EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 70, 353:361, January, 2024

Print ISSN 0070-9484 • Online ISSN 2090-2360

Fixed Prosthodontics and Dental Materials

Submit Date : 30-08-2023 • Accept Date : 24-09-2023 • Available online: 10-01-2024 • DOI : 10.21608/EDJ.2023.233018.2697

ACCURACY OF INTRAORAL SCANNING OF IMPLANT LEVEL IMPRESSION TECHNIQUE VERSUS ABUTMENT LEVEL IMPRESSION IN IMPLANT MANDIBULAR SUPPORTED OVERDENTURE. IN-VITRO STUDY

Doaa Mahmoud El Kady* *and* Nesma Mohamed Awaad*

ABSTRACT

Intraoral scanning has recently been investigated showing high accuracy in complete implant supported cases. The aim of this in vitro study was to compare the accuracy of intraoral scanning techniques for implant level impression versus abutment level impression techniques in patients with mandibular supported overdenture.

Methods: Ready-made scannable foam cast of completely edentulous mandible was scanned using the extraoral scanner representing an edentulous mandible where four implant were placed. This cast was used as the control group; which was used to fabricate one cast with the implant level impression technique and the other to fabricate cast with abutment level impression technique as interventions. For both interventions; Digital intraoral scans (DIOS) were made after connecting implant level scan bodies to the master cast and STL files were exported to be used in the superimposition by a MEDIT COMPARE software for determining the accuracy of both techniques.

Results: There was a statistically significant difference between (Implant level) and (Abutment level) where ($p=0.008$).

Conclusion: The implant level impression technique is more accurate than the abutment level impression technique when using Digital intraoral scanning.

KEYWORDS: Dimensional Measurement Accuracies, Implant-Supported Dental Prosthesis, Dental Impression Technic, Digital Technologies

* Lecturer of Prosthodontic Department, Faculty of Dentistry, Cairo University

INTRODUCTION

Advanced innovation within the prosthetic dental field has been greately developed, were ,it requires the need of more created scanners, intraoral scan bodies (ISB)s ,computer software, milling machines,and advanced ceramic materials [1-5].

Nowadays ; within this digital era we are been through, facilitating the fabrication of crowns and bridges, restoration of missing teeth, planning, and prosthetically driven implant placement has took place.[6-8] These digital techniques showed a highly reliable results in contrast with the previously used conventional techniques which gives more risk to human and technical errors [9,10].

Although several aspects affecting the accuracy when taking a digital impression, such as implant position, scanning strategy, light intensity, and arch length, may be responsible for the problems with complete arch implant prosthesis scanning regarding the passive fit[11-18].

Additionally, the IOS has difficulty identifying similar intraoral scan bodies and pinpointing their sites when scanning several implants. [19,20] Additionally, it's critical to collect reliable digital images from patients who lack teeth. Lack of reference points between point clouds can also lead to distorted images.

The stitched images that are produced may also contain a variety of faults, and the software may identify the main portions of the scan as trash and usually remove them[21-23].

The outcome of any prosthodontic rehabilitation depends largely on the impression process. Splinting of the impression copings, implant angulation, the form and rigidity of impression trays, the quantity of implants, and the impression materials employed all have a significant impact on the accuracy of implant impressions. The splinting and polymerization shrinkage of the employed impression material are the most important elements when taking impressions for numerous implants, especially for four or more implants on the dental arch[24].

The accuracy of the impression will be impacted by the number of implants, according to numerous articles, if there are more than 2 or 3 implants. For prostheses to work successfully, implant placement must be done with a high degree of accuracy. This can be accomplished by using a surgical guide which, at the time of surgery, fits on to the existing dentition or on to the edentulous span and offers adequate information regarding implant placement. Additionally, it helps with the accurate surgical positioning and angulation of dental implants, making it possible for a predictable and safe minimally invasive operation[25].

Accuracy, in accordance with ISO standards, is a combination of precision and trueness. Precision is the consistency of measurements within a certain group, which increases the predictability of the outcomes. But trueness refers to how closely these measurements correspond with reality. [26,27.]

