

Evaluation of Elastomeric Impression Techniques and Tray types on Dimensional Accuracy of First and Second-Pour Dental Stone Casts: An In Vitro Study

Dr. Himabindu Ravella¹, Dr. Gnana Sruthi Mayakuntla²

¹Professor, Department of Prosthodontics, GITAM Dental College & Hospital, Visakhapatnam, Andhra Pradesh, India
Corresponding Author Email: [hravella\[at\]gitam.edu](mailto:hravella[at]gitam.edu)

²PGT, Department of Prosthodontics, GITAM Dental College & Hospital, Visakhapatnam, Andhra Pradesh, India

Abstract: ***Aim:** To assess the dimensional accuracy of first- and second-pour dental stone models fabricated from four impression techniques using metal and plastic stock trays. **Materials and Methodology:** Measurement-specified Stainless steel dies (ADA no. 19) simulating tooth preparations was mounted in a typodont teeth set. Polyvinylsiloxane impressions were made with "One-step", "Two-step", "Monophase", and "New Two-step techniques", in combination with metal and plastic full-arch and dual-arch trays. First- and second-pour casts were evaluated using a Coordinate Measuring Machine (CMM) to measure changes in mesiodistal width and occlusogingival height relative to the master dies. **Results:** Statistical analysis (One-way ANOVA, t-tests, two- and three-way ANOVA) have been done to analyze the study data. The New Two-step technique exhibited the least difference in the dimensions of casts than other techniques. Resultant casts from impressions made with Metal trays showed the slightest difference in dimensions compared to Plastic trays. The p-values ($p < 0.05$) from statistical analysis shows that width and height significantly differed in values for the Monophase technique and Plastic trays between first and second pour casts. **Conclusion:** The "New Two-step technique" yielded accurate working casts among the impression methods tested. Metal full-arch trays provided greater accuracy than plastic trays. First-pour casts demonstrated better dimensional accuracy than second-pour casts.*

Keywords: Impression trays, Impression techniques, Dental stone casts, Dimensional accuracy

1. Introduction

A fixed prosthesis to replace the missing teeth is the preferred treatment for patients due to its comfort¹. Impressions must capture precise surface details of the teeth, remain compatible with dental stone products, and maintain dimensional accuracy². The dimensional changes in impression can significantly impact fit of the prosthesis. Therefore, selecting appropriate impression materials and techniques is critical to successful treatment outcomes. Polyvinyl siloxanes introduced in the 1970s accurately reproduce surface details and exhibit remarkable dimensional stability³. Impression techniques can be single-phase or dual-phase⁴. The essential requirements of an impression tray are rigidity and stability so that it can confine the material to make an impression⁵. Christophe introduced dental impression trays in 1820⁶. Stock trays are available in metal and plastic materials as full, partial, and dual arch trays.

Dimensional accuracy of impressions with repeated pour is of clinical interest⁷. Duplicate dies are helpful when the original die is affected in a critical area, or at the margins of the abutment. The accuracy of the dental casts obtained from repeated pour depends upon the elastic recoil of the material during cast retrieval and polymerization shrinkage. It is essential to understand the role of different impression methods on the accuracy of the resultant dies after multiple pours⁸. The present study aims to evaluate the dimensional changes of the first and second-pour dental stone casts obtained from impressions of Additional silicone

elastomeric impression material made with four different impression trays and techniques.

2. Methodology

Fabrication of Stainless-Steel Dies: Standardized steel dies are fabricated according to ADA Specification No. 19, with 8.015 mm height, 6.330 mm diameter at the top, and 8.450 mm at the base, were used. Cross-reference grooves were prepared on the occlusal and axial surfaces (Fig. 1). These dies were incorporated into a typodont jaw model to simulate clinical conditions (Fig. 2).

