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ACCURACY ASSESSMENT OF DIGITAL ORTHODONTIC MODELS OBTAINED BY INTRA-ORAL SCANNING

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ABSTRACT

Introduction: Intra-oral scanning have the advantage of completely eliminating the conventional impression making process. In this study, the accuracy of intra-oral scans was evaluated in relation to the gold standard plaster orthodontic model.

Material and methods: The sample consisted of 50 patients with age ranging from 18 to 28 years old. For each subject, upper and lower alginate impressions and intra-oral scans were made. Maxillary and mandibular arch widths (inter-canine, inter-first premolar, inter-second premolar and inter-molar widths) were measured on digital models using OrthoAnalyzer software (3Shape Dental Systems, Copenhagen, Denmark) and compared to those made on plaster models using digital Vernier caliper. All data were collected, tabulated and subjected to statistical analysis.

Results: Maxillary and mandibular arch widths had positive correlation with a highest value (0.999) for the upper inter-first premolar width and lower inter-molar width and the lowest was for the upper inter-canine width (0.994).

Conclusion: High accuracy of maxillary and mandibular digital models obtained by direct intra-oral scanning.

INTRODUCTION

Plaster study models have been the "gold standard" in orthodontic diagnosis and treatment planning. They were the only three dimensional records available to represent the dentition in a functional occlusion which allow the orthodontists to view, evaluate and make objective measurements for detailed evaluation of the malocclusion to formulate treatment objectives and design treatment plan.[1,2]

In the last few decades, the field of dentistry has widely revolutionized with the increased use of digital technology as digital photographs, digital radiographs and digital models which are becoming the commonly used dental records. Digital models have alleviated many of the obstacles encountered

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with using plaster models as they are not subjected to physical damage, require negligible storage space with fast and efficient retrieval. They, as well, can be transferred electronically to colleagues, specialists and laboratories which decreases the time and expenses of model duplication and shipment.[3–6]

Digital models can be created either indirectly by capturing the surface data of plaster models or impressions and wax bite, or directly by scanning the patient's mouth using an intra-oral (IO) scanner.[4,5,7] With IO scanners, the conventional impression making process can be omitted. Thus, overcoming the inevitable degree of error attributed to impression and stone material properties and steps of materials manipulation and enhance patient's comfort.[4,6,8]

Obviously, any potential advantages of digital models acquired by the different scanning technologies introduced would be negated if the accuracy and efficiency of their measurements were not comparable with those of the conventional plaster models, the current gold standard with a long and proven history in orthodontics.

As part of the digital revolution, the Orthodontic Digital Center – Ain Shams University (ODC-ASU) was founded and equipped with TRIOS® IO scanner (3Shape Dental Systems, Copenhagen, Denmark). Our study was conducted to evaluate the diagnostic accuracy of the digital models obtained from direct IO scanning using TRIOS® provided in ODC-ASU compared to the conventional plaster model.

MATERIALS AND METHODS

This study was conducted on 50 patients with age ranging from 18 to 28 years old randomly selected from the outpatient clinic of the Orthodontic Department, Faculty of Dentistry, Ain Shams University according to the following inclusion criteria: (1) permanent dentition erupted from second molar to second molar, (2) stable centric occlusion with at least 3 occlusal contacts, and (3) the teeth display no visible attrition, caries, or restorations affecting the mesiodistal or buccolingual diameter of the crown. Exclusion criteria were: (1) obvious teeth mobility (mobility degree higher than one), (2) undergoing orthodontic treatment, or (3) poor oral hygiene. Subjects who met the inclusion criteria, and before their enrollment in the study, were asked to sign a written consent where the aim of the study and the study protocol were clearly described.

For each subject, upper and lower alginate impressions were made with suitable size perforated metal tray and modified with pink wax when needed. Alginate impression material (Cavex CA37, normal set alginate, Germany) was then mixed and loaded following the manufacturer's guidelines and after making the impression, firm quick snap removal of the impression was done to avoid impression and model inaccuracies. A wax bite (Cavex, Germany) registration in centric occlusion was then obtained. The alginate impressions and wax bite were inspected for defects, rinsed under gently running cool tap water, disinfected,[9] wrapped in moist cotton and placed in a sealed plastic bag until poured. Alginate impression was poured with improved orthodontic stone, within one hour from impression making, for the fabrication of orthodontic study models with orthodontic bases guided by the bite registered.

