This study was twofold: an in-vivo study aimed to compare between the clinical efficiency of heat-cured and microwave-cured overdenture bases, and an in-vitro study to relate the chemical, physical and mechanical properties, to the clinical performance of these overdentures.

Fourteen mandibular overdentures were constructed for edentulous patients with remaining two natural mandibular canines. Overdentures were divided equally according to the curing mode into two groups using heat cured acrylic resin material. Group I was processed in water bath for 1½ hrs at 74ºC and then for another 1 hr at 100 ºC. Group II was processed using dry heat of microwave energy at 550 W for 3 minutes. In-vivo study, the mandibular overdentures were weighed and their thicknesses were measured at predetermined fixed points on denture bases at delivery, 6 months and 12 months follow-up periods to evaluate the wear resistance. In-vitro study involved preparing of twenty rectangular specimens assigned to two equal divisions with respect to the processing technique. A 4-point loading bending test was used to determine the flexural characteristics under static and cyclic loading. Hardness was evaluated using Vicker’s hardness tester. Uncured, water bath (heat) cured and microwave cured solid samples were analyzed using Fourier Transform Infrared spectral analysis (FTIR) to determine the degree of conversion. The porosity was also assessed using stereomicroscope for samples cured by both investigated modes.

Although heat cured acrylic resins exhibited higher wear resistance, their overdenture bases decreased in weight in contrast to microwave cured bases which showed slight increase in weight over the follow up periods. Significant decrease in thickness either for heat or microwave cured overdenture bases over periods; however, this change was insignificant regarding the mode of curing. Heat cured acrylic resin showed significantly higher flexural characteristics than microwave ones except for flexural modulus which was insignificantly different. The degree of conversion using microwave irradiation resulted in (67.21% DC) but it was (52.17% DC) for heat curing. Microwave cured specimens showed widely spread porosity accompanied with lower significant hardness.

Depending on the mode of curing, the clinical efficiency could be related to the chemical, physical and mechanical properties of acrylic resin. Water bath method showed favorable results in processing heat cured resin material than microwave irradiation, however, the curing conditions of the latter should be considered.
INTRODUCTION

Acrylic resins, based on polymethyl methacrylate (PMMA), have been widely used for the fabrication of overdenture bases (1). Various reports have cited desirable properties of this polymer material, such as biocompatibility, adequate mechanical properties, satisfactory dimensional stability, insolubility in oral fluids, acceptable aesthetic, ease of handling and moderate cost. However, the strength of these bases remains far from ideal for maintaining the longevity of dentures (2-4).

Curing processes are among the influential factors that govern the physical, mechanical and working properties of denture resins (1). Various activation modes of acrylic resin polymerization have been used involving chemical, heat, microwave energy and visible light (4). During curing of acrylic resin, polymerization is initiated by free radicals from the benzoyl peroxide. As polymerization proceeds, the reaction never reach 100% conversion i.e. conversion of monomer into polymer is not completed. The degree of conversion is the most important criterion that account for unreacted residual monomer levels. An exothermic heat is liberated during the polymerization reaction and it is generally believed that the supplied heat and the generated heat may exceed the boiling point of monomer before the process is completed (5). The vapor trapped would then give rise to internal porosity that result in high internal stress and adversely affecting the mechanical properties (6,7).

Some authors stated that the mechanical properties of denture base materials varied depending on the polymerization method (8-12) as well as the presence of porosity (4). Porosities are associated with decreased mechanical properties, poor aesthetic (13), potential harboring of organisms and retention of fluids (14). Taylor (15) stated that the presence of porosity in heat cured acrylic resin is dependent on the rate of polymerization, the efficiency of heat dissipation and the concentration of initiator. Acrylic resins cured by microwave have also demonstrated moderate to severe porosity (16).

Smith et al. (8) investigated hardness, transverse strength and modulus of elasticity of several resins cured using a water bath, microwave energy or by visible light. Microwave curing improved the modulus of elasticity of two resins, but had a little effect on the other resins. On the other hand, Peyton (17) reviewed the curing methods and concluded that when all factors were considered, it was doubtful that any of these methods had any real advantage over the water-bath method and the important factor for consideration was the careful control of the temperature during processing. Reitz et al. (18) confirmed that the porosity, hardness and transverse strength of microwave and water bath specimens were of no significant differences. Haydem (19) found that the flexural strength of acrylic resin cured by microwave energy did not absorb as much energy before fracture as the water-bath cured acrylic.

