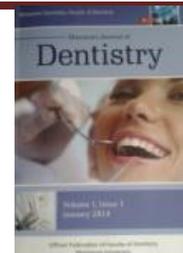




Accuracy of Digital Models Prepared by Spiral CT in Comparison to Standard Cast Models



Ahmed El-Beialy¹, Shaza Abd El-Nabi², Ahmed Fouda³ and Marwa Shamaa⁴

¹Professor of Orthodontics, Faculty of Dentistry, Mansoura University, Egypt.

²Assistant Professor of Orthodontics, Faculty of Dentistry, Mansoura University, Egypt.

³Lecturer of Orthodontics, Faculty of Dentistry, Mansoura University, Egypt.

⁴Assistant Lecturer of Orthodontics, Faculty of Dentistry, Mansoura University, Egypt.

Abstract:

Objectives: Spiral CT has the potential to overcome the limitations of standard transmission radiography and current CT based methods.

Methods: The objective of this study was to compare the standard plaster models taken using alginate impression material with their digital counterparts prepared by scanning the patients with a spiral CT (Light speed Pro, General Electric medical CT scan machine, Wakesha, Wis).

Results: On the basis of the results of the present study, the following could be detected: excellent agreement between both models as proved by the absence of significant difference and the significantly excellent agreement and association between the two modalities for the different measurements: mesiodistal width of the maxillary and mandibular teeth, and the different arches measurements like: maxillary and arch perimeters; arch lengths; arch widths and the mandibular intercanine width.

Conclusions: In conclusion; digital models are acceptable replacement for plaster casts for the routine measurements made in most orthodontic practices.

Keywords: Digital Models, Spiral CT, Standard Cast Models.

Introduction

Successful orthodontic treatment is based on extensive diagnosis and treatment planning. Dental models, photographs, radiographs, and clinical examinations provide essential information for diagnosis. Study casts are a standard component of orthodontic records and are fundamental to diagnosis, case presentation, treatment planning, evaluation of treatment progress, and record keeping [1].

Since the development of CT, 3D imaging techniques have gained more applications in dentistry and orthodontics. The demand for the digitization, manipulation, and full use of the patient's virtual 3D model is increasing. The long-term goal of orthodontic digital treatment planning with 3D digital models is inevitable without the precision of the digital diagnosis phase. Current spiral/helical CT scanners have a fast scanning speed so that motion artifacts, generated by swallowing and respiration, are greatly reduced; less radiation exposure is needed than with conventional CT [2].

The objective of this study was to compare the standard plaster models which are the gold standard for cast measurements with their digital counterparts by comparing the accuracy of the dental measurements taken with Boley gauge on plaster dental casts and those taken from computed tomography scans of the dentition [3].

Patients and methods

The sample of this study consisted of twenty patients ranging in age from 13-19 years. Class II division 1 cases, selected from the Outpatient Clinic of the Orthodontic Department, Faculty of Dentistry, Mansoura University. All the patients were informed of the procedure and signed consent and the study was approved by the ethical committee. None of the patients had prior orthodontic

treatment, nor had a previous history of dental trauma. Patients with abnormal oral habits or craniofacial anomalies were excluded.

The following records were taken: Photographs: both intraoral and extraoral photographs were taken. Radiographs: panoramic and lateral cephalometric x-ray. Study casts were prepared: upper and lower impressions of the dental arches were taken using alginate impression material. They are poured immediately in stone. CT records (CD including digital casts) were obtained: Each subject's head was scanned with a DCT device (Light Speed Pro, General Electric medical CT scan machine, Wakesha, Wis) at an axial section of 1.25 mm. Effective milli-ampereage was based on the preliminary scanogram, 80 mAs, spiral scanning of 120 Kv, high resolution mode.

During the CT scanning, the patient had a prefabricated splint (1mm) to keep the maxillary and mandibular teeth separated; this was done to reproduce the occlusal anatomy and prevent blurring of the dental images. The inclination of the gantry was set parallel to the occlusal plane of the maxilla. All data was saved with a DICOM extension.

