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RESEARCH AND EDUCATION

Evaluation of impact of intraoral scanning technology and scan body design on the accuracy of maxillary complete arch digital scans: A clinical study

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ABSTRACT

Statement of problem. Intraoral scanners (IOSs) can be used to digitize complete arches with multiple dental implants; however, the influence of intraoral scanning technology and scan body system selection on accuracy in maxillary complete arches remains unclear.

Purpose. The purpose of this clinical study was to evaluate the accuracy in the maxillary arch, encompassing both trueness and precision, of 2 distinct intraoral scanning systems and 2 diverse scan body systems in comparison with the conventional reference method.

Material and methods. Two participants were recruited with 6 maxillary bone-level implants (JDEvolution Plus; JDentalCare) placed in positions corresponding to the right first molar, right canine, right central incisor, left central incisor, left canine, and left first molar. All implants had multiunit abutments (Conical Abutment Straight; JDentalCare) screwed to the implants. Definitive casts from 2 edentulous maxillary impressions were made using a conventional method. The casts were digitized to create reference models using a laboratory scanner (E3; 3Shape A/S). Two experimental groups were created based on the IOS used: the TRIOS 3 group (TR3) and the Primescan group (PS). Two subgroups were generated depending on the scan body system used to digitize the spatial position of the implants: IPD scan body (IPD) and DAS scan body (DAS). The digital implant scan discrepancies between the control group and experimental scans were calculated. The normality of the data was assessed using the Shapiro-Wilk test (α=.05). Two-way ANOVA and post hoc pairwise comparison tests were used to compare the trueness, precision, and interaction between the intraoral scanner and the scan body (α=.05)

Results. Statistically significant differences ($P<.001$) were found between the intraoral scanners tested. No significant differences were found between the IPD and DAS scan body systems ($P=.649$), and none were found for the interaction between the IOS and the scan body ($P=.524$). Significant differences were observed between the following groups: PS-IPD and TR3-IPD, PS-IPD and TR3-DAS, PS-DAS and TR3-IPD, and PS-DAS and TR3-DAS (all $P<.001$).

Conclusions. The combination of intraoral scanner and scan body system is crucial to improve the accuracy of digital complete arch intraoral implant scans. In the maxillary arch, the Primescan IOS obtained the highest accuracy when compared with the TRIOS 3 IOS, independently of the scan body system used. (J Prosthet Dent xxxx;xxx:xxx-xxx)

The accuracy of definitive casts for complete arch implant-supported prostheses is critical for their long-term success.[1–4] The selected scanning technique must precisely replicate the intraoral 3-dimensional (3D) position and orientation of the implants to avoid biological or mechanical complications.[5–7] With conventional methods, factors that influence the accuracy of definitive casts for implant-supported prostheses include the impression technique and material,[1,8,9] implant connection type,[10–12] implant angulation,[13–17] inter-implant distance,[18] impression coping design, whether the copings are splinted,[1] polymerization shrinkage of resin assembly materials,[19] number of implants,[19] custom tray design,[20–22] and expansion properties of the dental stone.[22–24]

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Clinical Implications

The selection of an appropriate intraoral scanner is critical for achieving accurate maxillary digital implant scans involving multiple implants. The performance of intraoral scanners has a greater impact on accuracy than the scan body system used.

Advances in digital technologies, including intraoral scanners (IOSs) and photogrammetry systems (PGs), have simplified the process of obtaining recordings for complete-arch implant-supported prostheses.[25,26] However, the accuracy of complete arch implant intraoral scans is influenced by factors that include operator skill[27] and patient-,[28] technology-,[29–31] and scan body-related variables.[32–34] Among these, the scanning technology and the scan body design play a significant role in obtaining accurate intraoral scans for multiple implants.[29–33]

According to the International Organization for Standardization (ISO) 5725–1 standard, the term accuracy is defined by trueness and precision.[33] Trueness refers to the ability of an intraoral scanner to replicate a dental arch in a manner that closely matches its actual form without distortion or deformation, while precision denotes the consistency of results obtained from multiple scans conducted under identical conditions.[33]

Previous studies have evaluated the effects of various intraoral scanning patterns,[34–38] the influence of rescanning and locking existing scans when using rescanning techniques,[39–42] and the impact of splinting scan bodies using different methodologies on the scanning accuracy of IOSs.[43] However, the majority of these investigations were conducted under laboratory conditions, and, because of the heterogeneity of study designs, clinical insights into multiple implant digital scans remain inconclusive. Additionally, scientific evidence for the impact of different scan body designs using multiple intraoral scanning technologies in a clinical environment is lacking.[44,45]

The aim of this in vivo study was to assess the impact of scan body design on the accuracy (trueness and precision) of maxillary complete arch multiple implant intraoral scans obtained using 2 different intraoral scanning technologies (PrimeScan; Dentsply-Sirona and Trios 3; 3Shape A/S). The null hypothesis was that no statistically significant differences in accuracy (trueness and precision) would be found between the scan body designs or the intraoral scanning technologies or systems.

