as well as for microwave curing systems. These were considered to be representative of heat cured and microwave cured resin systems. They are used as for manufacturers recommended procedures.

H. Preparation of Experimental Specimens

i. Preparation of specimen by conventional water-bath curing of PMMA

1. Wax Pattern: 15 uniformly replicated wax pattern attached to denture tooth were taken from group of 60 patterns for conventional curing of PMMA.

2. Flasking: The resultant wax patterns and attached tooth were flaked using dental stone in conventional flask. The patterns were invested in such a way as to ensure that teeth and bodies of wax cylinder were submerged at tooth PMMA interface. Each flask pour was allowed to set for 1 hour. A thin film of sodium alginate was applied to the surface of investing material.

3. Elimination of wax: The flask was placed in
boiling water for 5 minutes to soften the wax. Then the lids were separated and wax was eliminated. Each half of flask thoroughly flushed with 3 application of hot household detergent solution (2 teaspoonful of Nirma powder in 1 liter Water) followed by rinsed in lean boiling water.

4. Application of Separating medium: Upper and lower halves of flask dried and separating medium (cold mold seal) applied to investing surface of both halves of flask with camel hair brush when mould is warm. Care was taken to avoid application of separating medium to ridge lap surface of tooth.

5. Mixing of polymer & monomer (According to manufacturer's recommendations) the mix of resin prepared using ratio of 4 ml. Monomer liquid to 10 gram of powder. The necessary quantity of monomer was taken into a mixing jar and powder was added to it with slow continuous vibration until a layer of liquid disappears. The material was thoroughly mixed with a clean carver and mixing jar lid was closed.

6. Surface treatment: 30 specimens were chosen to study the effect of surface treatments on the bond strength. Group B, (15 Specimens) was selected to study the effect of monomer and Group C (15 specimens) was selected to study the effect of sand blasting of the ridge lap surface of teeth on bond strength between teeth and denture base.

In Group B specimens, application of the Acron heat cure monomer was done on the ridge lap surface of the teeth, with a cotton pellet held in tweezers before packing resin dough into the mold. Care was taken not to pool the monomer around ridge lap surface of the teeth. In Group C specimens the ridge lap surface of tooth was sand blasted with aluminium oxide powder. At controlled distance of 52mm and for 30 seconds.

7. Packing: When mixture reached dough stage that is when resin separated cleanly from walls of mixing jar 43, the dough was collected from mixing jar using the polyethylene sheet provided without producing air bubbles. 

8. Bench Curing: Acrylic resin was allowed to bench cure for 30 minutes to allow the free monomer available in dough to penetrate outer layer of tooth surface and later polymerize across junction to form chemical union between tooth and denture base.

9. Water bath curing: The PMMA heat cure resin was processed by short curing cycle according to manufacturer's recommendation. Flask was immersed in water at about 70°C (158°F) and it was maintained at this temperature for 30 minutes. Then water temperature was raised to 100°C (212°F) and allowed to boil for 30 minutes. After bench cooling for 30 minutes the flasks were immersed into cold water until they were cooled to room temperature.

B. Preparation of specimen by Microwave curing of PMMA

1. Wax Pattern: 45 uniformly replicated wax pattern attached to tooth were taken from group of 60 for microwave curing PMMA (This includes 15 specimens with sandblasted ridge lap surface of teeth).

2. Flasking: A specially fabricated fibre reinforced plastic flask (Supreme Fibre Glass INC. Bombay) was used for microwave curing of PMMA. The flasking procedure for microwave processing is similar to that of conventional techniques. The wax patterns were flasked using dental stone in FRP flask. The patterns were invested in such a way as to ensure that teeth and bodies of wax cylinder submerged at tooth PMMA interface. Each flask pour was allowed to set for 1hr. A thin film of Sodium alginate was applied to surface of investing material.

3. Elimination of wax: The FRP flask was placed in oven with a high power setting for 1 min. to soften the wax. Then the flask was separated and softened wax removed all in one piece. Each half of flask was then thoroughly flushed with 3 applications of hot household detergent solution and rinsed in clean boiling water.

4. Application of Separating medium: Separating medium (cold mold seal) applied to dried surface of investing medium of the both halves of flask with a camel hair rush when it is warm. Special care was taken, not to apply separating medium to ridge lap surface of tooth.

5. Mixing of polymer and monomer: The max of PMMA resin was prepared with standard powder liquid ratio as recommended by manufacture. That is 4 ml. of liquid to 10gm of powder. The necessary amount of liquid was taken in a mixing jar and then powder was added to liquid while tapping jar until layer of excess liquid disappeared. The lid was closed until mixture reached dough stage that is when resin separated cleanly from walls of mixing jar.

6. Surface Treatment: Group E, (15 Specimens) was selected to study the effect of monomer and Group F (15 specimens) was selected to study the effect of sand blasting of the ridge lap surface of teeth on bond strength between teeth and denture base. In Group E specimens, application of the Acron heat cure monomer was done on the
ridge lap surface of the teeth, with a cotton pellet held in tweezers before packing resin dough into the mold. Care was taken not to pool the monomer around ridge lap surface of the teeth.

In Group F specimens the ridge lap surface of teeth were sandblasted with aluminum oxide power. At controlled distance of 2mm and for 30 seconds.

7. Packing: The dough resin removed using polyethylene sheet provided to avoid direct contact of dough with operator’s hand. Dough was removed in one piece from mixing jar without producing air bubbles and packed into the mould and converted with thin polyethylene sheet. The flask was opened and excess flash cut with a carver, such 3 trial closures were done to remove excess flash.

