A. Ender, M. Zimmermann, A. Mehl

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

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; CS: Carestream Dental 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 (α = 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.

Keywords: *intraoral scanner, digital impression, conventional impression, accuracy, precision, trueness*

Introduction

Digitalization of the alveolar arch using intraoral scanners (IOSs) represents a viable approach for obtaining digital dental models directly from the patient. Compared with conventional impression methods with irreversible materials, digital impression methods offer several advantages such as easy repeatability of the impression, direct visualization of the model, better time efficiency, and the possibility of chairside production for computer-aided design/computer-aided manufacturing (CAD/CAM) restorations.[1-5] Intraoral scans can be further used within the digital dental workflow using data fusion options with other digital datasets, such as cone beam computed tomography (CBCT) scans and face scans.[6,7] Three-dimensional (3D) difference analysis options based on intraoral scans have been demonstrated to offer great potential in terms of patient monitoring.[8,9]

The fact that the accuracy of digital impressions has been subject to several recent investigations demonstrates that there is still a need for scientific evidence in this field. For short-span areas such as single tooth areas and partial-arch areas such as quadrant and sextant areas, digital impressions have been demonstrated to perform within the same accuracy range as conventional impressions with high-precision materials.[10-12] For long-span areas such as complete-arch, it has been demonstrated that there is a need for improvement

Fig 1 Customized complete-arch maxillary cast with teeth made from feldspar ceramic material (Cerec Blocs; Dentsply Sirona) that served as the reference cast.

of IOSs to reach the accuracy levels of conventional impressions.[13-17] Shortcomings for digital impressions with IOSs have also been reported, both for edentulous and multi-implant clinical situations.[18-20]

Accuracy is defined by two independent factors: trueness and precision.[21] Trueness is obtained by comparing the original geometry, ie, the reference master cast with the digitized model, while precision is obtained by an intragroup comparison of digitized models.[21] High accuracy of dental models is needed to guarantee the sufficient fit of dental restorations and correct virtual articulation of the models.[22,23]

In literature, different approaches have been described for the evaluation of the accuracy of IOSs. Indirect approaches such as the evaluation of restoration fit have been described.[24,25] Direct approaches through linear measurements on the dental arch geometries or 3D surface comparisons after best-fit alignment have also been described and are most commonly used for accuracy evaluations.[26-28] It is important to emphasize that the correct method for accuracy measurements should be selected depending on the respective focus of interest, as there is not one approach that describes all the relevant factors. The interpretation of results for accuracy measurements always has to be based on very specific knowledge and assumptions in combination with a profound understanding of correct statistical data analysis.

There are well-known discrepancies for accuracy measurements between *in vitro* and *in vivo* accuracy studies using

IOS devices.[29,30] Factors such as the surface characteristics of scanned objects, oral environment factors, and patient movements might negatively influence the accuracy of IOSs *in vivo*.[31,32] Determination of the *in vivo* trueness parameter is difficult because there is a lack of a reference master geometry. *In vitro* studies thus provide an insight into the possible accuracy of IOSs and might facilitate obtaining validity with a more *in vivo*-like test setup.[33-35]

The aim of the present study was to evaluate the accuracy of new and actual digital and conventional impression methods *in vitro* for complete- and partial-arch areas using a customized model simulating *in vivo*-like conditions in terms of tooth surfaces and optical characteristics. The null hypothesis of this study was that there are no statistically significant differences between different impression methods for complete- and partial-arch segments.

Materials and methods

A custom maxillary complete-arch cast with unprepared teeth was used as a reference cast for the evaluation of *in vitro* accuracy. Teeth were made from feldspar ceramic material (Cerec Blocs; Dentsply Sirona) to approximate the optical properties of natural teeth (Fig 1).[32,36,37] The reference cast was scanned with a high-resolution reference scanner (ATOS III Triple Scan MV60; GOM) to obtain a highly accurate digitized reference model.[11]

Eight different IOSs setups comprising different hardware and software combinations were used in this study: Trios 3 Pod v. 1.18.2.6 (3Shape) using normal scan speed mode (TRn); Trios 3 Pod v. 1.18.2.6 (3Shape) using insane scan speed mode (TRi); Carestream Dental CS 3600 v. 3.1.0 (Carestream Dental [CS]) ; Medit i500 v. 1.2.1 (Medit [MD]); iTero Element 2 v. 1.7 (Align Technology [iT]); Cerec Omnicam v. 4.6.1 (Dentsply Sirona [OC4]); Cerec Omnicam v. 5.0.0 (Dentsply Sirona [OC5]); and Primescan v. 5.0.0 (Dentsply Sirona [PS]). Scans of the complete-arch cast were repeated 10 times per group (n = 10) using the manufacturers' recommended scanning strategies. All scans were exported into binary standard tessellation language (STL) files for further processing.