MATERIAL AND METHODS

The protocol of the present investigation was reviewed and approved by an ethical committee (2024-0255-1) and was conducted according to the principles of the declaration of Helsinki. Two participants, who voluntarily consented to participate in this study, had been thoroughly informed about the objectives of the study, and their written informed consent was obtained. They were over 18 years old, in good general health (ASA Type I), without temporomandibular joint disorders and without mouth opening limitations, and with 6 osseointegrated implants in the maxilla. The 2 participants each had 6 maxillary bone-level implants (JDEvolution Plus; JDentalCare) and attended a private dental office for an appointment for implant review. The implants had been placed at a private practice in the positions corresponding to the right first molar, right canine, right central incisor, left central incisor, left canine, and left first molar. All had multiunit abutments (Conical Abutment Straight; JDentalCare) screwed to the implants. As part of the review appointment, the prostheses had been unscrewed. Subsequently, conventional impression copings were attached, and a splinted framework was applied to the implant impression copings using a photopolymer resin (Conlight; Kuss) (Fig. 1). A polyether impression material (Impregum F; 3M ESPE) was used to obtain definitive impressions. Definitive casts of the maxillary arches were fabricated using a low-expansion Type IV dental stone (FujiRock EP; GC Corp)

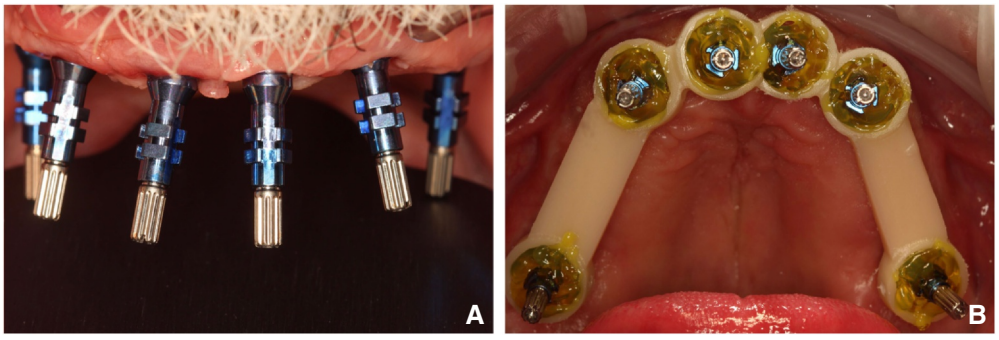

Figure 1. Maxillary complete arch conventional multiple implant impression. A, Implant abutment coping impression placed. B, Splinting framework.

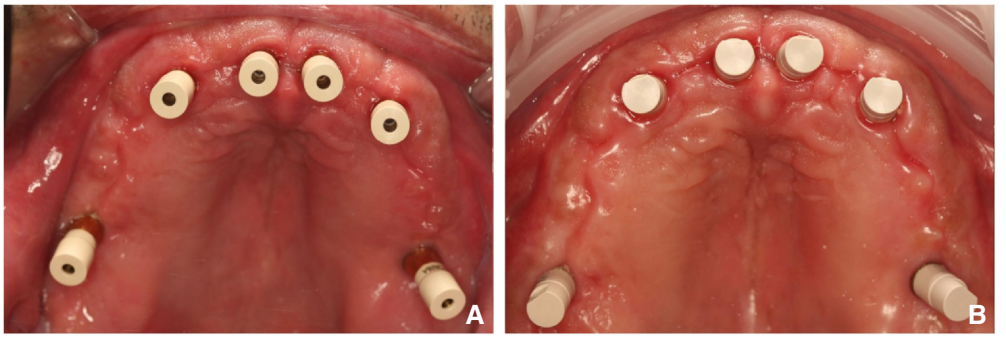

Figure 2. Scan body systems tested. A, IPD. B, DAS.

by following the manufacturer's instructions. The definitive casts were digitized using a laboratory scanner (E3; 3Shape A/S) to generate maxillary reference standard tessellation language (STL) files. The laboratory scanner had been calibrated before use by following the recommendations provided by the manufacturer. The scanner manufacturer states a trueness of <5 μm and a precision of <10 μm.

Two experimental groups were created based on the intraoral scanner used: the TR3 group (TRIOS 3; 3Shape A/S) and the PS group (Primescan; Dentsply Sirona). Subsequently, for each intraoral scanner, 2 subgroups were generated based on the scan body system used: the IPD group (IPD; IPD) and the DAS group (DAS; Talladium) (Fig. 2A, B). With each IOS system, 10 intraoral scans were performed for each scan body system (n=10). A total of 40 experimental STL files were obtained per participant (N=40). The STL file associated with the TR3 group were exported as TR3-IPD and TR3-DAS, while the STL files associated with PS were exported as PS-IPD and PS-DAS (Fig. 3). All intraoral scans were performed by the same dentist (P.L.C.) with 5 years of IOS experience. Digital scans were performed under controlled ambient conditions in a room with an ambient lighting condition of 1000-lux, assessed with a luxometer (LX1330B Light Meter; Dr. Meter Digital Illuminance), and a room temperature of 21.5 ºC.

