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Comparative evaluation of dimensional accuracy of multi implant impressions made with open tray, closed tray and scan body impression copings – An in Vitro Study

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Abstract

Background: Achieving an absolutely passive fit of prosthetic restorations is nearly impossible due to various error sources. The precise recording of positioning and angulation of implants are crucial for achieving a good fit. There are two main types of impressions used in dental implant treatment: conventional (oen and closed tray) and digital impression techniques. In contrast, digital impressions offer several advantages, including improved accuracy, faster processing times, and enhanced patient comfort.

Aim: To evaluate and compare dimensional accuracy of multi implant impressions made with open tray, closed tray and scan body impression copings.

Materials and Methods: An edentulous maxillary acrylic master model with four parallel implants was fabricated. A total of 15 samples were prepared and divided into three groups (n=5 each) of open tray(OTM), closed tray(CTM), and digital scan body implant

impressions(DM). The samples were analyzed for linear inter-implant distances using a profile projector. Results were statistically evaluated with ANOVA and Tukey's post-hoc tests.

Results: Significant differences were observed with the highest mean discrepancy in the closed tray method (CTM), followed by the open tray method (OTM), with the least in digital method (DM). ANOVA showed significant differences (p=0.003). Tukey's test revealed CTM significantly differed from OTM and DM, while OTM and DM showed no significant difference.

Conclusion: This in-vitro study compared open tray, closed tray, and digital implant impression techniques using a maxillary master model with four implants. Digital impressions showed the highest accuracy, open tray was clinically acceptable, and closed tray least accurate. Within study limits, digital impressions are recommended, though further research is necessary.

Keywords: Intraoral scanner, Digital Impression, Profile Projector, Splinting, Open tray, Closed Tray, Pattern resin, cast accuracy.

Introduction

Dental implant is defined as a prosthetic device made of alloplastic material(s) implanted into the oral tissues beneath the mucosal and/or periosteal layer and on or within the bone to provide retention and support for a fixed or removable dental prosthesis; a substance that is placed into and/or on the jaw bone to support a fixed or removable dental prosthesis;(GPT- 9)[1]. Implant treatment has proven to be durable and predictable option for the placement of missing teeth in oral cavity. The evidence has shown outstanding success as well as subsequent improvement in the quality of life for the individual concerned[2]. Recent implantology standards focus on achieving optimal esthetic and functional outcomes through parameters like adequate bone height, width, projection, soft-tissue quality, and preservation of the buccal sulcus and gingival contour. Solutions for insufficient ridge height include short implants, vertical ridge augmentation, or cantilever prostheses[3].The open-tray technique allows direct removal of impression copings, while the closed-tray retains them for repositioning, useful in limited space or posterior regions. Conventional impressions can be digitized, but intraoral scanners with scan bodies enable direct capture of implant positions. Digital workflows reduce distortion, chairside time, and procedural steps, improving accuracy, patient comfort, and efficiency in implant prosthetics.[4] Digital Technology, particularly CAD/ CAM and intraoral scanners (IOS), has transformed implant dentistry by enabling accurate digital impressions for prosthesis fabrication. IOS capture 3D data via laser or structured light, processed into virtual models. Accuracy depends on trueness (matching reality) and precision (consistency). While reliable for single units, challenges arise in edentulous and multi-implant cases due to limited landmarks and stitching errors. Factors influencing accuracy include implant number, depth, scan body design, and material. Advances in IOS and scan body design are key for improved outcomes.[5] The purpose of the present *in vitro* study was to measure and compare the dimensional accuracy of full arch implant impressions with open tray impression technique, closed-tray impression technique and with intraoral scanners (IOS) using scan body transfer copings. Accuracy was defined as mean dimensional difference between the superimposed digitized control model and digitized models from different impression techniques.

