ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 6, Issue – 2, April - 2023, Page No. : 83 – 88

Comparative Evaluation of Scanning Accuracy of Two Intraoral Digital Scanners: An In-Vitro Study

[1]Dr. Sayyam Jain, Postgraduate Student, Department of Prosthodontics and Crown and Bridge, Chhattisgarh Dental College and Research Institute, Rajnandgaon, Chhattisgarh

[2]Dr. Anurag Dani, Professor, Department of Prosthodontics and Crown and Bridge, Chhattisgarh Dental College and Research Institute, Rajnandgaon, Chhattisgarh

[3]Dr. Shailendra Kumar Sahu, Professor and HOD, Department of Prosthodontics and Crown and Bridge, Chhattisgarh Dental College and Research Institute, Rajnandgaon, Chhattisgarh

[4]Dr. Manupreet Kaur, Reader, Department of Prosthodontics and Crown and Bridge, Chhattisgarh Dental College and Research Institute, Rajnandgaon, Chhattisgarh

[5]Dr. Shruti S. Marwadkar, Postgraduate Student, Department of Prosthodontics and Crown and Bridge, Chhattisgarh Dental College and Research Institute, Rajnandgaon, Chhattisgarh

[6]Dr. Taniya Gaba, Postgraduate Student, Department of Prosthodontics and Crown and Bridge, Chhattisgarh Dental College, and Research Institute, Rajnandgaon, Chhattisgarh

Corresponding Author: Dr. Sayyam Jain, Postgraduate Student, Department of Prosthodontics and Crown and Bridge, Chhattisgarh Dental College, and Research Institute, Rajnandgaon, Chhattisgarh

Citation of this Article: Dr. Sayyam Jain, Dr. Anurag Dani, Dr. Shailendra Kumar Sahu, Dr. Manupreet Kaur, Dr. Shruti S. Marwadkar, Dr. Taniya Gaba, "Comparative Evaluation of Scanning Accuracy of Two Intraoral Digital Scanners: An In-Vitro Study", IJDSIR- April - 2023, Volume – 6, Issue - 2, P. No. 83 – 88.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Purpose: The first of this study was to evaluate the scanning accuracy and precision of two intraoral scanners.

Materials and Methods: A reference master model was fabricated with four implants & implant scan bodies were tightened to the master model. Inter implant distances were measured using digital vernier caliper that served as control. The models were then scanned with intraoral scanners (Trios 3 shape, Medit i700) for five times (n=5/group). For trueness, the values were compared with control and for measuring precision difference in the repeated values were calculated.

Results: The data was analyzed using IBM SPSS Statistics v16. Trueness of scans were analyzed by comparing the measurements of intra oral scanner from Vernier Caliper. Precision was tested through the measurement of repeated scans. One way ANOVA followed by Bonferroni test as Post hoc test was used for inferential statistics. Trios readings were almost in line

with vernier calliper (more trueness). Medit showed higher standard deviation (less precision).

Conclusion: In comparison with conventional method, IOS is accurate and easier. Scanners differ in trueness and precision. Trueness and precision of Trios 3 was better in reference to digital vernier caliper in comparison with Medit.

Introduction

In recent decades, there has been continuous advancement in digital technologies in dentistry, such as computer-aided design/computer- aided manufacturing (CAD/CAM) systems, milling systems, three-dimensional (3D) scanning, and printing of various dental biomaterials.[1] One of the most recent techniques introduced to dentistry is the ability to digitize the oral cavity and create a three-dimensional virtual model; this device is known as an intraoral scanner (IOS).[2]

The first step in this digital workflow is the acquisition of a digital scan by means of an intraoral scanner, a method that has been reported to provide excellent accuracy for short-span prostheses, both tooth- and implant supported, compared with conventional impression methods. Controversy still exists, however, regarding the accuracy of IOSs for scanning complete arches. An IOS should achieve clinically acceptable levels of accuracy, often specified at 100 µm, although a definitive consensus and a scientific correlation between global deviation and actual marginal prosthesis misfit is lacking.[3]

New scanners are being introduced to the dental market every year. The accuracy of IOS is specified as trueness and precision according to the International Organization for Standardization. The trueness is defined as 'the closeness between the test object and the reference object' and precision is defined as 'the variability of repeated measurements of the object'.[4]

The purpose of this in vitro study was to measure the complete-arch trueness and precision of 2 recently introduced intraoral scanners, the TRIOS 3 color Pod (3Shape), and the i700 (Medit) equipped with their latest software versions and to compare them with the measurements of digital vernier calliper as reference. The null hypotheses were that no statistically significant difference would be found in the complete-arch trueness and precision of the tested scanners.

