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Evaluation of linear dimensional changes in the acrylic denture base subjected to first and second curing: An *in vitro* study

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Abstract
Aim: To evaluate the linear dimensional changes of the denture bases when subjected to two curing cycles (First cure and second cure).
Objectives: To evaluate the changes in the linear measurements after first and second cure of the denture base.
Results: Significant differences were observed in the dimension changes between the first and second curing suggest that the curing process significantly affects the dimensions of PMMA denture bases. These findings highlight the importance of consistent and controlled curing processes to ensure dimensional stability in dental prosthetics. All comparisons (AB vs AB1, BC vs BC1, CD vs CD1, AD vs AD1) indicate significant differences in dimensions between the first and second curing. This conclusion is supported by both the paired t-test (For normally distributed data) and the Wilcoxon signed-rank test (for non-normally distributed data like AB1).
Conclusion: Within the limitation of this study, linear dimensional changes of acrylic resin after the first and second curing are observed. This has a significant clinical importance. When evaluated with variable parameters like retention, stability and support in a clinical scenario, the results will be more credible.

Keywords: Linear dimensional changes, Acrylic denture base, PMMA (Poly methyl methacrylate)

Introduction
Poly methyl methacrylate (PMMA) resin is a cornerstone material in the field of prosthodontics. PMMA has excellent biological and physical properties making it suitable for its various applications in biomedical field. Accurate fitting of the denture base is essential to ensure patients comfort and function. Any significant dimensional changes during the processing can lead to poor adaptation to the oral tissues compromising the denture's fit. Despite its widespread use in prosthodontics for complete denture fabrication, removable partial denture, obturators, stents fabrication, cranial implants [1, 2]. PMMA has its limitations such as polymerization shrinkage, thermal distortion and susceptibility to fracture under stress. Dimensional stability is a key factor in the performance of PMMA denture bases. Controlling the factors that influence dimensional stability, such as polymerization shrinkage, thermal expansion, and water absorption is critical for successful prosthodontic outcomes.

Aim
To evaluate the linear dimensional changes of the denture bases when subjected to two curing cycles (First cure and second cure).

Objectives
To evaluate the changes in the linear measurements after first and second cure of the denture base.

Materials and Methods
The completely edentulous mould was used for making the completely edentulous cast using type III Gypsum products (Kalabhai Kalstone®). Four grooves measuring 2 mm in depth where marked using the round bur were engraved in the casts for index marks (The letters A,

B, C, and D). Two layers of wax (Cavex®, Netherlands) were placed on edentulous stone cast and flasked. To process this denture bases, type III dental stone (Kalabhai Kalstone®) was used before dewaxing. The acrylic resin was mixed and packed in the flask. Conventional PMMA specimens were then fabricated using a conventional flasking and pressure-pack technique.

