Accuracy of Mesiodistal Crown Measurements using CBCT Images: A Comparison with Plaster Models

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Abstract

Aim: Comparison of the mesiodistal crown measurements made on plaster models and CBCT-images.

Materials & Methods: Thirty pre-existing CBCT records of the maxillary arch and type-III stone orthodontic models, soaped and polished were used in this study. A digital vernier caliper was used to make measurements on each cast. The largest mesiodistal crown dimension of each tooth was measured from central incisor to the second premolar of one quadrant of the maxillary arch. The OnDemand 3D program (Cybermed Co, Seoul, Korea) was used to convert CT DICOM images into 3D reconstructed images. The mesiodistal crown width measured using the OnDemand 3D program.

Results: The precision of the measurements on the plaster models and on the CBCT 3D reconstructed images were the same. There was no significant difference between them as evaluated by paired t test.

Conclusion: The distance and the precision of the measurements on the plaster models and on the CBCT 3D reconstructed images are equivalent. CBCT 3D reconstructed images can replace the process of making plaster models.

Keywords: *CBCT, study models, orthodontics.*

Introduction

The CBCT, specifically developed for the maxillofacial region, provides numerous clinical applications, from the positioning of dental implants to the study of the respiratory system. Furthermore, it provides greater spatial resolution of high-quality images, through shorter scans and with less radiation than conventional computed tomography.

In the field of orthodontics, CBCT allows us to undertake a more precise diagnosis, by providing information on the three-dimensions of the orofacial structures and to replace two-dimensional (2D) radiographs. Moreover, we can obtain three-dimensional images of teeth that can then be measured; measurements that traditionally were done by hand on plaster study models.[1] CBCT scans have the potential to be as acceptable to patients and practitioners as other forms of dental models.

Plaster models of the dentition have been used traditionally for orthodontic evaluation and are considered the "gold-standard" for arch space analysis. Some of the advantages of plaster dental models include accuracy, a high level of physical permanence over time and a relatively low production cost.[2] However, plaster models have disadvantages, including breakage, storage costs and weight. It has been evident from experience that plaster casts present precise and reliable information about patients' dental arches, position of teeth and their dimensions.[3] Patients' orthodontic data is usually obtained from measurements of dental casts by a digital caliper and are further stored for future use. Currently

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it is necessary to store the patients' plaster casts for legislative and further clinical workups, however with the use of stored patients' data in the digital form we not only retain the possibility of reproducing the dental casts when the necessities arise we also eliminate the unnecessary storage of plaster casts which are not readily required. The disadvantage of using the plaster casts include the burden of their storage, risk of damage or breakage, their heavy weight and difficulties in sharing their data with other professionals involved in the patients' care[4].

The purpose of this study was to compare measurements made on traditional plaster models with measurements made from digital renderings of CBCT scans of the same patients.

Materials & Methods

A retrospective, hospital-based study was conducted using the following pre-existing records of 30 consecutive patients who attended the Department of Orthodontics & Dentofacial Orthopaedics, School of Dental Sciences, Sharda University, Greater Noida:

® CBCT records of the maxillary arch.

® Type-III stone orthodontic models.

In this study, a Digital Vernier Caliper with a measuring range of 0–150 mm/ 0–6 inch, resolution: 0.01mm/ 0.0005 in, repeatability: 0.01mm/ 0.0005 in, accuracy: + 0.02 mm/ 0.001 in. (<100 mm), + 0.03 mm/ 0.001 in. (>100 – 150 mm), maximum measurement speed: 1m/s, was used to make measurements on each cast to the nearest 0.01 millimeter. The largest mesiodistal crown dimension was measured of each tooth from central incisor to the second premolar of one quadrant of the maxillary arch. As described by Hunter and Priest in 1960, the greatest mesiodistal diameter was taken from the anatomic mesial contact point to the anatomical distal contact point of each tooth measured parallel to the occlusal plane.[5]

The CBCT images of these subjects were obtained from the archives of the Department of Oral Medicine & Radiology using CareStream 9300, USA at a slice thickness of 0.75 mm.

