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EFFECT OF ORTHODONTIC BRACKETS ON THE ACCURACY OF INTRA-ORAL SCANNING: A CROSS-SECTIONAL STUDY

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ABSTRACT

Aim: to evaluate the effect of orthodontic bracket presence on the accuracy of the intra-oral scanning.

Methodology: The maxillary and mandibular dental archs scanned twice. The first time was before orthodontic brackets placement using two different scanner medit i500 and trios 3-shape scanner and the second time was after brackets positioning. Linear and angular measurements were then performed. The inter-canine, inter-first premolar, inter-second premolar, inter-first molar, and inter-second molar widths were among the linear arch dimension measurements. Each tooth's mesio-distal width was included in the linear tooth dimension measurements. The angular arch dimension measurements included 12 angles, 6 angles in each arch.

Results: The results of the current study showed statistically significant difference in some linear and angular measurements which were clinically significant. Although the results were clinically significant, they showed small mean difference except in the mesio-distal width of the left maxillary second molar and the angular measurements especially the posterior angles at the last molar and that angle at the canine region.

Conclusion: Based on the results of the current study There was no significant effect of the orthodontic brackets on the accuracy of the intra-oral scan.

KEYWORDS: Scanner; digital models; accuracy

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INTRODUCTION

Digital orthodontics is the coming escalating era of the orthodontic profession. Digitization of all the orthodontic procedures will be a default in the following years or even sooner. Starting from the diagnostic procedures till the very end treatment steps will be digitized aiming to produce more efficient and accurate orthodontic services. This can start with digitization of the intraoral impressions.

The scanning process is easier for the operator to use and more comfortable for the patient than traditional impression techniques.[1]The precision, validity, and reliability of measurements between digital and traditional plaster models were evaluated in various research. According to the results, the digital models' accuracy, dependability, and reproducibility were on par with those of the conventional plaster models. It can be regarded as the gold standard in contemporary practice and is also cost-effective when time is saved and less storage space is required.[2,3]

There are many softwares available in the market that differ regarding service, usability, and features. On testing the various scanners commercially available in the market regarding validity, reproducibility, precision, time efficacy and acceptance by the patient,it was found out that the data present was not up to date. So, there is need for better methodologically sound studies testing time efficacy, reproducibility and accuracy of different intra oral scanner.[4] There are different factors that could affect the accuracy of the intra oral scan. These factors include the presence or absence of orthodontic brackets, type of the intra oral scanner and the scanning technique.

Nowadays there is an increasing need to scan the dental arch during the orthodontic treatment for monitoring the tooth movement and record the progress of the case. Presence of the orthodontic brackets could have an impact on the accuracy of the intra-oral scans. The effect of the orthodontic brackets coming from the possibility of shadowing the area under the bracket's wings. Also, presence of the brackets complicates the scanning for assessing the occlusion during orthodontic treatment. Clinicians frequently do intraoral scanning of the patients' braced dentition. Therefore, compared to the pre- and post-treatment records, the interim records through scanning of the dentitions of orthodontic patients wearing braces is equally important. [5]

The aim of the current study was to identify if the presence of orthodontic brackets affect the scan accuracy.

MATERIAL AND METHODS

Sample size:

The effect of the orthodontic bracket presence was used as primary outcome. Mean difference was used for the outcome evaluation. Entry 1 was mean (SD) of group 1: 0.041 (0.010). Entry 2 was the predicted mean difference which was 0.01. The alpha level of significance was 0.05 with study power of .8 (80%). T-test was the statistical test used by the PS program. The calculated sample size was 10 subjects per each group with no need to increase the number for anticipated missing data as it was cross-sectional study.

Study design:

A Cross-sectional study, in which the effect of the orthodontic bracket presence on the scan accuracy tested in orthodontic patients using two different scanners. The maxillary and mandibular dental arch scanned twice. The first time was before orthodontic brackets placement using two different scanner medit i500 and trios 3-shape scanner and the second time was after brackets positioning. Linear and angular measurements were then performed.

In accordance with the eligibility requirements, the patients were selected from the orthodontic department's outpatient clinic at Cairo University's Faculty of Dentistry. Adolescent patients (15–20 years old) with fully erupted permanent dentition

met the inclusion criteria. Extreme malocclusion that precludes full arch bracket placement, dento-facial deformities like cleft lip/palate or cranio-facial syndrome, a significant skeletal disparity in any of the three planes of space, a TMD issue with limited mouth opening, and the presence of crowns or bridges were the exclusion criteria.

