Dimensional Changes in Microwave Processed Acrylic Resin and Conventional Heat Polymerized Resin Cured by Water Bath and Microwave Energy - An In Vitro Study

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Abstract:
Background: Poly-methyl-methacrylate (PMMA) and microwaveable acrylic resin are used for complete denture and removable partial denture services. This study was conducted to comparatively evaluate dimensional changes in microwave processed acrylic resin and in conventional heat polymerized resin cured by water bath and microwave energy.

Materials and Methods: A total of 30 maxillary denture bases (3 mm thick) were made on cast in our study. These samples were demarcated into 3 groups. Group 1: Control, conventional heat cure PMMA cured by water bath method; Group 2 denotes conventional heat cure PMMA cured by microwave energy (500 W for 3 min); Group 3 denotes microwave acrylic resin cured by microwave energy (500 W for 3 min). After polymerization of test samples, the base/cast sets were cut transversally in the posterior palatal seal area. The measurements were made at the right marginal limit, left marginal limit, right ridge crest, left ridge crest, and the palatal midline. Stereomicroscope used to see the gaps between the casts and denture base. The data were collected and statistically analyzed.

Results: The highest dimensional inaccuracies were seen in conventional heat cure PMMA samples cured by microwave energy (500 W for 3 min), and lowest dimensional changes were seen with the microwaveable acrylic resin samples cured by microwave energy (500 W for 3 min).

Conclusion: Within the limitations of this study, it can be concluded that the highest dimensional stability is seen in microwaveable acrylic resin cured by microwave energy (500 W for 3 min) and lowest dimensional stability in conventional heat cure PMMA samples cured by microwave energy (500 W for 3 min).

Key Words: Dimensional changes, microwaveable acrylic resin, poly-methyl-methacrylate and stereomicroscope

Introduction
Poly-methyl-methacrylate (PMMA) has been used conventionally for denture bases. The acrylic resin has few short comings, i.e., poor dimensional stability, lacks strength, abrasion resistance, and lengthy polymerization time. Microwave can also be used for sterilization and pasteurization process. Various studies have been done on microwaveable acrylic resin and PMMA resin by different authors. Wallace et al. proved that the microwave processed denture had better dimensional accuracy than conventionally processed bases. Levin et al. stated that there was no significant difference of curing denture by microwave energy or conventional hot water bath polymerization techniques, but microwave cured dentures energy has the advantages of reduced curing time and cleanliness. Singh et al. stated that method of curing PMMA resin samples by water bath heat activation have disadvantage of lengthy polymerization time, therefore they advised PMMA resin samples to be cured by microwave energy. The results of various studies were conflicting; the advantages and disadvantages of curing methods for denture fabrications are unclear; therefore, this study was conducted to comparatively evaluate dimensional changes in microwave processed acrylic resin and in conventional heat polymerized resin cured by water bath and microwave energy.

Aims and objectives
1. To evaluate the dimensional changes in conventional heat polymerized resin cured by water bath
2. To evaluate the dimensional changes in conventional heat polymerized resin cured by microwave energy. The curing of PMMA resin samples by microwave energy is also recommended by Singh et al.
3. To evaluate the dimensional changes in microwave acrylic resin cured by microwave energy
4. To comparatively evaluate the dimensional changes in microwave processed acrylic resin and in conventional heat polymerized resin cured by water bath and microwave energy.
Materials and Methods

The maxillary acrylic bases (3 mm thick) were prepared for this study (Figure 1). The double shellac base plate (Y dent) was joined and used as denture bases to ensure uniform thickness throughout. The sample size was chosen to be 30 using the previous studies done by Pavan et al. The sample size was calculated to be 10 per group. The sample size selection was done using Master software keeping power of 80% and keeping a confidence interval of 5%. Resin bases were processed on duplicate stone casts prepared from a cobalt chromium master die. Type 111 dental stone was used to fabricate cast. The ideal standardize cobalt chromium master die was used to obtain ideal cast with U shaped palate. One heat cure base material Lucitone 199 and one microwaveable acrylic resin (Acron MC, GC, Corporation Japan) was used in our study. Thereafter, the specimens were assigned into 3 groups.

- Group 1: Control, conventional heat cure PMMA cured by water bath method
- Group 2: Conventional heat cure PMMA cured by microwave energy (500 W for 3 min)
- Group 3: Microwave acrylic resin cured by microwave energy (500 W for 3 min).

