REVIEW

CYPRUS
JOURNAL OF MEDICAL SCIENCES

DOI: 10.4274/cjms.2024.2024-31
Cyprus J Med Sci 2025;10(1):13-21

Guide to Optimizing the Accuracy of Intraoral Implant Scans: A Review Article

Çise Özal

Department of Prosthodontics, Cyprus Health and Social Sciences University Faculty of Dentistry, Morphou, North Cyprus

Abstract

As intraoral scanners (IOS) develop daily, their trueness and precision are increasingly being questioned and evaluated. Accuracy is affected by both patient and operator factors. These factors cause image distortion and impression inaccuracies. To maximize the accuracy, it is necessary to master the scanning process. The purpose of this review is to summarize the knowledge of the factors and highlight the points that should be considered to ensure maximum accuracy. Studies conducted with the IOSs technologies used today have revealed that operator experience, scanning distance, scanning head size, distance between implants, scanned area (full/half arch), implant depth, and the presence of saliva or blood in the area to be scanned are factors that significantly affect accuracy. When choosing and using a scanner, obtaining maximum performance from the scanner and knowing what factors affect the accuracy of the impression taken will enable us to use the scanner more accurately, have a higher accuracy of the impression taken, and therefore produce more successful and long-lasting restorations. Although an optimum condition that increases accuracy cannot be determined due to differences in the evaluation of studies, the lack of a sufficient number of studies for each factor, and the conditions changing from case to case, preliminary conclusions that should be paid particular attention to in increasing accuracy have been determined. In addition, the manufacturer's instructions should also be considered in improving the performance of the IOS.

Keywords: Digital implant scans, accuracy, implant scanning factors, intraoral scanners

To cite this article: Özal Ç. Guide to optimizing the accuracy of intraoral implant scans: a review article. Cyprus J Med Sci. 2025;10(1):13-21

INTRODUCTION

Recent developments in digital technology have provided advantages for both clinicians and patients. These systems, which provide advantages to clinicians from diagnosis to production, also increase patient comfort, reduce treatment time, and prevent human errors. As digital systems have developed, material diversity has also increased.[1] Intraoral scanners (IOS), which have become widely used, have made it possible to produce implant-supported restorations with a digital workflow. Using the scan body, the scanned data are sent to CAD software, and after the prosthetic restorations are designed, the data are sent directly to the milling machine for production.[2] On the other hand, the accuracy of this process directly affects the success of the treatment. However, it is essential to understand the variables that affect the scanning process and results to maximize the effectiveness and accuracy of IOSs.

Digital impression accuracy is critical for the production of accurate and properly fitting implant restorations. Accuracy is given by two measuring techniques in ISO 5725: trueness and precision.[3] Trueness is the degree to which the true or accepted reference value and the arithmetic mean of a large number of test findings match. The degree of agreement between the test results is known as the precision.

Accuracy is affected by various factors. Factors like the file type used in special format or STL format during the design phase, depth of implant, whether the scanned area is wet or dry, lighting of the environment, use of different optical systems, tongue and cheek movements,

ORCID ID of the author: Ç.Ö. 0000-0002-7335-7006.

Corresponding author: Çise Özal
E-mail: ciseozal@gmail.com
ORCID ID: orcid.org/0000-0002-7335-7006

Received: 21.04.2024
Accepted: 02.12.2024
Publication Date: 14.03.2025

edentulous ridge length, quantity and form of keratinized gingiva, angle, location, and quantity of implants, and features of scan bodies. Factors that reduce intraoral scan accuracy result in the development of accumulated scan distortion.[1,2,4,5]

Consequently, by being aware of and cognizant of these influencing factors, dental treatments carried out through the use of digital workflows can become more predictable and reliable.[5] The aim of this article is to evaluate operator- and patient-related factors that negatively affect the accuracy of intraoral implant scans.

Operator-Related Factors

Intraoral Scanner and Software

IOS has different working principles and imaging techniques. IOS is manufactured by various companies; they operate in various protocols, including laser and video, confocal microscopy, triangulation, structural illumination, interferometry, and wave sampling. These different operating principles affect the image clarity of the scanners. Differences in scanning technologies and systems used in the production of implant-supported restorations have been reported in the literature (Table 1).[6,7]

Operator Experience

In the use of IOS, the scanning time and image volume are taken into account in the formation of image clarity and distortion. With the experience of the operator, it can reduce the extra time and number of images that may occur during recording. Scanners with longer scan times have been reported to be less accurate when associated with less experienced users (Table 1).[8-10] However, some studies reported that operator experience had no significant effect.[11,12]

File Format

The file format used affects how scanned data are stored, processed, and transmitted across software programs and systems. In addition, the file format used when exporting or importing digital impressions across different software programs or systems is crucial. File format incompatibility may result in data loss, conversion problems, or inaccuracies during the transfer process. For storing scanned data, several file formats provide various levels of accuracy and resolution. Higher precision and resolution enable the capture of more fine aspects of the implant surface, resulting in improved accuracy. Choosing a file format that offers higher accuracy and resolution ensures that the digital impression is more accurate. In addition, to minimize file size, certain file formats use compression techniques; however, this compression may result in data loss or degradation. It is critical to select a file format that works with both the scanner used to record the digital impression and the software required to process and design the final restoration.[2]

Scanning Head Size

Various IOSs are available on the market, each with a different scan head size. The literature has reported that when larger scan head sizes are used, higher trueness and precision values and fewer scanning images are required.[13] More studies are required to evaluate the impact of scan head size on precision and trueness in various IOSs.

