

## Original Research

### Evaluation of Dimensional Accuracy In Addition Silicone Impressions Made By Single Step versus Double Step Impression Techniques

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#### ABSTRACT:

**Purpose:** This study aimed to compare the dimensional accuracy of Addition Silicone Impressions obtained by single step and double step Impression techniques. As precision in impression making is critical for optimal fit, function, and durability of prostheses in Prosthodontics, this study evaluate the accuracy of method for Addition Silicone Impression material used in fixed Prosthodontics. **Materials and Methods:** Study utilized a Maxillary Typodont model to simulate clinical conditions following abutment preparation. A total of Twenty-four impressions were made using addition silicone impression material following single step impression technique and double step impression technique (n=12 each). Type IV gypsum product was used to pour casts, and dimensional accuracy was assessed by measuring three specific linear distances between reference points using a calibrated Digital Vernier Caliper. The collected data were statistically analyzed using SPSS version 27, with significance determined at  $p \leq 0.05$ . **Results:** Study Findings revealed that single step impression technique showed higher linear mean values (36.36, 37.58, 36.27 mm) than the double step impression technique (34.90, 36.79, 35.88 mm) for all measurements, indicating dimensional expansion. Differences were highly significant ( $p < 0.005$ ), with the double step impression techniques showing better accuracy and consistency when compared with single step impression techniques. **Conclusion:** The study concludes that double step impression technique provides superior dimensional fidelity due to stress relief between steps and optimal flow of light-body consistency material, minimizing distortion and improving cast accuracy. **Keywords:** Impression Accuracy, Single-Step Impression Technique, Polyvinyl Siloxane, Double-Step Impression Technique

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#### INTRODUCTION

In fixed prosthodontics, the success of any restoration depends heavily on the accuracy of the impression technique, as it forms the basis for fabricating a well-fitting and long-lasting prosthesis.<sup>[1]</sup> Capturing precise details, especially the finish line of the prepared tooth, is essential for achieving optimal marginal fit and avoiding biological complications such as secondary caries and periodontal inflammation.<sup>[2]</sup> According to ADA Specification Number 19, Polyvinyl siloxane (PVS) addition silicone impression material is the material of choice for most clinicians due to its superior properties, including excellent dimensional stability, tear strength, elastic recovery, minimal polymerization shrinkage, and high detail

reproduction.<sup>[3]</sup> Among the techniques employed with PVS impression material, single-step and double-step impression technique are most commonly used. The single-step impression technique involves the simultaneous use of putty and light body consistency of material, offering simplicity and reduced chair side time.<sup>[4]</sup> However, its major limitation lies in the lack of controlled wash space, which may lead to displacement of the light body consistency material and result in incomplete capture of critical marginal and subgingival details. This can compromise the final restoration's fit and longevity.<sup>[5]</sup> On the other hand, the double-step impression technique involves making a preliminary impression with putty consistency followed by a second step where the light

body consistency material is introduced into the relieved space.<sup>[6]</sup> This method allows for better control over material thickness, improved adaptation, and enhanced detail reproduction, especially in subgingival areas.<sup>[7]</sup> Though it requires more time and careful handling, it often results in superior dimensional accuracy and marginal fit. Since both techniques use the same material, the accuracy of the final impression largely depends on the method of application. Johnson and Craig in 1985, in one of the foundational studies on this topic, highlighted the importance of a uniform spacer for the wash material to prevent distortion.<sup>[8]</sup> More recent research by Caputi and Varvarain 2008 and Nouri et al.<sup>[9,10]</sup> in 2019 further supports this, concluding that the dual-phase, double-step impression technique with adequate space for the wash material is proven to be highly accurate and remains the standard technique for fixed prosthodontics. While some studies have presented conflicting results, others have shown that single-step impression technique, when performed with proper material handling and moisture control, can achieve comparable accuracy with the added benefits of reduced chair side time and fewer procedural steps therefore, this study aims to compare the dimensional accuracy of addition silicone impressions obtained using single step and double step impression technique, to determine which method yields greater precision in fixed prosthodontic restorations.