Material and Methods

A reference master model was fabricated using heat cure clear acrylic resin (DPI Heat Cure) according to Carl Misch classification of mandibular overdenture. The reference model mimics a mandibular implant supported overdenture clinical situation. Four implants (4.2mmD x 8mmL, Adin dental implant systems ltd) were placed in mandibular anterior region in overdenture position A (implant no. 4), B (implant no. 3), D (implant no. 2) & E (implant no. 1) (fig. 1) Dental surveyor (Delta Labs) was used for proper orientation and parallelism of the implant.

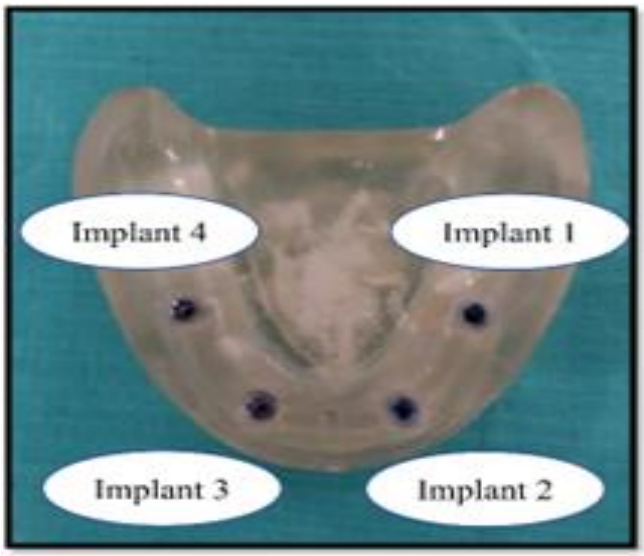

Fig. 1: Master reference model

Implant scanning abutments were secured to master reference model using 10 Ncm torque. A one step procedure was used for the scanning of master reference

model. One step procedure involves scanning both the master reference model and the integrated scan bodies simultaneously. All scans started from the right side of the model. A standardized scan path was followed which consisted of scanning the occlusal surface, then the buccal surface and followed by palatal surface. All the scans were timed from start to finish and the scan was considered completed once the scan body surface were captured entirely and no major holes were present in the reference model. Five consecutive digital scans (for measuring precision) of the master model (n=5/group) were made with the intraoral scanner. Same scanning protocol was followed for both (TRIOS 3, MEDIT) intraoral scanners.

Analysis 0f Models

To evaluate the accuracy of each impression, The inter implant distance (transverse and anteroposterior distance) was measured. (Fig. 2). It was measured with the help of digital vernier caliper with accuracy of 0.02 mm on the reference model to serve as control group.

The impression accuracy was examined by comparing the absolute differences of the 6 distances (Fig. 3) between the master reference model and value of control group. All the measurements were made after attaching the implant scanning abutment.

Distance 1: Position A- B (Between implant no.4 and implant no. 3)

Distance 2: Position B-D (Between implant no. 3 and implant no. 2)

Distance 3: Position D-E (Between implant no.2 and implant no. 1)

Distance 4: Position E- A (Between implant no.1 and implant no.4)

Distance 5: Position A-D (Between implant no.2 and implant no.4)

Distance 4: Position B-E (Between implant no.1 and implant no.3)

Fig. 2: Measurement with vernier calliper

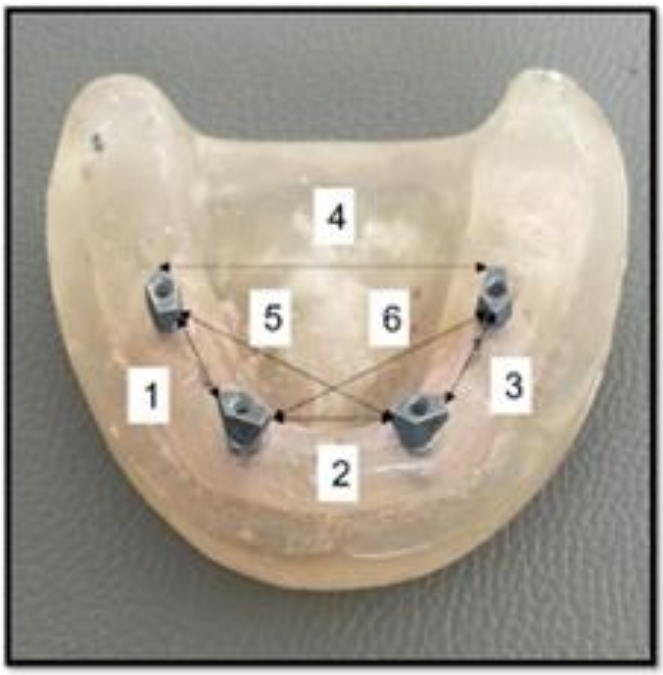

Fig. 3: Inter implant distance

Measurements of Master Reference Model

The implant scanning abutments were attached to the implant replica on the master reference model. The prongs of the digital vernier were mount on the parallel surface between the implant scanning abutments which served as the reference point for each measurement. The

digital vernier calliper was used to record inter implant distance. For inter implant distances, each measurement was made thrice, and average was taken to remove errors. This was done to compensate for the unevenness of the edentulous ridge. Measurements obtained from master reference model served as control group.

