Primescan™ Intraoral Scanner

Study Overview 2019-2021

Status November 2021

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Overview Primescan™ Studies*

Study Name	Author/Date	Method	Claims
Accuracy of complete- and partial-arch impressions of actual intraoral scanning systems in-vitro	Ender, Zimmermann, Mehl (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.
The effect different substrates have on the trueness and precision of eight different intraoral scanners	Dutton et al. (2019)	In-vitro	Primescan™ was ranked number 1 in 11 out of 15 categories, for the remaining 4 categories a top rank was achieved.
Do “cut out-rescan” procedures have an impact on the accuracy of intraoral digital scans?	Reich, Yatmaz, Raith (2019)	In-vitro	Primescan™ ranked top in trueness and precision.
Impact of different scanning strategies on the accuracy of two current intraoral scanning systems in complete-arch impressions: an in-vitro study	Passos, Meiga, Brigagão, Street (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.
In-vitro study on digital splint effect to the accuracy of digital dental implant impression	Gedrimiene et al. (2019)	In-vitro	Primescan™ showed the best results of trueness and precision of distance and angle measurements.
Local accuracy of actual intraoral scanning systems for single-tooth preparations in-vitro	Zimmermann, Ender, Mehl (2020)	In-vitro	Results showed that PS had higher trueness and values were statistically significantly different from the other IOS systems, except TRIOS®.
Accuracy of digital and conventional full-arch 2 impressions in patients: an update	Schmidt, Klussmann, Wöstmann, Schlenz (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, Schubert, Schmidt, Wöstmann, Ruf, Klaus (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.
Congruence between meshes and library files of implant scanbodies: an in-vitro study comparing five intraoral scanners	Mangano, Lerner, Margiani, Solop, Latuta, Admakin (2020)	In-vitro	Primescan™ showed the lowest mean absolute deviation. The difference to the other IOS systems was statistically significant, except Carestream CS-3700.
Accuracy of intraoral scanning in completely and partially edentulous maxillary and mandibular jaws: an in-vitro analysis	Schimmel, Akino, Srinivasan, Wittneben, Yilmaz, Abou-Ayash (2020)	In-vitro	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 three intraoral scans for primary impressions of edentulous jaws	Cao, Chen, Deng, Wang, Sun, Zhao (2020)	In-vitro	The precision of CEREC Primescan™ scanner was significantly better than that of the other two scanners for maxilla. There was no significant difference in trueness of the three scanners when scanning the maxilla and mandible.

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Trueness of 12 intraoral scanners in the full-arch implant impression: a comparative in-vitro study	Mangano, Admakin, Bonacina, Lerner, Rutkunas, Mangano (2020)	In-vitro	Primescan™ belonged to the group of IOS with the highest accuracy (together with iTero® Elements® 5D, Carestream CS 3700, Carestream CS 3600, TRIOS® 3, Medit i-500) In the analysis of the overall trueness with the nurbs/nurbs method Primescan™ belonged to the three best IOS (together with iTero® Elements® 5D and TRIOS® 3)
Comparing the accuracy of six intraoral scanners on prepared teeth and effect of scanning sequence	Diker, Tak (2020)	In-vitro	Primescan™ showed statistically the highest trueness. The highest precision value was also measured for Primescan™ but with no statistically significant difference to TRIOS®, iTero®, and Omnicam®.
In-vitro analysis of intraoral digital impression of inlay preparation according to tooth location and cavity type	Kim, Son, Lee, Kim, Park (2020)	In-vitro	The overall accuracy of digital impressions with Primescan™ for inlay preparations was clinically acceptable. Small differences were observed depending on tooth location (< 2 µm) and inlay cavity type (< 1 µm).
Accuracy and repeatability of different intraoral scanners on shade determination	Ebeid, Sabet, Bona (2020)	In-vitro	There was no statistical difference for shade detection between Primescan™, Omnicam® and TRIOS® 3.
Effect of pulp chamber depth on the accuracy of endocrown scans made with different intraoral scanners versus an industrial scanner: an in-vitro study	Gurpinar, Tak (2020)	In-vitro	CEREC Primescan™ was found to have the best trueness and precision among the evaluated IOSs (P<.05). Statistically significant differences were found for all tested pulpal chamber depths.
Influence of preparation design, marginal gingiva location, and tooth morphology on the accuracy of digital Impressions for full-crown restorations: an in-vitro investigation	Bernauer, Müller, Zitzmann, Joda (2020)	In-vitro	The overall accuracy of Primescan™ for all abutment teeth was very high whereby Primescan™ and TRIOS® 3 revealed homogenous results.
Scanning Accuracy of Bracket Features and Slot Base Angle in Different Bracket Materials by Four Intraoral Scanners: An In Vitro Study	Shin, Yu, Cha, Kwon, Hwang (2021)	In-vitro	"Considering only the scan of the bracket in this study, Primescan and Trios 3 were more accurate among the four types of IOSs: Primescan, Trios 3, CS3600, and i500."
Trueness of ten intraoral scanners in determining the positions of simulated implant scan bodies	Kim, Benic, Park (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.
Accuracy of digital complete-arch, multi-implant scans made in the edentulous jaw with gingival movement simulation: An in vitro study	Knechtle, Wiedemeier, Mehl, Ender (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.

TRIOS®, Carestream CS 3600, Carestream CS-3700, iTero®, and Medit i500 are not registered trademarks of Dentsply Sirona Inc.

* The summaries are mere abstracts of the studies. For complete details, please see the full studies noted at the bottom of each summary page.

Overview Primescan™ Studies*

Study Name	Author/Date	Method	Claims
Accuracy of Digital Impressions Obtained Using Six Intraoral Scanners in Partially Edentulous Dentitions and the Effect of Scanning Sequence	Diker, Tak (2021)	In-vitro	Together with Trios and iTero scanners, Primescan was in the group of the best 3 intraoral scanners with precision levels significantly higher than the other scanners in the study whereas a total of 6 scanners was tested.
Accuracy of six intraoral scanners for scanning complete-arch and 4-unit fixed partial dentures: An in vitro study	Diker, Tak (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.
Accuracy of four different intraoral scanners according to different preparation geometries	Schmidt, Benedickt, Schlenz, Wöstmann	In-vitro	The accuracy of four different intraoral scanners was evaluated in terms of four different preparation geometries. Primescan achieved the highest accuracy in terms of precision in all geometries but one and the highest or second highest accuracy in terms of trueness in all geometries.
Influence of different inlay configurations and distance from the adjacent tooth on the accuracy of an intraoral scan	Son, Kim, Seo, Park (2021)	In-vitro	„During the intraoral scanning of class II inlay restoration, interproximal distance and cavity type affected the accuracy of an intraoral scan“
The effect of software updates on the trueness and precision of intraoral scanners	Vág, Renne, Revell, Ludlow, Mennito, Teich, Gutmacher (2021)	In-vitro	“Primescan was the one scanner that showed consistent performance in all substrates”. Regarding complete-arch trueness, Primescan was statistically among the three best IOSs. There was no significant difference of SW updates on the Primescan accuracy.
Comparison of the acquisition accuracy and digitizing noise of 9 intraoral and extraoral scanners: An objective method	Dupagne, Tapie, Lebon, Mawussi (2021)	In-vitro	Primescan achieved the lowest digitizing noise and lowest precision error value (on small-scale model equivalent in size to a 4-tooth wide cast).
Evaluation of complete-arch implant scanning with 5 different intraoral scanners in terms of trueness and operator experience	Revell, Simon, Mennito, Evans, Renne, Ludlow, Vág (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.”
Feasibility of using an intraoral scanner for a complete-arch digital scan, part 2: A comparison of scan strategies	Son, Jin, Lee (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

