The Effect Of Microwave Disinfection On The Bond Strength Of Two Commercially Available Acrylic Denture Teeth To Acrylic Denture Base Resin – An In Vitro Study

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Context: To prevent spread of infectious diseases through dental procedures, disinfection of removable prosthesis is required. Microwave radiation is one of the effective and economical method for denture disinfection. But effect of microwave radiation on physical properties of denture teeth and denture base resin need to be evaluated.

Aim: To evaluate the effect of microwave disinfection on the bond strength of two commercially available acrylic denture teeth to acrylic denture base resin.

Material and Method: 60 specimens were prepared in which central incisor was attached to acrylic block at 45 degree angle and 3 groups were prepared Control, D2 and D7. Control group was not subjected to microwave radiation, D2 group was subjected to 2 cycles and D7 group was subjected to 7 cycles of microwave disinfection. Shear bond strength of each specimen were then tested according to Japanese standard using knife edged shear test in a universal testing machine.

Statistical analysis used: The obtained data was statistically analysed using ANOVA test and the Turkey Honesty Significance Difference post hoc test (α=0.05).

Results: There was no statistically significant difference found in bond strength before and after microwave disinfection procedure.

Conclusion: We can use microwave disinfection procedure effectively and safely for routine disinfection of removable dental prosthesis.

Keywords: Microwave disinfection, Bond strength, Universal testing machine, Removable dental prosthesis
INTRODUCTION:
Recent increase in incidence of communicative diseases like AIDS, hepatitis, infectious mononucleosis and viral infections now require thorough infection control in dentistry\(^1\). Microscopic studies have demonstrated that a biofilm similar to that formed on natural teeth is present on dentures. Large quantity of candida species and some bacterial species associated with systemic diseases have been found in dentures with predominance of gram-positive bacteria such as staphylococcus species, streptococcus species, actinomyces species and Gram-negative species, such as Neisseria perfava, P. aeruginosa, and enterobacter cloacaecript. Concern about dissemination of these organisms has produced renewed interest in denture sterilization and disinfection. Sterilization and disinfection procedures have become popular and widely used methods for eradicating micro-organisms from the surfaces of denture base materials and controlling cross contamination\(^2\). Disinfection methods are less lethal than sterilization and are used only when sterilization cannot be carried out. Acrylic dentures cannot be autoclaved and hence various methods for its disinfection are recommended. Proper disinfection of prosthesis can be achieved with chemical solutions such as sodium hypochlorite, iodoform, gluteraldehyde, chlorine dioxide or alcohol solutions. Nevertheless, these denture-soaking solutions can cause deleterious effects on acrylic resins. Sodium hypochlorite may stain or whiten the plastic components of prosthesis. Gluteraldehyde has shown severe risk of cytotoxicity. Chlorine dioxide has a bleaching action on denture base resin and corrosive effects on frameworks. To overcome the problems associated with chemical solutions, a major research effort has been focused on alternative methods for prosthesis disinfection. The goal of any disinfection method is to inactivate infectious viruses and bacteria without damaging the dentures and its properties\(^3\).

Michael Rohrer\(^4\) in 1985 suggested microwave energy for disinfection of prosthesis. Microwave irradiation is claimed to be a simple, effective and inexpensive method for prosthesis disinfection. Webb at al\(^5\) indicated that microwaving may be a more effective method of denture sterilization than denture soaking in sodium hypochlorite. As the acrylic resin denture base may be contaminated externally and internally, microwave energy has been recommended as an ideal method of denture disinfection. A study was conducted by Silva M, Vergani, Neppelenbroek\(^6\) to evaluate the effectiveness of microwave irradiation on the disinfection of simulated complete dentures and concluded that microwave irradiation for 6 minutes at 650 W produced sterilization of complete dentures contaminated with S aureus and C.albicans and disinfection of those contaminated with P aeruginosa and B subtilis. Saadi et al\(^7\) evaluated the effectiveness of six disinfection methods and the influence of these methods on the adaptation of maxillary dentures. He concluded that microwave oven at medium power and sodium hypochlorite(5.25%) are effective and safe methods of disinfecting removable dentures. Klironomos et al\(^8\) did a study on effect of microwave disinfection on denture and concluded that Microwave disinfection (650 W / 3 min / 3 cycles) is a safe alternative for the disinfection of denture bases and liners compared to the chemical one when the procedure is carried out in dry conditions, but could possibly cause dimensional changes of clinical significance when the irradiation takes place in wet environment. Mojarad et al\(^9\) compared efficacy of mechanical, chemical, and microwave radiation methods in disinfecting complete dentures and concluded that microwave irradiation, 2% glutaraldehyde, and Corega tablets disinfected complete dentures contaminated with S. aureus and P. aeruginosa which lasted for a long and a short terms.