Materials and Method

Implant Master Model

An edentulous maxillary acrylic master model was prepared using impression compound to obtain a

cast(Fig.1). Following flasking and dewaxing (Fig.2), the acrylic master model was finalized. Four implant analogs were drilled from first molar to first molar region, placed parallel using a dental surveyor, and labeled 1, 2, 3, and 4. (Fig.3)

Fabrication of Custom Tray For Open And Closed Tray Impression Technique

In this study, closed tray and open tray impression posts were secured to implant analogs in the master model. Two sheets of modelling wax were adapted to ensure uniform space for impression material. A custom tray was then fabricated using self-cure acrylic resin, finished, polished, and fitted with auto polymerizing resin handles. Perforations were created with a no.8 round bur to allow venting and proper material flow. The completed tray was subsequently utilized for both open and closed tray Impression Techniques in the Experiment (Fig.4&5).

Impression Techniques

Impressions were made by three implant level impression techniques grouped as:

Group A- Open tray impression technique

Group B- Closed tray impression technique

Group C- Digital scan impression technique

Open Tray Impression Technique

In the open tray technique, custom trays with access windows were used to accommodate transfer copings. Copings were splinted with floss and pattern resin (Fig.9), sectioned, and rejoined to reduce shrinkage stress. Impressions were made with poly vinylsiloxane putty-wash, posts unscrewed, and analogs attached (Fig.6&10). Casts poured with Type IV stone underwent precise linear inter-implant distance analysis using a Profile Projector (Fig.16).

Closed Tray Impression Technique

In the closed tray technique, custom trays were prepared with spaces for transfer copings and coated with adhesive. Polyvinylsiloxane single-step putty-wash impressions were

made and allowed to set(Fig.7). Posts remained in the master model, then analogs were attached and repositioned into impressions using groove indications (Fig.11). Casts poured with Type IV stone underwent precise linear inter-implant distance analysis using a Profile Projector (Fig.15).

Digital Impression Technique

The direct method using a MEDIT intraoral scanner captured 3D digital images of implants with scan bodies (Fig.8&12), generating precise virtual models (Fig.13). Printed using ELEGOO Standard Photopolymer Resin and post-processed in washer and curing chambers, the models incorporated digital analogs at implant sites. These 3D-printed casts were then evaluated for linear inter-implant distances using a high-precision Profile Projector (0.0025 mm accuracy) (Fig.17).

For the implant master model and the study models obtained, the reference point to measure linear inter-implant distance between the implant analogs was taken as the mid-point of the diameter of the analog. In total 15 casts were poured with the analogs respectively and linear inter-implant distance between point 1-2,2-3,3-4,-4,1-3,2-4(Fig.18)were measured using a high-precision Profile Projector (Fig.14).

Using the analogue centres as reference ponts minimized edge- related discrepancies and ensured standardized, reproducible measurements acoss all casts.

Statistical Analysis

The comparison of discrepancy in distance (in mm) from the master model among the three study groups. The maximum mean discrepancy was found in CTM group, followed by OTM group and the least discrepancy from the master model was observed in DM group. The statistical analysis was carried out using analysis of

variance (ANOVA) which showed that there was a statistically significant difference in the mean discrepancy among the study groups.

Post-hoc pair wise comparisons were carried out using Tukey's test which showed that:

- There was a statistically significant difference in discrepancy between CTM and OTM (mean difference=0.077, p=0.003). The mean discrepancy in CTM group was significantly higher than that in OTM group.

- There was a statistically significant difference in discrepancy between CTM and DM (mean difference = 0.113, p<0.001). The mean discrepancy in CTM group was significantly higher than that in DM group.

- There was no statistically significant difference in discrepancy between OTM and DM (mean difference =0.036, p=0.147).

