Primescan™ Intraoral Scanner

Study Overview 2019-2022

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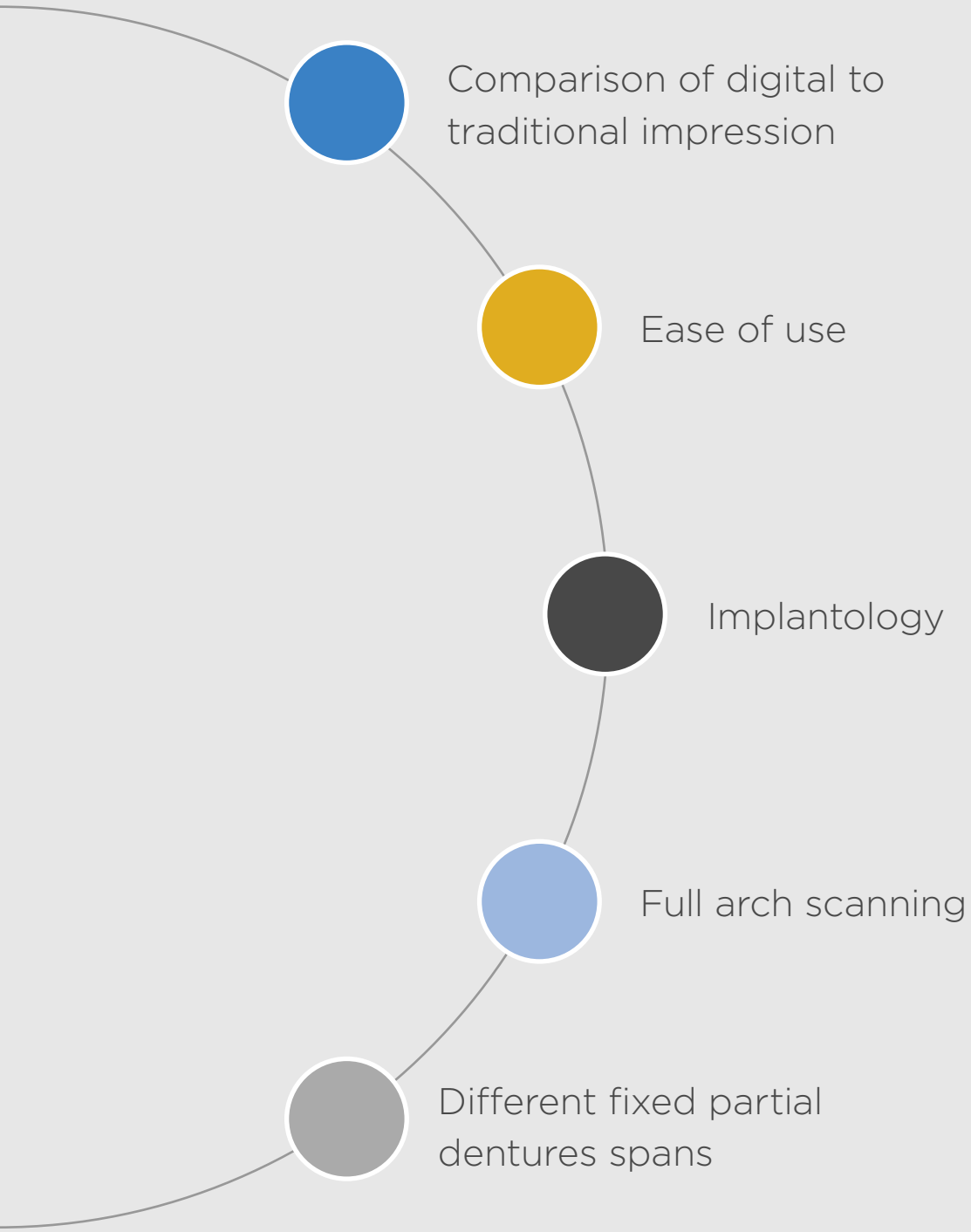
Content

Clinical Studies by features and applications



Comparison of digital to traditional impression

The following document selection includes scientific publications covering, among other topics, the comparison of digital impressions made with Primescan to traditional impression methods.

Study Name	Author/Date	Method	Study Conclusions
Local accuracy of actual intraoral scanning systems for single-tooth preparations in-vitro	Zimmermann *et al.*, (2020)	In-vitro	Results showed that Primescan had higher trueness and values were statistically significantly different from the other IOS systems, except TRIOS®.
Accuracy of digital and conventional full-arch impressions in patients: an update	Schmidt *et al.*, (2020)	In-vivo	Primescan™ yielded the lowest deviation for digital impressions in-vivo.
Digital versus conventional impression taking focusing on interdental areas: a clinical trial	Schlenz *et al.*, (2020)	In-vivo	Primescan™ can display a higher percentage of Interdental Areas (IA) than CVI. Amongst the powder-free IOS, Primescan™ displayed the highest percentage of IA together with Carestream CS 3600.
Accuracy of digital complete-arch, multi-implant scans made in the edentulous jaw with gingival movement simulation: An in vitro study	Knechtle *et al.*, (2021)	In-vitro	Primescan showed lowest deviation values of implant position for direction in all gingival levels and for position in 3 of 4 gingival levels but with no statistical significance to Omnicam (G0, G1, G3) and Trios 3 (G0, G1). Primescan showed no statistically significant differences to the conventional impression.
In Vitro Accuracy of Digital and Conventional Impressions for Full-Arch Implant-Supported Prostheses	D'haese *et al.*, (2022)	In-vitro	Overall, Primescan v5.2 demonstrated the lowest discrepancies in trueness and precision and performed as good as the analogue impression in terms of coronal deviation and even better in terms of angular deviation.

Ease of use

The ease of use of an intraoral scanner is considered one of the main reasons to integrate digital impression in the dental practice. The efficiency of the intraoral scanner allows a shorter learning curve and an easy adaptation to the current workflows. This also facilitates the delegation of the scanning to every team member of the dental practice.

Although, few studies on this topic have been published, the 2 documents included in this section evaluate the scanning time of Primescan and the influence of the scan experience on the accuracy of Primescan. Nevertheless, further studies focusing primarily on the ease of use would be required.

Study Name	Author/Date	Method	Study Conclusions
Accuracy of intraoral scanning in completely and partially edentulous maxillary and mandibular jaws: an in-vitro analysis	Schimmel *et al.*, (2020)	In-vivo	The accuracy of Primescan™ for partially and completely edentulous arches in in-vitro settings was high. The operator's experience with intraoral scanners had small influence on the accuracy of the scans.
In-vitro accuracy of complete arch scans of the fully dentate and the partially edentulous maxilla	Waldecker *et al.*, (2021)	In-vivo	Primescan showed the lowest values for maximum mean absolute distance deviations followed by Trios 4 and Omnicam. The scanning time of Primescan was significantly shorter than for the other tested scanners.

Implantology

The following document selection inlcudes scientific publications covering, among others, topics related to implantology.

Study Name	Author/Date	Method	Study Conclusions
Congruence between meshes and library files of implant scanbodies: an in-vitro study comparing five intraoral scanners	Mangano *et al.*, (2020)	In-vitro	Primescan™ showed the lowest mean absolute deviation. The difference to the other IOS systems was statistically significant, except Carestream CS-3700.
Trueness of ten intraoral scanners in determining the positions of simulated implant scan bodies	Kim *et al.*, (2021)	In-vitro	"Overall, the CEREC Primescan and Trios 3 had the highest trueness in partially edentulous mandible digital implant scans, followed by the i500, Trios 2, and iTero Element, albeit not statistically significant." In the study, 10 intraoral scanners were tested.
Evaluation of complete-arch implant scanning with 5 different intraoral scanners in terms of trueness and operator experience	Revell *et al.*, (2021)	Ex-vivo	In 7 of 8 cases Primescan ranked best or second best in scanner performance. "The recommended 30 µm for passive fit was only achieved by the Primescan in the present study."
Accuracy of digital complete-arch, multi-implant scans made in the edentulous jaw with gingival movement simulation: An in vitro study	Knechtle *et al.*, (2021)	In-vitro	Primescan showed lowest deviation values of implant position for direction in all gingival levels and for position in 3 of 4 gingival levels but with no statistical significance to Omnicam (G0, G1, G3) and Trios 3 (G0, G1). Primescan showed no statistically significant differences to the conventional impression.
In Vitro Accuracy of Digital and Conventional Impressions for Full-Arch Implant-Supported Prostheses	D'haese *et al.*, (2022)	In-vitro	Overall, Primescan v5.2 demonstrated the lowest discrepancies in trueness and precision and performed as good as the analogue impression in terms of coronal deviation and even better in terms of angular deviation.

Full arch scanning

The following document selection inlcudes scientific publications covering, among others topics, full arch scans with Primescan.