On the workday the patient presented early in the digital centre and Patient education performed. Then the scanning process performed before and after orthodontic brackets placement by Two scanners Medit i500 and Trios 3shape using S-shape scaning technique.

Starting from the palatal side of the left second molar, the S-shaped scanning technique scans the arch by moving the scanner tip in alternating buccopalatal and palatobuccal S-shaped movements along the arch to the contra-lateral side. Next, go longitudinally in a postro-anterior direction to inspect the mid-palate region. Figure (1,2)

The effect of the orthodontic brackets evaluated by the comparisons between the STL files obtained before and after brackets placement using linear and angular measurements by the ortho-analyzer software. The inter-canine, inter-first premolar, inter-second premolar, inter-first molar, and inter-second molar widths were among the linear arch dimension measurements. Each tooth's mesio-distal width was included in the linear tooth dimension measurements. The angular arch dimension measurements which included 12 angles, 6 angles in each arch.

Statistical methods

When applicable, the data were statistically reported using frequencies (number of cases), median and range, mean ± standard deviation (±SD), and percentages. The Kolmogorov Smirnov test was used to check numerical data for the normal assumption. The paired t test was used to compare the study groups. P values that were less than 0.05 on both sides were deemed statistically significant. All statistical analyses were conducted using IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows.

RESULTS

The results of the current study showed statistically significant difference in some linear and angular which were clinically significant. Although the results were clinically significant, they showed small mean difference except in the mesio-distal width of the left maxillary second molar and the angular measurements especially the posterior angels at the last molar and that angel at the canine region.

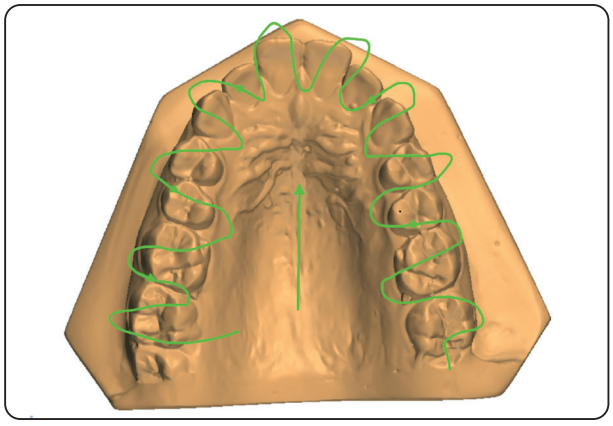

Fig. (1) S-shape technique

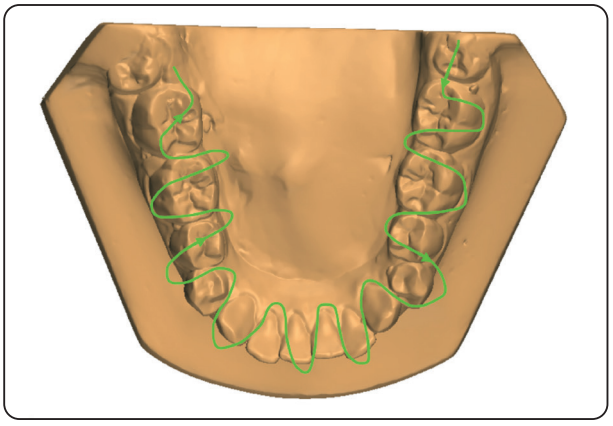

Fig. (2) S-shape technique

The Comparison of the Data from S-shape technique using Medit i500 scanner before versus after brackets placement showed no significant difference except the mandibular right canine and the mandibular left lateral incisor with p-value 0.047 and 0.004 with mean difference -0.21mm and -0.18mm respectively with no clinical significance. (Table 1)

Moreover, the comparison of the Data from S-shape technique using Trios 3-shape scanner before versus after brackets placement showed no statistically significant difference except the maxillary inter first premolar and the maxillary inter second molars width with p-value 0.013 and 0.013 with mean difference -0.30mm and -0.34mm respectively with clinical significance. Regarding the angular arch dimension measurements, the results showed no statistical significance except the angel (C-D-L7-MX) with p-value 0.008 and mean difference -0.83mm with clinical significance. (table 2)