Conventional impressions of the reference cast were taken with stock metal trays (ASA Perma-Lock; ASA Dental) prepared with VPS universal adhesive (Coltène AG) and polyvinylsiloxane (PVS) material (President 360 heavy body and President light body; Coltène AG) using a one-step two-viscosity technique. This served as the control group (CO). The

Table 1 Test groups with respective impression techniques and software used to generate STL model files

Test group	System	Software	Impression technique	Postprocessing
CO	President 360 heavy body + President light body		Standard metal tray PVS tray adhesive Setting time: 10 min Storage time prior to pouring: 8 h Storage time prior to digitizing: 24 h	Poured with type IV gypsum, digitized with inEos X5, direct export to STL
TRn	Trios 3 normal scan speed mode	Trios software v. 1.18.2.6	Recommended by manufacturer (https://www.youtube.com/watch?v=M_KbWcCianY) (User manual)	Direct export to STL
TRi	Trios 3 insane scan speed mode	Trios software v. 1.18.2.6	Recommended by manufacturer (https://www.youtube.com/watch?v=M_KbWcCianY) (User manual)	Direct export to STL
CS	Carestream CS 3600	CS IO 3D Acquisition software v. 3.1.0	Recommended by manufacturer (https://www.dmiequipment.ie/wp-content/uploads/2017/06/CS3600-User-Manual.pdf) (User manual)	Direct export to STL
MD	Medit i500	Medit Link v. 1.2.1	Recommended by manufacturer (https://www.youtube.com/watch?v=-XMgOdb3-ww) (User manual)	Direct export to STL
iT	iTero Element 2	iTero Element software v. 1.7	Recommended by manufacturer (http://storagy-itero-production-eu.s3.amazonaws.com/download/en-us/iTero-Element-Restorative-Guidebook.pdf) (User manual)	Direct export to STL
OC4	Cerec Omnicam	Cerec software v. 4.6.1	Recommended by manufacturer (https://manuals.sirona.com/home.HomeDmsDocument.download.html?id=21927) (User manual)	Direct export to STL
OC5	Cerec Omnicam	Cerec software v. 5.0.0	Recommended by manufacturer (User manual)	Direct export to STL
PS	Primescan	Cerec software v. 5.0.0	Recommended by manufacturer (User manual)	Direct export to STL

setting time for the impression material was 10 min, and the storage time prior to pouring the impressions with type IV gypsum (Fujirock EP; GC Corporation) was 8 h. Poured casts were stored for 24 h and subsequently digitized with an extraoral laboratory scanner (inEos X5; Dentsply Sirona). Conventional impressions were repeated 10 times (n = 10). Again, all scan data were exported into binary STL files. Table 1 summarizes the impression procedures of all the test groups. The online references for the respective scanning strategies used are given within the table, where these are available. All other scanning strategies can be found in the user manuals provided by the respective manufacturers.

In the present study, three different regions of interest were used for the evaluation of accuracy of digital and conventional impression methods: complete-arch (tooth 17 to tooth 27); anterior segment (tooth 14 to tooth 24); and posterior segment (tooth 14 to tooth 17). The respective regions were selected from the digitized complete-arch dataset obtained for each group from the digitized complete-arch master model (Fig 2) (GOM Inspect 2018 rev. 114010; GOM).