The same scanning protocol was performed in all test groups. Digital scans were started from the occlusobuccal area of the first left scan body molar with the tip of the scanners tilted 45 degrees in an occlusal direction and moved occlusally along the dental arch up to the first right scan body molar. Then, the tip of the scanner was guided from the right first scan body molar across the entire scan body arch back to the left first scan body molar in an occlusopalatal or occlusolingual direction to complete the scans, obtaining the entire geometry of the scan bodies. A critical requirement was the seamless

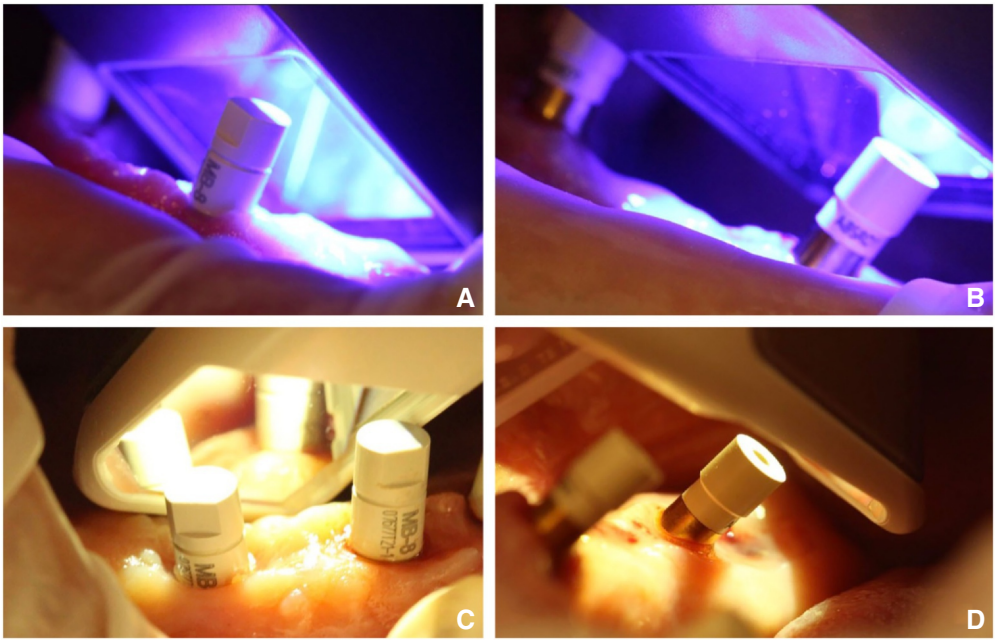

Figure 3. Intraoral scanning of different groups. A, PS-DAS group. B, PS-IPD group. C, TR-DAS group. D, TR-IPD group.

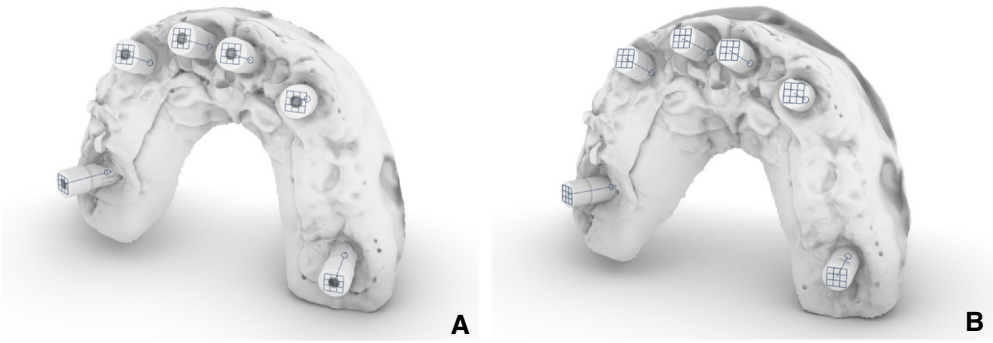

Figure 4. Representative figures of data preparation to perform linear and angular measurements. A, IPD scan body system. B, DAS scan body system.

execution of digital intraoral scans, without interruptions or holes in the meshes.