Adequate bonding of acrylic resin teeth to denture base resin is necessary because it increases the strength and durability of the denture. Debonding of denture teeth from the acrylic resin still remains a major problem in prosthodontic practice and is one of the common causes of failures in dentures. Studies have been conducted to evaluate the influence of mechanical and chemical preparation of the denture teeth, different polymerization methods and types of acrylic resins and denture teeth on the adhesion between denture teeth and acrylic resin. However,
only few studies have been found in the literature describing the effect of microwave disinfection on the shear bond strength of acrylic denture teeth to denture base acrylic resin. This in-vitro study was done to evaluate the effect of microwave disinfection on bond strength of two commercially available acrylic denture teeth to acrylic denture base resin.

MATERIALS AND METHOD:

A. Fabrication of specimens for testing shear bond strength:

Specimens for testing shear bond strength were made according to Japanese standard (JIST 6506) in which block was made of self cure acrylic resin (ASHVIN-self polymerizing cold cure acrylic resin) of size 8 mm×10 mm×20mm. Putty impression material (SPEEDEX) was used to make impression of self cure acrylic resin block to get the mold. Modelling wax was melted and poured into the putty mold. Once the modeling wax was hard, the wax block was carefully retrieved from the putty impression. In this manner sixty blocks of size 8 mm×10 mm×20 mm were prepared.

A maxillary central incisor denture tooth of each brand; BIOROCK and B-TON was randomly selected from the teeth set and was thoroughly cleaned. The tooth was attached to the 8mm×10mm×20mm surface of wax block so that the long axis of the maxillary central incisor tooth was oriented 45° to the wax surface. The ridge lap and the collar portion of the maxillary central incisor tooth were embedded into the wax. In this manner, thirty specimens were prepared for each brand of acrylic resin denture teeth. The wax block with attached acrylic tooth was then processed for polymerization and then finished and polished. In this manner sixty specimens were prepared with thirty specimens for each brand of acrylic resin denture teeth. All the procedure was carried out by a single operator.

B. Grouping of the specimens:

The thirty specimens of each brand were grouped into one control and two test groups (n=10). The control was not subjected to microwave disinfection and D2 and D7 were subjected to microwave disinfection. The details of the groups are:

Group I – Control: The specimens were kept in distilled water.

Group II – D2: The specimens were subjected to two cycles of microwave disinfection (600 W for 6 minutes/cycle).

Group III – D7: The specimens were subjected to seven cycles of microwave disinfection (600 W for 6 minutes/cycle).

C. Microwave disinfection of the specimens:

The D2 and D7 specimens of each brand of denture teeth were disinfected by using microwave energy. In test group D2, specimens were subjected to two cycles of microwave disinfection (600 W for 6 minutes/cycle). Specimens from D2 test group were disinfected twice to simulate when contaminated dentures come from the patient and before being returned to the patient. In test group 2 i.e. D7, the specimens were subjected to seven cycles of microwave disinfection (600 W for 6 minutes/cycle). This group was intended to detect any possible cumulative effect of microwave disinfection on the bond strength between the denture teeth and acrylic resin. The microwave disinfection was done in a domestic microwave oven with rotating table, power and time control. The specimens were immersed in water because they are transparent to microwave energy. The continued use of any microwave oven
without a load to absorb the generated energy will result in damage to microwave generator or magnetron. Therefore a parallel load to absorb energy must be used with the sterilization technique for acrylic resin. The use of water is convenient and simple to protect the magnetron.