Scanning Distance

The scanning distance is the distance between the IOS tip and the target surface. Studies have reported that scanning accuracy changes as the scanning distance changes.[14,15] The ideal scanning distance is specified by the IOS manufacturer for each IOS version. These are the recommended distances recommended by the company, and following them maximizes the performance of the IOS accuracy. Miyoshi et al.[15] scanned six implants placed in the edentulous maxilla in their *in vitro* study five times for each scanner, with four different IOSs: True Definition, CEREC Omnicam, Trios Scanner 2, and CS 3600. As a result of the study, the precision declined as the impression ranges expanded.

Table 1. Studies evaluating the impact of intraoral scanner-software and operator experience on intraoral implant scanning accuracy

Study	Variable	Study type	Sample size	Arch type	Number of implant	IOS	Results
Ciocca et al.[11]	Operator experience	*In vitro*	5	Mandible	6	- True Definition, 3M ESPE	The operator experience had no significant effect.
Schmidt et al.[6]	Intraoral scanner and software	*In vitro*	10	Maxilla and mandible	3	- Trios 3 Pod; 3Shape A/S shape)	Accuracy depends on the software and hardware used by intraoral scanners; however, new software and systems do not warrant increased accuracy.
Revell et al.[10]	Operator experience	*In vitro*	8	Maxilla	5	- iTero Element 2, Cadent -Medit i500 -Primescan, CEREC -Trios 3, 3Shape A/S -Trios 4, 3Shape A/S	The deviation in the implant platform was greater in the scans performed by the less experienced operator than in the scans performed by the experienced operator.
Marques et al.[9]	Operator experience	*In vitro*	10	Maxilla	1	- Trios 3, 3Shape A/S	The operator experience had little impact on the accuracy of full and partial arch scans.
Verniani et al.[7]	Intraoral scanner and software	*In vitro*	10	Maxilla	Separately 3	- Trios 3; 3Shape A/S - I700, Medit	When the full arch model was analyzed, Trios 3 performed significantly better than Medit I700 in acquiring the scanbody position.

IOS: Intraoral scanner.

Scanned Area

When performing IOS, whether the area to be scanned is full of half arc affects the accuracy. In full-arch implant-supported restorations, the digital data recorded increase with the increase in scan length and rotation of the opposing arch.[16,17] The increase in the number of images recorded in IOS causes overlapping of images and distortions. Manufacturers recommend a limited number of images to avoid this distortion and folds. It has been stated that impression accuracy is affected because this number of images is exceeded in full-arch intraoral scans, and the scanner cannot combine the images (Table 2).[11,18,19]

Scan Protocol

The term "scan protocol" describes the precise guidelines and procedures followed during the scanning process to record the digital impression. The sequence of scans, number of scan bodies, and order of scanning implant fixtures or abutments are all important. The aspects of the scan protocol that affect the accuracy of the digital impression. A clear and consistent scan protocol helps minimize errors during the scanning process and ensures reproducibility. Since the imaging methods and software used by IOS in digital impression systems differ from each other, each company recommends a scanning protocol that is specific to its own system.[8,17,20] Previous research has shown that changing the scanning pattern can affect the accuracy of intraoral digital scans (Table 3).[12,21,22] Additionally, regardless of the proposed scanning protocol, it is known that the impression accuracy of the scanners is much better in the region where scanning is started than in the region where scanning ends.[8,17]

Scan Body Design

The transfer of the implants' three-dimensional location to the virtual model mayn occasionally deviate due to the use of scan bodies. The material of the scan body, geometric design, clinical height, implant position, connection, and angle in the dental arch are among the other factors that affect the accuracy of the digital implant size.[23,24] There are various implant-scan body designs on the market. Based on their retention system or the material they are composed of, the scan bodies can be categorized. A few manufacturers also offer identical scan bodies at different heights. Scanning parts can be produced from polyetheretherketone (PEEK), titanium alloy, or various resins. Today, PEEK is generally preferred for the production of scanning pieces. This material has a matte appearance and optical properties that do not absorb or reflect light.[25]