Study Name	Author/Date	Method	Study Conclusions
Accuracy of complete- and partial-arch impressions of actual intraoral scanning systems in-vitro	Ender *et al.*, (2019)	In-vitro	In certain aspects, Primescan™ was viewed as the most accurate among the tested intraoral scanners that were compared in an in-vitro study.
Impact of different scanning strategies on the accuracy of two current intraoral scanning systems in complete-arch impressions: an in-vitro study	Passos *et al.*, (2019)	In-vitro	For trueness and precision of complete-arch scans, group M was the dominant scanning strategy in Primescan™, while there was no dominant strategy in Omnicam®. OC and PS had very good results.
Do "cut out-rescan" procedures have an impact on the accuracy of intraoral digital scans?	Reich *et al.*, (2019)	In-vitro	Primescan™ ranked top in trueness and precision.
Feasibility of using an intraoral scanner for a complete-arch digital scan, part 2: A comparison of scan strategies	Son *et al.*, (2021)	In-vitro	Primescan was recommended by the author for long-span prostheses.* For 12 of 14 teeth Primescan showed no differences in accuracy (RMS value) to one or both laboratory scanners. * until verification by additional studies which are needed to verify this by fabricating actual fixed dental prostheses
Influence of intraoral conditions on the accuracy of full-arch scans by Cerec Primescan AC: an in vitro and in vivo comparison	Keul *et al.*, (2022)	In-vivo vs. In-vitro	In-vitro and in-vivo digitalization using the CEREC Primescan AC leads to comparable accuracy for full-arch digitalization. However, no general trend could be observed related to the digitalization milieu (in-vitro versus in-vivo).
Accuracy of intraoral scanning in completely and partially edentulous maxillary and mandibular jaws: an in-vitro analysis	Schimmel *et al.*, (2020)	In-vivo	The accuracy of Primescan™ for partially and completely edentulous arches in in-vitro settings was high. The operator's experience with intraoral scanners had small influence on the accuracy of the scans.
Accuracy of digital complete-arch, multi-implant scans made in the edentulous jaw with gingival movement simulation: An in vitro study	Knechtle *et al.*, (2021)	In-vitro	Primescan showed lowest deviation values of implant position for direction in all gingival levels and for position in 3 of 4 gingival levels but with no statistical significance to Omnicam (G0, G1, G3) and Trios 3 (G0, G1). Primescan showed no statistically significant differences to the conventional impression.

Full arch scanning

The following document selection inlcudes scientific publications covering, among others topics, full arch scans with Primescan.

Study Name	Author/Date	Method	Study Conclusions
Evaluation of complete-arch implant scanning with 5 different intraoral scanners in terms of trueness and operator experience	Revell *et al.*, (2021)	Ex-vivo	In 7 of 8 cases Primescan ranked best or second best in scanner performance. "The recommended 30 µm for passive fit was only achieved by the Primescan in the present study."
In-vitro accuracy of complete arch scans of the fully dentate and the partially edentulous maxilla	Waldecker *et al.*, (2021)	In-vivo	Primescan showed the lowest values for maximum mean absolute distance deviations followed by Trios 4 and Omnicam. The scanning time of Primescan was significantly shorter than for the other tested scanners.

Different fixed partial dentures spans

The following document selection includes scientific publications covering, among others topics, the effect of fixed partial denturs span on the accuracy of Primescan.

Study Name	Author/Date	Method	Study Conclusions
Accuracy of six intraoral scanners for scanning complete-arch and 4-unit fixed partial dentures: An in vitro study	Diker *et al.*, (2021)	In-vitro	The study on scanning accuracy of complete-arch and prepared teeth by 6 IOSs concludes: Primescan showed the highest trueness and the highest median (IQR) precision value of the 4-unit FPD preparations.
Effect of posterior span length on the trueness and precision of 3 intraoral digital scanners: A comparative 3-dimensional in vitro study	Fattouh *et al.*, (2021)	In-vitro	Primescan AC had the highest accuracy (trueness and precision), followed by Trios 3 and then Planmeca Emerald. Increasing the span length reduced the trueness and precision of the 3 tested scanners. Nonetheless, the values were still within the accepted successful ranges.

Local accuracy of actual intraoral scanning systems for single-tooth preparations in-vitro

Study Background

The authors evaluated the local accuracy of intraoral scanning (IOS) systems for single-tooth preparation impressions with an in-vitro setup.

Table 1. Test groups including indication of software versions, manufacturers, and postprocessing protocols to obtain STL* data sets for the evaluation of accuracy of impression methods for local accuracy of tooth preparations.

TEST GROUP	SYSTEM	MANUFACTURER	SOFTWARE	POSTPROCESSING
CO†	PRESIDENT 360 Heavy Body and PRESIDENT Light Body	Coltène AG	Not applicable	Poured with type IV gypsum, digitized with inEOS X5, direct export to STL
TRn	TRIOS 3 Pod normal scan mode	3Shape	TRIOS 3 software, Version 1.18.2.6	Direct export to STL
TRi	TRIOS 3 Pod insane speed scan mode	3Shape	TRIOS 3 software, Version 1.18.2.6	Direct export to STL
CS	CS 3600	Carestream Dental	CS IO 3D acquisition software, Version 3.1.0	Direct export to STL
MD	Medit i500	Medit	Medit Link, Version 1.2.1	Direct export to STL
iT	iTero Element 2	Align Technology	iTero Element 2 software, Version 1.7	Direct export to STL
OC4	CEREC Omnicam	Dentsply Sirona	CEREC software, Version 4.6.1	Direct export to STL
OC5	CEREC Omnicam	Dentsply Sirona	CEREC software, Version 5.0.0	Direct export to STL
PS	Primescan	Dentsply Sirona	CEREC software, Version 5.0.0	Direct export to STL

* STL: Standard tessellation language. † CO: Conventional impression method.

Talking Points

"We found statistically significant differences of CO for all IOS systems except PS. Among the IOS systems, our results showed that the PS group had higher trueness for SU parameter, with median (IQR) of 19.4 (5.0) mm; values were statistically significantly different from the other IOS systems, except TRn and TRi."

VARIABLE	PREPARATION SURFACE, MICROMETERS		PREPARATION MARGIN, µm	
	Median (IQR†)	Mean (SD‡)	Median (IQR)	Mean (SD)
Trueness				
Group				
CO§	11.8 (2.0)	12.2 (2.3)^{a}	17.7 (2.6)	18.2 (3.0)^{a}
TRn¶	23.3 (4.2)	22.6 (2.7)^{b,d}	31.9 (7.0)	32.0 (4.8)^{b,e,f}
TRi#	23.6 (5.4)	23.6 (3.0)^{c,d}	30.7 (6.0)	31.5 (4.6)^{b,c,d}
CS**	28.9 (9.4)	31.1 (7.9)^{e,f,g}	34.9 (8.4)	35.8 (6.0)^{c,f,g,i}
MD††	31.4 (5.1)	32.0 (3.2)^{e,h,i}	34.5 (6.2)	34.6 (4.3)^{g,e,g,h,i}
iT‡‡	34.6 (8.6)	36.3 (7.8)^{f,h,i,k}	38.1 (11.1)	40.0 (6.9)^{h,i}
OC4§§	36.7 (10.1)	36.6 (6.4)^{g,i,j}	54.3 (9.0)	53.4 (6.2)^{j}
OC5¶¶	40.5 (10.9)	41.7 (7.0)^{k,j}	55.9 (15.5)	58.0 (10.6)^{j}
PS##	19.4 (5.0)	18.7 (2.8)^{a,b,c}	21.4 (2.7)	22.4 (2.4)^{a}
Precision				
Group				
CO	8.7 (2.2)	9.5 (3.9)^{a}	14.3 (9.0)	17.7 (8.8)^{a}
TRn	13.6 (3.8)	14.0 (2.4)^{b}	18.9 (8.7)	21.2 (6.7)^{b,c,d}
Tri	15.8 (3.5)	16.0 (2.3)^{c}	22.5 (12.4)	24.4 (6.9)^{c,e}
CS	18.3 (6.7)	19.5 (6.1)^{d,f}	38.0 (17.7)	38.5 (12.0)^{f}
MD	13.4 (3.4)	13.6 (2.5)^{b}	21.0 (7.6)	21.6 (6.9)^{d,e}
iT	17.8 (7.7)	19.6 (8.0)^{d,e,g}	47.0 (14.9)	47.6 (11.3)^{g}
OC4	21.1 (6.0)	20.3 (4.0)^{e,f,g}	39.0 (15.7)	38.5 (10.6)^{f}
OC5	23.9 (8.8)	24.7 (5.3)^{g}	48.8 (24.4)	50.2 (15.4)^{g}
PS	8.3 (2.4)	8.3 (1.5)^{a}	15.5 (8.4)	17.9 (7.6)^{a,b}

Abstract

Background

The authors evaluated the local accuracy of intraoral scanning (IOS) systems for single-tooth preparation impressions with an in-vitro setup.

Methods

The authors digitized a mandibular complete-arch model with 2 full-contour crowns and 2 multisurface inlay preparations with a highly accurate reference scanner. Teeth were made from zirconia-reinforced glass ceramic material to simulate toothlike optical behavior. Impressions were obtained either conventionally (PRESIDENT Micosystem™, Coltène) or digitally using the IOS systems TRIOS® 3 and TRIOS® 3 using insane scan speed mode (3Shape), Medit i500, Version 1.2.1 (Medit), iTero® Element® 2, Version 1.7 (Align Technology), Carestream CS 3600, Version 3.1.0 (Carestream Dental), CEREC Omnicam®, Version 4.6.1, CEREC Omnicam®, Version 5.0.0, and Primescan™ (Dentsply Sirona). Impressions were repeated 10 times per test group. Conventional (CO) impressions were poured with type IV gypsum and digitized with a laboratory scanner. The authors evaluated trueness and precision for preparation margin (MA) and preparation surface (SU) using 3-dimensional superimposition and 3-dimensional difference analysis method using (95% – 5%) / 2 percentile values. Statistical analysis was performed using Kruskal-Wallis test. Results were presented as median (interquartile range) values in micrometers.