D. Shear bond testing of specimens:

The shear bond strength was tested according to Japanese standard using knife edged shear test in a universal testing machine (INSTRON). The specimen was positioned vertically within the specimen holder. Load was applied to the long axis of each denture tooth on palatal surface of the tooth at a crosshead speed of 1 mm/min until it fractured. The values were recorded in Newton (N). The obtained data was statistically analysed using ANOVA test and the Turkey Honesty Significance Difference post hoc test (α=0.05).

RESULTS:
Table 1 and graph 1 shows mean and standard deviation of shear bond strength values (Newton) amongst 3 groups i.e. Control, D2 and D7.

Table 1

<table>
<thead>
<tr>
<th>Brands of teeth</th>
<th>Control</th>
<th>D2</th>
<th>D7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean(N)</td>
<td>SD</td>
<td>Mean(N)</td>
</tr>
<tr>
<td>Brulon</td>
<td>786.24</td>
<td>113.39</td>
<td>796.59</td>
</tr>
<tr>
<td>P&amp;S</td>
<td>712.89</td>
<td>105.14</td>
<td>725.38</td>
</tr>
</tbody>
</table>

Graph 1

Table 2 shows one way ANOVA for brands of denture teeth (i.e. Biorock and Premi & Sons).

Table 2

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>ANOVA P VALUE</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>143122.090</td>
<td>5</td>
<td>28624.418</td>
<td>2.240</td>
<td>.083</td>
<td>Not Significant</td>
</tr>
<tr>
<td>Within Groups</td>
<td>306660.119</td>
<td>24</td>
<td>12777.505</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>449782.209</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
One way ANOVA showed there is no significant difference between two main factors i.e. denture teeth and group and the interaction (p>0.05).

Table 3 and graph 2 shows comparison of bond strength values of Biorock and Premi and Sons denture teeth in 3 groups i.e. Control, D2 and D7.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean(N)</th>
<th>SD</th>
<th>P value</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>786.24 N</td>
<td>113.39</td>
<td>.905</td>
<td>Not Significant</td>
</tr>
<tr>
<td>BRULON Control P&amp;S</td>
<td>712.89 N</td>
<td>105.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2 - BRULON D2 - P&amp;S</td>
<td>796.59 N</td>
<td>95.15</td>
<td>.915</td>
<td>Not Significant</td>
</tr>
<tr>
<td>725.38 N</td>
<td>63.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D7 - BRULON D7 - P&amp;S</td>
<td>711.82 N</td>
<td>191.86</td>
<td>.500</td>
<td>Not Significant</td>
</tr>
<tr>
<td>585.00 N</td>
<td>53.61</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In control group, Biorock teeth showed highest bond strength compared to P & S teeth. This difference was statistically not significant (p>0.05).

In D2 group, Biorock teeth showed highest bond strength compared to P & S teeth. This difference was statistically not significant (p>0.05).

In D7 group, Biorock teeth showed highest bond strength compared to P & S teeth. This difference was statistically not significant (p>0.05).
Table 4 shows comparison of bond strength values in 3 groups i.e. control, D2 and D7 for P & S teeth.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>COMPARISON</th>
<th>P VALUE</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL</td>
<td>D2-P&amp;S</td>
<td>1.000</td>
<td>Not Significant</td>
</tr>
<tr>
<td>P &amp; S</td>
<td>D7-P&amp;S</td>
<td>.491</td>
<td>Not Significant</td>
</tr>
<tr>
<td>D2-P&amp;S</td>
<td>CONTROL - P &amp; S</td>
<td>1.000</td>
<td>Not Significant</td>
</tr>
<tr>
<td></td>
<td>D7-P&amp;S</td>
<td>.391</td>
<td>Not Significant</td>
</tr>
<tr>
<td>D7-P&amp;S</td>
<td>CONTROL - P &amp; S</td>
<td>.491</td>
<td>Not Significant</td>
</tr>
<tr>
<td></td>
<td>D2-P&amp;S</td>
<td>.391</td>
<td>Not Significant</td>
</tr>
</tbody>
</table>

For P&S teeth, when control group compared with D2 & D7 group, there was not statistically significant difference in bond strength (p>0.05) .

For P&S teeth, when D2 group compared with control & D7 group, there was not statistically significant difference in bond strength (p>0.05) .

For P&S teeth, when D7 group compared with control & D2 group, there was not statistically significant difference in bond strength (p>0.05) .