Overall, 1-piece PEEK scan body designs showed higher displacements than the metallic-scan bodies.[26,27] Moreover, sterilization processes may also affect the positioning and accuracy of the scan body.[28] As a result, based on the limited data that is currently available, a metallic-scan body design may be selected to minimize displacement caused by PEEK material distortion from tightening or sterilization.[26,27] These results further support the idea that 1-piece PEEK scan bodies should only be used once.[28] Recurrent utilization of the scan bodies can cause distortion of the scan body and affect the accuracy of intraoral digital implant scans.[25] Many studies have been conducted *in vitro*, and different results have been obtained (Table 4).[17,23,29,30] No scan body design that works best for every IOS that is available may exist in this direction.[27] The scanning piece has a certain geometric shape registered in the digital library created by the manufacturer. It is stated that the scanner must be of high sensitivity to match the image of the scan piece in the digital library with the image taken during the measurement. The easy recognition and recording of the geometry of the scan piece, which was previously defined in the library in the system, affects the scanning performance of the digital impression technique.[24]

Scan Resolution and Mesh Quality

The accuracy of the scanned data may be affected by the resolution of the IOS used for digital impressions. Scanners with higher resolution can capture more precise digital impressions and more detailed information. The accuracy of the scanners may suffer from lower resolution, especially when trying to capture intricate implant geometry or fine details. In addition, mesh quality refers to the precision and resolution of the digital mesh representation created from the scanned data. The IOS software is capable of producing files with various mesh densities. However, a high mesh density for the entire tooth is meaningless because of the long computation time required. The morphological structure of indented-protruding surfaces provides dense mesh quality (i.e., high accuracy, flat surfaces create low mesh quality (i.e., low accuracy. A large number of triangles is required to precisely follow the emergence profile, whereas a small number of triangles may result in margin smoothing.[31]

Table 2. Studies evaluating the effect of scanning area on intraoral implant scanning accuracy

Study	Study type	Sample size	Arch type	Number of implant	IOS	Results
Flügge et al.[16]	*In vitro*	10	Mandible	2 and 5	- iTero, Cadent - Trios, 3Shape - True Definition of 3M ESPE	There is a difference in scanning precision between the tested IOS devices. The precision of the IOS system decreased as the distance between scan bodies increased.
Ciocca et al.[11]	*In vitro*	5	Mandible	6	- True Definition, 3M ESPE	The error rate increased as the length of the scanned arch increased.
Yilmaz et al.[19]	*In vitro*	10	Maxilla	1	- Trios 3; 3Shape A/S	Comparative partial- and complete-arch scans of anterior single implants with an intraoral scanner resulted in similar.
Donmez et al.[18]	*In vitro*	14	Maxilla	2	- Primescan, Dentsply Sirona - Trios 3; 3Shape A/S	Considering the mesiodistal angular deviations, the 3D distance and interimplant distance showed that IOSs had an effect on the trueness of the scans. The trueness of the scans was affected by IOSs when mesiodistal angular deviations, 3D distance, and interimplant distance were considered. Only 3D distance deviations were affected by the scanned region.

IOS: Intraoral scanner.

Table 3. Studies evaluating the effect of scan protocol on intraoral implant scanning accuracy

Study	Type study	Sample size	IOS	Arch type	Number of implant	The implant scan body	Scanning pattern	Results
Giménez et al.[12]	*In vitro*	5	iTero (Cadent)	Maxilla	6	PEEK (Createch Medical)	Stitching halves	The first quadrant was significantly more accurate than the second quadrant as follows:
Mandelli et al.[21]	*In vitro*	10	True Definition	Maxilla	6	NA	Stitching half technique; strategy without stitching halves (occlusalpalatal-buccal)	Stitching showed better accuracy than no stitching. A noteworthy positive association was observed between the inaccuracies and the reference length.
Mizumoto et al.[20]	*In vitro*	7	Trios 3, 3Shape A-S	Maxilla	4	DESS (Barcelona, Spain)	Stitching or unstitching of the palate, occlusalbuccal-palatal	Stitching and unstitching of the palate showed no significant differences. Implant position had a significant effect on trueness.
Wu et al.[22]	*In vitro*	160	D2000; 3A-S shape Orbscan 3, 3DShining	Maxilla	4 [16 (A) - 13 (B) - 23 (C) - 26 (D)]	IO 2C-A, ELOS MEDTECH, Gorlose, Denmark	**SP-A** O (A-D) P (D-A) B (A-D) **SP-B** O (A-B-C) O (B-C-D) The OPB sequence **SP-C** O (A-B) O (B-C) O (C-D) The OPB sequence **SP-D** Zig-zag **SP-E** O (B-C) O (C-D) O (B-A) The OPB sequence **SP-F** O (B-A) O (B-C) O (C-D) The OPB sequence **SP-G** O (B-C-D) O (C-B-A) The OPB sequence **SP-H** O (B-D) P (D-A) O (A-B) B (B-D) B (B-A)	The SPF and SPG methods demonstrated lower linear trueness

IOS: Intraoral scanner, SP: Scanning protocol, PEEK: Polyetheretherketone, O: Occlusal, B: Buccal, P: Palatinal, L: Lingual.

