A comparison of three dimensional change in maxillary complete dentures between conventional heat polymerizing and microwave polymerizing techniques

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ABSTRACT

The purpose of this study was to measure and compare two different polymerizing processes, heat polymerizing (HP) and microwave polymerizing (MP), on the three dimensional changes in the fitting surface and artificial teeth of maxillary complete dentures. A three-dimensional coordinate measurement system was used to record distortion of the specimens. The distortion of the fitting surface was measured from the reference plane on the fitting side from which a coordinate system was set, and the movement of the artificial teeth and the distortion of the polished surface was measured from the reference plane of the artificial tooth side, from which a coordinate system was set. It was clearly showed that various distortions of denture specimens after polymerization process can be measured with this three-coordinate measuring machine. The study showed that the overall distortion of the fitting surface in HP specimens was shown to be larger than in MP ones.

Key words: *Maxillary complete denture, Three dimensional change, Microwave polymerizing*

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INTRODUCTION

It is now widely recognized that natural teeth can be retained for life. The number of people retaining their natural teeth is growing, and the absolute number of persons over the age of 65 is increasing rapidly. However, the actual number of patients requiring complete dentures remains almost constant.[1] With the increasing percentage of population over the age of 65, the number of individuals with dementia will also grow. It constitutes a serious problem. However, a two-year follow-up study in a dementia ward in a mental hospital suggested that denture wearing has an effect on some activities of daily life.[2]

The dimensional accuracy of heat-cured denture resin was evaluated by comparing the distance between reference points in the deflasked specimen and the master model after the deflasked specimen was adapted to the master model,[3–5] or by comparing the distance between marked points in the deflasked specimen and the master model.[6–8] Other studies examined changes in the position of teeth in complete dentures.[9,10] Several papers have investigated the accuracy of three-dimensional coordinate measurement on the mucosal surface of dentures.[11–14]

In this study, the three dimensional change in the fitting surface and artificial teeth of maxillary complete dentures was measured and compared for two different polymerizing processes.

MATERIALS AND METHODS

Specimen preparation

To fabricate the working cast, a die of an edentulous maxillary arch (402U, Nisshin, Kyoto, Japan) was duplicated using silicone elastomer (GC, Tokyo, Japan). A master cast was made of dental stone (New Fujirock, GC, Tokyo, Japan) according to the manufacturer's recommendation. The measuring points on the master cast consisted of 12 points on the alveolar ridge related to each second molar and first premolar tooth and the midway point of the incisor teeth, and on the denture flange in the molar, premolar and anterior regions. In addition, we set three datum-points (reference points) to set the coordinate system in the palate. The measuring points were set with steel balls with a diameter of 2 mm, and the datum-points were steel balls with a diameter of 4 mm set on the model using self-curing resin. The master cast was duplicated and six master casts were made. A wax denture was made on one of the six working casts. One thickness (approximately 1.5 mm) of base plate wax (paraffin wax, GC, Tokyo, Japan) was adapted to the working cast and the artificial teeth (GC Duradent: anterior teeth C3, posterior teeth 30M, GC, Tokyo, Japan) were positioned in the usual manner. The core of the wax denture was made with dental stone and silicon impression material. After the working casts were measured, three steel balls 4 mm in diameter were set in the appointed positions as datum-points, and the wax dentures were made from the core. The measurement points were prepared on mesiolingual cusps of the right and left second molar tooth, the lingual cusps of the right and left first premolar tooth, and the mesial edge of the right incisor with a diamond point 1.8 mm in diameter (Diamond Point FG regular 340, Shofu, Kyoto, Japan).

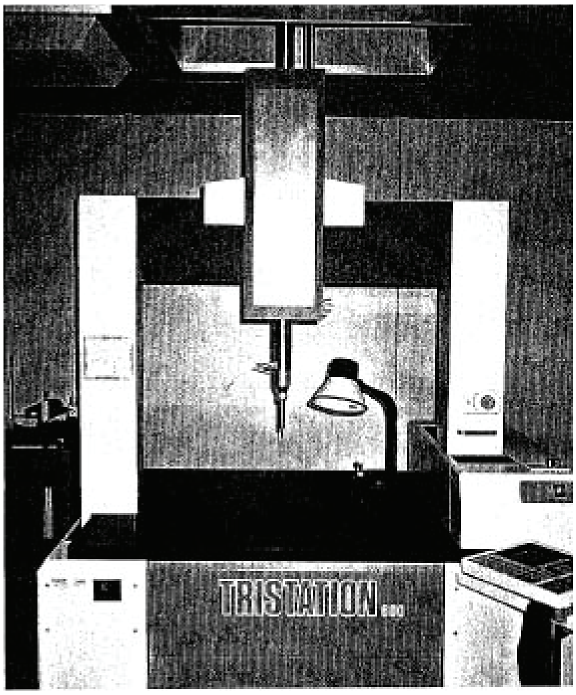

Figure 1. The measuring machine used in this study (Tristation).