The present in vitro study compares the accuracy of impression techniques in terms of trueness and precision of these methods of four placed mandibular dummy implants by using Geomagic Software in recording the accuracy of three casts and superimposing the two implant impression casts and compare them to the original cast.

MATERIAL AND METHODS

This invitro study was targeting mandibular edentulous ridges as a population, with two interventions; intervention 1 represented as Implant level impression while intervention 2 represented as abutment level impression. Comparator was a ready foam cast received 4 implants and scanned with an extraoral scanner. Accuracy of both groups was measured and assessed. 10 scans were made for each group.

After ethical approval from Research ethics committee faculty of dentistry, Cairo University was given with number 37523; all study settings were conducted in the Artificial intelligence and digital dentistry center, Faculty of Dentistry, Cairo University.

Reference cast preparation

Ready-made scannable foam cast of completely edentulous mandible was scanned using the extraoral scanner inEos X5 blue light scanner (**CEREC inLab, Sirona Dental Systems, Germany**) to obtain an STL (standard tessellation language) saved for later.

Then this foam scannable cast was imaged with CBCT (cone beam CT) by placing the cast within the machine platform as recommended by the manufacture (**PLANMECA Pro max 3D mid CBCT machine)** obtaining a DICOM file saved for later.

The STL file of the foam cast obtained from the extra oral scanning was exported to Exocad software (**Exocad GmbH CAD/CAM software**) for denture designing using the denture design module. Virtual teeth were selected with the surrounding denture borders and saved for later as an STL file.

The DICOM file of CBCT imaging and the STL file of the designed denture were all imported into the planning software **(Blue sky Bio,LLC. planning software**) for surgical guide fabrication which was printed by using CHITUBOX V1.7.0 software (**Chitubox V1.7.0 software CBD-Tech, Chinese)** by a 3D printer (**Phrozen Sonic Mini 4K, 3D printer**) using a clear resin (**Proshape Surgical Guide, Resin Type).**

The four metal sleeves were inserted into their position in the guide. The guide was placed on the foam cast for checking stability and complete seating. Drilling for the 4 implants was done using standard sequential drills in the foam cast guided by the computer guide stent according to the predetermined positions. Using Neobiotech Implant kit (**Neobiotech, Implant kit, korea**). Implants used were 3.5 mm according to the ridge width while the implant length was chosen to be 11.5 for the anterior implants and 10 mm for posterior implants. **(Neobiotech IS, Implant, korea).**

The drill holes were irrigated with water to remove any foam debris that may prevent implant from complete seating. The dummy implants (**Neobiotech IS, Implant, korea)** were placed accurate in the planned

Four scan bodies (**Neo Biotech IS scan body, Korea)** were tightened to the four implants with a torque wrench to 15 N/cm, the model was then scanned with Medit i700 wired intraoral scanner (IOS) with new STL file obtained named "control group " . The obtained STL file was our Reference model to which we compared both groups of interventions.

Intervention's casts fabrication

Intervention 1: Implant Level Impression Technique (Group 1):

In order to obtain the cast model for group 1 (implant level impression); four open tray transfer abutments replaced the scan bodies in the reference model were connected and tightened on the four dummy implants reaching 35NCM torque as recommended by the manufacture, then dental floss (**Oral B floss Satin Dental Tape ,Irland)** strengthened with duralay (**Duralay GC AMERICA INC.3737,ALSIP IL 60803 USA)** was used for transfers splinting during impression making.

A special tray with widened four openings corresponding to the implants position was used to make an open tray impression (Implant level impression which was taken using poly-vinyl siloxane rubber impression material (**Zetaplus. C-silicone putty. Zhermack Company – Italy).**

After complete setting of the impression, the splinted implant transfers were unscrewed to be picked up into the impression. Four analogues were screwed into the four embedded open transfers, tissue mimic was placed and impression was poured with type IV gypsum (**Type 4, Gc Fujirock, Japan).** The obtained cast represented cast model for group 1.

Intervention 2: Abutment Level Impression (Group 2):

Multi-unit Abutments was tightened on the dummy implants (neobiotech implant IS, Korea) reaching 35NCM torque as recommended by the manufacture. Followed by tightening four multiunit open transfer for making the impression as the impression sequence made with group 1. The obtained cast represented the model cast for group 2 (abutment level impression).

