IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 7 Ser.4 (July 2025), PP 09-15
www.iosrjournals.org

Comparative Assessment of Investing Materials and Flask Designs on Tooth Position Stability During Acrylization of Maxillary Complete Dentures

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Abstract:
Background: Dimensional fidelity in complete dentures is vital for successful prosthodontic rehabilitation. Shifts in tooth position during processing can compromise fit and occlusion.
Objective: This laboratory-based study aimed to evaluate the influence of three investing agents (plaster, stone, and a 1:1 stone-plaster blend), two flask configurations (two-piece and three-piece), and two polymerization schedules (short and long) on tooth displacement during denture processing.
Methods: Forty-eight standardized maxillary denture specimens were prepared and grouped based on investing media, flask configuration, and polymerization schedule. Pre- and post-processing linear distances from the central incisor to the first molar were recorded with a digital caliper.
Results: Statistical analysis via one-way ANOVA revealed significant intergroup differences. Minimal tooth displacement was observed in samples processed with stone in three-piece flasks using a prolonged curing schedule. Conversely, the combination of plaster, two-piece flasks, and rapid polymerization yielded the highest movement.
Conclusion: Denture accuracy is significantly influenced by material and technique. Optimal outcomes were obtained using stone, three-piece flasks, and extended curing cycles.
Keywords: *Complete denture, investing medium, flask configuration, polymerization method, acrylic resin, tooth displacement, dimensional accuracy*

Date of Submission: 04-07-2025 Date of Acceptance: 14-07-2025

I. INTRODUCTION

Achieving dimensional precision in maxillary complete dentures is essential to ensuring successful functional and esthetic outcomes in prosthodontics. Polymethyl methacrylate (PMMA), a widely used heat-polymerized acrylic resin, is favored for its aesthetics and acceptable mechanical performance. Nonetheless, its inherent polymerization shrinkage can induce tooth displacement and base distortion, adversely impacting prosthesis fit, occlusion, and stability [1,2].

Several factors contribute to these changes, notably the type of investing medium, the design of the flask, and the polymerization schedule. Plaster and dental stone differ in setting expansion, compressive resistance, and rigidity—properties that significantly influence the degree of dimensional change during processing [3]. Additionally, flask design governs pressure distribution during compression molding, while the curing protocol dictates the extent of residual stress and polymerization completeness [4,5].

This investigation aims to analyze how these variables—alone and in combination—influence linear tooth movement. The overarching objective is to identify processing conditions that maintain tooth alignment and minimize distortion.

II. MATERIALS AND METHODS

Sample Preparation:

Forty-eight identical maxillary complete denture specimens were fabricated using uniform molds and tooth positioning. Grouping was as follows:

1. **Investing Media:**
   - Group A: Plaster of Paris
   - Group B: Dental stone
   - Group C: Equal parts stone and plaster

2. **Flask Designs:**
   - Subgroup 1: Conventional two-piece flask
   - Subgroup 2: Modified three-piece flask
3. **Polymerization Schedules:**
   - Short cycle: 100°C for 1 hour
   - Long cycle: 74°C for 8 hours, followed by boiling at 100°C for 1 hour

Figure 1: Wax-up of maxillary complete denture.

Figure 2: Investing denture in two-piece flask with plaster.

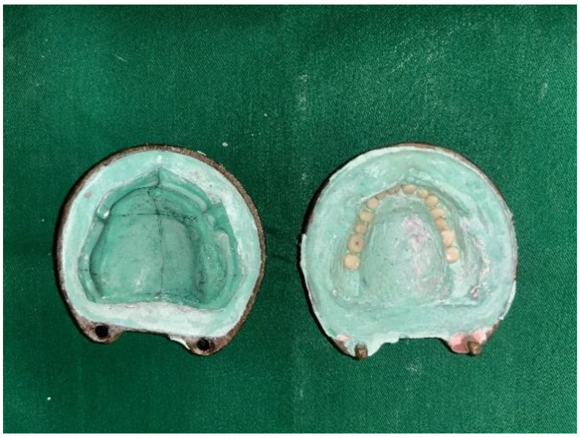


Figure 3: Investing in three-piece flask with dental stone.

Figure 4: Water bath curing.

Figure 5: Measurement of linear tooth movement using a digital caliper.

Figure 6: Final Denture

Processing Protocol:
After dewaxing, PMMA resin was packed into the molds during the dough stage. Samples were processed per assigned curing cycles and then bench-cooled for 30 minutes to allow internal stress relaxation.