The $STLr_1$ and $STLr_2$ files were imported into a 3-dimensional (3D) analysis software program (Rhinoceros 8; TLM Inc) to determine the coordinates corresponding to the center of the connection surface of each scan body, thereby obtaining reference data (Fig. 4A, B). To establish the reference center point for conducting linear distance measurements, the point of intersection between the z-axis of each implant, oriented perpendicularly to a plane encompassing the top face of each scan body, was used (Fig. 4A, B). The derivation of the z-axis for each scan body involved tracing a 0.2-mm segment extending from every point on the corresponding mesh, oriented at a distance equivalent to the scan body's diameter in a direction perpendicular to that point's surface. Points at which these segments intersected with the mesh were considered to belong to the cylindrical body of the scan body, consequently enabling an initial estimation of the scan body's z-axis. Then, those mesh points with a direction average to the z-axis were filtered out, generating the plane that most closely approximated the points on the top face of each scan body. The process was repeated in 2 iterations. The methodology was performed over the entire experimental datasets to obtain the linear and angular measurements of the STL files of the test groups. All the possible combinations of interimplant linear and angular deviations were analyzed in each scan.

In the evaluation of trueness, statistical analysis of the results was conducted by using 2-way ANOVA, post hoc Tukey Honestly Significant Difference and paired-sample Student *t* test (α=.05). To gauge precision, an examination of the variance of linear distances and angular deviations between the STLr file and the experimental digital casts produced by both the intraoral scanning systems and scan bodies was performed using the quadratic Levene test as the analytic method. Precisely, variance assessments were performed to ascertain the value and significance of precision, which was associated with the standard deviation of distance and angular disparities. All statistical analysis calculations were performed by using a statistical software program (IBM SPSS Statistics, v25; IBM Corp).

RESULTS

The normality of the data was assessed using the Shapiro-Wilk test (α=.05) (Table 1). The linear interimplant distances for trueness and precision are described in Table 2. Regarding linear trueness values, the repeated measures ANOVA test showed a significant difference between the tested intraoral scanners ($F(1, 76) = 23.45$, $P<.001$), indicating that PS groups achieved significantly lower deviations than TR3 groups (Table 3). In contrast, no significant difference was found for the scan body factor ($F(1, 76)=0.91$, $P=.34$) or for the

Table 1. Normality tests conducted for studied variables

	Group	Normality Test	w-Statistics	*P*
Linear Measurements	PS-IPD	Shapiro-Wilk	.972	.743
	PS-DAS	Shapiro-Wilk	.967	.612
	TR3-IPD	Shapiro-Wilk	.467	.467
	TR3-DAS	Shapiro-Wilk	.391	.391
Angular Measurements	PS-IPD	Shapiro-Wilk	.972	.743
	PS-DAS	Shapiro-Wilk	.967	.612
	TR3-IPD	Shapiro-Wilk	.959	.467
	TR3-DAS	Shapiro-Wilk	.955	.391
Intraoral Scanners	PS	Shapiro-Wilk	.969	.532
	TR3	Shapiro-Wilk	.957	.432

Table 2. Descriptive statistics of overall linear interimplant discrepancies on different groups

Group	Mean Difference (mm)	SD (mm)
PS-DAS	0.061	0.023
PS-IPD	0.055	0.019
TR3-DAS	0.114	0.033
TR3-IPD	0.115	0.020

SD, standard deviation.

interaction between IOS and scan body (F (1, 76) =0.52, *P*=.47) (Table 3). Similarly, regarding linear precision values, the repeated measures ANOVA test indicated a significant effect of the IOS factor (Table 4, P<.01), again confirming differences between PS and TR3 groups (Fig. 5A, B). However, no significant difference was observed for the scan body factor (*P*=.27) or for the interaction between IOS and scan body (*P*=.43) (Table 4). The PrimeScan intraoral scanner obtained the best linear trueness and precision values (Table 2).

The post hoc Tukey Honestly Significant Difference (HSD) test was applied, and pairwise comparisons confirmed that the differences between the PS and TR3 groups were statistically significant, regardless of the scan body system used. Specifically, significant differences were observed between the following groups: PS-IPD and TR3-IPD, PS-IPD and TR3-DAS, PS-DAS and TR3-IPD, and PS-DAS and TR3-DAS (all *P*<.001) (Table 5). These results indicate that PrimeScan IOS has significantly better accuracy than TRIOS 3 IOS. No significant differences were found between the IPD and DAS scan body systems within the same IOS (all *P*>.05), confirming that the scan body choice did not significantly influence trueness or precision in the maxillary arch. Table 6 shows the descriptive statistics of overall angular deviations in different groups.

The angular measurements for trueness and precision are described in Tables 7 and 8. The ANOVA test for trueness did not reveal a statistically significant effect of IOS type on angular measurements (F (1, 76)=3.38, *P*=.070), nor a significant effect of the scan body system (F (1, 76)=2.30, *P*=.134) (Table 7, Fig. 6). Additionally, the interaction between scanner type and scan body system showed a statistically significant difference (F (1, 76)=6.16, *P*=.015), suggesting that scan body performance in trueness was dependent on the IOS used.

Conversely, for precision, a statistically significant effect of IOS type on angular deviations was observed (F (1, 76)=1236.81, *P*<.001), indicating a clear difference among scanners (Table 8). The scan body system also had a significant effect on precision (F (1, 76)=24.98, *P*<.001), with variations depending on the scan body used. Furthermore, a significant interaction between IOS type and scan body system was found (F (1, 76) =24.70, *P*<.001), suggesting that the precision performance of scan bodies was highly dependent on the scanner used.