The evaluation of accuracy started with a superimposition of the scans according to the method of best-fit alignment (GOM Inspect 2018 rev. 114010). After superimposition, 3D distances were calculated for each surface point and analyz-
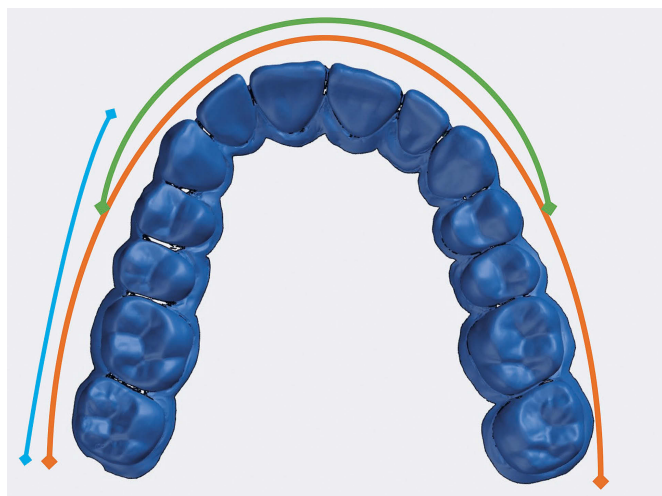
Fig 2 Digitized reference model (ATOS III Triple Scan MV60). The color-coded lines indicate the regions of interest for the *in vitro* accuracy evaluation: orange – complete-arch segment (tooth 17 to tooth 27), green – anterior segment (tooth 14 to tooth 24), blue – posterior segment (tooth 13 to tooth 17).

68.4 [10.9] μm (MD) for the anterior segment, and from 9.7 [1.2] μm (CO) to 46.8 [4.9] μm (MD) for the posterior segment.

Precision values ranged from 10.6 [3.8] μm (CO) up to 58.6 [38.4] μm (iT) for the complete-arch impressions, from 7.8 [1.4] μm (CO) to 39.0 [18.3] μm (MD) for the anterior segment, and from 6.6 [1.4] μm (CO) up to 21.5 [8.6] μm (CS) for the posterior segment.

The conventional impression method (CO) showed significantly higher trueness (16.3 [2.8] μm) and precision (10.6 [3.8] μm) than all tested IOS devices for the complete-arch impressions. The IOS devices showed a great variability in terms of trueness and precision for the complete- and partial-arch segments. Within the IOS devices, group PS showed higher trueness (32.4 [9.8] μm) for the complete-arch impressions, with statistically significant differences to all the other IOS groups, except TRi. In the anterior segments, the lowest deviations concerning trueness for IOS devices were also found for group PS. Within the posterior region, PS, TRi, and TRn did not exhibit statistically significant differences to group CO for trueness.

ed with 3D difference analysis software (GOM Inspect 2018 rev. 114010). Values for trueness (comparisons with reference scan; N = 10) and precision (intragroup comparisons; N = 45) for each group and for each respective area were calculated using (90–10)/2 percentile values. The results were evaluated using statistical software (SPSS 25; IBM), and descriptive statistic values were given as median with respective interquartile range [IQR] and mean ± standard deviation (SD) (all values in μm). Normal distribution and equality of variance were tested with the Shapiro-Wilk and Levene's tests. Statistically significant differences were then calculated using either the Kruskal-Wallis test for non-normal distributed data or the one-way analysis of variance (ANOVA) with the post hoc Dunnett T3 test for normal distributed data (significance level α = 0.05).

Results

Results for the complete- and partial-arch impression methods *in vitro* including statistical analysis are shown in Figure 3, and in Table 2 as median with interquartile range (IQR) and mean ± standard deviation (SD) in μm. Values for trueness ranged from 16.3 [2.8] μm (CO) up to 89.8 [26.1] μm (OC4) for the complete-arch impressions, from 14.3 [2.3] μm (CO) to

Discussion

In this study, the accuracy of both new and actual digital impression methods and a conventional impression method *in vitro* for complete- and partial-arch segments was evaluated using a new customized model simulating *in vivo*-like conditions. There were eight different IOS setups comprising different hardware and software combinations, and one conventional impression method using PVS material served as a control. The evaluation of accuracy was performed using the superimposition method, with a best-fit alignment of digitized models and a difference analysis using 3D difference analysis software and (90–10)/2 percentile values. Results varied with regard to statistically significant differences among different test groups for accuracy of the complete- and partial-arch impression methods (p < 0.05). Based on the findings of this study, the null hypothesis that there are no statistically significant differences between different impression methods for complete- and partial-arch segments has to be rejected. The results of this study are discussed next according to various aspects.

