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Original Research Article

Comparison of dimensional accuracy of digital impression technique versus conventional impression technique on parallel endosseous dental implants: An in vitro study

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ABSTRACT

Background: To create an implant prosthesis that fits well, a precise implant impression is necessary. This in vitro study assessed the dimensional accuracy of open tray impressions vs digital impressions taken with an intraoral scanner for tracking the locations of parallel-placed endosseous implants.

Materials and Methods: Two parallel endosseous implants were positioned in a mandibular customized model made up of epoxy resin at the first premolar sites. The inter-implant distance was measured using a Co-ordinate Measuring Machine (SIPCON SVI CNC 3D). Conventional open tray impressions were made using addition silicone, while digital impressions were captured with an intraoral scanner (CEREC OMNICAM). A total of 10 impressions were collected for both techniques. The inter-implant distance for both groups was measured using the analyzing tool in CEREC Dentsply Sirona software and compared with the CMM readings.

Results: The mean values of the two groups were compared using a Student's t-test, and statistical significance was established using a p-value threshold of less than 0.05. A p-value of 0.547 for the Open Tray group i.e more than 0.05—showed no statistical significance. When compared to other groups, the digital scan group showed statistically significant outcomes with a p-value of 0.031, which is less than 0.05.

Conclusion: Within the limitations of this in vitro study, the results showed that digital impressions demonstrated significantly greater dimensional accuracy compared to conventional (open tray) impressions for parallel-placed endosseous implants.

1. Introduction

Dental implants have transformed modern dentistry, becoming a defining feature of current clinical practices.[1] Nowadays they addressed a broad spectrum of dental replacement requirements, including full-mouth rehabilitation and the restoration of numerous lost teeth. These methods of therapy necessitate careful planning, accurate diagnosis, skill in surgery, and cutting-edge prosthetic reconstruction methods.[2]

The accuracy of the impression-making process for osseointegrated implants, used in rehabilitating fully and partially edentulous patients, is essential for the long-term success of dental implants.[3] Several factors influence the precision of implant impressions, including the choice of impression materials, techniques, splinting of impression posts, the level and depth of the impression, and the implant's angulation. An inaccurate impression can result in incompatibility between the implant and prosthesis, leading to complications such as screw loosening, screw fractures,

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loss of osseointegration, and even implant failure. Thus, maintaining accuracy and utilizing proper techniques in implant dentistry is critically important.[4]

CAD/CAM technology facilitates the fabrication of implant-supported restorations through a fully digital workflow. The process begins with digital impressions, which capture the intraoral condition and create a virtual model, marking a critical first step. The accuracy of this step is essential for treatment success as it ensures the correct transfer of the implant position.[5] Digital impressions not only expedite data collection but also minimize patient discomfort and improve the predictability of prosthesis design and production. To accurately capture implant positions, a specialized transfer post known as an intraoral scan body can be used, as intraoral scanners often struggle to interpret edentulous areas. A digital impression can be taken directly via intraoral scanning or indirectly by scanning models made from conventional impressions. Direct scanning allows the digital data to be transferred directly to a milling unit for model fabrication, eliminating steps such as tray selection, impression technique, disinfection, transportation, and gypsum cast fabrication.[6]