Polymerizing process

Two acrylic resins were used: Bio resin (Shofu, Kyoto, Japan) and Acron MC (GC, Tokyo, Japan) (Table 1). The Bio resin was mixed using 4.5 ml liquid to 10 g powder. The polymerizing process followed Japan Industrial Standard's (JIS) recommendation: an initial 90 minutes at 70 °C followed by 30 minutes at 100 °C (HP). The Acron MC was mixed using 4.3 ml liquid to 10 g powder. Specimens (MP) were processed for 3 minutes in a 500 W microwave oven (EM-M 535 T, Sanyo Electric, Osaka, Japan). Ten standardized denture specimens were fabricated: five using the conventional technique and five using the microwave technique. After polymerization, flasks were allowed to cool at room temperature for over 12 hours and deflasked.

Measuring method

Dimensional change was measured using a three-coordinate measuring machine (Tristation, TST 600-FC, Nikon Corp., Tokyo, Japan) graduated to an accuracy of 0.5 μm or less at 20 °C with a ball stylus measuring 0.5 mm in diameter (Figure 1).

A device made of plaster was put on the surveyor to provide fixation for the denture specimen when measuring by probe. Two types of fixation devices were prepared to allow measurements to be taken on the fitting surface and the occlusal side. The measurements were performed on working casts, wax dentures, and dentures after deflasking.

The probe interfaces with the computer to measure and record point locations in the x-, y-, and z-axes. Such

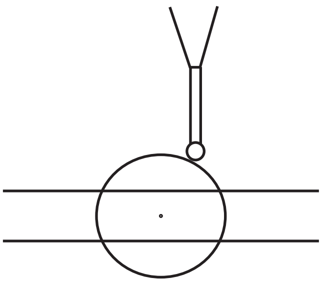

Figure 2. Probing to detect reference point.

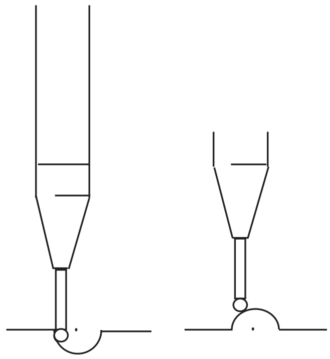

Figure 3. Probing to detect measuring point.

Tabel 1. Materials used in this study

Processing method	Brand	Polymerizing cycle	Processing technique	Powder-to-liquid ratio (g/ml)	Manufacturer
Heat polymerizing (HP)	Bio resin	90 min at 70 °C 30 min at 100 °C	Hot water bath	10/4.5	Shofu Kyoto, Japan
Microwave polymerizing (MP)	Acron MC	3 min	Microwave 500W	10/4.3	GC Tokyo, Japan

a digitizing system requires a reference plane to standardize the three-dimensional measurements. In this study, the reference plane (x-y plane) was established as the plane linking the centers of the hemispherical elevations 4 mm in diameter placed at three points on the palate of the denture, on both the polishing side and the fitting side. The center was measured by probing the surface of each reference hemisphere ten times (Figure 2).

The measurement points consisted of 12 points on the cast and five points on the artificial teeth in the form of hemispherical hollows 2 mm in diameter. Each measurement point was measured three times, and the average value was used (Figure 3).

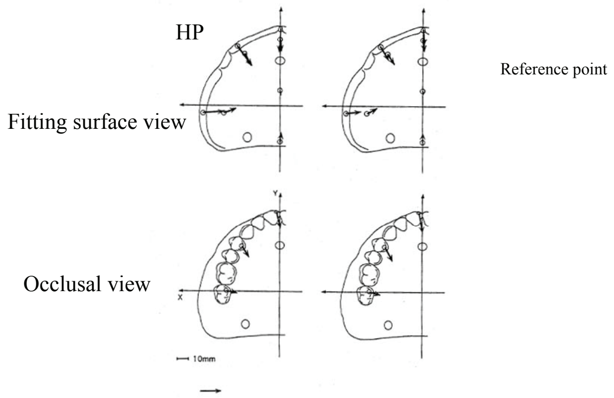

Figure 4. Dimensional change after polymerization. The cross point of the axes indicates the center of the three reference points. Arrows indicate the direction of the change.