## MATERIALS AND METHODS

This in-vitro study was conducted in the Department of Prosthodontics and Crown & Bridge. The proposed study was reviewed and approved by the Institutional ethical committee with reference no. IPDC/SS/2024/2198A (17). This is a comparative study to evaluate dimensional accuracy of addition silicone impressions (Express XT, 3M ESPE, Germany) made with single-Step and double-Step impression Techniques. Tooth preparations were performed on the master typodont model using an airtor handpiece with diamond burs (Shofu Dental, India). Occlusal reduction of 2.0 mm was achieved using flat-end tapered diamond burs along with a functional cusp bevel to provide adequate clearance. Axial reduction of 1.0 mm in two planes was carried out using flat-end tapered diamond burs, while proximal contacts were broken with thin tapered needle diamond burs. For the finish lines, 1.0 mm shoulder was prepared by using a flat-end tapered diamond. In Group 1 (n=12) single-Step impression

Technique equal amounts of putty consistency material base and catalyst were hand-mixed and loaded into the perforated tray, while light-body consistency material was injected onto the abutments using an auto-mix syringe with an attached tip following manufacturer instructions. The tray was then seated with uniform pressure, ensuring homogeneous distribution of the impression material (Figure 1). In Group 2 (n=12) double-Step impression Technique a preliminary impression was made using putty consistency addition silicone material along with a 0.3 mm polyethylene spacer to provide controlled space for the light body consistency material. After spacer was removed, and light body consistency material was applied onto the putty consistency impression and the prepared teeth. The tray was reseated carefully to ensure proper adaptation and reline accuracy (Figure 2). In both groups, tray adhesive (3M™ ESPE™ VPS, USA) was applied and allowed to dry before the impression procedure to enhance bonding between the tray and the impression material. All impressions were visually inspected under adequate lighting to ensure the absence of voids, folds, or tray show-through. The impressions were poured within 30 minutes using Type IV gypsum product (ULTRAROCK, Kalabhai Karsan Pvt Ltd, India) mixed under vacuum, Water-to-Powder ratio to minimize air entrapment and improve cast density (Figure 3). The stone casts were allowed to set for one hour before separation and were then stored at room temperature until further evaluation. Dimensional accuracy was evaluated by measuring three linear distances on each stone cast and comparing them to the corresponding measurements on the master model. The reference points selected were anatomically stable and these were: the distance between the mesio-palatal cusps tip of the maxillary right and left first molars, the distance from the right mesio-palatal cusp tip to the mid-point of incisal tip of the maxillary central incisor, and the distance from the left mesio-palatal cusp tip to mid-point of incisal tip of maxillary central incisor (Figure 4). All measurements were performed using a calibrated digital vernier calliper (Figure 5) with an accuracy of 0.01 mm. To reduce examiner variability, each measurement was repeated three times by a single calibrated operator, and the mean value was recorded. The collected data were analysed using SPSS version 27. Descriptive statistics, including mean and standard deviation, were calculated for each group. One-way ANOVA was used to compare the differences between groups, with the level of statistical significance set at  $p \leq 0.05$ .



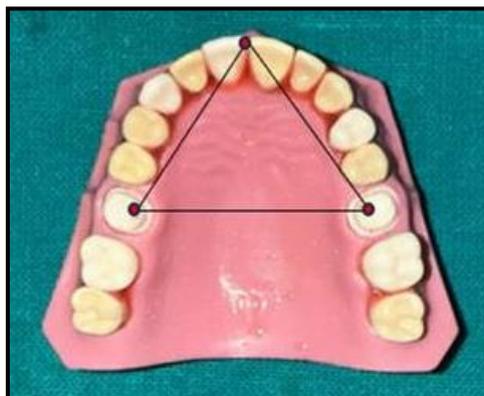
**Figure 1: Group 1 (n=12) Sample Impressions made using the Single-Step Impression Technique**



**Figure 2: Group 2 (n=12) Sample Impressions made using the Double-Step Impression Technique**



**Figure 3: 24 Sample of gypsum poured Casts; A – Single Step impression cast, B – Double Step impression cast**



**Figure 4: Three reference points: Incisal tip of the maxillary right central incisor, Mesio-palatal cusp tip of the maxillary right first molar, Mesio-palatal cusp tip of the maxillary left first molar**