Discussion

Achieving a passive fit in implant-supported prosthetics is challenging due to potential errors, making accurate impressions essential. This in-vitro study compared the dimensional accuracy of open tray, closed tray, and digital scan body–based impression techniques using a maxillary master model with four parallel implants. Fifteen samples were prepared, five for each technique. Conventional impressions (open and closed tray) were made with poly vinyl siloxane, while digital impressions were obtained using intraoral scanning and 3D printing. Casts were analyzed for linear inter-implant and inter-abutment distances using a Profile Projector with 0.0025 mm accuracy. ANOVA and Tukey's post-hoc tests assessed differences across groups. Results revealed that digital impressions produced the most accurate casts, with linear values closest to the master model and minimal variability. Open tray impressions were within clinically acceptable limits but less accurate, while closed tray impressions showed the greatest deviations. Overall, digital techniques demonstrated superior accuracy, reliability, and clinical potential for implant-supported prostheses.

Moura et al., (2018)[6] This study evaluated digital and conventional impression techniques for angulated implants. No significant accuracy differences were found between techniques, and implant angulation did not affect accuracy.

Flügge et al., (2018)[7] compared the accuracy of conventional and digital implant impressions for implant-supported dental prostheses. Their study found high heterogeneity in the accuracy of both conventional and digital impression techniques. Despite promising results, the research indicated a low level of evidence regarding the accuracy of these methods, highlighting a lack of sufficient in vivo data to make definitive clinical recommendations. This suggests that while both techniques can be effective, more comprehensive studies with real-life clinical data are needed to better understand their accuracy and establish guidelines for their use in implant prosthodontics. Muhammed Necati Yasar et al., (2022)[8] This study review highlights the importance of accurate implant impressions for long-term implant success. Factors like impression materials, technique, splinting, implant angle, and number of implants influence accuracy. Open tray splinted impressions are preferred for four or more implants.In the study done by ous we have consensus on the most accurate method which is the intraoral scanning digital impression with scan bodies is better in pasive fit, pressison and accuracy comparative to the other conventional impression technique.

Cappare et al., (2019)[9] compared conventional and digital impressions for full-arch maxillary rehabilitations

supported by six immediately loaded dental implants. The study concluded that the use of an intraoral scanner (IOS) for digital impressions was a reliable alternative to conventional methods for full-arch implant reha bilitations. Digital impressions using the IOS showed satisfactory accuracy and predictability in clinical practice, making it a viable option for clinicians. The study highlighted that digital impressions offer advantages over conventional methods, such as reduced procedure time and increased patient comfort, while still maintaining the accuracy necessary for successful implant restorations. This research supports the growing adoption of digital impression techniques in Implantology, demonstrating their potential to streamline the process without compromising quality or clinical outcomes.

Liu et al., (2019)[10] compared the accuracy of multi-implant impressions for full dental arches made using 3D printing technology with those made using conventional techniques. They found that 3D printed impressions exhibited less deviation in implant position and had stronger mechanical properties compared to conventional impressions. This suggests that 3D printing technology may offer improved precision and durability, making it a promising alternative to traditional impression techniques for full-arch implant restorations.

Papaspyridakos P. et al., (2022)[11] compared the accuracy of full-arch digital scans to conventional implant impressions in 36 edentulous jaws. They concluded that the 3D implant deviations found between the full-arch digital and conventional impressions were within the clinically acceptable threshold. Bedia et al., (2022)[12] This in-vitro study compared the accuracy of open tray, closed tray, and snap-on multiple implant impression techniques using stock and custom trays. The Custom Open Tray technique was found to be the most accurate, followed by Snap-on techniques. As compared the study done by ous say that the digital impression is relatively better.

Albanchez -González M. et al., (2022)[13] evaluated the in vitro accuracy of dental implants impressions taken with intraoral scanner compared with impressions taken with conventional techniques. They concluded that digital impressions are a valid alternative to conventional impressions for partial dentation and single implants, but conventional impressions are considered more accurate. More studies are needed to recommend digital impressions for complete dentation. This study is in favour with the study which we have performed. But when evaluated in terms of accuracy in our study the digital impression is proven to be the better choice.

