

# Influence of High Expansion Dental Stone on the Changes in the Occlusal Vertical Dimension of Complete Dentures

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**Abstract** - Although many factors that generate changes in OVD of complete dentures are known, no information is available in the dental literature regarding the effect of using high expansion dental stone (type V) on changes in OVD. This study therefore investigated the effect of a high expansion dental stone on the changes in OVD of complete dentures. A compression moulding technique was used to process twenty sets of simulated upper and lower dentures. Sample was equally divided into two groups: group of type III dental stone (DST III), and group of type V dental stone (DST V). In DST III, the lower, middle and upper parts of flask were filled with type III dental stone; In DST V, the procedure was the same as DST III except for the middle layer that was made of type V high expansion dental stone. Changes in OVD were measured before and after denture processing. A Shapiro-Wilk Normality Test was applied, and then collected data were analysed with t-test statistics for statistically significant differences at the 95% confidence level. The two groups revealed small but statistically significant increase in OVD as a result of processing. The increase in OVD was significantly less in DST V than in DST III. The use of high expansion dental stone can be recommended as investing material to reduce the increase in OVD that occurs after processing complete dentures.

**KEYWORDS:** Acrylic resin, Complete Denture, Denture Base, High expansion dental stone, Investing, Occlusal Vertical Dimension.

## INTRODUCTION

Poly methyl methacrylate (PMMA) acrylic resin is still the most commonly used material for the fabrication of denture bases<sup>1</sup>. It has favourable physical mechanical and aesthetic properties, and is easy to manipulate with inexpensive equipment<sup>2</sup>. However, this material has not achieved all the requirements of ideal denture base material<sup>1,3</sup>. Many researchers have shown that PMMA is submitted to deformation during polymerization, and it is considered as a major disadvantage of acrylic resin<sup>4</sup>. The acrylic resin of complete dentures undergoes to a thermal expansion during heating, contraction during cooling, and it also exhibits polymerization shrinkage<sup>5</sup>. These characteristics produce an internal stress which is released during the deflasking step, creating unavoidable dimensional changes and denture base deformation<sup>6,8</sup>. In general, heat polymerized acrylic resin dentures have a processing linear shrinkage of 0.3% to 0.5%, and show subsequently a linear expansion of 0.1% to 0.2%, which occurs upon immersion in water. The remaining linear shrinkage then equals to 0.1% to 0.4%<sup>9</sup>.

Increase in occlusal vertical dimension (OVD) during laboratory procedures of complete dentures is an important clinical consideration, and it is related to essential characteristics of the materials and techniques<sup>10</sup>.

Although "incisal pin opening" may happen after processing complete dentures, a compression molding technique is still regarded as acceptable<sup>11</sup>. Correcting changes in vertical

dimension of the upper and lower complete dentures is a time-consuming occlusal adjustment<sup>12</sup> that often changes the anatomy of the artificial teeth<sup>11</sup>.

Studies related to investing and processing procedures which were developed to improve the dimensional accuracy and reduce tooth movements are common in the dental literature.<sup>13-18</sup> On the other hand, high expansion stone casts were tested to determine its ability to compensate for some of the dimensional changes of the acrylic resin of complete dentures<sup>2,19,20</sup>. However, the literature contains no information regarding the influence of high expansion dental stone used as investing medium on the changes in OVD of complete dentures.

The objective of this study was to evaluate the effect of a high expansion dental stone used to form the middle portion of the mould during investing procedure on the changes in OVD of complete dentures. The null hypotheses was that there would be no significant differences in changes in OVD of complete dentures fabricated by using an artificial type III dental stone or type V high expansion dental stone as the investing medium.

