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Original Article

Influence of Operator Experience on Scanning Time and Accuracy with Two Different Intraoral Scanners - A Prospective Clinical Trial

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Main Points
- Operator experience influences scanning time but not accuracy of scanning.
- The type of intraoral scanner (IOS) used influences the scanning time.
- An operator with an experience of more than 50 to 100 scans can efficiently perform intraoral scanning.

ABSTRACT

Objective: Operator experience and scanner type may influence the time taken and obtained accuracy of intraoral scanning. This study aimed to evaluate the influence of operator experience on the scanning time and correlate the accuracy of the scans taken with two different intraoral scanners (TRIOS 3, 3Shape and i500, Medit).

Methods: In this trial, a total of 20 subjects who required intraoral scanning for orthodontic treatment were included. Intraoral scanning was done with two different scanners, TRIOS 3 and i500. One operator each with high (group 1), medium (group 2) and low (group 3) levels of experience performed intra-oral scanning with two different intraoral scanners. A One-Way ANOVA test was performed to assess the intergroup difference in scanning time and Kendall's tau's correlation test to determine the correlation between the experience of the operator and accuracy among the three groups using the two scanners. Also Independent samples t-test were performed to assess the intragroup differences in scanning time with two different scanners.

Results: The scanning time was influenced by the type of intraoral scanner and operator experience ($p<0.05$). No significant correlation between operator experience and scanning accuracy in the three groups was noted ($p>0.05$). Statistically significant intragroup differences in scanning time between the two scanners were noted ($p<0.05$).

Conclusion: Less experienced operators took more time to scan a subject. Accuracy of scanning among three groups using two scanners was not influenced by the experience of the operator. Scanning with i500 IOS took more time than TRIOS.

Keywords: Accuracy, digital models, intraoral scanners, operator experience, scanning time

INTRODUCTION

Impression of the oral cavity represents an important step, and intraoral scanners (IOSs) enable obtaining data directly without the need of any impression materials or other impression making devices. Digital models are now being widely used for orthodontic diagnosis and treatment planning. They have several advantages over the conventional plaster models that include less storage space, lower risk of damage or breakage, and ease in transferring the data to other clinicians for efficient and extended patient care. Additionally, the 3D models allow prior visualization of hard and soft-tissues, which increases the treatment efficiency, reduces the clinical time and increases patient acceptance and comfort.[1-3] Recent advances in chairside and laboratory digital technology

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have resulted in the widespread use of digital equipment in dentistry.[4,5] Digital models can be obtained through either indirect or direct methods. Indirect methods involve either laser scanning or computed tomographic imaging of the alginate impressions or plaster models, and direct methods involve IOSs. Currently, with the advent of chair-side IOSs, digital dental models can be obtained using the direct method.

In orthodontics 3D models can be used to virtually move teeth. Diagnostic set up using digital models can be used for treatment planning and convincing patients by simulating tooth movements. Digital models are widely used for indirect bonding, aligner planning and fabrication.

Operator experience and scanner type may play an important role in time taken for scanning and the achieved scanning accuracy. To evaluate the accuracy of the IOSs, previous studies used vernier caliper measurements on plaster models[6,7] or on dry skulls as the gold standard, or scans of dental models made from conventional impressions.[8] Operator influence on scanning time and accuracy was assessed in an *in vitro* study by Resende et al.[9] and it was reported that the scanning time reduced as the experience increased.

Since there is a lack of *in vivo* studies evaluating the influence of operator experience on the IOS time and accuracy, this study was proposed to evaluate the influence of operator experience on the accuracy and the scanning time of scans taken with two different IOSs (TRIOS 3, 3Shape and i500, Medit). The null hypothesis of this study was that the operator experience had no influence on the scanning time and accuracy of the scans taken.

METHODS

This prospective study was conducted at the Department of Orthodontics, Saveetha Dental College. The inclusion criteria for the study subjects were: the presence of all permanent teeth from second molar to second molar, Class I malocclusion with mild crowding or proclination requiring orthodontic correction. The exclusion criteria were the presence of any metal or gold crown restorations, tooth agenesis, missing teeth, proximal or occlusal caries. In this study, 20 subjects who applied for orthodontic treatment and required IOS of the maxillary arch were included after fulfilling the eligibility criteria. Informed consent was obtained from the subjects involved in the study.

The sample size calculation was performed using G*Power 3.1 (Franz Faul, University of Kiel, Germany). The total calculated sample size was 60 (20 in each group) based on the mean scanning time for each group obtained from study of Resende et al.[9]. The effect size was 0.64 and the power was set at 0.80.

