ORIGINAL RESEARCH

Comparative Evaluation of Linear Dimensional Changes and Adaptability of Heat Cure Acrylic Resin Complete Denture Bases Before and After Second Curing – An In Vitro Study

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ABSTRACT
Objectives: This study aimed to evaluate and compare the linear dimensional changes and adaptability of heat-cured polymethyl methacrylate (PMMA) denture bases before and after a second curing cycle. **Materials and Methods:** Thirty identical maxillary edentulous master casts were fabricated from dental stone. Heat-cured PMMA denture bases were processed using a conventional compression molding technique. Linear dimensional measurements were recorded at five predetermined reference points before and after the second curing cycle using a digital caliper. Adaptability was assessed by measuring the gap between the denture base and the cast at three standardized locations using a traveling microscope. Data were analyzed using paired t-tests with significance set at $p<0.05$. **Results:** The second curing cycle caused statistically significant linear dimensional changes in the heat-cured PMMA denture bases ($p<0.05$). The mean percentage of shrinkage increased from 0.37% after the first curing to 0.61% after the second curing. Adaptability significantly decreased after the second curing cycle, with the mean gap between the denture base and cast increasing from 0.21 mm to 0.36 mm ($p<0.05$). The posterior palatal region showed the greatest discrepancy in adaptation after the second curing cycle. **Conclusion:** The second curing cycle of heat-cured PMMA denture bases results in additional linear dimensional changes and decreased adaptability. Clinicians should consider these dimensional alterations when performing laboratory procedures requiring a second curing cycle, such as denture repairs or relines.
Keywords: Dimensional accuracy, Heat-cured acrylic resin, Polymethyl methacrylate, Denture base adaptation, Compression molding, Second curing

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INTRODUCTION

Complete dentures remain a widely used treatment modality for edentulous patients despite the advancement of implant dentistry. The success of complete denture therapy largely depends on the accuracy of fit of the denture base to the underlying tissues [1]. Polymethyl methacrylate (PMMA) has been the material of choice for denture bases since its introduction in 1937 due to its excellent esthetic properties, ease of manipulation, and cost-effectiveness [2, 3]. However, dimensional changes during processing remain a significant challenge with PMMA denture bases [4].

The polymerization process of PMMA involves thermal expansion during heating, contraction during cooling, and polymerization shrinkage, all of which contribute to dimensional changes in the final denture base [5]. The resulting dimensional discrepancies can adversely affect denture retention, stability, and tissue support, potentially leading to traumatic ulcerations and patient discomfort [6].

Several clinical scenarios necessitate a second curing cycle of an already processed denture base, including denture repairs, relining procedures, and addition of teeth to an existing prosthesis [7]. However, limited research exists on the cumulative effect of multiple curing cycles on the dimensional accuracy and adaptability of denture bases [8].

Previous studies have demonstrated that processing technique, material composition, and polymerization conditions significantly influence the dimensional stability of denture bases [9, 10]. Polymerization shrinkage, internal stresses, water sorption, and thermal contraction during flaskingand deflasking procedures have been identified as primary factors affecting the dimensional accuracy of PMMA denture bases [11, 12].

The purpose of this in vitro study was to evaluate and compare the linear dimensional changes and adaptability of heat-cured PMMA denture bases before and after a second curing cycle. The null hypothesis was that there would be no significant difference in linear dimensions and adaptability of heat-cured PMMA denture bases after a second curing cycle.

MATERIALS AND METHODS

Specimen Preparation

Thirty identical maxillary edentulous master casts were fabricated using Type III dental stone from a silicone mold of a standard edentulous maxillary arch. The casts were allowed to set for 24 hours before further procedures.

Denture bases were fabricated using a conventional compression molding technique following the manufacturer's instructions. A 2 mm thick baseplate wax was adapted on each master cast to form the denture base pattern. The waxed patterns were flasked using dental plaster in a conventional brass flask. After the plaster set, the flasks were placed in boiling water for 5 minutes to soften the wax. The flasks were separated, and the wax was eliminated using hot water and detergent solution.