Scanning for the intervention's models

The Two final stone cast models (group 1 and group 2) were now ready for scanning and deviation analysis. Four scan bodies were tightened to a 20 N/cm on both stone casts (group 1 and 2) and were scanned using a intraoral scanner (Medit i700 wired intraoral scanner, IOS) to obtain an STL file for each group. As Fig 1 and 2.

Fig. (1) Scan bodies on cast ready for scan

Fig. (2) Medit IOS i700 wired

The scans of both final stone casts was performed using the same procedure and the same parameters as the control group scan. After completing the scan, the scan data was evaluated for any defective areas until it was free from missing data or holes at that time the scanning procedure was considered complete.

Superimposition of both impression techniques to the original cast:

Stl files for each cast (control, implant level cast and abutment level cast) were imported into the Medit design app feature for superimposition.

In the Medit link software a file was created for each group by its name, as implant level /abutment level superimposition. In the assigned file, the Medit design app feature was used to perform superimposition. Once the STL file formats for each group were imported into the Medit design software, superimposition of the control cast scan and each individual scan for implant level and abutment level was made.

Medit for clinics software was used, and the color-coded deviation map was available using the Medit Design app. The control group scan was selected as reference scan and the other two scans implant and abutument level were selected as target scan; each one in its turn.

Medit design software was used to visualize the distribution of deviation. This allowed the interpretation of 3D deviation into 2D color-coded maps.

A color-coded map for accuracy was visualized where each color in the color map translated into a specific numerical value. The color maps indicated the displacements between overlapped structures. The same colorimetric parameters were set for both groups where; the maximum deviation ranged from 1000 μm to–1000 μm for better fit accuracy between the overlapped scans.

Trueness and precision can be evaluated through measuring the accuracy where; trueness refers to the devotion of virtual data obtained to the actual dimensions of the reference measurements, while precision is how the measurements are being repeatable (Fig 3 and 4).

All the data were collected and tabulated in microns to be statistically analyzed to determine degree of deviation and accuracy of both impression technique implant level and abutment level.

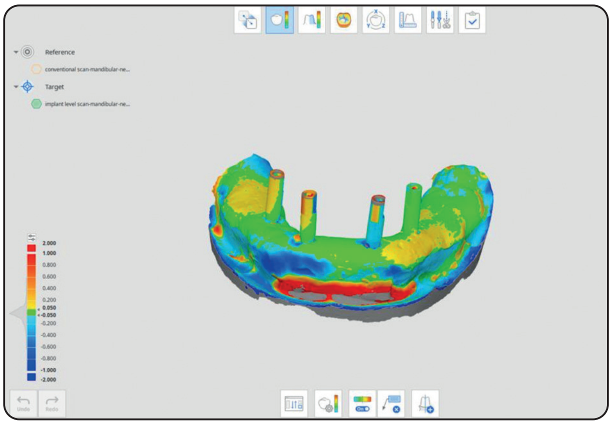

Fig. (3) Implant level impresion superimposed

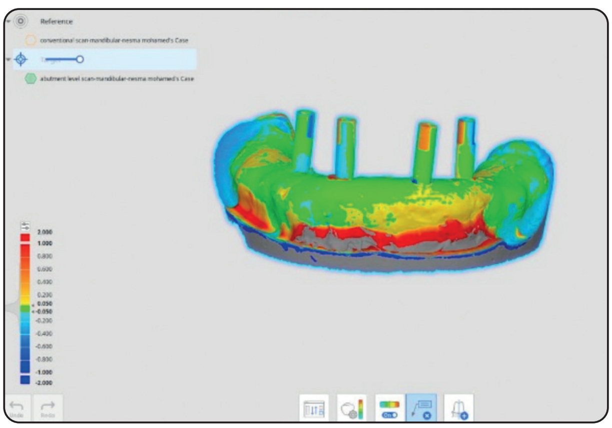

Fig. (4) Abutment level impresion superimposed

RESULTS

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and ShapiroWilk tests where data showed parametric (normal) distribution.

Independent sample t-test was used to compare between two groups in non-related samples.