## MATERIAL AND METHODS

Twenty sets of identical upper and lower stone casts were prepared using a silicone mould (Vertex Castil 21, Vertex dental, Zeist, The Netherland) of master edentulous maxillary and mandibular casts without irregularities in the alveolar ridge surfaces. A power analysis (using G\*Power Version 3.1.5) was undertaken to determine the required sample size. The casts were made of artificial type III dental

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stone (Durguix, Hard natural stone, Protechno, Gerona, Spain) and the water/ powder ratio was 28 mL: 100 g. Record bases were made of auto-polymerizing acrylic resin (Vertex Self Curing, Vertex) on master edentulous maxillary and mandibular casts and occlusion rims were made using pink baseplate wax (Tenatex Red, Associated Dental Product Ltd, Wiltshire, UK). The master casts were mounted on the semi-adjustable articulator (Dentatus ARL articulator; AB Dentatus, Hagersten, Sweden) using the following references: Bennett angle at 15 degrees, and condylar guide at 30 degrees, before proceeding with the setting of the artificial teeth. Acrylic resin denture teeth (Major-Dent, Major Prodotti Dentari S.P.A., Moncalieri, Italy) were arranged in conventional balanced occlusion. The arranging prosthetic teeth for the interocclusal relationship was anterior vertical overlap and posterior in Angle class I. The wax-up was performed to form the polished surfaces of upper and lower dentures. Replicate dentures were reproduced using a silicone matrix. Two sprue holes were prepared in the resulting mould. After placing artificial teeth and prepared stone casts in the matrix, molten pink baseplate wax was poured into the matrix and allowed to cool before removal. All sets of teeth were of the same mould. The remounting jig was made on the lower arm

of the articulator, while the master maxillary trial denture fixed on the upper arm, to facilitate mounting the other sets of trial dentures in the same positions in the articulator (Fig. 1). Sets of trial dentures were mounted on the articulator by using the remounting jig and centric relation records as a guide. Small modifications were needed to completing occlusion of denture teeth and positive contact of the incisal pin with the incisal table was rechecked. The vertical dimension between reference lines delineated on the upper and lower arms of the articulator was measured by a digital caliper, which can record changes as small as 0.01 mm (Fig. 2). The vertical measurements were made at the wax denture stage (prepolymerization), and changes in vertical dimension for each denture were evaluated at a simulated laboratory remount just after denture deflasking (postpolymerization). The difference between the final and initial measurement referred to the changes in OVD.

Samples were equally divided into two groups according to investing medium and flasking technique: group of type III dental stone (DST III), and group of type V dental stone (DST V). In DST III, the lower part of flask (the drag) was filled with artificial type III dental stone, artificial type III dental stone also was poured up to the level of the incisal



Figure 1. Remounting jig.



Figure 2. Measurement of the vertical dimension between the upper and lower arms of the articulator.

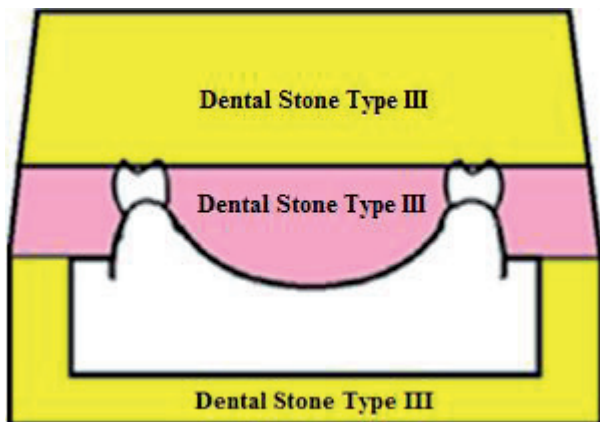


Figure 3. Schematic drawing of the gypsum mould cross-section of DST III specimens.

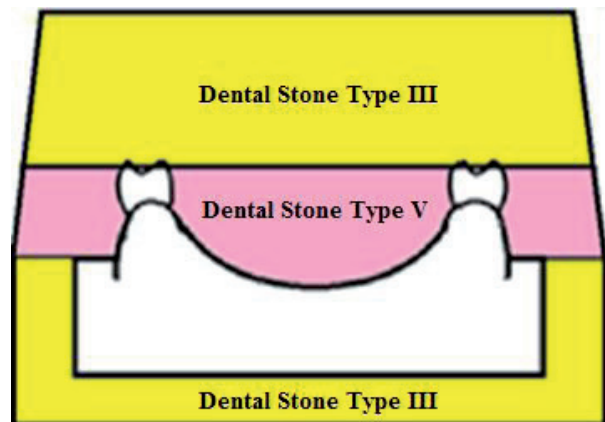


Figure 4. Schematic drawing of the gypsum mould cross-section of DST V specimens.

