

COMPARISON OF ADAPTATION ACCURACY BETWEEN THREE DIFFERENT DENTURE BASE MATERIALS FOR THE COMPLETELY EDENTULOUS UPPER ARCH. AN INVITRO STUDY

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ABSTRACT

Objectives: This study was conducted to compare the adaptation accuracy of three different denture base materials for the edentulous maxilla; compression molded heat cured polymethyl methacrylate (PMMA), injection molded thermoplastic resin and versacryl.

Methodology: A completely edentulous model for the upper arch was duplicated to 15 stone casts, then divided equally into three groups: group I (compression molded PMMA), group II (injection molded thermoplastic resin), group III (versacryl). The dentures on their respective casts were sectioned 5 mm anterior to the posterior border and the gap distance between the denture base and the cast was measured using a traveling microscope at the mid-palatal and crestal regions. The data was collected and statistically analyzed.

Results: The least gap measurement was found in group II at the crestal and mid-palatal sections, while the highest gap measurement was found in group I followed by group II. 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.

Conclusions: Injection molded thermoplastic resin showed the highest adaptation accuracy as measured by gap distance, followed by versacryl and then compression molded heat cured PMMA.

KEYWORDS: Thermoplastic resin, compression molding, injection molding, denture base materials.

INTRODUCTION

The complete denture remains an effective and widely used treatment option for the completely edentulous patient. One of the most

important criteria for the success of the complete denture is retention, which depends primarily on denture adaptation and close fit to the underlying mucosa ¹. The smaller the gap distance between

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the denture base and the mucosa the more enhanced are the physical means of retention such cohesion, adhesion and atmospheric pressure, and subsequently the better the performance and mastication of the denture²⁻⁴.

The conventional material for complete denture fabrication is compression molded heat cured polymethyl methacrylate (PMMA). This material has been widely used for decades due to its relatively low cost, high esthetics, as well as ease of manipulation and repair^{3,5}. However, it is known for its drawbacks regarding dimensional stability due to polymerization shrinkage, release of thermal stresses and the presence of residual monomer, resulting in inaccuracies and compromising the adaptation of the denture base^{2,6-8}.

Techniques such as injection molding have been used to overcome the shortcomings of the conventional compression molded PMMA. Injection molding of PMMA depends primarily on the continuous supply of thermoplastic material from the sprue, which compensates the effect of any polymerization shrinkage that occurs^{6,9}. Studies have reported that linear deformation ranges from 0.4% to 0.9% for compression molding and 0.65% for injection molding techniques^{10,11}. Injection molding using thermoplastic resins have provided denture bases that are free from residual monomer and porosities and have improved mechanical properties such as hardness, flexural and impact strengths¹²⁻¹⁵.

Other materials and techniques have been used as alternatives to conventional heat cured PMMA. Versacryl is a thermo-elastic, cross-linked, heat sensitive acrylic resin that is durable, has high fatigue and wear resistance and no residual monomer^{16,17}. The addition of plasticizers to Versacryl controls its viscoelastic properties and is claimed to improve its adaptation¹⁸. However, limited studies are present in the literature regarding its adaptation when compared to other materials.

Dimensional stability and subsequent adaptation accuracy has been measured by several techniques. Microscopic measurements of the gap distance beneath the denture base is one of the most commonly used methods to evaluate adaptation accuracy due to its accuracy and simplicity^{9,19,20}.

This study compares the adaptation accuracy of maxillary complete dentures fabricated from compression molded heat cured PMMA, injection molded thermoplastic resin, and versacryl as measured by the gap distance beneath the denture base.

METHODOLOGY

Fabrication of the stone casts

An educational model of a completely edentulous upper arch with a moderately curved palatal vault and no undercuts was selected for this study and duplicated into 15 stone casts. This was done to avoid the effect of palatal curvature and undercuts on the adaptation of the different denture base materials. Silicon was used to create a mold for this model and it was duplicated 15 times using type IV dental stone. The 15 stone casts were then divided equally into three groups to receive three types of denture bases; group I (compression molded, heat cured PMMA), group II (injection molded thermoplastic resin), and group III (versacryl) (fig 1).