Results

The authors found statistically significant differences for MA and SU among different test groups for both trueness and precision ($P < .05$). Median (interquartile range) trueness values ranged from 11.8 (2.0) µm (CO) up to 40.5 (10.9) µm (CEREC Omnicam®, Version 5.0.0) for SU parameter and from 17.7 (2.6) µm (CO) up to 55.9 (15.5) µm (CEREC Omnicam®, Version 5.0.0) for MA parameter.

Conclusions

IOS systems differ in terms of local accuracy. Preparation MA had higher deviations compared with preparation SU for all test groups.

Practical implications

Trueness and precision values for both MA and SU of single-unit preparations are equal or close to CO impression for several IOS systems.

M. Zimmermann, A. Ender, A. Mehl, Local accuracy of actual intraoral scanning systems for single-tooth preparations in vitro, J Am Dent Assoc 151(2) (2020) 127-135.

Go to study: https://www.sciencedirect.com/science/article/abs/pii/S0002817719307664

Accuracy of digital and conventional full-arch impressions in patients: an update

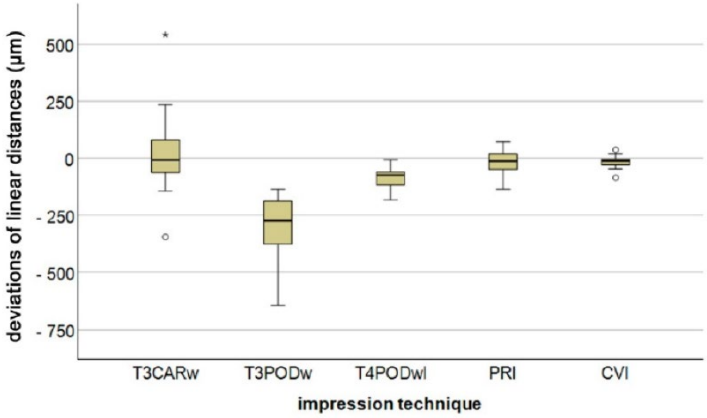
Study Background

- Five patients with a complete lower dental arch were included in this invivo study.
- Four bearing steel spheres with a diameter of 5 mm were reversibly luted on the teeth of the lower jaw using a flowable composite
- Subsequently, in every patient four digital full-arch impressions were taken using TRIOS® 3 Cart wired, TRIOS® 3 Pod wired, TRIOS® 4 Pod wireless and Primescan™ as well as a high precision conventional impression was taken
- Distances between the single spheres were compared

Talking Points

- For the two short distances in the posterior segments (i.e., spheres D1_2 and D3_4), digital had more precise results were found using digital compared with conventional impressions.
- For long-span distances, the CVI technique provided the lowest deviation, although no significant difference was demonstrated for PRI and T4PODwl.
- Hardware components of the TRIOS® scanner exhibited an influence on accuracy.

Figure 1. Metallic reference aid with four steel spheres.



Abstract

The aim of this clinical study was to update the available data in the literature regarding the transfer accuracy (trueness/precision) of four current intraoral scanners (IOS) equipped with the latest software versions and to compare these data with conventional impressions (CVI). A metallic reference aid served as a reference dataset. Four digital impressions (TRIOS® 3 Cart, TRIOS® 3 Pod, TRIOS® 4 Pod, and Primescan™) and one CVI were investigated in five patients. Scan data were analyzed using three-dimensional analysis software and conventional models using a coordinate measurement machine. The transfer accuracy between the reference aid and the impression methods were compared. Differences with $p < 0.05$ were considered to be statistically significant. Overall, mean ± standard deviation (SD) transfer accuracy ranged from 24.6 ± 17.7 µm (CVI) to 204.5 ± 182.1 µm (TRIOS® 3 Pod). The Primescan™ yielded the lowest deviation for digital impressions (33.8 ± 31.5 µm), followed by TRIOS® 4 Pod (65.2 ± 52.9 µm), TRIOS® 3 Cart (84.7 ± 120.3 µm), and TRIOS® 3 Pod. Within the limitations of this study, current IOS equipped with the latest software versions demonstrated less deviation for short-span distances compared with the conventional impression technique. However, for long-span distances, the conventional impression technique provided the lowest deviation. Overall, currently available IOS systems demonstrated improvement regarding transfer accuracy of full-arch scans in patients.

A. Schmidt, L. Klussmann, B. Wostmann, M.A. Schlenz, Accuracy of Digital and Conventional Full-Arch Impressions in Patients: An Update, J Clin Med 9(3) (2020).

Go to study: https://www.ncbi.nlm.nih.gov/pubmed/32143433

Digital versus conventional impression taking Focusing on interdental areas: a clinical trial

Study Background

- Overcome limitations of in-vitro study
- Compare the ability of one conventional and four digital impression techniques to reproduce Interdental Areas (IA) of periodontally compromised dentitions (PCD)
- In-vivo, 30 patients, 1 experienced operator
- Four digital impressions were taken for each jaw with 3M True Definition, Primescan™, Carestream CS 3600, TRIOS® 3
- Comparison against digitized conventional impression
- 3D best-fit alignment
- Calculation of percentage of displayed IA in relation to absolute IA

Talking Points

- IOS can display higher percentage of IAs then CVI
- IAs in the anterior area of the jaw are better displayed than in the posterior area by IOS
- A higher percentage of IA was displayed for class III PCD
- True definition displayed a higher percentage of IAs but requires application of optical powder for impression taking
- Primescan™ and Carestream CS 3600 displayed the highest percentage of IA amongst the powder-free IOS
- TRIOS® 3 displayed the lowest percentage of IA compared to all other IOS

Abstract

Due to the high prevalence of periodontitis, dentists have to face a larger group of patients with periodontally compromised dentitions (PCDs) characterized by pathologic tooth migration and malocclusion. Impression taking in these patients is challenging due to several undercuts and extensive interdental areas (IAs). The aim of this clinical trial was to analyze the ability of analog and digital impression techniques to display the IAs in PCDs. The upper and the lower jaws of 30 patients (n = 60, age: 48–87 years) were investigated with one conventional impression (CVI) using polyvinyl siloxane and four digital impressions with intraoral scanners (IOSs), namely 3M True Definition (TRU), Primescan™ (PRI), Carestream CS 3600 (CAR), and TRIOS® 3 (TIO). The gypsum models of the CVIs were digitalized using a laboratory scanner. Subsequently, the percentage of the displayed IAs in relation to the absolute IAs was calculated for the five impression techniques in a three-dimensionalmeasuring software. Significant differences were observed among the impression techniques (except between PRI and CAR, p-value < 0.05). TRU displayed the highest percentage of IAs, followed by PRI, CAR, TIO, and CVI. The results indicated that the IOSs are superior to CVI regarding the ability to display the IAs in PCDs.

M.A. Schlenz, V. Schubert, A. Schmidt, B. Wostmann, S. Ruf, K. Klaus, Digital versus Conventional Impression Taking Focusing on Interdental Areas: A Clinical Trial, Int J Environ Res Public Health 17(13) (2020).

Go to study: https://www.mdpi.com/1660-4601/17/13/4725

Accuracy of digital complete-arch, multi-implant scans made in the edentulous jaw with gingival movement simulation: An in vitro study

Study Background

- Examine the accuracy of acquiring multiple implant positions in an edentulous master cast with different configurations of fixed and movable gingiva-like surfaces
- Reference scan was done with inEOS X5
- Digital scans were made with 4 different intraoral scanners: TRIOS 3, TRIOS Color, Omnicam and Primescan
- Conventional impressions served as control group
- Position and direction of scanned implants were evaluated
- The accuracy of the digital scans was assessed in 2 steps, first at G0 without free gingiva and then with interference from different amounts of free gingiva (G1-G3).

Talking Points

- In 7 out of 8 categories PS is equal or more accurate than all other tested IOS with no statistically significant differences to the conventional impression.
  - Primescan showed the lowest deviation for position and direction at gingival level G1 but with no statistical significance to Omnicam and Trios 3
  - For G2 Primescan showed lowest deviations for position and direction with statistically significance
  - For G3 Primescan showed lowest deviations for position with statistically significance as well as for direction but with no significant difference to Omnicam
  - For G0 Primescan showed no significant difference in position and direction to Omnicam, Trios and conventional impression

Abstract

Statement of problem

The use of computer-aided design and computer-aided manufacturing (CAD-CAM) technologies is widely established, with single restorations or short fixed partial dentures having similar accuracy when generated from digital scans or conventional impressions. However, research on complete-arch scanning of edentulous jaws is sparse.

Purpose

The purpose of this pilot in vitro study was to compare the accuracy of a digital scan with the conventional method in a workflow generating implant-supported complete-arch prostheses and to establish whether interference from flexible soft tissue segments affects accuracy.

Material and methods

An edentulous maxillary master cast containing 6 angled implant analogs was used and digitized with mounted scan bodies by using a high-precision laboratory scanner. The master cast was then scanned 10 times with 4 different intraoral scanners: TRIOS 3 with a complete-arch scanning strategy (TRI1) or implant-scanning strategy (TRI2), TRIOS Color (TRC), CEREC Omnicam (CER), and CEREC Primescan (PS). The same procedure was repeated with 4 different levels of free gingiva (G0eG3). Ten conventional impressions were obtained. Differences in implant position and direction were evaluated at the implant shoulder as mean values for trueness and interquartile range (IQR) for precision. Statistical analysis was performed by using the KruskaleWallis and post hoc Conover tests (a=.05).