The CT DICOM (digital imaging and communication in medicine) images were converted into 3D reconstructed images using the OnDemand 3D program (Cybermed Co, Seoul, Korea). Radiodensity was set between +1000 and +3000 on the Hounsfield unit (HU) scale so that all the hard tissue of a tooth could be expressed.

With these 3D reconstructed images, the 3D tooth images were acquired by eliminating the adjacent anatomic structures and the mesiodistal crown width measured using the OnDemand 3D program.

Fig. 1. Digital Vernier Caliper

Fig. 2. Orthodontic Study Models

Fig. 3. Measurement of mesio-distal width of orthodontic study models

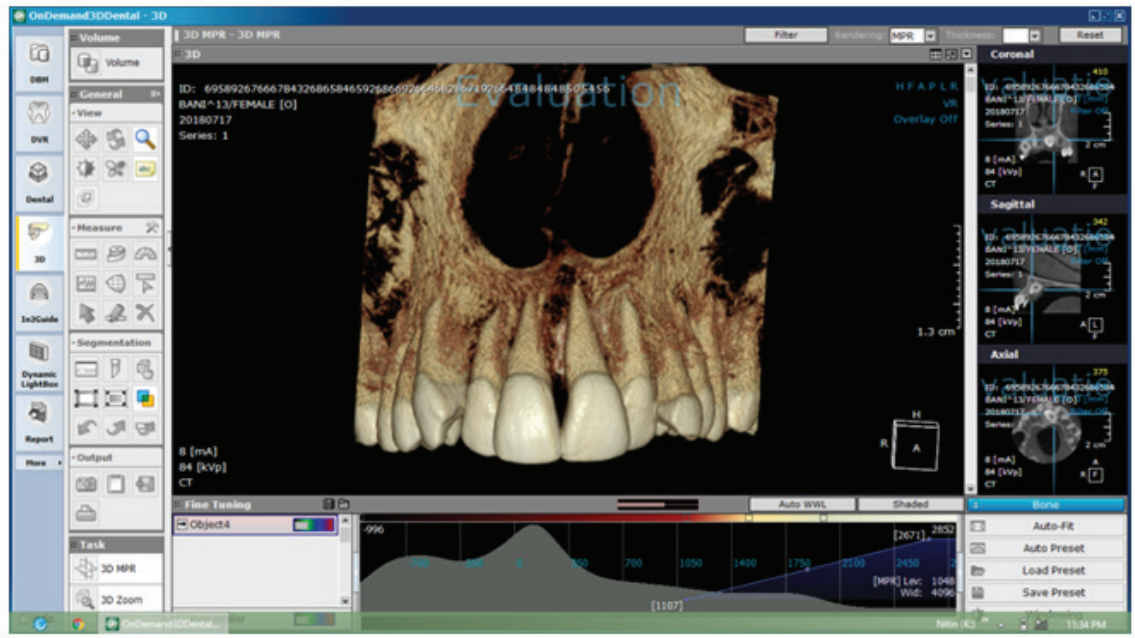

Fig. 4. 3D reconstructed CBCT image of maxilla

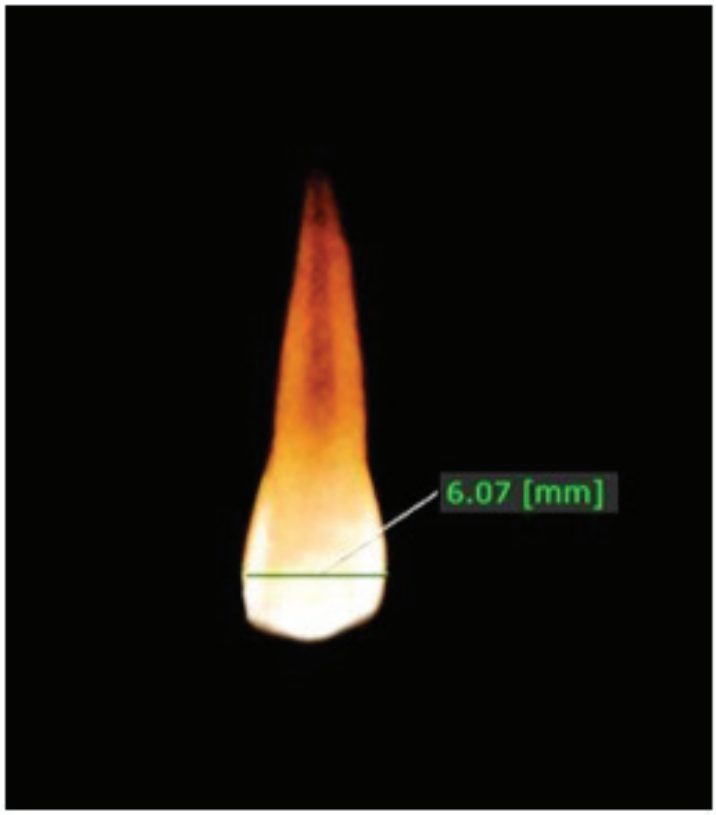

Fig. 5. Measurement of mesio-distal width using OnDemand 3D software

Study Design

The mesiodistal width of the crown of five permanent teeth in a maxillary quadrant was measured. The teeth included were the central incisor to the second premolar of one quadrant of the maxillary arch on the plaster model and in the CBCT image for the same subject. The data was collected, compiled and analyzed statistically using software for statistical analysis. After testing for normality, the paired student's t-test was applied for comparison between the groups. Level of significance (p-value) was set at 5%. This data was compared using statistical analysis to verify if the digital images from CBCT are an acceptable alternative to plaster models.

Inclusion Criteria

- A complete permanent dentition of ten permanent from the second premolar of one quadrant to the second premolar of the other quadrant of the maxillary arch .
- Absence of anomalies in the number, size, and dental shape.
- Good quality of study models.
- Absence of large occlusal restorations or the presence of prostheses

Exclusion Criteria

- Blebs or voids on the plaster models
- Fractures on the teeth of the plaster models
- Missing teeth
