ORIGINAL ARTICLE

Effect of Investing Materials on Changes in Occlusal Vertical Dimension of Complete Dentures: A Comparative Experimental Study from Jamshoro, Pakistan

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ABSTRACT

Objective: The purpose of this study is to compare changes in occlusal vertical dimension when dental plaster versus dental stone is used as the investing material.

Study Design: Comparative experimental study.

Place and Duration of Study: This study was conducted at the Department of Prosthodontics, Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan, from December 2024 to May 2025.

Methods: An edentulous silicone mould was used to fabricate sixty identical sets of maxillary and mandibular stone casts. Pre-polymerisation occlusal vertical dimension (OVD) was recorded at the wax denture stage, and post-polymerisation OVD was measured after denture deflasking using a digital caliper. The difference between the two measurements represented the change in occlusal vertical dimension.

Prior to the main study, a pilot study was conducted to estimate the sample size. The mean change in occlusal vertical dimension for Type III dental stone was 1.098 ± 0.107 mm, while the mean change for the comparison group was 0.602 ± 0.033 mm. The dentures were then divided into two groups based on the investing medium: Dental Stone Type II and Dental Stone Type III. Data were analysed using SPSS version 22. The Mann–Whitney U test was applied, and $P \leq 0.05$ was considered statistically significant.

Results: Median occlusal vertical dimension was 1.115 mm (interquartile range = 0.14) in the hard plaster group and 0.605 mm (interquartile range = 0.04) in the soft plaster group. A statistically significant difference was observed ($U = 900$, $P = 0.005$), with greater dimensional changes in the hard plaster group (effect size $r = 0.859$).

Conclusion: The investing medium significantly affects changes in the occlusal vertical dimension of complete dentures. Using high-expansion dental stone type III investment material may increase occlusal vertical dimension discrepancies during denture fabrication in comparison with dental stone type II investment material.

Keywords: *Complete Denture, Polymethyl Methacrylate, Vertical Dimension*.

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Introduction

In prosthodontics, polymethyl methacrylate (PMMA) is often used for the fabrication of artificial teeth, denture bases, dentures, obturators, orthodontic retainers, temporary or provisional crowns, and the repair of prostheses.[1] Researchers have found that PMMA denture bases offer a number of desired qualities, such as biocompatibility, outstanding aesthetics, insolubility in oral fluids, and low cost.[2] Despite the benefits, PMMA is still not considered as an ideal denture base material due to some dimensional changes, for

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example, as heat-polymerised acrylic resin dentures exhibiting a linear shrinkage of 0.3–0.5% during processing, followed by water-induced linear expansion of 0.1–0.2%, resulting in residual shrinkage of 0.1% to 0.4%.[3,4]

These dimensional changes can result in alteration of the occlusal vertical dimension (OVD), which is the superior-inferior relationship of the maxilla and mandible when the teeth are in maximum intercuspation. Which is typically regarded as the distance between the incisal pin and the incisal plate on the articulator.[5] A number of variables, such as the investment method, investment material, flasking technique, polymerisation process, and cooling method, can affect the stability and OVD of dentures during processing. It is common to notice changes in incisal pin opening and occlusal contacts both before and after processing. A analysis has documented measurable vertical deviations in processed dentures when comparing different processing techniques, underscoring that even subtle changes remain clinically relevant.[6] Salloum AM found an average incisal pin opening of < 1 mm after processing of denture prosthesis.[7]

Studies have also reported alterations in the occlusal vertical dimension, resulting in traumatic occlusion, inefficient mastication, and increased ridge resorption.[8] Addressing these problems frequently requires aggressive occlusal modifications, which could damage the prosthetic teeth's structure.[9] In addition, post- processing dimensional stability also affects patients' fit of dental prosthesis and hence, affects their satisfaction.[10] Several attempts have been made to improve polymethylmethacrylate physical characteristics by co-polymerisation as well as altering the investing and processing processes, such as packing, curing, and moulding methods.[11] More recently, in vitro investigations, such as that by Sayed ME et al., have focused on tooth position shifts resulting from various processing methods but have not isolated the effect of investing stone expansion as the sole variable influencing vertical dimensional changes.[6]

Although the dimensional changes in dentures with the effect of investing media related to processing techniques or using mixed investing materials have been studied previously, there is limited recent evidence specifically examining the comparisons among high- and low-expansion stones and their distinct effects on OVD.[6,12] Therefore, there was a need for further studies specifically evaluating the effect of different expansion dental stone types on vertical dimension.