Results

At G0, position deviations ranged from 34.8 mm (IQR 23.0 mm) (TRC) to 68.3 mm (12.2 mm) (CER). Direction deviations ranged from 0.34 degrees (IQR 0.18 degrees) (conventional) to 0.57 degrees (IQR 0.37 degrees) (TRI2). For digital systems, the position deviation ranged from 48.4 mm (IQR 5.9 mm) (PS) to 76.6 mm (IQR 8.1 mm) (TRC) at G1, from 36.3 mm (IQR 9.3 mm) (PS) to 79.9 mm (IQR 36.1 mm) (TRI1) at G2, and from 51.8 mm (IQR 14.3 mm) (PS) to 257.5 mm (IQR 106.3 mm) (TRC) at G3. The direction deviation ranged from 0.45 degrees (IQR 0.15 degrees) (CER) to 0.64 degrees (IQR 0.20 degrees) (TRC) at G1, from 0.38 degrees (IQR 0.05 degrees) (PS) to 0.925 degrees (IQR 0.09 degrees) (TRI) at G2, and from 0.44 degrees (IQR 0.07 degrees) (PS) to 1.634 degrees (IQR 1.08 degrees) (TRI) at G3. Statistical analysis revealed significant differences among the test groups for position (G0: P<.001; G1: P<.05; G2: P<.001; G3: P<.001) and direction (G0: P<.005; G1: P<.001; G2: P<.001; G3: P<.001).

Conclusions

Without soft tissue interference, the accuracy of certain digital scanning systems was comparable with that of the conventional impression technique. The amount of flexible soft tissue interference affected the accuracy of the digital scans.

N. Knechtle, D. Wiedemeier, A. Mehl, A. Ender, Accuracy of digital complete-arch, multi-implant scans made in the edentulous jaw with gingival movement simulation: An in vitro study, J Prosthet Dent (2021).

Go to study: https://www.thejpd.org/article/S0022-3913(21)00019-6/fulltext

Comparison **Ease of use** **Implantology** **Full arch scanning** **Fixed partial dentures**

In Vitro Accuracy of Digital and Conventional Impressions for Full-Arch Implant-Supported Prostheses

Study Background

- Evaluate the accuracy of full-arch digital impressions when compared to conventional impressions when performed on the abutment or implant level
- Two edentulous mastercasts incl. 6 implants were used whereby on one cast abutments were connected to the implants
- Scanning with Primescan SW 5.1, SW 5.2, Trios 3 and Trios 4 with and without scanbodies
- Measurement by a coordinate machine served as reference
- Analogue impressions were made
- Evaluation of trueness and precision by the difference in angulation and coronal linear deviation of the center of the neck of the implants

Talking Points

Trueness on implant level impression:

- For angular measurements, Primescan SW 5.2 demonstrated a lower deviation compared to all other types of impressions and analogue impression missed significance with Primescan SW 5.2 and Trios.
- For the coronal measurements, Primescan SW 5.2 performed significantly better compared to all other impressions, except for Primescan SW 5.1. Primescan SW 5.1 was significantly better compared to Trios 4 and no significance with Trios 3 was observed.

Trueness on abutment level impression:

- The angular deviation for Primescan SW 5.2 was significantly lower compared to all other impressions ($p < 0.050$).
- The coronal deviation for Primescan SW 5.2 was significantly lower($p < 0.001$) compared to all other impressions, except for analogue impression.
- Precision of Primescan SW 5.2 was significantly higher compared to all other impressions except for coronal deviation at abutment level where no significant difference to analogue impression was detected

Abstract

Purpose

The aim of this study was to evaluate the accuracy of full-arch digital impressions when compared to conventional impressions, when performed on the abutment or implant level.

Methods

One resin cast with six implants and another cast with six abutments were scanned with Primescan v5.1 (PS51), Primescan v5.2 (PS52), Trios 3 (T3), and Trios 4 (T4). Additionally, conventional impressions (A) were made, poured in gypsum, and digitized using a lab scanner (IScan D104i). A coordinate machine (Atos, GOM, Braunschweig, Germany) was used to generate the reference scan of both casts. For all scans, the position of the implants was calculated and matched with the reference scan. Angular and coronal measurements per implant were considered for trueness and precision.

Results

For the implant-level model, PS52 performed significantly better in terms of trueness and precision compared to all other impressions, except for the angular trueness of A ($p = 0.072$) and the coronal trueness of PS51 ($p = 1.000$). For the abutment-level model, PS52 also performed significantly better than all other impressions, except for the coronal trueness and precision of A ($p = 1.000$).

Conclusions

Digital impressions for full-arch implant supported prostheses can be as accurate as conventional impressions, depending on the intra-oral scanner and software. Overall, abutment level impressions were more accurate compared to implant level impressions.

R. D'Haese, T. Vrombaut, H. Roeykens, S. Vandeweghe, In Vitro Accuracy of Digital and Conventional Impressions for Full-Arch Implant-Supported Prostheses, J Clin Med 11(3) (2022).

Go to study: https://www.mdpi.com/2077-0383/11/3/594

Accuracy of intraoral scanning in completely and partially edentulous maxillary and mandibular jaws: an in-vitro analysis

Study Background

- Analyze the accuracy (trueness and precision) of IOS in completely and partially edentulous maxillary and mandibular models
- Evaluated the influence of the operators' experience with this new generation IOS device on the scan accuracy and scan time
- Resin models: edentulous and partially edentulous, mandibular and maxillary models
- Digital scans were performed by two specialist prosthodontists, one experienced and one inexperienced in IOS. Neither of the clinicians had ever used the tested IOS device before
- For the reference data, all models were digitized using an industrial high-precision scanner
- Determination of trueness and precision

Talking Points

- Overall median trueness comprising of all digital scans by the two operators was 24.2 µm (IQR 20.7 µm–27.4 µm)
- Significantly higher trueness was found in the scans of the edentulous mandibular model by the inexperienced operator
- No differences were detected among the other scans
- Overall median precision was 18.3 µm (IQR14.4–22.1 µm)
- A significantly higher precision was found for the scans of the edentulous maxillary model by the inexperienced operator
- No differences were detected among the other scans
- Overall median scan time was 100.5 s (IQR 72.0,139.2 s)
- Scans of experienced operator were faster than the scans of inexperienced operator
- Longer scan times could be associated with a higher level of trueness

Abstract

Objectives

New generation intraoral scanners are promoted to be suitable for digital scans of long-span edentulous spaces and completely edentulous arches; however, the evidence is lacking. The current study evaluated the accuracy of intraoral scanning (IOS) in partially and completely edentulous arch models and analyzed the influence of operator experience on accuracy.

Materials and methods

Four different resin models (completely and partially edentulous maxilla and mandible) were scanned, using a new generation IOS device (n = 20 each). Ten scans of each model were performed by an IOS-experienced and an inexperienced operator. An industrial high-precision scanner was employed to obtain reference scans. IOS files of each model-operator combination, their respective reference scan files (n = 10 each; total = 80), as well as the IOS files from each model generated by the same operator, were superimposed (n = 45; total = 360) to calculate trueness and precision. An ANOVA for mixed models and post hoc t tests for mixed models were used to assess group-wise differences (α = 0.05).

Results

The median overall trueness and precision were 24.2 µm (IQR 20.7-27.4 µm) and 18.3 µm (IQR 14.4-22.1 µm), respectively. The scans of the inexperienced operator had significantly higher trueness in the edentulous mandibular model (p = 0.0001) and higher precision in the edentulous maxillary model (p = 0.0004).

Conclusion

The accuracy of IOS for partially and completely edentulous arches in in-vitro settings was high. Experience with IOS had small influence on the accuracy of the scans.

Clinical relevance

IOS with the tested new generation intraoral scanner may be suitable for the fabrication of removable dentures regardless of clinician's experience in IOS.

M. Schimmel, N. Akino, M. Srinivasan, J.G. Wittneben, B. Yilmaz, S. Abou-Ayash, Accuracy of intraoral scanning in completely and partially edentulous maxillary and mandibular jaws: an in vitro analysis, Clin Oral Investig 25(4) (2021) 1839-1847.

Go to study: https://pubmed.ncbi.nlm.nih.gov/32812098/

In-vitro accuracy of complete arch scans of the fully dentate and the partially edentulous maxilla

Study Background

- Evaluate and compare the dimensional accuracy of complete arch scans CAS of two maxillary models: a fully dentate (FD) model and a partially edentulous (PE) model.
- Five ceramic precision balls intented for use as calibration spheres for optical measurement devices were distributed buccally along the dental arch at the level of the preparation margins of the models.
- Position of the precision balls was measurement by using a coordinate measuring machine.
- Models were digitized with Omnicam, Trios 4, Primescan
- Measurement of scanning time
- Evaluation of Accuracy for distance and angle

Talking Points

- For the PE model, distance deviations over the cross arch were significantly smaller for PS than for the other two scanners, for the FD model, this was only true compared with OC
- The largest distance deviations were found over the cross arch for all scanners: Primescan: 190 µm (FD) and 145 µm (PE); Trios 4: 272 mm (FD) and 259 µm (PE), Omnicam: 272 µm (FD) and 259 µm (PE)
- For short distances only minor distance deviations were detected, the largest mean deviations were: Primescan: 36 µm (FD) and 43 µm (PE); Trios 4: 45 µm (FD) and 70 µm (PE); Omnicam: 62.0 µm (FD) and 34.0 µm (PE)
- Regardless of dental status the shortest scanning times were recorded with PS and the longest with Omnicam, whereby the three scanners were significantly different from each other. For all scanners, scanning time was significantly shorter for the PE model.

