

## Research Report

## Various curing methods on transverse strength of acrylic resin

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**ABSTRACT**

**Background:** Acrylic resin were first used in dentistry for denture bases. The basic knowledge of acrylic resin curing method should be known by the dentist, because the improved performance of acrylic resin depends on the curing method. **Purpose:** This study was aimed to find the most effective curing method to produce the highest transverse strength of acrylic resin. **Method:** 18 rectangular acrylic resin samples with  $65 \times 10 \times 2.5$  mm size, divided into 3 groups based on difference curing method (Japan Industrial Standard, 24 hour in  $70^\circ$  C boiling water, and microwave). There were tested for their transverse strength. **Result:** The result of this study showed that conventional JIS method has the highest mean and deviation scores ( $60.85 \text{ MPa} \pm 2.10$ ) compared to those of 24 hour in  $70^\circ$  C boiling water method ( $55.77 \text{ MPa} \pm 2.09$ ) and of microwave method ( $56.60 \text{ MPa} \pm 1.45$ ). **Conclusion:** The highest transverse strength is derived from the conventional JIS curing method.

**Key words:** Acrylic resin, curing method, transverse strength

**ABSTRAK**

**Latar belakang:** Resin akrilik pertama kali dipakai dalam bidang kedokteran gigi untuk basis protesa gigi. Pengetahuan dasar berbagai metode polimerisasi resin akrilik harus diketahui oleh dokter gigi karena penyempurnaan penampilan resin akrilik tergantung dari berbagai metode polimerisasi. **Tujuan:** Penelitian ini bertujuan untuk mendapatkan metode polimerisasi yang menghasilkan resin akrilik dengan kekuatan transversal yang paling tinggi. **Metode:** 18 sampel dari resin akrilik berbentuk balok dengan ukuran  $65 \times 10 \times 2,5$  mm dibagi dalam 3 kelompok berdasarkan metode polimerisasi yang berbeda (JIS, 24 jam dalam air  $70^\circ$  C, dan microwave). **Hasil:** Hasil dari penelitian ini menunjukkan bahwa rerata dan angka deviasi metode polimerisasi JIS konvensional adalah yang terbesar kekuatan transversa ( $60,85 \text{ MPa} \pm 2,10$ ) dibandingkan dengan metode air  $70^\circ$  C 24 jam ( $55,77 \text{ MPa} \pm 2,09$ ) dan metode microwave ( $56,60 \text{ MPa} \pm 1,45$ ). **Kesimpulan:** Kekuatan transversa yang paling besar diperoleh dari metode polimerisasi JIS konvensional.

**Kata kunci:** Akrilik resin, metode polimerisasi, kekuatan transversa

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**INTRODUCTION**

There are many kinds of denture materials used for denture base, such as cellulose, phenol formaldehyde, resin vinyl, and vulcanite. However, those materials have many weaknesses, only acrylic resin which has been used since mid 1940 is still commonly used as denture base material. The reason is because this material meet certain

criteria such as: possessing natural character, high strength, stable dimension, good thermal conductivity, radiopaque, relatively not expensive, resistance from oral liquid or saliva, and bacterial growth, relatively easy to manipulate and clean.<sup>1-4</sup>

Acrylic resin used for removable denture base are available in powder and liquid. The powder consists of prepolymerized spheres derived from poly (methyl

methacrylate) and little benzoyl peroxide. Benzoyl peroxide is used as initiator in the early curing process. The liquid consists of nonpolymerized methyl methacrylate with little hydroquinone. Hydroquinone is used as inhibitor that can prevent both unexpected curing and setting derived from liquid during storing process. Furthermore, cross-linking material, glycol dimethacrylate, is also added into the liquid. In this case, glycol dimethacrylate is usually used as cross-linking material in poly (methyl methacrylate) acrylic resin denture base. Actually, glycol dimethacrylate is chemically and structurally the same as methyl methacrylate that can be combined with polymer bond growth.<sup>4</sup>

Acrylic resin curing method has developed due to the development of science, technology, and dental materials. The commonly curing method technique are evaporation, pressure dry-heating, dry air oven, infrared heating, induction technique, and microwave radiation. Each of those curing techniques has both advantages and disadvantage.