The multiple pairwise comparisons using the post hoc Tukey HSD test indicated significant differences in angular trueness between the PS-IPD and TR3-IPD groups (*P*<.001), PS-IPD and TR3-DAS groups (*P*<.001), and PS-DAS and TR3-IPD groups (*P*<.001). However, no significant differences were found between PS-IPD and PS-DAS (*P*=.074) or TR3-IPD and TR3-DAS (*P*=.612) (Table 9). Regarding precision, significant differences were observed between PS-IPD and TR3-IPD (P<.001), PS-IPD and TR3-DAS (*P*<.001), PS-DAS and TR3-IPD (*P*<.001), and PS-DAS and TR3-DAS (*P*<.001), whereas no significant difference was detected between PS-IPD and PS-DAS (*P*=.081) (Table 9). These results suggest that the PrimeScan IOS combined with the IPD

Table 3. Repeated measures ANOVA table for trueness analysis of intraoral scanner, scan body, and interaction between intraoral scanner and scan body in linear deviations

Source	Sum of Squares	DF	Mean Square	F-Value	*P*
Intraoral Scanner	0.0050	1	0.0050	23.45	<.001*
Scan body	0.0002	1	0.0002	0.91	.34
Interaction	0.0001	1	0.0001	0.52	.47
Error	0.0162	76	0.00021	-	-
Total	0.0215	80	-	-	-

DF, degrees of freedom

**P*<.001

Table 4. Repeated measures ANOVA table for precision analysis of intraoral scanner, scan body, and interaction between intraoral scanner and scan body in linear deviations

Source	Sum of Squares	DF	Mean Square	F-Value	*P*
Intraoral Scanner	0.0031	1	0.0031	18.44	<.01*
Scan body	0.0002	1	0.0002	1.32	.27
Interaction	0.0001	1	0.0001	0.69	.43
Error	0.0015	76	0.00002	-	-
Total	0.0050	80	-	-	-