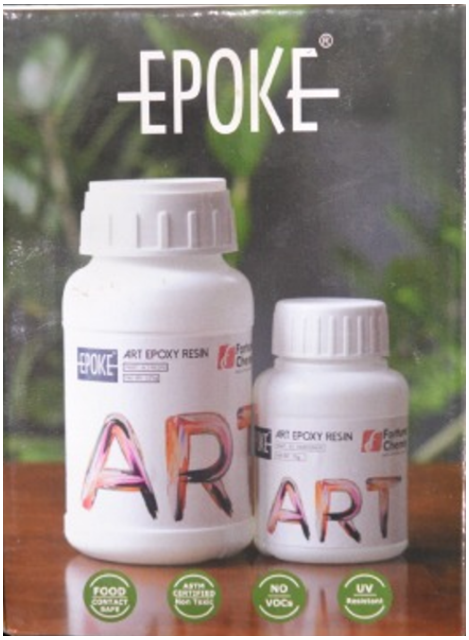


Figure 1: EPOKE ART epoxy resin

2. Materials and Methods

A fully edentulous transparent mandibular model was created using epoxy resin (EPOKE ART) with a silicone mold (Figure 1), which served as the master model. With the aid of a paralleling kit, two parallel endosseous implants (OSSTEM IMPLANT INDIA PVT. LTD), sized 4x10 mm (Figure 2), were placed at the first premolar sites at a 90-degree angle to the base of the model. Modified custom trays made from self-cure acrylic resin were prepared for taking open-tray impressions (Figure 3). Ten open-tray impressions (Figure 4) were obtained, and Type 5 dental stone was used to pour the models (Figure 5). Osstem non-coated scan bodies were affixed to the implants on the master model and scanned with a CEREC intraoral scanner to get digital impressions (OMNICAM) (Figure 6). The OMNICAM scanner has a mean trueness deviation of 41.5 microns and a mean precision deviation of 18±5 microns.

The inter-implant distance of the epoxy resin master model was measured using a standardized device, the Co-ordinate Measuring Machine (CMM) (Figure 7). To measure the master model and acquire accurate three-dimensional position data for the implants, an industrial three-dimensional CMM was employed. The National Entity of Accreditation has confirmed the accuracy of the CMM, which meets ISO 10360-2 geometrical product criteria with a maximum allowable error of (1.9 + 3L/1000 μm) for length measurement scanner.

The machine operates with MSU3D-PRO 3D measuring software.

The dental stone models created using the open tray technique (n=10) were scanned to generate STL files

Figure 2: Endosteal dental implants (Osstem implant India Pvt. Ltd)

Figure 3: Modified custom tray

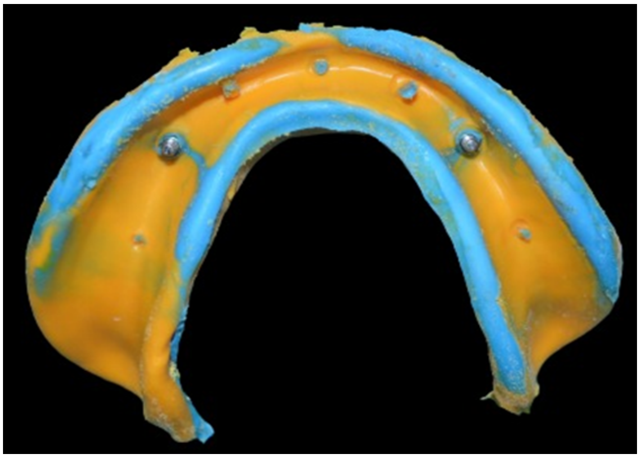


Figure 4: Open tray impression

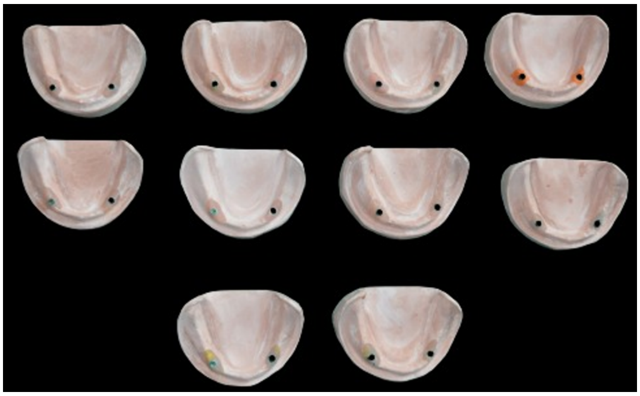


Figure 5: Type 5 dental stone models

Figure 6: CEREC omnicam scanner (Dentsply Sirona)

(Figure 8). Similarly, digital impressions of the master model were saved as STL files. The inter-implant distances for both groups were measured using the analyzing tool in CEREC Dentsply Sirona software and compared with the measurements from the CMM.