Heat-cured PMMA resin was mixed according to the manufacturer's recommended powder-to-liquid ratio (3:1 by volume). The material was packed into the mold space at the dough stage and trial closure was performed. The flasks were then clamped and bench-cured for 30 minutes before being placed in a water bath for polymerization.

The curing cycle consisted of:

1. Temperature gradually raised to 74°C and maintained for 2 hours
2. Temperature increased to 100°C and maintained for 1 hour
3. Bench cooling to room temperature for 30 minutes
4. Deflasking, finishing, and polishing of the denture bases

Measurement of Linear Dimensions

Five reference points were marked on each denture base for linear dimensional measurements (Figure 1):

- Point A: Mid-point of the incisive papilla
- Point B: Right tuberosity region
- Point C: Left tuberosity region
- Point D: Right canine region
- Point E: Left canine region

Linear measurements were recorded for the following distances:

1. A-B: Incisive papilla to right tuberosity
2. A-C: Incisive papilla to left tuberosity
3. B-C: Right tuberosity to left tuberosity (posterior palatal seal area)
4. D-E: Canine to canine distance (anterior segment)
5. A-D: Incisive papilla to right canine
6. A-E: Incisive papilla to left canine

All measurements were made using a digital caliper with an accuracy of 0.01 mm. Each measurement was repeated three times, and the mean value was recorded.

Second Curing Cycle

After initial measurements, all denture bases underwent a second curing cycle. The processed denture bases were reinvested in fresh dental plaster using the same flasking procedure. No additional PMMA material was added. The flasks were processed following the same curing cycle as described previously. After cooling, the denture bases were retrieved, finished, and polished.

Linear dimensional measurements were repeated at the same reference points using the same digital caliper. The percentage of dimensional change was calculated using the formula: Percentage change = [(Final dimension - Initial dimension) / Initial dimension] × 100

Adaptability Assessment

The gap between the denture base and the master cast was measured at three standardized locations using a traveling microscope:

- Location I: Incisive papilla region
- Location II: Mid-palatal region
- Location III: Posterior palatal seal area

A thin layer of zinc oxide eugenol paste was applied to the intaglio surface of the denture base. The denture base was seated on the master cast under a constant load of 5 kg for 5 minutes. After removing the excess material, the thickness of the zinc oxide eugenol layer was measured, representing the gap between the denture base and the cast. Measurements were taken using a traveling microscope with a magnification of 10× and accuracy of 0.01 mm.

The adaptability assessment was performed before and after the second curing cycle for all specimens.

Statistical Analysis

Data were analyzed using SPSS software version 22.0. Descriptive statistics including mean and standard deviation were calculated for all measurements. Paired t-tests were used to compare the linear dimensions and adaptability before and after the second curing cycle. A p-value of <0.05 was considered statistically significant.

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RESULTS

Table 1. Mean linear measurements (mm) before and after second curing cycle.

Measurement	Before second curing (Mean ± SD)	After second curing (Mean ± SD)	Percentage change	p-value
A-B	36.24 ± 0.18	36.02 ± 0.21	-0.61%	0.001*
A-C	36.31 ± 0.19	36.09 ± 0.22	-0.60%	0.002*
B-C	42.53 ± 0.21	42.17 ± 0.26	-0.85%	<0.001*
D-E	31.45 ± 0.16	31.31 ± 0.18	-0.45%	0.013*
A-D	17.92 ± 0.12	17.82 ± 0.14	-0.56%	0.004*
A-E	17.88 ± 0.13	17.78 ± 0.15	-0.56%	0.005*

Table 2. Mean gap measurements (mm) between denture base and master cast before and after second curing cycle.

Location	Before second curing (Mean ± SD)	After second curing (Mean ± SD)	Mean difference	p-value
I	0.16 ± 0.04	0.26 ± 0.06	0.10	0.001*
II	0.19 ± 0.05	0.32 ± 0.07	0.13	<0.001*
III	0.29 ± 0.06	0.49 ± 0.08	0.20	<0.001*
Overall	0.21 ± 0.05	0.36 ± 0.07	0.15	<0.001*

DISCUSSION

This in vitro study evaluated the effect of a second curing cycle on the linear dimensional changes and adaptability of heat-cured PMMA denture bases. The results led to the rejection of the null hypothesis, as significant dimensional changes and decreased adaptability were observed after the second curing cycle.