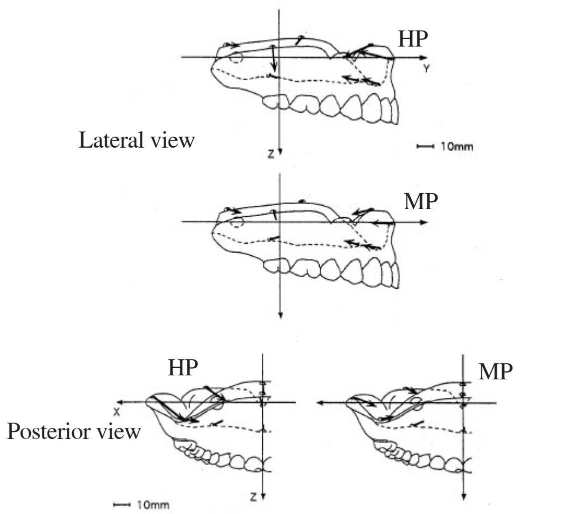

Figure 5. Dimensional change after polymerization. The cross point of the axes indicates the center of the three reference points.

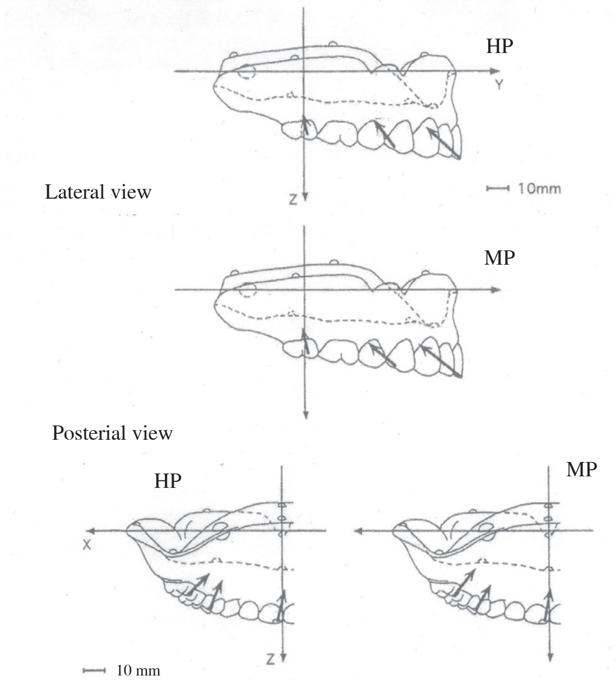

Figure 6. Dimensional change after polymerization (artificial teeth). The cross point of the axes indicates the center of the three reference points.

RESULTS

Measurement accuracy

The measurement accuracy of each method was determined by calculating the square root of the standard deviation of each measured value.[15] The measurement accuracy on the stone casts was X-axis (5.6 μm), Y-axis (2.9 μm) and Z-axis (4.7 μm). On artificial teeth, the measurement accuracy was X-axis (5.6 μm), Y-axis (7 μm) and Z-axis (7.5 μm). The official measurement accuracy of the three-dimensional coordinate measuring machine was 5 μm, so the above accuracies were considered to be adequate.

Dimesional changes

Figure 4, 5, and 6 show the dimensional changes after each polymerizing process for both the fitting surface and the polishing surface. The cross point of the x and y axes of the reference plane is the center of the three reference points, and this point is the reference point for measurement in this study. The distortion of the fitting surface of the alveolar ridge in both HP and MP occurred in a horizontal direction towards the center of the palate. The fitting surface of the alveolar ridge of the posterior section of MP moved slightly towards the alveolar mucosa compared to HP. The amount of distortion at the fitting surface of the alveolar ridge was similar in both polymerizing methods (Figure 7). The distortion of flanges in both polymerizing

