Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies *NLM ID: 101716117*

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Indian Citation Index (ICI) Index Copernicus value = 100

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

Assessment of Dimensional Accuracy of Three Elastomeric Impression Techniques Using 3D Digital Superimposition: An In Vitro Study

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ABSTRACT:

Purpose: To evaluate and compare the dimensional accuracy of three elastomeric impression techniques—Matrix Impression System (MIT), Putty Reline Technique (PRT), and Multiple Mix Technique (MMT)—using 3D superimposition analysis. **Materials and Methods:** A Frasaco mandibular model with typhodont teeth was modified to simulate a 3-unit fixed partial denture. Thirty impressions (n = 10 per group) were made using three techniques (MIT, PRT, and MMT) with polyvinyl siloxane (PVS) materials. The resulting casts were scanned using a laboratory scanner, and Root Mean Square (RMS) deviations from the master model were computed using 3D superimposition software. **Results:** Group B (MIT) exhibited the lowest mean RMS deviation (0.0071 ± 0.0099 mm), followed by Group A (PRT) (0.0285 ± 0.0065 mm) and Group C (MMT) (0.0549 ± 0.0079 mm). The differences were statistically significant ($p < 0.05$). **Conclusion:** The Matrix Impression System demonstrated superior dimensional accuracy compared to the Putty Reline and Multiple Mix Techniques. CAD-CAM analysis provided precise and reproducible measurements of trueness. Clinically, the findings highlight the importance of selecting an accurate impression method to improve prosthesis fit, reduce chairside adjustments, and enhance patient outcomes. It may be recommended for clinical situations requiring high-precision prosthetic outcomes

Keywords: matrix impression, putty reline, multiple mix, polyvinyl siloxane, 3D superimposition, prosthodontics

Received: 20 July, 2025 Accepted: 23 August, 2025 Published: 28 August, 2025

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This article may be cited as: Agarwal A, Khandelwal M, Yadav N. Assessment of Dimensional Accuracy of Three Elastomeric Impression Techniques Using 3D Digital Superimposition: An In Vitro Study. J Adv Med Dent Scie Res 2025; 13(8):66-71.

INTRODUCTION

Restoring severely damaged or aesthetically compromised teeth is a common challenge in prosthodontics, often due to caries, fractures, or other conditions. Fixed Dental Prostheses (FDPs), supported by natural teeth or implants, are a reliable solution for restoring function and esthetics. [1] Their long-term success depends on factors like esthetic integration, mechanical strength, and, most importantly, precise marginal adaptation. [2]

Among FDPs, Fixed Partial Dentures (FPDs) are widely accepted. However, their clinical success hinges on the accuracy of each procedural step—particularly impression making, which forms the basis for the final prosthesis. [3–4] Accurate impressions must clearly capture the finish lines of prepared teeth. This often requires gingival displacement, especially in subgingival areas, and effective control of fluids and tissue. Inadequate impressions can result in poor marginal fit, leading to secondary caries, cement failure, and periodontal complications. [5–6]

The choice of impression material and technique is crucial. Addition silicones (polyvinyl siloxanes) are preferred due to their dimensional stability and elastic recovery. [4] Among techniques, variations like one-step, two-step, matrix, and multiple-mix methods offer different outcomes in terms of accuracy and ease of use.

Most previous studies used 2D measurements, which lack detail in evaluating the full surface accuracy. Advancements in digital scanning and 3D superimposition software now allow more precise assessments of dimensional accuracy. [7 23] However, there is still no standardized method for evaluating impression accuracy, and many tools—such as

microscopes or callipers—are limited in detecting subtle surface discrepancies. [8–9]

The matrix impression technique, using a custom matrix for sulcular management and subgingival detail capture, has shown potential in improving outcomes in complex cases. [16–18]

This study aims to compare the dimensional accuracy of three impression techniques—Putty Reline, Matrix Impression, and Multiple Mix—using 3D superimposition methods.