SUPPLEMENTAL TABLE (1) Linear arch dimension measurements:

	Measurements	Definition	Abbreviation
1	Maxillary inter-canine width.	Linear measurement between the maxillary canines cusp tips.	IC-Mx
2	Maxillary inter-Premolar width (4s).	Linear measurement between the maxillary first premolars cusp tips.	IP4-Mx
3	Maxillary inter-Premolar width (5s).	Linear measurement between the cusp tips of the maxillary second premolars.	IP5-Mx
4	Maxillary Inter-Molar width (6s).	Linear measurement between the mesio buccal cusp tips of the maxillary first molars.	IM6-Mx
5	Maxillary inter-Molar width (7s).	Linear measurement between the mesio buccal cusp tips of the maxillary second molars.	IM7-Mx
6	Mandibular Inter-Canine width.	Linear measurement between the mandibular canine's cusp tips.	IC-M
7	Mandibular Inter-Premolar width (4s).	Linear measurement between the mandibular first premolars cusp tips.	IP4-M
8	Mandibular Inter-Premolar width (5s).	Linear measurement between the mandibular second premolars cusp tips.	IP5-M
9	Mandibular Inter-Molar width (6s).	Linear measurement between the mesio buccal cusp tips of the mandibular first molars.	IM6-M
10	Mandibular Inter-Molar width (7s).	Linear measurement between the mesio buccal cusp tips of the mandibular second molars.	IM7-M
	Maxillary total arch length.	Length of the perpendicular line from the midpoint of a line connecting the mesial surfaces of the maxillary first molars to the mesial contact point of the two central incisors.	TA-MX
11	Mandibular total arch length.	Length of the perpendicular line from the midpoint of a line connecting the mesial surfaces of the mandibular first molars to the mesial contact point of the two central incisors.	TA-MX
12	Curve of spee.	Average between the distances from the deepest point of the lower arch to a plane connecting the contact point of the 2 central incisors and the distal cusps of the lower first molars.	CS

SUPPLEMENTAL TABLE (2) Linear tooth dimension:

	Measurements	Definition	Abbreviation
1	Maxillary right molar width (7).	Mesio-distal width of the maxillary right second molar.	R7-MX
2	Maxillary right molar width (6).	Mesio-distal width of the maxillary right first molar.	R6-MX
3	Maxillary right premolar width (5).	Mesio-distal width of the maxillary right second premolar.	R5-MX
4	Maxillary right premolar width (4).	Mesio-distal width of the maxillary right first premolar.	R4-MX
5	Maxillary right canine width.	Mesio-distal width of the maxillary right canine.	R3-MX
6	Maxillary right lateral incisor width.	Mesio-distal width of the maxillary right lateral incisor.	R2-MX
7	Maxillary right central incisor width.	Mesio-distal width of the maxillary right central incisor.	R1-MX
8	Maxillary left central incisor width.	Mesio-distal width of the maxillary left central incisor.	L1-MX
9	Maxillary left lateral incisor width.	Mesio-distal width of the maxillary left lateral incisor.	L2-MX
10	Maxillary left canine width.	Mesio-distal width of the maxillary left canine.	L3-MX
11	Maxillary left premolar width (4).	Mesio-distal width of the maxillary left first premolar.	L4-MX
12	Maxillary left premolar width (5).	Mesio-distal width of the maxillary left second premolar.	L5-MX
13	Maxillary left molar width (6).	Mesio-distal width of the maxillary left first molar.	L6-MX
14	Maxillary left molar width (7).	Mesio-distal width of the maxillary left second molar.	L7-MX
15	Mandibular right molar width (7).	Mesio-distal width of the mandibular right second molar.	R7-M
16	Mandibular right molar width (6).	Mesio-distal width of the mandibular right first molar.	R6-M
17	Mandibular right premolar width (5).	Mesio-distal width of the mandibular right second premolar.	R5-M
18	Mandibular right premolar width (4).	Mesio-distal width of the mandibular right first premolar.	R4-M
19	Mandibular right canine width.	Mesio-distal width of the mandibular right canine.	R3-M
20	Mandibular right lateral incisor width.	Mesio-distal width of the mandibular right lateral incisor.	R2-M
21	Mandibular right central incisor width.	Mesio-distal width of the mandibular right central incisor.	R1-M
22	Mandibular left central incisor width.	Mesio-distal width of the mandibular left central incisor.	L1-M
23	Mandibular left lateral incisor width.	Mesio-distal width of the mandibular left lateral incisor.	L2-M
24	Mandibular left canine width.	Mesio-distal width of the mandibular left canine.	L3-M
25	Mandibular left premolar width (4).	Mesio-distal width of the mandibular left first premolar.	L4-M
26	Mandibular left premolar width (5).	Mesio-distal width of the mandibular left second premolar.	L5-M
27	Mandibular left molar width (6).	Mesio-distal width of the mandibular left first molar.	L6-M
28	Mandibular left molar width (7).	Mesio-distal width of the mandibular left second molar.	L7-M

