ORIGINAL ARTICLE

Three-dimensional dental measurements: An alternative to plaster models

Hend Mohammed El-Zanaty,[a] Amr Ragab El-Beialy,[b] Amr Mohammed Abou El-Ezz,[c] Khaled Hazem Attia,[d] Ahmed Ragab El-Bialy,[e] and Yehya Ahmed Mostafa[f]

Cairo, Egypt

Introduction: The aim of this study was to compare the accuracy of dental measurements taken with calipers on plaster dental casts and those from computed tomography scans of the dentition with a dental measurement program. **Methods:** The sample consisted of plaster dental models of 34 orthodontic subjects. Dental arch measurements, including mesiodistal widths of teeth, arch widths, arch lengths, arch perimeters, and palatal depths were made with the calipers. The patients were also scanned with computed tomography, and measurements were made digitally with a 3-dimensional-based dental measurements program (3DD, Biodent, Cairo, Egypt). **Results:** The results showed strong agreement in most measurements between the conventional method and the 3DD in the 3 planes of space. The mesiodistal measurements of the maxillary right and left second premolars, left central incisor, and right first molar, and the mandibular left and right central incisors, right canine, and left first premolar had fair agreement. **Conclusions:** Excellent agreement between the measurements with the conventional and 3DD methods in the 3 planes of space was found; 3DD can be an alternative to conventional stone dental models. (Am J Orthod Dentofacial Orthop 2010;137:259-65)

Successful orthodontic treatment is based on extensive diagnosis and treatment planning. Dental models, photographs, radiographs, and clinical examinations provide essential information for diagnosis.[1] 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. Tooth size, crowding or spacing, overjet, overbite, and Bolton analysis are typically measured manually on models.[1-3]

Digital photographs and radiographs are now routinely incorporated into electronic files, but digital dental models are not as widely used. Electronic storage of patient information, including study models, eliminates problems of physical storage, retrieval, maintenance, and office management. Documentation of treatment progress and communication between professional colleagues can be enhanced by digital records.[3-7]

Attempts have been made to transform dental plaster models into 3-dimensional (3D) virtual models.[4,8-12] OrthoCAD (Cadent, Carlstadt, NJ) is a commercially available system that transforms casts or impressions into 3D digital models.[13] Tomassetti et al[14] evaluated various measuring methods, including OrthoCAD, to analyze the Bolton tooth size discrepancy. OrthoCAD values were found to be less correlated to the baseline values established by the average of 3 repeated measurements with a Boley gauge.

The SureSmile (OraMatrix, Dallas, Tex) process begins with a direct clinical 3D scan of the patient's dentition with the OraScanner (OraMatrix), a light-based imaging device that projects a precise patterned grid onto the teeth. The orthodontist can then diagnose and plan treatment on the computer screen, using software tools to measure tooth and arch dimensions, and create symmetric and asymmetric archforms.[15]

Several studies were conducted to compare 3D virtual models with plaster models. Stevens et al[16] compared the analysis of the gold-standard plaster model with the digital counterpart of the e-model (GeoDigm) for tooth sizes and occlusal relationships, specifically the Bolton analysis and the peer assessment rating index. Strong agreement between the measurements indicated that the digital models are a good replacement for conventional plaster models.

From Cairo University, Cairo, Egypt.
[a]Resident, Orthodontic Department, Faculty of Oral and Dental Medicine.
[b]Assistant lecturer, Orthodontic Department, Faculty of Oral and Dental Medicine.
[c]Professor, Orthodontic Department, Faculty of Oral and Dental Medicine.
[d]Assistant professor, Orthodontic Department, Faculty of Oral and Dental Medicine.
[e]Assisstant professor, Systems and Biomedical Engineering Department, Faculty of Engineering.
[f]Professor and head, Orthodontic Department, Faculty of Oral and Dental Medicine.
The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.
Reprint requests to: Yehya Ahmed Mostafa, Orthodontic Department, Faculty of Oral and Dental Medicine, Cairo University, 52 Arab League St, Mohandesseen, Giza, Egypt; e-mail, yehya.mostafa@aaomembers.org.
Submitted, July 2007; revised and accepted, April 2008.
0889-5406/$36.00

