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THE ACCURACY OF ADAPATION OF RESIN BASIS FABRICATEED BY THRE DIFFERENT PROCESSING TECHNIQUES FOR MAXILLARY COMPLETE DENTURE (AN IN INVITRO STUDY)

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ABSTRACT

Objectives: The present study was conducted to compare the adaptation accuracy of three different denture base materials for maxillary complete denture; compression molded heat cured polymethyl methacrylate (PMMA), injection molded thermoplastic resin and microwave processed denture base resin.

Materials and Methods: 18 casts were duplicated from a completely edentulous model for the upper arch, then divided equally into three groups: group A (compression molded PMMA), group B (injection molded thermoplastic resin), group C (microwave processed denture base). The dentures on their respective casts were sectioned 5 mm anterior to the posterior border and measurement of the posterior border gap between the denture base and the cast was measured using a traveling microscope at the mid-palatal, right and left crestal regions. The data was collected and statistically analyzed.

Results: The least gap measurement was found in group B at the crestal and mid-palatal sections, while the highest gap measurement was found in group C followed by group A. A statistically significant difference was found between the three groups at the crestal and mid-palatal sections, and between the crestal and mid-palatal measurements within each group.

Conclusion: Injection molded thermoplastic resin showed the highest adaptation accuracy as measured by gap distance, followed by compression molded heat cured PMMA and then the microwave processed denture base resin.

KEY WORDS: Denture base; thermoplastic resin; compression molding; microwave polymerization; adaptation accuracy.

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INTRODUCTION

Edentulism has always been associated with several disabilities which can drastically influence an individual's quality of life. Although over the years the overall percentage of edentulous patients has been decreasing, the number of these patients is still increasing because of the general growth in populations. The increased life expectancy due to the improvement of the health standards worldwide lead to the prevalence of edentulism which is more evident within an older age group and dental practitioners usually deals with the difficulties in giving these individuals the proper care. (D. J. Lee & Saponaro, 2019)(Limpuangthip et al., 2018) (Patel et al., 2018)

Provision of high-quality complete denture remains a popular treatment choice for a great number of edentulous patients, and it is still an important skill for the dental practitioners. One of the most crucial requirements for successful complete dentures is the adaptation of the denture base to the mucosa. The complete denture's base is a critical element to its retention. Adequate retention is accomplished when the gap between the base and the mucosa is as small as possible. (Darvell & Clark, 2000)(Oğuz et al., 2021) The accuracy of the basis considerably affects the clinical treatment outcomes.(S. Lee et al., 2019)

It is well known that the maxillary and mandibular arches have distinctive anatomical structures with different denture base foundation areas.(Limpuangthip et al., 2018) Denture base adaptation varies depending on which edentulous arch the prosthesis will be inserted as much as the construction procedure. (Hsu et al., 2020) It is agreed on that keeping dimensional changes to a minimum is crucial for preserving the posterior palatal seal adaption and ensuring successful denture retention. (Artopoulos et al., 2013)

Poly methyl methacrylate (PMMA) resin happens to be the most widely used denture base material from the time when it was first introduced in the 1930s. Despite the excellent properties of the material, high esthetics and ease of manipulation as well as its significant low cost, acrylic resin denture bases have got some innate drawbacks concerning dimensional stability owing to the release of thermal stresses, polymerization shrinkage, and the existence of the residual monomer, which can result in errors that can compromise the denture base's final adaptation. (de Oliveira Limírio et al., 2021) (Aldegheishem et al., 2021)

Polymerization by compression molding and heat activation techniques of different denture base resins are vastly used. It has been shown that acrylic resin complete dentures undergo dimensional changes during the polymerization cycle. Using injection molding and microwave polymerization techniques have been reported to reduce these changes and thus improve the clinical fit. Several studies have shown that stresses introduced during the processing procedure often led to the deformation of denture bases. Microwave, Chemical, and light energy activation, and the various combinations (including polymerization under pressure polymerization) have been presented as a substitute for denture fabrication. The above mentioned techniques were efforts to enhance the accuracy of fit of the dentures. (Takamata et al., 1989) (Keenan et al., 2003) (Hsu et al., 2020)