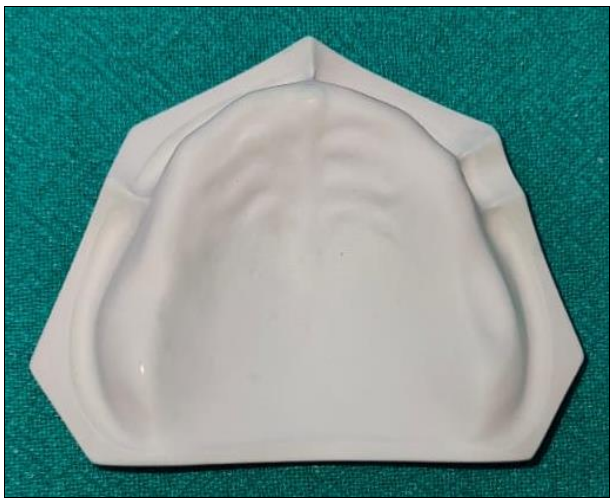

Fig 1: Edentulous Stone model

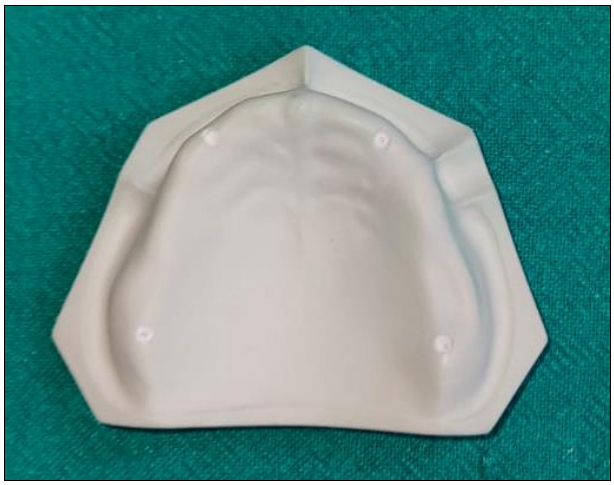

Fig 2: Depth hole created by using 2 mm round bur

Polymerization was done in boiling water under a pressure of 100 N using the short curing cycle. After polymerization, the curing flasks were bench cooled to room temperature and the specimens were deflasked. The surfaces without reference points were finished using 800- 400 and 200- grit. A total of 10 denture bases were made using the above procedure.

The reference points in each acrylic denture bases were designated by letters A, B, C, and D (Fig: 1, 2) Four measurements (Distances AB, BC, CD, AD) (Fig 3) were recorded for each acrylic specimen. Measurements were made three times for each of the four dimensions by a single operator and a mean value was calculated. All the specimens were stored in distilled water at room temperature until measured. Measurements were recorded immediately with a digital calliper (Bombay® Tools) accurate to 0.01 mm with the raised indentations as reference points. Then the denture bases were again subjected to another short curing cycle (Second cure). Again, the measurements were repeated in a similar manner.

All measurements were carried out by the same investigator to ensure reliability and consistency to minimize the investigator errors. At each time interval the specimens were removed from the water and dried by blotting with absorbent tissue. Subsequently, the percentage of the linear dimensional change (ΔL) of the studied denture base resins was calculated as follows:

$\Delta L\ (\%) = 100\ (L - L_0)$

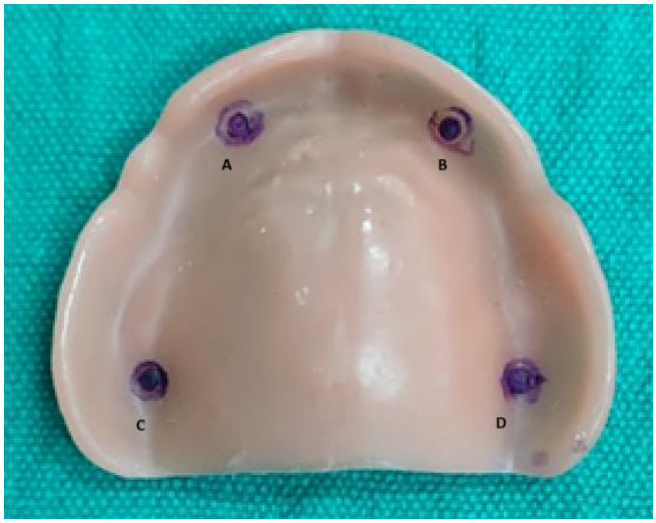

Fig 3: Processed denture base for measurements

Statistical analysis

Data was entered in computer using IBM-SPSS for windows version 28.0.0.0 (190) IBM (SPSS Inc., Chicago, IL).

For the linear measurements (AB, BC, CD, and AD) the p-values are greater than 0.05, indicating that the data follows a normal distribution. (Table 1)

- For AB', the p-value is less than 0.05, indicating that the data does not follow a normal distribution. So, Wilcoxon signed-rank test was performed for the AB1 group.
- For BC', CD', and AD' the p-values are greater than 0.05 indicating that the data these columns follow a normal distribution. Then, a paired t test is performed (Table 2)