Abstract

Purpose

This in-vitro study aimed to compare the accuracy of complete arch scans (CAS) of a fully dentate (FD) and a partially edentulous (PE) maxillary model. Three intraoral scanning systems were used: Omnicam AC (OC), TRIOS 4 (TR),and Primescan (PS).

Methods

Each intraoral scanner was used to take 30 scans each of two clinical scenarios (FD and PE) simulated by a reference model. The PE model simulated a maxilla with six prepared teeth to accommodate a jaw-spanning fixed partial denture (FPD). The missing teeth were then added to create an FD model. Five ceramic precision balls (ball centers P1–P5) mounted on metal pins were welded to the metal base on the buccal side of the dental arch. These were later used to determine dimensional (given by each 2 ball centers) and angular changes (given by each 3 or 4 ball centers) between the reference model (digitized with high precision before the tests) and the intraoral scans. Data were statistically analyzed using a type II ANOVA.

Results

The maximum mean absolute distance deviations were as follows. OC: 147 µm (FD) and 139 µm (PE). TR: 133 µm (FD) and 136 µm (PE). PS: 87 µm (FD) and 80 µm (PE). The scanning system used had a significant effect on distance deviations ($p < 0.027$) and CAS scanning time ($p < 0.001$). Dental status had no clear effect on distance deviations but did significantly affect angular changes ($p < 0.001$) and scanning time ($p < 0.001$).

Conclusions

The manufacture of jaw-spanning FPDs based on a CAS cannot yet be recommended.

M. Waldecker, W. Bomicke, R. Behnisch, P. Rammelsberg, S. Rues, In-vitro accuracy of complete arch scans of the fully dentate and the partially edentulous maxilla, J Prosthodont Res (2021).

Go to study: https://doi.org/10.2186/jpr.JPR_D_21_00100

Congruence between meshes and library files of implant scanbodies: an in-vitro study comparing five intraoral scanners

Study Background

- Assess and compare reliability of five different IOS in the capture of implant Scanbodies (SB)
- Verify dimensional congruence between meshes of SB captured during scan of a complete arch model with six implants and the corresponding library file
- In-vitro
- Gypsum cast representing a fully endentulous maxilla with 6 implant was scanned with: Primescan™, Carestream CS 3700, Medit i-500, iTero® Elements® 5D, Emerald™ S
- 3D analysis of the congruence between scanned mesh of SB and SB library file, best fit alignment
- Calculation of quantitative and qualitative deviation between scanned mesh of SB and SB library file

Talking Points

- Primescan™ and Carestream CS 3700 showed the highest congruence between SB MEs and LF, with the lowest mean absolute deviations
- Statistically significant difference between these two scanners and the other three
- Primescan™ was the IOS with the lowest mean absolute deviation but the difference to Carestream CS 3700 was statistically not significant

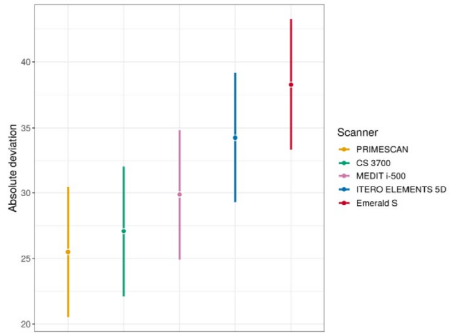


Figure 5. Mean absolute deviations estimates (with 95% confidence interval (CI)) for each type of IOS (these quantities were estimated using linear mixed effects model).

Abstract

Purpose

To compare the reliability of five different intraoral scanners (IOSs) in the capture of implant scanbodies (SBs) and to verify the dimensional congruence between the meshes (MEs) of the SBs and the corresponding library file (LF).

Methods

A gypsum cast of a fully edentulous maxilla with six implant analogues and SBs screwed on was scanned with five different IOSs (Primescan™, Carestream CS 3700, Medit i-500, iTero® Elements® 5D, and Emerald™ S). Ten scans were taken for each IOS. The resulting MEs were imported to reverse engineering software for 3D analysis, consisting of the superimposition of the SB LF onto each SB ME. Then, a quantitative and qualitative evaluation of the deviations between MEs and LF was performed. A careful statistical analysis was performed.

Results

Primescan™ showed the highest congruence between SB MEs and LF, with the lowest mean absolute deviation (25.5 ± 5.0 µm), immediately followed by Carestream CS 3700 (27.0 ± 4.3 µm); the difference between them was not significant ($p = 0.1235$). Primescan™ showed a significantly higher congruence than Medit i-500 (29.8 ± 4.8 µm, $p < 0.0001$), iTero® Elements® 5D (34.2 ± 9.3 µm, $p < 0.0001$), and Emerald™ S (38.3 ± 7.8 µm, $p < 0.0001$). Carestream CS 3700 had a significantly higher congruence than Medit i-500 ($p = 0.0004$), iTero® Elements® 5D ($p < 0.0001$), and Emerald™ S ($p < 0.0001$). Significant differences were also found between Medit i-500 and iTero® Elements® 5D ($p < 0.0001$), Medit i-500 and Emerald™ S ($p < 0.0001$), and iTero® Elements® 5D and Emerald™ S ($p < 0.0001$). Significant differences were found among different SBs when scanned with the same IOS. The deviations of the IOSs showed different directions and patterns. With Primescan™, iTero® Elements® 5D, and Emerald™ S, the MEs were included inside the LF; with Carestream CS 3700, the LF was included in the MEs. Medit i-500 showed interpolation between the MEs and LF, with no clear direction for the deviation.

Conclusions

Statistically different levels of congruence were found between the SB MEs and the corresponding LF when using different IOSs. Significant differences were also found between different SBs when scanned with the same IOS. Finally, the qualitative evaluation revealed different directions and patterns for the five IOSs.

F. Mangano, H. Lerner, B. Margiani, I. Solop, N. Latuta, O. Admakin, Congruence between Meshes and Library Files of Implant Scanbodies: An In Vitro Study Comparing Five Intraoral Scanners, J Clin Med 9(7) (2020).

Go to study: https://pubmed.ncbi.nlm.nih.gov/32660070/

Trueness of ten intraoral scanners in determining the positions of simulated implant scan bodies

Study Background

- Evaluate the trueness of 10 IOSs for acquiring the accurate positions of simulated implant scan bodies on a partially edentulous model
- A 3D printed Co-Cr master model incl. 1) a cylinder at each of the 6 trimmed teeth and 2) three reference spheres with a diameter of 3.5 mm around the mandibular left second molar
- Digital scans using 10 IOSs (CEREC Omnicam, CEREC Primescan, CS 3600, DWIO, i500, iTero Element, PlanScan, Trios 2, Trios 3, and True Definition)
- Reference values were determined by measuring the XYZ coordinates for each cylinder position with CMM
- Median trueness values of the IOSs were analyzed using the Kruskal–Wallis test, followed by Mann–Whitney U test and Bonferroni correction for pairwise comparisons at a significance level of 0.05.

Talking Points

- Primescan and Trios3 exhibited the lowest overall deviation, albeit not statistically significant, compared with the i500, Trios 2, and iTero Element ($p > 0.05$)
- For the X-axis Primescan showed the lowest deviation with statistically significance
- For the Y-axis Primescan showed the lowest deviation but not statistically significant to CS 3600, i500, Trios3 and True Definition
- Overall, the CEREC Primescan and Trios 3 had the highest trueness in partially edentulous mandible digital implant scans, followed by the i500, Trios 2, and iTero Element, albeit not statistically significant

Abstract

Few investigations have evaluated the 3-dimensional (3D) accuracy of digital implant scans. The aim of this study was to evaluate the performance of 10 intraoral scanners (IOSs) (CEREC Omnicam, CEREC Primescan, CS 3600, DWIO, i500, iTero Element, PlanScan, Trios 2, Trios 3, and True Definition) in obtaining the accurate positions of 6 cylinders simulating implant scan bodies. Digital scans of each IOS were compared with the reference dataset obtained by means of a coordinate measuring machine. Deviation from the actual positions of the 6 cylinders along the XYZ axes and the overall 3D deviation of the digital scan were calculated. The type of IOSs and position of simulated cylindrical scan bodies affected the magnitude and direction of deviations on trueness. The lowest amount of deviation was found at the cylinder next to the reference origin, while the highest deviation was evident at the contralateral side for all IOSs ($p < 0.001$). Among the tested IOSs, the CEREC Primescan and Trios 3 had the highest trueness followed by i500, Trios 2, and iTero Element, albeit not statistically significant ($p > 0.05$), and the DWIO and PlasScan had the lowest trueness in partially edentulous mandible digital implant scans ($p < 0.001$).

R.J.Y. Kim, G.I. Benic, J.M. Park, Trueness of ten intraoral scanners in determining the positions of simulated implant scan bodies, Sci Rep 11(1) (2021) 2606.