Group I (compressional molded heat cured PMMA)

A sheet of baseplate wax of 1.5 mm thickness was adapted on the cast and artificial teeth were set and waxed up following the conventional guidelines of teeth arrangement. A silicon index of the outer and occlusal surfaces of the trial denture base was fabricated to standardize teeth size and arrangement with the rest of the denture bases in the the groups. The remaining steps of flasking, wax elimination and packing were done in the conventional manner using heat cured PMMA (Vertex regular, Zeist, Netherlands).

Group II (injection molded thermoplastic resin)

A sheet of baseplate wax of 1.5 mm was adapted on the casts as was done in group I. The previously fabricated silicon index was used for the arrangement of the artificial teeth. The dentures were then processed by injecting a thermoplastic resin (Poly-an IC, Modified methacrylate, Bredent, Germany) using a programmable injection molding machine (Thermopress 400 version 2.4/2.56, Bredent, Germany) under controlled temperature and pressure according to the manufacturer's instructions.

Group III (Versacryl)

The trial denture base and teeth set up were done in the same manner as in groups I and II. Versacryl (Keystone Industries GmbH, Sigen, Germany) was used to fabricate the dentures in this group. The material was mixed according to the proportions recommended by the manufacturer and then processed in the curing unit for 90 minutes at 70 °C then 30 minutes at 100 °C. The dentures were then allowed to bench cool to room temperature for 30 minutes then immersed in cold water for 15 minutes.

After processing, excess material was trimmed from all sample dentures while keeping them on their casts to avoid any distortion before adaptation accuracy measurements.

Adaptation accuracy measurements

All 15 casts with their respective dentures were sectioned transversely using a vertical trimmer with a diamond cutting disc under a water coolant to avoid over heating of the denture base materials during cutting, particularly in groups II and III. The transverse section was made 5 mm anterior to the posterior border of the dentures.

Measurements were done at three locations: mid palatally (at the center of the cast) and at the crest of the alveolar ridge on both sides. For standardization of the measurements, an indelible pencil was used to make vertical lines on the base of the cast at the location of the measurements. An acrylic resin template with vertical slots opposite to the lines was used to transfer these locations to the rest of the casts.

A travelling microscope (Carl Zeis, Jenna, Germany) with an accuracy of 0.001 mm and a magnification power of 50x was used to measure the gap distance between the denture bases and the casts at the three locations (fig 2 & 3). The gap distance was measured three times for each location and a mean value was obtained. The measurements were tabulated for statistical analysis.



Fig (1) denture base for group I (a), group II (b), group III (c)

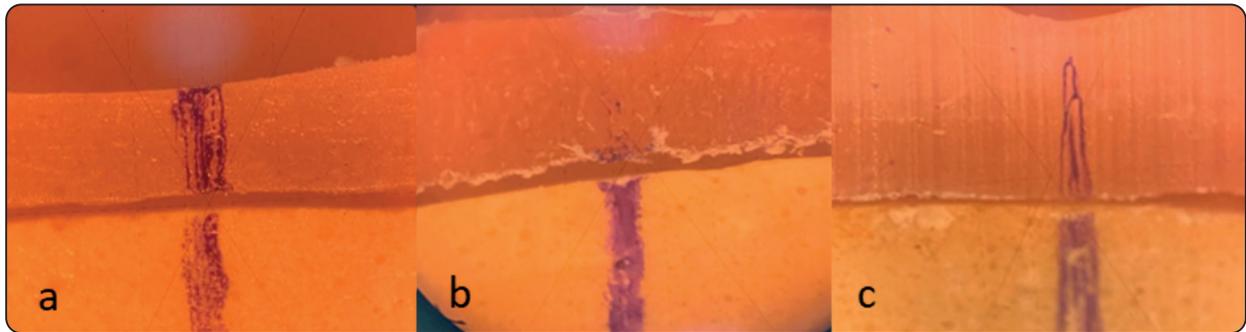


Fig. (2) microscopic images of mid-palatal gap distance for group I (a), group II (b), group III (c)