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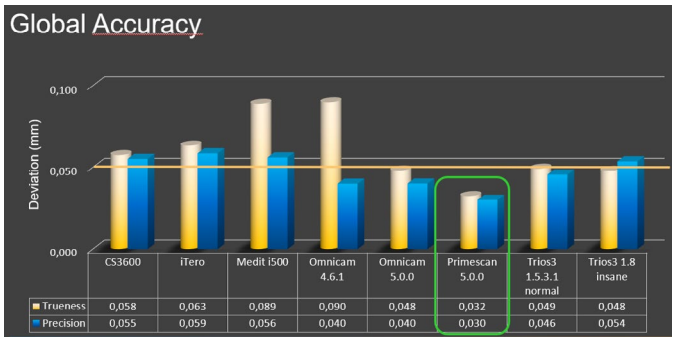
Accuracy of complete- and partial-arch impressions of actual intraoral scanning systems in-vitro

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.

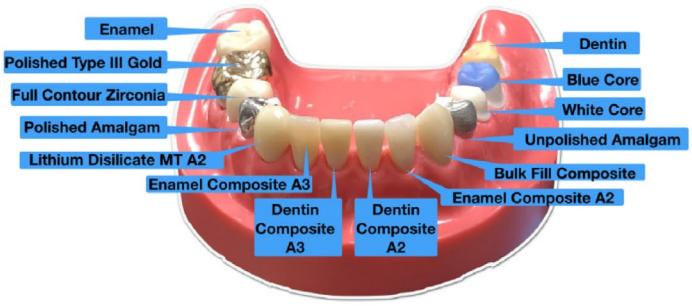
Go to study: https://ijcd.quintessenz.de/ijcd_2019_01_s0011.pdf

Back to Table of Contents

The effect different substrates have on the trueness and precision of eight different intraoral scanners

Study Background

- In-vitro study with local and global accuracy
- Primescan™, Omnicam®, TRIOS® 3, Element2, Medit i500, Emerald™, Emerald™ S
- Dentin, Enamel, Gold, Amalgam, Resin, Zirconia, Lithium Disilicate, Enamel/Dentin Composite, White/ Blue Core, Bulk Fill Composite
- 3D best fit alignment
- Average of the absolute values of the average positive and negative deviations of the IOS data.



Talking Points

- Except for TRIOS® 3, substrate influences trueness and precision -> doesn't say anything about the level of accuracy
- Different scanners show different accuracy for same substrate
- Latest generation scanners more accurate than older scanners
- Primescan™ ranked #1 in 11 out of 15 categories
- Amongst those the important categories: Enamel, Dentin, Cross arch
- Primescan™ ranked within top 4 for remaining 4 categories
- Omnicam® was used with an old SW version, results are expected to be significantly better with latest version
- Study supports the proven accuracy of Primescan™ once again

Abstract

Objective

This in-vitro study compares the newest generation of intraoral scanners to their older counterparts, and tests whether material substrates affect the trueness and precision of intraoral scanners (IOS).

Material and methods

A custom model, used as the reference standard, was fabricated with teeth composed of different dental materials. The reference standard scan was obtained using a three dimensional (3D) optical scanner, the ATOS III. Experimental scans were obtained using eight different IOS, operated by experienced clinicians, using the manufacturer's recommended scanning strategy. A comprehensive metrology program, Geomagic Control X, was used to compare the reference standard scan with the experimental scans.

Results

For all scanners tested, except TRIOS® 3, the substrate does influence the trueness and precision of the scan. Furthermore, differences exist when comparing the same substrate across different scanners with some of the latest generation scanners clearly leaping ahead of the older generation regarding both trueness and precision.

Conclusions

Substrate type affects the trueness and precision of a scan. Active Triangulation scanners are more sensitive to substrate differences than their parallel confocal counterparts. Some scanners scan certain substrates better, but in general the new generation of scanners outperforms the old, across all substrates.

Clinical significance

The substrates being scanned play an import role in the trueness and precision of the 3D model. The new generation of scanners is remarkably accurate across all substrates and for complete arch scanning.

Go to study: https://onlinelibrary.wiley.com/doi/full/10.1111/jerd.12528

Back to Table of Contents

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.

Go to study: https://www.sciencedirect.com/science/article/abs/pii/S0022391319307553 Back to Table of Contents

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.

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

Back to Table of Contents

In-vitro study on digital splint effect to the accuracy of digital dental implant impression

Abstract

Background

Digital implant impressions (DII) with intraoral scanners (IOS) are a relatively novel, but continuously improving technique. Since IOS devices can only capture part of the object at a time, images have to be stitched together to form a 3D object and therefore it is the source of possible errors of the scan. Digital splinting at edentulous areas can possibly improve the accuracy of DII.

Aim/Hypothesis

The aim of this in-vitro study was to compare the trueness and precision of three different IOS scanning partially and fully edentulous models with 2 or 4 implants with attached scan bodies and digital splints.

Material and Methods

Two types of maxilla models were printed with Asiga™ Max 3D printer. The first model was missing both premolars and molars on the right side, so Straumann BL dental implants were inserted instead first premolar (straight) and second molar (tilted 20° mesially). Four implants were inserted in the second edentulous model symmetrically at second incisors (straight) and first molar areas (tilted 20° mesially). Scan bodies were attached to the implants and models were scanned with Nikon Altera 10.7.6. coordinate measurement machine (CMM) to form a reference scan. DII was taken with a Primescan™ (version 5.0.1), Carestream CS 3600 (version 3.1.0), TRIOS® 3 (version 1.18.2.10) IOS ten times each (n = 10) without digital splint. After that, tablets of hardened Fuji Plus® cement was glued in edentulous areas to form digital splint and all models were scanned with three different IOS. Scanning data were exported in standard tessellation language format for analysis.

Results

Trueness of distance and angle in Carestream partially edentulous models was 185 µm in the group with splint and 280 µm without one and 0.22° in the group with splint and 0.29° in the group without respectively. Precision of distance and angle measurements in the splint groups were 87 µm and 0.13°, in the groups without −202 µm and 0.25°. In fully edentulous models trueness of distance varied 53–106 µm in the groups with splint and 67–8 µm in the groups without. Trueness of Primescan™ in partially edentulous models with splints was 21 µm and 0.16° in distance and angular measurements. Without splints −27 µm and 0.21°. For fully edentulous models trueness and precision of distance and angle was better n groups with splint than without. Trueness of distance and angle of TRIOS® 3 in partially edentulous splinted models was 15 µm and 0.3°;53 µm and 0.11° in unsplinted models respectively.

Conclusion and Clinical Implications

Primescan™ showed the best results of trueness and precision of distance and angle measurements. Since digital splints improve the accuracy of DII, the impact of their forms and materials should be more researched.

Carestream CS 3600 (version 3.1.0), TRIOS® 3 (version 1.18.2.10), Asiga Max™ and Fuji Plus® are not registered trademarks of Dentsply Sirona Inc.