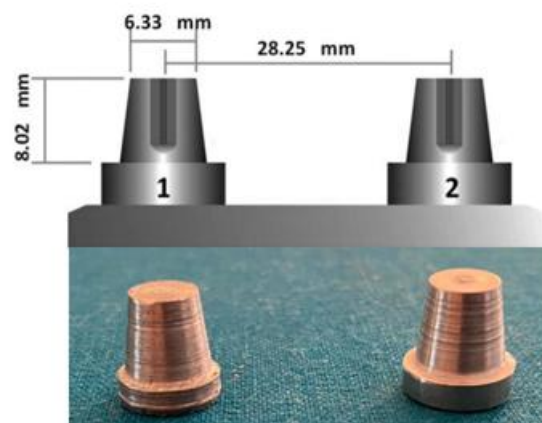


Figure 1: Measurement of Steel dies



Figure 2: Mounted dies with reference grooves

Study Design and Grouping

The study included 160 impressions, divided into four groups (n = 40) based on the impression tray used: Group I Full-arch metal trays; Group II Full-arch plastic trays, Group III Dual-arch metal trays and Group IV Dual-arch plastic trays (Fig. 3). Group were further subdivided into four subgroups (n = 10) according to the impression technique: "One-step technique", "Two-step technique", "Monophase technique" and "New two-step technique". With each group of tray 40 impressions were made (n=10 per technique), resulting in 160 impressions. Each impression was poured twice, yielding 320 casts (first pour = 160; second pour = 160). Dimensional accuracy was assessed using a Coordinate measuring machine (CMM) (GITAM University) (Fig. 4).



Figure 3: Full and Dual arch Metal and Plastic trays



Figure 4: Measurement of cast using CMM

Impression Techniques

- **One-step technique:** Putty (Aquasil) was hand-kneaded until color uniformity was achieved and loaded into the

tray. Light body material was syringed onto the abutments of the typodont (Nissin Dental study model), and the tray was seated on the mandibular teeth. The upper member of the teeth set was closed, and a 1-kg weight was applied over it for standardization of pressure ⁶.

- **Two-step technique:** Initial impression was made with putty (Aquasil) with 1 mm metal copings over the abutments to provide space for the wash material ⁹. After polymerization, the tray was removed, copings detached, and light body was syringed onto the abutments. Impression with putty material was resealed for the final impression.
- **Monophase technique:** Medium body material (Aquasil) was dispensed simultaneously into the tray and directly over the dies using an automix system, and the impression was made.
- **New two-step technique:** The initial impression was done using putty in the tray and light body syringed over 1 mm copings placed over the abutments. After setting, the tray was removed, copings detached, and multiple holes were drilled in the impression with a carbide bur (012 HP 558). The tray was resealed, and extra light body material was syringed through the occlusal holes until it extruded through the tray vents, ensuring complete coverage of the dies ⁴.

Pouring of Working Casts: Impressions were inspected for tears and voids. After one hour, Type IV gypsum stone (Asian Chemicals Pvt. Ltd, India) has been used to pour the casts. After casts were retrieved, the same impressions were repoured to obtain second-pour casts. For dual-arch impressions, die stone was poured only on the working side.

Measurement of Casts: Dimensional accuracy of casts was compared with measurements of stainless-steel dies (height = 8.015 mm; diameter = 6.330 mm at the top, 8.450 mm at the base). Measurements included: Occluso-gingival height of abutments and Mesiodistal inter-abutment distance. These were recorded using a coordinate measuring machine (Faro Gage, USA) equipped with a spherical probe, which measured the distances between cross-reference grooves.

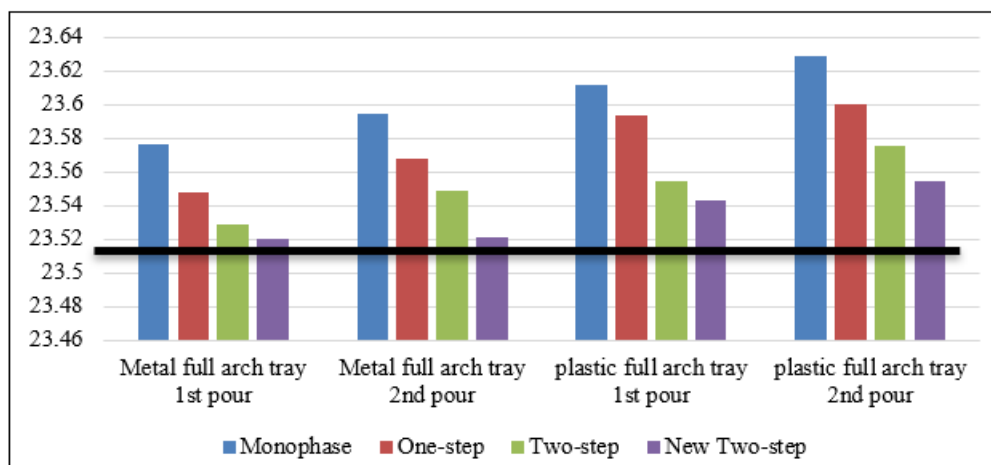
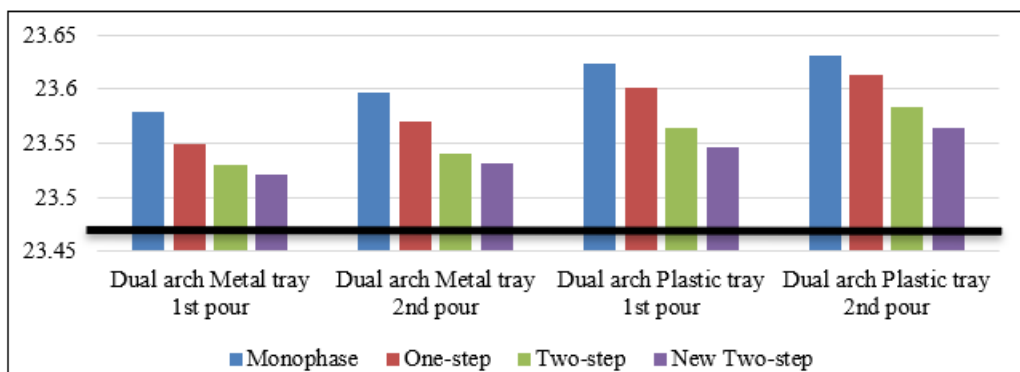
Statistical Analysis: Data was analyzed by IBM SPSS v20 (IBM Corp., Armonk, NY, USA). Independent t-tests were applied for inter-group comparisons. One-way, two-way, and three-way ANOVA were done to assess the effect of tray type, impression technique, and pour sequence on dimensional accuracy (mesio-distal width and occluso gingival height) of dental casts.