- Definitive obstructions (e.g., odontoma or supernumerary teeth);
- Impacted teeth.

Results

The precision of the distance measurements on the plaster models and on the CBCT 3D reconstructed images were the same. This was confirmed by the estimated characteristics including confidence intervals.

There was no significant difference between them as evaluated by paired t test. The accuracy of the CBCT 3D reconstructed images for measurements with respect to the plaster models was estimated using standard deviation of differences between the plaster models and the CBCT images. The standard deviation values did not significantly differ between the plaster models and the CBCT 3D reconstructed images.

Table 1: Mesiodistal crown measurements on the plaster models and CBCT 3D reconstruction images

Parameters	Group	N	Mean	S.D.	Std. Error Mean	df	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		Cohen's d	t	p Value
									Lower	Upper			
CENTRAL INCISOR	CBCT	30	10.5427	0.5487	0.1002	29	-0.1043	0.051	-0.2096	0.0009	0.17349726	2.0277	0.0519
	CAST	30	10.6470	0.6494	0.1186								
LATERAL INCISOR	CBCT	30	7.8187	0.4140	0.0756	29	-0.0923	0.048	-0.1912	0.0065	0.20883077	1.9103	0.0660
	CAST	30	7.9110	0.4683	0.0855								
CANINE	CBCT	30	8.0103	0.6505	0.1188	29	-0.0127	0.052	-0.1187	0.0934	0.02188272	0.2443	0.8087
	CAST	30	8.0230	0.5005	0.0914								
FIRST PREMOLAR	CBCT	30	7.0273	0.5235	0.0956	29	-0.0140	0.007	-0.0289	0.0009	0.02667165	1.9187	0.0649
	CAST	30	7.0413	0.5263	0.0961								
SECOND PREMOLAR	CBCT	30	6.5677	0.4149	0.0757	29	-0.0360	0.029	-0.0947	0.0227	0.08532681	1.2550	0.2195
	CAST	30	6.6037	0.4288	0.0783								

Discussion

The goal of the present study was to compare the accuracy of measurements taken on a CBCT image with manual measurement data of a dental cast. There were no significant differences observed in between the measurement methods. Of the two methods, the smallest mean error (0.075 mm) was observed when registering the CBCT dental image.