SUPPLEMENTAL TABLE (3) Angular measurements:

	Measurements	Definition	Abbreviation
1	Angle 1- maxillary.	There is an angle between the palate's midline and the line that connects the tip of the maxillary right canine cusp to the place where the upper central incisors meet.	C-P-R-MX
2	Angle 2- maxillary.	Angle between the palate's midline and the line that connects the upper central incisors' contact point and the tip of the maxillary left canine cusp.	C-P-L-MX
3	Angle 3- maxillary.	Angle between the line that connects the right maxillary canine cusp tip to the distal contact point of the maxillary right second molar and the line that connects the contact point between the maxillary central incisors and the cusp tip.	C-D-R7-MX
4	Angle 4- maxillary.	Angle between the line that connects the left maxillary canine cusp tip to the distal contact point of the maxillary left second molar and the line that connects the contact point between the maxillary central incisors and the left maxillary canine cusp tip.	C-D-L7-MX
5	Angle 5- maxillary.	An angle formed by the line joining the distal contact points of the maxillary second molars on both sides and the line joining the right maxillary canine cusp tip and the right maxillary second molar's distal contact point.	DR7-D7s-MX
6	Angle 6- maxillary.	Angle between the line joining the distal contact points of the maxillary second molars on both sides and the line joining the left maxillary canine cusp tip and the left maxillary second molar's distal contact point.	DL7-D7s-MX
7	Angle 7-mandibular.	There is an angle between the mandibular midline and the line that connects the tip of the left canine cusp to the place where the lower central incisors meet.	C-M-L-M
8	Angle 8-mandibular.	There is an angle between the mandibular midline and the line that connects the tip of the right canine cusp to the place where the lower central incisors meet.	C-M-R-M
9	Angle 9-mandibular.	Angle between the line that connects the left mandibular canine cusp tip to the distal contact point of the mandibular left second molar and the line that connects the contact point between the mandibular central incisors and the left mandibular canine cusp tip.	C-D-L7-M
10	Angle 10-mandibular.	Angle between line connecting between the contact point between the mandibular central incisors and the right mandibular canine cusp tip and the line connecting between the right mandibular canine cusp tip and the distal contact point of the mandibular right second molar.	C-D-R7-M
11	Angle 11-mandibular.	An angle between the line that connects the distal contact points of the mandibular second molars on both sides and the line that connects the left mandibular canine cusp tip and the left mandibular second molar's distal contact point.	DL7-D7s-M
12	Angle 12-mandibular.	There is an angle between the line that connects the distal contact points of the mandibular second molars on both sides and the line that connects the right mandibular canine cusp tip to the distal contact point of the right mandibular second molar.	DR7-D7s-M