However, the rendering of files in a GUI often misleads about the accuracy of a scan due to the use of shaders and smoothing algorithms. Mesh quality factors such as triangle density, surface smoothness, and surface detail accuracy all affect the digital impression accuracy. Inadequate mesh quality, which is manifested by low-resolution surfaces or inconsistencies in capturing fine details, can result in inaccurate virtual models and subsequent restorations.[32]

Ambient Lighting Conditions

The amount of light (lux) in the space corresponding to the intraoral digital scan is known as the ambient illuminance conditions.[1] According to previous in vitro and clinical research, the ideal lighting conditions for scanning patients who are completely dentate vary depending on the IOS chosen.[33,34]

Most IOSs function better under 1000-lux ambient illumination conditions, also referred to as room lighting conditions, although there is no single ideal lighting condition that can maximize accuracy for all IOSs. To attain this ambient lighting condition, the dental chair light was turned off while the room ceiling light was left on. It is crucial to realize that the ambient lighting intensity in each room or facility may vary; for this reason, it is recommended to use a luxmeter to standardize ambient lighting conditions.[33,34]

Scan Body Splinting

Scan body splinting is the connection of close scan bodies to each other using a rigid material to increase scanning accuracy and facilitate scanning (Table 5).[35-38] Different splinting techniques were analyzed to improve intraoral digital implant scan accuracy. A systematic review conducted in 2021 emphasized that there are 17 different splinting techniques.[37] The best implant-scan body-splinting technique is difficult to determine as IOS technology advances daily. Therefore, the splinting method should be determined according to the IOS.

Patient-Related Factors

Implant Depth

The implant levels can be divided into bone or tissue levels, which can affect the impression accuracy. To obtain precise impressions, consideration must be given to the emergence profile and margin placement of the abutment. Incomplete capture of implant components due to subgingival margins or poor emergence profiles can result in inaccurate digital impressions. Clinical implant scan body height is correlated with implant depth (Table 6).[4,39,40] In cases in which the gingival height is high, the sensitivity of the scanner weakens as a result of the decrease in the visibility of the scanning piece. It is recommended to use long scan pieces in these cases to increase the imaging of IOS.[40]

Implant Angulation

Research has revealed that implant depth and angulation can have a negative impact on the accuracy of IOS (Table 6).[1,39,41,42] According to certain studies, implant angulation reduces digital scan accuracy compared with conventional impressions, or it reduces the accuracy of IOS scanning.[39,40] In addition, Papaspyridakos et al.[43] Study reported that there was no difference between the conventional technique and impression accuracy in cases in which the implant angle was less than 15°. It is known that with an increase in the angle, there are difficulties in recording impressions using both conventional and digital techniques.[44]

Table 4. Studies evaluating the impact of body scan design on intraoral implant scanning accuracy

Study	Study type	Sample size	Variable	Condition	IOS	Extraoral scanner	Scan body	Scan body design	Results
Althubaitiy et al.[29]	*In vitro*	140	Scan body material	Partially edentulous mandible	Trios 3, 3Shape A-S	E1; 3Shape A/S	Scan body 1: PEEK Scan body 2: metallic	Cylinder	The extraoral scanner provided the best results. Metallic scan body resulted in the best
Alvarez et al.[30]	*In vitro*	10	Scan body geometry	Partially edentulous mandible	Trios 3, 3Shape A-S	E1; 3Shape A/S	Scan body 1: PEEK Scan body 2: metallic	Cylinder	The extraoral scanner provided the best results. Metallic scan body resulted in the best
Gómez-Polo et al.[17]	*In vitro*	15	Scan body geometry	Full-arch, edentulous, and Maxilla	Trios 3, 3Shape	7Series Desktop Dental Wings	PEEK on Ti-based	Cylindric with bevels	The accuracy; implant position, angulation, and scan body geometry was affected by bevel location
Lawand et al.[23]	*In vitro*	15	Scan body geometry	Full-arch, edentulous, and Maxilla	Trios 3, 3Shape	-	PEEK	Cylinder with rounded and flat lateral sections	Subtractive modifications of scan bodies increased scanning trueness in full arch implant scans. Additive modifications to scan bodies reduced scanning trueness. The scan body geometric modifications did not affect the scanning time

IOS: Intraoral scanner, PEEK: Polyetheretherketone.