Polymerisation technique for Group 1 samples

The samples of control, conventional heat cure PMMA were invested and after 60 min. Of stone setting, dewaxing was carried out by keeping flask in boiling water for 6 min. The mingling of polymer and monomer, used in ratio of 3:1 by volume was proportioned before mixing. Once the mix reached the dough consistency, it was packed in the mold. After the flasks were clamped, closure was done under force of 20 KN and kept for 30 mins. The heat curing cycle was as per manufacturer instruction (70°C for 90 min, thereafter 100°C for 30 min and finally flasks were then kept at room temperature for 60 min.

A total of 10 test specimens were prepared using this procedure.

Polymerisation technique for Group 2 conventional heat cure PMMA samples cured by microwave energy

The Group 2 conventional heat cure PMMA acrylic resin was mixed according to manufacturer’s instructions and a domestic microwave oven was used for polymerization. The special type of flask was used for curing the samples. The curing procedure followed was 500 W for 3 min. Bench cooling was done for half an hour, and a total of 10 test specimens were prepared using this curing technique. The similar study of curing PMMA resin by microwave energy is also recommended by Singh et al.

Polymerization technique for Group 3 microwave acrylic resin samples cured by microwave energy

The special type of dental flask was used for curing Acron GC samples. The resin mixed following manufacturer’s instructions. It was done in domestic microwave. The curing procedure followed was 500 W for 3 min. A total of 10 test specimens were prepared using this curing technique.

Thus, each group consists of 10 test samples and total of 30 samples from 3 study groups.

Assessment of dimensional inaccuracies in test specimens

The base/cast sets were cut transversally in the posterior palatal seal area with a vertical cutting machine with a diamond disk (2800/3800 revolution/min WOCOS0, Jean Wirtz, GmbHand Co Kg, Germany) under water cooling. The discrepancies between the cast and denture base inner surface were calculated using stereomicroscope (Figure 2). The measurements were made at the right marginal limit (A), left marginal limit (B), right ridge crest (C), left ridge crest (D), and the palatal midline (E) (Figure 3). The gap of the investigated resin heat or microwave cured was photographed at magnification ×15 by charge-coupled device digital camera (DP 10 Olympus, Japan) attached to zoom microscope (Olympus, SZ-PT, Japan). The availability of the stereomicroscope and being a cost effective alternative to three-dimensional (3D) technique, it was used in present study for measuring adaptation accuracy. It was measured and data were statistically analyzed.
The software used for the statistical analysis were Statistical Package for Social Sciences (SPSS). The data was statistically analyzed using Kruskal–Wallis test and Mann–Whitney U-test.

Results
The mean marginal discrepancy was compared between the Groups 1-3 at right marginal limit, left marginal limit, right ridge crest, left ridge crest and palatal midline using the Kruskal–Wallis test.

The post-hoc inter-group comparison was done between the Groups 1-3, at right marginal limit, left marginal limit, right ridge crest, left ridge crest, and palatal midline using the Mann–Whitney U-test. Group 3 (microwave acrylic resin cured by microwave energy) showed lowest discrepancy in denture bases at all measurement points and differed statistically from other groups (P < 0.001).

There was no significant difference (P > 0.05) between Group 1 (control, conventional heat cure PMMA cured by water bath method) and Group 2 conventional heat cure PMMA cured by microwave energy (500 W for 3 min) regarding adaptation of denture bases to casts at any of the measurement point (Table 1).

At all the margins, the mean marginal discrepancy was significantly more among Groups 1 and 2 in comparison to Group 3. When measurements point in same group were compared, the greatest discrepancy were seen in point B (left marginal point), which differed significantly from the other points in all groups studied (P < 0.001).

Discussion
PMMA is used widely in all conventional removable partial denture and complete denture work but the search for the understanding of this material continues. The adhesive influences the area covered with the biofilm on inner surfaces of complete denture. The heat polymerized resin is less cytotoxic than autopolymerized resin as it has less residual monomer which reduces cell and tissue changes in the oral mucosa. The important fact of reducing polymerization time of microwave heating is to remove the induction period associated with in situ catalyst manufacture and initiation. The denture base resin can be cured by heat activation (water bath or microwave energy), chemical activation or visible light activation. One of the disadvantages of the compression molding technique is that the gap increases between the denture base and the underlying mucosa, compromising the fit of dentures. The curing of PMMA resin samples by water bath heat activation has disadvantage of elongated polymerization time, hence curing of PMMA resin samples by microwave energy was recommended. Artopoulos et al. proved that compression molding and injection molding gave similar results for polymethylmethacrylate resin. They had used 3D scanning technology and software to check adaptation accuracy between cast and denture base. Kasina et al. reported that heat polymerized PMMA resin samples had lesser mean porosity values than microwave-polymerized groups. Consani et al. reported similar effects on the hardness of heat-activated denture base resins with different curing cycles. Compagnoni et al. stated that adding 10% poly (2 tert-butyllaminomethyl methacrylate) into denture base resin improves the wettability and roughness of acrylic resin surface. Badr et al. stated that microwave cured samples had widely spread porosity, and the water bath method showed favorable results in processing heat cured resins than the microwave irradiations. The microwave

Figure 3: The gap between maxillary denture base and cast at the right marginal limit, (A) left marginal limit (B), right ridge crest (C), left ridge crest (D) and the palatal midline (E) seen with posterior palatal border view.