The significance level was set at P ≤ 0.05. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows

Accuracy assessment:

There was a statistically significant difference between (Implant level) and (Abutment level) where (*p*=0.008) where the highest mean value of deviation from control group impressions was found in Abutment level impression technique (Less accurate), while the lowest mean value of deviation from control group impressions was found in Implant level impression technique (More accurate). As seen in fig 5.

TABLE (1): The mean, standard deviation (SD) values of accuracy of different groups.

Variables	Accuracy	
	Mean	SD
Implant level	0.221	0.022
Abutment level	0.244	0.011
p-value	**0.008***	

Means with different letters in the same column indicate significant difference. *; significant (p<0.05) ns; non-significant (p>0.05)

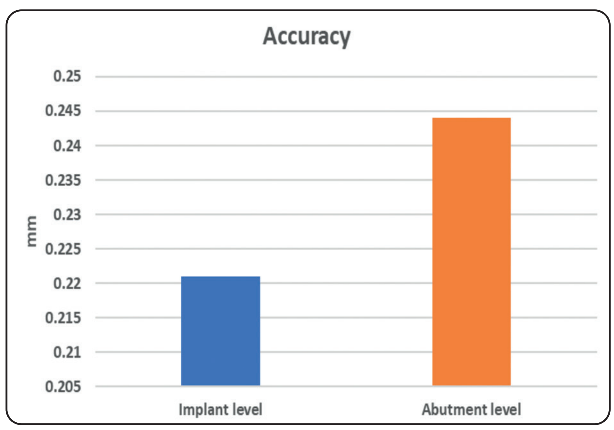

Fig. (5) Bar chart representing accuracy for different groups

DISCUSSION

Accuracy is defined by "trueness" and "precision", as described in the ISO 5725 standard. Trueness and precision are terms used to describe the accuracy of measurement method. Trueness term refers to the closeness of agreements between arithmetic mean of large number of test result and true or accepted reference value. While precision term refers to closeness of agreements between test results. [28]

Several factors can influence impression accuracy which may project in the passivity of the prosthesis including implant angulation, implant depth, implant connection type, and inter-implant distance. [29,30.]

In earlier studies, these aspects were highlighted using conventional impressions. However, while looking at scans of digital impressions, other paths to results can be discovered. Because there is no concern with impression material deformation during removal or movement of impression transfer using this procedure, implant angulation should not have an impact on the fidelity of digital imprints. [31,32]

Using digital scanning and specialized software for superimposition of the generated STL files, one effective method for determining and contrasting precision and trueness at the tiny scale is digital scanning.

Inconstancy of studies related to the accuracy of digital impression regarding trueness and precessions ranges from studies found that digital impressions had the same level of trueness or precision as conventional impressions [34,35]

Other studies revealed that the conventional impressions showed better results related to trueness or precision when compared to the digital impressions [36,37]

While others in agreement with our study found that; digital impressions had better trueness or precision when compared to conventional impressions. [38-40]

These discrepancies between the researches could be attributed to variations in experimental conditions, impression range, data processing techniques, choice of outcome data, or IOS capability.

Results of this study came in accordance with the results of the previous study revealed that implant level impression technique showed less deviation (more accurate) than the abutment level impression technique which may be attributed to the lack of parallelism between the implants which leads to undesirable path of impression withdrawal which is considered a cause of impression distortion.[41]

This may also be explained by the IO's directional error when bent as it moves toward a new plane, which makes it difficult to catch scan bodies near the curve. In contrast to photogrammetry systems, which are fixed in a particular position and at a predetermined standardized distance are not influenced by motion or camera's inclination, errors may depend less on implant angulation and more on the arch shape and how the scanner is oriented to capture the needed image.[42]

In a previous research, Alikhasi et al. evaluated the dimensional accuracy of impression techniques on levels of implant and abutment along with its effect on lack of marginal integrity. They concluded that the impression method affects its accuracy. Moreover, implant level methods are more accurate for creating a 3D implant position in the impression made with polyether impression material.[43]