In this study, clinically acceptable results for all IOS devices were found for partial-arch posterior segments with deviations below 50 μm for all test groups. These results support findings from previous studies and recently published review

Table 2 Results for trueness and precision values for digital and conventional impression methods using the (90-10)/2 percentile method

Group	Trueness (µm) Median [IQR] and mean ± SD of percentile (90–10)/2								
	Complete-arch*			Anterior segment*			Posterior segment		
CO	16.3 [2.8]	16.2 ± 1.6	A,B,C,D,E,F,G,H	14.3 [2.3]	13.8 ± 1.7	A,B,C,D,E,F,G,H	9.7 [1.2]	9.8 ± 0.9	A,B,C,D,M
TRn	49.2 [17.1]	50.5 ± 9.6	A,I,K,L	39.3 [10.1]	37.9 ± 5.1	A,I,K,L	27.3 [2.4]	27.5 ± 1.8	E
TRi	47.8 [20.5]	51.1 ± 16.1	B,M,N	34.1 [8.1]	36.5 ± 6.7	B,M,N,O	27.1 [1.4]	27.2 ± 1.1	F
CS	57.5 [31.4]	61.4 ± 17.3	C,O,P	40.2 [5.5]	41.1 ± 5.2	C,P,Q	35.3 [5.4]	35.5 ± 2.9	A,I
MD	88.9 [28.2]	93.1 ± 20.2	D,I,M,O,Q,R,S	68.4 [10.9]	68.7 ± 9.3	D,I,M,P,R,S,T,U	46.8 [4.9]	46.8 ± 2.6	B,E,F,G,H
iT	63.3 [24.8]	60.7 ± 11.5	E,Q,T,U	39.0 [2.9]	39.4 ± 3.1	E,R,V,W	34.4 [1.8]	34.9 ± 1.6	C,K
OC4	89.8 [26.1]	87.3 ± 18.5	F,K,N,T,V	47.2 [7.9]	47.7 ± 5.6	F,K,N,S,V,X	28.5 [4.4]	28.9 ± 3.2	D,G
OC5	48.0 [12.8]	49.7 ± 8.8	G,R,V,W	40.3 [2.9]	40.1 ± 2.8	G,T,Y	36.2 [1.8]	36.4 ± 1.5	L,M
PS	32.4 [9.8]	33.9 ± 7.8	H,L,P,S,U,V,W	23.7 [3.4]	23.3 ± 2.0	H,L,O,Q,U,W,X,Y	21.9 [1.5]	22.2 ± 1.1	H,I,K,L

Group	Precision (µm) Median [IQR] and mean ± SD of percentile (90–10)/2								
	Complete-arch			Anterior segment			Posterior segment		
CO	10.6 [3.8]	12.0 ± 4.2	A,B,C,D,E,F,G,H	7.8 [1.4]	8.4 ± 1.8	A,B,C,D,E,F,G	6.6 [1.4]	7.0 ± 1.4	A,B,C,D,E,F,G
TRn	45.6 [38.3]	51.3 ± 22.1	A,I	25.2 [16.1]	28.6 ± 8.7	A,H,I	15.1 [1.9]	15.5 ± 1.7	A,H,I,K,L,M,N
TRi	53.7 [28.3]	57.4 ± 23.5	B,K	27.3 [8.8]	29.2 ± 7.4	B,K,L	18.2 [3.2]	18.4 ± 2.0	B,H,P
CS	55.2 [41.7]	63.2 ± 26.1	C,L,M,N	32.1 [11.5]	34.3 ± 8.5	C,M,N	21.5 [8.6]	23.3 ± 6.5	C,I,Q
MD	56.1 [35.6]	66.3 ± 26.2	D,O,P,Q	39.0 [18.3]	40.9 ± 11.8	D,H,K,O,P,Q	20.5 [4.9]	21.0 ± 2.9	D,K,R
iT	58.6 [38.4]	66.0 ± 31.0	E,R,S,T	28.5 [16.7]	33.2 ± 10.8	E,R	18.4 [15.1]	21.7 ± 7.6	E,L,S
OC4	40.0 [14.1]	41.2 ± 12.0	F,L,O,R	25.3 [4.3]	26.2 ± 4.4	F,M,O,S	17.7 [4.8]	18.8 ± 4.1	F,M,T
OC5	40.1 [22.0]	43.7 ±15.7	G,M,P,S	27.0 [7.8]	28.8 ± 7.1	G,P,T	20.1 [1.6]	20.1 ± 1.0	G,N,U
PS	30.1 [15.8]	31.3 ± 10.3	H,I,K,N,Q,T	15.1 [4.4]	16.5 ± 4.0	I,L,N,Q,R,S,T	12.3 [2.6]	12.9 ± 2.2	P,Q,R,S,T,U