**Figure 5: All measurements were performed using a calibrated Digital Vernier Caliper**

**RESULTS**

The comparison of dimensional accuracy between the single-step and double-step impression techniques revealed statistically significant differences in all measured parameters. Table 1, the dimensional measurements obtained from the double-step addition silicone impressions technique were consistently closer to the standardized reference model and demonstrated lower variability compared to the single-step impression technique. For the distance between the mesio-palatal cusp tip of the maxillary right and left first molars, the single-step impression technique group recorded a mean of 36.3620 mm (SD = 0.09445), whereas the double-step impression technique group yielded a mean of 34.8975 mm (SD = 0.01215). A similar trend was observed for the distance from the right mesio-palatal cusp tip to the incisal tip, where the single-step impression technique mean was 37.5800 mm (SD = 0.09539) and the double-step impression technique mean was 36.7933 mm (SD = 0.01775). For the left mesio-palatal cusp tip to incisal tip, the single-step impression technique mean was 36.2720 mm (SD = 0.11563) compared to 35.8767 mm (SD = 0.01073) for the double-step impression technique group. Table 2, presents the results of the one-way ANOVA, which confirmed that these differences were highly significant for all

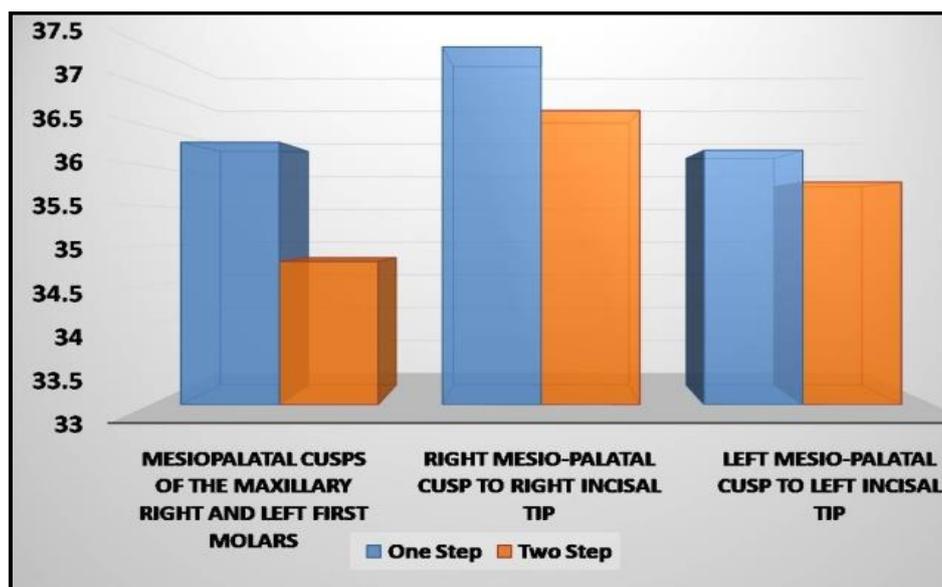
parameters ( $p < 0.001$ ), with F-values of 3043.724, 821.798, and 151.134, respectively, indicating strong statistical evidence for the superiority of the double-step impression technique. A visual representation of the data using a bar graph further illustrated the differences between the techniques. The bars representing the single-step impression technique were consistently taller across all three measured parameters, indicating greater dimensional discrepancies. In contrast, the double-step impression technique showed shorter bars, reflecting values that were closer to the original reference measurements.) Graph 1, showing compared the mean measurements for the single-step and double-step impression techniques across three parameters. In all measurements, the double-step impression technique produced slightly lower mean values—34.90 mm vs. 36.36 mm for mesio-palatal cusp tip of the maxillary right and left first molars, 36.79 mm vs. 37.58 mm for right mesio-palatal cusp tip to incisal tip, and 35.88 mm vs. 36.27 mm for left mesio-palatal cusp tip to incisal tip -indicating reduced distortion and greater dimensional accuracy. The consistent bar height differences visually reinforce the statistical findings that the double-step impression technique is more accurate and reproducible than the single-step impression technique.

**Table 1: Assessment of the dimensional accuracy of impressions made using the single step and double step impression techniques with a standardized reference model**

VARIABLE		Mean (mm)	Std. Deviation (mm)	Min (mm)	Max (mm)
Mesio-palatal Cusps of the Maxillary Right and Left First Molars	Single Step	36.3	0.094	36.28	36.50
	Double Step	34.8	0.012	34.88	34.92
Right Mesio-Palatal Cusp to Incisal Tip	Single Step	37.5	0.095	37.49	37.71
	Double Step	36.7	0.017	36.77	36.82
Left Mesio-Palatal Cusp to Incisal Tip	Single Step	36.2	0.115	36.15	36.41
	double Step	35.8	0.010	35.86	35.89

**Table 2: Comparison of the dimensional accuracy of impressions made using the single step and double step impression techniques with a standardized reference model**