A systematic review by Kong et al. (2022) compared the accuracy of digital and conventional impression for full arches. After analyzing 22 studies the results showed 0.9 mm 3D deviation and 0.1 mm difference in precision, between digital and conventional full arch impressions; where the majority of the literature that is examined almost always comes to the conclusion that IOS can produce full arch impression accuracy to some extent. The employment of digital impression techniques in full arch scanning of partially and completely edentulous instances is not, however, neutralized by the large accuracy differences between conventional and digital or between the reference and test scans by IOS.[44]

A systematic review by Carneiro Pereira Ana Larisse et al. concluded that intraoral scanning technique Promoting physical paths that join the digitization bodies can increase the accuracy of transferring the position of the implants), environmental conditions.[13]

Despite the important results of this study, limitations exist. Correlation between the results of this in vitro study and clinical status should be done carefully as there are contributing factors that, although standardized, are different in the oral setting. This includes varying light reflectivity, presence of saliva, and limited accessibility during the scan..

CONCLUSION

Within the limitations of this in vitro study, it can be concluded that implant level impression technique is more accurate than abutment level impression technique when using an intraoral scanner when compared to the conventional impression technique.

REFERENCES

1. Moreira AH, Rodrigues NF, Pinho AC, Fonseca JC, Vilaça JL. Accuracy Comparison of Implant Impression Techniques: A Systematic Review. Clinical Implant Dentistry and Related Research. 2015 Oct;17 Suppl 2:e751-64. DOI: 10.1111/cid.12310. PMID: 25828851.

2. Joda, Tim et al. "Digital technology in fixed implant prosthodontics." Periodontology 2000 vol. 73,1 (2017): 178-192. doi:10.1111/prd.121643.

3. Mangano, F., Gandolfi, A., Luongo, G. et al. Intraoral scanners in dentistry: a review of the current literature. BMC Oral Health 17, 149 (2017). https://doi.org/10.1186/s12903-017-0442-x

4. Mizumoto, Ryan M, and Burak Yilmaz. "Intraoral scan bodies in implant dentistry: A systematic review." The Journal of prosthetic dentistry vol. 120,3 (2018): 343-352. doi:10.1016/j.prosdent.2017.10.029

5. Pyo, Se-Wook et al. "Ceramic Materials and Technologies Applied to Digital Works in Implant-Supported Restorative Dentistry." Materials (Basel, Switzerland) vol. 13,8 1964. 22 Apr. 2020, doi:10.3390/ ma13081964

6. Papadiochou, Sofia, and Argirios L Pissiotis. "Marginal adaptation and CAD-CAM technology: A systematic review of restorative material and fabrication techniques." The Journal of prosthetic dentistry vol. 119,4 (2018): 545-551. doi:10.1016/j.prosdent.2017.07.001

7. Scolozzi, Paolo et al. "Computer-Aided Design and Computer-Aided Modeling (CAD/CAM) for Guiding Dental Implant Surgery: Personal Reflection Based on 10 Years of Real-Life Experience." Journal of personalized medicine vol. 13,1 129. 9 Jan. 2023, doi:10.3390/jpm13010129

8. Bover-Ramos, Fernando et al. "Accuracy of Implant Placement with Computer-Guided Surgery: A Systematic Review and Meta-Analysis Comparing Cadaver, Clinical, and In Vitro Studies." The International journal of oral & maxillofacial implants vol. 33,1 (2018): 101–115. doi:10.11607/jomi.5556

9. Keul, Christine, and Jan-Frederik Güth. "Accuracy of full-arch digital impressions: an in vitro and in vivo comparison." Clinical oral investigations vol. 24,2 (2020): 735-745. doi:10.1007/s00784-019-02965-2

10. Mohammed Alassiry, Ahmed. "Clinical aspects of digital three-dimensional intraoral scanning in orthodontics - A systematic review." The Saudi dental journal vol. 35,5 (2023): 437-442. doi:10.1016/j.sdentj.2023.04.004

11. Giuliodori, Giovanni et al. "Intraoral Scans of Full Dental Arches: An In Vitro Measurement Study of the Accuracy of Different Intraoral Scanners." International journal of environmental research and public health vol. 20,6 4776. 8 Mar. 2023, doi:10.3390/ijerph20064776