Values indicated as median [IQR] and mean ± SD; all values in µm; values with the same uppercase letter within the same column indicate statistically significant differences (Kruskal-Wallis test for non-normal distributed data, and one-way ANOVA with post hoc Dunnett T3 test for normal distributed data (*), p < 0.05.

articles recommending digital intraoral impressions as a suitable alternative to conventional impression methods for this specific indication.[30] In this study, the best results for complete- and partial-arch impression methods were found for group CO, both for the trueness and precision parameters. IOS devices showed the highest accuracy for posterior segments for all test groups compared with anterior segment and complete-arch impressions. Higher deviations of IOS devices for both the trueness and precision parameters were found for the anterior segment compared with the posterior segment, presumably caused by the specific morphological structure of anterior teeth, with only scant morphological information. Higher deviations within the anterior segment resulted in lower complete-arch accuracy for IOS devices. Group PS showed a higher trueness with significantly lower deviations compared with all the other IOS groups for in the
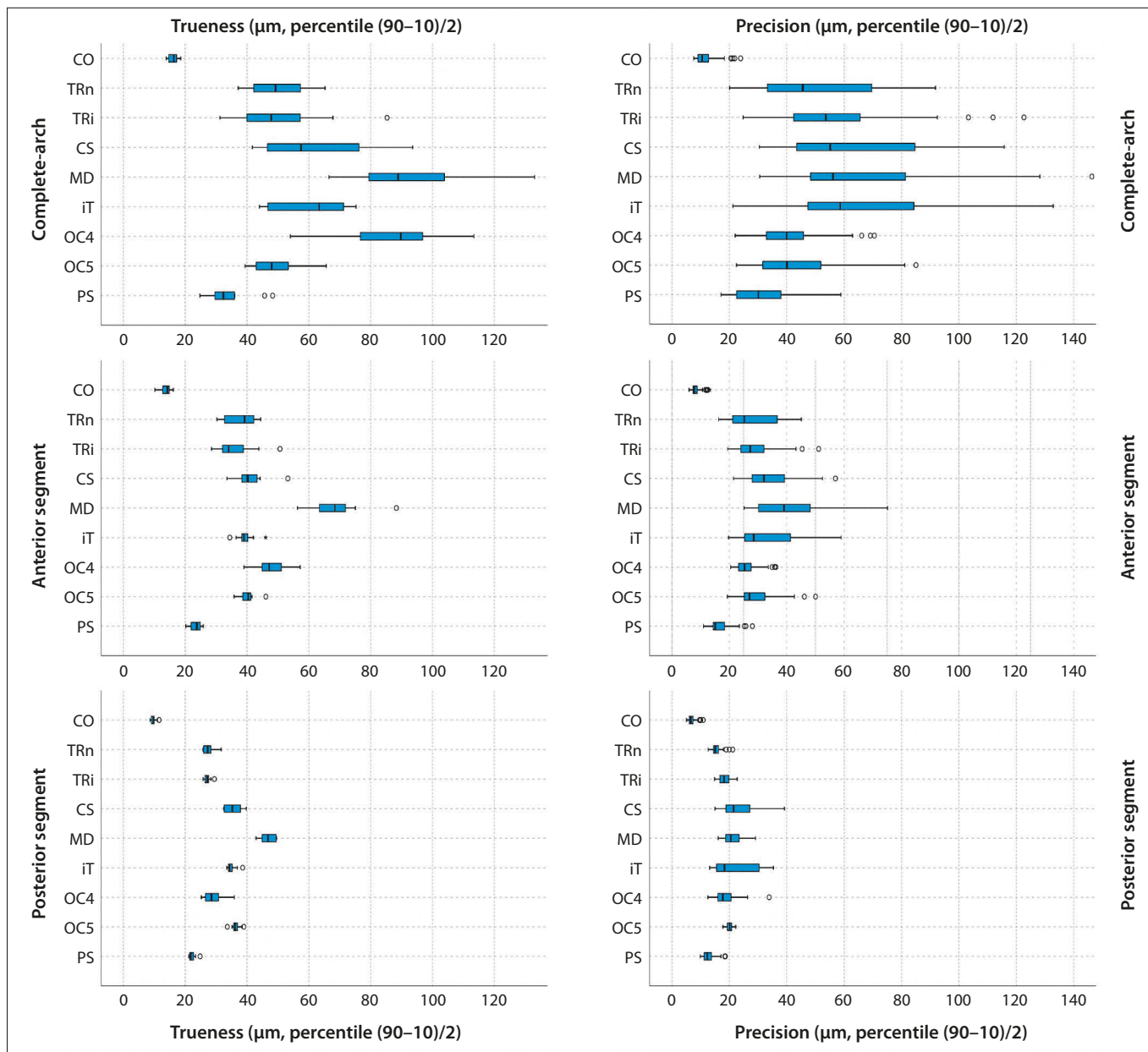
Fig 3 Boxplot diagrams showing the trueness and precision values for the digital and conventional impression methods using (90–10)/2 percentile values. The box represents the interquartile range [IQR]. The bar within the box represents the median value. Three different regions of interest were evaluated for each group: complete-arch, anterior segment, and posterior segment.