Methods

This study was conducted at the Department of Prosthodontics, Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan, from December 2024 to May 2025, after obtaining ethical approval from the Institutional Ethical Review Committee of the university vide letter no: PR-058, dated: 12th August 2024.

Using the OpenEpi sample size calculator, the minimum sample size per group was 2 due to the large mean difference and small standard deviations. However, to ensure adequate statistical power and reliability and to fulfil minimum methodological requirements, a final sample size of 30 specimens per group was selected.

An edentulous silicone mold was used to create sixty identical sets of upper and lower stone casts. The casts were made with DST II (Pak Plaster of Paris, Falcon) and poured at a water-to-powder ratio of 28 ml:100 g. Denture bases were made with self-polymerising acrylic resin, and pink baseplate wax was used to fabricate occlusion rims. Using a semi-adjustable articulator (Bio Art A7 Plus) with standard settings, the casts were mounted. And artificial acrylic resin teeth were arranged in balanced occlusion.

A silicone matrix was used to replicate dentures. Two spur holes were added. Wax dentures

were created using molten baseplate wax poured into the matrix. A remounting jig was fabricated to standardise measurements. Vertical dimensions were measured using a digital caliper (accuracy 0.01 mm) between marked reference points before and after polymerisation. The dentures were divided into two groups based on the investing medium: Dental Stone II group- (all portions of the flask filled with Type II dental plaster),

- Dental Stone III group-all) portions of the flask filled with Type III dental stone i.e, water: powder ratio 23 ml: 100 g).

Compression moulding with heat-cured acrylic resin was used to fabricate dentures. The final closure pressure was 24.13 N/mm2 for 30 minutes. Polymerisation followed a long cycle: 1 hour to reach 74 °C, held for 8 hours. After cooling, dentures were de-flasked and remounted for post- polymerisation OVD measurements.

Data was analysed using SPSS v22. Means, SDs, medians, and interquartile ranges were computed. The Mann-Whitney U test was used for non-normally distributed data. A *P*-value ≤ 0.05 was considered significant.

Results

The occlusal vertical dimension (OVD) measurements for the hard and soft plaster groups are summarized in Table 1. The median OVD was 1.105 mm (SD = 0.105) for the hard plaster group and 0.605 mm (SD = 0.041) for the soft plaster group. The mean change in OVD between the two groups was 0.497 ± 0.021 mm. Statistical analysis using the Mann–Whitney U test showed a significant difference between the groups (U = 900, *P* ≤ 0.05), indicating that the type of investment material significantly affects OVD changes.

Table 1: Comparison of Mean/Median changes in occlusal vertical dimension between groups

Outcome	Hard Plaster	Soft Plaster	*Mann–Whitney* Test	*P*- value
OVD change (mm), Mean ± SD	1.105 ± 0.105	0.605 ± .041	U = 900	0.005
OVD change (mm), Median (IQR)	1.10 (0.14)	0.60 (0.04)		
Mean difference in OVD (mm)	0.497 ± 0.021	-		

Dentures invested with hard plaster showed a greater change in occlusal vertical dimension compared to those invested with soft plaster. The median OVD change was 1.10 mm (IQR = 0.14) in the hard plaster group and 0.60 mm (IQR = 0.04) in the soft plaster group. Mann–Whitney U test revealed a statistically significant difference between the two groups (U = 900, *P* = 0.005).

Figure 1 illustrates the distribution of OVD values for the hard plaster group. Most observations clustered around 1.10–1.20, indicating a narrow, symmetric distribution with few lower outliers (e.g., 0.80 and 0.91). This indicates consistent results and minimal variability (SD = 0.105) among samples fabricated using hard plaster.