Although producing a dental stone cast model can be laborious, this is the preferred method due to requirement of less skill than in CBCT image processing and measurements.

There has not been any study comparing directly the linear measurements taken on a 3D reconstructed CBCT image and plaster model. Kasparova et al. (2013) in a study compared traditional plaster casts, digital models and 3D printed copies of dental plaster casts based on various criteria in order to determine whether 3D printed copies obtained using an open source system can replace traditional plaster casts in dental practice. They concluded that the scans can replace traditional plaster casts primarily due to their accuracy and price.[3]

Disadvantages include high cost of CBCT imaging and the exposure to radiation. It was noted by Signorelli et al. (2016) that although a single CBCT image can replace most of the conventional set of orthodontic radiographs, one set of conventional orthodontic radiographs still entails 2-4 times less radiation than one CBCT. In CBCT, reducing the height of the field of view and shielding the thyroid are advisable methods and must be implemented to lower the exposure dose.[6] The advantages of the CBCTs is that they do not require production of a dental stone model and that registration can be non-invasive. Keeping patients' data in digital form can help solve the storage problem, as all of the study models must be kept for certain period of time, which requires a large storage space. On the other hand, the CBCT files take up no physical space. This is an environmentally sensible choice as opposed to the traditional gypsum casts.[7] Digitalization of the data also offers a solution for retrieval and transfer of the patients' data as and when required by the team of various physicians responsible in the care of the patient. However, from the legal point of view one must be vigilant when sharing patients' data as there are potential confidentiality and privacy issues that could be prone to misuse.

Further investigations are required in this field and there is a need to focus on simplifying the process of CBCT imaging. There is also a scope for reconstructing data for 3D printers directly from the CBCT scans to eliminate the intermediary step of manufacturing traditional plaster casts.

Conclusions

The precision of the measurements on the plaster models and on the CBCT 3D reconstructed images are equivalent. CBCT 3D reconstructed images can replace the process of making plaster models. The CBCT imaging has the advantage of being faster, easy to store and environmentally sustainable option when compared to taking impressions and making plaster models.

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Conflict of Interest: None

References

1. Tarazona B, Llamas JM, Cibrian R, Gandia JL, Paredes V. A comparison between dental measurements taken from CBCT models and those taken from a Digital Method. Eur J Orthod. 2013;35(1):1–6.
2. Lee JT, Cangialosi TJ. Comparison of Measurements made on Plaster and CBCT-Scanned Models. J Oral Health Dent Management. 2014;13(4):1124-30.
3. Kasparova et al. Possibility of reconstruction of dental plaster cast from 3D digital study models . BioMedical Engineering OnLine. 2013;12:38-49.
4. Fleming P, Marinho, V, Johal A. Orthodontic measurements on digital study models compared with plaster models: a systematic review. Orthodontics & Craniofacial Research. 2010;14(1):1–16.
5. A. Anand Kumar. Digital model as an alternative to plaster model in assessment of space analysis. J Pharm Bioallied Sci. 2015;7(2):465–69.
6. Signorelli L, Patcas R, Peltomäki T, Schätzle

M. Radiation dose of cone-beam computed tomography compared to conventional radiographs in orthodontics. J Orofac Orthop. 2016;77(1):9-15.

7. Mullen SR, Martin CA, Ngan P, Gladwin M. Accuracy of space analysis with emodels and plaster models. Am J Orthod Dentofacial Orthop. 2007;132:346–52.