anterior segment. Within the posterior segment, PS, TRi, and TRn did not exhibit statistically significant differences to CO for trueness.

For some IOS devices, previous studies with similar evaluation methods report lower values in terms of complete-arch *in vitro* trueness.[15,38] This may be related to the use of a different reference cast (stainless steel) with non-translucent tooth surfaces.[15,38] The higher deviations observed in the present study might be caused by the translucent surface of the cast teeth made from feldspar ceramic material (Cerec Blocs). Feldspar ceramic shows natural tooth-like scanning behavior due to its natural tooth-like translucency.[32,36,37] It seems important to emphasize this fact because it might influence the comparability of different *in vitro* studies that use different reference

cast materials. Interestingly, the results of the present study for *in vitro* precision of complete-arch impressions were within the same range as previously published results for *in vivo* complete-arch precision for some IOS devices.[39]

In this study, a 3D surface comparison approach using (90–10)/2 percentile values was used, following a well-established protocol.[15,40] It is difficult to compare the results of this study directly with the results of other studies that used different statistical interpretations and distance measurements. There are different evaluation methods for the accuracy of dental impressions depending on different kinds of measures for trueness and precision. For the linear evaluation approach, an exact determination of specific reference points is a major requirement. This approach is thus preferred for accuracy evaluations of defined geometries with defined sharp edges or knots such as implant scan bodies or other geometrical objects. In the case of freeform surfaces such as teeth and anatomical structures, this procedure is generally not recommended. Therefore, 3D surface comparison approaches are used for real comparisons of freeform surfaces such as natural tooth surface morphology, which comprises thousands of linear surface distance point measurements. The superimposition of digitized models with best-fit algorithms is the standard procedure for 3D surface comparisons. However, there are also multiple different ways to summarize the 3D-difference values, which result from the pointwise distance calculations of the superimposed surfaces. Examples from the most recent literature are root mean square (RMS) error, mean value, and positive and negative (absolute) mean deviation. The amount of incorporated measurement data and therefore the region of interest is different for all these evaluations, which makes it difficult to compare the results of different studies.[10-12]

The influence of scanning strategies and scanning software on the accuracy of digital impressions has been demonstrated in the literature.[14,41] Scanning strategies for IOS devices are system specific, as IOSs are based on different technologies. A system-specific scanning strategy with actual scanning software for every IOS device was used in this study to obtain optimal results. The influence of the scanning software is apparent when comparing the results of groups OC4/OC5, where the same hardware components but different scanning software modes/versions were used. Previous studies show increasing deviations for trueness and precision with an increasing area of scanned surface for IOS devices, whereas this statement cannot be made for conventional impression methods.[10-12,39,42] The results of this study accord well with this statement. Short-span areas such as the anterior and posterior segments showed the lowest deviation val-

ues for IOS devices, whereas only small differences were found between partial- and complete-arch accuracy for the conventional impression methods.

Conclusion

Accuracy for complete-arch impressions is still challenging for specific IOS devices. Certain actual IOS devices, however, are well within the required accuracy necessary for full-arch scans. In case of partial-arch impressions, IOS devices represent a suitable alternative to conventional impression methods even with highly accurate impression materials. The results of the present study show that new hardware and/or software developments can provide major improvements in terms of impression accuracy for IOS devices. Further *in vivo* studies are needed to validate the accuracy of IOS devices under different clinical conditions.

Disclaimer

The authors declare that there are no conflicts of interest.