Conclusion

This in-vitro study compared the dimensional accuracy of open tray, closed tray, and digital scan body–based implant impression techniques using a maxillary master model with four parallel implants. Fifteen impressions were made, five per technique. Conventional impressions used polyvinylsiloxane, while digital impressions were captured by intraoral scanning and 3D printed. Linear inter-implant distances were measured with a high-precision Profile Projector and analyzed statistically. Results showed digital impressions were most accurate, open tray impressions clinically acceptable but less precise, and closed tray impressions least accurate, though within limits. Digital impressions are recommended, but further research is needed for clinical validation.

Fig 1: Impression compound model.

Fig 2: Flasking and dewaxing.

Fig 3: Master model with implants placed.

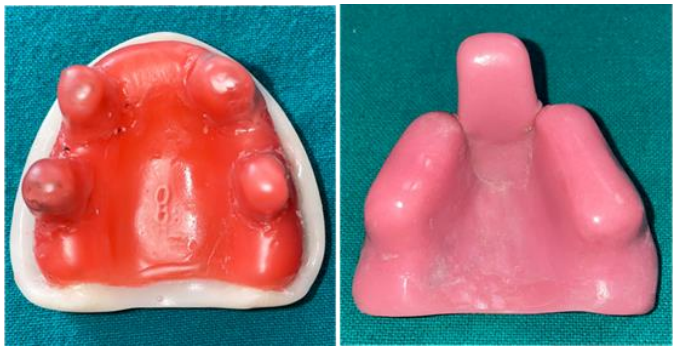


Fig 4: Master model with single and double spacer adapted, closed tray analogues blocked with modelling wax, Costume Tray for closed tray impression technique.

Fig 5: Master model with single and double spacer adapted, open tray analogues blocked with modelling wax, Costume Tray for open tray impression technique .

Fig 6: Master model with open tray analogues.

Fig 7: Master model with closed tray analogues.

Fig 8: Master model with Scan bodies screwed in implants.

Fig 9: Splinting of open tray analogues with dental floss and pattern resin.

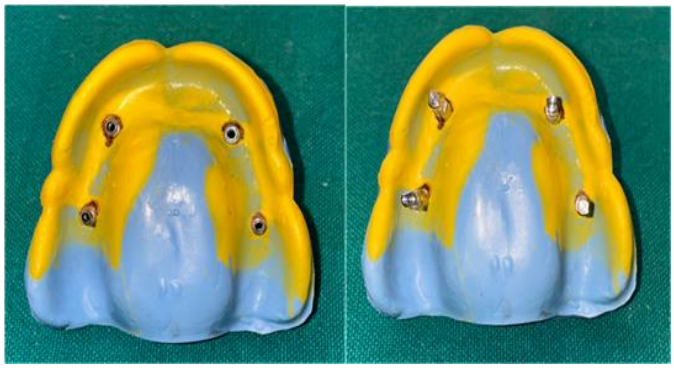


Fig 10: Open tray impression obtained and analoges screwed in place.

Fig 11: Closed tray impression obtained and analogues screwed in place.

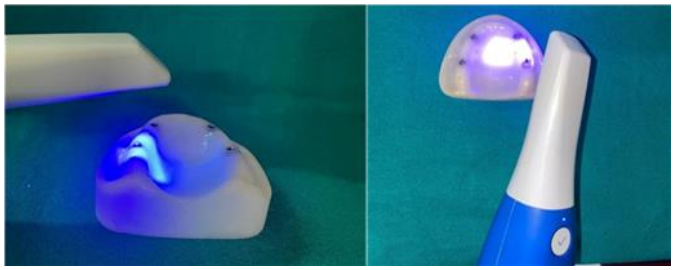


Fig 12: Intra oral scanner and the master model which is being scanned.