Measurements of the 3D volume were made with the measuring analysis tool of the 3DD program. For accuracy and ease of measurements, the images were enlarged on the screen by using a built-in magnifying tool.

The following dental arch measurements were taken for the digital casts using the computed tomography scans of the dentition and compared with those taken for the plaster study casts (Fig. 1):

1. Mesiodistal tooth width from the mesial of the first permanent molar of one side to the mesial of the first permanent molar of the other side.
2. Maxillary and Mandibular intercanine width.

- 3- Maxillary and Mandibular interfirst molar width.
4. Maxillary and Mandibular arch length.
- 5- Maxillary and Mandibular arch perimeter.

Results

Non significant difference and excellent agreement was detected between both conventional and digital models as regards the maxillary and mandibular arch perimeters with PCC of 0.974 and 0.995 for the maxillary and mandibular arches respectively (Table 1).

Non significant difference in arch length with a good agreement was also detected between both measuring modalities with PCC of 0.991 and 0.955 for maxillary and mandibular arch length respectively (Table 1).

There was no statistically significant difference between the mean conventional and digital levels for both maxillary and mandibular arch width ($p>0.05$). There was significant positive correlation between the two methods' readings (conventional & digital cast) ($p<0.05$) (Table 2).

There was no statistically significant difference between the mean conventional and digital levels for the mesiodistal widths (mm) of the maxillary left central incisor, lateral incisor, canine, right first premolar and second premolar ($p>0.05$). There was significant difference between mean conventional and digital width in the right central incisor and left first premolar ($p<0.05$). There was significant positive correlation between the two methods' readings (conventional & digital cast) ($p<0.05$) as regards the mesiodistal tooth width (mm) of the maxillary teeth (Table 3).

There was significant difference between the mean conventional and digital mesiodistal widths (mm) in the mandibular right canine only ($p<0.05$). However, there was no statistically significant difference between mean conventional and digital levels for the mesiodistal tooth width of other mandibular teeth ($p>0.05$). There was significant positive correlation between the two methods' readings (conventional & digital cast) ($p<0.05$) as regards the mesiodistal tooth width (mm) of the mandibular teeth (Table 4).

Discussion

Dental study models play an important role in diagnosis, treatment planning and post treatment evaluation [2]. Study models can be obtained by digitalization of plaster cast, scanning of a dental impression or by a capture CT scan of the patient using the DICOM images to render a 3D volume of dentition [3].

In the present study: dental casts were taken using alginate impression material poured immediately in stone and measurements were taken using Boley gauge. Digital models were prepared by scanning the patients with a spiral CT. The result of the current study is in the line with that obtained with El-Zanaty et al. [4] who recorded excellent agreement between both methods in the three planes of space was found and that a 3DD can be an alternative to conventional stone dental models. Our results showed that there was an excellent agreement in arch perimeter in both jaws with no statistically significant difference by the paired t test between measurements done on the conventional casts and digital models.

Non significant difference in arch length with a good agreement was also detected between both measuring modalities for both the maxillary and mandibular arch length. These results are similar to that of Harrell [5], who reported that using this 3D technology allow the orthodontist to automatically measure such things as the Bolton tooth size and arch length discrepancy quickly and accurately, this information can allow the evaluation of different treatment options, such as different extraction patterns and for minimum, moderate or maximum anchorage requirements. It also allows for the evaluation of possible expansion or uprighting of buccal and/or anterior segments, and interproximal stripping to gain arch length and the orthodontist can decide if this treatment fits into the treatment scheme.

In accordance with Sousa et al. [6] who found no statistically significant difference in the measurements of arch width and length directly made on the dental casts and on the digital models. They concluded that linear measurements on digital models are accurate and reproducible. Our study recorded that there was no statistically significant difference between the mean conventional and digital levels for both maxillary and mandibular arch width.