3. Results

In the present study, Table 1 summarizes the mean values comparing the alterations in the width of all first and second pour stone casts. An increase in mesio-distal width compared to stainless-steel dies [Graph No.1(a) and 1(b)] is observed from the results. The new two-step technique and full arch metal trays produced the most dimensionally accurate casts in relation to width, followed by the two-step, one-step, and monophase techniques.

Table 1: Comparison of Mesiodistal width between first and second pour dental stone cast

Parameter	Tray	Technique	First pour	Std. Deviation	Second pour	Std. Deviation	P value
Mesio-distal width	Metal Full Arch Tray	One-Step	23.5473	.40988	23.5673	.44576	0.375
		Two-Step	23.5291	.25945	23.5490	.49993	0.065
		Monophase	23.5761	.44263	23.5941	.42396	0.113
		New Two-Step	23.5201	.29242	23.5213	.41207	0.328
	Plastic Full Arch Tray	One-Step	23.5932	.24111	23.6001	.25973	0.74
		Two-Step	23.5541	.27544	23.5749	.30906	0.841
		Monophase	23.6112	.24290	23.6289	.20412	0.027*
		New Two-Step	23.5431	.25441	23.5543	.31828	0.289
	Dual Arch Metal Tray	One-Step	23.5500	.44138	23.5701	.41865	0.007*
		Two-Step	23.5299	.35147	23.5401	.29345	0.015*
		Monophase	23.5799	.43701	23.5968	.49027	0.224
		New Two-Step	23.5216	.53793	23.5316	.45504	0.056
	Dual Arch Plastic Tray	One-Step	23.6014	.19666	23.6129	.26056	0.002*
		Two-Step	23.5641	.22697	23.5841	.48543	0.008*
		Monophase	23.6231	.21776	23.6314	.33831	0.12
		New Two-Step	23.5461	.16191	23.5643	.23385	0.006*