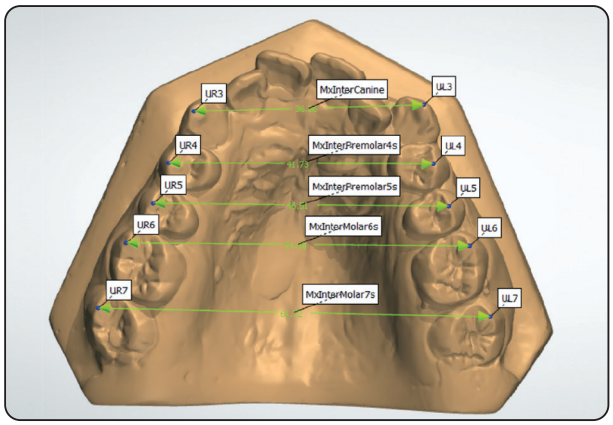

Fig. (1) Linear arch dimension

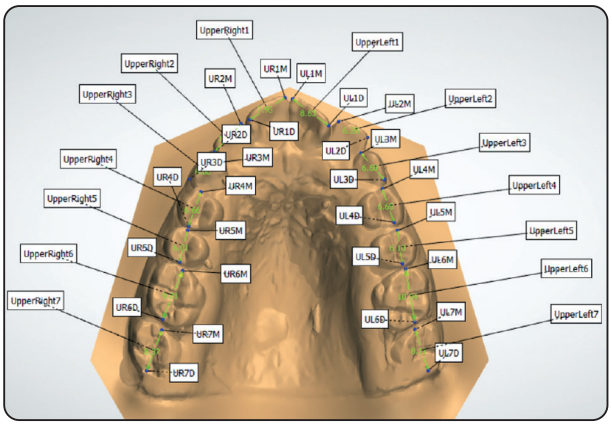

Fig. (2) Linear tooth dimension

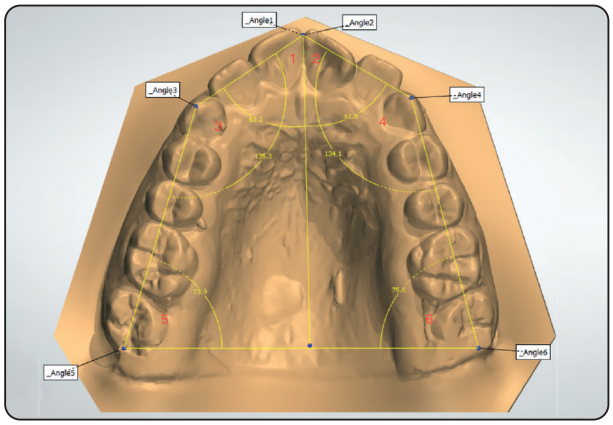

Fig. (3) Angular arch dimension

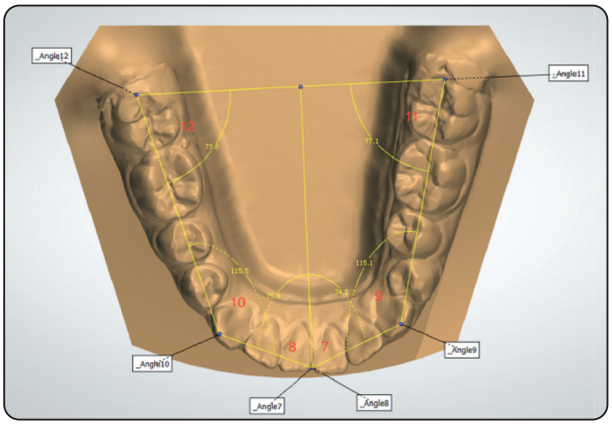

Fig. (4) Angular arch dimension

TABLE (1) Data from S-shape technique using Medit i500 scanner before versus after brackets placement.

	Without brackets		With brackets		MD	95% CI		P-value
	Mean	SD	Mean	SD		Lower	Upper	
R3-M	6.16	0.17	6.37	0.36	-0.21	-0.42	0.00	0.047*
L2-M	5.87	0.37	6.05	0.35	-0.18	-0.29	-0.07	0.004*

TABLE (2) Data from S-shape technique using Trios 3-shape scanner before versus after brackets placement.

	Without brackets		With brackets		MD	95% CI		P-value
	Mean	SD	Mean	SD		Lower	Upper	
IP4-Mx	41.12	2.81	41.42	2.62	-0.30	-0.51	-0.08	0.013*
IM7-Mx	56.85	3.31	57.19	3.27	-0.34	-0.60	-0.09	0.013*
C-D-L7-MX	124.73	4.62	125.57	4.85	-0.83	-1.39	-0.28	0.008*

DISCUSSION

One of the first ways to create three-dimensional digital models was with ortho CAD services. Nowadays, 3D computer models are commonly used by orthodontists. These can be made by either directly using the intraoral scanner on the patient or indirectly scanning the plaster models.[6] Digital models provide several advantages over traditional stone models, including less physical storage space needed, more cost-free transfer, tremendous data processing capabilities, and no breaking danger.[7]For better visualization of malocclusion and evaluation of tooth material arch length discrepancy, inter-arch relationship, tooth dimensions and arch shapes and dimensions the 3D study models can take the role of real research models.[8] When compared to direct measurement on stone models, digital models provide a higher level of validity and comparable accuracy.[9]