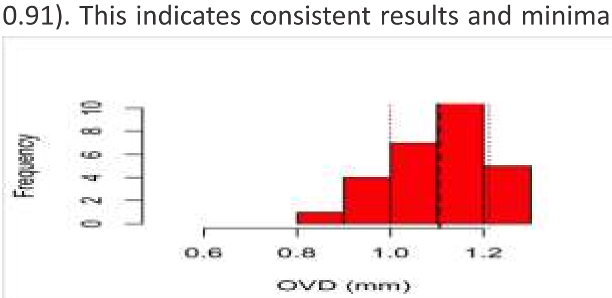

Fig.1: Histogram showing the distribution of occlusal vertical dimension (OVD) in the hard plaster group

Figure 2 presents the distribution for the soft plaster group, with most OVD values ranging from 0.58 to 0.64 mm. The distribution appears tighter than that of the hard plaster group, reflecting lower variability (SD = 0.041). No extreme values were observed in this group, and the data are centered closely around the median (0.605).

Figure 3 directly compares median OVD values

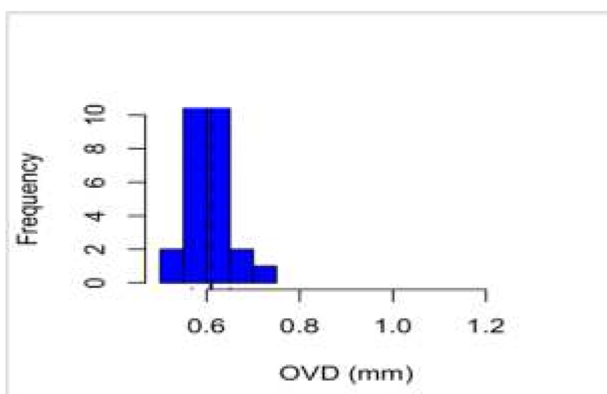

Fig.2: Histogram showing distribution of OVD in soft plaster group

between the two groups, showing that the hard plaster group had a higher median OVD (1.105) than the soft plaster group (0.605). The visual difference highlights the significant reduction in OVD when soft plaster is used as the investment material.

Overall, these results demonstrate that dentures processed with hard plaster maintain a higher and more consistent occlusal vertical dimension compared to those processed with soft plaster, confirming a statistically significant material-dependent effect.

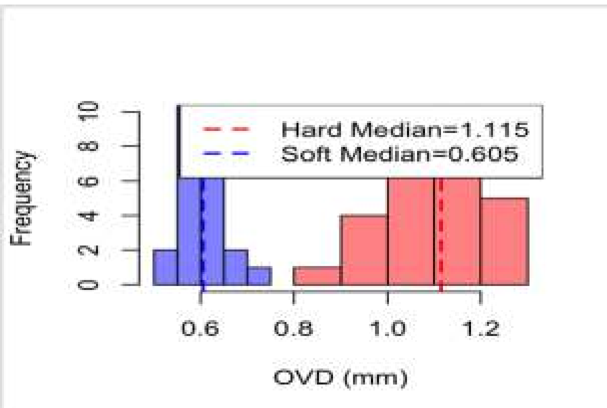

Fig.3: Comparison of median OVD between groups

Discussion

Polymethyl methacrylate (PMMA) is the sole material used for denture base fabrication because of its prime physical and esthetic properties, along with relatively low toxicity as compared to other denture bases. The dimensional changes within denture bases most often result from polymerization shrinkage and stresses released post-polymerization.[13] Mishra S et al. stated that light-activated urethane dimethacrylate resins are more dimensionally stable compared with conventional heat-cured PMMA, validating the fact that both the resin type and polymerization methods affect the distortion of denture bases.[14] Similarly, another study comparing CAD–CAM milled and 3D-printed denture base resins reported thermal aging and temperature-related effects on dimensional accuracy and color stability of denture bases.[15] Furthermore, Altarazi A et al. also reported improved dimensional and mechanical properties with nano filler modified acrylic formulations, indicating that polymer composition remains a critical determinant of denture base performance.[16] All these findings suggest that both material composition and temperature and processing variables play key roles in achieving dimensional stability in denture fabrication. Despite these advancements, undesirable polymerization shrinkage still makes achieving a precise fit and occlusal accuracy challenging.