12. Alikhasi, Marzieh et al. "Three-Dimensional Accuracy of Digital Impression versus Conventional Method: Effect of Implant Angulation and Connection Type." International journal of dentistry vol. 2018 3761750. 4 Jun. 2018, doi:10.1155/2018/3761750

13. Carneiro Pereira, Ana Larisse et al. "Influence of implant position on the accuracy of intraoral scanning in fully edentulous arches: A systematic review." The Journal of prosthetic dentistry vol. 126,6 (2021): 749-755. doi:10.1016/j.prosdent.2020.09.008

14. Arcuri, Lorenzo et al. "Influence of implant scanbody material, position and operator on the accuracy of digital

impression for complete-arch: A randomized in vitro trial." Journal of prosthodontic research vol. 64,2 (2020): 128-136. doi:10.1016/j.jpor.2019.06.001

15. Kuroda, Shota et al. "The effect of scanning pathways on trueness and precision in full-arch optical impression." BMC oral health vol. 23,1 390. 14 Jun. 2023, doi:10.1186/s12903-023-03101-z
16. 16- Revilla-León, Marta et al. "Intraoral digital scans-Part 1: Influence of ambient scanning light conditions on the accuracy (trueness and precision) of different intraoral scanners." The Journal of prosthetic dentistry vol. 124,3 (2020): 372-378. doi:10.1016/j.prosdent.2019.06.003
17. Revilla-León, Marta et al. "Intraoral digital scans: Part 2-influence of ambient scanning light conditions on the mesh quality of different intraoral scanners." The Journal of prosthetic dentistry vol. 124,5 (2020): 575-580. doi:10.1016/j.prosdent.2019.06.004
18. Tan, Ming Yi et al. "Comparison of Three-Dimensional Accuracy of Digital and Conventional Implant Impressions: Effect of Interimplant Distance in an Edentulous Arch." The International journal of oral & maxillofacial implants vol. 34,2 (2019): 366–380. doi:10.11607/jomi.6855
19. Fluegge, Tabea et al. "A Novel Method to Evaluate Precision of Optical Implant Impressions with Commercial Scan Bodies-An Experimental Approach." Journal of prosthodontics : official journal of the American College of Prosthodontists vol. 26,1 (2017): 34-41. doi:10.1111/jopr.12362
20. Kao, Tzu-Yung et al. "Accuracy of digital impressions for three-unit and four-unit implant supported fixed dental prostheses using a novel device." Journal of dental sciences vol. 18,2 (2023): 702-708. doi:10.1016/j.jds.2022.10.014
21. Costa, Vitória et al. "In Vitro Comparison of Three Intraoral Scanners for Implant-Supported Dental Prostheses." Dentistry journal vol. 10,6 112. 15 Jun. 2022, doi:10.3390/dj10060112.
22. 22. Goodacre, Brian J et al. "Using Intraoral Scanning to Capture Complete Denture Impressions, Tooth Positions, and Centric Relation Records." The International journal of prosthodontics vol. 31,4 (2018): 377–381. doi:10.11607/ijp.5741
23. Zingari, Francesco et al. "Predictability of intraoral scanner error for full-arch implant-supported rehabilitation." Clinical oral investigations vol. 27,7 (2023): 3895-3905. doi:10.1007/s00784-023-05011-4
24. Onbasi, Yonca et al. "Trueness of full-arch dental models obtained by digital and conventional impression techniques: an in vivo study." Scientific reports vol. 12,1 22509. 29 Dec. 2022, doi:10.1038/s41598-022-26983-5
25. Zarb GA, Bolender CL , Eckert SE. (2004): Prosthodontic treatment for edentulous patient:complete denture and implant supported prosthesis. 12th st.louis; Mosby Co.
26. Drancourt, Noemie et al. "Accuracy of Conventional and Digital Impressions for Full-Arch Implant-Supported Prostheses: An In Vitro Study." Journal of personalized medicine vol. 13,5 832. 15 May. 2023, doi:10.3390/jpm13050832
27. Giachetti, Luca et al. "Accuracy of Digital Impressions in Fixed Prosthodontics: A Systematic Review of Clinical Studies." The International journal of prosthodontics vol. 33,2 (2020): 192-201. doi:10.11607/ijp.6468
28. In the Merriam-Webster's dictionary (Nez Edition). 2016. https://www.merriam-webster.com/dictionary/accuracy
29. Shaikh, Mohsin et al. "Do digital impressions have a greater accuracy for full-arch implant-supported reconstructions compared to conventional impressions? An in vitro study." Journal of Indian Prosthodontic Society vol. 22,4 (2022): 398-404. doi:10.4103/jips.jips_52_22
30. Alikhasi, Marzieh et al. "Three-Dimensional Accuracy of Digital Impression versus Conventional Method: Effect of Implant Angulation and Connection Type." International journal of dentistry vol. 2018 3761750. 4 Jun. 2018, doi:10.1155/2018/3761750
31. Carneiro Pereira, Ana Larisse et al. "Influence of implant position on the accuracy of intraoral scanning in fully edentulous arches: A systematic review." The Journal of prosthetic dentistry vol. 126,6 (2021): 749-755. doi:10.1016/j.prosdent.2020.09.008
32. Vojdani, Mahroo et al. "Accuracy of different impression materials in parallel and nonparallel implants." Dental research journal vol. 12,4 (2015): 315-22. doi:10.4103/1735-3327.161429
33. Ender, Andreas et al. "Accuracy of complete- and partial-arch impressions of actual intraoral scanning systems in vitro." International journal of computerized dentistry vol. 22,1 (2019): 11-19.
34. Hayama, Hironari et al. "Trueness and precision of digital impressions obtained using an intraoral scanner with different head size in the partially edentulous mandible."