Microwave curing does not depend on thermal conductivity. The major advantages over conventional curing for the materials are that temperature rise occurs within the material and not in the oven in an extremely short period of time to cure the material (20). A denture base can be fully polymerized in only 3 minutes rather than the 9 hours normally used for water bath polymerization, less equipment is required, and is more economical (19,21). Microwave polymerized resins have exhibited acceptable physical and mechanical properties and they performed successfully in the clinical situation (9,22,23). These resins have demonstrated superior adaptation to master casts compared with heat polymerized prostheses (24).

Therefore, the aim of this study is to compare between the clinical efficiency of overdenture bases made of heat cured resin material when processed by hot water-bath or microwave irradiated and to relate the chemical, physical and mechanical properties to the clinical performance of these overdentures.

MATERIALS AND METHODS

This study was divided into two parts. The first part involved a clinical application; in-vivo study, while the second part involved laboratory testing; in vitro study.
Clinical work: Fourteen completely edentulous patients except for remaining two mandibular canines were selected from the out patient clinic of the Faculty of Oral and Dental medicine, Cairo University. All patients fall within the criteria of being free of any systemic disease that may lead to excessive bone resorption or abnormal tissue inflammation. Moreover, normal ridge relation, tongue size and TMJ condition, moderate ridge size and interarch space and intact mucosa were selected. The age range was from 40-65 years. Endodontic treatment was carried out for all canines, decapitation, dome shape preparation, post construction and copings were performed (Fig. 1).

The microwave oven used in this study was a Panasonic model NE – 541 (Mistubishi Electric trading Co LLC, Osaka, Japan). A rotating turn table ensured uniform absorption of microwaves during operation. The output power was controlled by adjustment of the variable power controller unit. The recommended polymerization method of curing acrylic was applied for 3 minutes at 550 W (26). A special dental FRP flask (Acron M C microwave flask, GC America Inc., USA) was employed.

Steps for construction of complete maxillary dentures were followed as usual for all patients. Meanwhile, mandibular overdentures were cured from the same heat cured acrylic resin material but with the two different modes according to the group type. Just before denture delivery, three lines were drawn vertically on the polished buccal and lingual surfaces of the mandibular overdenture passes by the tip of the canines, embrasure between the lower second premolar and first molar and just distal to the second molar bilaterally. These lines were continued on the fitting surfaces of the overdentures. At the canine region the continued lines passes through the concavity area related to the copings. A horizontal line was then drawn on the fitting surface parallel to the area of the crest of the ridge cutting the previous six vertical lines, (Fig. 2). A digital caliper was used to measure the thickness of the denture at the area of bisecting of the vertical and horizontal lines. A round bur was used to indent all the areas touched by the caliper on the polished surface to help in measuring the thickness at fixed points during the follow-up periods. These lines were drawn at the same regions at each follow-up periods. All mandibular dentures were weighed using an electronic balance after final adjustment and just before their delivery. The follow-up periods were carried out at the delivery time, after 6 months and after 12 months. During these periods, mandibular denture base thickness at the previous mentioned regions were assessed as well as their weights.

Patients were divided into two equal groups to receive heat cured acrylic resin materials (Acrostone, WHW plastic, England Packed by Anglo Egyptian Lab) cured by two different methods for each group; water-bath conventional method (Group I) and dry heat method using microwave energy (Group II).

For water-bath cured dentures, the conventional metal dental flasks (Brass flask, Kavo EWL, Germany) were used. Acrylic resins were processed in a water bath curing tank for 1½ hour at 74°C and another 1hour at 100°C. Then, the dental flasks were cooled to room temperature.
Laboratory work: A commercial brand of acrylic resin previously used to construct the overdenture prosthesis was also used to prepare the experimental specimens in this study. Twenty rectangular specimens were prepared according to ADA specification No. 12 in dimensions of 65 X 10 X 2.5 mm. They were assigned to two equal divisions in respect to the processing technique into heat cured and microwave cured, 10 specimens each. To determine the flexural characteristics of acrylic resin, the specimens of each division were classified into two groups according to the mode of loading. A group was subjected to static loading and the other group was subjected to cyclic loading simulating the clinical condition and then loaded up to failure under static loading.