Any new denture base material or manufacturing technique is the key factor in assessing changes in occlusal vertical dimension (OVD) in order to evaluate dimensional accuracy and clinical performance of the prosthesis. A study reported significantly larger incisal pin openings with compression moulding, resulting in an increase in OVD compared to injection moulding. The authors also mentioned that such issues require laborious occlusal adjustments, which can further hamper the anatomical integrity of artificial teeth.[17] Helal et al. and Gad et al. demonstrated that 3D-printed denture bases exhibit greater dimensional alterations and reduced stability compared with conventional and CAD-CAM milled dentures, while CAD-CAM milling provides superior dimensional accuracy and resistance to aging or thermocycling, thereby aiding in the preservation of occlusal vertical dimension.[18,19] They also reported that, regardless of these advancements in technology, further refinement is required for ideal fabrication in terms of accuracy and ensuring long-term functional and aesthetic benefits in prosthodontics.

Thermal and polymerisation shrinkage are the two primary types of shrinkage associated with heat-activated polymethyl methacrylate (PMMA), with the former resulting in internal stresses and dimensional distortions, and the latter a reduction in volume and potential discrepancies in the final denture dimensions.[20] In addition, the extent of these dimensional changes is influenced by its contact with the investing material, as its thermal conductivity and mechanical properties determine the behavior of acrylic resins during cooling or polymerisation.[21]

In the present study, the mean occlusal vertical dimension (OVD) was 1.105 ± 0.0105 mm in the hard plaster group and 0.605 ± 0.041 mm in the soft plaster group, with an overall mean change in OVD of 0.497 ± 0.021 mm between the two investment materials. The mean OVD value was significantly

higher in dentures processed with hard plaster compared to those
fabricated with soft plaster ($P = 0.0005$).
This suggests that the enhanced stiffness and reduced water content of hard plaster may limit compensatory flow during polymerisation shrinkage, leading to increased vertical expansion after processing. These results are in line with those of Salloum AM et al., who observed that Type III and Type V dental stones increased vertical dimension after denture processing (Group DST III: 0.721 0.077 mm; Group DST V: 0.157 0.060 mm), demonstrating that the investing material's physical characteristics affect OVD stability.[7] Another recent *in vitro* investigation found that complete dentures invested with different materials (dental stone, silicone putty, and plaster–stone mixtures) exhibited significantly different dimensional changes and tooth movement during processing, indicating that the choice of investing medium influences denture stability and fit after flasking.[22] This suggests that the combination of material layering also has an impact on dimensional results. When comparing various flask closure techniques, Maguga and Mthethwa also used dental stone.[9] They concluded that the technique has a significant impact on OVD, with RS flask closure producing lower post-processing OVDs (135.0 +.274) than conventional closure (135.3 +.325), indicating that flask compression and polymerisation stresses can change denture base dimensions. Collectively, these studies support the present finding that both the investing medium and processing method influence OVD stability. The current work offers novel information by directly comparing hard and soft plaster investment, indicating that softer investing materials may better tolerate resin contraction, hence minimizing vertical discrepancies and enhancing dimensional integrity in processed dentures.

Conclusion

The investing medium significantly influences changes in occlusal vertical dimension during complete denture fabrication. Using Type III dental stone results in greater dimensional changes compared to Type II plaster. For improved denture accuracy, DST II may be the preferred investing medium.

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Conflict of Interest: The authors declare no conflict of interest

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Author Contributions

SM: Conception and design of the work, Manuscript writing for methodology design and investigation, Validation of data, interpretation, and write-up of results
PK: Data acquisition, curation, and statistical analysis
AS: Revising, editing, and supervising for intellectual content
NM: Validation of data, interpretation, and write-up of results
HM: Conception and design of the work and supervising for intellectual content
AMB: Revising, editing, and supervising for intellectual content
MRM: Writing the original draft, proofreading, and approval for final submission