Comparative Evaluation of Accuracy, Chair Side Time And Patient Experience Of Conventional Open Tray And Digital Implant Impression For Partially Edentulous Patient – An In Vivo Study

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Abstract

Aim:
This study aims to evaluate and compare the accuracy, chairside time, and patient experience of conventional open tray and digital implant impressions for partially edentulous patients.
Materials and Methods:
A total of 22 patients were selected and divided into two groups: Group 1 of conventional splinted open tray impressions and Group 2 of digital intraoral scanning. Key materials included implant scan bodies, polyvinyl siloxane, type IV gypsum, and a coordinate measuring machine (CMM) for accuracy assessment. Each participant underwent both techniques, with measurements taken for inter-implant distance, linear displacement, angular displacement, chairside time, and patient experience, assessed via a Likert scale questionnaire. Statistical analysis was conducted using SPSS software.
Results:
The study found no statistically significant difference ($p>0.05$) in accuracy between conventional and digital implant impressions concerning inter-implant distance, linear displacement, and angular displacement. However, chairside time was significantly lower for digital impressions ($p<0.05$), with an average of 10.59 minutes compared to 18.64 minutes for the conventional technique. Patient experience was notably improved with digital impressions ($p=0.001$), as they minimized discomfort and procedural time.
Conclusion:
Both conventional and digital impressions provide accurate results in implant positioning. However, digital impressions offer significant advantages in reducing chairside time and enhancing patient comfort. Factors such as cost, operator expertise, and scanner type must be considered before widespread adoption. Future research should explore larger sample sizes, long-term clinical outcomes, and advancements in artificial intelligence to optimize digital impression accuracy further.

Introduction
Oral rehabilitation for partially and completely edentulous patients has become a routine procedure, with dental implants offering a reliable, long-term solution. Clinical studies validate their effectiveness, providing both functional and aesthetic benefits.[1] A critical step in creating implant-supported prostheses is capturing accurate impressions, as this stage determines the accuracy of implant positioning and alignment relative to adjacent oral structures. Precise impressions are essential for the passive fit of the implant framework, which impacts the prosthesis's final outcome. Errors in impressions can lead to a poor fit, negatively affecting the durability, function, and comfort of the prosthesis. Therefore, precise impression-taking is crucial in implant dentistry. [2-3]

Conventional impressions are fundamental in implant prosthetics due to their proven accuracy and reliability. Polyether and addition silicone materials are widely regarded as the "gold standard" because they maintain dimensional stability well, which is critical for capturing precise details.[4] These materials, paired with gypsum casts, produce an accurate physical replica of the patient's mouth, which enables dentists to create a prosthesis with a precise fit. Conventional materials can experience shrinkage and minor distortions, particularly during handling and transport. Additionally, the positioning of analogs (replicas of implants) in the lab can sometimes be unstable, leading to slight inaccuracies in the final model.[5] Such deviations, though small, can affect the passive fit of the prosthesis, potentially compromising its comfort and durability. Despite these challenges, conventional impressions remain highly valued for complex cases. Their time-tested accuracy in capturing intricate details makes them indispensable for cases. [6,7]

Digital technology has transformed the workflow in both fixed and implant prosthodontics. With advances in 3D imaging, digital treatment planning and guided implant placement, digital tools offer an alternative to traditional methods.[8] Digital impressions are taken either through direct intraoral scanning or by scanning casts made from conventional impressions, bypassing multiple intermediate steps. Digital impressions allow for instant data transfer to laboratories, reducing the need for physical impression materials and manual processes.[9] The ability to store and manage digital files facilitates efficient record-keeping and eases patient data access.[10]

Digital and conventional impression techniques vary significantly in terms of accuracy, patient comfort and efficiency, each offering distinct advantages depending on the clinical scenario. Digital impressions are generally associated with higher patient comfort, as they eliminate the need for impression trays and materials, which can cause discomfort.[11] Additionally, digital scans reduce chairside time since the data can be captured and transmitted electronically to the laboratory, enabling immediate feedback and real-time adjustments. This feature is particularly beneficial for partially edentulous patients with single or multiple adjacent implants as it allows for more efficient workflows. Other benefits include minimized material consumption, accelerated workflows, and convenient digital storage, eliminating the need for physical models and supporting a paperless practice.[12]