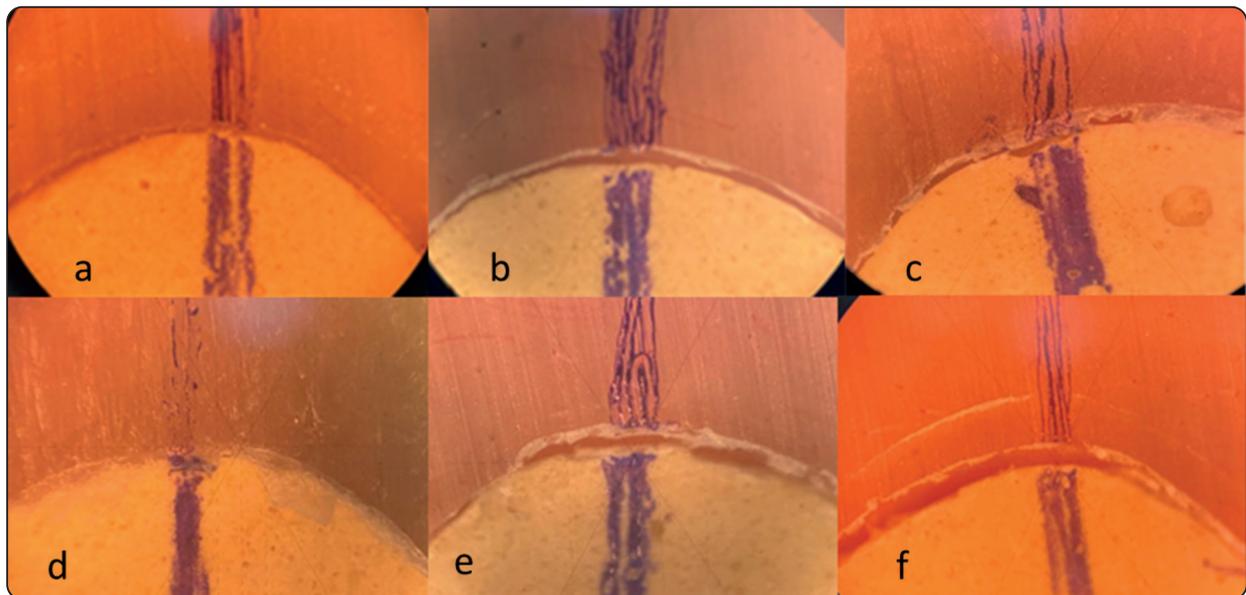


Fig. (3) microscopic images of right and left crestal gap distance for the group I (a,b), group II (c, d), group III (e,f)

Statistical analysis

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests, data showed parametric (normal) distribution.

One-way ANOVA followed by Tukey post hoc test was used to compare between more than two groups in non-related samples. Repeated measure ANOVA test was used to compare between more than two groups in related samples. Paired sample t-test was used to compare between two groups in

related samples. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

RESULTS

The results of the mid-palatal, right crestal and left crestal gap measurements are found in table (1), fig (4). There was no statistically significant difference between the right and left crestal gap measurements in the three groups, therefore a mean of the two sides for each group ($\{\text{right crestal} + \text{crestal left}\} / 2$) was taken and used for the remaining comparisons (table 2, fig 4).

On comparing mid-palatal and crestal gap measurements within each group, the mean value for mid-palatal gap measurements was higher than the crestal measurements in all groups, and the difference was statistically significant (table 2, fig 4).

On comparing crestal gap measurements between the three groups, the highest mean value was in group I (PMMA) while the lowest was in group II (thermoplastic resin). No statistically significant difference was found between the three

groups (table 2, fig 4).

On comparing mid-palatal gap measurements between the three groups, the highest mean value for mid-palatal measurements was in group I (conventional PMMA) while the lowest was in group II (thermoplastic resin). The difference between group I and group II was found to be statistically significant. Additionally, the difference between groups I and III, and II and III were also statistically significant (table 2, fig 4).