**Specimens’ Preparation**

The powder/liquid ratio was mixed following the manufacturer’s instructions. For heat curing specimens, the dough was packed by conventional compression moulding technique. The previously employed curing cycle was applied. After deflasking, the specimens were finished using finishing stone to remove excess material and polished with wet silicon carbide paper of 400, 600 and 1000 grit successively. For microwave cured specimens, the dough was packed in a special flask appropriate for a microwave oven as previously mentioned then, finished and polished. The exact final dimensions for each specimen were ensured using the digital caliper. All the specimens were kept in water for 48 hrs at room temperature (23±1°C) prior to testing except samples that used for determination of degree of conversion.

**Testing:**

- **Determination of flexural characteristics**

4-point loading bending test was used to evaluate the flexural characteristics. Each specimen of statically load group was centrally positioned with a distance 50 mm between the supporting rods and 20 mm between the loading rods. The load was statically applied using a universal testing machine (LRX Lloyd Instruments, Ltd, Facham, UK) at cross head speed 1 mm/min until fracture occurred. Meanwhile, the samples of other group underwent preloading in a cyclic manner for 5000 cycles. Load profile was in the form of sine wave at a frequency rate of 1 Hz which is approximately the physiological chewing rate. The rate was used as equivalent to the average masticatory cycle of 0.8-1s. The load was cycled between a specified maximum load (20% of static failure load) and small but non-zero minimum load (3N) to stabilize the specimen and to avoid lateral dislocation of the loading tip during the test. Then, the samples were statically loaded as previously described till fracture. The load-deflection curve was obtained for each specimen and then transverse strength, flexural modulus of elasticity and maximum deflection were calculated as follow:

\[
\sigma = \frac{6 Pa}{2 wd^2}
\]

Where \(\sigma\) : transverse strength

\(P\) : Load applied till fracture (N)

\(a\) : Distance between the loading and supporting rods (15 mm).

\(W\) : Width of the specimen (10 mm).

\(d\) : Thickness of the specimens (2.5 mm).
and $E = \frac{Pa (4a^2 - 3L^2)}{48eI}$

Where $E$: modulus of elasticity.
$I$: moment of inertia $wd 3/12$
$P$: A selected load up to $PL$ on the linear portion of load deflection curve (N)
$e$: deformation corresponding to the selected load (mm)
$L$: distance between the supporting points (50 mm).

• **Degree of Conversion**

Other three solid samples of uncured, heat cured and microwave cured were analyzed using Fourier Transform Infrared Spectral Analysis (FTIR-spectrometer, Jasco-6300) to determine the amount of remaining double bond i.e. residual monomer content and hence the degree of conversion. The quantitative analysis of FT/IR spectra at absorbance units from 2000-1000 cm$^{-1}$, using the base line method was performed. The intensity of aliphatic double bond ($C = C$) appeared at $1636 \pm 5$ cm$^{-1}$ was divided by the chosen internal standard group $C = O$ at $1735 \pm 5$ cm$^{-1}$ or aromatic ($C = C$) at $1608 \pm 5$ cm$^{-1}$. The degree of conversion was calculated for heat cured and microwave cured according the following equations (29).

Remaining double bond =

\[
x \frac{\text{abs. of } C=C}{\text{abs. of } C=C \text{ of cured specimen}} \times 100
\]

\[
\text{abs. of } C=C / \text{abs. of } C=C \text{ of } \text{uncured specimen}
\]

DC$\% = 100 – \text{remaining double bond}$.

• **Hardness**

Vicker’s hardness number of heat and microwave cured samples was determined. The specimens were smoothened, flattened with parallel surfaces and loaded by the indentor of the hardness tester (Microhardness HMV, Shimadzu, Japan) with 10 gm load for 15 sec. duration. Five readings were considered for each group.

• **Porosity**

Using stereomicroscope, the porosity of the investigated resin either heat or microwave cured was observed and photographed at magnification X15 by CCD digital camera (DP 10, Olympus, Japan) attached to zoom microscope (Olympus SZ-PT, Japan).

• **Statistical Analysis**

All data of both in-vivo and in-vitro studies were gathered, tabulated and statistically analyzed. Statistical analysis was carried out using SAS program (30). Paired t-test (Procedure Means of SAS) was run to test the effect of time interval within each curing technique. Student t-test (Procedure TTEST of SAS) was run to compare the effect of curing technique on different measurements within each time interval.