DF, degrees of freedom

**P*<.01

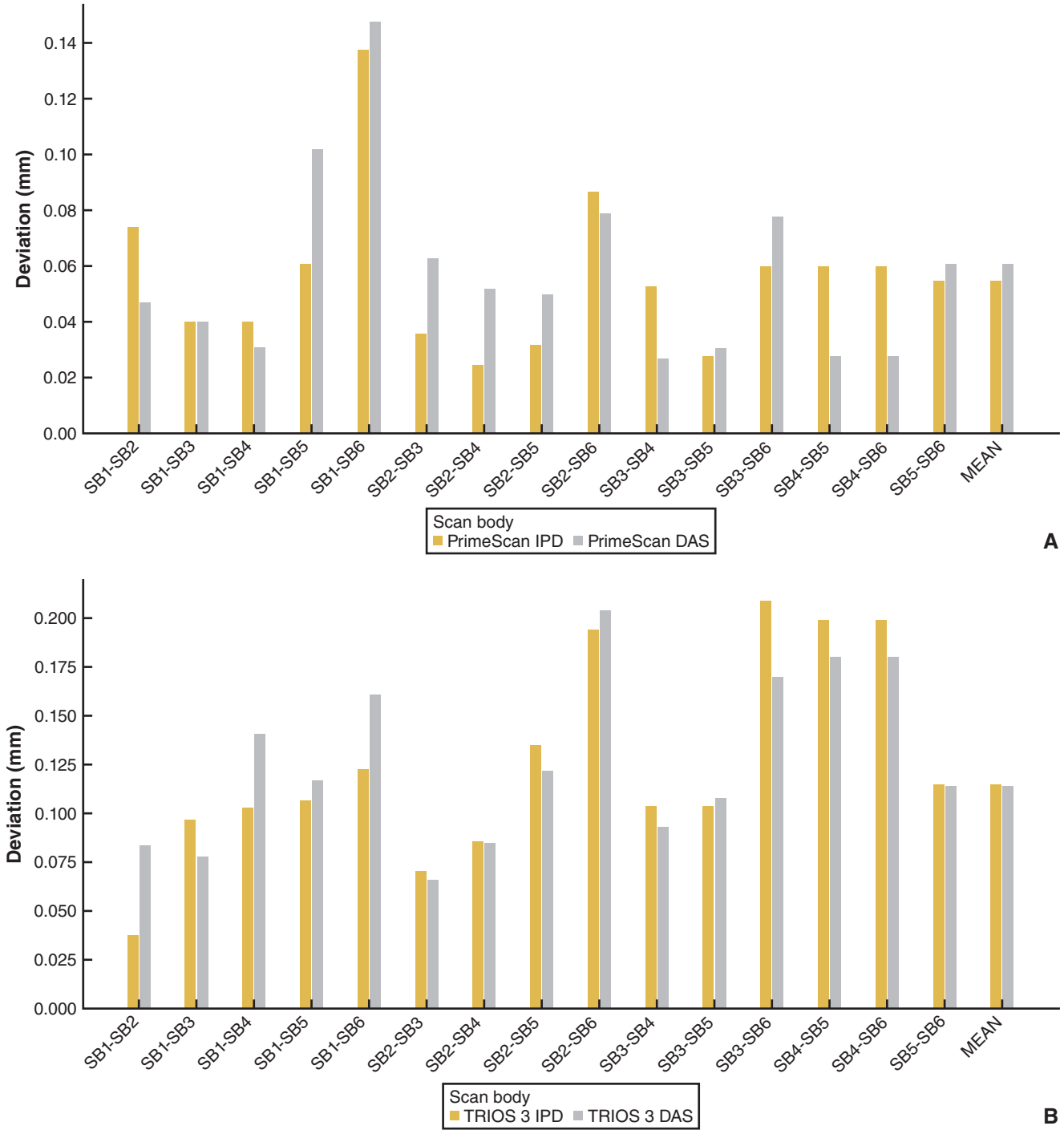

Figure 5. Linear interimplant accuracy boxplots for scan body and intraoral scanning system tested. A, PS group (PrimeScan). B, TR3 group (TRIOS 3).

scan body system achieved the highest values in trueness and precision in angular measurements compared with the TRIOS 3 IOS and the DAS scan body system.

DISCUSSION

Based on the results of this study, the IOS systems tested had a significant impact on the scanning accuracy of complete arch 6-implant digital recordings. Therefore, the null hypothesis that no statistically significant differences in accuracy (trueness and precision) would be found between the scan body designs or the intraoral scanning technologies was partially rejected. However, no significant differences were observed between the scan body systems tested in the maxillary arch when multiple implant digital intraoral scans were performed.

Table 5. Post hoc Tukey HSD test for pairwise comparisons between intraoral scanners and scan bodies

	Pairwise Comparison	Mean Difference (mm)	Standard Error (SE)	*P*	Interpretation
Trueness	PS-IPD vs PS-DAS	−0.006	0.005	.45	Not significant
	PS-IPD vs TR3-IPD	−0.060	0.008	<.001*	Significant difference (PS<TR3)
	PS-IPD vs TR3-DAS	−0.059	0.009	<.001*	Significant difference (PS<TR3)
	PS-DAS vs TR3-IPD	−0.054	0.010	<.001*	Significant difference (PS<TR3)
	PS-DAS vs TR3-DAS	−0.053	0.009	<.001*	Significant difference (PS<TR3)
	TR3-IPD vs TR3-DAS	0.001	0.006	0.95	Not significant
Precision	PS-IPD vs PS-DAS	−0.003	0.006	.50	Not significant
	PS-IPD vs TR3-IPD	−0.045	0.010	<.001*	Significant difference (PS<TR3)
	PS-IPD vs TR3-DAS	−0.048	0.011	<.001*	Significant difference (PS<TR3)
	PS-DAS vs TR3-IPD	−0.042	0.009	<.001*	Significant difference (PS<TR3)
	PS-DAS vs TR3-DAS	−0.045	0.008	<.001*	Significant difference (PS<TR3)
	TR3-IPD vs TR3-DAS	−0.003	0.005	.71	Not significant

*P<.001

Table 6. Descriptive statistics of overall angular deviations in different groups

Group	Mean Angular Deviations (Degrees)	SD (Degrees)
PS-DAS	0.5144	0.1719
PS-IPD	0.3438	0.0573
TR3-DAS	0.6302	0.2865
TR3-IPD	0.5729	0.1719

SD, standard deviation.

Factors that affect the accuracy of IOSs can be classified as operator-related (learning curve and scanning protocol), intraoral-related (mobile tissue, saliva, and blood), environmentally related (ambient lighting and temperature),[36] system-related (IOS technology and software program), and scan body-related (material, geometry, and design).[27,29] Digital scanning for implant-supported prostheses has been extensively studied.[32,34–39,44,45] However, these studies were conducted predominantly under in vitro conditions and intraoral factors needed to be considered, warranting cautious interpretation of their conclusions.

Sallorenzo et al[16] reported a trueness of 100 µm and a precision of 292 µm with an IOS (TRIOS 3; 3Shape A/S) on 6 scans when implants were placed parallel or angled. The authors reported a trueness and precision of 20 and 230 µm respectively.[16] Gómez-Polo et al[36] studied the accuracy of different techniques in the maxillary and mandibular arches using a TRIOS 4 IOS and reported accuracy in the maxilla ranging between 88 ±86 µm and 142 ±136 µm. Mangano et al[38] studied 12 different IOSs and reported trueness from 30.4 to 98.4 µm and statistically significant differences among CS 3600, CS 3700, i500, TRIOS 3, PrimeScan, and Itero Element 5D IOSs. The IOSs with the best trueness had an intrinsic error below 40 µm. However, this research did not analyze the precision of the, intraoral implant scans of edentulous patients, which is crucial in a clinical scenario.