I. Curing cycles followed
1. Conventional curing cycle (According to manufacturer’s instruction) the flask was immersed into water at 70°C (150°p). This temperature was maintained for 30 minutes, then water bath temperature was brought to 100°C (212°F) and allowed to boil for 30 minutes (short curing cycle was chosen because it is most commonly used laboratory procedure for fabrication of resins)
2. Microwave curing cycle: Resin was microwave irradiated for 3 minutes at 495 W (since power level setting at 500W as recommended by manufactures was not possible in present model of microwave oven. The nearest power level setting that is medium power ±95 W was selected)

J. Testing of specimens - Tensile strength testing: Tensile bond testing was performed on a digitally operated universal testing machine. Model UTM E-10/83 - 958 (fuel instrument and Engg. Pvt. Ltd.) With cross head speed - 0.05 cm/Minute. The load cell was in the upper cross member of the machine. The specimen was inserted into UTM grips with upper and lower member tightened equally. The specimens were loaded until fracture and the tensile strength required to break specimen was recorded from digital display monitor in Kilo Newton.

Results

Group - A showed mean bond strength value of 329.33 Kg/cm² which meets ADA SP requirement of 315 kg/cm². Group - B showed mean bond strength 385.02 Kg/cm² which is highest ADA SP requirement of 315 KG/ cm². Group - C showed mean bond strength value of 335.62 Kg/cm² which meets ADA SP requirement of 315 KG/cm². Group - D showed mean bond strength value of 312.12 Kg/cm² which less than ADA SP requirement of 315 KG/cm². Group-E showed mean bond strength value of 382.49 Kg/cm² which more than ADA SP requirement of 315 KG/cm². Group-F showed mean bond strength value of 338.07 Kg/cm² which meets ADA SP requirement of 315 KG/cm².

The mean bond strength and standard deviation of group-F under estimated because 8 out of 15 specimens tooth fracture before loss of bound, this occurred with seven specimens in group-E and group-D. The tooth fractured specimens not eliminated from data because tooth fractured according to samples displaying higher bond strength. This occurrence should however deny the interface superiority of bonding in group-F but it would definitely cause the improvement to be underestimated. The value may be improved with use of teeth with high impact resistance.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>V** (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>329.33</td>
<td>588</td>
<td>1.79</td>
</tr>
<tr>
<td>B</td>
<td>385.02</td>
<td>8.450</td>
<td>2.19</td>
</tr>
<tr>
<td>C</td>
<td>335.62</td>
<td>6.164</td>
<td>1.84</td>
</tr>
<tr>
<td>D</td>
<td>312.12</td>
<td>5.414</td>
<td>1.73</td>
</tr>
<tr>
<td>E</td>
<td>382.49</td>
<td>8.380</td>
<td>2.191</td>
</tr>
<tr>
<td>F</td>
<td>338.07</td>
<td>5.571</td>
<td>1.65</td>
</tr>
</tbody>
</table>

Table – 7 shows mean, Standard deviation and coefficient of variation for each group
* 315Kg/Cm² ADA standard value for bond strength
** Coefficient of variations.
* 315Kg/Cm² ADA standard value for bond strength

The mean bond strength of 6 groups differ significantly F=9.36 P<0.001. The coefficient of variation is not statistically significant with each other groups.

Discussion

The loss of teeth is a matter of great concern to the majority of people and their replacement by artificial substitutes such as dentures, is vital to lead normal life. One of the problems encountered in provision of dentures is whether the limitations of strength of such prosthesis meet functional demands of oral cavity. Polymethyl methacrylate despite being most commonly employed in construction of dentures is far from ideal in fulfilling mechanical
requirements of such appliances. A total 90 specimens are tested for the tensile bond strength processing done with conventional and microwave energy and tensile bond testing was performed on a digitally operated universal testing machine. The bond strength measurements indicated that microwave cured PMMA demonstrated inferior bond strength than conventional cured PMMA.

Application of monomer on ridge lap surface of denture teeth showed increase in the bond strength of conventionally cured specimens showed little more bond strength were compared with conventional cure and microwave cure in comparison of conventional microwave cure specimens showed higher bond strength. Out of 6 groups of specimens tested exhibited mean bond strength values which passed ADA specification standards minimum value 315 kg/cm² for bond strength except for microwave cured specimens without any surface treatment (312.12 kg/cm²). Since bond strength exhibited for microwave cured specimens without any surface treatment is below ADA sp. Standard value 315 kg/cm² for bond strength and priming tooth ridge lap with monomer exhibited maximum bond strength of microwave cured specimens, this method is recommended when microwave curing method required to be used for denture fabrication. Microwave energy minimizes debond failure and attributes the advantages like quicker and clean procedure for denture curing.

Conclusion

Conventionally cured specimen exhibited statistically significant P<0.001 higher bond strength than microwave cured specimens. Conventionally cured specimens with applications of monomer ridge lap surface of the denture teeth showed the higher bond strength than microwave cured specimens with same surface treatment. Conventionally cured specimens with sandblasting of ridge lap surface of the denture tooth showed less bond strength than the microwave cured specimens with same surface treatment. Since bond strength exhibited for microwave cured specimens without any surface treatment is below ADA sp. Standard value 315 kg/cm² for bond strength and priming tooth ridge lap with monomer exhibited maximum bond strength of microwave cured specimens, this method is recommended when microwave curing method required to be used for denture fabrication. Microwave energy minimizes debond failure and attributes the advantages like quicker and clean procedure for denture curing.

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References


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