Table 5 shows comparison of bond strength values in 3 groups i.e. control, D2 and D7 for BIOROCK teeth.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>COMPARISON</th>
<th>P VALUE</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL</td>
<td>D2-BRULON</td>
<td>1.000</td>
<td>Not Significant</td>
</tr>
<tr>
<td>BRULON</td>
<td>D7-BRULON</td>
<td>.899</td>
<td>Not Significant</td>
</tr>
<tr>
<td>D2-BRULON</td>
<td>CONTROL-BRULON</td>
<td>1.000</td>
<td>Not Significant</td>
</tr>
<tr>
<td></td>
<td>D7-BRULON</td>
<td>.839</td>
<td>Not Significant</td>
</tr>
<tr>
<td>D7-BRULON</td>
<td>CONTROL-BRULON</td>
<td>.899</td>
<td>Not Significant</td>
</tr>
<tr>
<td></td>
<td>D2-BRULON</td>
<td>.839</td>
<td>Not Significant</td>
</tr>
</tbody>
</table>

For BRULON teeth, when control group compared with D2 & D7 group, there was not statistically significant difference in bond strength (p>0.05) .

For BRULON teeth, when D2 group compared with control & D7 group, there was not statistically significant difference in bond strength (p>0.05) .

For BRULON teeth, when D7 group compared with control & D2 group, there was not statistically significant difference in bond strength (p>0.05) .

DISCUSSION:

Prefabricated denture teeth for dentures were introduced in 1940[10]. Since then this material has become the most popular artificial material for denture teeth. Apart from the advantage of economy, it also bonds chemically to the denture base and has a life like translucent quality, even in thin sections of less than 1 mm. Acrylic resins are used as denture base materials since 1937 (Craig, 1993) and heat cure poly methyl methacrylate composed of methacrylate chains is the most popular of them. However, the fracture and debonding of acrylic resin teeth from the acrylic resin denture base is still all too common clinical problem. It has been estimated that between 22% and 30% of denture repairs involve tooth bonding, usually in anterior region of denture[11].
Robert chuqui ribeiro et al\textsuperscript{[12]} stated that the different denture teeth types might influence the tooth/denture resin bond strength. Considering these results the type of denture teeth selected in this study were cross linked (Premi and Sons) and two layer resin teeth (Brulon) to evaluate the effect of microwave disinfection on the type of denture teeth. Huggett et al\textsuperscript{[13]} and Fletcher et al\textsuperscript{[14]} have also suggested that the quality of denture base may contribute to the bond strength of the tooth to the denture base. They concluded that high-impact, heat cured denture bases give a better bond than do autopolymerizing or non-high-impact, heat-cured denture bases. So in this study high impact denture base resin i.e. DPI was used. Microwave irradiation was initially used for thermally activated acrylic resin polymerization. According to Neppellenbroek et al. microwave energy has been recommended for prosthesis disinfection, when the probability of the denture base being contaminated internally and externally is considered\textsuperscript{[13]}. The microwave energy has been recommended as an alternative to decrease the disadvantages of chemical disinfection and as an ideal method for denture disinfection\textsuperscript{[16]}. Moreover it has advantages like lower operational cost and ease of use. So microwave energy was used as disinfection method in this study. The lethal action of microwave irradiation on various microorganisms seems to be well established, even though the mechanisms responsible for the microwave killing are unclear. Some studies maintain that the effect of microwave irradiation on microorganisms is of a directly thermal nature. On the other hand, other investigations claim that killing organisms also probably results from the interaction of the electromagnetic field with the cells and surrounding liquid medium (non thermal effect). It has been reported that microwave irradiation affects the metabolic activity of S.aureus in a manner which could not be explained by the thermal effect alone. A possible explanation of the non thermal effect of microwave irradiation could lie in the selectivity of absorption of microwave by certain essential biochemical molecules such as nucleic acid, protein and the protein-lipopolysaccharide compound of cell membranes. This process would detrimentally influence the vital activities of microorganisms. Moreover, since most microbial cells bear an electrical charge, usually negative, the possibility exists of the cell being mechanically disrupted by causing it to oscillate rapidly in the high frequency field. Despite the nature of the lethality of microwave irradiation, some authors have attributed the favourable results of water immersion during procedure. This can probably be explained based on the increase in the water temperature during microwave irradiation, which provides uniform heating of the specimens. A study regarding microwave disinfection of acrylic resins contaminated with C. albicans demonstrated that all 5 minutes irradiated acrylic resin specimens immersed in water were effectively sterilized, while the 5 minutes irradiated specimens in dry state were only disinfected\textsuperscript{[17]}. In this study the evaluation of bond strength was done according to the Japanese standard as it was more clinically relevant. The same standard was followed by the studies done by Roberta Chuqui Ribeiro et al\textsuperscript{[18]}. According to Japanese standard for acrylic resin teeth, the bond shall be considered satisfactory if the failure load exceeds 110 N for upper teeth and 60 N for lower teeth. Both the denture teeth tested in this study i.e. Premi and Sons and Biorock teeth showed the bond strength above the minimum acceptable bond strength as suggested by Japanese standard, in both the control groups and microwave disinfection test groups. The bond strength values for Brulon denture teeth were 786.24N, 796.59N, 711.82N in control, D2 and D7 groups respectively. The bond strength values for premi and Sons denture teeth were 712.89N, 725.38N, 585N in control, D2 and D7 groups respectively.