![RESULTS](image)

**Alteration in weight**

Table (1) shows that the heat cured acrylic resin overdentures were significantly higher in weight at the time of denture delivery. As the time of usage elapsed, a significant decrease in weight was observed in heat cured acrylic overdenture bases. On contrast, microwave cured ones exhibited an increase in weight. This weight change was significant after 6 months but was insignificant after 12 months, (Fig. 3). Regarding the mode of curing, the level of significance was gradually decreased till it became insignificant after 12 months.
Changes in thickness
The mean values of twelve predetermined points on the overdentures’ surfaces exhibited that there was always a significant decrease in thickness either for heat or microwave cured at the time of delivery, 6 and 12 months. However, this change was insignificant regarding the mode of curing (Table 2, Fig. 4).

Flexural characteristics
Under static loading, heat cured acrylic resin showed higher significant values than microwave cured except for flexural modulus. While under cyclic loading all the flexural properties values were significantly reduced by about 1/4 (Table 3,4,5).

### TABLE (1): Descriptive statistics and test of significance for the effect of time and curing technique on denture weight

<table>
<thead>
<tr>
<th>Interval</th>
<th>Technique</th>
<th>Heat cured</th>
<th>Microwave cured</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>ls</td>
</tr>
<tr>
<td>At delivery</td>
<td>Heat cured</td>
<td>18.014</td>
<td>0.968</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Microwave cured</td>
<td>16.351</td>
<td>0.667</td>
<td>A</td>
</tr>
<tr>
<td>6 months</td>
<td>Heat cured</td>
<td>17.646</td>
<td>0.964</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>Microwave cured</td>
<td>16.578</td>
<td>0.667</td>
<td>B</td>
</tr>
<tr>
<td>12 months</td>
<td>Heat cured</td>
<td>17.309</td>
<td>0.932</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Microwave cured</td>
<td>16.982</td>
<td>0.873</td>
<td>B</td>
</tr>
</tbody>
</table>

S.D. = Standard deviation.  
NS = Insignificant (p>0.05).  
** = Significant at p≤0.01.
*** = Significant at p≤0.001.  
l.s = Least square means for repeated measurements.
Means with the same letter within each column are not significantly different at p≤0.05.

### TABLE (2) Descriptive statistics and test of significance for the effect of time and curing technique on denture thickness.

<table>
<thead>
<tr>
<th>Interval</th>
<th>Technique</th>
<th>Heat cured</th>
<th>Microwave cured</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>ls</td>
</tr>
<tr>
<td>At delivery</td>
<td>Heat cured</td>
<td>6.244</td>
<td>0.563</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Microwave cured</td>
<td>6.393</td>
<td>0.331</td>
<td>A</td>
</tr>
<tr>
<td>6 months</td>
<td>Heat cured</td>
<td>6.205</td>
<td>0.564</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>Microwave cured</td>
<td>6.130</td>
<td>0.363</td>
<td>B</td>
</tr>
<tr>
<td>12 months</td>
<td>Heat cured</td>
<td>6.174</td>
<td>0.565</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Microwave cured</td>
<td>5.826</td>
<td>0.365</td>
<td>C</td>
</tr>
</tbody>
</table>

S.D. = Standard deviation.  
NS = Insignificant (p>0.05).  
** = Significant at p≤0.01.
*** = Significant at p≤0.001.  
l.s = Least square means for repeated measurements.
Means with the same letter within each column are not significantly different at p≤0.05.
TABLE (3) Descriptive statistics and test of significance for the effect of time and curing technique on flexural strength (MPa).

<table>
<thead>
<tr>
<th>Interval</th>
<th>Technique</th>
<th>Heat cured</th>
<th>Microwave cured</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>Static load</td>
<td>120.570</td>
<td>9.955</td>
<td>90.675</td>
</tr>
<tr>
<td></td>
<td>Cyclic load</td>
<td>93.695</td>
<td>7.581</td>
<td>67.551</td>
</tr>
<tr>
<td>P1</td>
<td></td>
<td>**</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td>77.711</td>
<td></td>
<td>74.498</td>
</tr>
</tbody>
</table>

TABLE (4) Descriptive statistics and test of significance for the effect of time and curing technique on maximum deflection (mm).

<table>
<thead>
<tr>
<th>Interval</th>
<th>Technique</th>
<th>Heat cured</th>
<th>Microwave cured</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>Static load</td>
<td>3.856</td>
<td>0.137</td>
<td>3.112</td>
</tr>
<tr>
<td></td>
<td>Cyclic load</td>
<td>2.824</td>
<td>0.219</td>
<td>2.332</td>
</tr>
<tr>
<td>P1</td>
<td></td>
<td>***</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td>73.246</td>
<td></td>
<td>74.946</td>
</tr>
</tbody>
</table>

TABLE (5) Descriptive statistics and test of significance for the effect of time and curing technique on flexural modulus (MPa).