METHODS

This in-vitro study was conducted in the Department of Prosthodontics, Rajasthan Dental College & Hospital, Jaipur, and Yadav Dental Lab, Ajmer. It aimed to evaluate and compare the dimensional accuracy of three impression techniques: the Putty Reline Technique, the Matrix Impression Technique, and the Multiple Mix Technique**.**

A mandibular Frasaco model with a missing first molar (36) was used as the master model. The second premolar and second molar were conservatively prepared for a 3-unit fixed partial denture using standard guidelines for ceramic crowns (shoulder finish line, 6–10° taper, 2 mm occlusal clearance, 1.5 mm axial reduction).

Impression materials used included:

Study Groups:

Group A: Putty Reline Technique

Group B: Matrix Impression Technique

Group C: Multiple Mix Technique Each group included 10 test specimens.

Custom Tray Fabrication: Irreversible hydrocolloid impressions were made to pour preliminary casts. Two layers of baseplate wax were adapted with three tissue stops, covered with aluminum foil, and custom trays were fabricated using self-cure acrylic resin. After polymerization, trays were trimmed and adhesive was applied.

Group A – Putty Reline Technique Custom trays were fabricated with a 2 mm wax spacer and three tissue stops (central incisor and non-functional cusps of third molars). After removing the wax spacer, tray adhesive was applied. For the two-step impression, addition silicone putty was mixed and loaded into the tray, then covered with a cellophane sheet to create relief for the wash material. The tray was seated onto the model and allowed to set. The set impression was removed, and the cellophane was discarded. Light body impression material was then applied both on the set putty and around the prepared teeth. The tray was reseated carefully to avoid compressing the putty. After setting, impressions were examined for voids, stored at room temperature for 30 minutes, and poured with Type IV dental stone. Casts were allowed to set for 1 hour before retrieval.

RESULT

The results of the present study demonstrated a significant variation in dimensional accuracy among the three impression techniques evaluated—putty reline (Group A), matrix impression (Group B), and multiple mix technique (Group C). Using CAD/CAM superimposition software, STL files of each of the 10 impressions per group were compared with the STL file of the master model to assess trueness. The mean trueness values were found to be 0.05495 ± 0.00793 for Group A, 0.02851 ± 0.00647 for Group B, and 0.07795 ± 0.00998 for Group C. These results indicate that Group B exhibited the highest dimensional accuracy, followed by Group A, with Group C showing the least accuracy.

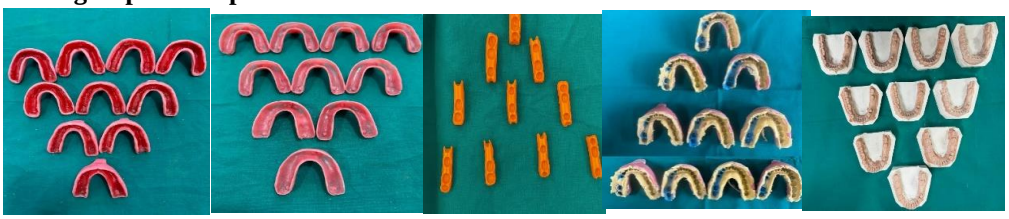
Preparation of Group A test specimens

A- Custom tray with spacer B- Custom tray without spacer C- Putty impression D- Putty reline impression E- Master cast

Group B – Matrix Impression Technique

A wax spacer and custom tray were fabricated as in Group A. A matrix was constructed by adapting two layers of baseplate wax over the prepared teeth, extending one tooth mesially and distally and 2–3 mm beyond the gingival margin. After removing the wax, putty was placed in the matrix and seated on the tooth. Once set, the matrix was trimmed and refined to enhance embrasure space and relieve unprepared teeth. Internal axial surfaces were relieved (0.25–0.75 mm), maintaining the occlusal portion as a vertical stop. The matrix was coated with adhesive, and heavy body material was loaded inside and around the prepared tooth. The matrix was seated with gentle pressure. Medium body impression material was applied in the custom tray, which was then positioned over the matrix. After polymerization, the impression was removed, stored, and poured with Type IV dental stone. Master casts were obtained after a 1-hour setting period.