This study was approved by the Scientific Review Board of Saveetha Dental College and Hospitals (SRB/SDC/ORTHO-1902/21/007). IOS of subjects was carried out with two different scanners - TRIOS 3 (3Shape, Copenhagen, Denmark) and Medit i500 (Medit Corp., Seoul, Korea); i500 connected to a desktop with a specified configuration (Intel R core i7-6700 HQ CPU @ 2.60GHz and 16.0 GB RAM). Three operators with high, medium and low levels of experience scanned the patients. Group 1 with more than 1 year of experience (>100 scans), Group 2 with 3-6 months of experience (<50 and >100 scans), Group 3 with less than 1 month of experience (<10 scans). A dental assistant retracted the cheeks and lips while the scanning was performed. After scanning was done, the primary investigator evaluated the scanned images for completeness to check whether the entire buccal and lingual surfaces of the teeth and sulcus were recorded and whether any incomplete scans were repeated. The scanning time (for both scanners) was derived from the software in seconds (sec). All obtained scans were exported in STL format and the 3D orthoanalyzer software (3Shape, Copenhagen, Denmark) was used with a screen size of 16:9 ratio and all measurements were performed. Intercanine width (ICW) and intermolar widths (IMW) were measured on the 3D models of scans taken by highly, moderately and less experienced operators using TRIOS 3 and i500 IOS separately. ICW was measured between the cusp tips of the right and left canines and the IMW was measured between the central fossae of the right and left first molars.

Statistical Analysis

The data of scanning time data was tabulated in an Excel sheet and transported to IBM SPSS software version 23.0 to perform descriptive statistics. Shapiro-Wilk's test ($p<0.05$) showed that the parameters assessed were normally distributed. One-Way ANOVA was performed to assess the intergroup difference in scanning time and Kendall's tau's correlation test was performed to determine the correlation between the experience of the operator and accuracy among the three groups using TRIOS 3 and i500 IOS, respectively. An Independent samples t-test was performed to evaluate the intragroup difference in scanning time with the two different scanners.

RESULTS

The scanning time is influenced by the type of IOS ($p<0.05$) and by the operator experience ($p<0.05$). Less experienced operators took significantly more time to perform the scans compared with moderately and highly experienced operator (Table 1). Table 2 shows the post hoc results of the intergroup difference in scanning time with 3Shape scanner. Scanning time differences between groups 1 and 3 and groups 2 and 3 were significant ($p<0.05$) with higher scanning times in group 3 followed by group 2. Table 3 shows the post hoc results of the intergroup difference in scanning time with i500. Scanning time differences between groups 1 and 3 and groups 2 and 3 were significant ($p<0.05$).

Operator experience does not influence the accuracy of the scans ($p>0.05$) (Table 4). There was a statistically significant difference in scanning time between the two types of IOS used and more time was needed for the i500 IOS ($p<0.05$) (Table 5).

Table 1. Comparison of scanning time and interdental widths among groups by One-Way ANOVA test

Variables	Type of scanners	High experience Mean ± SD	Moderate experience Mean ± SD	Low experience Mean ± SD	p value
Time (sec)		96.75 ± 5.21	106.60 ± 3.83	150.50 ± 15.28	0.000***
Intercanine width (mm)	TRIOS 3	34.77 ± 2.16	34.86 ± 2.61	35.32 ± 2.70	0.763
Intermolar width (mm)		46.45 ± 2.58	47.06 ± 3.15	46.73 ± 2.90	0.799
Time (sec)		107.05 ± 6.35	113.80 ± 4.58	175.05 ± 28.74	0.000***
Intercanine width (mm)	i500	34.58 ± 2.30	34.59 ± 2.34	35.28 ± 2.49	0.569
Intermolar width (mm)		46.49 ± 2.38	47.37 ± 2.49	46.72 ± 2.40	0.500

sec: second
***p<0.001

Table 2. Results of the post hoc test regarding TRIOS 3 scanning time of high, moderate and low experienced operators

Levels of experience	Mean difference	p value	95% Confidence interval
High experience / Moderate experience	-9.85	0.005**	-17.14 to -2.56
/ Low experience	-53.75	0.000***	-61.04 to -46.46
Moderate experience / High experience	9.85	0.005**	2.56 to 17.14
/ Low experience	-43.90	0.000***	-51.19 to -36.61
Low experience / High experience	53.75	0.000***	46.46 to 61.04
/ Moderate experience	43.90	0.000***	36.61 to 51.19

**p<0.01, ***p<0.001

Table 3. Results of the post hoc test regarding i500 scanning time of high, moderate and low experienced operators

Levels of experience	Mean difference	p value	95% Confidence interval
High experience / Moderate experience	-6.75	0.434	-19.84 to 6.34
/ Low experienced	-68.00	0.000***	-81.09 to -54.91
Moderate experience / High experience	6.75	0.434	-6.34 to 19.84
/ Low experienced	-61.25	0.000***	-74.34 to -48.16
Low experience / High experience	68.00	0.000***	54.9 to 81.09
/ Moderate experienced	61.25	0.000***	48.16 to 74.34