This acrylic resin curing methods for denture base can also be conducted by some techniques such as activated heating, compression molding, chemically activated, and light activated.<sup>4,5</sup> Many studies even showed that those curing techniques had the similar result as conventional curing method in evaluating transverse strength. Nevertheless, choosing the right curing method of acrylic resin that is still important in order to obtain acrylic resin suitable with physical and biocompatible characters of mouth cavity tissue.<sup>6</sup>

The acrylic resin with microwave curing method has actually been evaluated by many researchers and produces electromagnetic wave from electric generator known as magnetron. The microwave used has 2450 MHz and 12 cm wave length. Methyl methacrylate molecule facing the microwave electromagnetic area even can be changed its direction, about 5 billions/second. As a result, this condition causes many intermolecular collisions which can produce heat quickly. The curing method with microwave has some advantages such as saving time, producing cleaner result, and causing more similar dimension change than conventional curing method.<sup>7</sup>

As a denture base, acrylic resin must meet a mechanical character, which is about transverse strength. The denture base resistance during chewing process actually is analogous with that of test bar during receiving transverse load. In the USA, acrylic resin used as denture base should be evaluated for its transverse strength.<sup>8</sup>

The acrylic resin transverse strength actually depends on the curing method. Unfortunately, the curing method is influenced by certain factors such as temperature, mass, humidity, and environment like air or water is still discussed in many studies. Therefore, it is assumed that all kinds of curing methods with many kinds of variables cause different transverse strength. This study was aimed to analyze how

the different curing methods can influence the acrylic resin transverse strength. The significance of this study is to find the right acrylic resin curing method that can possibly produce the highest transverse strength.

## MATERIAL AND METHOD

Samples were made through the following procedures: first, master model made of brass was polished with vaseline, put in the middle of the denture flask filled with hard gypsum, and then left over in press until the gypsum was set. The denture flask was opened, and the master model was taken but from the gypsum. Brush the gypsum's surface with cold mould seal, and left until dry. Then mixing the powder and liquid of acrylic resin Bioresin (Shovu, Japan) based on the direction (10 grams powder: 4.5 ml liquid). After around 10 to 15 minutes, the mixing of the powder and liquid entering to the dough stage then it is ready for pouring to the flask (Yoshida, Japan). Before the denture flask was closed, the dough stage acrylic covered with plastic cellophane and pressed slowly with hydraulic press (Yoshida, Japan). After that, the denture flask was reopened and the over dough of acrylic resin was cut. Afterwards, it was closed again and pressed with 2200 psi pressure or 50 kg/cm<sup>2</sup>. Those procedures must be redone approximately two to three times. Then, it was moved into flask press, and left over for about 24 hours before curing process was conducted. Meanwhile, samples cured with oven microwave were made of 10 grams of powder: 4.3 ml of liquid (based on the direction from the producer) and cured in special denture flask for microwave.

The sample was divided into three groups. The first group, acrylic resin was cured with 70° Celsius boiling water for about 2 hours, which then was continued into 100° Celsius boiling water at the temperature of 100° Celsius for about 30 minutes (Japan Industrial Standard). The second group, acrylic resin was cured with a heating technique using 70° Celsius boiling water for about 24 hours. And, the third group, acrylic resin was cured with a heating technique using microwave oven (500 watt) for about 3 minutes. After all the curing process was conducted, those treatment groups were being left until they were cold. Each of those treatment groups consisted of six samples. Before being tested, those samples were immersed into distilled water at 37° Celsius for about 48 hours.<sup>9</sup>

The transverse strength testing method of samples was conducted with ADA no. 12 specification. First, samples were put in the palate center of Autograph tool, 50 mm between both buffers. Afterwards, the mass was reduced with cross head speed 1/10 mm/minute until the sample was broken. The result number from the test tool then was noted and analyzed with transverse strength formula.<sup>6</sup>

$$\sigma = \frac{3 P l}{2 b d^2}$$

Note:  $\sigma$  = Stress;  
 P = Load;  
 l = Length;  
 b = Width;  
 d = Thickness

The data were analysed by using Kolmogorov-Smirnov and LSD test for the difference of acrylic resin transverse strength and among those treatments respectively. And as for the different curing methods were analysed by One-Way ANOVA.

## RESULT

Mean and standard deviation of transverse strength of acrylic resin cured with different methods can be seen in Table 1.