Go to study: https://onlinelibrary.wiley.com/doi/pdf/10.1111/clr.322_13509

Back to Table of Contents

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}	34.5 (6.2)	34.6 (4.3)^{f,e,g,h}
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,k,l}	54.3 (9.0)	53.4 (6.2)^{j}
OC5¶¶	40.5 (10.9)	41.7 (7.0)^{k,l}	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)^{c,d,e}	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.

Go to study: https://www.sciencedirect.com/science/article/abs/pii/S0002817719307664 Back to Table of Contents

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

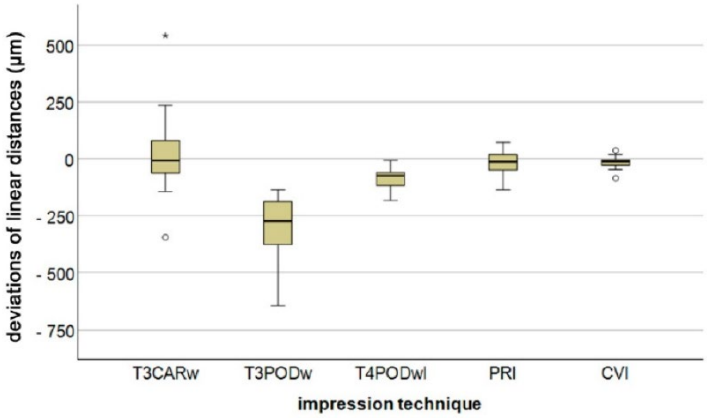
Study Background

- 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.

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

Back to Table of Contents

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.

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

Back to Table of Contents

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

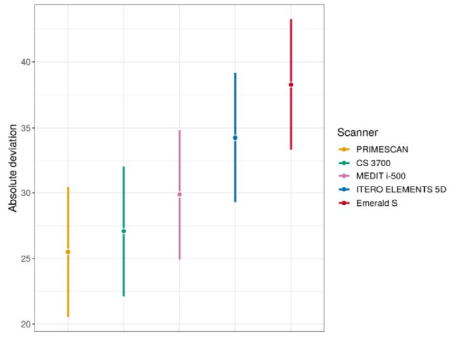


Figure 5. Mean absolute deviations estimates (with 95% confidence interval (CI)) for each type of IOS (these quantities were estimated using linear mixed effects model).

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.

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

Back to Table of Contents

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 ($\alpha = 0.05$).

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.

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

Back to Table of Contents

Accuracy of three intraoral scans for primary impressions of edentulous jaws

Abstract

Objective

To provide a reference for using intraoral scanners for making clinical diagnostic dentures of edentulous jaws by comparing the accuracy of three intraoral scanners for primary impression and jaw relation record of edentulous jaws.

Methods

This study contained 6 primary impressions of the edentulous patients. Each of the impressions consisted of the maxillary primary impression, the mandibular primary impression and the jaw relation record. For each of them, a dental cast scanner (Dentscan Y500) was used to obtain stereolithography (STL) data as reference scan, and then three intraoral scanners including Medit i500, TRIOS® 3 and CEREC Primescan™ were used for three times to obtain STL data as experiment groups. In Geomagic Studio 2013 software, trueness was obtained by comparing experiment groups with the reference scan, and the precision was obtained from intragroup comparisons. Registered maxillary data of the intraoral scan with reference scan, the morphological error of jaw relation record was obtained by comparing jaw relation record of the intraoral scan with the reference scan. Registered mandibular data with jaw relation record of intraoral scan and the displacement of the jaw position were evaluated. Independent samples t test and Mann-Whitney U test in the SPSS 20.0 statistical software were used to statistically analyze the trueness, precision and morphological error of jaw relation record of three intraoral scanners. The Bland-Altman diagram was used to evaluate the consistency of the jaw relationship measured by the three intraoral scanners.

Results

The trueness of Medit i500, TRIOS® 3 and CEREC Primescan™ scanners was (182.34±101.21) μm, (145.21±71.73) μm, and (78.34±34.79) μm for maxilla; (106.42±21.63) μm, and 95.08 (63.08) μm, (78.45±42.77) μm for mandible. There was no significant difference in trueness of the three scanners when scanning the maxilla and mandible ($P>0.05$). The precision of the three scanners was 147.65 (156.30) μm, (147.54±83.33) μm, and 40.30 (32.80) μm for maxilla; (90.96±30.77) μm, (53.73±23.56) μm, and 37.60 (93.93) μm for mandible. The precision of CEREC Primescan™ scanner was significantly better than that of the other two scanners for maxilla ($P<0.05$). TRIOS® 3 and CEREC Primescan™ scanners were significantly better than Medit i500 scanner for mandible ($P<0.05$). The precision of the Medit i500 and TRIOS® 3 scanners for mandible was superior to maxilla ($P<0.05$). The upper limit of 95% confidence intervals of trueness and precision of three scanners for both maxilla and mandible were within ±300 μm which was clinically accepted. The morphological error of jaw relation record of the three scanners was (337.68±128.54) μm, (342.89±195.41) μm, and (168.62±88.35) μm. The 95% confidence intervals of i500 and TRIOS® 3 scanners were over 300 μm. CEREC Primescan™ scanner was significantly superior to Medit i500 scanner ($P<0.05$). The displacement of the jaw position of the three scanners was (0.83±0.56) mm, (0.80±0.45) mm, and (0.91±0.75) mm for vertical dimension; (0.79±0.58) mm, (0.62±0.18) mm, and (0.53±0.53) mm for anterior and posterior directions; (0.95±0.59) mm, (0.69±0.45) mm, and (0.60±0.22) mm for left and right directions. The displacement of the jaw position of the three scanners in vertical dimension, anterior and posterior directions and the left and right directions were within the 95% consistency limit.

Conclusion

Three intraoral scanners showed good trueness and precision. The Medit i500 and TRIOS® 3 scanners had more errors in jaw relation record, but they were used as primary jaw relation record. It is suggested that three intraoral scanners can be used for obtaining digital data to make diagnostic dentures and individual trays, reducing possible deforming or crack when sending impressions from clinic to laboratory.

Go to study: https://www.ncbi.nlm.nih.gov/pubmed/32071476

Back to Table of Contents

Trueness of 12 intraoral scanners in the full-arch implant impression: a comparative in-vitro study

Study Background

- Assessment and comparison of the trueness of 12 different IOSs in full arch (FA) impression: (iTero® Elements® 5D, Primescan™, Omnicam®, Carestream CS 3700, Carestream CS 3600, TRIOS® 3, Medit i-500, Emerald™ S, Emerald™, Virtuo Vivo™, DWIO, RUNEYES QUICKSCAN)
- Using a type IV gypsum model representing a totally edentulous maxilla with 6 implant analogues and PEEK ScanBodies screwed on
- Reference virtual models in STL were aquired by a desktop scanner
- A single operator captured the scans with each of the IOSs
- Evaluation of overall generall trueness via mesh/mesh and nurbs/nurbs method
- The evaluation of the linear and cross distances between the different SBs, for analysis of the local trueness of the intraoral scanning models