Table 1: Comparative mean marginal discrepancy values (mm) between the Groups 1-3 at right marginal limit, left marginal limit, right ridge crest, left ridge crest and palatal midline.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Right marginal limit (mm)</th>
<th>Left marginal limit (mm)</th>
<th>Right ridge crest (mm)</th>
<th>Left ridge crest (mm)</th>
<th>Palatal midline (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>1.346±0.987</td>
<td>1.849±1.049</td>
<td>0.451±0.293</td>
<td>0.493±0.383</td>
<td>0.991±0.479</td>
</tr>
<tr>
<td>Group 2</td>
<td>2.356±1.301</td>
<td>2.897±1.292</td>
<td>0.672±0.348</td>
<td>0.832±0.459</td>
<td>1.492±0.798</td>
</tr>
<tr>
<td>Group 3</td>
<td>0.261±0.180</td>
<td>0.759±0.218</td>
<td>0.005±0.002</td>
<td>0.005±0.002</td>
<td>0.012±0.009</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Group 1 versus 2º</td>
<td>0.062º</td>
<td>0.057º</td>
<td>0.163º</td>
<td>0.09º</td>
<td>0.112º</td>
</tr>
<tr>
<td>Group 1 versus 3º</td>
<td>0.042º</td>
<td>0.046º</td>
<td>0.002º</td>
<td>0.010º</td>
<td>0.001º</td>
</tr>
<tr>
<td>Group 2 versus 3º</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

Since in Group 2 at all measurement point marginal discrepancy is excessive so the method of curing PMMA resin samples by microwave energy is not be recommended. *Significant difference, Non-significant difference, Kruskal–Wallis test, Mann–Whitney U-test.
disinfection at 690 W for 6 min promoted significant increase of baseplate distortion in a denture resin polymerized by microwave energy but not when same resin was polymerized by conventional water bath.\textsuperscript{17}

The results of various studies conducted by researchers were mixed and contradictory.

Hence, an attempt has been made to comparatively evaluate dimensional changes in microwave processed acrylic resin and in conventional heat polymerized resin cured by water bath and microwave energy.

In this study, at all the margins, the mean marginal discrepancy was significantly more among Groups 1 (control, conventional heat cure PMMA samples cured by water bath method) in comparison to Group 3 (microwave resin samples cured by microwave energy) (Table 1).

These results are in accordance with results reported by Consani \textit{et al.}\textsuperscript{18} They reported that during curing of heat cure PMMA samples by water bath method internal stresses are released from resin dough before polymerization. These stresses along with polymerization shrinkage and thermal contraction during flask cooling results in dimensional adaptation inaccuracies.\textsuperscript{19}

The highest dimensional inaccuracy was seen in conventional heat cure PMMA samples cured by microwave energy (500 W for 3 min) but did not differ statistically from the conventional heat cure PMMA samples cured by water bath method. At all the margins, the mean marginal discrepancy was significantly more among Groups 2 (conventional heat cure PMMA samples cured by microwave energy) in comparison to Group 3 (microwave resin samples cured by microwave energy) (Table 1). The probable reason may be that the time/power setting using microwave energy affected negatively the acrylic resin properties, therefore, affecting their dimensional adaptability.

**Interpretation and Conclusion**

1. The microwave acrylic resin samples cured by microwave energy (500 W for 3 min) showed lowest dimensional inaccuracies
2. The highest dimensional inaccuracy was seen in conventional heat cure PMMA samples cured by microwave energy (500 W for 3 min) but did not differ statistically from the conventional heat cure PMMA samples cured by water bath method.

**Strength of the study**

The highest dimensional stability is seen in microwaveable acrylic resin cured by microwave energy and since microwave polymerization have advantage of time saving, uniform and save polymerization, so this method of curing microwaveable acrylic resin by microwave energy (500 W or 3 min) can be employed for fabrications of denture.

**Limitations in Our Study**

Only one type of curing cycle, i.e., (500 W for 3 min) was employed in our study. Therefore, further studies are required using different curing (short and long) cycles.

**Future Research Direction**

Future studies are required evaluating time/power settings using microwave energy for the polymerization of latest denture base materials.

**References**

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