edges of the anterior teeth and the tips of the cusps of the posterior teeth (the middle portion of the mould or the cope), and the remaining portion of flask (cap) was filled with artificial type III dental stone (Fig. 3). In DST V, the procedure was the same as DST III except for the second layer (the cope) that was made of a type V high expansion dental stone (BK GIULINI GmbH, Ludwigshfen /Rh, Germany) (Fig. 4). The water/ powder ratio was 23 ml: 100 g.

A compression molding technique was used to preparing all dentures. The heat-polymerized acrylic resin (Vertex Regular, Vertex) was mixed with a polymer: monomer ratio of 3: 1 by volume. When the mixture reached a dough consistency, it was placed in the mould over the teeth. A sheet of separating plastic was applied between the gypsum and the acrylic resin. The flask was closed and submitted to trial packing procedure. The final closure was at 24.13 N/mm<sup>2</sup> and maintained for 30 min. The acrylic resin was polymerized in water with a long polymerization cycle. The polymerizing unit (Hanau Engineering Company, Buffalo, N.Y., U.S.A.) was controlled to increase the temperature to 74°C at 1 hour, and then kept at 74°C for 8 hours. After polymerizing and cooling inside the water bath to room temperature, deflasking was carefully completed. The processed dentures attached to the casts were returned to their original mountings and secured using plaster of Paris (type II). The vertical dimension between reference lines drawn on the upper and lower members of the articulator was measured once again. A Shapiro-Wilk Normality Test was applied, and then collected data were analyzed with t-test statistics for statistically significant differences at the 95% confidence level.

## RESULTS

The two groups revealed small but statistically significant increase in vertical dimension between the upper and lower arms of articulator. Mean values of OVD changes and standard deviations in two groups were: DST III (0.721 ± 0.077), and DST V (0.157 ± 0.060). In each group, the vertical measurements which were made at the wax denture stage and after processing were compared. The difference between vertical dimensions in DST III, as a result of processing, was significant (t = 29.63, P<.05). Results indicated a significant difference for DST V (t = 8.33, P<.05) (Table 1). Average pin opening was compared between the two groups with a separate variance independent t test. The increase in vertical dimension was significantly less for DST V than in DST III (t = 18.32, P<.05) (Table 2).

## DISCUSSION

In accordance with results of the present research, the stated null hypothesis was rejected. The used of type V high expansion dental stone as investing material for denture procedure may possibly aid in a reduction of increase in OVD which results from polymerizing process.

Properties of acrylic resin of complete dentures have been improved but undesirable shrinkage is still a problem<sup>21-23</sup>. A comparison of changes in OVD is considered an important method for estimating new denture base materials and processing techniques<sup>24</sup>. The rise of the incisal pin from the incisal table after processing dentures using dental stone investing medium and compression moulding technique has been reported in several studies<sup>10,11,15-17,25</sup>.

**Table 1.** Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Investing method									
Group DST III	Postpolymerization-prepolymerization	0.72100	0.07695	0.02433	0.66595	0.77605	29.630	9	0.000*
Group DST V	Postpolymerization-prepolymerization	0.15700	0.05964	0.01886	0.11434	0.19966	8.325	9	0.000*

\*Statistically significant (p<0.05)

**Table 2.** Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Differences	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper			
Change in OVD	Equal variances assumed	0.874	0.362	18.320	18	0.000*	0.56400	0.03079	0.49932	0.62868
	Equal variances not assumed			18.320	16.945	0.000*	0.56400	0.03079	0.49903	0.62897

\*Statistically significant (p<0.05)

In the study of Mosharraf *et al*<sup>18</sup>, Barbosa<sup>24</sup>, Keenan *et al*<sup>26</sup> and Swords *et al*<sup>27</sup> an increase of OVD of a single denture was recorded rather than overall pin opening on both maxillary and mandibular complete dentures. The OVD could have been increased as a result of movement of the upper and lower posterior teeth during processing, so measuring an increase of OVD of a single denture was not particularly accurate<sup>27</sup>. This study aimed to reduce the amount of incisal pin opening by pouring high expansion dental stone for making the middle portion (the cope) of the mould.