Later, IO scanning was done with TRIOS® (3Shape Dental Systems, Copenhagen, Denmark) at the out-patient clinic, ODC-ASU, by scanning of the lower then the upper arch and the occlusion scan following the scanning sequence recommended by the manufacturer.[10]

Arch widths were measured on the maxillary and mandibular plaster models of the 50 subjects using a digital Vernier caliper, and measured on the digital models by the provided software, OrthoAnalyzer software (3Shape Dental Systems, Copenhagen, Denmark). The arch widths measured (Figure 1) were: inter-canine width (ICW): the distance between the cusp tips of permanent canines, inter-

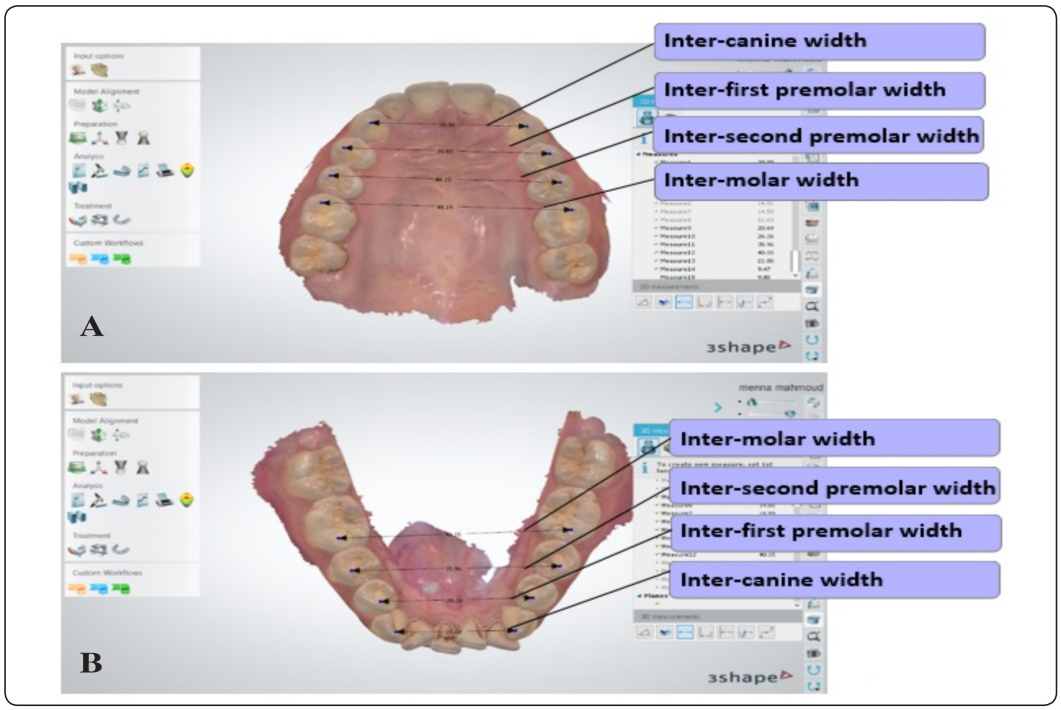

Fig. (1) Measurement of arch widths on IO scans using OrthoAnalyzer software (A) maxillary, (B) mandibular.

first premolar width (IPW-1): the distance between the buccal cusp tips of the first premolars, inter-second premolar width (IPW-2): the distance between the buccal cusp tips of the second premolars, and inter-molar width (IMW): the distance between the mesiobuccal cusp tip of the right and left first permanent molars.[11,12]

Statistical analysis

Collected data were tabulated and analyzed using by SPSS in general (version 20), also Microsoft office Excel was used for data handling and graphical presentation. Quantitative variables were described by the Mean (M) and Standard Deviation (SD), and for assessment of the accuracy with respect to the reference method, Dahlberg error (DE) and Relative Dahlberg Error (RDE) were used together with Concordance Correlation Coefficients (CCC) including the 95% confidence limits. To measure and quantify the size of the differences, Bland and Altman 95% confidence Limits of Agreements (LOA) were applied.

RESULTS

Descriptive statistics showed that the maxillary arch widths had positive correlation with a highest value for the IPW-1 (0.999) and the lowest was for the ICW (0.994) as shown in Table 1. Also, mandibular arch widths had positive correlation which was 0.999 for the IMW, 0.998 for ICW and IPW-2 and 0.997 for the IPW-1 (Table 1).