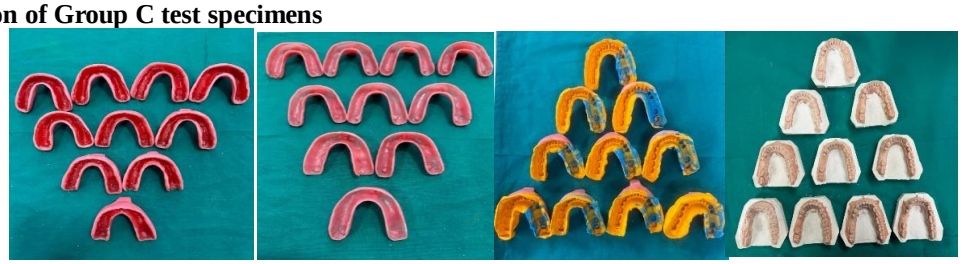
Preparation of group B test specimen



A-Custom trays with spacer B- Custom trays without spacer C- Matrix D – Matrix impression E- Master cast

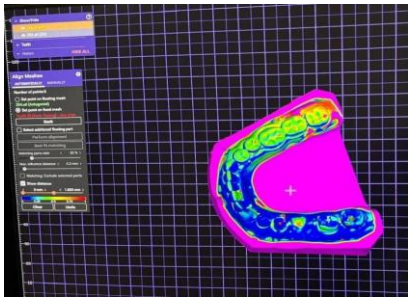
Group C – Multiple Mix Technique Custom trays were used as in previous groups. Heavy body material was dispensed into the tray while light body material was simultaneously syringed around the prepared teeth. The tray was immediately seated over the model and held in position for 8 minutes. Once set, the impression was gently removed. Ten such impressions were made, stored for 30 minutes, and poured with Type IV dental stone. After 1 hour of setting, master casts were retrieved.

Preparation of Group C test specimens



8.A- Custom tray with spacer 8.B – Custom tray without spacer 8.C– Multiple mix impressions 8.D – Master cast

Scanning and Evaluation: All resulting casts and the original acrylic model were scanned using a Medit T310 scanner. The scans were exported in STL format. A 3D inspection software was used to superimpose test scans onto the reference model. Dimensional accuracy (trueness) was measured using Root Mean Square Deviation (RMSD) values.



Statistical Analysis: Data were tabulated and analyzed using one-way ANOVA, followed by Tukey's post hoc test for pairwise comparisons. A significance level of $p < 0.05$ was used.

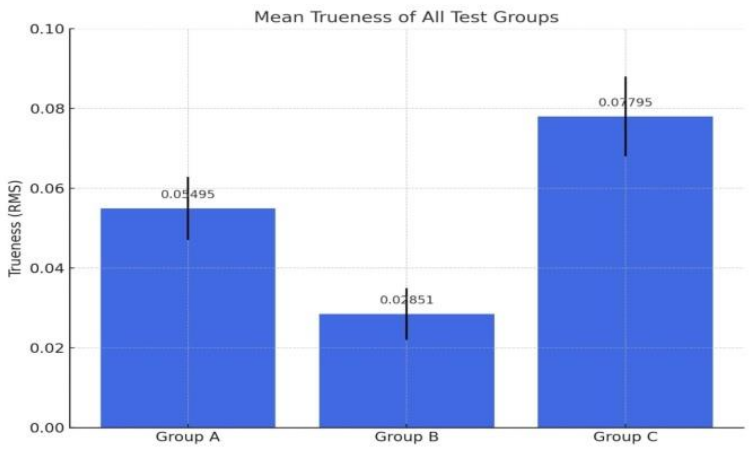


Table – Descriptive statistics for dimensional accuracy(truness) of all test group

Sep.	Mean	Std. deviation	Std. Error	lower Bound	Upper bound	minimum
A	0.0594500	0.00793025	0.00250777	0.0492770	0.0606230	.04275
B	0.0285050	0.00647171	0.00204653	0.0238754	0.0331346	.02010
C	0.0779500	0.00997856	0.00315550	0.0708118	0.0850882	.06550
TOTAL	0.0538017	0.02203673	0.00402334	0.0455730	0.0620303	.02010