Figure 7: Inter-implant distance by CMM

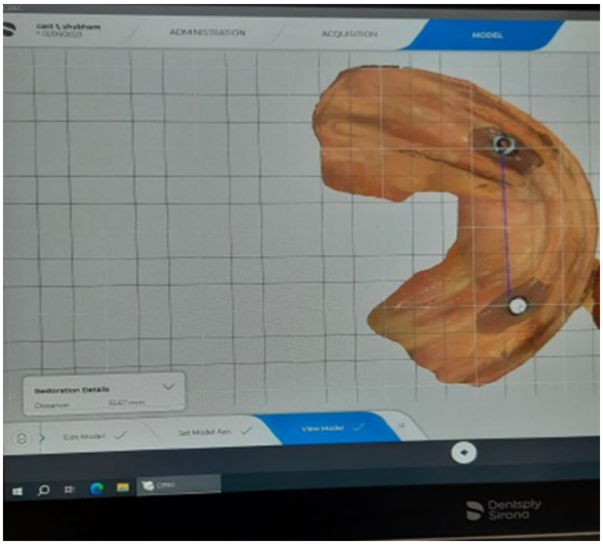


Figure 8: Digital scan of die stone casts

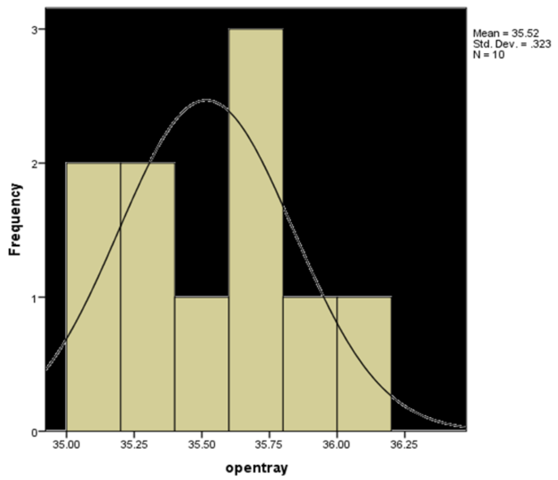
3. Results

SPSS (Statistical Package for the Social Sciences) version 23 (IBM Corp., 2015) was used for the statistical analysis.

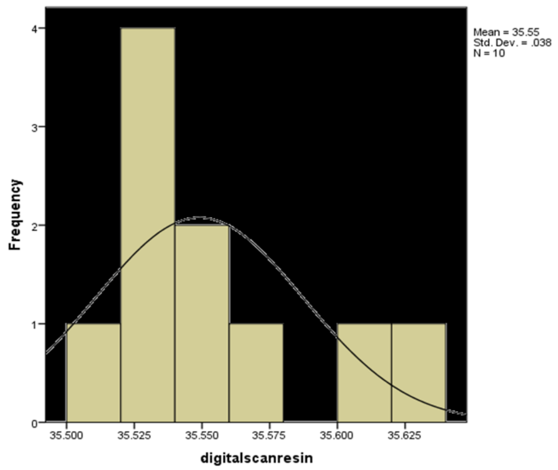
IBM Corp., Armonk, NY, published IBM SPSS Statistics for Windows, Version 23.0. The values were presented as means and counts (n). A Microsoft Excel spreadsheet was used to enter the data and arrange it into a master table. Each group's parameter mean and standard deviation were determined.

After calculating the mean and standard deviation, the resin model (digital scan) had a mean of 35.5490 with a standard deviation of ± 0.03843, while the open tray approach had a mean of 35.5160 with a standard deviation of ± 0.32319.

Calculations were made to determine the significant values for the open tray and digital impressions. The open tray approach got a significance value of 0.547, which is more than 0.05, indicating no statistical significance. On the other hand, the digital scan demonstrated statistical significance with a significance value of 0.031, which is less than 0.05.