However, in cases of fully edentulous patients, where precision in implant angulation and positioning is essential, conventional impressions are often preferred. Conventional materials like polyether and addition silicones have inherent dimensional stability, which is crucial for accurately transferring complex intraoral details to the model. The physical properties of these materials provide consistent results, making them highly reliable for complex cases where minor errors could significantly impact the prosthesis longevity. Despite their advantages, digital impressions have limitations. High initial costs for intraoral scanners and other equipment can be a barrier for some practices.[13] Additionally, there is a learning curve associated with digital impression systems, requiring training for both practitioners and laboratory staff to adapt to the new workflows. Not all intraoral scanners have been scientifically proven to be as accurate as conventional methods, and research in this area is limited. While digital impressions are gaining popularity, they may not fully replace conventional techniques, especially for more complex cases. Conventional impressions are still preferred for their established reliability in transferring implant positions accurately to gypsum casts.[14]

The clinical passivity of implant-supported prostheses is influenced by various factors throughout the construction process, including the implant impression technique, master cast fabrication, wax pattern creation, framework fabrication, definitive prosthesis construction and final delivery. Since each step is directly affected by the previous one, the dimensional accuracy of the initial implant impression is a critical factor crucial for achieving a clinically passive and acceptable prosthesis.[15] Regardless of whether a conventional or digital-aided approach is used, a primary goal remains the fabrication of passive-fit restorations which is directly affected by the dimensional accuracy of impression.[16]

Patient outcomes play a crucial role in evaluating perceptions of a given treatment as comfort and ease during the impression process significantly impact overall satisfaction. Numerous studies have assessed subjective satisfaction between traditional and digital impression methods, focusing on factors such as comfort and speed.[17] Some authors have reported that conventional implant impressions often require bulky trays and materials that may cause discomfort, whereas digital scanning offers a less intrusive alternative.[21,22] Additionally, chairside time during treatment can influence the patient experience, further highlighting the importance of choosing an efficient and comfortable impression technique.[18] However, due to the limited number of clinical investigations, definitive conclusions have yet to be reached.

While many authors reported that the digital approach offers numerous benefits over conventional implant impression technique, it has not been scientifically validated as precise alternative to conventional technique.[19] The literature contains limited studies on the accuracy, time efficiency and patient satisfaction for implant impressions, with most of the studies being in vitro. Since there is no conclusive data, the present study was conducted to evaluate the accuracy, chair side time and patient experience for conventional open tray and digital implant impression for partially edentulous patients.

The null hypothesis of the present study was that there was no significant difference in accuracy, chair side time and patient experience for conventional open tray and digital implant impression technique for partially edentulous patients.

Materials and Method
A total number of 22 patients were selected from the outpatient department of Prosthodontics and Crown & Bridge, using predetermined inclusion & exclusion criteria and divided into two groups:
Group 1 (n=11): conventional splinted open tray impression technique.
Group 2 (n=11): digital implant impression technique.

Ethical approval was obtained from the Institutional Ethical Committee reference number ITSCDSR/IIEC/LD/PROSTHO/2022-25/006. Patients with two implants in posterior region, Implants from same manufacturer, Implant diameter between 3.75 to 5 mm for all selected cases, Implants with no more than 3 mm gingival depth, less than 30-degree difference between two implants in angulation were included for the study. Patients with long term edentulous leading to drifting of posterior teeth leading to decreased mesio-distal space and supra-eruption of opposing tooth leading to decreased vertical space, occlusal anomalies like deep bite, cross bite, para-functional habits, bruxism, clenching, past or present history of TMJ disorders and history of radiation therapy in maxillofacial area were excluded from the study. Before initiating any clinical procedures, informed consent was obtained from all participants.

The participants selected for the study underwent both conventional and digital impression procedure. This ensure that participants served as their own control, thereby minimizing inter-patient variability and allowing for a direct comparison between the two techniques.