Talking Points

- Primescan™ belonged to the group of IOS with the highest accuracy (together with iTero® Elements® 5D, Carestream CS 3700, Carestream CS 3600, TRIOS® 3, Medit i-500)
  - With average intrinsic error < 40 µm with the mesh/mesh method and < 25 µm with the nurbs/nurbs method, representing a theoretically compatible solution for taking impressions for FA restorations.
- In the analysis of the overall trueness with the nurbs/nurbs method Primescan™ belonged to the three best IOS (together with iTero® Elements® 5D and TRIOS® 3)
  - With no statistically significant difference between the IOS (for α=00.05)
- The best absolute performance with mesh/mesh method was obtained by Carestream CS 3700, iTero® Elements® and Medit i-500
  - Only iTero® Elements® 5D was significantly different to Primescan™ (for α=00.05) with a mean difference of 7 µm
  - Carestream CS 3700 and Medit i-500 were not significantly different to Primescan™ (for α=00.05)
- For the cross-distance method, the distance category S2-S4 is missing which could cause a bias in the results.
- Primescan™ has the lowest mean error value in „Linear distances method“ (see table 5)
- Best performance for the cross-distance method was obtained by iTero® Elements® 5D and Medit i-500 but with no statistically significant difference to Primescan™ (for α=00.05)
- In general, the selected model type (gypsum) enables good scanning results for all intraoral scanners applied in this study
- Other factors are important in determining the reliability of an optical impression including the operator, patient, environnemental conditions and SB. Further studies are therefore necessary to understand the weight of each factor.

Go to study: https://bmcoralhealth.biomedcentral.com/track/pdf/10.1186/s12903-020-01254-9

Back to Table of Contents

Trueness of 12 intraoral scanners in the full-arch implant impression: a comparative in-vitro study

Abstract

Objective

The literature has not yet validated the use of intraoral scanners (IOSs) for full-arch (FA) implant impression. Hence, the aim of this in-vitro study was to assess and compare the trueness of 12 different IOSs in FA implant impression.

Materials and methods

A stone-cast model of a totally edentulous maxilla with 6 implant analogues and scanbodies (SBs) was scanned with a desktop scanner (Freedom UHD®) to capture a reference model (RM), and with 12 IOSs (iTero® Elements® 5D; Primescan™ and Omnicam®; Carestream CS 3700 and Carestream CS 3600; TRIOS® 3; Medit i-500; Emerald™ S and Emerald™; Virtuo Vivo™ and DWIO®; RUNEYES QUICKSCAN®). Ten scans were taken using each IOS, and each was compared to the RM, to evaluate trueness. A mesh/mesh method and a nurbs/nurbs method were used to evaluate the overall trueness of the scans; linear and cross distances between the SBs were used to evaluate the local trueness of the scans. The analysis was performed using reverse engineering software (Artec Studio software, Geomagic software, and Materialise Magics software). A statistical evaluation was performed.

Results

With the mesh/mesh method, the best results were obtained by Carestream CS 3700 (mean error 30.4 µm) followed by iTero® Elements® 5D (31.4 µm), Medit i-500 (32.2 µm), TRIOS® 3 (36.4 µm), Carestream CS 3600 (36.5 µm), Primescan™ (38.4 µm), Virtuo Vivo™ (43.8 µm), RUNEYES® (44.4 µm), Emerald™ S (52.9 µm), Emerald™ (76.1 µm), Omnicam® (79.6 µm) and DWIO® (98.4 µm). With the nurbs/nurbs method, the best results were obtained by iTero® Elements® 5D (mean error 16.1 µm), followed by Primescan™ (19.3 µm), TRIOS® 3 (20.2 µm), Medit i-500 (20.8 µm), Carestream CS 3700 (21.9 µm), Carestream CS 3600 (24.4 µm), Virtuo Vivo™ (32.0 µm), RUNEYES® (33.9 µm), Emerald™ S (36.8 µm), Omnicam® (47.0 µm), Emerald™ (51.9 µm) and DWIO® (69.9 µm). Statistically significant differences were found between the IOSs. Linear and cross distances between the SBs (local trueness analysis) confirmed the data that emerged from the overall trueness evaluation.

Conclusion

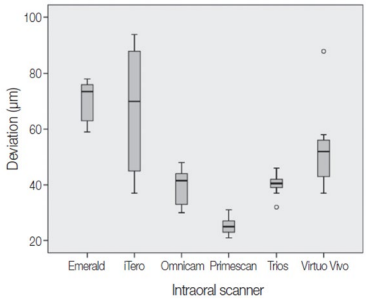
Different levels of trueness were found among the IOSs evaluated in this study. Further studies are needed to confirm these results.

Go to study: https://bmcoralhealth.biomedcentral.com/track/pdf/10.1186/s12903-020-01254-9 Back to Table of Contents

Comparing the accuracy of six intraoral scanners on prepared teeth and effect of scanning sequence

Study Background

- Using a maxillary complete arch model, right and left canine teeth prepared for single crowns
- Using a highly accurate industrial reference scanner to create digital reference
- Six IOSs (TRIOS® 3, iTero® Element® 2, CEREC Omnicam®, Planmeca Emerald™, Primescan™, Virtuo Vivo™) were used to investigate precision and trueness
- Ten scans were taken of the model using each intraoral scanner. The first 5 scans started from the right maxillary quadrant (Scan Right-ScanR) and the following 5 scans started from the left maxillary quadrant (Scan Left- ScanL) to evaluate effect of scanning sequence
- For trueness, models were superimposed on the reference model using a best-fit algorithm
- For precision, a two-way pairwise comparison was performed



Talking Points

- The statistically higher trueness was obtained from Primescan™ (25 µm), followed by TRIOS® (40.5 µm), Omnicam® (41.5 µm), Virtuo Vivo™ (52 µm), iTero® (70 µm), and Planmeca Emerald™ (73.5 µm)
  - There was no statistically significant difference between TRIOS®, Omnicam®, Virtuo Vivo™, and iTero® (P > .003)
- The highest precision was obtained from Primescan™ (10 ± 2 µm), followed by TRIOS® (11 ± 3 µm), iTero® (12 ± 3 µm),Omnicam® (18 ± 5 µm), Virtuo Vivo™ (37 ± 19 µm), and Planmeca Emerald™ (60 ± 27 µm).
  - There was no statistically significant difference between Primescan™, TRIOS®, iTero®, and Omnicam®.
  - The difference between Primescan™ and Planmeca Emerald™ and Virtuo Vivo™ was statistically significant.
- No significant difference was found between the precision and trueness values of the ScanR and ScanL obtained from each IOS for the prepared teeth

Abstract

Objective

The aim of this study was to evaluate the accuracy of six recently introduced intraoral scanners (IOSs) for single crown preparations isolated from the complete arch, and to determine the effect of scanning sequence on accuracy.

Materials and methods

A complete arch with right and left canine preparations for single crowns was used as a study model. The reference dataset was obtained by scanning the complete arch using a highly accurate industrial scanner (ATOS Core 80, GOM GmbH). Six different IOSs (TRIOS®, iTero®, Planmeca Emerald™, CEREC Omnicam®, Primescan™, and Virtuo Vivo™) were used to scan the model ten times each. The scans performed with each IOS were divided into two groups, based on whether the scanning sequence started from the right or left quadrant (n=5). The accuracy of digital impression was evaluated using three-dimensional analyzing software (Geomagic Studio 12, 3D Systems). The Kruskal Wallis and Mann-Whitney U statistical tests for trueness analysis and the One-way ANOVA test for precision analysis were performed (α=.05).