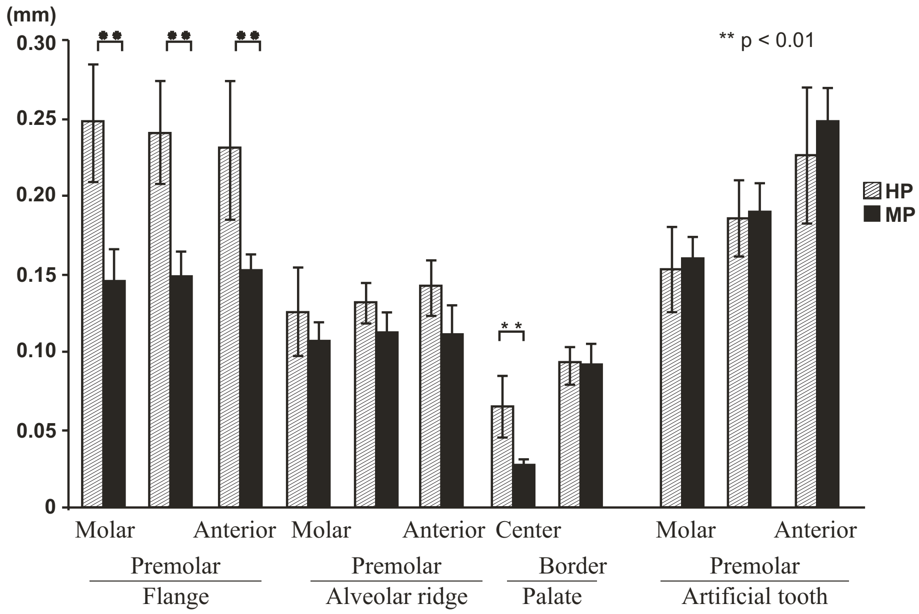

Figure 7. Amount of distortion.

methods involved horizontal movement towards the center of the palate. The center and posterior border of the palate in both polymerizing methods were displaced in the original direction, and the palate center in HP was distorted to a greater degree than in MP (Figure 7). The artificial teeth moved slightly backwards from the origin in a horizontal direction in specimens polymerized by both methods; however, the artificial teeth polymerized by MP tended to move more than those polymerized by HP (Figure7).

The dimensional changes in the lateral and posterior views are shown in Figure 5 and 6. In the vertical direction, the anterior flange of the HP denture moved slightly, but the distortion of the flange was larger in the premolar region, and larger again in the molar region. In the MP denture, the vertical distortion was similar over the entire surface of the denture, and there was less distortion than in the HP denture (Figure 7).

DISCUSSION

We revealed the influence of thickness on the linear dimensional change of a denture base resin.[16] Developments in coordinated measuring systems, such as the Nikon 6000 (Figure 1), which was originally developed for applications in engineering, would appear to have considerable potential in studies on the dimensional accuracy and stability of prosthetic appliances. This system offers the advantages of three dimensional measuring linked with sophisticated computer technology.

In this study, denture specimens were not polished because the generation of excessive heat during finishing and polishing with burs and arbor bands may have contributed to stress release.[17–20]

A three-dimensional coordinate measurement system that situates a coordinate system on the denture specimens was used to record distortion of the specimens in this study. The coordinate system used a hemisphere form of datum-point. The distortion of the fitting surface was measured from the reference plane on the fitting side from which a coordinate system was set, and the movement of the artificial teeth and the distortion of the polishing surface were measured from the reference plane of the artificial tooth side, from which a coordinate system was set. The coordinate system of the fitting surface and the artificial teeth and polishing surface is not the same because of the measuring error created by the 4 mm standard balls. However, it is considered acceptable for comparison of the measured values between both surfaces. The vertical movement of the artificial teeth was measured using the standard plane set by the polishing surface.

Takahashi[11] recorded the distortion in the vector of the fitting surface of specimens made by the similar model used in this study. This study used a different measurement method, but there was little difference between them in the measurements on the fitting surface. Some studies found that the distortion of the fitting surface and the movement of the artificial teeth were indicated by the vector. Our study found that the overall distortion of the denture occurred as a displacement into the center of the denture after polymerization. The fitting surface in the HP denture showed more vertical displacement after polymerization than the MP denture and this tendency was most sifnificant in the flange. In the HP denture, the heat is conducted from the surface to the center of the flask, so this process might be the cause of the vertical distortion of the flange in denture specimens. The amount of movement of the fitting surface in the MP denture was smaller than that in the HP denture, especially in the flange. These results are consistent with several reports.[21,22] Nelson *et al.*[23] also found that the amount of movement of artificial teeth in MP specimens tended to be greater than in HP specimens. Our results might be similar to their results. This may be due to the difference of thermal conductivity of both polymerizing process because microwave energy is independent of thermal conductivity.