Injection molding technique for PMMA basically depends on the continuous flow of the material from the sprue, that can compensate for the shrinkage which may occur during polymerization. The mechanical properties as well as fitting accuracy of these denture bases were found to be significantly higher due to the absence of porosities or any residual monomer. (Artopoulos et al., 2013) (Wada et al., 2015)

Microwave processing of dentures proved to be much cleaner, consumes less time, and gives a homogenous mix of the material with excellent adaptation in addition to a decrease in the residual monomer than the conventional resins. The appropriate choice of the polymerization cycle is essential to avoid overheating of the monomer which can have a deleterious effect on the denture base properties in the form of porosities or degradation.(Figuerôa et al., 2018) Microwave polymerization usually acts only on the monomer, which decreases in the same proportion as the polymerization degree increases. Consequently, the same amount of energy is absorbed by fewer and fewer amount of monomer, rendering the molecules even more active. This is significant because a form of self-regulation of the curing program takes place and leads to complete polymerization of the resin. (Somkuwar et al., 2017)(Samman et al., 2018)(Matos et al., 2018) It was also reported that acrylic resin cured by microwave energy is extra resistant to mechanical failures than conventionally cured acrylic ones and that this method can be used in the construction of denture bases without risk.(Ilbay et al., 1994)

Previous studies have investigated the accuracy of adaptation of acrylic denture bases by detecting the amount of space present between the denture base and the cast at the posterior palatal area, it is crucial that the denture base of the finished denture be a precise replica of the denture bearing tissue for dimensional accuracy.(Consani et al., 2002)(Jagger et al., 2003)(Ono et al., 2004)(Consani et al., 2004) One of the most commonly used tools for measurements of the posterior gap is the travelling microscope which is a great aid in the evaluation of denture adaptation to its master cast. This can be attributed to its simplicity and feasibility. (C.-J. Lee et al., 2010)(Thomas et al., 2018)(Begum et al., 2019) (Nassouhy, 2022)

It was therefore the objective of this study to compare the adaptation accuracy of different maxillary complete denture bases; compression molded heat cured polymethyl methacrylate (PMMA), injection molded thermoplastic resin and microwave processed denture base resin by measurement of the gap distance underneath the denture base.

MATERIALS AND METHODS

Construction of the cast

Selection of an edentulous maxillary arch model having no undercuts to prevent the consequence of different palatal anatomy and undercuts on the denture base adaptability. A silicone mold (Nissin, Kyoto, Japan) of an edentulous maxillary arch was poured with Type III Dental stone with a ratio of 30 ml of water to each100 gm of powder and was left to set for 1 hr. A silicone mold was done for this cast model, duplication of this cast was done 18 times to produce 18 stone casts using type IV dental stone. These casts were split into 3 equal sets to receive the 3 types of investigated denture bases which are; group A (compression molding, heat cured PMMA), group B (injection molding thermoplastic resin), and group C (microwave processed denture base resin).

Regarding Group A (compression molding heat cured PMMA resin denture base) after the adaptation of a 1.5 mm thickness sheet of baseplate wax on the cast, the artificial teeth setting and waxing up was done according to standard procedure. A silicon index of the facial and occluding surfaces of the artificial teeth on the trial denture base was created to standardize tooth dimensions and setting across all groups. Using heat cured PMMA, the conventional processing procedures of flasking, removal of the wax, packing, and curing were carried out. (Vertex regular, Zeist, Netherlands).

Regarding Group B (injection molding thermoplastic resin denture base) A 1.5 mm thickness baseplate wax sheet was adapted on the casts as it was previously made for group A. The setting of the artificial teeth was then done using the previously created silicon index. Then the dentures were processed by injecting the thermoplastic resin (Polyan IC, Modified methacrylate, Bredent, Germany) following the manufacturer instructions using an injection molding machine. (Thermopress 400 version 2.4/2.56, Bredent, Germany).