<u>Conventional Splinted Open Tray Impression Technique</u>
The conventional impression method employed a splinted open tray technique using polyvinyl siloxane (PVS) impression material. Pick – up impression copings were secured to the implants and splinted using pattern resin to reduce distortion during the impression-making process. To ensure accuracy, a periapical radiograph was taken to verify the correct seating of the impression copings before proceeding with the impression-taking step. Holes were drilled in stock plastic tray in region of pick-up impression coping placement.
Once verified, the PVS impression material was used to make implant level impression. Putty consistency and light-body impression material were applied simultaneously and loaded in the patient's mouth using a one-step impression technique. Following impression, implant analogs were attached to the impression copings and gingival mask was applied to replicate the peri-implant soft tissue. This step was essential in simulating the clinical environment for laboratory processing. Finally, a master cast was fabricated using Type IV dental stone, ensuring precise reproduction of the implant positions for prosthetic fabrication.

Digital Implant Impression Technique

For the digital impression method, an intraoral scanner (Shining 3D) intraoral scanner was utilized to capture the implant positions. Scan body was attached to the implants to facilitate accurate digital impression-taking. This specialized component provided a reference for the scanner, ensuring precise localization of the implants.

Intraoral scanning was performed to capture detailed images of the implant positions, occlusion, and surrounding soft tissues. The high-resolution imaging capabilities of the scanner ensured an accurate digital representation of the oral structures. Once the scanning process was completed, the STL file generated was sent to the laboratory for further evaluation. This digital format allowed for easy storage, transmission, and analysis of the impression data. To ensure consistency and accuracy, scanning procedures strictly adhered to the manufacturer's guidelines, minimizing errors and enhancing the reliability of the digital impressions.

Evaluation of Accuracy

The accuracy of impressions was measured using a coordinate measuring machine (CMM), which recorded inter-implant distances, linear displacement, and angular displacement. These objective measurements provided a quantitative assessment of how precisely each technique replicated implant positions.

Evaluation of Patient Experience

Patient experience was assessed using a Likert scale using a questionnaire which measured factors such as comfort levels, gag reflex occurrence, breathing difficulties, and the overall duration of the procedure. Participants completed the questionnaire immediately after each impression procedure to ensure accurate and unbiased feedback on their experience with both conventional and digital techniques.

Evaluation of Chairside Time

Chairside time was recorded using a stopwatch to measure the total duration of all procedural steps in both conventional and digital techniques. Steps in the conventional method included tray preparation, impression material mixing, impression making, and necessary adjustments. For the digital method, it included scan body placement, intraoral scanning, and any modifications required by re-scan procedure. This allowed for an objective comparison of efficiency between the two approaches.

The data was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The intergroup comparison was done using the independent t tests. The Shapiro–Wilk test/Mann Whitney U test was used to investigate the distribution of the data. The level of the significance for the present study was fixed at 5%.

Results

Table 1 and Graph 1 shows that no statistically significant difference ($p > 0.05$) was found in inter-implant distance, linear displacement and angular displacement for conventional splinted open tray implant impression technique and digital implant impression technique. The mean values for each parameter were similar in both the groups, with p-values indicating no significant variation. This suggests that both techniques provide comparable accuracy in implant impressions.

Table 2 and Graph 2 shows that there was significant difference in time taken of time taken by the digital method ($p < 0.05$) as compared to the conventional method. The mean time for the conventional impression was 18.64 minutes, while the digital impression took only 10.59 minutes. These findings suggest that digital impressions using an intra-oral scanner are more time-efficient, making them a preferable choice for reducing chair time during implant procedures.

Table 3 and Graph 3 shows that there was significant difference in patient experience ($p< 0.05$) for digital impressions over conventional methods. The mean experience score for the digital technique was 15.9 as compared to 4.4 for the conventional method. These findings suggest that digital impressions offer a better patient experience.

The null hypothesis of present study that there was no co-relation between the accuracy, chair side time and patient experience between conventional splinted open tray implant impression and digital implant impression of partially edentulous patient was partially rejected. A significant co-relation ($p<0.05$) was found between chair side time and patient experience for conventional splinted open tray implant impression and digital implant impression of partially edentulous patient. However no significant relation($p>0.05$) was found in accuracy for conventional splinted open tray implant impression and digital implant impression of partially edentulous patient.