Table 5. Studies evaluating the effect of the scan body splinting technique on intraoral implant scanning accuracy

Study	Type study	Sample size	IOS	Arch type	Number of implant	The implant scan body	Scanning pattern	Results
Mizumoto et al.[36]	*In vitro*	5	Trios (hardware version unknown)	Maxilla	4	-Atlantis Intraoral FLOIO (Dentsply Sirona) -NT (Nt-Trading, Karlsruhe, Germany) -DE (DESS) -C3D (Core3D Centers, Maartensdijk, Holland) -ZI (Zimmer Biomet	OBP	Accuracy is affected by the scan technique and scan body. The ZI scan body showed better accuracy. Splinting scan bodies using floss showed lower accuracy than GB, PP, and no modification technique.
Pozzi et al.[38]	*In vitro*	30	Trios 3, 3Shape A-S	Mandibula	4	1-piece PEEK Height 9 mm Screw retained	OLB	The scan body splinting accuracy increased accuracy. Reduce the angular and linear deviations of the posterior implants
Çakmak et al.[35]	*In vitro*	14	Trios 3, 3Shape A-S	Maxilla	4	PEEK healing abutment with a screw retained and medical-grade acrylic resin scan body with friction-fitted	Conventional technique Land-marking technique Novel scanning body splinting technique	Different scanning techniques affected the trueness of the scans when the distance and angular deviation were considered. Precision was also affected when distance deviation was considered

IOS: Intraoral scanner, PEEK: Polyetheretherketone, O: Occlusal, B: Buccal, P: Palatinal, L: Lingual.

However, other studies have shown that implant angulation had no impact on the accuracy of IOS.[12]

Interimplant Distance and Interdental Space Between the Adjacent Teeth Implant and Scan Body

Only a few studies have examined the impact of interimplant distance on intraoral digital implant scan accuracy.[39,45] Studies have shown that with increasing distance between implants, similar flat gingival and crest appearances are areas that are difficult for the scanner to combine and cause distortions.[17] To address this disadvantage of the system, it has been suggested to place reference points in the inter-implant areas or splint the scan bodies (Table 6).[23,35]

The impact of the digital impression of a partial arch with missing teeth or a combination of natural teeth and implants on the accuracy of intraoral digital scans. To obtain accurate digital impressions, factors such as the position and angulation of the implants in relation to the natural teeth, accurate representation of the emergence profile, and precise details of the abutments and adjacent teeth are critical. The alignment and fit of the partial arch restoration were based on the digital impression's accuracy (Table 6).[9,46]

Palate

Few investigations have assessed the influence of palate digitization on the accuracy of maxillary intraoral digital scans in complete-arch implant digital scans in edentulous patients.[46,47] In a clinical study, when the effect of low, medium, or high maxillary palatal vault height on the accuracy of intraoral digital scans was evaluated, it was observed that the accuracy decreased as the palatal height increased, although it was not statistically significant. It also showed higher mean accuracy and precision values when the palate was not included in the intraoral digital scan.[47]

Arch Location

There are only few studies in the literature that examined the effect of whether the scanned arch is maxillary or mandibular on accuracy in digital implant scans.[48,49] In studies where the authors compared intraoral digital implant scans of the maxillary and mandibular full arch and maxillary and mandibular anterior or posterior regions, lower trueness and precision mean values of maxillary also maxillary-posterior and mandibular-posterior intraoral digital implant scans.[36,49]

Blood or Saliva

The accuracy of digital impressions can be negatively affected by blood or saliva on the implant site. Fluids can impede the scanning process, resulting in incomplete or distorted impressions. To reduce the impact of fluids on the accuracy of digital impressions, the operative field must be properly isolated and controlled.[50]

CONCLUSION

The accuracy of the digital impression directly affects the passive fit and success of restoration. The accuracy of intraoral implant scanning is affected by a variety of factors that must be carefully evaluated to provide accurate and precise outcomes. By knowing the factors that affect accuracy, dental treatments performed using digital workflows can become more predictable and reliable. Because there is not enough literature to analyze every factor, it is not possible to establish a systematic clinical recommendation. It is challenging to reach a conclusion regarding ambient light, full or partial arch scanning, scan body material or geometry, scanner used, and number of implants, and studies give contradictory results. When choosing and using a scanner, obtaining maximum performance from the scanner and knowing what factors affect the accuracy of the impression taken will enable us to use the scanner more accurately, have a higher accuracy of the impression taken, and therefore produce more successful and long-lasting restorations.