Finally for Group C (microwave processed resin denture base). The trial denture base and setting of the artificial teeth was done following the same technique as previously done in group A and B. The flasking method for microwave processing is the same as that for conventional techniques. A microwave flask (ECO-CRYL M, Protechno, made in Spain) was used and the resin was microwave irradiated for at 495 W for three minutes. (Fig 1).

Measurement of adaptation accuracy

Before measurement of adaptation accuracy, the excess material for all groups was trimmed while the dentures were still on their respective casts to avoid any deformation.

The denture bases on each cast were transversely cut using a vertical trimmer and a diamond cutting disc, a water coolant was used to prevent the denture base from overheating. These sections were created 5 mm anterior to the denture bases' posterior border. The three proposed locations for measurement were the crest of the alveolar ridge on the right and left sides and mid palatally (center of the cast). The three locations were then marked with vertical lines using an indelible pencil on the cast base, and a resin template was attached with vertical slits matching the lines enabling the transfer of these locations to the remaining casts. Using a travelling microscope with an accuracy of 0.001 mm and a magnification power of 50x (Carl Zeis, Jenna, Germany), the distance between the denture bases and the casts was then measured at the three locations and the average was calculated in centimeters. (Fig 2). A mean value was calculated by measuring the posterior gap distance three times for each location. For statistical analysis, the data were tabulated.

Data analysis

For each group in each test, the mean and the standard deviation values were calculated. After performing the Shapiro-Wilk and Kolmogorov-Smirnov tests to determine whether the data were normal, the data revealed a parametric (normal) distribution. The One-way ANOVA and Tukey post hoc test were used to compare more than two groups in samples from unrelated populations. Repeated action In linked samples, comparisons between more than two groups were made using the ANOVA test. To compare two groups in related samples, the Paired Sample T-test was applied. The cutoff for significance was chosen at P 0.05. With IBM® SPSS® Statistics Version 20 for Windows, a statistical analysis was carried out.

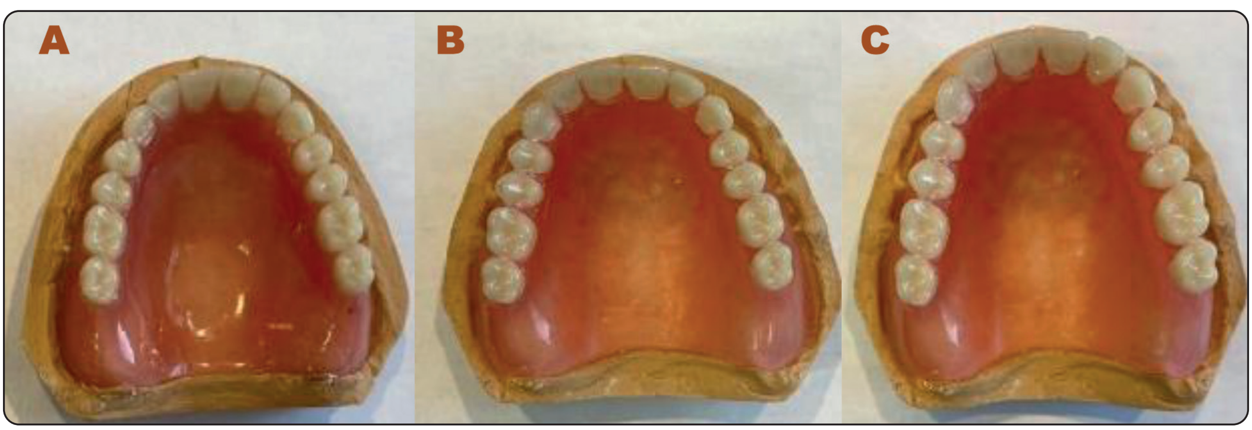

Fig. (1): Complete denture bases on their respective casts for group A, group B, and group C.