Digital test scan was obtained in STL file. Rea converter software was used to convert STL file into DWG format. Digital scans were transferred to ProgeCAD software for the measurements Proge CAD was used to measure inter implant distances (Fig. 4). For inter implant distance parallel sides between two implant scan bodies were used as the reference points. Measurements obtained from this group were compared to control group and for accuracy. These measurements were done for all the 5 scans of each group for measuring the precision.

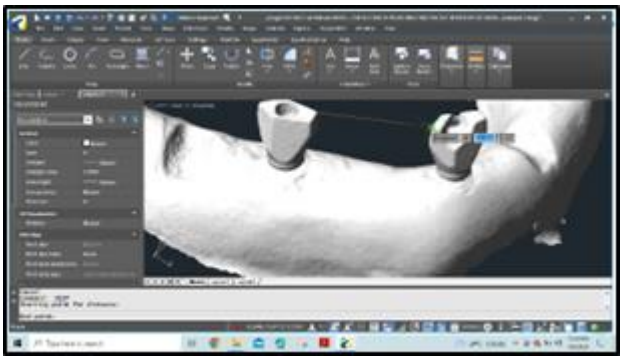

Fig. 4 Measurement using CAD software

Results

The data was analyzed using IBM SPSS Statistics v16. Trueness of scans were analyzed by comparing the measurements of intra oral scanner from Vernier Caliper. Precision was tested through the measurement of repeated scans. One way ANOVA followed by Bonferroni test as Post hoc test was used for inferential statistics. Descriptive statistics were expressed in terms of mean, standard deviation, minimum, maximum and 95% Confidence Interval for Mean (Upper limit & lower limit) for all the 6 distances as shown in Table 1. P value is considered to be significant at 95 % confidence interval. The Precision of Trios 3 Shape, Medit & Vernier Caliper at all six different distances is represented in Table 1. Vernier Caliperis considered to be the reference (Standard). One way ANOVA and post hoc tukey test revealed statistically significant difference amongst the three groups with respect to Distance 2 & 3. Trueness was calculated on basis of difference between Vernier Caliper reading and scanner readings. Medit showed statistically significant difference with Vernier Calliper readings at Distance 2 & 3 where Trios 3 Shape didn't show any statistically significant difference except at Distance 2. Trios readings are almost in line with vernier calliper (more trueness). Medit shows higher standard deviation (less precision)

Table 1. Precision study

Distance		Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Distance 1	Trios 3 Shape	12.2500	.10886	12.1148	12.3852	12.13	12.39
	Medit	12.0960	.15405	11.9047	12.2873	11.95	12.28
	Vernier Caliper	12.1400	.00000	12.1400	12.1400	12.14	12.14
Distance 2	Trios 3 Shape	13.7460	.07162	13.6571	13.8349	13.65	13.83
	Medit	13.4860	.11929	13.3379	13.6341	13.35	13.64
	Vernier Caliper	13.2800	.00000	13.2800	13.2800	13.28	13.28
Distance 3	Trios 3 Shape	12.9360	.17009	12.7248	13.1472	12.80	13.23

	Medit	14.1800	1.48228	12.3395	16.0205	12.70	16.13
	Vernier Caliper	12.4700	.00000	12.4700	12.4700	12.47	12.47
Distance 4	Trios 3 Shape	39.4880	.23805	39.1924	39.7836	39.13	39.74
	Medit	39.1600	.29606	38.7924	39.5276	38.78	39.60
	Vernier Caliper	39.3700	.00000	39.3700	39.3700	39.37	39.37
Distance 5	Trios 3 Shape	29.6680	.22599	29.3874	29.9486	29.27	29.82
	Medit	29.6900	1.98391	27.2267	32.1533	27.90	32.96
	Vernier Caliper	28.7200	.00000	28.7200	28.7200	28.72	28.72
Distance 6	Trios 3 Shape	28.2060	.11546	28.0626	28.3494	28.01	28.31
	Medit	28.5480	1.40559	26.8027	30.2933	27.40	30.98
	Vernier Caliper	27.7200	.00000	27.7200	27.7200	27.72	27.72
	Total	28.1580	.83183	27.6973	28.6187	27.40	30.98