The results are similar to Leifert et al. [7] who compared digitized models with plaster study models and found a slight (0.4 mm) but statistically significant difference in the space analysis measurements on the maxillary models; measurements on the mandibular models were not significantly different. They concluded that the accuracy of space analysis on digital models was clinically acceptable and reproducible when compared with traditional plaster study model analyses. In the current study there was no statistically significant difference between the conventional and digital measurements of the mesiodistal widths (mm) of most maxillary anterior teeth like, left central incisor, lateral incisor, canine, right first premolar and second premolar. There were only significant difference between mean conventional and digital mesiodistal width in the maxillary right central incisor and the left first premolar.

There was no statistically significant difference between the measurements taken from the dental casts and those taken from the E model for the mesiodistal tooth width of the mandibular teeth except in the mandibular right canine only. This was in consistency with Stevens et al. [8] who reported excellent reliability and validity of the digital models in most measurements and that there was no statistically significant difference in tooth size between digital and conventional models. They concluded that preliminary results did not indicate that digital models would cause an orthodontist to make a different diagnosis of malocclusion compared with plaster models and that digital models are not a compromised choice for treatment planning or diagnosis.

Conclusion

This study is a further proof of the accuracy of digital study models in a comparison with the standard plaster models. Virtual digital models if clinically applicable can greatly benefit orthodontists due to the efficiency of having patient records instantly accessible on the computer screen versus

retrieving plaster models from a storage area, the accuracy, efficiency and ease of measurement of tooth and arch sizes

and dental crowding and the ability to send virtual images anywhere in the world for consultation.

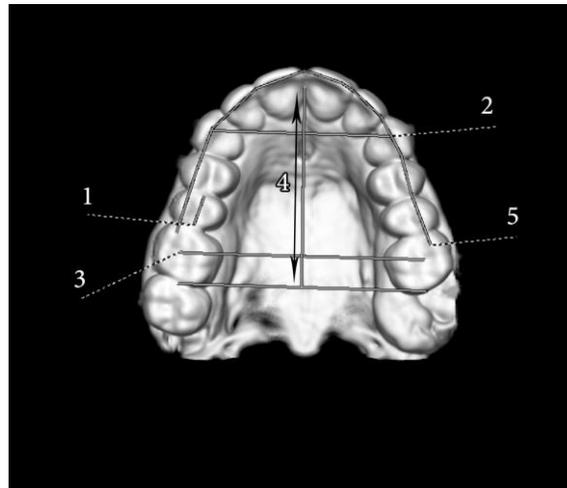


Figure 1: shows the digital cast with the measurements taken from it. (Where 1 is: the mesiodistal tooth width, 2: the intercanine width, 3: the intermolar width, 4: the maxillary arch length, 5: The maxillary arch perimeter).

Table 1: Comparison between CT Digital cast and conventional cast as regards arch perimeter and arch length.

Arch perimeter (mm)	Conventional		Digital		T	P	PCC
	Mean	SD	Mean	SD			
Maxillary	72.4	4.39	72.49	4.265	1.157	0.262	0.974*
Mandibular	61.08	5.239	60.97	5.303	-0.95	0.353	0.995*
Arch length(mm)							
Maxillary	36.44	2.259	36.832	2.767	0.451	0.657	0.991*
Mandibular	30.54	2.619	30.49	2.593	-0.95	0.353	0.995*

T: Paired t test PCC: Pearson correlation coefficient * significant: p<0.05

Table 2: Comparison between C.T digital cast and conventional cast as regards the maxillary and mandibular arch width.

Maxillary arch width (mm)	Conventional		Digital		T	P	PCC
	Mean	SD	Mean	SD			
Inter canine	35.4	2.4	35.4	2.4	0.13	0.8	0.9*
Inter molar	45.3	2.2	45.2	2.2	0.16	0.8	0.9*
Mandibular arch width (mm)							
Inter canine	27.25	1.650	27.32	1.7	0.13	0.8	0.9*
Inter molar	40.19	2.175	40.19	2.2	0.00	0.11	0.9*

Table 3: Comparison between C.T digital cast and conventional cast as regards the mesiodistal tooth width (mm)of the maxillary teeth.

