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Pacific Northwest Prosthodontics specializes in fixed, removable and implant Prosthodontics as well as being highly trained in fully edentulous immediate implant provisionalization (aka all on 4) options for your patients with failing or missing dentitions.

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Prosthodontics Newsletter™

Focusing on Dental Implants

Making Impressions for Edentulous Dental Implants

Making impressions is a critical early step in fabricating any dental prosthesis. The use of an intraoral scanner or conventional impression trays with splinted implant impression components to capture edentulous ridge contours and 3-dimensional implant positions and relationships is a complex, technique-sensitive clinical process. Research to date has failed to provide a consensus on the best methods. To assist clinicians in this challenging area, this issue of Prosthodontics Newsletter *reviews recent professional literature on edentulous implant impression techniques and their accuracy.*

Adding Landmarks to Digital Scans

Although open-tray impressions represent the standard approach for obtaining accurate impressions for prostheses supported by multiple implants, the procedure is complex and inefficient, with several factors affecting the accuracy of the impression. Intraoral scanners are accurate for single- and 3-unit implant scanning, but older models are not reliable for scanning edentulous jaws or edentulous spaces with long distances between implants that lack geometric variation. One suggested solution to this problem involves the placement of prefabricated landmarks on the edentulous jaw.

Ke et al from Peking University, China, evaluated the accuracy of scanned implant impressions made with prefabricated landmarks in edentulous jaws. They fabricated an edentulous mandibular stone cast with a gingival replica into which they placed 4 implant abutment analogs at the right and left first molars and canines, then scanned the cast with a laboratory scanner. Each landmark consisted of a collar, a long plate with protruding letterforms, and a connecting cylinder linking the collar and the long plate. Two different intraoral scanners were used. Ten scans with identical parameters were taken for each of 4 groups:

- TRIOS 4 scanner without landmarks
- TRIOS 4 scanner with landmarks
- Aoralscan 3 scanner without landmarks
- Aoralscan 3 scanner with landmarks

A conventional splinted open-tray implant impression technique fabricated stone casts that were scanned by a laboratory scanner and served as the control. All scans were evaluated for accuracy based on trueness and precision.

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Adding Landmarks to Digital Scans

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Digital scans without landmarks showed significantly better results for distance trueness and angle precision than the conventional technique. Digital scans with landmarks showed significantly greater trueness and precision than digital scans without landmarks. The TRIOS 4 scanner achieved significantly greater accuracy than the Aoralscan 3 scanner when each was used without landmarks; conversely, the Aoralscan 3 achieved significantly higher accuracy when used with landmarks (Table 1).

Comment

Digital scans exhibited better results than conventional impression methods; the addition of prefabricated landmarks significantly increased their accuracy. The results of this in vitro study need to be confirmed with actual patients in a clinical setting.

Ke Y, Zhang Y, Wang Y, et al. Comparing the accuracy of full-arch implant impressions using the conventional technique and digital scans with and without prefabricated landmarks in the mandible: an in vitro *study.* J Dent *2023;doi:10.1016/j.dent.2023.104561.*

Gingival Impact On Scan Accuracy

Due to implant–bone connection rigidity, even a small difference in restoration measurement can lead to negative outcomes regarding long-term success, longevity and survival rate. While the usual standard for achieving a passive fit of the prosthesis calls for a discrepancy of <150 µm, recent studies have suggested a much lower threshold of 59 to 72 µm. Approximately half of any inaccuracy originates from impression-making process and definitive cast fabrication. While the use of a digital workflow has led to more accurate results for smaller restorations, complete-arch scans of edentulous patients continue to show variability in precision, with the surrounding soft tissue being the primary source of error.

Knechtle et al from the University of Zurich, Switzerland, designed an in vitro study to better understand the impact of soft tissue on the accuracy of intraoral scans. They fabricated an edentulous maxillary stone cast with 6 implant analogs that was scanned 10× using 4 different high-precision laboratory intraoral scanners (TRIOS 3, TRIOS Color, CEREC Omnicam and CEREC Primescan). A gingival mask was then placed on the cast to simulate 3 levels of free gingiva; 10 conventional impressions of the cast without the gingival mask were also made. All scans and the conventional impressions were evaluated based on

- the position of the scanned implants, defined as the center point of a modeled plane at the implant shoulder
- the direction of the scanned implants, based on the implant axis

For scans taken without the gingival mask, the TRIOS Color scanner captured the position of the implants with the greatest accuracy and, along with the TRIOS 3, outperformed the conventional impression. The results of all scanners fell below the 72 µm threshold. As the amount of fixed gingiva on the cast increased, the TRIOS scanners showed decreasing levels of accuracy; conversely, scans made by the CEREC scanners continued to show discrepancies of <72 µm.