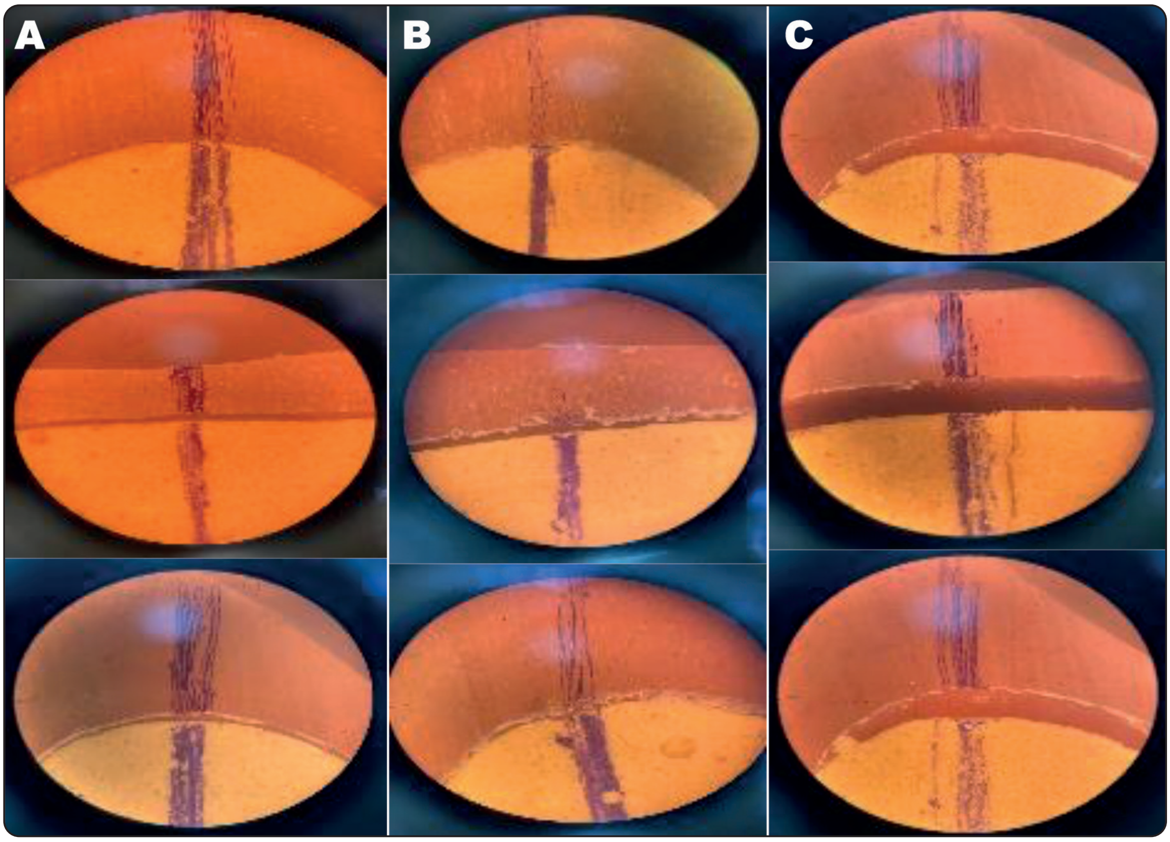

Fig. (2): Microscopic images for right crestal, mid palatal and left crestal distance analysis for the three groups.

RESULTS:

The findings of this study indicated that there was no statistically significant difference between the three groups' measurements of the right and left crestal gaps. Accordingly, a mean of each group's right and left sides was calculated and used for the remaining statistical comparisons (right crestal + crestal left/2). (Table 1,2).

When comparing the gap measurements in the mid-palatal and crestal within each group, group A and B's mean mid-palatal gap measurements were higher than the crestal measurements, whereas group C's mean mid-palatal gap distance measurements were lower than that of the crestal ones. This difference was found to be significant statistically. (Table 2, fig. 3).