<table>
<thead>
<tr>
<th>Interval</th>
<th>Technique</th>
<th>Heat cured</th>
<th>Microwave cured</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>Static load</td>
<td>21310.324</td>
<td>1600.183</td>
<td>18713.706</td>
</tr>
<tr>
<td></td>
<td>Cyclic load</td>
<td>16775.849</td>
<td>1291.559</td>
<td>13688.474</td>
</tr>
<tr>
<td>P1</td>
<td></td>
<td>**</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td>78.722</td>
<td></td>
<td>73.147</td>
</tr>
</tbody>
</table>

S.D. = Standard deviation.

P1 = Probability level for the effect of load.

P2 = Probability level for the effect of curing technique.

NS = Insignificant (p>0.05).

* = Significant at p≤0.05.

** = Significant at p≤0.01.

*** = Significant at p≤0.001.
Degree of Conversion (DC)

Calculation of the remaining double bond of heat cured acrylic resin (0.4783) was much higher than that of microwave cured one (0.3279). The degree of conversion using microwave curing resulted in (67.21 % DC) but it was (52.17 % DC) for heat curing. i.e. (DC) seemed higher for microwave irradiation (Fig. 5).

Hardness

It was clear that there was a significant difference between heat cured acrylic resin which was recorded higher values (27.933 V.H.N.) than that of microwave cured one (21.567 V.H.N.) (Table 6).

<table>
<thead>
<tr>
<th></th>
<th>Heat cured</th>
<th>Microwave cured</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>27.933</td>
<td>21.567</td>
<td>**</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.159</td>
<td>0.907</td>
<td></td>
</tr>
</tbody>
</table>

S.D. = Standard deviation.  
P = Probability level for the effect of curing technique.  
NS = Insignificant (p>0.05).  
** = Significant at p≤0.01.

• Porosity

Figure (6-a) shows a black arrow pointing to the minimum porosities of heat cured sample. Meanwhile, figure (6-b) exhibits a widely spread porosities allover the microwave cured sample.
DISCUSSION

During the polymerization reaction of acrylic resin, varying amounts of free or unreacted monomer remain in the polymerized resin which are closely related to the curing condition (31,32). The level of residual monomer is detrimental to mechanical properties of the cured resins because of its plasticizing effect and the liability to form more porosity (31,33). However, the relationship between conditions of material preparations and the mechanical properties of the cured resin is insufficiently obvious (34).

It has been reported that a decrease in the residual monomer content could be achieved either by immersing conventional acrylic resin in hot water for diffusion and hydrolysis mechanisms would be involved (35) or using microwave irradiation in dry state (11,36). Hence, determination of the amount of the residual monomer within the samples of the present study was not kept in water.

Regarding the method of curing, hot water bath involves a period of boiling which is close to the boiling temperature of methyl methacrylate (MMA) which is 100.3°C. MMA could be changed into gas producing bubbles that may be trapped in a polymer matrix. This would be exaggerated by exothermic polymerization reaction resulting in increased voids i.e. porosity (10). Meanwhile, microwave curing has major advantages over conventional water bath technique which are the rapid rise in temperature accompanied with almost equal heating inside and outside of substance (19-21).

A microwave is an electromagnetic wave having 300,000 to 100 megacycles /second (MHz). Microwave ovens used in general cooking purposes produce microwaves of 2450 Hz i.e. the generated electrostatic field changes direction 2450 times per second. A material heated by microwaves has polarized molecules. The polarized molecule has a +ve charge end, while the other end has a –ve charge. In an electrostatic field which rapidly changes direction, polarized molecules are flipped over rapidly and generate heat due to molecular friction. Then, initiated radicals are able to react with monomer to start polymerization without the development of a high exothermic temperature. Therefore, microwave curing cycles involves the application of rapid heating which is independent of thermal conductivity (29). For the microwave cured acrylic resin, it has been demonstrated that the temperature developed during the reaction is not constant. It increases quickly at the beginning goes through a maximum and then decays, being able to reach peaks of the order of 150-200°C, depending on the working conditions (37).

Some authors reported that a high temperature is reached within the sample so that the polymerization reactions proceeds to a high conversion and consequently low level of residual monomer are detected (11,23,34,36,38,39). Other researchers suggested that the decrease in residual monomer by microwave heating might be due to the monomer volatilization (40). Becker et al. (16) proved the presence of moderate to severe porosity in acrylic resin cured by microwave. The present study proposed that the less detected residual monomer in microwave cured samples is due to the higher temperature produced during employing this technique. The evaporation of monomer left widely spread generalized porosity (Fig. 6-a & b).