Discussions

Based on the results of present study it was found that the difference between inter-implant distance for conventional splinted open tray implant impression and digital implant impression for partially edentulous patients was not statistically significant ($p>0.05$). These findings suggest that both conventional and digital impressions yield comparable results in capturing inter-implant distances. The results of the present study are in accordance with the study conducted by Conrad et al.[1] and Ribeiro et al.[10] who found minimal deviation between conventional and digital impression techniques, reinforcing the findings of the present study. Their research highlighted that digital impressions offer an additional advantage by eliminating potential errors associated with material shrinkage and distortion, which are inherent risks in conventional impressions. These issues can arise during the setting process, transportation, or environmental exposure, potentially affecting the final implant position. Whereas digital impressions can capture and store data electronically, reducing the likelihood of such inaccuracies and ensuring greater consistency in clinical applications.[2,6,25]

The research findings of the present study stated that the linear displacement of conventional splinted open tray implant impression was higher than the digital implant impression. Notably, the standard deviation was smaller for the conventional method compared to the digital technique, suggesting that conventional impressions yielded marginally more consistent results. Despite these variations, the differences between the two techniques were minimal, with both falling within clinically acceptable limits. The statistical analysis further supported this observation as the p-value (0.912) indicated no significant difference between the two groups. These results align with previous research by Lee et al.[24] and Mizumoto et al.[9] who also reported comparable accuracy in linear displacement between conventional and digital methods and reinforced the reliability of both the techniques.

Angular displacement is a crucial factor in determining the accuracy of implant impressions, as deviations can impact the final prosthesis fit. The results of the present study indicated no statistically significant difference ($p > 0.05$) in angular displacement between the conventional splinted open-tray implant impression and the digital implant impression for partially edentulous patients. Similar findings were reported by Flugge et al.[12] and Kim et al.[29] who observed that digital impressions were highly reliable in maintaining angular accuracy. Some variations could occur depending on scanner type, scan path, and operator expertise, which should be considered when choosing an impression technique.

However, the results are in contradiction to the studies conducted by Alshawaf et al.[8] who documented that casts fabricated from digital impression exhibited lower accuracy as compared to conventional pick-up/transfer method. This discrepancy was observed in inter-implant distance, angular displacements, and linear displacements measured using a coordinate measuring machine (CMM). Likewise, Menini et al.[17] assessed the accuracy of conventional and digital implant impression techniques by examining the superimposition of a 3D digital model. It was found that the digital intraoral impression had insufficient accuracy to perform implant impressions. Minor discrepancies in angular displacement can be clinically significant in cases of full-arch implant-supported restorations, where even slight deviations can affect occlusion and passive fit.[3,12,16-18] Therefore, while digital impressions appear reliable, further studies assessing their effectiveness in more complex cases are recommended.

Chairside time is an essential consideration for clinical efficiency.[24] The results showed a statistically significant reduction in impression time for digital implant impression technique as compared to conventional splinted open tray technique using addition silicon for partially edentulous patient ($p < 0.05$). The result is corroborated with the findings of Joda et al.[28] and Burhardt et al.[7] who reported that digital impressions significantly reduced chairside time by eliminating the need for material setting and impression tray handling. However, this contradictory with Glisic's et al.[14] study which stated that no significant difference in chairside time was found between the intraoral scan and the alginate impression. The reduction in chair side time could be particularly beneficial for patients with gag reflex sensitivity or those with limited tolerance for lengthy dental procedures.[6,13,22]

Based on results of present study it was found that there was statistically significant difference ($p = 0.001$) between the patient experience in Conventional splinted open tray implant impression and digital implant impression, these results suggest that the digital impression technique using an intraoral scanner provides a substantially better patient experience than the conventional splinted open tray impression technique, likely due to reduced discomfort and a quicker procedure. The results are supported by studies conducted by Yuzbasioglu et al.[5] and Rech-Ortega et al.[27] who demonstrated that patients preferred digital scans due to their non-invasive nature and reduced procedural time. Additionally, digital impressions provide immediate visualization of the scanned area, which could help educate patients about their treatment process, potentially improving patient satisfaction a compliance.[5,7]

The statistical analyses, including group comparisons and inferential statistics of the present study provide insights into the effectiveness of digital implant impression technique comparable to conventional splinted open tray implant impression technique. While digital impressions offer advantages in terms of patient comfort and workflow efficiency, conventional methods remain highly reliable, particularly in cases requiring maximum dimensional accuracy. Clinicians should consider factors such as cost, equipment availability and patient preference when selecting an impression technique. The findings may also contribute to optimizing workflows, enhancing patient satisfaction, and improving overall treatment outcomes.