Go to study: https://www.nature.com/articles/s41598-021-82218-z

Evaluation of complete-arch implant scanning with 5 different intraoral scanners in terms of trueness and operator experience

Study Background

- Evaluate the effect of the experience on the trueness of 5 intraoral scanners for complete-arch implant scans of an edentulous cadaveric maxilla
- Maxilla was resected from a fresh cadaver head with a completely edentulous maxilla and five endosseous ASTRA TECH EV dental implants (Ø4.2×13 mm) were placed
- Scan bodies were attached to the implants
- Reference scan was obtained by ATOS Scanner
- Comparison of 5 different intraoral scanners (Primescan, Trios 4, Trios 3, i500, Element 2), 8 scans with experienced and 8 scans with inexperienced operator

Talking Points

- Primescan obtained the best implant platform deviation but with no statistical difference to Trios 4
  - Primescan achieved significantly lower deviation than the other IOS after scan body alignment in implant platform deviation and angle between cylinders except Trios 4 with experienced operator
  - Primescan achieved significantly lower deviation than Element 2 after complete surface alignment in implant platform deviation and angle between cylinders but shows comparable results to the other IOS
- "The recommended 30 µm* for passive fit was only achieved by the Primescan in the present study. However, the recommended value was achieved in a clinical study by splinting the scan bodies together before intraoral scan which could decrease the deviation."

* according to Ref. 16 of the publication

Abstract

Statement of problem

The intraoral scanning of the edentulous arch might be challenging for an inexperienced operator because of the large mucosal area and the use of scan bodies.

Purpose

The purpose of this ex vivo study was to compare the trueness of 5 intraoral scanners in replicating implant scan bodies and soft tissues in an edentulous maxilla and to investigate the effects of operator experience.

Material and methods

The maxilla was resected from a fresh cadaver, 5 implants placed, and a reference scan made. Eight scans were made by experienced operators and 8 by an inexperienced operator with each scanner (iTero Element 2, Medit i500, Primescan, TRIOS 3, TRIOS 4). The implant platform deviation was measured after complete surface alignment and after scan body alignment. Deviation data were analyzed with a generalized linear mixed model (a=.05).

Results

After complete surface alignment, the mean ±standard deviation implant platform deviation was higher for the inexperienced operator (421 ±25 mm) than for experienced ones (191 ±12 mm, P<.001) for all scanners. After scan body alignment, no significant differences were found between operators for Element 2, Primescan, and TRIOS 3. The experienced operators produced a lower deviation for TRIOS 4 (35 ±3.3 mm versus 54 ±3.1 mm, P<.001), but higher deviation for i500 (68 ±4.1 mm versus 57 ±3.6 mm, P<.05). The scanner ranking was Element 2 (63 ±4.1 mm), i500 (57 ±3.6 mm, P=.443), TRIOS 4 (54 ±3.1 mm, P=.591), TRIOS 3 (40 ±3.1 mm, P<.01), Primescan (27 ±1.6 mm, P<.001) for the inexperienced operator and i500 (68 ±4.1 mm), Element 2 (58 ±4.0 mm, P=.141), TRIOS 3 (41 ±2.8 mm, P<.001), TRIOS 4 (35 ±3.3 mm, P=.205), Primescan (28 ±1.8 mm, P=.141) for the experienced operators.

Conclusions

Mucosal alignment greatly overestimated the platform deviation. The intraoral scanners showed different trueness during the complete-arch implant scanning. The operator experience improved the trueness of the edentulous mucosa but not implant platform deviation.

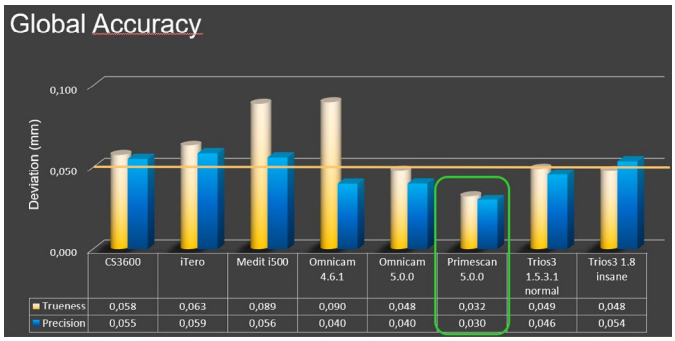
G. Revell, B. Simon, A. Mennito, Z.P. Evans, W. Renne, M. Ludlow, J. Vag, Evaluation of complete-arch implant scanning with 5 different intraoral scanners in terms of trueness and operator experience, J Prosthet Dent (2021).

Go to study: https://www.thejpd.org/article/S00223913(21)00052-4/fulltext

Accuracy of complete- and partial-arch impressions of actual intraoral scanning systems in-vitro

Study Background

- In-vitro study with local and global accuracy
- Translucent, ceramic tooth model was used
- Primescan™, Omnicam®, TRIOS® 3, Medit i500, Carestream CS3600, iTero®



Talking Points

- In certain aspects, Primescan™ was viewed as the most accurate among the tested intraoral scanners that were compared in an in-vitro study
- In the peer group of intraoral scanners, which did not cover several systems commercially available today, Primescan™ showed the best median and mean values across complete arch, anterior and posterior segments, few statistical limitations apply
- Omnicam® results have significantly improved with the latest CEREC SW 5

Abstract

Objective

Intraoral scanners (IOSs) are widely used for obtaining digital dental models directly from the patient. Additionally, improvements in IOSs are made from generation to generation. The aim of this study was to evaluate the accuracy of new and actual IOS devices for complete- and partial-arch dental impressions in an in-vitro setup.

Materials and methods

A custom maxillary complete-arch cast with teeth made from feldspar ceramic material was used as the reference cast and digitized with a reference scanner (ATOS III Triple Scan MV60). One conventional impression technique using polyvinylsiloxane (PVS) material (President) served as the control (CO), and eight different IOS devices comprising different hardware and software configurations (TRn: TRIOS® 3; TRi: TRIOS® 3 insane; Carestream CS: Carestream Dental Carestream CS 3600; MD: Medit i500; iT: iTero® Element® 2; OC4: CEREC Omnicam® 4.6.1; OC5: CEREC Omnicam® 5.0.0; PS: Primescan™) were used to take complete-arch impressions from the reference cast. The impressions were repeated 10 times (n = 10) for each group. Conventional impressions were poured with type IV gypsum and digitized with a laboratory scanner (inEos X5). All datasets were obtained in standard tessellation language (STL) file format and cut to either complete-arch, anterior segment, or posterior segment areas for respective analysis. Values for trueness and precision for the respective areas were evaluated using a three-dimensional (3D) superimposition method with special 3D difference analysis software (GOM Inspect) using (90-10)/2 percentile values. Statistical analysis was performed using either one-way analysis of variance (ANOVA) or Kruskal-Wallis test ($\alpha = 0.05$). Results are given as median and interquartile range [IQR] values in µm.

Results

Statistically significant differences were found between test groups for complete- and partial-arch impression methods in-vitro ($p < 0.05$). Values ranged from 16.3 [2.8] µm (CO) up to 89.8 [26.1] µm (OC4) for in-vitro trueness, and from 10.6 [3.8] µm (CO) up to 58.6 [38.4] µm (iT) for in-vitro precision for the complete-arch methods. The best values for trueness of partial-arch impressions were found for the posterior segment, with 9.7 [1.2] µm for the conventional impression method (CO), and 21.9 [1.5] µm (PS) for the digital impression method.

Conclusion

Within the limitations of this study, digital impressions obtained from specific IOSs are a valid alternative to conventional impressions for partial-arch segments. Complete-arch impressions are still challenging for IOS devices; however, certain devices were shown to be well within the required range for clinical quality. Further in-vivo studies are needed to support these results.

A. Ender, M. Zimmermann, A. Mehl, Accuracy of complete- and partial-arch impressions of actual intraoral scanning systems in vitro, (1463-4201 (Print)).

Go to study: https://www.quintessence-publishing.com/deu/en/article/833683

Impact of different scanning strategies on the accuracy of two current intraoral scanning systems in complete-arch impressions: an in-vitro study

Study Background

- A customized complete-arch maxillary cast was scanned
- A master reference scan was obtained through an ATOS III Triple Scan 3D optical scanner
- Omnicam® (CEREC SW 5.1.0) and Primescan™ (CEREC SW 5.0.2) were used for complete-arch scanning with 13 different scanning strategies
- Best fit alignment of the scans with master scan
- Evaluation of trueness and precision
- Statistical analyses utilized Welch's unequal variances t test

Talking Points

- This scan strategy has very good value and is easy to use.
- Primescan™ featured a better trueness index (4.79 µm) than that of Omnicam® (19.13 µm). Primescan™, also featured a better precision index (4.67 µm) than Omnicam®, group B (16.75 µm), with a statistically significant difference.

Abstract

Aim

To determine the scanning strategy that obtains the most accurate results for two intraoral scanners (IOS) in complete-arch digital impressions. Scan time was evaluated and correlated with scan strategies.

Materials and method

A custom model used as the reference standard was fabricated with teeth having dentin- and enamel-identical refractive indices simulating natural dentition. A reference scan of the custom typodont was obtained using an ATOS III Triple Scan 3D optical scanner. Two IOS setups – Omnicam® v 5.1.0 and Primescan™ v 5.0.2 – were used for complete-arch scanning, each using 13 scanning strategies, obtaining 260 digital files (n = 10 per group), recording each scan time, converting all experimental scans to standard tessellation language (STL) format, and using a comprehensive metrology program to compare the reference standard scan with the experimental scans. Statistical analyses utilized Welch's unequal variances t test.