Results

The trueness and precision values were the lowest with the Primescan™ (25 and 10 µm), followed by TRIOS® (40.5 and 11 µm), Omnicam® (41.5 µm and 18 µm), Virtuo Vivo™ (52 and 37 µm), iTero® (70 and 12 µm) and Planmeca Emerald™ (73.5 and 60 µm). Regarding trueness, iTero® showed more deviation when scanning started from the right (P=.009).

Conclusion

The accuracy of digital impressions varied depending on the IOS and scanning sequence used. Primescan™ had the highest accuracy, while Planmeca Emerald™ showed the most deviation in accuracy for single crown preparations.

Go to study: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7604233/

Back to Table of Contents

In-vitro analysis of intraoral digital impression of inlay preparation according to tooth location and cavity type

Study Background

- Evaluate influence of tooth location and inlay cavity type on the accuracy of digital intraoral impression
- Teeth with inlay cavities were screw-retained on four typodont sets which were mounted on a phantom head during the scanning procedure
- 10 scans of each tooth with Primescan™
- Reference scan data was obtained by scanning with a laboratory scanner (E3, 3Shape) which has an accuracy of 7 µm.
- Assessment of accuracy by trueness and precision.
- Best fit alignment

Talking Points

- Overall trueness for tooth 16 (average deviation: 10.43 µm ± 0.39 µm) was higher than for tooth 46 (12.42 µm ± 0.59 µm)
- Precision was similar between the teeth (tooth 16: 3.08 µm ± 0.92 µm; tooth 46: 3.08 µm ± 0.76 µm)
- The cavity type affected the trueness and precision but with differences < 1 µm
- In contrast to other in-vitro studies intraoral scanning was performed on the phantom head what might have permitted less freedom while placing the scanning walls. A greater degree of freedom ensures a direct-line of sight, favorable angle of incidence which can affect the quality of scan.
- The overall accuracy of digital impressions for inlay preparations was clinically acceptable, but positive deviations were observed at the margins of the proximal boxes

Abstract

Objective

This study aimed to evaluate the influence of tooth location and inlay cavity type on the accuracy of intraoral digital impressions.

Materials and methods

Class II inlay preparation was performed on anatomical models of the maxillary first molar (16) and mandibular first molar (46). Mesio-occlusal and disto-occlusal cavities were prepared, such that the axial wall of the proximal box measured 1 mm or 2 mm in height. Thus, four types of inlay cavities were prepared in 16 and 46, respectively. Ten digital impressions of each cavity were obtained using CEREC Primescan™ (Dentsply Sirona).

Reference scans were obtained with a laboratory scanner (E3, 3Shape). All scan data were exported for comparative analysis of the three-dimensional models. Mean absolute deviation values were calculated to evaluate the trueness and precision of the digital models. Color-coded maps were used for the qualitative analysis of deviations.

Results

The overall results showed that the trueness for 16 (10.43 ± 0.39 µm) was higher than that for 46 (12.42 ± 0.59 µm) ($p < 0.05$), while the precision was similar between 16 (3.08 ± 0.92 µm) and 46 (3.08 ± 0.76 µm). The cavity type affected the accuracy of the digital impressions. The highest deviation was observed in positive directions at the margins of the proximal boxes regardless of the cavity type.

Conclusion

Tooth location and cavity type affected the accuracy of intraoral digital impressions. Positive deviations were observed at the margins of the proximal boxes.

Go to study: https://www.jstage.jst.go.jp/article/jpr/advpub/0/advpub_JPR_D_20_00169/_article Back to Table of Contents

Accuracy and repeatability of different intraoral scanners on shade determination

Study Background

- Evaluate the accuracy and repeatability of different intraoral scanners on shade determination in comparison to a dental spectrophotometer
- Ten different shades (A1, A2, A3, A3.5, A4, B2, B3, C2, C3, and D3) of VITABLOCS® Mark II monochromatic CAD-CAM block were used
- One disc-shape specimen per ceramic block was milled and polished
- Color measurements (n = 10) were performed to each specimen using an intraoral spectrophotometer (VITA Easyshade® V) and three intraoral scanners (3shape TRIOS®, CEREC Omnicam®, CEREC Primescan™)

Talking Points

- No statistical difference was found on the overall accuracy between the spectrophotometer Easyshade® V (78%) and the scanner 3Shape TRIOS® (66%) ($p > 0.05$), with the latter being similar to the other scanners Primescan™ (63%) and Omnicam® (57%) ($p > 0.05$)
- Scanner's accuracy was only significantly different on reading a specific shade (A4), with the Primescan™ (90%) showing greater accuracy than 3Shape TRIOS® (50%)
- There was no statistical difference on the overall repeatability for the evaluated devices, ranging from 44.3% for Easyshade® V to 51.9% for Omnicam®

Abstract

Objective

To evaluate the accuracy and repeatability of different intraoral scanners on shade determination.

Materials and methods

Ten different shades of VITABLOCS® Mark II monochromatic CAD-CAM block were used. A disc-shape specimen (10 mm in diameter and 1 mm thick) per ceramic block was fabricated. Ten color measurements per specimen were performed by each instrument (VITA Easyshade® V [control], 3shape TRIOS®, CEREC Omnicam®, CEREC Primescan™) and recorded in VITA Classic color system. The number of correct shade match per instrument for each shade was recorded. Instrumental accuracy was compared using Cochran Q test and repeatability was analyzed using Cronbach's alpha.

Results

There was a significant difference in the instrumental accuracy for shade determination ($p < 0.001$). There was no statistical difference between the Easyshade® V (78%) and the 3Shape TRIOS® (66%) ($p > 0.05$), with the latter being similar to the other scanners Primescan™ (63%) and Omnicam® (57%) ($p > 0.05$). No significant difference was found ($p > 0.05$) when different shades were evaluated by the same instrument. Similar repeatability was found for the different devices, ranging from 44.3% for VITA Easyshade® V to 51.9% for Omnicam®.

Conclusion

The evaluated instruments showed less than expected repeatability and accuracy on measuring different dental shades. Therefore, caution should be exercised when using instrumental shade determination, which should be accompanied by experienced human visual assessment.

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Back to Table of Contents

Effect of pulp chamber depth on the accuracy of endocrown scans made with different intraoral scanners versus an industrial scanner: an in-vitro study

Study Background

- Evaluate the effect of different pulpal chamber extension depth (PCEDs; 2, 3.5, 5 mm) and IOSs on the scanning accuracy of endocrown preparations
- Master reference scans of a model with specimens were created by using an industrial structured blue light 3D scanner (ATOS; GOM Technologies)
- Experimental scans were made with 6 IOSs (TRIOS® 3, Primescan™, Omnicam®, iTero® Element® 2, Planmeca Emerald™, Virtuo Vivo™, Rhinoceros®, Telio® and ATOS)
- Trueness and Precision measurement

Talking Points

- A statistically significant difference in the accuracy of endocrown cavities with different PCEDs was found among compared IOSs, and PCED affected the scanning accuracy significantly
- For all PCEDs evaluated, Primescan™ was found to have the best results among the tested IOSs with regard to trueness and precision
  - Trueness and precision of Primescan™ were significantly different in all cases.

Increasing the pulpal chamber extension depth of endocrown preparations can reduce scanning accuracy. CEREC Primescan™ appears to be the best IOS choice for scanning endocrowns with deep pulpal chamber extensions.