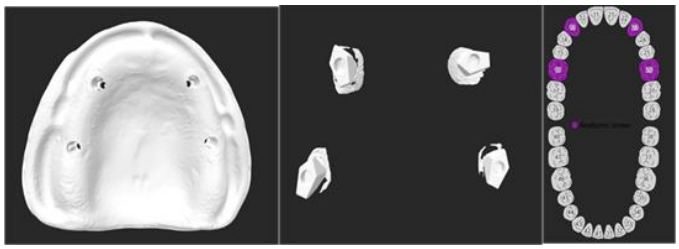


Fig 13: Digital impression obtained with scan bodies screwed in the implants.

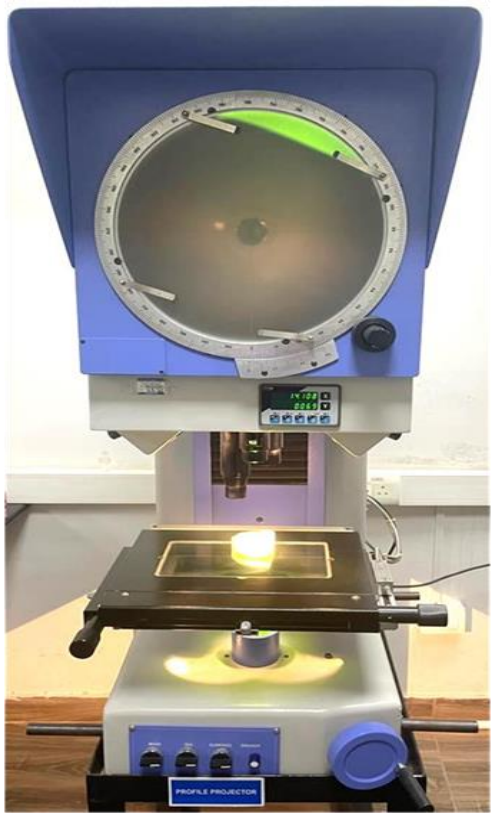


Fig 14: Profile Projector.

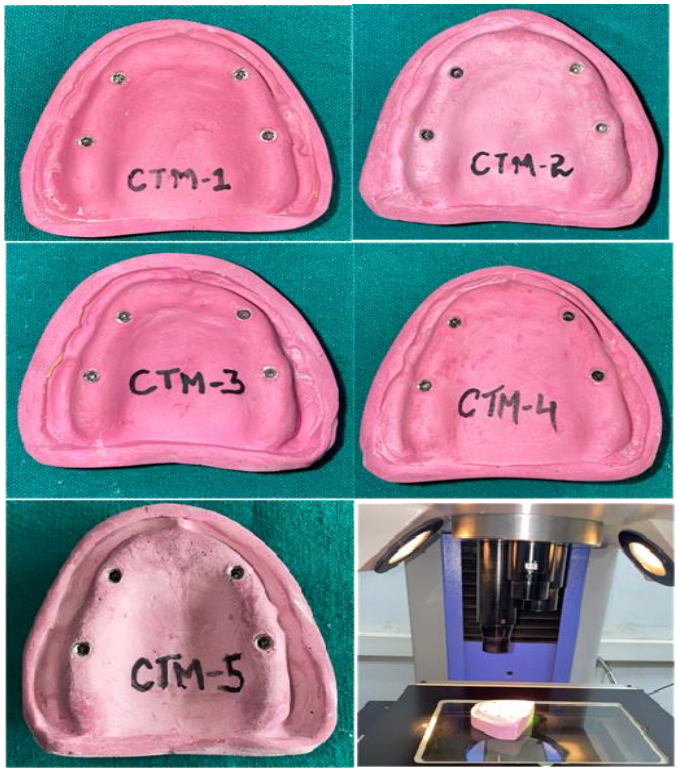


Fig 15: Closed tray model 5 samples and accuracy checked with profile projector.