doi:10.1016/j.ajodo.2008.04.030

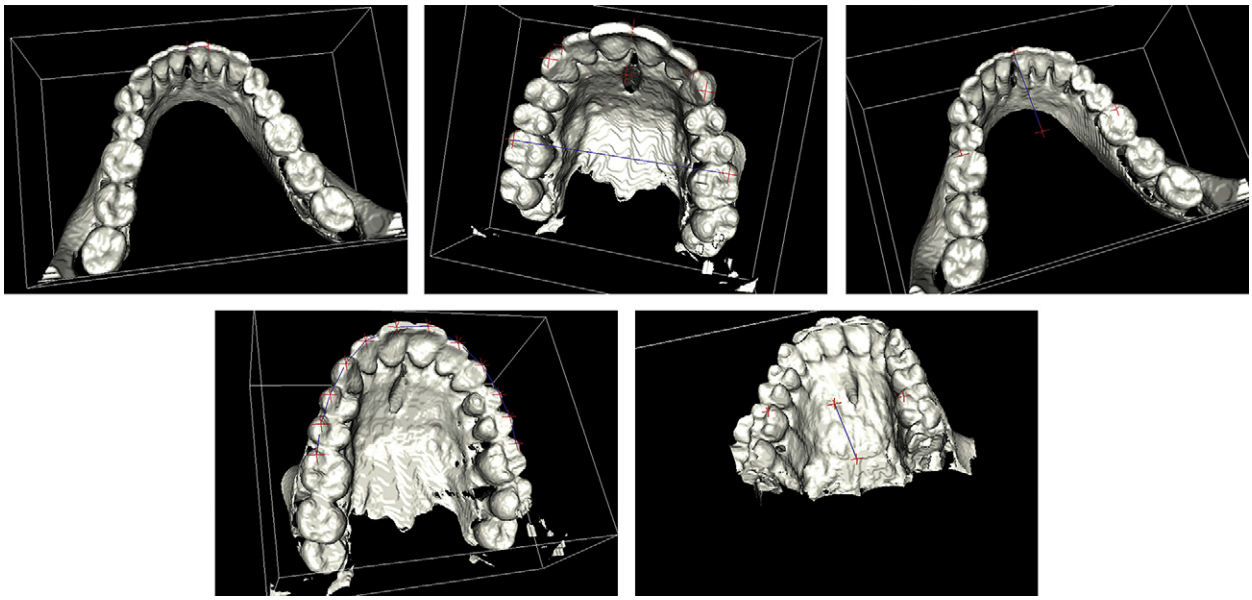

Fig 1. 3D virtual models showing some of the measurements taken.

Whetten et al[17] investigated the difference between plaster models and the virtual 3D model (e-model) in treatment planning for Class II patients. They concluded that digital orthodontic study models (e-models) were a valid alternative to traditional plaster models in treatment planning for these patients.

The aims of this study were to test the accuracy of a 3D-based dental (3DD) measurement program (Biodent, Systems and Biomedical Engineering Department, Faculty of Engineering, Cairo University, Cairo, Egypt) that uses computed tomography (CT) scans and to compare it with manual measurements made on plaster models.

MATERIAL AND METHODS

Our sample consisted of 34 adults, equally divided between men and women. Their ages ranged from 20 to 25 years. Approval for this study was obtained from the hospital Board of Research Ethics. All subjects had erupted permanent dentitions from the first molar of one side to the first molar of the other side, with no orthodontic appliances. Measurements were recorded on both the conventional model and the 3D virtual model from the CT scan with a blind protocol.

For the conventional plaster models, the maxillary and mandibular casts of the 34 subjects were measured with Vernier calipers (OISt Orthodontics, Aston, Pa) calibrated to the nearest 0.1 mm.

For the 3D virtual models, 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-amperage was based on the preliminary scanogram, 80 mAs, spiral scanning of 120 Kv, high resolution mode. The reconstruction interval was 0.6 mm with table feed of 17.5 mm per rotation. The total rotation time was 15 to 20 seconds. During the CT scanning, the subject was given a prefabricated splint (1 mm) 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 were saved with a DICOM extension.

For the 3D reconstruction, custom-made 3D computer software (Biodent) was used to reconstruct the 3D volume from the axial CT scans and separate the maxillary and mandibular dentitions. This software is based on the concept of window center and window width (brightness and contrast) produced by CT scanners.

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.

From the occlusal view, the following dental arch measurements were taken for both the conventional casts and the 3D virtual models by the same observer (H.M.Z.) (Fig 1).

1. Mesiodistal tooth width from the first permanent molar of 1 side to the first permanent molar of the other side.