The influence of implant scan body height, geometric design, and position on the accuracy of implant digital scans has been evaluated. Batak et al[34] reported that scan body height did not affect distance deviations, although it did impact angular deviation, with smaller heights resulting in reduced deviations. They also observed that the position of the scan body within the arch influenced trueness, with anterior scan bodies showing higher trueness values than posterior scan bodies.[33] Similarly, Alkindi et al[34] investigated the impact of scan body length on accuracy and reported that short scan bodies demonstrated lower discrepancy values for trueness and precision than long scan bodies. Gómez-Polo et al[45] conducted a systematic review to study the impact of scan body design on scanning accuracy,

Table 7. ANOVA table for trueness of intraoral scanner, scan body, and interaction between intraoral and scan body angular deviations

Source	Sum of Squares	DF	Mean Square	*F* Value	*P*
Intraoral Scanner	0.224	1	0.224	3.38	.070
Scan body	0.152	1	0.152	2.30	.134
Interaction	0.409	1	0.409	6.16	.015
Error	5.041	76	0.066	-	-
Total	5.827	79	-	-	-

Table 8. ANOVA table for precision of intraoral scanner, scan body, and interaction between intraoral and scan body angular deviations

Source	Sum of Squares	DF	Mean Square	*F* Value	*P*
Intraoral Scanner	0.820	1	0.82	1236.81	<.001*
Scan body	0.0166	1	0.0166	24.98	<.001*
Interaction	0.0164	1	0.0164	24.70	<.001*
Error	0.0504	76	0.00066	-	
Total	0.904	79	-	-	

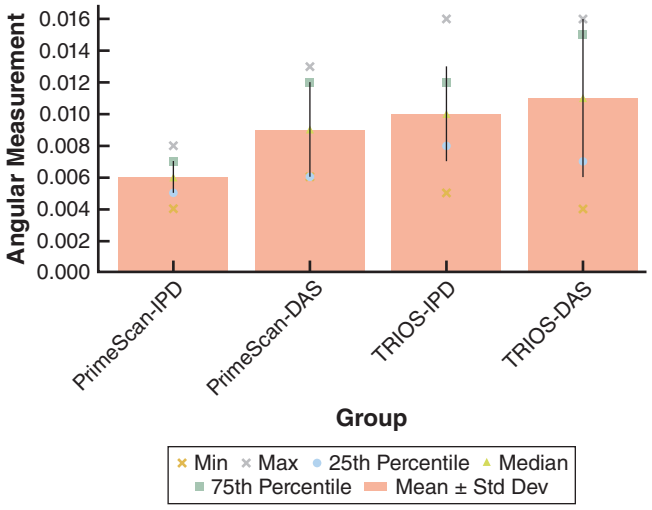

Figure 6. Boxplot of angular discrepancies for intraoral scanning and scan body systems tested.

concluding that the current scientific evidence did not provide concrete conclusions. In the present clinical study, the results suggested that, in the maxillary arch, scan body design appears to have a limited effect on scanning accuracy.[45]

These previous studies were performed under laboratory conditions, where factors such as oral cavity humidity and temperature variations that can lead to condensation on the intraoral scanner lens were not considered. In addition, saliva, which can create reflections, or limitations of mouth aperture or the tip size of the scanner, which could interfere with the proper handling of the scanner, especially in posterior areas, were not modeled.

Clinical studies measuring both trueness and precision in complete arch digital scans are sparse. Nedelcu et al[44] studied the trueness and precision of an IOS (TRIOS 3; 3Shape A/S), scanning 6 scan bodies in the maxillary arch with and without splinting the scan bodies, resulting in 3 scanning protocols (control scan, splinting with dental floss, and splinting with bis-acrylic composite resin). The results for trueness ranged between 41 μm and 55 μm, while precision ranged from 45 μm to 50 μm. Limitations of the Nedelcu et al[44] study included that an STL obtained from an industrial grade scanner (ATOS) was used as the reference and that only 1 scan body system (Elos Medtech) was analyzed. The reference can explain the differences obtained scanning with TRIOS 3 if compared with the present investigation, where the trueness of the TRIOS 3 ranged from 114 μm to 115 μm, while precision ranged from 20 μm to 22 μm.

Photogrammetry technology (PIC Camera; PIC Dental) has been reported to be the criterion standard in digital implant recording.[15,26] Under in vitro conditions, its trueness has been reported to range from 20.15 μm to 75 μm and its precision from 16 μm to 25.41 μm.[16,26] However, the conventional protocol using a splinting framework and an individual impression tray has demonstrated the highest accuracy, with a trueness of 11.7 μm to 18 μm and a precision of 6.81 μm to 14 μm.[24,25] Therefore, a conventional definitive cast obtained using a splinting framework was used as the reference STL for linear and angular measurements in the present study. Misfit values for implant-supported prostheses are not clearly defined, and there is no consensus in the literature.[46] However, it has been reported that vertical misfits in complete-arch implant prostheses range from 30 to 160 μm, and horizontal misfits of up to 150 μm could be considered acceptable.[46] Photogrammetry technology (PIC Camera; PIC Dental) is regarded as the standard, and using digital technologies, a maximum misfit of 100 μm could be deemed acceptable.[15,26] Therefore, in the authors' opinion, a maximum threshold of 100 μm should be considered the limit when performing intraoral scanning for complete-arch digital impressions.