Table 6. Studies evaluating the effects of implant depth, angulation, and inter-implant distance on intraoral implant scanning accuracy

Study	Study type	Sample size	Variable	Conditior	IOS	Scan body material	Scan body geometry	Results
Gómez-Polo et al.[45]	*In vitro*	30	Implant depth	Full-arch, edentulous, and Maxilla	Trios 3, 3Shape A-S	PEEK on Ti-based	Cylindric with bevels	Accuracy was affected by inter-implant distance and scan body angulation. Greater accuracy was obtained with parallel implants.
Sequeira et al.[4]	*In vitro*	15	Implant depth	A partially edentulous cast with one implant analog at different depths (7, 6, 3 and 0 mm)	Zfx Scan III, Zfx GmbH	PEEK	Cylindric with bevels	Truness and precision were high when the implant was 0 mm deep. However, it decreased as the implant was placed subgingivally. There was no significant increase in accuracy after 3 mm submergence of the implant.
Taghva et al.[42]	*In vitro*	10	Implant depth and angulation	Four maxillary models with 2 analogs (first premolar and first molar) at depths of 1 (G1), 2 (G2), 3 (G3), and 4 (G4) mm.	Trios 3, 3Shape A-S	Titanium	Cylindric with bevels	G1 and G4 showed significantly better results
Sicilia et al.[41]	*In vitro*	15	Height of the scan body and implant angulation	Two edentulous maxillary casts with four implant abutment analogs: parallel (P) and angulated (NP) (18 degrees).	7 Series Dental Wings, Trios 4, 3Shape A-S	PEEK on Ti-based	Cylindric with bevels	An implant inclination of 18° did not significantly influence the scanning accuracy, nor did the supramucosal height of the scan body.
Gómez-Polo et al.[39]	*In vitro*	10	Interimplant distance, implant depth, and angulation	Two edentulous maxillary casts with six parallel and angulated (30 degrees) implant	Trios 3, 3Shape A-S	PEEK	Cylindric	The implant angulation and clinical implant scan body height were significant predictors of discrepancies in the angular measurement.

IOS: Intraoral scanner, PEEK: Polyetheretherketone, Ti: Titanium.

MAIN POINTS

- Ambient light, scanning distance, and scanning protocols should be applied while considering the recommendations of the manufacturer of the selected intraoral scanner.
- Blood and saliva negatively affect the scanning process and cause incomplete or distorted impressions. Therefore, the scanned area must be isolated and dry.
- With experienced operator scanning in a shorter time, less data are obtained and higher accuracy is achieved.
- Scanning devices and file formats that provide high precision and resolution allow more details to be recorded during scanning, resulting in higher accuracy.
- There is no optimal scanning protocol. Each manufacturer's recommended scanning method should be taken into consideration.

FOOTNOTES

Financial Disclosure: The author declared that this study had received no financial support.

REFERENCES

1. Revilla-León M, Kois DE, Kois JC. A guide for maximizing the accuracy of intraoral digital scans. Part 1: Operator factors. J Esthet Restor Dent. 2023; 35(1): 230-40.
2. Joda T, Ferrari M, Gallucci GO, Wittneben JG, Brägger U. Digital technology in fixed implant prosthodontics. Periodontol. 2000. 2017; 73(1): 178-92.
3. Ender A, Mehl A. Accuracy of complete-arch dental impressions: a new method of measuring trueness and precision. J Prosthet Dent. 2013; 109(2): 121-8.
4. Sequeira V, Harper MT, Lilly CL, Bryington MS. Accuracy of digital impressions at varying implant depths: an in vitro study. J Prosthodont. 2023; 32(1): 54-61.
5. Revilla-León M, Kois DE, Kois JC. A guide for maximizing the accuracy of intraoral digital scans: part 2-patient factors. J Esthet Restor Dent. 2023; 35(1): 241-9.
6. Schmidt A, Schlenz MA, Liu H, Kämpe HS, Wöstmann B. The influence of hard- and software improvement of intraoral scanners on the implant transfer accuracy from 2012 to 2021: an in vitro study. Applied Sciences. 2021; 11(15): 7166.
7. Verniani G, Casucci A, Nosrati N, D'Arienzo LF, Val M, Cagidiaco EF. Accuracy evaluation of two different intraoral scanners in implant prosthodontics. A comparative in vitro study. Journal of Osseointegration. 2024; 16(1): 61-4.