	Conventional		Digital		T	P	PCC
	Mean	SD	Mean	SD			
Central incisor Rt	9.35	0.587	9.285	0.571	2.22	0.04*	0.975*
Lt	9.29	0.631	9.232	0.64	1.89	0.07	0.965*
Lateral incisor RT	7.415	0.467	7.285	0.427	1.06	0.3	0.958*
LT	7.475	0.595	7.46	0.58	0.61	0.54	0.983*
Canine RT	8.45	0.536	8.41	0.512	1.71	0.104	0.981*
LT	8.42	0.567	8.395	0.58	0.85	0.397	0.975*
First premolar RT	7.1	0.5	7.04	0.605	0.708	0.487	0.890*
LT	7.18	0.519	7.147	0.59	2.39	0.03*	0.979*
Second premolar RT	6.98	0.563	6.98	0.596	0.000	1	0.934*
LT	7.085	0.625	7.05	0.64	1.13	0.273	0.977*

Table 4: Comparison between C.T digital cast and conventional cast as regards the mesiodistal tooth width (mm)of the mandibular teeth.

	Conventional		Digital		T	P	PCC
	Mean	SD	Mean	SD			
Central incisor RT	5.715	0.56	5.76	0.546	0.655	0.53	0.85*
LT	5.785	0.55	5.74	0.559	0.74	0.46	0.88*
Lateral incisor RT	6.39	0.513	6.36	0.514	0.78	0.44	0.944*
LT	6.375	0.483	6.395	0.462	0.49	0.623	0.929*
Canine RT	7.475	0.617	7.380	0.592	2.594	0.02*	0.964*
LT	7.405	0.605	7.345	0.630	1.87	0.08	0.974*
First premolar RT	7.45	0.604	7.445	0.570	0.181	0.858	0.98*
LT	7.423	0.654	7.370	0.644	1.67	0.110	0.975*
Second premolar RT	7.794	0.788	7.706	0.788	0.181	0.858	0.98*
LT	7.671	0.719	7.577	0.636	1.95	0.07	0.96*

References

1. Quimby M., Vig K., Rashid R., Firestone A. and Mayers M., (2004): The accuracy and reliability of measurements made on computer-based digital casts, *Angle Orthod* 74:298–303.
2. Hayashi K, Ueechi J and Mizoguchi I (2003): three-dimensional analysis of dental casts based on newly defined palatal reference plane. *Angle Orthod* 73: 539-44.
3. Plooij JM, . Maal J.J, Haers Piet, Borstlap W A, Kuijpers-Jagtman A M and Bergé S. (2011): J Digital three-dimensional image fusion processes for planning and evaluating orthodontics and orthognathic surgery. A systematic review, *Int J Oral Maxillofac Sur* 40, 341-352.
4. El-Zanaty HM, El-Beialy AR, Abou El-Ezzc AM, Attia KH, El-Bialye AR and Mostafa YA (2010): Three-dimensional dental measurements: An alternative to plaster models. *Am J Orthod Dentofac Orthop* 137(2): 259-265.
5. Harrel WE (2009): 3D diagnosis and treatment planning in orthodontics. *Semin Orthod* 15:35-41.
6. Sousa M, Vasconcelos E, Janson G, Garib D, Pinzan A (2012): Accuracy and reproducibility of 3-dimensional digital model measurements. *Am J Orthod*; 142 (2): 269-273.
7. Leifert MF, Leifert MM, Efstratiadis SS and Cangialosi TJ. (2009): Comparison of space analysis evaluations with digital models and plaster dental casts; *Am J Orthod Dentofac Orthop. Jul*; 136(1): 16.e1-4.
8. Stevens D.R., Flores-Mir C., Nebbe B., Raboud D.W., Heo G. and Major P.W., (2006): Validity, reliability and reproducibility of plaster versus digital study casts: comparison of peer assessment rating and Bolton analysis and their constituent measurements, *Am J Orthod Dentofac Orthop* 129:794–803.