Denture base resin should not deform under loading to permit proper distribution of forces to the underlying structures. The flexural modulus reflects the rigidity of the material and the distribution of stress within a specimen (41), which in turn is important for the integrity of the supporting ridge and tissues, along with the fitting accuracy of the dentures (41-43). On the other hand, greater flexibility of (PMMA) which is the ability to absorb more energy and better resistance for crack propagation may be referred to the plasticizing effect of the residual monomer (44).

In-vitro tests may not always reflect intra oral conditions but they are valuable and predictive for clinical performance (45). The flexural strength under static loading is specified by American Dental Association Specification (ADAS) No 12 (26), but actually the failure due to fatigue stress is the phenomenon of relevance from clinical standpoint and estimate the survival rate (46). Fracture initiation and propagation depend on the total local stress.
which include the externally applied load and residual stress within the specimens. These stresses should exceed a critical value to initiate and to propagate from the largest and most favorably oriented flaw (47). Therefore, the flaws induced during processing, mechanical grinding and polishing or due to intrinsic imperfection in the structure of the material might potentially reduce the strength of the material (48). It was reported that porosities develop an internal stresses and may act as initiating sites for cracks, thereby, contributing significantly to an acceleration of the degradation process of the denture (20,49).

Denture fracture due to flexural fatigue is a common problem because cyclic loading encourage degradation and shorten the clinical life (43). Cyclic loading was applied and then followed by static loading till fracture in an attempt to simulate clinical condition (44,50,51). The mechanical stresses were submitted to 5000 cycles flexural loading at frequency of 1 Hz (27). This frequency was selected to better simulate the rate of masticatory cycle which ranges from 0.5 to 2 Hz (50,52). In agreement with the present results, mechanical cyclic stresses showed detrimental effect on the acrylic resin (44). It was reported that repeated cyclic loading causes internal damage that results in eventual reduction in flexural strength (53). Accumulation of mechanical stresses reduced the load needed for catastrophic fracture. It has been proposed that internal porosities concentrated stresses in the resin matrix and contribute to the formation of microcracks under loading. Small flaws may have resulted in propagation of microcracks followed by coalescence of these cracks into growing fissure that weakened the denture base (54).

Ilbay et al. (25) reported that conventional acrylic resins used for the production of denture bases can also be used in the microwave method as followed in the present study. In accordance with the present results, Blagojevic and Murphy (11) and Jagger (55) reported that water-bath methods generally demonstrated superior properties. However, when the water bath-polymerized material was microwave processed, sever porosity was observed especially with an increased thickness (9,18,32).

On the other hand, Pfiffer et al. (56) showed no significant differences in transverse strength or hardness either heat or microwave curing was employed.

The clinical significance of wear can mainly attributed to impaired aesthetics, biological consequences of ingested worn materials and/or alteration in the stomatognathic system via changes in the vertical height between the upper and the lower jaws that may cause occlusal imbalance (57). Wear characteristics of a material are best determined through clinical trials because wear is a multifactorial mechanism involving the nature of wear substances, interface between sliding surfaces and lubrication (2). However, it should be pointed out that the hardness is in direct relation with the wear and it is often used as an index of wear resistance predicting its clinical longevity (58). In addition, the process of wear is associated with some physical parameters such as elastic modulus (59).

Obviously, the less significant weight loss and reduction in thickness of heat cured resin indicated its higher wear resistance. This is also documented by significantly higher hardness and flexural modulus and the least detected porosity. On contrast, the lower wear resistance showed by microwave-cured resin might be attributed to the same reasons. However, the increase in weight of microwave-cured overdentures during the follow-up periods might be interpret on the basis of saliva diffusion into the widely spread porosity observed in the microwave samples.

CONCLUSIONS

From the current study, the followings could be concluded:

- The higher degree of conversion of the microwave cured resins was not an indication for less amount of residual monomer, but it was due to the evaporation of the monomer leading to widely spread porosity.
- Microwave cured overdentures proved less wear resistance in spite of the increase in their weight.
- Processing of heat cured materials using microwave
curing mode necessitate further investigation to find out the best conditions to get porosity-free resin.

- Depending on the mode of curing, a close relationship is well established between the clinical performance and physical, chemical and mechanical properties of acrylic resin.

**REFERENCES**