Measurement Protocol:
Tooth displacement was quantified using a digital caliper to measure the linear distance from the central incisor (CI) to the first molar (M1) on the same side before and after polymerization.

Statistical Analysis:
Differences between groups were analyzed using one-way ANOVA followed by post hoc Tukey's test. A significance level of $p < 0.05$ was applied.

III. RESULTS

The least displacement was observed in samples invested with stone, cured using the long cycle, and housed in a three-piece flask. Conversely, the highest movement occurred in the plaster-invested group using two-piece flasks and rapid polymerization. Mixed-material groups consistently demonstrated intermediate displacement.

Table -1 Intergroup Comparison of Movement of Teeth with Use of Three Different Investing Materials in Two Piece Flask-Long Cycle

	Mean	Std. Deviation	Std. Error	95% CI Lower	95% CI Upper	Minimum	Maximum	P value
Stone Group	0.313	0.030	0.015	0.265	0.360	0.280	0.350	**0.001{Sig}**
Plaster Group	0.488	0.030	0.015	0.440	0.535	0.450	0.520	
Stone+ Plaster Group	0.425	0.053	0.026	0.341	0.509	0.380	0.500	

One Way ANOVA with p value less than 0.05 is statistically significant

Post Hoc Analysis

		Mean Difference	Std. Error	Sig.	Significance
Stone Group	**Plaster Group**	-0.175	0.028	0.001	Significant
Stone Group	**Stone+ Plaster Group**	-0.113	0.028	0.003	Significant
Plaster Group	**Stone+ Plaster Group**	0.063	0.028	0.049	Significant

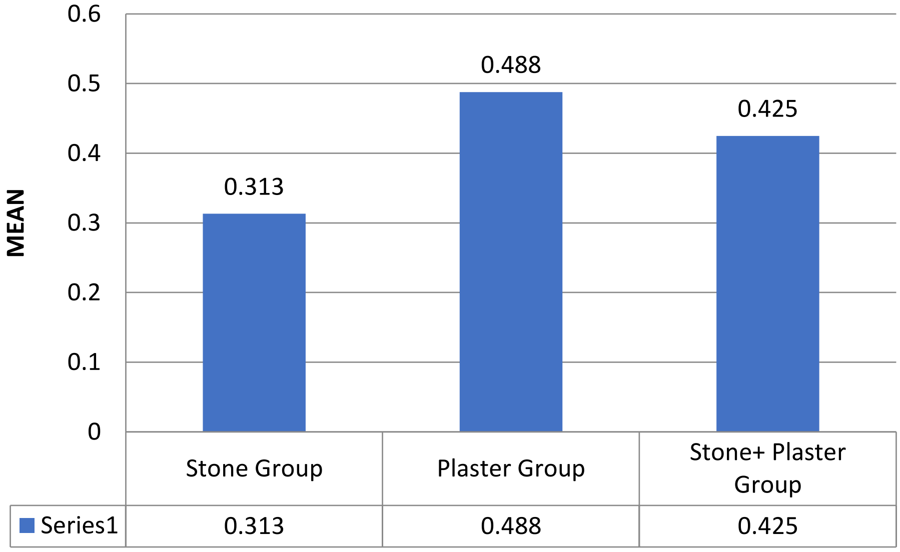


Table -2 Intergroup Comparison of Movement of Teeth with Use of Three Different Investing Materials In Two Piece Flask-Short Cycle

	Mean	Std. Deviation	Std. Error	95% CI Lower	95% CI Upper	Minimum	Maximum	P value
Stone Group	0.505	0.021	0.010	0.472	0.538	0.480	0.530	**0.001{Sig}**
Plaster Group	0.625	0.021	0.010	0.592	0.658	0.600	0.650	
Stone+ Plaster Group	0.558	0.022	0.011	0.522	0.593	0.530	0.580	

One Way ANOVA with p value less than 0.05 is statistically significant

Post Hoc Analysis

		Mean Diff	Std Error	P value	Significance
Stone Group	**Plaster Group**	-0.120	0.015	0.001	Significant
Stone Group	**Stone+ Plaster Group**	-0.053	0.015	0.007	Significant
Plaster Group	**Stone+ Plaster Group**	0.068	0.015	0.002	Significant