Results

Group M exhibited the lowest trueness and precision values ($P < 0.05$) for Primescan™ (47.5% of the average among all other groups) and the lowest trueness value ($P < 0.05$) for Omnicam® (53.4% of the average among all other groups), where group B exhibited the lowest precision value (65.6% of the average among all other groups) with $P < 0.05$. Primescan™ featured a better trueness index (4.79 µm) than that of Omnicam® (19.13 µm), with a statistically significant difference ($P < 0.00001$). Primescan™, group M, also featured a better precision index (4.67 µm) than Omnicam®, group B (16.75 µm), with a statistically significant difference ($P < 0.00001$).

Conclusion

For both IOS systems, group M provided the lowest scanning times. For trueness and precision of complete-arch scans, group M was the dominant scanning strategy in Primescan™, while there was no dominant strategy in Omnicam®. Group M had the best scanning time for both IOS systems.

L. Passos, S. Meiga, V. Brigagão, A. Street, Impact of different scanning strategies on the accuracy of two current intraoral scanning systems in complete-arch impressions: an in vitro study, (1463-4201 (Print)).

Go to study: https://www.ncbi.nlm.nih.gov/pubmed/31840139

Do “cut out-rescan” procedures have an impact on the accuracy of intraoral digital scans?

Study Background

- Complete-arch scan data of a maxillary master cast were generated 10 times with 3 intraoral scanners: TRIOS® 3 [TR], CEREC Primescan™ [PR], and CEREC Omnicam® [OM].
- For the “cut-out-rescan”:
  - all complete arch scans were duplicated
  - the posterior area from the right lateral incisor was cut out from the duplicated scan data and rescanned
  - superimposition of the rescanned area onto the cut-out scan ([TR_rs], [PR_rs], [OM_rs])
- As reference the master cast was scanned with a high precision industrial structured light scanner
- Evaluation of trueness and precision
- To evaluate statistical differences, either the Mann-Whitney U test or the t test was used (α=.05)

Talking Points

- The t test revealed statistically significant differences among the different scanners
- The comparison of the trueness values of the complete arch scan data with those of the corresponding “cut out-rescanned” data of each scanner system did not reveal statistically significant differences in any scanner system
- Significant differences were found between the precision results of the OM and PR as well as for the pairs OM_rs/TR_rs and TR_rs/PR_rs

Table 1. Trueness values

Types of STL Data Sets	N	Minimum (µm)	Maximum (µm)	Mean ± Standard Deviation (µm)
OM	9	48	59	53^{ab} ±4
OM_rs	9	48	69	55^{de} ±6
TR	10	36	51	42^{ac} ±5
TR_rs	10	31	46	38^{df} ±5
PR	10	26	34	29^{bc} ±3
PR_rs	10	26	40	31^{ef} ±5

Table 2. Precision values

Types of STL Data Sets	N	Min. (µm)	Max. (µm)	Mean ±Standard Deviation (µm)	Median (µm)
OM	36	12	31	20±4	19^{a}
OM_rs	36	16	63	28±11	25^{de}
TR	45	12	24	18±3	19
TR_rs	45	12	28	17±4	16^{d}
PR	45	8	29	15±5	14^{a}
PR_rs	45	8	27	16±5	14^{e}

Abstract

Statement of problem

The software of digital intraoral scanners typically offers the option to cut out areas from 3D casts, to do rescans, and to merge them with the initial scan. However, evidence of whether this procedure has an impact on the accuracy of the scan is lacking.

Purpose

The purpose of this study was to determine whether “cut out-rescan” procedures change the accuracy of a 3D cast.

Material and methods

A maxillary master cast was digitized with an industrial structured light scanner to obtain a digital reference cast. This master cast was repeatedly scanned by 3 intraoral scanners: TRIOS® 3 [TR], CEREC Primescan™ [PR], and CEREC Omnicam® [OM]. The scan data were duplicated, and the posterior area from the right lateral incisor was cut out and rescanned to obtain complete-arch casts containing the rescanned data [TR_rs], [PR_rs], and [OM_rs]. The trueness and precision of the scans were evaluated by superimposing procedures of the relevant data sets. To evaluate statistical differences, either the Mann-Whitney U test or the t test was used (α=.05).

Results

The median precision values of the complete-arch scan data was 19 µm for [OM] and [TR], whereas the median for [PR] was 14 µm. In the “cut out-rescanned” data group, the values were 25 µm for [OM_rs], 16 µm for [TR_rs], and 14 µm for [PR_rs]. Statistically significant differences were found among the scanners [OM]/[PR], [OM_rs]/[TR_rs], and [TR_rs]/[PR_rs]. The mean ± standard deviation values of trueness for the complete-arch scan data were 54 ±4 µm for [OM], 42 ±5 µm for [TR], and 30 ±2 µm for [PR]. In the group of the “cut out-rescanned” data, the mean trueness results were 55 ± 6 µm for [OM_rs], 38 ±5 µm for [TR_rs], and 31 ±5 µm for [PR_rs]. Significant differences were found among the complete-arch scan data and the “cut out-rescanned” data of the different scanners, but not between the complete-arch scan data and the “cut out-rescanned” data within one scanning system.

Conclusions

Significant differences were found among the scanners, but “cut out-rescan” procedures did not affect the accuracy within each scanning system.

S. Reich, B. Yatmaz, S. Raith, Do “cut out-rescan” procedures have an impact on the accuracy of intraoral digital scans?, J Prosthet Dent 125(1) (2021) 89-94.

Go to study: https://www.sciencedirect.com/science/article/abs/pii/S0022391319307553

Feasibility of using an intraoral scanner for a complete-arch digital scan, part 2: A comparison of scan strategies

Study Background

- Compare the 3-dimensional (3D) distortion of complete-arch scans as part of the scan strategy and analyze the clinically recommended scan range
- Reference model was fabricated by replicating a typodont with dental stone and scanned with an industrial scanner (Solutionix C500; MEDIT)
- Six IOSs (TRIOS2, TRIOS3, CS3500, CS3600, i500, Primescan) and 2 dental laboratory scanners (DOF, E1) were used
- After the scanning of the left maxillary second molar was done preferentially, 2 scan strategies (ss1 and ss2) were applied
- 3D accuracy has been evaluated by calculating the root mean square (RMS) value for all teeth, which were segmented before
- All divided teeth were analyzed together to obtain the overall RMS values

Talking Points

- Primescan was the only IOS which showed a clinically acceptable* scan range of 3 teeth (RSP, RFM, RSM) from the right second premolar to the right second molar
  - For RSP, RFM and RSM the RMS values of Primescan were significantly lower then for the other IOS with no statistically significant difference only for Trios 3 (ss2) and CS3600 (RSP with ss1)
- For 12 of 14 teeth Primescan showed no differences in RMS value to one or both laboratory scanners
- "From the right maxillary canine to the right maxillary second molar, Primescan was the only IOS with no significant difference to laboratory scanners"
- Primescan was recommended by the author for long-span prostheses (until verification by additional studies which are needed to verify this by fabricating actual fixed dental prostheses).

* accuracy to within 100 µm for fixed dental prostheses acc. to REF 10,11,28 of the publication

Abstract

Statement of problem

Various strategies for intraoral scanners (IOSs) can be used to scan the oral cavity. However, research on the scan range that can be clinically is lacking.

Purpose

The purpose of this in vitro study was to compare the 3-dimensional (3D) distortion of complete-arch scans as part of the scan strategy and analyze the clinically recommended scan range.

Material and methods

A computer-aided design (CAD) reference model was obtained with an industrial scanner. A CAD test model was obtained by using 6 IOSs (TRIOS2, TRIOS3, CS3500, CS3600, i500, and Primescan) to apply 2 scan strategies and 2 dental laboratory scanners (DOF and E1) (N=15). All the teeth were segmented in the reference model by using 3D inspection software (Geomagic control X). The 3D analysis was performed by aligning the test model to the reference model and evaluating the root mean square values of all segmented teeth. The Mann-Whitney U-test was performed for a statistical comparison of the 2 scan strategies (a=.05), the Kruskal-Wallis test (a=.05) was used to compare the scanners, and the Mann-Whitney U-test and Bonferroni correction method were used as post hoc tests (a=.0017).

Results

The 8 scanners obtained significant differences in the root mean square values of all teeth (P<.001). The root mean square value of IOSs increased from the left maxillary second molar to the right maxillary second molar. The difference in the 2 scan strategies showed different patterns depending on the IOS.

Conclusions

Scan strategy 2 improved the accuracy of the IOSs. TRIOS2 and CS3500 are for single crowns; TRIOS3, CS3600, and i500 are for short-span prostheses; and Primescan is for long-span prostheses.

K. Son, M.U. Jin, K.B. Lee, Feasibility of using an intraoral scanner for a complete-arch digital scan, part 2: A comparison of scan strategies, J Prosthet Dent (2021).

Go to study: https://www.thejpd.org/article/S0022-3913(21)00285-7/fulltext

Influence of intraoral conditions on the accuracy of full-arch scans by Cerec Primescan AC: an in vitro and in vivo comparison.

Study Background

- Investigate the accuracy of one IOS-system for in-vivo and in-vitro digitalization using the same reference object and maxilla
- For the in-vitro data acquisition the metal bar was fixed on a resin model of the patient's upper jaw. Digital impressions were carried with Primescan
- For the in-vivo data acquisition the metal bar was temporarily attached to the occlusal surfaces of the patient´s second molars using light curing resin without tooth conditioning. Digital impressions were carried with Primescan
- The metal bar was scanned with coordinate measuring machine and served as reference
- Evaluation of trueness and precision based on linear (VE) and angular parameter of the metal bar

Talking Points

- For the parameters VE (p=0.014), VE_Y (p=0.001), VE_Z (p=0.003), Angle (p=0.008) and Angle_coronal (p=0.003) the in-vivo digitalization resulted in significant higher trueness as the in-vitro digitalization.
- For the parameter VE (p=0.035), VE_Y (p=0.005), VE_Z (p=0.013), Angle (p=0.013) and Angle_coronal (p=0.013) the in-vitro digitalization resulted in significant better precision than the in-vivo digitalization.