Abstract

Objective

The purpose of this in-vitro study was to assess the effect of pulpal chamber extension depth (PCED) on scanning accuracy and to compare the accuracy of different IOSs on scanning different PCEDs.

Materials and methods

Six different IOSs were compared: TRIOS® 3, CEREC Omnicam®, CEREC Primescan™, Planmeca Emerald™, iTero® Element® 2, Virtuo Vivo™, Rhinoceros®, Telio® and ATOS. Endocrown preparations were digitally designed with a computer-aided design and computer-aided manufacturing (CAD-CAM) software program (Rhinoceros®), and the PCEDs of preparations were 2, 3.5, and 5 mm. Designed preparations were milled from a polymethylmethacrylate block (Telio® CAD) with a milling unit. Reference scans were obtained from an industrial scanner (ATOS), and 5 test scans of each cavity were made with 6 IOSs. All scans were converted into standard tessellation language (STL) files. The data sets obtained from the IOSs were superimposed on the reference scan to evaluate trueness and on each other within groups to determine precision by using a 3D analysis software program (Geomagic Control X). Obtained data were analyzed with 1-way ANOVA and Tukey HSD tests (α=.05).

Results

CEREC Primescan™ was found to have the best trueness and precision among the evaluated IOSs ($P<.05$), while Planmeca Emerald™ was found to have the lowest trueness ($P<.05$). For all tested PCEDs, statistically significant differences were found among IOSs. A PCED with a 2-mm depth (18.57 ±4.80 µm) showed significantly better scanning trueness than that with a 5-mm depth (23.81 ±6.53), while no significant differences were found between 2 and 3.5 mm ($P>.05$).

Conclusion

Deep pulpal chamber extensions of endocrown restorations could negatively affect scanning accuracy, and scanning accuracy varies depending on the selected IOS. CEREC Primescan™ appears to be the best IOS choice for scanning endocrowns with deep pulpal chamber extensions.

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Back to Table of Contents

Influence of preparation design, marginal gingiva location, and tooth morphology on the accuracy of digital Impressions for full-crown restorations: an in-vitro investigation

Study Background

- Analyze the influence of different finish lines for complete crown preparations, their locations related to the gingival margin, and tooth morphology on the accuracy of digital impressions
- Maxillary dental training model was used as reference, a maxillary central incisor (FDI 11) represented the anterior tooth morphology, a first maxillary molar (FDI 16) represented posterior sites
- Prepared typodonts were digitized with a laboratory desktop scanner and served as the basis for the digital designs of the virtual modifications to create the test specimens, involving four different finish-line designs for both morphologies
- 16 virtual tooth preparations were 3D-printed and mounted in the reference model
- Scanning with Primescan™ and TRIOS® 3.5 times
- Accuracy determination

Talking Points

- The overall accuracy for all abutment teeth was very high, without significant differences in the performance of 3Shape TRIOS® 3 Pod versus Primescan™
- The supragingival finishing lines were captured significantly better than the epigingivally located margins using IOS. If the clinical situation allows, a supragingival margin should be chosen accordingly
- The tooth morphology seems to be a negligible factor for IOS accuracy in terms of single-unit complete crown restorations

Abstract

Objective

Intraoral optical scanning (IOS) has gained increased importance in prosthodontics. The aim of this in-vitro study was to analyze the IOS accuracy for treatment with full crowns, considering possible influencing factors.

Materials and methods

Two tooth morphologies, each with four different finish-line designs for tooth preparation and epi- or supragingival locations, were digitally designed, 3D-printed, and post-processed for 16 sample abutment teeth. Specimens were digitized using a laboratory scanner to generate reference STLs (Standard Tessellation Language), and were secondary-scanned with two IOS systems five times each in a complete-arch model scenario (TRIOS® 3 Pod, Primescan™ AC). For accuracy, a best-fit algorithm (Final Surface) was used to analyze deviations of the abutment teeth based on 160 IOS-STLs compared to the reference STLs (16 preparations × 2 IOS-systems × 5 scans per tooth).

Results

Analysis revealed homogenous findings with high accuracy for intra- and inter-group comparisons for both IOS systems, with mean values of 80% quantiles from 20 ± 2 µm to 50 ± 5 µm. Supragingival finishing lines demonstrated significantly higher accuracy than epigingival margins when comparing each preparation ($p < 0.05$), whereas tangential preparations exhibited similar results independent of the gingival location. Morphology of anterior versus posterior teeth showed slightly better results in favor of molars in combination with shoulder preparations only.

Conclusion

The clinical challenge for the treatment with full crowns following digital impressions is the location of the prospective restoration margin related to the distance to the gingiva. However, the overall accuracy for all abutment teeth was very high; thus, the factors tested are unlikely to have a strong clinical impact.

Go to study: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7763051/

Back to Table of Contents

Scanning Accuracy of Bracket Features and Slot Base Angle in Different Bracket Materials by Four Intraoral Scanners: An In Vitro Study

Study Background

- Evaluate the accuracy of digital scan images of brackets produced by four IOSs
- Dental model attached with different bracket materials was used
- All brackets were analyzed by SEM
- Scanning with 4 IOS (Trios3, CS3600, Medit i500, Primescan) and one extraoral scanner (E4)
- Measurement of slot base angle (SBA), upper angle (UA) and lower angle (LA)
- For total precision, one-way analysis of variance (ANOVA) and post-hoc Tukey test were used.

Talking Points

- In all brackets, the precision was significantly different in the order of Trios 3 < Primescan < CS3600 < i500 ($p < 0.001$)
- For SBA Primescan showed best trueness amongst the intraoral scanner together with Trios 3. There was no significant difference between Primescan and Trios 3 but in all others.
- The parallelism of the bracket slot wall was not significantly different between Primescan, Trios 3 and CS3600
- "Considering only the scan of the bracket in this study, Primescan and Trios 3 were more accurate among the four types of IOSs."

Abstract

The accurate expression of bracket prescription is important for successful orthodontic treatment. The aim of this study was to evaluate the accuracy of digital scan images of brackets produced by four intraoral scanners (IOSs) when scanning the surface of the dental model attached with different bracket materials. Brackets made from stainless steel, polycrystalline alumina, composite, and composite/stainless steel slot were considered, which have been scanned from four different IOSs (Primescan, Trios, CS3600, and i500). SEM images were used as references. Each bracket axis was set in the reference scan image, and the axis was set identically by superimposing with the IOS image, and then only the brackets were divided and analyzed. One-way analysis of variance (ANOVA) was used to compare the differences. The difference between the manufacturer's nominal torque and bracket slot base angle was 0.39 in SEM, 1.96 in Primescan, 2.04 in Trios, and 5.21 in CS3600 ($p < 0.001$). The parallelism, which is the difference between the upper and lower angles of the slot wall, was 0.48 in SEM, 7.00 in Primescan, 5.52 in Trios, 6.34 in CS3600, and 23.74 in i500 ($p < 0.001$). This study evaluated the accuracy of the bracket only, and it must be admitted that there is some error in recognizing slots through scanning in general.

Go to study: https://www.mdpi.com/1996-1944/14/2/365

Back to Table of Contents

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 ($p < 0.001$).

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

Back to Table of Contents

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.