The accuracy of the digital models obtained by direct IO scanning showed high accuracy in relation to the reference models as the absolute DE of maxillary and mandibular arch widths were far less than 0.5 mm, the RDE were far less than 5% and CCC were well above 0.9 as presented in Table 1.

TABLE (1): Showing the accuracy analysis of the maxillary and mandibular arch widths of the digital models obtained from IO scans.

								Bland & Altman Limits of Agreement (LOA)		Concordance Correlation Coefficient		
Arch Widths	**Method**	**MM**	**sSD**	**dDE**	**RDE**	**Mean of Difference**	**SD of the Difference**	**95% confidence limits**			**95% confidence limits**	
								Lower	**Upper**	**CCC**	**Lower**	**Upper**
Maxillary ICW	Cast	33.97	3.14	0.24	0.7%	0.09	0.33	-0.57	0.74	0.994	0.990	0.996
	Intraoral Scanning	33.88	3.16									
Maxillary IPW-1	Cast	40.32	4.84	0.13	0.3%	0.06	0.17	-0.28	0.41	0.999	0.999	1.000
	Intraoral Scanning	40.25	4.85									
Maxillary IPW-2	Cast	44.80	4.22	0.21	0.5%	0.03	0.30	-0.55	0.62	0.997	0.996	0.998
	Intraoral Scanning	44.77	4.16									
Maxillary IMW	Cast	49.73	3.79	0.20	0.4%	0.04	0.28	-0.52	0.60	0.997	0.996	0.998
	Intraoral Scanning	49.69	3.86									
Mandibular ICW	Cast	25.43	3.69	0.17	0.7%	0.06	0.24	-0.40	0.53	0.998	0.997	0.998
	Intraoral Scanning	25.36	3.69									
Mandibular IPW-1	Cast	33.52	3.56	0.20	0.6%	0.06	0.28	-0.48	0.60	0.997	0.996	0.998
	Intraoral Scanning	33.46	3.52									
Mandibular IPW-2	Cast	37.64	3.95	0.16	0.4%	0.04	0.22	-0.39	0.47	0.998	0.998	0.999
	Intraoral Scanning	37.60	3.95									
Mandibular IMW	Cast	42.59	2.96	0.10	0.2%	-0.01	0.15	-0.30	0.28	0.999	0.998	0.999
	Intraoral Scanning	42.60	2.96									

M: Mean, SD: Standard Deviation, RDE: Relative Dahlberg Error, CCC: Concordance Correlation Coefficients, LOA: Limits of Agreements, ICW: Inter-Canine Width, IPW-1: Inter-First Premolar Width, IPW-2: Inter-Second Premolar Width, IMW: Inter-Molar Width.

DISCUSSION

Several IO scanners have been commercialized for the use in orthodontics with a great advantage of generating digital models directly in which the intermediate steps of impression and stone cast fabrication can be omitted.[5,13]

In our study, we evaluated the accuracy of the digital models produced by direct IO scanning, by TRIOS®, in relation to plaster models, the "gold standard" in orthodontic diagnosis and treatment planning.

Statistical analysis of the arch widths of the digital models had proven high accuracy which are consistent with that of other studies evaluating the accuracy of digital models obtained by TRIOS®.[4,7,14–16] In a study by Labib et al.[16], the mean difference of ICW, IPW-1 and IMW for the upper arch (0.58mm, 0.54mm, 0.58mm) respectively and for the lower arch (0.53mm, 0.23mm, 0.64mm) respectively were a little higher than the findings of our study but considered insignificant. This can be referred to examiner variables and to not following the scanning path recommended by the manufacturer leading to lower accuracy.[8,17–19]

Digital models acquired by IO scanner could result in more valid measurements than plaster models because there is no physical barrier dictating placement of the measurement points.[20] Also, when fabricating dental models, there is an inherent loss of information for many reasons as dimensional changes that occur to the impression and stone materials or may result from the inability of the impression material to flow into some areas which may lead to loss of fine details of tooth anatomy.[7,20] These reasons may also dictate preference of the IO scanner over scanned impression or plaster models in the terms of accuracy as there are fewer sources of error.[8,17]

The procedure, IO scanning, is not difficult and inexperienced practitioners may find completion of the IO scans to be more time consuming but tend to decrease as the operator's experience increased.[4,17,21] As reported, TRIOS® appears to require less training time than other IO scanners, making it easier to use in clinical practice.[14]

CONCLUSION

The accuracy of virtual models acquired by IO scanning is high and can replace the conventional plaster orthodontic models in all aspects of orthodontic treatment.