VARIABLE		Mean (mm)	Std. Deviation (mm)	F-value (mm)	p-value, S/NS (mm)
Mesio-palatal Cusps of the Maxillary Right and Left First Molars	Single Step	36.3620	0.09445	3043.724	<0.001,HS
	Double Step	34.8975	0.01215		
Right Mesio-Palatal Cusp to Incisal Tip	Single Step	37.5800	0.09539	821.798	<0.001,HS
	Double Step	36.7933	0.01775		
Left Mesio-Palatal Cusp to Incisal Tip	Single Step	36.2720	0.11563	151.134	<0.001,HS
	Double Step	35.8767	0.01073		



**Graph 1: Compares the mean linear measurements for the single step and double step addition silicone impression techniques across three**

**DISCUSSION**

This comparative study assessed the dimensional accuracy of addition silicone impression material using both the single-step and double-step impression techniques—an important factor in ensuring the success and longevity of prosthodontic restorations. While polyvinyl siloxane (PVS) impression material is well known for its superior mechanical properties, including excellent elastic recovery, high tear resistance, and minimal polymerization shrinkage, the clinical outcome is heavily dependent on the impression technique.<sup>[11]</sup> Even the best material can yield inaccurate results if the method of use is suboptimal. Inaccuracies in impressions can compromise the marginal fit of the final prosthesis, leading to microleakage, plaque accumulation, periodontal irritation, secondary caries, and premature failure of the restoration.<sup>[12]</sup> The double-step impression technique demonstrated significantly greater dimensional accuracy compared to the single-step impression technique. Linear measurements recorded on the resultant casts were more closely aligned with those of the reference master model in the double-step impression technique group, with consistently lower standard deviations. This reflects a higher degree of precision and reproducibility, likely

due to two main factors: first, the stress relaxation of the putty consistency material after its initial polymerization; and second, the creation of a uniform, controlled wash space for the light-body consistency material.<sup>[13]</sup> This wash space allows the low-viscosity PVS material to flow freely and adapt intimately to critical areas, particularly around the finish line and in subgingival regions, thereby improving fine detail reproduction. In contrast, while the single-step technique offers advantages such as reduced clinical time and fewer procedural steps, it involves simultaneous polymerization of both putty and light-body consistency materials.<sup>[14]</sup> This can result in uneven material distribution, particularly in the gingival sulcus, and increased polymerization stresses, which may negatively impact the accuracy of the impression. The problem is more pronounced in subgingival areas or when gingival retraction is inadequate, as the wash material may be displaced by the putty during tray seating. From a clinical perspective, the double-step impression technique, although more technique-sensitive and time-consuming, is better suited for cases requiring the highest degree of precision—such as long-span fixed partial dentures, implant-supported restorations, and esthetically critical anterior prostheses. Its ability to

capture fine anatomical details and provide more accurate working casts can directly influence restoration fit, reduce the need for adjustments, and improve long-term success rates.<sup>[15]</sup> Despite its valuable insights, this in vitro study did not replicate intraoral conditions such as saliva, patient movement, soft tissue dynamics and temperature changes which can influence impression accuracy.

## CONCLUSION

The study concluded that the double-step impression technique using addition silicone material demonstrated superior dimensional accuracy compared to the single-step impression technique. Statistically significant differences were observed across all measured parameters, with the double-step impression technique consistently producing values closer to the actual dimensions of the reference model. These findings emphasize the importance of selecting an impression technique that minimizes distortion and enhances clinical precision. The double-step impression technique may therefore be recommended in prosthodontic practice where accuracy is critical for the fit and longevity of prosthetic restorations.

## Clinical Significance

The impression technique chosen by the clinician plays a decisive role in the accuracy, fit and longevity of the final prosthesis. In situations demanding exceptional precision—such as implant-supported restorations, extensive fixed partial dentures, or esthetically demanding cases—the double-step impression technique remains a preferred option. By providing a controlled and uniform space for the light-body consistency material, it allows for accurate reproduction of fine margins and detailed tooth anatomy. This reduces the risk of distortion during seating, resulting in a working cast that closely matches the actual tooth preparation. A more accurate cast leads to a prosthesis that fits better, requires fewer adjustments, and is less likely to cause complications over time. In addition, improved fit enhances both the comfort and satisfaction of the patient, while saving valuable chairside time for the clinician. Hence, choosing the impression technique that best matches the clinical situation and required level of accuracy is essential for achieving consistent, high-quality results in prosthodontic treatment.

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