Twenty sets of simulated upper and lower wax dentures were prepared, so the variation in polymerization changes which may result from differences in shape and size were precluded<sup>17</sup>. Changes in OVD were measured by using a digital caliper according to the method proposed by Mosharraf *et al*<sup>18</sup>, Barbosa *et al*<sup>24</sup> and Swords *et al*<sup>27</sup>.

Heat-activated resin suffers from two kinds of shrinkage during the polymerizing process. When it is mixed, the density of the mass changes. This change in density results in a polymerization shrinkage<sup>8,28</sup>. In the early stages of the cooling process, the resin remains relatively soft, and it is submitted to contraction at approximately the same rate as the surrounding investing material. When cooling becomes beyond the glass transition temperature of the resin, the mass of resin exhibits thermal shrinkage which occurs at a rate different from that of surrounding investing material<sup>28</sup>. Consequently, the variant shrinkage rate of investing materials may affect the overall dimensional changes of processed denture bases.

In the current study, the two investing methods produced a small increase in vertical measurements after processing the simulated complete dentures (DST III:  $0.721 \pm 0.077$ ; DST V:  $0.157 \pm 0.060$ ); and the difference was statistically significant. These results are compatible with those of previous studies that showed an increase in OVD of complete dentures as a result of processing<sup>10, 11, 13, 16, 17, 24, 25, 29</sup>. The mean increases in OVD after processing for DST III was greater than those found by Strohaber (0.63 mm)<sup>17</sup> and Wesley *et al* (0.56 mm)<sup>30</sup> but less than Nogueira *et al* (1.16 mm)<sup>11</sup>, Basso *et al* (0.872 mm)<sup>29</sup> and Dukes *et al* (0.76 mm)<sup>15</sup>. An important fact is that the mean increases in OVD for DST V was less than those found by aforementioned authors. The different results among these studies may be attributed to differences in form and size of the casts, acrylic resin used, and number of trial packing(s)<sup>29</sup>.

Comparisons between dentures fabricated by using type V dental stone (DST V) and those fabricated by using type III dental stone (DST III) showed that the increase in OVD was significantly less for DST V. Differences in the content of water in two investing materials may explain this result. Teraoka and Takahashi<sup>31</sup> stated that reduction in the amount of free water in the gypsum mold plays considerable role in fabricating well-fitting dentures. Type V high expansion dental stone contains less water in the powder-water ratio when compared to type III dental stone. This fact can probably contribute to provide more OVD accurate in dentures procedure with less incisal pin opening.

The compressive strength of gypsum products is conversely related to the water/ powder ratio of the mix, and consequently, type V dental stone shows an even higher compressive strength than does the type III dental stone<sup>28</sup>. Type V dental stone with higher strength may probably

restrict the artificial teeth movement and contribute to reducing the increase in OVD of complete dentures.

The increases in OVD for both investing methods were less than 1 mm and in accordance to Nelson *et al*<sup>25</sup> these changes are considered clinically acceptable. Complete dentures made by using type V dental stone as investing material may be easier to adjust after processing because of the smallest increase in OVD. Clinicians may think about this type of dental stone as investing material to reduce adjustment time during insertion of the dentures.

Limitations of the present in vitro study include that changes in OVD during denture construction are affected by several factors. In this study, changes were evaluated when the type V dental stone was used to embed only the middle portion of the flask.

The findings of this study suggest that the investing material has a positive effect on changes in OVD of complete dentures occurring during the denture construction. There also seems to be a need for further research to understand the effects of investing materials and techniques on the mechanism of changes in OVD of complete dentures.

## CONCLUSIONS

Within the limitation of the current investigation, it could be concluded that using type V high expansion dental stone as investing material for embed the middle portion of the mould may probably to reduce the increase of the OVD in complete dentures which results from polymerizing process.

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