This study clearly showed that various distortions of denture specimens after polymerization can be measured with a three-coordinate measuring machine. The overall distortion of the fitting surface in HP specimens was shown to be larger than in MP specimens. A more complete understanding of the distortion caused by different curing methods might improve the outcome for patients requiring complete dentures by shortening the adjustment period.

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REFERENCES

1. Budtz-Jorgensen E. Treatment of edentulous patients. In: Prosthodontics for the elderly: Diagnosis and treatment. Chicago, IL: Quintessence; 1999, p. 203–28.
2. Sadamori S, Hamada T, Nakai N, Nishimura M. Influence of denture wearing on the stage of dementia and ADL of the elderly with severe dementia - a two-year follow-up study in a dementia ward in a mental hospital. Dentistry in Japan 2004; 40:163–7.
3. Kraut RA. A comparison of denture base accuracy. J Am Dent Assoc 1971; 83:352–7.
4. Laughlin GA, Eric JD, Glaros AG, Young L, Moore DJ. A comparison of palatal adaptation in acrylic resin denture bases using conventional and anchored polymerization techniques. J Prosthodont 2001; 10:204–11.
5. Consani RL, Domitti SS, Rizzatti Barbosa CM, Consani S. Effect of commercial acrylic resins on dimensional accuracy of the maxillary denture base. Brazilian Dent J 2002; 13:57–60.
6. Huggett R, Brooks SC, Bates JF. The effect of different curing cycles on the dimensional accuracy of acrylic resin denture base materials. Quint Dent Tech 1984; 8:81–5.
7. Jagger RG. Dimensional accuracy of thermoformed poly-methyl methacrylate. J Prosthet Dent 1996; 76:573–5.
8. Wong DM, Cheng LY, Chow TW, Clark RK. Effect of processing method on the dimensional accuracy and water sorption of acrylic resin dentures. J Prosthet Dent 1999; 81:300–4.
9. Mainieri ET, Boone ME, Potter RH. Tooth movement and dimensional change of denture base materials using two investment methods. J Prosthet Dent 1980; 44:368–73.
10. Garfunkel E. Evaluation of dimensional changes in complete dentures processed by injection-pressing and the pack and press technique. J Prosthet Dent 1983; 50:757–61.
11. Takahashi Y. Three dimensional changes of the denture base of the complete denture following polymerization. J Jpn Prosthodont 1990; 34:136–48.
12. Turck MD, Lang BR, Wilcox DE, Meiers JC. Direct measurement of dimensional accuracy with three denture-processing techniques. Int J Prosthodont 1992; 5:367–72.
13. Jackson AD, Lang BR, Wang RF. The influence of teeth on denture base processing accuracy. Int J Prosthodont 1993; 6:333–40.
14. Nogueira S, Ogle R, Davis EL. Comparison of accuracy between compression- and injection-molded complete dentures. J Prosthet Dent 1999; 82:291–300.
15 Takahashi Y, Takeuchi T, Sawamura N, Inanaga A, Habu T. Improved denture measuring method using the three dimensional measurement system. J Jpn Prosthodont 1988; 32: 1358–1362.
16. Sadamori S, Ishii T, Hamada T. Influence of thickness on the linear dimensional change, warpage, and water uptake of a denture base resin. Int J Prosthodont 1997; 10:35–43.
17. Woelfel JB, Paffenbarger GC. Dimensional changes occurring in artificial dentures. Int Dent J 1959; 9:451–60.
18. Woelfel JB, Paffenbarger GC, Sweeney WT. Dimensional changes occurring in dentures during processing. J Am Dent Assoc 1960; 61:413–30.
19. Woelfel JB, Paffenbarger GC, Sweeney WT. Clinical evaluation of complete dentures made of eleven different types of denture base materials. J Am Dent Assoc 1965; 70:1170–88.
20. Lorton L, Phillips RW. Heat-released stress in acrylic dentures. J Prosthet Dent 1979; 42:23–6.
21. Takamata T, Setcos JC, Phillips RW, Boone ME. Adaptation of acrylic resin dentures as influenced by the activation mode of polymerization. J Am Dent Assoc 1989; 119:271–6.
22. Wallance PW, Graser GN, Myers ML, Proskin HM. Dimensional accuracy of denture resin cured by microwave energy. J Prosthet Dent 1991; 66:403–9.
23. Nelson MW, Kotwal KR, Sevedge SR. Changes in vertical dimension of occlusion in conventional and microwave processing of complete dentures. J Prosthet Dent 1991; 65:306–8.