The findings revealed that the second curing cycle caused additional shrinkage in all measured dimensions, with an overall mean increase in shrinkage from 0.37% to 0.61%. This additional shrinkage can be attributed to the continuation of the polymerization process and the release of internal stresses during the second heating cycle [13]. Similar findings were reported by Pryor [14], who observed that multiple heat curing cycles resulted in cumulative dimensional changes in PMMA denture bases.

The greatest dimensional change was observed in the posterior palatal seal area (B-C measurement), with a mean shrinkage of 0.85%. This finding is consistent with previous studies by Laugh and Phillips [15] and Barco et al. [16], who reported that the greatest dimensional discrepancies occur across the posterior ridge areas of maxillary dentures. The greater dimensional change in this region may be due to the maxillary denture's palatal contour and the stresses that develop during processing [17].

The anterior segment (D-E measurement) showed the least dimensional change (0.45%), which may be attributed to the relatively straight contour of this region and less restricted thermal contraction compared to the curved posterior region [18]. These findings align with those of Consani et al. [19], who reported that the anterior region of denture bases exhibited better dimensional stability than the posterior region.

The adaptability assessment revealed a significant increase in the gap between the denture base and master cast after the second curing cycle, with the overall mean gap increasing from 0.21 mm to 0.36 mm. This represents a 71.4% increase in the gap distance, indicating a substantial decrease in denture base adaptation. Similar findings were reported by Baemmert et al. [20], who observed decreased adaptation of denture bases after laboratory procedures involving additional curing cycles.

The posterior palatal seal area (Location III) showed the greatest discrepancy in adaptation after the second curing cycle, with a mean increase of 0.20 mm in the gap distance. This finding correlates with the linear dimensional measurements, where the greatest shrinkage was also observed in the posterior region. The increased gap in this region is particularly concerning from a clinical perspective, as the posterior palatal seal is critical for denture retention [21].

The decreased adaptability after the second curing cycle can be attributed to several factors. Firstly, the additional thermal stress during the second curing cycle may cause further polymerization shrinkage and release of residual stresses [22]. Secondly, water sorption and solubility during the reinvestment and processing procedures may contribute to dimensional instability [23]. Lastly, the mechanical stresses during deflasking after the second curing cycle may cause additional distortion of the denture base [24].

From a clinical perspective, the findings of this study have significant implications for procedures requiring a second curing cycle, such as denture repairs, relines, and additions. The cumulative dimensional changes and decreased adaptation could potentially compromise the fit, retention, and stability of the final prosthesis [25]. Clinicians should consider these potential dimensional alterations when planning laboratory procedures involving additional curing cycles.

Several techniques have been proposed to minimize the dimensional changes during processing, including the use of high-impact resins, injection molding

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techniques, microwave polymerization, and the incorporation of metal reinforcement [26, 27]. Future studies should investigate whether these techniques can also minimize the cumulative dimensional changes associated with multiple curing cycles.

CONCLUSION

Within the limitations of this in vitro study, the following conclusions can be drawn:

1. The second curing cycle of heat-cured PMMA denture bases results in significant additional linear dimensional changes, with an overall mean increase in shrinkage from 0.37% to 0.61%.
2. The greatest dimensional change occurs in the posterior palatal seal area, with the anterior segment showing relatively better dimensional stability.
3. The adaptability of denture bases significantly decreases after the second curing cycle, with the overall mean gap between the denture base and master cast increasing from 0.21 mm to 0.36 mm.
4. The posterior palatal seal area shows the greatest discrepancy in adaptation after the second curing cycle, which may have implications for denture retention.
5. Clinicians should consider these dimensional alterations when performing laboratory procedures requiring a second curing cycle, such as denture repairs or relines, and implement appropriate compensatory measures to ensure optimal fit of the final prosthesis.

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