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

Back to Table of Contents

Accuracy of Digital Impressions Obtained Using Six Intraoral Scanners in Partially Edentulous Dentitions and the Effect of Scanning Sequence

Study Background

- Evaluate the accuracy of digital impressions of two partially edentulous dentitions with anterior and/or posterior missing teeth, as well as the effect of scanning sequence
- Two maxillary complete-arch model were used, a Kennedy Class I model and a Kennedy Class IV model
- Models were scanned using a highly accurate industrial reference scanner (ATOS) to create a digital reference dataset
- Six intraoral scanners were used: Trios 3, iTero Element 2, Omnicam, Primescan, Emerald, 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])
- For trueness measurement, models were superimposed with a best-fit algorithm on the reference model. For precision evaluation, three scans were selected from both ScanR and ScanL and superimposed within groups

Talking Points

- For trueness in Class I model Primescan had statistically lower deviation values for trueness than the other intraoral scanners, except for Trios
- No significant difference was found between the trueness values of ScanR and ScanL
- For precision in Class I model Primescan had no statistically significant difference to Trios and iTero but showed statistically lower deviation values than the other IOS
- For precision in Class IV model Primescan had no statistically significant difference to Trios and iTero and therefore belonged to the group of IOS showing the best values

Abstract

Purpose

To compare the accuracy of six intraoral scanners in two different partially edentulous maxillary models and to evaluate the effect of scanning sequence on accuracy.

Materials and Methods

Maxillary Kennedy Class I and Class IV situations were used as reference models. The reference datasets were obtained by scanning the models using a highly accurate industrial scanner (ATOS Core 80, GOM). The following six intraoral scanners were evaluated: Trios 3 (3Shape), iTero Element 2 (Align Technology), Emerald (Planmeca), CEREC Omnicam (Dentsply Sirona), CEREC Primescan (Dentsply Sirona), and Virtuo Vivo (Dental Wings). A total of 120 scans from both models were obtained using the six intraoral scanners and divided into two groups based on scanning sequence. Accuracy was evaluated by deviation analysis using 3D image processing software (Geomagic Studio 12, 3D Systems). Kruskal Wallis and Mann-Whitney U tests were performed ($P \leq .05$) for statistical analysis.

Results

There were significant differences in the accuracy of digital impressions among intraoral scanners and scanning sequences. The trueness of the Trios scanner and the precision of the Trios, Primescan, and iTero scanners were significantly higher than for the other scanners. The Emerald had the lowest accuracy among the six intraoral scanners tested. Accuracy was affected by scanning sequence when using the Virtuo Vivo, Emerald, Primescan, and iTero.

Conclusion

In Kennedy Class I and Class IV partially edentulous cases, it is useful to consider that the intraoral scanner used may affect the accuracy of the digital impression.

Go to study: http://quintpub.com/journals/ijp/abstract.php?iss2_id=1723&article_id=21011#.YD38NjjsauU Back to Table of Contents

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.

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

Back to Table of Contents

Accuracy of four different intraoral scanners according to different preparation geometries

Study Background

- Evaluate the accuracy (trueness and precision) achievable with four intraoral scanners and different preparation geometries
- Model of an upper jaw with 4 different prosthodontic preparations served as master and was digitized using a laboratory scanner (Lava ST)
- Reference scan was measured with ATOS scanner
- Scanning with 4 IOS: Primescan, Trios 2, Omnicam, True Definition
- Evaluation of trueness and precision

Talking Points

- Primescan achieved the best precision in all geometries with statistically significance in most cases
- Primescan achieved best or second-best trueness values for positive and negative deviations. Primescan achieved highest trueness
  - For positive deviations on full crown and inlay with statistically significant difference to the other IOS
  - For negative deviations on full crown but with no statistically significance to Trios and True Definition
  - For Negative deviations on onlay but with no statistically significance

Abstract

Purpose

To evaluate the accuracy (trueness and precision) achievable with four intraoral scanners (IOSs) and different preparation geometries.

Materials and Methods

A model of a maxillary arch with different preparation geometries (onlay, inlay, veneer, full-crown) served as the reference master model (RMM). The RMM was scanned 10 times using four commonly used IOSs (Trios 2 [TR], 3Shape; Omnicam [OC], Dentsply Sirona; TrueDefinition [TD], 3M ESPE; and Primescan [PS], Dentsply Sirona). Scans were matched using a 3D measurement software (Inspect 2019, GOM) and a best-fit algorithm, and the accuracy (trueness and precision) of the preparation types of the scanning data was evaluated for positive and negative deviations separately. All data were subjected to univariate analysis of variance using SPSS version 24 (IBM).

Results

Mean (± SD) positive deviations ranged from 4.6 ± 0.7 µm (TR, veneer) to 25.9 ± 2.4µm (OC, full crown). Mean negative deviations ranged from -7.2 ± 0.6 µm (TR, veneer) to -26.4 ± 3.8 µm (OC, full crown). There were significant differences ($P < .05$) in terms of trueness and precision among the different IOSs and preparation geometries.

Conclusion

The transfer accuracy of simple geometries was significantly more accurate than those of the more complex prosthetic geometries. Overall, however, the IOSs used in this study yielded results that were clinically useful for the investigated preparation types, and the mean positive and negative deviations were in clinically acceptable ranges

Go to study: http://quintpub.com/journals/ijp/abstract.php?iss2_id=1453&article_id=21144#.YEDuXDjsY2w

Back to Table of Contents

Influence of different inlay configurations and distance from the adjacent tooth on the accuracy of an intraoral scan

Study Background

- Evaluate the effect of interproximal distance and cavity type on the accuracy of digital scans for inlay cavities, including proximal cavities
- Four cavity types were prepared based on the buccolingual width and location of the gingival margin of the disto-occlusal (DO) proximal box
- Reference scans were made with 3Shape E3; 3Shape A/S
- The 4 prepared teeth and adjacent molars were placed as close as possible to electronic calipers, stabilized with silicone impression material; a dental dam was passively applied, the interproximal distances were adjusted to 0.6, 0.8, and 1.0 mm and attached to a mannequin
- 10 scans per group with Primescan
- Determination of accuracy (trueness and precision)

Talking Points

- The average deviation for trueness of the interproximal distances 0.6, 0.8 and 1.0 mm was 10.9 ±1.1, 10.8 ±1.0 and 10.6 ±1.0 with statistically significant difference between the 0.6 and 1.0 mm group
- The average precision of the interproximal distances 0.6, 0.8 and 1.0 mm was 3.2 ±0.5, 3.1 ±0.3 and 3.2 ±0.6 with no statistically significant difference
- For the cavity type, the average trueness value ranged from 9.5 ±0.5 to 12.1 ±0.4 mm whereby the narrow long group had the highest value.
- The average deviation of precision for cavity type ranged from 3.0 ±0.3 to 3.6 ±0.6 mm. The narrow long group had a significantly lower precision than the other cavity type groups

Abstract

Statement of problem

Clinical guidelines for obtaining accurate scan data during the intraoral scanning of inlay cavities with various configurations and interproximal distances are lacking.

Purpose

The purpose of this in vitro study was to evaluate the effect of interproximal distance and cavity type on the accuracy of digital scans for inlay cavities, including proximal cavities.

Material and methods

Four artificial teeth with 4 types of inlay cavities designed based on the buccolingual width and gingival level of the proximal box were installed in a mannequin at distances of 0.6, 0.8, and 1.0 mm from the adjacent teeth. Reference scans of the 4 artificial teeth were obtained by using a laboratory scanner. The CEREC Primescan AC was used to acquire digital scan data (each n=10). Standard tessellation language (STL) files were analyzed with a 3-dimensional analysis software program. The mean deviation values were measured with a 3-dimensional best-fit alignment method to evaluate the accuracy of the digital scan data. Statistical analyses were performed by using 2-way ANOVA and the Bonferroni multiple comparison test (a=.05).