The current study aimed to evaluate the effect of the orthodontic brackets presence on the scan accuracy using two different scanners. The performed study considered the first to combine all these variables which were the scanning technique, the type of the intra-oral scanner and the presence of orthodontic brackets. On the other hand some studies tested only the effect of the scanning techniques on the scanning accuracy. [4,10]Moreover other studies evaluated the effect of the scanning technique and the intra-oral scanner on the efficiency of the intra-oral scans.[11] on the other hand, some studies tested the effect of the scanner on the scan accuracy without considering other factors.[5,12,13,14]Similar studies evaluated only the effect of the scanner type with the presence of orthodontic brackets.[15]

The current study tested the effect of the orthodontic bracket's presence on the scan's accuracy. As the metal brackets might cause distortion or shadowing effect on the tooth structure. orthodontic brackets were proved to cause a degree of distortion in the digital models during the intra-oral scan.[16] on the other hand some studies showed that the intra-oral scan accuracy was clinically acceptable even when brackets are present, and that regions beyond 0.50 mm around brackets could be used for super-imposition on the other scans without brackets.[15]

The current study performed on 10 adolescent orthodontic female patient with fully erupted dentition to allow assessment of the accuracy on the full arch range. Female patients were more committed to the oral hygiene measurements. Patients with limited mouth opening, TMD problem and sever degree of crowding were excluded from the study. The presence of sever crowding could obscure the scan of the proximal surfaces, in addition patients with limited mouth opening and TMD problems complicate the scanning procedure.[17] Similar study performed on 7 subjects without determining the age or the gender of the subjects.[18] Moreover, comparable study performed on 30 patients without determine the gender or the age of the patients.[15]

This study was conducted in-vivo which was more realistic in simulating the actual situation as far as factors affecting the intra-oral scan such as chair position, saliva presence and the patient cooperation. Moreover, the current study performed on both maxillary and mandibular arch. patients with limited mouth opening and TMD problems could complicate the scanning procedure together with presence of saliva could impede obtaining accurate scans.[18] Similar study performed on 19 mandibular stone casts.[5] Moreover, similar study performed on 10 dental casts.[12] Similar study performed on 61 dry mandible.[13] Moreover, other studies performed on dry dentition and dental casts.[15] Similar study performed on 15 mandibular dental cast.[10] On the other hand, comparable study used pair of mandibular dental casts.[11] comparable study performed on two completely edentulous maxillary typodonts.[4]

The current study used linear, angular measurements to compare between different scans. This allowed the assessment of the accuracy in

different planes using ortho analyzer software. Other studies used only the superimposition technique to evaluate the surface deviation between the scans using mesh mixer software.[4] on the other hand, studies used mesh superimposition to evaluate the effect of the scanning technique on the accuracy using view box software.[10] Similar studies compared between different scans using superimposition techniques by using ortho analyzer software.[11]

Unlike the current study, some studies used curvilinear measurements to compare the scan accuracy between two different scanners.[13] Similar studies used linear measurements as bucco-lingual and mesio distal crown diameter to assess the accuracy of different scans.[14] Likewise, some studies used super imposition technique by using the cloud compare to measure the complete arch trueness and precision of three different scanners.[5] Moreover studies assessed the effect of the orthodontic brackets presence on the scans accuracy by using superimposition technique using best-fit algorism.[15]

The results of the current study showed random statistically and clinically significant difference. Although the results were clinically significant, they showed small mean difference except in the mesio-distal width of the left maxillary second molar as well as most of the angular measurements especially the posterior angels at the last molar and that angle at the canine region. That great difference in the mesio-distal width of left maxillary second molar could be due to the critical position of this tooth at the retro-molar area in addition to its position on the opposite side of the dominant hand of the operator. Moreover, the great difference could be due to errors in points localization during the measurement procedure. The current study founded great inter and intra observer reliability which reflected on the measurement error especially in the angular measurements.

The performed study showed that presence of brackets did not affect the quality and accuracy of the digital images obtained using both Medit i500 and Trios 3-shape. Similar studies founded that the intra-oral scans accuracy not affected by the orthodontic bracket's presence.[15]

CONCLUSION

The current study showed no significant effect of the orthodontic brackets on the accuracy of the intra-oral scan.

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