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Genauigkeit von Gesamt- und Teilkieferabformungen aktueller intraoraler Scansysteme in vitro

Schlüsselwörter: *Intraoralscanner, digitale Abformung, konventionelle Abformung, Genauigkeit, Präzision*

Zusammenfassung

Ziel: Intraoralscanner (IOSs) werden inzwischen häufig für die Herstellung digitaler Modelle direkt am Patienten genutzt. Verbesserungen der IOSs werden zusätzlich von Generation zu Generation erreicht. Das Ziel der vorliegenden Studie war eine Beurteilung der Genauigkeit von neuen und aktuellen intraoralen Scansystemen für Gesamt- und Teilkieferabformungen in vitro.

Material und Methode: Ein spezielles Gesamtkiefermodell des Oberkiefers mit Zähnen aus Feldspatkeramik wurde als Referenzmodell verwendet und mit einem Laborscanner (ATOS III Triple Scan MV60) digitalisiert. Die Abformung des Gesamtkiefers erfolgte konventionell mit einem Polyvinylsiloxanmaterial (CO; President) und digital mit acht verschiedenen IOS Systemen (TRn: Trios 3; TRi: Trios 3 insane; CS: Carestream Dental CS 3600; MD: Medit i500; iT: iTero Element 2; OC4: Cerec Omnicam 4.6.1; OC5: Cerec Omnicam 5.0.0; PS: Primescan) (n = 10 pro Gruppe). Die konventionellen Abformungen wurden mit Typ IV Gips (Fujirock EP) ausgegossen und die Modelle mit einem Laborscanner (inEOS X5) digitalisiert. Alle Datensätze wurden im STL Dateiformat exportiert und für die weitergehende Analyse in verschiedene Bereiche beschnitten: Gesamtkiefer, vorderes Teilkiefersegment und hinteres Teilkiefersegment. Die Richtigkeits- und Präzisionswerte für die entsprechenden Bereiche wurden in einer 3D-Überlagerungsmethode mit spezieller 3D-Differenzanalyse-Software (GOM Inspect) unter Verwendung von (90-10)/2 Perzentil-Werten evaluiert. Die statistische Auswertung erfolgte mit der One-Way-ANOVA oder dem Kruskal-Wallis Test (α = 0.05). Die Angabe aller Ergebnisse erfolgt als Median[IQR] Wert in µm.

Ergebnisse: Die Werte für Gesamt- und Teilkieferabformungen in vitro zeigten statistisch signifikante Abweichungen zwischen den Testgruppen (p < 0.05). Für den Gesamtkiefer lagen die Richtigkeitswerte im Bereich von 16.3[2.8] µm (CO) und 89.8[26.1] µm (OC4) und die Präzisionswerte im Bereich von 10.6[3.8] µm (CO) und 58.6[38.4] µm (iT). Im Falle der Teilkieferabformungen wurden für alle Gruppen für das hintere Teilkiefersegment die besten Richtigkeiten ermittelt, mit 9.7[1.2] µm für die konventionelle Abformmethode (CO) und mit 21.9[1.5] µm (PS) als den besten Wert für die digitale Abformmethode.

Schlussfolgerung: Unter Berücksichtigung der Einschränkungen dieser In-vitro-Studie können bestimmte digitale Intraoralscanner als Alternative zur konventionellen Abformung für Teilkieferbereiche gesehen werden. Ganzkieferabformungen sind nach wie vor eine Herausforderung für Intraoralscanner, aber einige Systeme liefern auch jetzt schon Genauigkeiten innerhalb der klinischen Anforderungen. Weitere In-vivo-Studien sind nötig, um diese Ergebnisse abzusichern.

PD Dr. med. dent. Andreas Ender
Division of Computerized Restorative Dentistry, Clinic for Preventive Dentistry, Periodontology and Cariology, Center of Dental Medicine, University of Zurich, Zurich, Switzerland

Dr. med. dent. Moritz Zimmermann
Division of Computerized Restorative Dentistry, Clinic for Preventive Dentistry, Periodontology and Cariology, Center of Dental Medicine, University of Zurich, Zurich, Switzerland

Prof. Dr. med. dent. Dr. rer. hum.biol. Albert Mehl
Division of Computerized Restorative Dentistry, Clinic for Preventive Dentistry, Periodontology and Cariology, Center of Dental Medicine, University of Zurich, Zurich, Switzerland

Andreas Ender

Address
PD Dr. med. dent. Andreas Ender, Plattenstrasse 11, CH-8032 Zurich, E-mail: andreas.ender@zzm.uzh.ch