Comment

The results of this study indicated that, in the absence of soft tissue, the digital scanning systems tested had an accuracy comparable to that obtained from the conventional impression technique. As the amount of soft tissue increased, the accuracy of digital scans decreased, with the accuracy becoming significantly different.

Knechtle N, Wiedemeier D, Mehl A, Ender A. Accuracy of digital complete-arch, multi-implant scans made in the edentulous jaw with gingival movement simulation: an in vitro *study.* J Prosthet Dent *2022;128:468-478.*

Table 1. Mean trueness and precision of intraoral scans with and without prefabricated landmarks.

	Trueness		Precision	
	Distance (µm)	Angle (°)	Distance (µm)	Angle (°)
Conventional	207.4 ± 103.8	1.2 ± 1.0	280.2 ± 141.8	1.9 ± 1.0
IOS-NT	96.7 ± 43.8	0.6 ± 0.3	142.8 ± 57.8	0.7 ± 0.3
IOS-YT	59.9 ± 27.6	0.4 ± 0.2	81.5 ± 43.0	0.4 ± 0.2
IOS-NA	139.0 ± 60.9	1.1 ± 0.4	168.5 ± 91.1	0.6 ± 0.2
IOS-YA	74.5 ± 28.8	0.2 ± 0.1	45.5 ± 28.0	0.2 ± 0.1

IOS-NT, TRIOS 4 scanner without landmarks; IOS-YT, TRIOS 4 scanner with landmarks; IOS-NA, Aoralscan 3 scanner without landmarks; IOS-YA, Aoralscan 3 scanner with landmarks.

Accuracy of Photogrammetry Scanning

Photogrammetry systems, which create 3-dimensional (3D) objects from 2-dimensional images, capture a digital map of a patient's implant positions for use in computer-aided design programs. Few studies have been undertaken to analyze the accuracy of photogrammetry systems compared with conventional techniques for restorative dental procedures. Two elements combined measure the accuracy of these techniques:

➤ **Trueness:** the degree to which the measured implant position corresponds to its actual position

➤ **Precision:** the variability or deviation in implant position across repeated captures under the same conditions

Revilla-León et al from Texas A&M University conducted an in vitro study to evaluate the accuracy of a photogrammetry system used for the digitizing of implant positions.

The researchers fabricated a definitive cast of an edentulous maxilla with 6 implant abutment replicas. Ten impressions were made of the impression copings splinted to a cobalt–chromium framework with autopolymerizing acrylic resin. The maxillary edentulous arch was then recorded with an elastomeric impression using an additively manufactured open custom tray from which stone casts were created; these constituted the conventional group. Ten scans were created by tightening a scan body onto each implant abutment replica, then recording the implant positions using a photogrammetry camera; these constituted the photogrammetry group.

Table 2. Median (interquartile range) discrepancies in groups (µm).

	Conventional group	Photogrammetry group
x axis	11.18 (6.56)	13.36 (18.63)
y axis	11.86 (5.54)	11.47 (9.39)
z axis	2.82 (2.74)	8.05 (7.62)
3D discrepancy	18.40 (6.81)	20.15 (25.41)

The positions of the abutments on the definitive cast and the stone casts were determined by a coordinate-measuring machine; the results were compared with each other and with those of the photogrammetry files for trueness (mean discrepancy of the position of the abutments from the definitive cast) and precision (standard deviation of the mean absolute discrepancies from the definitive cast) along the x, y and z linear and rotational axes (Table 2).

The photogrammetry group was significantly less accurate along the x and z axes, as well as for 3D measurements for 4 of the 6 implant positions.

Comment

Although the overall trueness values for the 2 methods were similar, the precision values were significantly different. Unlike the conventional group, which returned similarly accurate measurements for all of the implants, the photogrammetry group showed significant differences in accuracy for different implant positions, suggesting that photogrammetry results are not as accurate as those obtained with more conventional methods.