8. Marques S, Ribeiro P, Falcão C, Lemos BF, Ríos-Carrasco B, Ríos-Santos JV, et al. Digital impressions in implant dentistry: a literature review. Int J Environ Res Public Health. 2021; 18(3): 1020.
9. Marques VR, Çakmak G, Yilmaz H, Abou-Ayash S, Donmez MB, Yilmaz B. Effect of scanned area and operator on the accuracy of dentate arch scans with a single implant. J Clin Med. 2022; 11(14): 4125.
10. Revell G, Simon B, Mennito A, Evans ZP, Renne W, Ludlow M, et al. Evaluation of complete-arch implant scanning with 5 different intraoral scanners in terms of trueness and operator experience. J Prosthet Dent. 2022; 128(4): 632-8.
11. Ciocca L, Meneghello R, Monaco C, Savio G, Scheda L, Gatto MR, et al. In vitro assessment of the accuracy of digital impressions prepared using a single system for full-arch restorations on implants. Int J Comput Assist Radiol Surg. 2018; 13(7): 1097-108.
12. Giménez B, Özcan M, Martínez-Rus F, Pradíes G. Accuracy of a digital impression system based on parallel confocal laser technology for implants with consideration of operator experience and implant angulation and depth. Int J Oral Maxillofac Implants. 2014; 29(4): 853-62.
13. An H, Langas EE, Gill AS. Effect of scanning speed, scanning pattern, and tip size on the accuracy of intraoral digital scans. J Prosthet Dent. 2024; 131(6): 1160-7.
14. Button H, Kois JC, Barmak AB, Zeitler JM, Rutkunas V, Revilla-León M. Scanning accuracy and scanning area discrepancies of intraoral digital scans acquired at varying scanning distances and angulations among 4 different intraoral scanners. J Prosthet Dent. 2024; 132(5): 1044-60.
15. Miyoshi K, Tanaka S, Yokoyama S, Sanda M, Baba K. Effects of different types of intraoral scanners and scanning ranges on the precision of digital implant impressions in edentulous maxilla: an in vitro study. Clin Oral Implants Res. 2020; 31(1): 74-83.
16. Flügge TV, Att W, Metzger MC, Nelson K. Precision of dental implant digitization using intraoral scanners. Int J Prosthodont. 2016; 29(3): 277-83.
17. Gómez-Polo M, Álvarez F, Ortega R, Gómez-Polo C, Barmak AB, Kois JC, et al. Influence of the implant scan body bevel location, implant angulation and position on intraoral scanning accuracy: an in vitro study. J Dent. 2022; 121: 104122.
18. Donmez MB, Mathey A, Gäumann F, Mathey A, Yilmaz B, Abou-Ayash S. Effect of intraoral scanner and fixed partial denture situation on the scan accuracy of multiple implants: an in vitro study. Clin Implant Dent Relat Res. 2023; 25(3): 502-10.
19. Yilmaz B, Rizzo Marques V, Guo X, Gouveia D, Abou-Ayash S. The effect of scanned area on the accuracy and time of anterior single implant scans: an in vitro study. J Dent. 2021; 109: 103620.
20. Mizumoto RM, Yilmaz B, McGlumphy EA Jr, Seidt J, Johnston WM. Accuracy of different digital scanning techniques and scan bodies for complete-arch implant-supported prostheses. J Prosthet Dent. 2020; 123(1): 96-104.
21. Mandelli F, Gherlone EF, Keeling A, Gastaldi G, Ferrari M. Full-arch intraoral scanning: comparison of two different strategies and their accuracy outcomes. Journal of Osseointegration. 2018; 10(3): 65-74.
22. Wu HK, Chen G, Wang J, Zhang Z, Huang X, Lin X, et al. Effect of prefabricated auxiliary devices and scanning patterns on the accuracy of complete-arch implant digital impressions. J Dent. 2024; 140: 104788.
23. Lawand G, Ismail Y, Revilla-León M, Tohme H. Effect of implant scan body geometric modifications on the trueness and scanning time of complete arch intraoral implant digital scans: an in vitro study. J Prosthet Dent. 2024; 131(6): 1189-97.
24. Lerner H, Nagy K, Pranno N, Zarone F, Admakin O, Mangano F. Trueness and precision of 3D-printed versus milled monolithic zirconia crowns: an in vitro study. J Dent. 2021; 113: 103792.
25. Arcuri L, Lio F, Campana V, Mazzetti V, Federici FR, Nardi A, et al. Influence of implant scanbody wear on the accuracy of digital impression for complete-arch: a randomized in vitro trial. Materials (Basel). 2022; 15(3): 927.
26. Diker E, Terzioglu H, Gouveia DNM, Donmez MB, Seidt J, Yilmaz B. Effect of material type, torque value, and sterilization on linear displacements of a scan body: an in vitro study. Clin Implant Dent Relat Res. 2023; 25(2): 419-25.
27. Shi X, Liu X, Liu S, Wang M, Liu F. Vertical deviation caused by tightening torque on implant scan body: an in vitro study. Int J Prosthodont. 2022; 35(5): 653-9.
28. Kim J, Son K, Lee KB. Displacement of scan body during screw tightening: a comparative in vitro study. J Adv Prosthodont. 2020; 12(5): 307-15.
29. Althubaitiy R, Sambrook R, Weisbloom M, Petridis H. The accuracy of digital implant impressions when using and varying the material and diameter of the dental implant scan bodies. Eur J Prosthodont Restor Dent. 2022; 30(4): 305-13.
30. Alvarez C, Domínguez P, Jiménez-Castellanos E, Arroyo G, Orozco A. How the geometry of the scan body affects the accuracy of digital impressions in implant supported prosthesis. In vitro study. J Clin Exp Dent. 2022; 14(12): e1008-14.
31. Ender A, Attin T, Mehl A. In vivo precision of conventional and digital methods of obtaining complete-arch dental impressions. J Prosthet Dent. 2016; 115(3): 313-20.
32. Aubreton O, Bajard A, Verney B, Truchetet F. Infrared system for 3D scanning of metallic surfaces. Machine Vision and Applications. 2013; 24(7): 1513-24.
33. Koseoglu M, Kahramanoglu E, Akin H. Evaluating the effect of ambient and scanning lights on the trueness of the intraoral scanner. J Prosthodont. 2021; 30(9): 811-6.
34. Revilla-León M, Subramanian SG, Att W, Krishnamurthy VR. Analysis of different illuminance of the room lighting condition on the accuracy (trueness and precision) of an intraoral scanner. J Prosthodont. 2021; 30(2): 157-62.
35. Çakmak G, Yilmaz H, Treviño Santos A, Kökat AM, Yilmaz B. Effect of scanner type and scan body location on the accuracy of mandibular complete-arch digital implant scans: an in vitro study. J Prosthodont. 2022; 31(5): 419-26.
36. Mizumoto RM, Alp G, Özcan M, Yilmaz B. The effect of scanning the palate and scan body position on the accuracy of complete-arch implant scans. Clin Implant Dent Relat Res. 2019; 21(5): 987-94.
37. Paratelli A, Vania S, Gómez-Polo C, Ortega R, Revilla-León M, Gómez-Polo M. Techniques to improve the accuracy of complete arch implant intraoral digital scans: asystematic review. J Prosthet Dent. 2023; 129(6): 844-54.
38. Pozzi A, Arcuri L, Lio F, Papa A, Nardi A, Londono J. Accuracy of complete-arch digital implant impression with or without scanbody splinting: an in vitro study. J Dent. 2022; 119: 104072.
39. Gómez-Polo M, Sallorenzo A, Ortega R, Gómez-Polo C, Barmak AB, Att W, et al. Influence of implant angulation and clinical implant scan body height on the accuracy of complete arch intraoral digital scans. J Prosthet Dent. 2024; 131(1): 119-27.
40. Laohverapanich K, Luangchana P, Anunmana C, Pornprasertsuk-Damrongsri S. Different implant subgingival depth affects the trueness and precision of the 3D dental implant position: a comparative in vitro study among five digital scanners and a conventional technique. Int J Oral Maxillofac Implants. 2021; 36(6): 1111-20.
41. Sicilia E, Lagreca G, Papaspyridakos P, Finkelman M, Cobo J, Att W, et al. Effect of supramucosal height of a scan body and implant angulation on the accuracy of intraoral scanning: an in vitro study. J Prosthet Dent. 2024; 131(6): 1126-34.
42. Taghva M, Mosaddad SA, Ansarifard E, Sadeghi M. Could various angulated implant depths affect the positional accuracy of digital impressions? An in vitro study. J Prosthodont. 2024; 33(8): 791-800.