A one-way ANOVA test revealed a statistically significant difference among the groups with an F-value of 89.877 and a p-value of 0.000 ($p < 0.05$). This confirmed that the variation in dimensional accuracy between the three groups was statistically significant. Post hoc Tukey's test further showed that all pairwise comparisons between the groups (A vs B, A vs C, and B vs C) were statistically significant, with Group B and Group C showing the highest mean difference (0.0494), and Group A and Group C showing the smallest mean difference (0.0230). Subset analysis also confirmed that each group belonged to a separate statistical subset, reinforcing that Group B had the most accurate impressions, followed by Group A and then Group C. Overall, the matrix impression technique (Group B) was found to produce the most dimensionally accurate impressions among the three techniques studied.

DISCUSSION

The present study compared the dimensional accuracy of three impression techniques—Matrix Impression System, Putty Reline Technique, and Multiple Mix Technique—using CAD-CAM superimposition software. Among the techniques evaluated, the Matrix Impression System exhibited the highest accuracy with the lowest mean RMS value (0.0285 ± 0.00281), followed by the Putty Reline (0.0549 ± 0.00595), and the Multiple Mix Technique (0.0779 ± 0.00780). These findings highlight the significant influence of impression technique on the accuracy and clinical success of fixed prosthodontic restorations.

The Matrix Impression System performed best due to its ability to maintain consistent light-body material thickness, minimize internal stress, and offer better marginal adaptation. This aligns with previous studies by Livaditis[16,17,18] and M Praveen Kumar et al.[25]. Additionally, Priyanka et al.6 validated that matrix-based impressions improve clinical outcomes by reducing marginal discrepancies. The Putty Reline Technique showed moderate accuracy, with variability possibly due to reline timing and pressure inconsistencies, as supported by Badr Idris et al.[14] and Saunders et al.[12]. The Multiple Mix Technique showed the least accuracy due to uneven flow and polymerization errors, consistent with findings by Stackhouse[10], Boulton et al.[15], and Quick et al.[13].

The use of CAD-CAM superimposition provided objective and reproducible assessment of trueness. Previous studies by Brosky et al.[19], DeLong et al.[20], and Limones et al.[33] support the reliability of RMS analysis in evaluating prosthetic fit. Heatmap visualizations further aided in identifying localized deviations, supporting the clinical application of digital verification methods.

Clinically, the Matrix Impression System is recommended for complex cases such as implants and long-span FPDs due to its superior accuracy and minimal chairside adjustments[6]. While the Putty Reline Technique remains a viable option when carefully executed, the Multiple Mix Technique should be used cautiously in situations requiring high precision.

Limitations: Being an in vitro study, intraoral conditions like saliva and temperature were not replicated. Tooth preparation was limited to a single span,[35–37] and all digital scans were performed by a single operator, which may introduce bias.

Clinical Implications: The study reinforces the importance of technique selection for optimal prosthesis fit and supports the integration of digital analysis in clinical practice.

Future Scope: Further in vivo studies are needed to validate findings under clinical conditions. Research should also explore full-arch restorations, long-term stability of materials, and patient comfort outcomes.

CONCLUSION

This in vitro study evaluated the dimensional accuracy of three impression techniques—Matrix Impression System, Putty Reline Technique, and Multiple Mix Technique—using CAD-CAM superimposition software on a standardized mandibular model. Among the three, the Matrix Impression System showed the highest accuracy with the lowest RMS deviation, owing to its controlled wash space and better adaptation. The Putty Reline Technique displayed moderate accuracy but was more technique-sensitive. The Multiple MixTechnique was the least accurate, with the highest deviation values.

CAD-CAM analysis provided precise and reproducible measurements of trueness. Clinically, the findings highlight the importance of selecting an accurate impression method to improve prosthesis fit, reduce chairside adjustments, and enhance patient outcomes. The Matrix Impression System is recommended for high-precision cases like implants and aesthetic restorations.

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