When comparing the crestal gap measurements of the 3 groups, group C (microwave processed) had the highest mean value while group B had the least measurements (thermoplastic resin). Between the three groups, there was no statistically significant difference (Table 2, fig. 4)

When the mid-palatal gap measurements of the 3 groups were compared, group C (microwave processed) had the highest mean value and group B had the lowest mean value (thermoplastic resin). The difference was statistically significant between group A and group B. In addition, it was observed that there was a statistically significant difference between groups A and C and B and C. (Table 2, fig.4).

TABLE (1): Gap distance measurements for the right crestal, left crestal, and mid-palatal sections, as well as their mean and standard deviation (SD) values

Variables	Accuracy					
	Group A (Conventional)		Group B (Thermopress)		Group C (Microwave)	
	Mean	SD	Mean	SD	Mean	SD
Crestal right	0.147	0.008	0.184	0.013	0.438	0.038
Crestal left	0.249	0.045	0.199	0.005	0.464	0.022
Mid palatal	0.313	0.013	0.225	0.008	0.376	0.005
p-value	0.019*		0.040*		0.043*	

Means with different letters indicate significant difference. ****; significant (p<0.05)***

TABLE (2): The crestal and mid-palatal regions of the three groups' mean and standard deviation (SD) results for gap distance measurements.

Variables	Accuracy				
	Crestal		Mid-Palatal		p-value
	Mean	SD	Mean	SD	
Group A Conventional	0.198 [b]	0.026	0.313 [b]	0.013	0.006*
Group B Thermopress	0.191 [b]	0.005	0.225 [c]	0.008	0.020*
Group C Microwave	0.451 [a]	0.031	0.376 [a]	0.005	0.038*
p-value	<0.001*		<0.001*		

Means with different letters indicate significant difference. ****; significant (p<0.05)***

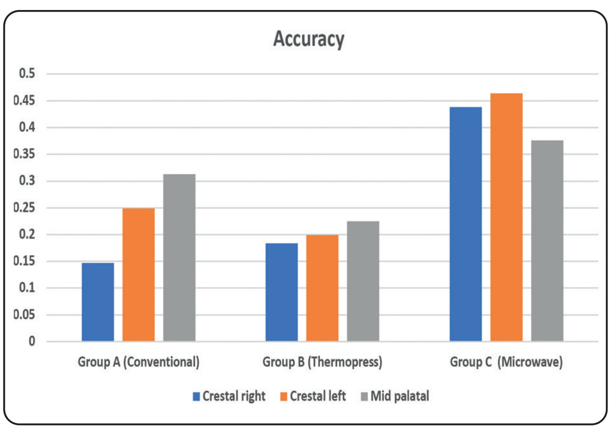

Fig. (3): Bar chart representing accuracy

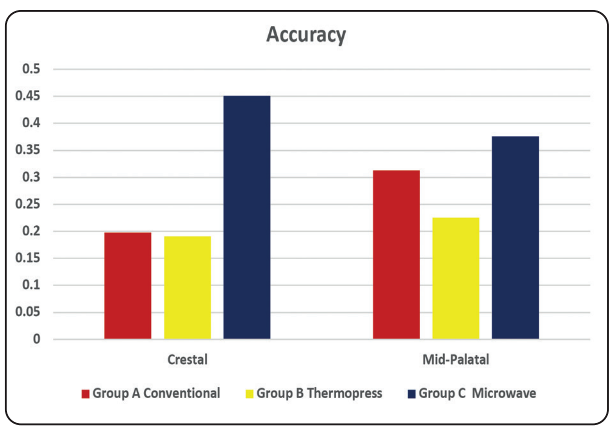

Fig. (4): Bar chart comparing crestal and midpalatal gap distance measurements of all groups.