Revilla-León M, Rubenstein J, Methani MM, et al. Trueness and precision of complete-arch photogrammetry implant scanning assessed with a coordinate-measuring machine. J Prosthet Dent *2023;129:160-165.*

Impressions in Edentulous Jaws

While multiple in vitro studies comparing full-arch digital implant scans and open-tray splinted impressions have shown comparable accuracy, little work has compared these techniques in vivo. Papaspyridakos et al from Tufts University, Massachusetts, conducted a retrospective study of edentulous maxillae and mandibles comparing 3-dimensional (3D) deviations between conventional implant impressions and full-arch digital scans.

The researchers reviewed the records of 27 patients (36 edentulous jaws: 21 maxillae, 15 mandibles) each treated during a 3-year period with 4 to 6 implants in the treated jaw. After successful implant osseointegration, patients underwent abutment level full-arch digital scans with the TRIOS 3 intraoral scanner. A conventional abutment-level impression was then made of each edentulous jaw after connecting abutment-level impression copings to the implant abutments. Conventional stone casts were created and digitized, then used to fabricate one-piece, screw-retained implant-supported fixed complete dental prostheses. The intraoral scans were compared with the cast digitized stone casts to evaluate 3D deviations between the scans.

The mean 3D deviation of the scans was 88 ± 24 µm; the deviation in the maxillae was 85 ± 25 µm and in the mandibles 92 ± 23 µm, a nonsignificant difference. These results fell well within the clinically acceptable threshold of 150 µm. None of the 36 intraoral scans showed a deviation of >150 µm.

Comment

Although this study included only a small number of patients, its in vivo nature makes it important in evaluating the accuracy of intraoral scans for use in fabricating fixed complete dental prostheses. Clinical studies are needed to test the accuracy of fit for digitally fabricated prostheses.

Papaspyridakos P, De Souza A, Finkelman M, et al. Digital vs conventional full-arch implant impressions: a retrospective analysis of 36 edentulous jaws. J Prosthodont *2023; 32:325-330.*

Intraoral Scanning Accuracy for Multiple Implants

Using intraoral scanners to plan implant-supported prostheses is quicker, less operator sensitive, easier to ship and store, and more comfortable than conventional impressions for patients. Because achieving a passive fit for the prosthesis is critical for long-term accuracy of the impression, Lyu et al from Peking University, China, investigated the accuracy of intraoral scans for restorations with multiple implant configurations, along with results using 2 different evaluation methods.

For this in vitro study, the researchers fashioned a mandibular model with 8 straight implants distributed equally around the arch, labeled A through H from left second molar to right second molar. Implants D and E occupied left and right incisors approximately. The model was scanned 10× with an intraoral scanner, after which a splinted open-tray impression was made at room temperature. The researchers created 5 ranges simulating different clinical situations:

- AB
- FGH
- CDEF
- BCDEFG
- ABCDEFGH

Trueness was measured using 2 different methods: root mean square values using a best-fit algorithm and absolute linear deviation.

Different scanning and impression methods, evaluation methods and scanning ranges all significantly affected the results. Accuracy showed no significant differences for the 2 groups limited to 1 quadrant (AB and FGH); scans covering cross-arch situations, however, showed significantly larger deviations than did results from the conventional impression. Using the absolute linear deviation method, digital scan discrepancies significantly increased as the scanned area increased beyond the CDEF model; the discrepancies with the conventional method remained stable. Using the absolute linear deviation method resulted in higher inaccuracy than did the best-fit algorithm, but not in all situations.

Comment

Regardless of the evaluation method, intraoral scans returned results significantly similar to those from conventional open-tray impressions for implant restorations within a single quadrant; cross-arch scans were less accurate. The trueness values, while greater than those for conventional impressions, did not exceed 80 µm for any scan. The conventional impression was made at room temperature, not mouth temperature, which resulted in a more accurate impression. Thus, the better result for the conventional impression may not be applicable in a clinical setting.

Lyu M, Di P, Lin Y, Jiang X. Accuracy of impressions for multiple implants: a comparative study of digital and conventional techniques. J Prosthet Dent *2022;128:1017-1023.*

In the Next Issue

The one abutment, one-time protocol: fact or fiction?

Our next report features a discussion of this issue and the studies that analyze them, as well as other articles exploring topics of vital interest to you as a practitioner.

Do you or your staff have any questions or comments about **Prosthodontics Newsletter**? Please write or call our office. We would be happy to hear from you.