Discussion

The IOS has various advantages such as they make easier for the clinician and the laboratory technicians to communicate, eliminating the dental plaster models and reduce the working time. The precision and trueness of the IOS are an important factor as it influences the restorations. The aim of this study was to measure trueness and precision of different IOS systems when digitizing a fully edentulous cast with multiple implants. The correlation between trueness and precision is a significant aspect in choosing a suitable IOS scanner for the intended application.The aim of the present study was to evaluate the accuracy of the two scanners (trios 3 and medit i700) and to compare it with the digital vernier caliper. Based on the results of present study the null hypothesis that there is no significant difference between the accuracy of the two scanners was rejected. A significant difference was found in the values distance 2 and 3 in medit group when compared to the digital vernier caliper. Therefore, in the present study Trios 3 presented higher accuracy in comparison compared to medit. The result of present study is supported by another study done by **Amornvit P et al**[1] in which trios series showed better trueness and precision results compared to other scanners. In a study by **Renne et al**[5] it was found the for complete arch scanning, the 3 shape trios was found to have the best balance of speed and accuracy. In another study by **winkler J. et al**[6] who evaluated trueness and precision of two widely used intraoral scanners (Trios 3,3Shape, and CS 3600, Carestream), Trios 3 showed slightly higher precision (approximately 10 μm) compared to CS 3600. The refractive index of scanned substrate has been shown to influence IOS complete arch accuracy, with enamel being less accurate than dentin because of its higher translucency. Errors can occur which scanning by the IOS. The IOS captures approx. 1200 images when scanning. Scanning errors can result from the superimposition of the images while scanning and processing.[5,7]Errors also can occur while computer processing from filter algorithms and calibration.[8,9] In addition, errors during computer processing are due to filter algorithms. Intraoral scanners do not have the ability to scan the entire arch in one stroke because of anatomical position and accessibility of underlying structures. The small hand-piece unit has to move across

the arch the scanner's software stitches the images of the arch and implant and combines one image after another image; this seems to induce errors, the clear effect of the stitching processes producing errors proportional to the scan distance, as noted in this study, has also been documented in other studies.[10]

Like other in vitro studies evaluating IOS accuracy, the present study has some limitations. Intraoral factors such as saliva, limited mouth opening, patient movement, and different refractive indexes of teeth and gingiva were not considered. Further studies that evaluate the accuracy of newly introduced hardware and/or software of IOSs for single crown preparation under in vivo conditions are required. It will also be clinically useful to evaluate the IOS accuracy by comparing the marginal fit of the crown. The accuracy of actual and new IOSs should be evaluated on prepared teeth for long-span prostheses as well as for single crown preparation.

Conclusion

Within the limitation of this study following conclusion were drawn:

1. In comparison with conventional method, IOS is accurate and easier
2. Scanners differ in trueness and precision.
3. Trueness and precision of Trios 3 was better in reference to digital vernier caliper in comparison with Medit.
4. High cost and need of regular software update are the drawbacks of IOS

References

1. Amornvit P, Rokaya D, Sanohkan S. Comparison of Accuracy of Current Ten Intraoral Scanners. Biomed Res Int. 2021; 2021: 1-10.
2. Mutwalli H, Braian M, Mahmood D, Larsson C. "Trueness and Precision of Three-Dimensional Digitizing Intraoral Devices", International Journal of Dentistry.2018;2018:1-10
3. Michelinakis G, Apostolakis D, Tsagarakis A, Kourakis A, Pavlakis E, A comparison of accuracy of 3 intraoral scanners: A single-blinded in vitro study. J Prosthet Dent. 2020; 124(5):581-8.
4. Diker B, Tak Ö. Comparing the accuracy of six intraoral scanners on preparedteeth and effect of scanning sequence. J Adv Prosthodont. 2020;12(5):299-306.
5. Rudolph H, Salmen H, Moldan M, Kuhn K, Sichwardt V, Wöstmann B, Luthardt RG. Accuracy of intraoral and extraoral digital data acquisition for dental restorations. J Appl Oral Sci. 2016;24(1):85-94.
6. Winkler J, Gkantidis N. Trueness and precision of intraoral scanners in the maxillary dental arch: an in vivo analysis. Sci Rep. 2020;10(1):1172.
7. Takeuchi Y, Koizumi H, Furuchi M, Sato Y, Ohkubo C, Matsumura H. Use of digital impression systems with intraoral scanners for fabricating restorations and fixed dental prostheses. J Oral Sci. 2018;60(1):1-7.
8. Mehl A, Ender A, Mörmann W, Attin T. Accuracy testing of a new intraoral 3D camera. Int J Comput Dent. 2009;12(1):11-28.
9. 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.
10. 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.