One way ANOVA test showed that there was no significant difference in bond strength between two main factors i.e. denture teeth and group and the interactions. Post hoc comparison of denture teeth revealed that in all the groups i.e. control, D2, D7, the mean shear bond strength of Brulon denture teeth was higher than Premi and Sons denture teeth but not statistically significant. Denture base resin monomer may be more freely diffused into acrylic resin of Brulon than acrylic resin of Premi and sons. According to study carried by Clancy JM et al. denture base resin monomer may be more freely diffused into acrylic resin of less cross linked denture tooth\textsuperscript{[19]}. The
highly cross-linked network of denture tooth resin is likely to prevent adequate acrylic resin monomer penetration into the denture tooth bonding surface.

When post hoc comparison was made between the groups, it was seen that after 2 cycles of microwave disinfection (i.e. D2 group), both denture teeth i.e. (Brulon and Premi and sons) showed increase in the bond strength but not statistically significant. Increase in the bond strength can be justified as, rise in temperature during microwave disinfection may have promoted further monomer conversion into polymer. Consequently the strength of the interpenetrating polymer formed at the interfacial region may have improved. The same results were obtained in the study by Roberta Ribeiro[12]. These results were in contrast with study done by Rafael L.X. Consani et al[19] where the bond strength was reduced.

After 7 cycles of microwave disinfection (i.e. D7 group), both denture teeth i.e. (Brulon and Premi and sons) showed decrease in the bond strength but not statistically significant. This can be explained as during repeated microwave disinfection, water may also percolate directly into the bond interface between the denture teeth and acrylic resin, thus reducing the bond strength. This result was in contrast with the study done by Rafael L.X. Consani et al[19] where there was increase in the shear bond strength of the denture teeth with the denture base resin after repeated microwave disinfection ( 5 cycles of microwave disinfection at 650W for 3 minutes). But when D7 group was compared with D2 group, the bond strength was significantly reduced. This can be explained as during repeated microwave disinfection, water may also percolate directly into the bond interface between the denture teeth and acrylic resin. The difference was not statistically significant, when D7 group was compared with control group.

Although this in vitro study evaluated the bond strength of denture teeth to denture base resin by shear test, it did not reproduce the clinical situation ideally. Further investigations are required to evaluate the bonding under more closely simulated clinical conditions.

**CONCLUSION:**
Following conclusions were drawn within limitation of this study:

- The shear bond strength of Biorock denture teeth was more than Premi and sons denture teeth in control group as well as microwave disinfection test groups but the difference in bond strength is not statistically significant.
- After two cycles of microwave disinfection, the shear bond strength of Brulon and Premi and Sons denture teeth was increased but the difference is statistically insignificant.
- After seven cycles of microwave disinfection, the shear bond strength of Brulon and Premi and Sons denture teeth was decreased but the difference is statistically insignificant.

So we can safely do disinfection of dentures by microwave radiation without affecting other physical properties of denture.

**REFERENCES:**


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