TABLE (1): The mean, standard deviation (SD) values of gap measurements for right crestal, left crestal and mid-palatal sections

Variables	Gap Measurements (mm)					
	Group I (Conventional PMMA)		Group II (Thermoplastic resin)		Group III (Versacryl)	
	Mean	SD	Mean	SD	Mean	SD
Right crestal	0.147	0.008	0.199	0.013	0.175	0.078
Left crestal	0.249	0.045	0.184	0.005	0.211	0.029
Mid-palatal	0.313	0.013	0.225	0.008	0.264	0.006
<i>p-value</i>	0.019*		0.040*		0.037*	

*, significant ($p < 0.05$)

TABLE (2): The mean, standard deviation (SD) values of gap measurements for crestal and mid-palatal sections of the three groups

	Gap Measurements (mm)				p-value
	Crestal		Mid-Palatal		
	Mean	SD	Mean	SD	
Group I Conventional (PMMA)	0.198	0.026	0.313	0.013	0.006*
Group II Thermoplastic resin	0.191	0.005	0.225	0.008	0.020*
Group III Versacryl	0.193	0.052	0.264	0.006	0.031*
<i>p-value</i>	<0.001*		<0.001*		

*, significant ($p < 0.05$)

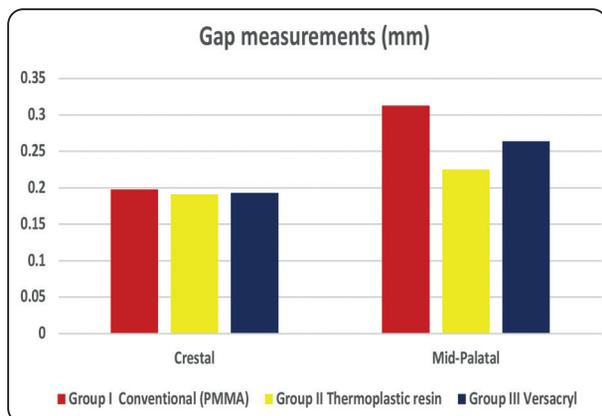


Fig. (4) Bar chart showing comparison of crestal and mid-palatal gap measurements of the three groups.

DISCUSSION

The intimate contact between the denture base and the underlying structures is key to enhancing complete denture retention and function. Denture base material and processing technique has been found to greatly affect denture base adaptation^{21,22}.

This study was done to compare the adaption accuracy of three different types of denture bases by measuring the gap distance beneath the denture base at different locations.

The results have shown that the smallest gap distance was found with thermoplastic resin (group II) both at the mid-palatal and crestal locations when compared to compression molding using heat cured PMMA (group I) as well as versacryl (group III) which are both fabricate by compression molding. This comes in accordance with several studies that reported on the effect of injection molding techniques on reducing dimensional changes of PMMA by compensating the polymerization shrinkage through the continuous controlled supply of material through the sprue^{11,21,22}. The fact that group I showed the greatest gap distance in the mid-palatal region is consistent with other studies that have reported that conventional heat cured PMMA suffers from distortion due to polymerization shrinkage and release of thermal stresses that

compromises the adaptation of the denture base^{6,23}.

Versacryl has shown significantly less gap distance at the mid-palatal region than PMMA, demonstrating that the presence of crosslinked plasticizers could have a positive effect on improving the adaptation of compression molded resins.

The patterns of distortion as presented by gap distance in the three groups also come in accordance with other studies that showed that the greatest distortion occurs in the mid-palatal region due to the linear rather than volumetric shrinkage that results in the pull of the material away from the cast^{9,11,22,24}. This could have a clinical significance not only on denture retention, but also on longevity of the denture considering that upper denture fracture occurs most commonly in the mid-palatal region and is mainly due to poor fit^{25,26}. The significantly less gap distance at the crestal region could be attributed to the thinner bulk of the material at the crestal area^{11,27}. The technique of fabrication whether compression molding or injection molding also has an effect as shown by the results of this study, with group II showing the least crestal gap distance and group I showing the greatest gap distance, even though the difference between the three groups is not statistically significant.

CONCLUSIONS

Within the limitations of this study, it can be concluded that thermoplastic injection molded denture bases have the highest adaptation when compared with compression molded heat cured PMMA and versacryl. Versacryl has also shown better adaptation when compared to heat cured PMMA.

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