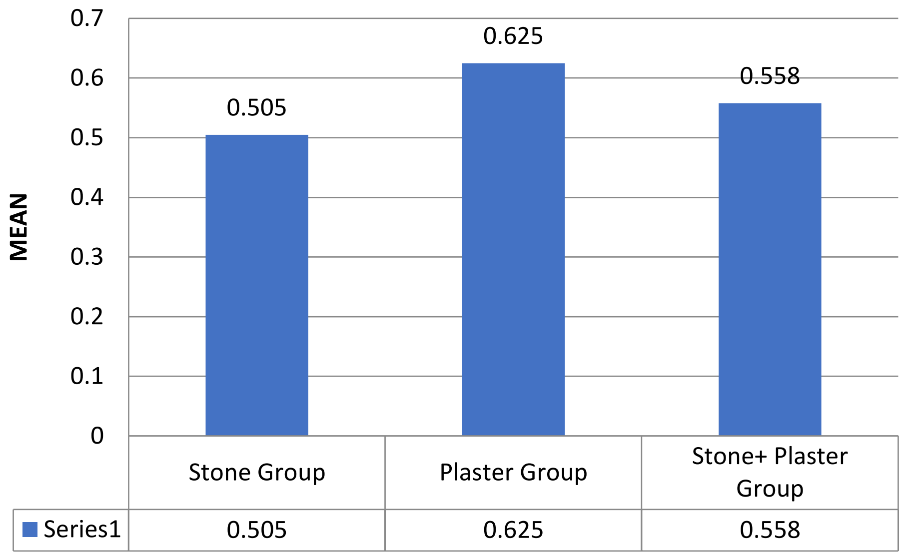


Table -3 Intergroup Comparison of Movement of Teeth with Use of Three Different Investing Materials In Three Piece Flask- Long Cycle

	Mean	Std. Deviation	Std. Error	95% CI Lower	95% CI Upper	Minimum	Maximum	P value
Stone Group	0.175	0.021	0.010	0.142	0.208	0.150	0.200	**0.001{Sig}**
Plaster Group	0.313	0.030	0.015	0.265	0.360	0.280	0.350	
Stone+ Plaster Group	0.248	0.017	0.009	0.220	0.275	0.230	0.270	

One Way ANOVA with p value less than 0.05 is statistically significant

Post Hoc Analysis

		Mean Diff	Std Error	P value	Significance
Stone Group	**Plaster Group**	-0.138	0.016	0.000	Significant
Stone Group	**Stone+ Plaster Group**	-0.073	0.016	0.002	Significant
Plaster Group	**Stone+ Plaster Group**	0.065	0.016	0.003	Significant

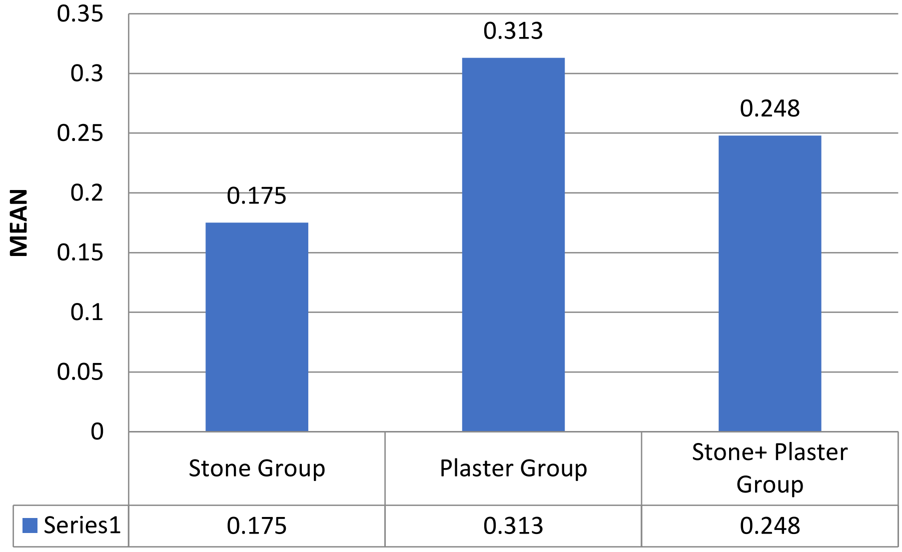
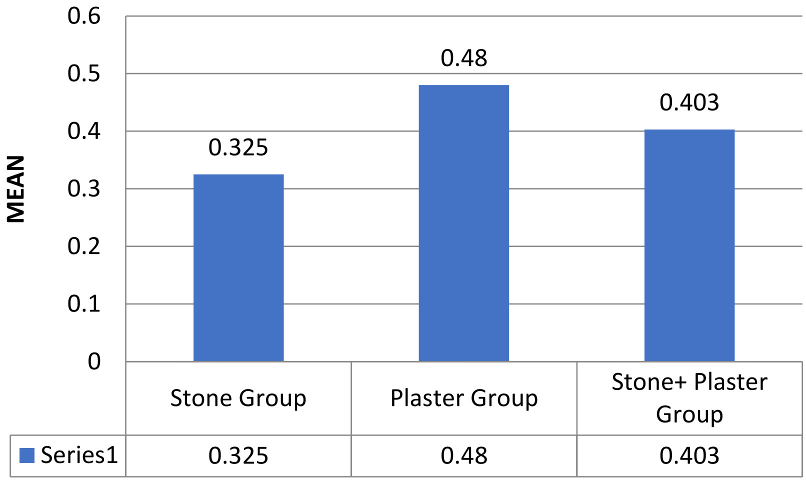