While this study provides valuable insights, several limitations must be acknowledged. The relatively small sample size per group may restrict the generalizability of the findings. Future research should incorporate larger sample sizes to enhance statistical power and validate the results on a broader scale. A multicentre study comparing different scanner brands and impression materials could offer a more comprehensive evaluation of accuracy variations.
Further analysis is needed to explore additional variables, such as the impact of implant angulation and scanner type, to refine clinical recommendations. Factors like scanning speed, operator experience, and laboratory workflow integration should also be considered.

Within limitation of present study, it was concluded that: (1) The inter-implant distance, linear displacement and angular displacement had no statistically significant difference($p>0.05$) between conventional splinted open-tray implant impressions and digital implant impression technique indicating comparable accuracy between both the techniques. (2) Digital implant impression technique required less chairside time as compared to conventional splinted open-tray impressions with statistically significant difference($p<0.05$) between both the techniques. (3) Digital implant impressions provided improved patient experience as compared to conventional splinted open-tray impressions with statistically significant difference($p<0.05$) between both the techniques.

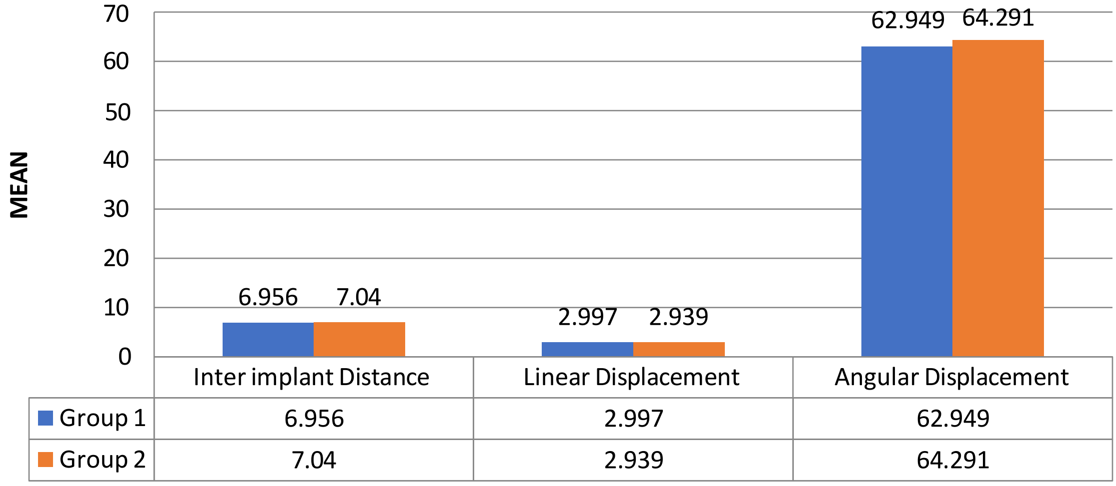
Figure 1: Conventional splinted open tray implant impression

Figure 2: Scan Body Placement

Figure 3: Co-ordinate measuring machine

Table 1: Intergroup Comparison of Inter-Implant Distance, Linear Displacement and Angular Displacement