43. Papaspyridakos P, Gallucci GO, Chen CJ, Hanssen S, Naert I, Vandenberghe B. Digital versus conventional implant impressions for edentulous patients: accuracy outcomes. Clin Oral Implants Res. 2016; 27(4): 465-72.

44. Rutkunas V, Gedrimiene A, Akulauskas M, Fehmer V, Sailer I, Jegelevicius D. In vitro and in vivo accuracy of full-arch digital implant impressions. Clin Oral Implants Res. 2021; 32(12): 1444-54.

45. Gómez-Polo M, Ortega R, Sallorenzo A, Agustín-Panadero R, Barmak AB, Kois JC, et al. Influence of the surface humidity, implant angulation, and interimplant distance on the accuracy and scanning time of complete-arch implant scans. J Dent. 2022; 127: 104307.

46. Huang MY, Son K, Lee KB. Effect of distance between the abutment and the adjacent teeth on intraoral scanning: an in vitro study. J Prosthet Dent. 2021; 125(6): 911-7.

47. Gan N, Xiong Y, Jiao T. Accuracy of intraoral digital impressions for whole upper jaws, including full dentitions and palatal soft tissues. PLoS One. 2016; 11(7): e0158800.

48. Ma Y, Guo YQ, Jiang L, Yu H. Influence of intraoral conditions on the accuracy of digital and conventional implant impression techniques for two-implant-supported fixed dental prostheses. J Prosthodont Res. 2023; 67(4): 633-40.

49. Papaspyridakos P, De Souza A, Finkelman M, Sicilia E, Gotsis S, Chen YW, Vazouras K, Chochlidakis K. Digital vs conventional full-arch implant impressions: a retrospective analysis of 36 edentulous jaws. J Prosthodont. 2023; 32(4): 325-30.

50. Zarbakhsh A, Jalalian E, Samiei N, Mahgoli MH, Kaseb Ghane H. Accuracy of digital impression taking using intraoral scanner versus the conventional technique. Front Dent. 2021; 18: 6.