Table -4 Intergroup Comparison of Movement of Teeth with Use of Three Different Investing Materials In Three Piece Flask- Short Cycle

	Mean	Std. Deviation	Std. Error	95% CI Lower	95% CI Upper	Minimum	Maximum	P value
Stone Group	0.325	0.021	0.010	0.292	0.358	0.300	0.350	**0.001{Sig}**
Plaster Group	0.480	0.022	0.011	0.446	0.514	0.450	0.500	
Stone+ Plaster Group	0.403	0.017	0.009	0.375	0.430	0.380	0.420	

One Way ANOVA with p value less than 0.05 is statistically significant
Post Hoc Analysis

		Mean Diff	Std Error	P value	Significance
Stone Group	**Plaster Group**	-0.155	0.014	0.001	Significant
Stone Group	**Stone+ Plaster Group**	-0.078	0.014	0.001	Significant
Plaster Group	**Stone+ Plaster Group**	0.078	0.014	0.001	Significant



IV. DISCUSSION:

Impact of Investing Materials:

Plaster, although economical and widely available, exhibits high setting expansion and lower compressive strength, contributing to denture base distortion. Studies have shown that its reduced mechanical resistance allows compression during flasking, resulting in significant tooth movement [6]. Dental stone, in contrast, offers superior dimensional control due to its lower expansion and higher rigidity [7]. The 1:1 plaster-stone combination demonstrated moderate performance, suggesting partial compensation of plaster's weaknesses.

Comparison of Flask Types:

The conventional two-piece flask lacks uniform pressure containment during processing, often leading to distortion. The three-piece design, incorporating a central ring, provides better alignment and pressure distribution. Machado et al. documented improved dimensional accuracy with three-piece flasks versus traditional designs [8].

Influence of Polymerization Cycles:

Extended curing allows gradual temperature increase and complete monomer conversion, minimizing residual stresses and distortion [3]. In contrast, short cycles induce rapid thermal changes, causing incomplete polymerization and internal stress, which increase the risk of tooth displacement. This aligns with findings by Kawara et al., who observed enhanced dimensional stability with longer curing regimens [3].

Justification of Material Choice:

The selection of plaster, stone, and their mixture reflects common clinical scenarios. Although plaster is cost-effective, its use may compromise quality. Dental stone, despite higher cost, ensures better outcomes. The mixed formulation provided a feasible compromise between cost-efficiency and performance [9].

Role of Three-Piece Flask Design:
The added ring in three-piece flasks enhances support along both vertical and lateral planes, reducing stress and minimizing displacement. When used with high-strength investing agents like dental stone, the results were notably more stable.

CLINICAL SIGNIFICANCE:
Accurate tooth positioning minimizes occlusal discrepancies and reduces chairside adjustments. Enhanced dimensional control improves prosthesis fit, retention, and patient comfort. This study reinforces the need for strategic selection of materials and processing techniques in routine prosthodontic practices [10].

V. CONCLUSION:

Within the scope of this laboratory study, the following conclusions were drawn:

- Dental stone ensures the highest dimensional stability compared to plaster and its mixtures.
- Three-piece flasks provide more consistent pressure distribution than two-piece designs, thereby reducing tooth displacement.
- Prolonged curing cycles are superior in mitigating polymerization shrinkage and residual stress.

Combining stone as the investing medium, three-piece flasking, and a long curing cycle is recommended for precise denture fabrication.

VI. LIMITATIONS:

- Laboratory conditions do not replicate intraoral variables.
- Only linear tooth movement was assessed; angular changes were not evaluated.
- The sample size may limit generalizability.

VII. FUTURE SCOPE:

- Implementation of 3D scanning and CAD/CAM analysis for comprehensive evaluation
- Exploration of innovative investing media and bio-compatible resins
- Inclusion of post-processing factors such as deflasking technique and delayed bench-cooling

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