REFERENCES

1. Callahan C, Sadowsky PL, Ferreira A. Diagnostic value of plaster models in contemporary orthodontics. Semin Orthod. 2015;11:94–97.
2. Rangel FA, Maal TJJ, Bergé SJ, Kuijpers-Jagtman AM. Integration of digital dental casts in cone-beam computed tomography scans. ISRN Dent. 2012;22:1215–1222.
3. Peluso MJ, Josell SD, Levine SW, Lorei BJ. Digital models: An introduction. Semin Orthod. 2004;10:226–238.
4. Camardella LT, Breuning H, Vilella O de V. Accuracy and reproducibility of measurements on plaster models and digital models created using an intraoral scanner. J Orofac Orthop. 2017;78: 211–220.
5. Claus D, Radeke J, Zint M, Vogel AB, Satravaha Y, Kilic F, Hibst R, Lapatki BG. Generation of 3D digital models of the dental arches using optical scanning techniques. Semin Orthod. 2018;24:416–429.
6. Barry M. The cutting edge: in-office digital study models. J Clin Orthod. 2011;45:385–389.
7. Murugesan A, Sivakumar A. Comparison of accuracy of mesiodistal tooth measurements made in conventional study models and digital models obtained from intraoral scan and desktop scan of study models. J Orthod. 2020;47:149–155.
8. Robles-Medina M, Romeo-Rubio M, Salido MP, Pradíes G. Digital intraoral impression methods : an update on accuracy. Curr Oral Health Rep. 2020;7:361-375.
9. Collins FM. Disinfecting impressions for infection prevention. Sultan University. 2013. p. 1–3. Available from: http://www.sultanuniversity.com/whitepapers/disinfecting-impressions-infectionprevention.

10. 3Shape A/S Ortho System™ 2015-1: orthodontics solution-user manual (OS-1.6.1.0-B-EN)

11. Bishara SE. Textbook of orthodontics, WB Saunders Company, 2001.

12. Taner T, Ciğer S, El H, Germeç D, Es A. Evaluation of dental arch width and form changes after orthodontic treatment and retention with a new computerized method. Am J Orthod Dentofacial Orthop. 2004;126:463–476.

13. Lim S, Hwang H, Cho I, Baek S, Cho J. Registration accuracy between intraoral-scanned and cone-beam computed tomography-scanned crowns in various registration methods. Am J Orthod Dentofacial Orthop. 2020;157:348–356.

14. Lim JH, Park JM, Kim M, Heo SJ, Myung JY. Comparison of digital intraoral scanner reproducibility and image trueness considering repetitive experience. J Prosthet Dent. 2018;119:225-232.

15. Glisic O, Hoejbjerre L, Sonnesen L. A comparison of patient experience, chair-side time, accuracy of dental arch measurements and costs of acquisition of dental models. Angle Orthod. 2019;89:868–875.

16. Labib MA, El-beialy AR, Attia KH. Evaluation of the accuracy of digital models obtained using intraoral and extraoral scanners versus gold standard plaster model (diagnostic accuracy study). Open J Med Imaging. 2020; 10:151–163.

17. Grünheid T, McCarthy SD, Larson BE. Clinical use of a direct chairside oral scanner: an assessment of accuracy, time, and patient acceptance. Am J Orthod Dentofacial Orthop. 2014;146:673–682.

18. Anh JW, Park JM, Chun YS, Kim M, Kim M. A comparison of the precision of three-dimensional images acquired by 2 digital intraoral scanners: Effects of tooth irregularity and scanning direction. Korean J Orthod. 2016;46:3–12.

19. Ender A, Mehl A. Influence of scanning strategies on the accuracy of digital intraoral scanning systems. Int J Comput Dent. 2013;16:11–21.

20. Grünheid T, Patel N, De Felippe NL, Wey A, Gaillard PR, Larson BE. Accuracy, reproducibility, and time efficiency of dental measurements using different technologies. Am J Orthod Dentofacial Orthop. 2014;145:157–164.

21. Wiranto MG, Engelbrecht WP, Nolthenius HET, Van Der Meer WJ, Ren Y. Validity, reliability, and reproducibility of linear measurements on digital models obtained from intraoral and cone-beam computed tomography scans of alginate impressions. Am J Orthod Dentofacial Orthop. 2013;143:140–147.