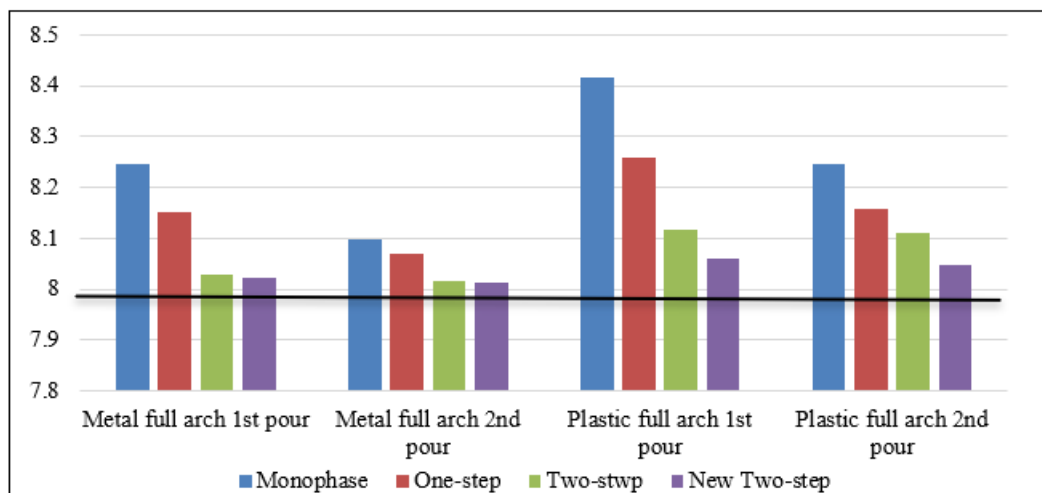
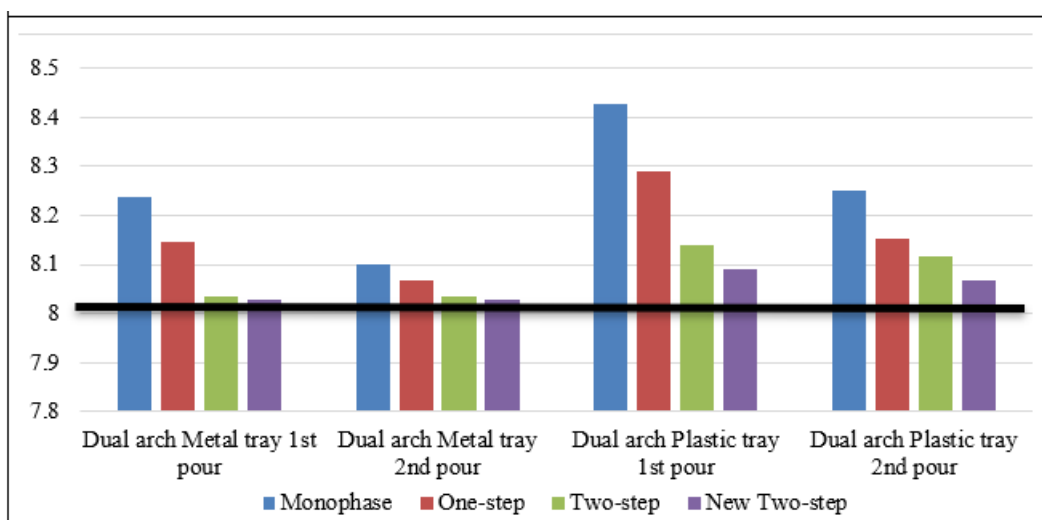
**Graph 1a:** Comparison of Mesio-distal width of first and second pour dental casts within Full arch Metal and Plastic trays**Graph 1b:** Comparison of Mesio-distal width of first and second pour dental stone casts within Dual arch Metal and Plastic trays

The New two-step technique and full arch metal trays produced the most dimensionally accurate casts in relation to height, followed by the One-step, Two-step, and Monophase

techniques. An increase in occluso gingival height compared to stainless-steel dies [Graph No.1(a) and 1(b)] is observed from the results.

Table 2: Comparison of height between first and second pour dental casts

Parameter	Tray type	Technique	First pour		Second pour		P value
			Mean	Std. Deviation	Mean	Std. Deviation	
HEIGHT	Metal Full Arch Tray	One-Step	8.1503	.34732	8.0694	.36404	0.002*
		Two-Step	8.0279	.33780	8.0163	.30016	0.025*
		Monophase	8.2456	.37988	8.0968	.38322	0.527
		New Two-Step	8.0221	.32188	8.0145	.37292	0.065
	Plastic Full Arch Tray	One-Step	8.2589	.15478	8.1589	.22663	0.03*
		Two-Step	8.1159	.04740	8.0197	.16908	0.049*
		Monophase	8.4156	.10865	8.2459	.15467	0.011*
		New Two-Step	8.0611	.06035	8.0486	.12428	0.48
	Dual Arch Metal Tray	One-Step	8.1463	.33039	8.0692	.35424	0.737
		Two-Step	8.0359	.21403	8.0339	.27863	0.014*
		Monophase	8.2389	.37901	8.0999	.37064	0.006*
		New Two-Step	8.0289	.43458	8.0269	.31763	0.147
	Dual Arch Plastic tray	One-Step	8.2888	.25114	8.1531	.32331	0.1
		Two-Step	8.1389	.29089	8.1173	.30605	0.004*
		Monophase	8.4257	.08179	8.2521	.30612	0.64
		New Two-Step	8.0897	.34281	8.0681	.60147	0.019*