The authors are unaware of a previous study that assessed the in vivo accuracy of maxillary complete arch digital implant scans using 2 IOSs and 2 scan body systems. Based on the results of the present study, the intraoral scanner plays a more critical role in accuracy than the scan body system used. Limitations of this study included testing only 2 intraoral scanning systems

Table 9. Tukey HSD post hoc multiple pairwise comparisons between intraoral scanners and scan bodies for angular deviations

	Pairwise Comparison	Mean Difference (Degrees)	Standard Error (SE)	*P*	Interpretation
Trueness	PS-IPD vs PS-DAS	0.2312	0.015	.085	Not significant
	PS-IPD vs TR3-IPD	0.2313	0.016	<.001	Significant
	PS-IPD vs TR3-DAS	0.1738	0.017	<.001	Significant
	PS-DAS vs TR3-IPD	0.0000	0.016	>.999	Not significant
	PS-DAS vs TR3-DAS	0.0575	0.018	.245	Not significant
	TR3-IPD vs TR3-DAS	0.0575	0.019	.182	Not significant
Precision	PS-IPD vs PS-DAS	0.1123	0.012	.092	Not significant
	PS-IPD vs TR3-IPD	0.1542	0.014	<.001	Significant
	PS-IPD vs TR3-DAS	0.1876	0.015	<.001	Significant
	PS-DAS vs TR3-IPD	0.0419	0.013	.178	Not significant
	PS-DAS vs TR3-DAS	0.0753	0.014	.094	Not significant
	TR3-IPD vs TR3-DAS	0.0334	0.015	.221	Not significant

with 2 PEEK scan body systems and only 2 participants were enrolled. Our study used 10 scans per subgroup (n=10) to compare scanning systems and scan bodies in a clinical environment. Future research is needed to clarify the results of this study by using scan bodies manufactured from other materials and with larger sample size. This will help optimize the scanning accuracy of complete arch multiple implant digital scans and simplify the fabrication of accurate implant-supported prostheses.

CONCLUSIONS

Based on the results obtained in the present clinical study, the following conclusions were drawn:

1. The intraoral scanner significantly impacted trueness and precision in maxillary complete arch implant scans. The PrimeScan demonstrated better accuracy than the TRIOS 3 IOS.
2. The scan body system used in maxillary complete arch digital scans did not significantly influence overall accuracy. The IPD and DAS systems performed equally well in the same IOS group.
3. No interaction was observed between the IOS and the scan body system in maxillary complete arch scans.
4. In maxillary complete arch implant scans, the intraoral scanner plays a more critical role in accuracy than the scan body system.

PATIENT CONSENT STATEMENT

Voluntary Participation

You are invited to participate in the study because you have a fixed dental prosthesis supported by implants. You should know that your participation in this study is voluntary, and you may decide NOT to participate. If you choose to participate, you may change your decision and withdraw your consent at any time without affecting your relationship with your dentist or compromising the quality of your healthcare. If you wish to revoke your consent, you must contact the lead investigator. If you decide to withdraw your consent, no new data will be added to the research database, and any existing identifiable data related to you will be deleted.

Objective of the Study

The primary objective of this proposal is to evaluate the use of intraoral scanners for taking full-arch impressions on implants, selecting from various types of scanners. Additionally, different scan bodies will be studied for each intraoral scanner.

Risks and Discomforts of Participation in the Study

The risks associated with participating in this study are minimal. However, you should know that verifying the proper maintenance of your implants and their prosthetic components requires radiographic verification, which is the standard protocol typically used in the clinic. The tests, including impressions and structure adjustments, will be performed in a single appointment on the same day to minimize the time required for travel, patient preparation, material preparation, and time in the waiting room. The study will require more time than a routine treatment, with the session lasting approximately 30 minutes. The patient is responsible for reporting any adverse events that may affect the study's outcome.

Potential Benefits

Your participation is voluntary, and you will not receive any financial compensation for participating. However, participants selected for the study will benefit from the optimization of the final adjustment of the work, which will enhance the biological and mechanical outcomes.

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Pablo Llinás-Ceballos: Idea, conceptualization and intraoral scanning methodologies. **Wenceslao Piedra-Cascón**: Protocol development, results interpretation and contributed to the manuscript writing. **Javier Ata-Ali**: Statistical analysis and contributed to the manuscript revision and proof-reading. All authors discussed the evolution and commented on the manuscript at all stages.

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