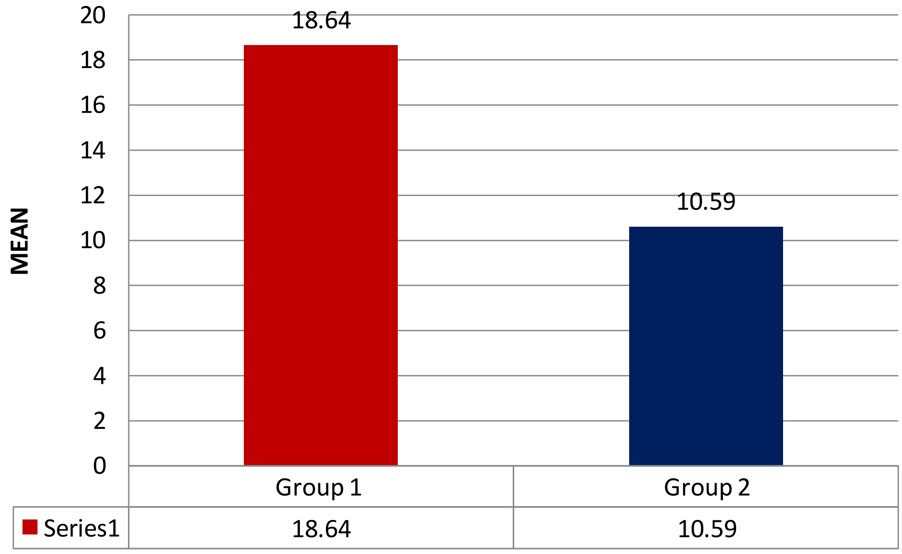
	Group	N	Mean	Std. Deviation	Std. Error Mean	T value	P value
Inter-implant Distance	Group 1	11	6.956	0.812	0.245	2.585	0.879
	Group 2	11	7.040	0.925	0.279		
Linear Displacement	Group 1	11	2.997	0.369	0.111	1.586	0.912
	Group 2	11	2.939	0.506	0.152		
Angular Displacement	Group 1	11	62.949	4.876	1.470	2.912	0.765
	Group 2	11	64.291	4.562	1.375		



Graph 1: Intergroup Comparison of Inter-Implant Distance, Linear Displacement and Angular Displacement

Table 2: Intergroup Comparison of Chair SideTime

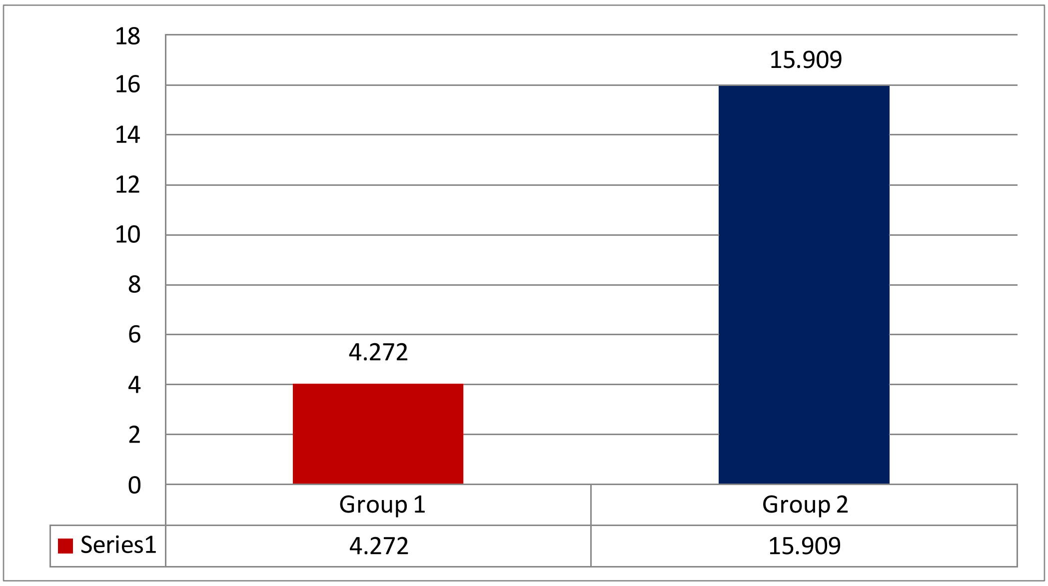
Group	N	Mean	Std. Deviation	Std. Error Mean	T value	P value	Significance
Group 1	11	18.64	1.234	0.235	14.228	0.001	Significant
Group 2	11	10.59	1.598	0.212			



Graph 2: Intergroup Comparison of Chair SideTime

Table 3: Intergroup Comparison of Patient Experience

Group	N	Mean	Std. Deviation	Std. Error Mean	T value	P value	Significance
Group 1	11	4.272	1.678	0.506	17.404	0.001	Significant
Group 2	11	15.909	1.513	0.456			



Graph 3: Intergroup Comparison of Patient Experience

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