DISCUSSION OF THE RESULTS

Achieving intimate contact between the underlying structures and the denture base is crucial for proper retention and function of complete denture. Using different denture base material and various processing techniques to provide the optimal mucosal adaptation was observed to highly affect denture base accuracy of adaptation. The reproducibility of the technique that can have the ability to produce the same accurate denture base every time is a critical factor in complete denture construction. (Goodacre et al., 2016) (Oğuz et al., 2021)

Adaptation accuracy of the denture base is usually evaluated by measuring the gap between the denture base and the mucosa that corresponds to edentulous cast in invitro studies. Also, several previous studies performed either by physical or digital techniques commonly evaluated the gap using linear measurement of the vertical distance between the cast and base.(Laughlin et al., 2001) (Sayed et al., 2019) (Akaltan et al., 2020)

The results of this study have shown that the least gap distance at both mid palatal and crestal locations occurred with the thermoplastic resin (group B) when compared to compression molding using heat cured PMMA (group A) as well as microwave processing (group C) both are fabricated using the compression molding technique. This is in agreement with various studies reporting on the effect of injection molding techniques on the reduction of dimensional changes of PMMA by compensation of the polymerization shrinkage that could happen through the continuous controlled flow of the material through the sprue. (Parvizi et al., 2004)(C.-J. Lee et al., 2010) Another study showed that the internal adaptation of the injection molded resin was superior to that of the conventional heat and microwave polymerized resins. (Ganzarolli et al., 2007) Another study linked the shrinkage to the longer cooling time needed after the heat cured material had hardened. (Parvizi et al., 2004)

Microwave processed denture bases group C showed the highest gap distance in the mid palatal and crestal regions, this comes in agreement with another study investigating the fit of microwave processed maxillary denture bases. Compared to other materials, microwave cured bases showed greater fit loss.(Ghani et al., 2010) this can be attributed to the linear shrinkage rather than volumetric shrinkage which results in the material pulling away from the cast. (C.-J. Lee et al., 2010) (Oğuz et al., 2021) Also, additional energy at the beginning of the polymerization reaction might have caused the resin temperature to rise quickly, causing porosities to occur.(Barbosa et al., 2008) (Lai et al., 2004)

A previous study showed that injection molding of the dentures demonstrated better adaptability than compression molding for shallow palates, whilst compression molding displayed significantly more space for these forms than injection molding. (McLaughlin et al., 2019) which can further explain why the results of this study showed that the greatest gap distance was found in the mid crestal region for microwave polymerized resin. Another study showed that conventionally processed bases showed better flexural strength and flexural modulus than the microwave processed ones.(Lai et al., 2004)

This results are inconsistent with previous studies that advocated for the use of microwave processing as an alternative to conventional heat processed resins in terms of better accuracy and adaptation specially in the palatal area. (Somkuwar et al., 2017) (Compagnoni et al., 2004) Furthermore, according to the studies, there are no appreciable differences in physical qualities between conventional resins and acrylic resins processed in less than five minutes using a microwave. (Compagnoni et al., 2004) To reduce porosity to a minimum and maximize the domain size and volume of the rubber phase, it is crucial to choose an appropriate microwave power and polymerization duration..(Lai et al., 2004)

Group A showed the second largest gap distance in the mid palatal area which comes in agreement with previous studies reporting that the distortion occurring in the conventionally heat cured PMMA as a result of the polymerization shrinkage and the release of thermal stresses which compromises the adaptation of the denture base. (Pronych et al., 2003)(Ganzarolli et al., 2007) (Gokay et al., 2021)

The construction method of the denture bases done either by injection or compression molding techniques plays a major role in the adaption of theses basses as shown by the results of this study in which the greatest mid palatal and crestal gap distances were found in the microwave processed denture bases while the injection molding denture bases showed the least crestal and mid palatal gap distances although the difference between the three groups is not statistically significant.

Contradictory results may be due to the difference in the sample sizes, materials, and test methods used in different studies. However, the clinical implication established on the results of the present study can be that complete denture bases constructed using injection molding technique can be expected to offer better adaptation to the mucosa, consequently, improve retention. Also, microwave polymerization of acrylic resin denture bases using longer microwave cycles could reduce porosities and enhance denture base adaptation.

CONCLUSION:

Within the limitations of this in invitro study, the denture bases fabricated with the thermoplastic injection molding technique were found to have better adaptation than those fabricated with compression molded heat cured PMMA and microwave processed dentures bases

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