Results

As per the interproximal distance, the 1.0-mm group showed significantly higher trueness than the 0.6-mm group (P<.05). As the interproximal distance increased, the maximum positive deviation significantly decreased (P<.05). Maximum negative deviation and precision of the scan data were not significantly different among the distance groups (P>.05). Cavity type had a significant influence on the trueness and precision of the scan data (P<.05). In particular, the narrow long cavity type had an adverse effect on the precision and maximum positive deviation of scan data.

Conclusions

During the intraoral scanning of class II inlay restoration, interproximal distance and cavity type affected the accuracy of an intraoral scan. As the interproximal distance increased, the trueness of the acquired digital images increased and the maximum positive deviation significantly decreased. The narrow long cavity type negatively affected the mean maximum positive deviation and precision of scan data.

Go to study: https://www.thejpd.org/article/S0022-3913(21)00034-2/fulltext

Back to Table of Contents

The effect of software updates on the trueness and precision of intraoral scanners

Study Background

- Evaluate if intraoral scan accuracy is impacted by software updates in seven different IOS systems
- 7 IOS systems tested: Emerald (SW 5.8 vs 6.2.1), Emerald S (SW 6.0 vs 6.2.1), Trios 3 (SW 1.3.4.5 vs 1.6.9.1), Primescan (SW 5.0.1 vs 5.1), Omnicam (SW 4.6.1 vs 5.1), Medit i500 (SW 1.2.0.3 vs 2.1.2), iTero Element 2 (SW 1.9.3.3. vs 1.9.3.7)
- A mandibular typodont where each tooth represented different substrates and 8 scans were made with each IOS system
- Scans were compared to a digital master scan made with Atos Capsule Scanner

Talking Points

- For the accuracy with updated software version Primescan obtained the best results for substrate groups cross-arch, natural and core but with no statistically significant difference to Trios 3, Element 2 and Emerald S
- For the accuracy with updated software version Primescan ranked within the first four best scanners for substrate groups ACC, alloy and composite
- Primescan did not show statistically differences in trueness and precision between SW 5.0.1 and 5.1
- "Primescan was the one scanner that showed consistent performance in all substrates, ie no other scanner performed statistically better in any category."

Abstract

Objective

The goal of the study was to determine the effects of software updates on the trueness and precision of digital impressions obtained with a variety of intraoral scanner (IOS) systems.

Method and materials

Seven IOS systems were investigated. Each system was tested using two versions of software, with the second version being the latest at the time of conducting the study. Scans were performed on a custom mandibular typodont model with natural teeth that were either unrestored or restored with amalgam, composite, lithium disilicate, zirconia, and gold. Eight scans were obtained for each software version on any of the tested IOS systems. Experimental IOS scans were compared against an industry-standard master scan of the typodont obtained with an ATOS Capsule scanner proven to have a trueness of 3 µm and a precision of 2 µm. Isolation of each substrate material on the digital experimental and master scans was achieved using the Geomagic metrology software for subsequent analysis of the substrate influence on accuracy. A generalized linear mixed model was used to determine the influence of the software version on the trueness and precision of the impression scan.

Results

For some IOS systems, scans made with older software versions differ in accuracy compared with those obtained with the most recent software versions. Trueness was improved for most scanners following the software update, although the Element2 IOS performance deteriorated. Software updates had lesser effects on precision and showed variable trends among different systems. Software updates also influence different substrate materials scans' accuracy, although the results show variability among IOS systems. When comparisons were done among IOS systems updated with the latest software version, best performers for complete arch trueness were the Emerald S, Trios 3, and Primescan systems.

Conclusion

Software updates have a statistically significant effect on the trueness and precision of different IOS systems. These updates can have both positive and negative effects on scan accuracy, although it appears that these variations are within the clinical acceptability levels.

Go to study: https://www.quintessence-publishing.com/deu/de/article/1098315/quintessence-international/preprint the-effect-of-software-updates-on-the-trueness-and-precision-of-intraoral-scanners

Back to Table of Contents

Comparison of the acquisition accuracy and digitizing noise of 9 intraoral and extraoral scanners: An objective method

Study Background

- Purpose was to build an evaluation protocol of 8 IOSs by using the objective method
- An 8-mm-thick grade 1 zirconia gauge block was used for the study and packed into a shell marked with spherical reliefs of varying sizes
- 10 optical impressions made with each scanner (IScan D104, Omnicam, Primescan, Itero5D, CS 3600, Trios 3, Emerald, Planscan, Medit i500)
- Evaluation of digitizing noise, trueness and precision

Talking Points

- Primescan achieved the lowest digitizing noise value with statistically significant difference to Itero 5D, CS 3600, Emerald and Planscan
- Primescan achieved the lowest precision value with statistically significant difference to Omnicam, Emerald, Planscan and Medit i500
- Primescan showed significant lower trueness values than Omnicam, Emerald, Planscan and Medit i500 but was similar to the other IOS

Abstract

Statement of problem

The quality of the digital cast obtained from an intraoral scanner is an important comparison parameter for computer-aided design and computer-aided manufacturing (CAD-CAM) restorations. However, data on cast quality are typically provided by manufacturers, and objective evaluation of these devices is lacking.

Purpose

The purpose of this in vitro study was to build an evaluation protocol of 8 intraoral scanners by using an objective method for a small-scale model equivalent in size to a 4-tooth wide cast. In addition, a laboratory scanner was included to compare the performance of intraoral and extraoral devices.

Material and methods

An 8-mm-thick zirconia gauge block was scanned 10 times with a laboratory scanner (Iscan D104) and 8 intraoral scanners (Omnicam, Primescan, Itero element 5D, CS 3600, TRIOS 3, Emerald, Planscan, and Medit i500). The obtained digital casts were extracted as standard tessellation language (STL) files and analyzed to evaluate the digitizing noise, dimensional trueness, and dimensional precision of each scanner. After validation of the normal distribution of the digitizing noise, dimensional trueness, and precision test results for each scanner with the Shapiro-Wilk test (a=.05), differences were determined with a 1-way ANOVA test.

Results

Statistical differences were found between scanners (P<.05). The digitizing noise ranged from 3.2 ±0.6 mm with the Primescan to 15.5 ±2.5 mm with the Planscan. The dimensional trueness ranged from 19.1 ±11.5 mm for the CS3600 to 243.8 ±33.6 mm for the Planscan. The dimensional precision ranged from 7.7 ±2.4 mm for the Primescan to 53.7 ±3.4 mm for the Emerald. The group Iscan D104, Primescan, Itero 5D, CS3600, and TRIOS 3 showed minimally significant differences.

Conclusions

Significant differences were found among the intraoral scanners for small-scale scans. The objective methodology of using a gauge block provided coherent and repeatable results.

Go to study: https://www.thejpd.org/article/S0022-3913(21)00076-7/fulltext

Back to Table of Contents

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.

Go to study: https://www.thejpd.org/article/S0022391321000524/fulltext

Back to Table of Contents

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.

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

Back to Table of Contents

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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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Back to Table of Contents

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