Journal of prosthodontic research vol. 62,3 (2018): 347-352. doi:10.1016/j.jpor.2018.01.003

35. Nedelcu, R et al. “Accuracy and precision of 3 intraoral scanners and accuracy of conventional impressions: A novel in vivo analysis method.” Journal of dentistry vol. 69 (2018): 110-118. doi:10.1016/j.jdent.2017.12.006

36. Orejas-Perez, Jaime et al. “In Vivo Complete-Arch Implant Digital Impressions: Comparison of the Precision of Three Optical Impression Systems.” International journal of environmental research and public health vol. 19,7 4300. 3 Apr. 2022, doi:10.3390/ijerph19074300

37. Alsharbaty, Mohammed Hussein M et al. “A Clinical Comparative Study of 3-Dimensional Accuracy between Digital and Conventional Implant Impression Techniques.” Journal of prosthodontics : official journal of the American College of Prosthodontists vol. 28,4 (2019): e902-e908. doi:10.1111/jopr.12764

38. Amin, Sarah et al. “Digital vs. conventional full-arch implant impressions: a comparative study.” Clinical oral implants research vol. 28,11 (2017): 1360-1367. doi:10.1111/clr.12994

39. Kamimura, Emi et al. “In vivo evaluation of inter-operator reproducibility of digital dental and conventional impression techniques.” PloS one vol. 12,6 e0179188. 21 Jun. 2017, doi:10.1371/journal.pone.0179188

40. Menini, Maria et al. “Accuracy of multi-unit implant impression: traditional techniques versus a digital procedure.” Clinical oral investigations vol. 22,3 (2018): 1253-1262. doi:10.1007/s00784-017-2217-9

41. Carneiro Pereira, Ana Larisse et al. “Influence of implant position on the accuracy of intraoral scanning in fully edentulous arches: A systematic review.” The Journal of prosthetic dentistry vol. 126,6 (2021): 749-755. doi:10.1016/j.prosdent.2020.09.008

42. Alikhasi M, Siadat H, Monzavi A, Momen-Heravi F. Threedimensional accuracy of implant and abutment level impression techniques: effect on marginal discrepancy. J Oral Implantol. 2011;37(6):649-657

43. Keul, C.; Güth, J.F. Accuracy of full-arch digital impressions: An in vitro and in vivo comparison. Clin. Oral Investig. 2020, 24, 735–745.

44. Kong, L., Li, Y., & Liu, Z. (2022). Digital versus conventional full-arch impressions in linear and 3D accuracy: a systematic review and meta-analysis of in vivo studies. Clinical Oral Investigations, 26(9), 5625–5642