Graph 1: Open tray variables



Graph 2: Resin model (Digital scan) variables

4. Discussion

In prosthetic dentistry, achieving a precise fit, referred to as passive fit, is essential for the success of implant restoration. This involves accurately replicating the three-dimensional position of intraoral implants onto the model cast.[7]

Even minor discrepancies in this process can lead to misfits in the prosthesis, potentially resulting in mechanical or biological complications. These issues can undermine the patient's functional expectations and waste valuable time for both the clinician and the patient. While achieving absolute perfection in passive fit may be challenging, the primary goal is to minimize misfits and reduce associated risks. Therefore, careful attention to detail during impression-taking and prosthetic fabrication is essential.[8]

Advanced technologies, including digital impressions and computer-aided design/computer-aided manufacturing (CAD/CAM), have transformed prosthetic dentistry by greatly improving precision in achieving passive fits.[9] By utilizing these cutting-edge techniques, clinicians can more accurately capture intraoral anatomy, resulting in prostheses with enhanced fit and function. This leads to better outcomes and greater patient satisfaction in prosthodontic rehabilitation with implant procedures.[10] Ultimately, the use of digital and CAD/CAM technologies enables clinicians to provide prosthetic solutions that meet the highest standards of accuracy and performance, supporting better long-term oral health for patients.[11]

howed the descriptive statistics for the open tray impression and digital scan values. The open tray technique had a mean value of 35.5160 ± 0.32319 with a standard error of 0.10220. The digital scan had a mean value of 35.5490 ± 0.03843 with a standard error of 0.01215. The digital scan demonstrated a smaller standard deviation compared to the open tray impression. These findings align with the research of Gnanavel A,[12] which examined the accuracy of digital implant impression, open tray, and closed tray procedures for parallel and non-parallel implants. The digital impression technique was more precise than the open tray technique for parallel implantation, while the closed tray technique was the least precise, according to his study, which also showed no statistically significant differences in the test findings.

To compare the two groups' means and evaluate the relevance of the accuracy between the open tray impression and digital scan procedures, a Student's t-test was used. Table 2 showed that there was no statistical significance for the open tray technique, with a significance value of 0.547, greater than 0.05. On the other hand, the digital scan demonstrated statistical significance with a significance value of 0.031, which is less than 0.05.

The study's findings, which are shown in Table 2, showed that the digital impression's (scan's) dimensional accuracy was higher than the open tray impression. These findings were in accordance with the research conducted by

Table 1: Mean value of open tray vs digital scan

	N	Mean	± SD	SE Mean
Open Tray	10	35.5160	.32319	.10220
Resin Model (digital scan)	10	35.5490	.03843	.01215

One sample t-test

Table 2: Inferential statistics

	t	df	Sig. (2-tailed)	Mean difference	95% Confidence Interval of the Difference	
					Lower	Upper
Open Tray	-.626	9	.547	-.06400	-.2952	.1672
Resin model (digital scan)	-2.551	9	.037	-.03100	-.0585	-.0035

Alikhasi M et al.,[13] which discovered substantial angular and linear differences (P<0.001) between straight and inclined abutments, as well as between internal and exterior connections. According to the study, using digital scans instead of traditional methods yielded better results.

Graph 1 and Graph 2 also represented the normal curve of open tray impression and digital scan variables respectively.

A study by Chinwongs A and Serichetapongse[14] compared the precision of digital versus traditional impression procedures for numerous implants in edentulous areas, with an emphasis on the levels of the abutment and the implant. Their study was in accordance which showed that digital impressions are clearly superior, especially when it comes to precisely capturing the angulation of angulated implants during implant-level impressions.

Farhan FA[15] conducted a study comparing the precision of digital impressions (DI) using an intraoral scanner (IOS) with conventional impressions (CI) in cases involving multiple implants. Using a mandibular edentulous model with four strategically placed implants, Farhan assessed dimensional accuracy by measuring distances between reference points. The results revealed that both DI and CI techniques had mean values and standard deviations similar to those of the control group. However, digital impressions with IOS showed significantly superior accuracy, closely aligning with the control model and underscoring the precision and reliability of digital technology in this area.

5. Conclusion

The statistical analysis produced the following findings within the limitations of this in vitro investigation comparing the dimensional accuracy of open tray and digital impression procedures for parallel-placed endosseous dental implants:

1. The open tray impression technique demonstrated lower dimensional accuracy for parallel-placed endosseous implants.
2. The digital impression technique exhibited higher dimensional accuracy for parallel-placed endosseous implants.
3. The digital impression technique had significantly higher dimensional accuracy than the conventional open tray impression technique for parallel-placed endosseous implants.

6. Source of Funding

None.

7. Conflict of Interest

None.

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