**Graph 2a:** Comparison of height of first and second pour dental casts with Full arch metal and plastic trays**Graph 2b:** Comparison of height of first and second pour dental casts within Dual arch Metal and Plastic trays

4. Discussion

The dimensional accuracy of impressions and resultant casts is a key determinant in the success of fixed prostheses ^{10,11}. This study compared four impression techniques using different tray types to evaluate the accuracy of casts from first and second pours. The “New two-step technique”

related to the most accurate casts, while the “Monophase technique” showed the least accuracy. The accuracy of the New two-step technique may be attributed to the reduction in polymerization shrinkage of the wash material ^{4,12}. By injecting extra light body material after the initial impression, contraction was minimized, thereby improving dimensional stability. These findings are consistent with

earlier reports by Caputi and Varvara ⁴ and ShivaKumar et al ¹, who also observed higher accuracy with the new two-step technique than with conventional methods.

Dheeraj Kumar et al ¹³ have demonstrated that silicone impression materials shrink toward the tray walls, producing oversized abutments, which supports the present findings ¹³. This increase can be linked to the expansion of Type IV gypsum during setting. Dugal R's ¹⁴ and Nithin et al. ³ study concludes that the Two-step technique showed the least variation in dimensions of casts compared to the One-step impression technique. In his study, Idris ¹⁵ stated that the inter-abutment distance increased for casts with different impression techniques.

In this study, **Full-arch metal trays provided the highest accuracy**, followed by Dual-arch metal, Full-arch plastic, and Dual-arch plastic trays. The improved accuracy with metal trays can be attributed to their higher rigidity, which resists deformation from the heavy-bodied impression material ^{16,17}. Their modulus of elasticity is approximately 60 times greater than plastic trays. Similar results have been reported by Cho and Chee, ¹⁸ and Santayana de Lima, ¹⁹ who attributed dimensional distortion in plastic trays to their lack of rigidity and greater susceptibility to flexure during impression making and removal. Cox ²⁰ stated that Plastic trays provide flexibility, which reduces support for impression material and may result in deformation. According to Bernd Westmann ²¹, it is the tendency of the tray to reset after deformation, influences impression accuracy.

In the present study, **First-pour casts were more accurate than Second-pour casts**. All the resultant dies from the second pour had greater inter-abutment distance when compared to the first pour casts. The accuracy of stone model from the second pour was affected by the continuing polymerization and distortion of the impression material during the removal of the first cast ²². The distortion between the first and second pour casts was less for metallic trays than for plastic trays due to the rigidity of the trays.

J Nissan (2002) ²² stated that uneven dimensional changes are due to the contraction of impression materials towards tray walls. As continuing polymerization occurs, there is a loss of volatile by-products. This results in a shrinkage of impression material, resulting in a lower cast accuracy. Breeding and Dixon ²³ explained that the increase in the measurement of the height of casts from Dual arch trays is due to more substantial distortion in Plastic trays due to the weight of gypsum. J. R. Broilo ²⁴, in his study, compared the first and second pour casts and stated that Metal trays are better than Plastic trays. Luebke et al. ²⁵ indicated that material shrinkage could be due to the evaporation of alcohol from the silicone impression.

While the findings generally align with previous studies, some contradictory results exist. In a study conducted by Ceyhan, ⁶ dies of shorter height are observed. He also stated that bonding material to the tray may be required to constrain shrinkage movement away from the tray.

For instance, Marcinak ²⁶ reported reduced cast height in second pours due to syneresis and shrinkage of putty-wash silicones over time. Such discrepancies highlight that multiple factors influence dimensional accuracy, including tray material, impression technique, material handling, and storage. Unrestricted polymerization shrinkage of the material would occur without the tray adhesive. Tray adhesives maintain the accuracy of impressions by preventing the unrestricted shrinkage of the material. Their proper use is essential for achieving accurate dental casts.

5. Conclusion

- The **New two-step technique** produced the most accurate casts, followed by the Two-step, One-step, and Monophase techniques.
- **Full-arch metal trays** yielded the most dimensionally accurate casts, followed by dual-arch, full-arch, and dual-arch plastic trays.
- **First-pour casts** demonstrated greater accuracy than Second-pour casts but not statistically significant, indicating that second pours can still be recommended for clinical use.
- These findings have practical implications for dental professionals, guiding them in selecting the most accurate impression technique for their clinical practice.

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