Abstract

Purpose

To determine the effect of intraoral conditions on the accuracy of digital full-arch scans

Material and methods

A reference bar was used for the in vivo and in vitro parts of the present study. For the in vitro part (PAT-vitro), the bar was fixed to connect the maxillary second molars on the patient's resin model. The same reference bar was fixed in a similar position intraorally for the in vivo testing (PAT-vivo). Model and patient were digitized using an intraoral scanner (Cerec Primescan AC, N = 40, n [PAT-vitro] = 20, n [PAT-vivo] = 20). Datasets were exported and metrically analyzed (Geomagic Control 2015) to determine the 3D linear and angular distortions in all three coordinate axes of the datasets with reference to the bar. Normality of the data distribution was tested using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Homogeneity of the variances was tested using the Levené test. Statistically significant differences for all measured parameters in view of trueness were determined using the two-sample t test, and in view of precision using the two-sample Kolmogorov-Smirnov test.

Results

The PAT-vivo group showed significantly higher trueness for most of the measured linear and angular distortion parameters than the PAT-vitro group. Regarding precision, the PAT-vitro group showed significantly better values for most of the measured linear and angular distortion parameters than the PAT-vivo group.

Conclusions

Within the limitations of the present study, Cerec Primescan AC leads to comparable accuracy parameters when applied in vivo and in vitro. The reproducibility (precision) was higher when scans were performed in vitro. Due to the high trueness, the system seems to be a valid tool to obtain digital full-arch datasets in vivo with comparable accuracy to in vitro tests.

C. Keul, J.F. Güth, Influence of intraoral conditions on the accuracy of full-arch scans by Cerec Primescan AC: an in vitro and in vivo comparison, (1463-4201 (Print). Study comissioned by Dentsply Sirona.

Go to study: https://www.quintessence-publishing.com/deu/en/article/2841895

Accuracy of six intraoral scanners for scanning complete-arch and 4-unit fixed partial dentures: An in vitro study

Study Background

- Evaluate the accuracy of 6 representative IOSs for complete-arch and 4-unit fixed partial dentures (FPD) preparations and to examine the effect of scanning sequence
- A maxillary complete-arch model was scanned by using a highly accurate scanner (ATOS) to create a digital reference data set
- Scanning with TRIOS 3, iTero Element 2, Omnicam, Planmeca Emerald, Primescan and Virtuo Vivo
- First 5 scans per IOS were started from the maxillary right quadrant (Scan Right [ScanR]), and the following 5 scans were started from the maxillary left quadrant (Scan Left [ScanL])
- Evaluation of trueness and precision

Talking Points

- Primescan showed the highest trueness for the prepared teeth, with statistically significant differences from the other scanners.
- Primescan showed the highest median precision value for preparations at 23(8) mm, but was not statistically different from Virtuo Vivo, TRIOS (P=.214) or Omnicam (P=.007)
- Primescan had statistically significant higher trueness for complete-arch scan than Omnicam and Emerald but had no significant difference to Trios 3, Vitruo Vivo and iTero
- No significant difference in the precision of digital complete-arch scans was found between IOSs

Abstract

Statement of problem

The digital scan accuracy of different intraoral scanners (IOSs) for long-span fixed prosthesis and the effect of the starting quadrant on accuracy is unclear.

Purpose

The purpose of this in vitro study was to evaluate the accuracy of 6 IOSs for complete-arch and prepared teeth digitally isolated from the complete-arch and to determine the effect of the starting quadrant on accuracy.

Material and methods

A maxillary model containing bilaterally prepared canines, first molar teeth, and edentulous spans between the prepared teeth was used. The model was scanned by using a highly accurate industrial scanner to create a digital reference data set. Six IOSs were evaluated: TRIOS, iTero, Planmeca Emerald, CEREC Omnicam, Primescan, and Virtuo Vivo. The model was scanned 10 times with each IOS by 1 operator according to the protocols described by the manufacturers. Five scans were made starting from the right quadrant (ScanR), followed by 5 scans starting from the left quadrant (ScanL). All data sets were obtained in standard tessellation language (STL) file format and were used to evaluate accuracy (trueness and precision) with a 3D analyzing software program (Geomagic Studio 12; 3D Systems) by using a best-fit alignment. The prepared teeth were digitally isolated from the complete-arch and evaluated with the analyzing software program. The Kruskal-Wallis and Mann-Whitney U statistical tests were used to detect differences for trueness and precision (a=.05).

Results

Statistically significant differences were found regarding IOSs (P<.003) and scanning sequence (P<.05). The TRIOS showed the best trueness for the complete-arch, but not statistically different from Primescan, Virtuo Vivo, and iTero (P>.003). The lowest median values for precision of the complete-arch were also found using TRIOS, but no significant difference was found among the scanners (P>.003). In terms of trueness and precision, Primescan had the best accuracy for preparations. Emerald showed significant differences depending on the scanning sequence for complete-arch accuracy. ScanR for trueness (P=.021) and ScanL for precision (P=.004) showed improved results. However, Emerald, TRIOS, and Virtuo Vivo showed statistically significant differences in precision of preparations depending on scanning sequence. ScanL deviated less than ScanR when scanned with TRIOS (P=.025) and Emerald (P=.004), and the opposite with Virtuo Vivo (P=.008). In terms of preparations trueness, no significant difference was found between the ScanR and ScanL of any IOS (P>.05).

Conclusions

Based on this in vitro study, the accuracy of the complete-arch and prepared teeth differed according to the IOS and scanning sequence.

B. Diker, Ö.Tak, Accuracy of six intraoral scanners for scanning complete-arch and 4-unit fixed partial dentures: An in vitro study. J. Prosthet Dent (2021).

Go to study: https://www.thejpd.org/article/S0022-3913(20)30797-6/fulltext

Effect of posterior span length on the trueness and precision of 3 intraoral digital scanners: A comparative 3-dimensional in vitro study

Study Background

- Comparison of 3 intraoral scanner systems (Trios 3, Planmeca Emerald, and Primescan AC) and identification of the influence of posterior span length on their accuracy
- Three KaVo phantom-lab basic study models with epoxy resin teeth were prepared to receive 3 units, 4-unit and 5 units fixed partial dentures.
- Reference models were obtained by scanning with E3 reference scanner
- Each model was scanned 10 times with each intraoral scanner.
- Evaluation of trueness and precision in the abutment and pontic regions by comparing the scanned STL models with the reference model

Talking Points

- For all span lengths, the smallest deviation (best trueness) values and best precision were recorded for Primescan AC, followed in descending order by Trios 3 and Planmeca Emerald, which showed the greatest deviation.
  - The differences in trueness were statistically significant for the 4- and 5-unit models. As for the 3-unit model, Trios 3 and Primescan AC showed significantly better trueness values than Planmeca Emerald.
  - The differences in trueness were highly significant among all 3 scanners.
- For all 3 scanners, increasing the span length resulted in a greater magnitude of deviation but with statistically significance for Primescan and Trios 3 only when comparing 3-unit and 5-unit models.
- Precision improved as the span length decreased.

Abstract

Purpose

This in vitro study measured and compared 3 intraoral scanners' accuracy (trueness and precision) with different span lengths.

Material and methods

Three master casts were prepared to simulate 3 different span lengths (fixed partial dentures with 3, 4, and 5 units). Each master cast was scanned once with an E3 lab scanner and 10 times with each of the 3 intraoral scanners (Trios 3, Planmeca Emerald, and Primescan AC). Data were stored as Standard Tessellation Language (STL) files. The differences between measurements were compared 3-dimensionally using metrology software. Data were analyzed using 1-way analysis of variance with post hoc analysis by the Tukey honest significant difference test for trueness and precision. Statistical significance was set at $P<0.05$.

Results

A statistically significant difference was found between the 3 intraoral scanners in trueness and precision ($P<0.05$). Primescan AC showed the lowest trueness and precision values (36.8 µm and 42.0 µm; (39.4 µm and 51.2 µm; and 54.9 µm and 52.7 µm) followed by Trios 3 (38.9 µm and 53.5 µm; 49.9 µm and 59.1 µm; and 58.1 µm and 64.5 µm) and Planmeca Emerald (60.4 µm and 63.6 µm; 61.3 µm and 69.0 µm; and 70.8 µm and 74.3 µm) for the 3-unit, 4-unit, and 5-unit fixed partial dentures, respectively.

Conclusions

Primescan AC had the best trueness and precision, followed by Trios 3 and Planmeca Emerald. Increasing span length reduced the trueness and precession of the 3 scanners; however, their values were within the accepted successful ranges.

M. Fattou, L. Mohammed, H. Fattou. Effect of posterior span length on the trueness and precision of 3 intraoral digital scanners: A comparative 3-dimensional in vitro study. Imaging Sci Dent. (2021)

Go to study: https://isdent.org/DOIx.php?id=10.5624/isd.20210076

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The summaries stated herein are mere abstracts of the studies and for complete details please see the full studies noted at the bottom of each summary page.

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