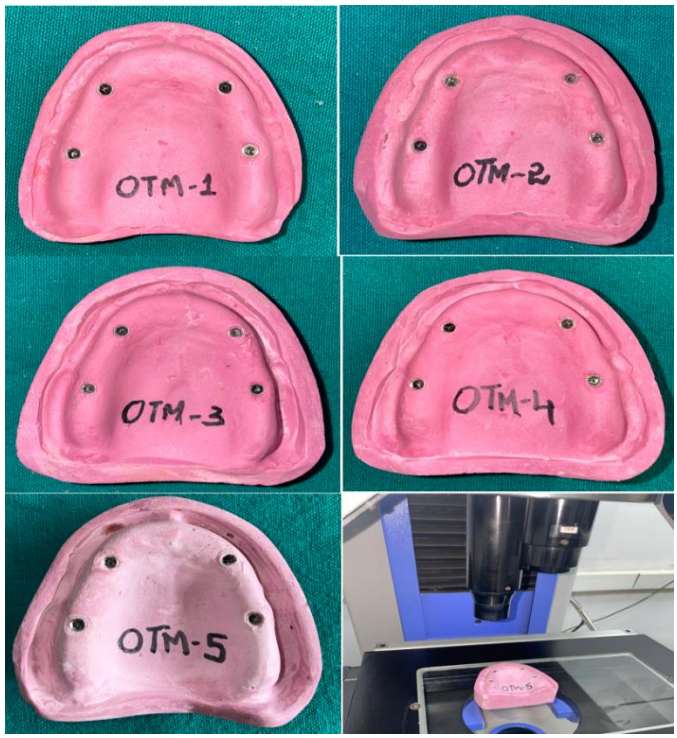


Fig 16: Open tray model 5 samples and accuracy checked with profile projector.

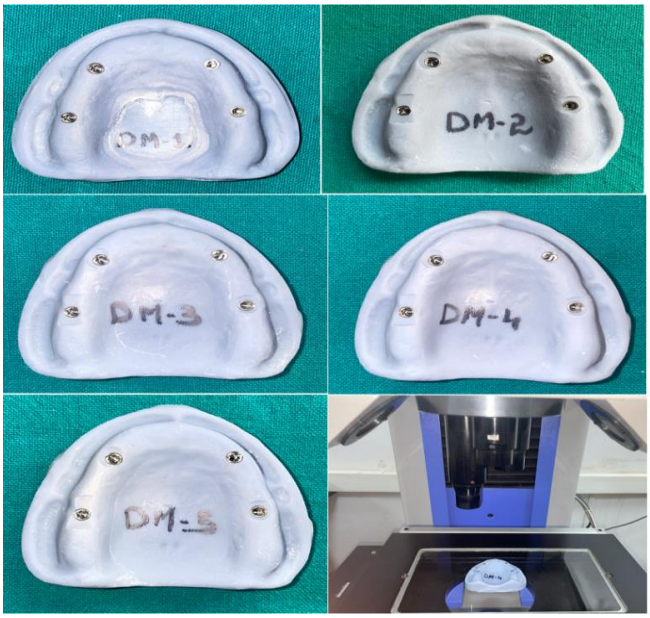


Fig 17: Digital scan model 5 samples and accuracy checked with profile projector.

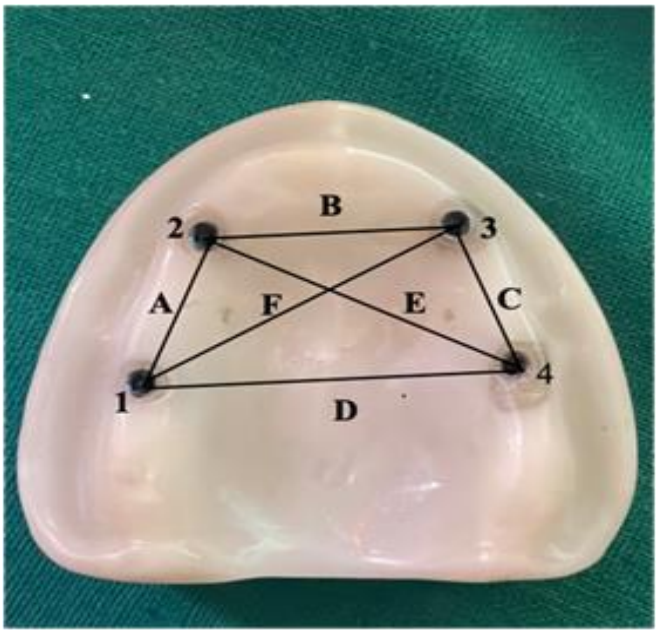


Fig 18: Master Model.