Inferences

Significant differences were observed in the dimension changes between the first and second curing suggest that the curing process significantly affects the dimensions of PMMA denture bases. These findings highlight the importance of consistent and controlled curing processes to ensure dimensional stability in dental prosthetics. All comparisons (AB vs AB1, BC vs BC1, CD vs CD1, AD vs AD1) indicate significant differences in dimensions between the first and second curing. This conclusion is supported by both the paired t-test (For normally distributed data) and the Wilcoxon signed-rank test (For non-normally distributed data like AB1). (Chart 1)

Discussion

Historical background

PMMA is an odorless polymer of acrylic acid that was reported by Redtenbacher for the first time in 1843[3]. According to The American Dental Association (ADA) specification No. 12 [4, 5], the denture base polymers are

classified into various types and classes. Based on the activation of the polymerization reaction, there are three main types of denture base polymers which may differ from each other in terms of their polymerization reactions and compositions.

Characteristics of PMMA

The composition of heat cure PMMA is elicited in Table 3 [7].

Usually in complete denture fabrication, after border molding and secondary impression permanent denture base is processed and cured (First-curing). After the wax try in, the denture base is again subjected to curing (Second curing). The setting reaction of the PMMA starts when the powder is mixed with liquid in a ratio of 3:1 and it requires heat energy to activate the initiator i.e., the benzoyl peroxide. The main purpose of the heating cycle is to achieve a high degree of polymerization and decrease residual monomers in the cured prosthesis. High degree of polymerization results in better physical properties. There are various curing cycles for this heat cure PMMA. Some of them are as mentioned in Table 4. [8, 9, 10].

Properties of PMMA

The polymerization shrinkage (Linear and volumetric) may result in remarkable dimensional changes and in accuracies during denture fabrication where closeness of adaptation plays a greater role. The polymerization shrinkage (Linear and volumetric) may result in remarkable dimensional changes and in accuracies during denture fabrication [11]. Therefore, least shrinkage is desired for dental applications.

Similar to the present study, complete edentulous and dentulous denture bases were utilized in separate research studies by Jackson [12], Nogueira [13], Abby [14] and Venus Salim [15] and in contrast, Baydas [16] used rectangular acrylic resin plates for dimensional change evaluation. There are different methods to measure the parameters which includes use of manual / digital vernier callipers, gauges, comparators, micrometres, radiographic evaluation utilising devices such as Computed tomography, Cone beam computed tomography, color mapping using digital superimposition software. In this study we have used the digital callipers.

Wolfaardt reported that many different factors affected dimensional changes of acrylic resin dentures [17]. Factors such as size and shape [18], denture thickness [19], different types of denture base materials [20], and presence of teeth [21], type of curing cycle [22] can influence dimensional changes during denture processing. In a study conducted by Goodkind [22], it was demonstrated that immersion in water did not significantly affect the dimensions of the denture base. This suggests that the dimensional stability of denture bases is maintained after being submerged in water, which is an important consideration for the durability and longevity of dentures. Negreiros [23] even explained about the influence of Flask closure method and post-pressing time on the displacement and linear dimensional changes in the denture bases.

Table 1: Descriptive statistics (* Wilcoxon signed rank test performed)

Data	AB	BC	CD	AD	AB' *	BC'	CD'	AD'
Mean	33.207	30.573	47.392	30.895	30.829	29.328	46.571	29.728
S.D	0.843	0.359	0.463	0.246	0.474	0.222	0.31	0.317
p- value for Shapiro Wilk test (p=0.05)	0.76	0.488	0.291	0.758	0.003	0.651	0.977	0.904

Table 2: Paired t Test

Measurements	p Value (p< 0.05) paired t test
AB Vs AB'	8.43×10−5
BC Vs BC'	4.11×10−5
CD Vs CD'	0.0015
AD Vs AD'	1.04×10−5

Table 3: Composition of heat cure PMMA

Powder -Components	Function
Polymethyl methacrylate	Powder molecules
Benzoyl peroxide	Initiator
Dibutyl Phthalate	Plasticizer
Titanium Oxide / Zinc Oxide	Opacifiers
Fibres, Pigments, Dyes	-
Liquid -Components	Function
Methyl methacrylate	Liquid
Ethylene glycol dimethacrylate	Cross linking agent
Hydroquinone	Inhibitor