***p<0.001

Table 4. Correlation between interdental widths and operator's experience (Kendall's tau's correlation test)

Variables	r	p value
Intercanine width (TRIOS 3)	0.107	0.299
Intercanine width (i500)	0.109	0.289
Intermolar width (TRIOS 3)	0.003	0.978
Intermolar width (i500)	0.048	0.639

Table 5. Comparison of scanning time of different intraoral scanners within groups by Independent samples t-test

Groups	Scan time (sec) Mean ± SD	p value
High experience (TRIOS 3)	98 ± 1.0	0.007**
High experience (i500)	106 ± 4.0	
Moderate experience (TRIOS 3)	106 ± 3.82	0.011*
Moderate experience (i500)	111 ± 6.0	
Low experience (TRIOS 3)	144 ± 10	0.029*
Low experience (i500)	176 ± 70	

DISCUSSION

With the development of digital technologies, IOSs have largely replaced plaster models as they are more time saving and do not require space for storage.[10-13] The ability to directly capture all dental arch information of the patient, and consequently their 3D models, without using conventional physical impressions, is one of the most important advantages of optical impressions.[14-17] Digital scanners can introduce inherent errors of alignment within the software, and the effects of the scan type, scanner time, and operator experience on the definitive results are unclear.[11,18-20] Hence, it is critical to assess the operator experience in scanning and the obtained accuracy.

In our study, we noted that the scanning time is influenced by the experience of the operator ($p<0.05$). Highly experienced operator took less time for intraoral scanning than the moderately and the less experienced operators. This is in accordance with a study by Sun et al.[21], showing that scanning time is likely to decrease as the operator experience increases. Hence null hypothesis was rejected in the present study.

The results of this study showed that the accuracy of the scans didn't depend on the experience level of the operator ($p>0.05$). The type of scanner influenced the scanning time irrespective of the operator's experience. There was a significant difference in scanning time between the two types of scanners ($p<0.05$). In an *in vitro* study by Resende et al.[9], the influence of operator's experience on the scanning time and accuracy of the scans was evaluated and they concluded that the accuracy of IOSs was influenced by experience of the operator, type of IOS, and scan size. This study reported that the accuracy of the scans improved with the operator's experience, which is conflicting with our findings. This can be due to the differences in the study design.

According to previous studies, there is a learning curve in adapting to the IOSs, and this aspect must be considered with attention.[19,22-24] Learning curve and level of experience was central to the scan time for both scanners. According to our study the less experienced operator took significantly longer time compared to the moderately and highly experienced operators. There was also a significant difference between moderately and highly experienced operators, with highly experienced operator taking less time.

According to a study by Schieffer et al.[25], digital models of permanent dentition are equally acceptable alternatives to stone models. They concluded that the virtual model measurements were reliable as measurements made on stone models and the results were influenced by operator experience.[25] The accuracy of the scans obtained can be explained as how far the measurements deviate from the measurements obtained on the standard plaster models.[26] Evaluation of the accuracy of digital scans has been reported in the literature to be accurately analyzed with sophisticated 3D software programs. To evaluate the accuracy of the scans taken by operators with different experience levels, parameters like the intercanine and intermolar widths were measured on 3D models using 3Shape ortho analyzer software. The results of our study showed that there is no significant difference in the accuracy of the scanning among the three groups. Irrespective of the type of scanner used or the operator experience, the accuracy of the scans was excellent, implying that even an operator with minimum scanning experience can obtain accurate scans.

In vitro studies assessing similar parameters have been reported in the literature, unlike this study.[9] Studies by Patzelt et al.[27] and Grünheid et al.[28] reported on the accuracy of four different IOSs and they included operators who already had IOS experience so the experience of the operators cannot be taken as a factor affecting the accuracy and IOS time.

The limitations of this study include a smaller sample size even though a prior sample size was calculated and the trueness and precision of the scanners were not evaluated. Also more operators could have been included. Future studies should be conducted to address the aforementioned limitations.

CONCLUSION

The following conclusions can be drawn from our study:

1. The scanning time is influenced by the experience of the operator and the type of scanner. Scanning time is reduced with the higher experience of the operators.

2. The accuracy of scanning was not related to the experience of the operator.

3. More time was required scanning with i500 scanners than with TRIOS 3 scanners.

Ethics

Ethics Committee Approval: This study was approved by the Scientific Review Board of Saveetha Dental College and Hospitals (SRB/SDC/ORTHO-1902/21/007).

Informed Consent: Informed consent was obtained from the subjects involved in the study.

Peer-review: Internally peer-reviewed.

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