**Table 1.** Mean and standard deviation of transverse strength of acrylic resin cured with different methods (MPa)

Treatment Group	Sample Number	Mean + Standard Deviation
Conventional JIS	6	60.85 ± 2.10
24 Hour Boiling Water	6	55.77 ± 2.09
Microwave	6	56.60 ± 1.45

Since the data result shown in Table 1 are homogenous and has normal distribution, the data then were tested with one sample Kolmogorov-Smirnov test. Furthermore, in order to find the difference of acrylic resin transverse strength processed by different curing method, One-Way ANOVA test was conducted. The result then showed that there was significant difference with score  $p < 0.05$ .

The result showed that acrylic resin cured with conventional JIS method had the highest mean score of transverse strength, meanwhile the cured with 24 hour boiling water method had the lowest mean score on the transverse strength. Moreover, in order to find the difference among those treatments, LSD test was conducted, as shown in Table 2.

**Table 2.** LSD test on transverse strength of acrylic resin cured with different methods (MPa)

Curing Method	Conventional JIS	24 Hour Boiling Water	Microwave
Conventional JIS		*	*
24 Hour Boiling Water			–
Microwave			

Note: \* : Significant, – : Not Significant

Finally, the result showed that there was significant difference between transverse strength of acrylic resin cured with conventional JIS method, compared to 24 hour in 70° C boiling water method, and microwave method. But, there was no significant difference between transverse strength of acrylic resin cured with 24 hour in 70° C boiling water method and microwave method.

## DISCUSSION

Poly (methyl methacrylate) used as denture base material actually can be produced through some curing methods. Thus, all of those curing methods evaluated in this study were aimed to find an easier technique, to reduce denture manufacturing time, and to achieve better acrylic resin character in the terms of hardness, porosities, and monomer discharge.<sup>5,10</sup> Due to the development of technology, curing method with water-bath and pressure is still used until now even though the use of microwave energy usually used in food industry has more advantages in dentistry since it can be used for acrylic resin curing process for denture base. The study on the activation system of acrylic resin with microwave energy was conducted not only for laboratorial needs, but also for clinical needs.<sup>10</sup>

In supporting the treatment success, the resistance of the acrylic resin denture base must be examined through the height of transverse strength. It means that in this examination, all of three pressure points working together on the denture base during chewing process will be compared.<sup>11</sup> In this study the acrylic resin transverse strength obtained through those three different kinds of curing process were examined. This study found that the acrylic resin transverse strength obtained from 24-hour boiling water curing method at the temperature of 70° Celsius, for instance, was lower than that obtained from the conventional JIS curing method and the microwave curing method (Table 1). This condition was caused by the fact that there was residual monomer which did not reacted since acrylic resin cannot reach the boiling point of monomer at the temperature of 100.8° Celsius. The residual monomer then will make acrylic resin more plastic because of the reduced transverse strength. As a result, the residual monomer will play potential tissue irritant which can make acrylic resin biocompatible.<sup>4</sup>

If the curing process were conducted in water-bath at low temperature for long period without increasing the temperature at the end of the process, the residual monomer will be three times as high as that with the increasing temperature at the end of the process. The residual monomer then can cause plasticizing effect, reduced acrylic resin strength, and cause many alteration because of pressure.<sup>12</sup> Similarly, another researcher also found that acrylic resin cured in water-bath for long period can cause acrylic resin to react as plasticizer, can reduced glass transition temperature

(tg), and can make its mechanical character decreased.<sup>13</sup>

Moreover, the cycle of curing process was successfully conducted for making the acrylic resin denture base in many sizes, forms, and depths when the curing process was conducted at 70° C for less than two hours and then continued at the temperature of 100° Celsius for more than one hour. The result obtained will show the strongest transverse strength.<sup>4</sup>

Acrylic resin curing method this microwave does not depend on thermal conduction, this is one of the advantage compared with the conventional boiling method. Some researchers have concluded that the physical character of acrylic resin cured with microwave was the same as cured with conventional curing method. Nevertheless, the acrylic resin denture base cured with microwave energy has more positive effects on the strength and resistance of the acrylic resin denture base since the microwave energy can potentially save time during the curing process of acrylic resin.<sup>10</sup> As a result, it is important to choose the right curing method in order to acquire high physical and mechanical characters of acrylic resin. Based on the result of this study, it can be concluded that different curing methods of acrylic resin can influence acrylic resin transverse strength. The strongest transverse strength was derived from Japan Industrial Standard curing method.

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