Table 1: Linear inter implant distance value on master casts obtained from closed tray impression technique by measuring on Profile Projector.

Sn.	Date of Measurement	Part No.	Results					
			A	B	C	D	E	F
Master Model			19.416	26.421	18.564	39.662	38.758	36.745
1	2/1/2025	CTM-1	19.328	26.242	18.424	39.523	38.648	36.590
2	2/1/2025	CTM-2	19.368	26.297	18.466	39.581	38.659	36.605
3	2/1/2025	CTM-3	19.330	26.268	18.436	39.499	38.621	36.561
4	2/1/2025	CTM-4	19.343	26.281	18.466	39.584	38.595	36.660
5	2/1/2025	CTM-5	19.364	26.308	18.469	39.517	38.673	36.653
Average			19.347	26.279	18.452	39.541	38.639	36.614

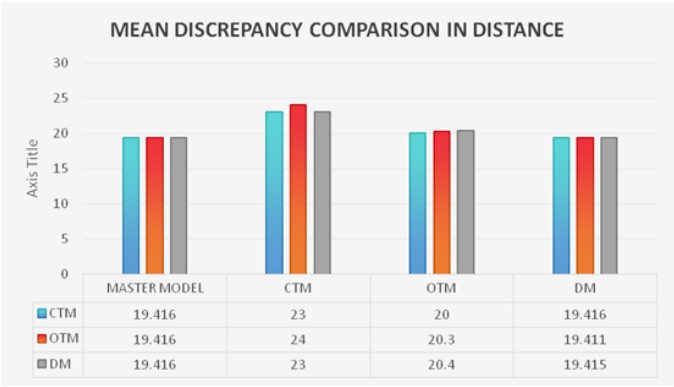
Table 2: Linear inter implant distance value on master casts obtained from open tray impression technique by measuring on Profile Projector.

Sn.	Date of Measurement	Part No.	Results					
			A	B	C	D	E	F
Master Model			19.416	26.421	18.564	39.662	38.758	36.745
6	1/23/2025	OTM-1	19.369	26.285	18.472	39.581	38.683	36.695
7	1/28/2025	OTM-2	19.345	26.319	18.497	39.601	38.664	36.656
8	1/29/2025	OTM-3	19.407	26.347	18.456	39.573	38.700	36.698

9	1/31/2025	OTM-4	19.392	26.301	18.482	39.602	38.706	36.722
10	2/14/2025	OTM-5	19.419	26.315	18.528	39.575	38.679	36.683
Average			19.386	26.313	18.487	39.586	38.686	36.691

Table 3: Linear inter implant distance value on master casts obtained from digital scanned impression technique by measuring on Profile Projector.

Sn.	Date of Measurement	Part No.	Results					
			A	B	C	D	E	F
Master Model			19.416	26.421	18.564	39.662	38.758	36.745
11	1/23/2025	DM-1	19.406	26.401	18.543	39.644	38.746	36.726
12	1/28/2025	DM-2	19.406	26.402	18.541	39.646	38.746	36.725
13	1/29/2025	DM-3	19.407	26.404	18.542	39.644	38.745	36.727
14	1/31/2025	DM-4	19.408	26.402	18.543	39.646	38.743	36.728
15	2/14/2025	DM-5	19.404	26.401	18.544	39.646	38.746	36.728
Average			19.406	26.402	18.543	39.645	38.745	36.727



Graph 1: Comparison of mean discrepancy in inter implant distance in (MM).

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