Table 4: Curing Cycles for heat cure PMMA

Heat cycles	Temperature	Time	Terminal Boiling
1	74 degrees	8 hrs	None
2	74 degrees	8 hrs	1 hour
3	74 degrees	3 hrs	1 hr

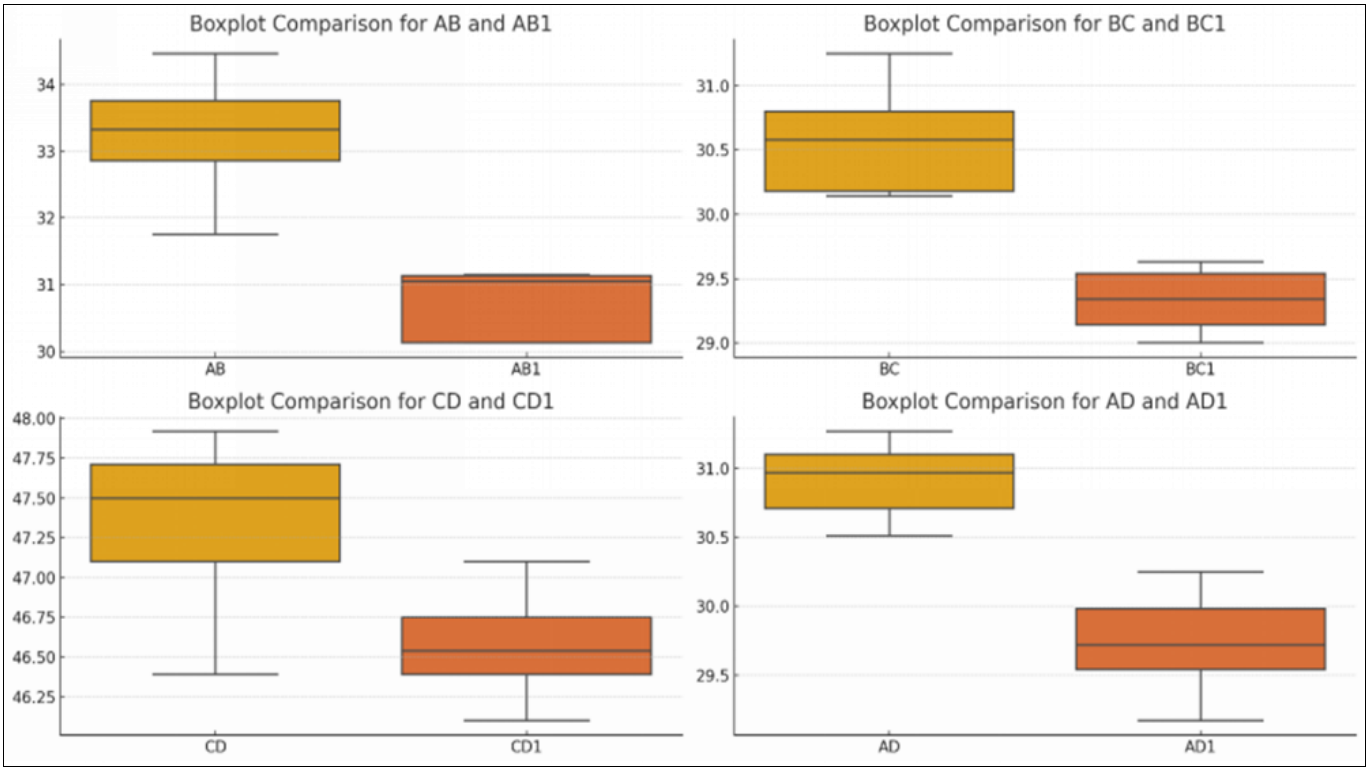

Chart 1: Box plot diagram for the linear differences

Conclusion

Within the limitations of this study, linear dimensional changes of acrylic resin after the first and second curing are observed. This has significant clinical importance. The results will be more credible when evaluated with variable parameters like retention, stability, and support in clinical scenarios.

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