Int. J. Oral Maxillofac. Surg. 2018; xxx: xxx–xxx
https://doi.org/10.1016/j.ijom.2018.03.028, available online at https://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Research Paper
Imaging

Three-dimensional surface models of the facial soft tissues acquired with a low-cost scanner

C. P. R. Maués, M. V. S. Casagrande, R. C. C. Almeida, M. A. O. Almeida, F. A. R. Carvalho
Orthodontic Department, State University of Rio de Janeiro, Vila Isabel, Rio de Janeiro, RJ, Brazil

C. P. R. Maués, M. V. S. Casagrande, R. C. C. Almeida, M. A. O. Almeida, F. A. R. Carvalho: Three-dimensional surface models of the facial soft tissues acquired with a low-cost scanner. Int. J. Oral Maxillofac. Surg. 2018; xxx: xxx–xxx.

Abstract. Although there has been an increase in three-dimensional (3D) scanning methods available on the market, they are generally expensive. The DI3D system is considered a good scanner for the acquisition of soft tissue surface images. The Microsoft Kinect scanner is a much more affordable alternative for acquiring 3D models. The aim of this study was to determine whether the precision and accuracy of Kinect are similar to those of DI3D. To verify the accuracy, 10 patients were scanned with both methods The models of each patient acquired from the two scanners were superimposed using a surface-to-surface registration technique, and the distances between the models were recorded for 10 different anatomical regions of interest. For the evaluation of precision, one patient was scanned 11 different times with the Kinect scanner, and these models were compared using the same superimposition method. It was found that the average difference between the two methods was 0.3 ± 2.03 mm. The assessment of reproducibility showed an average difference between the images taken with Kinect of 0.1 ± 0.6 mm ($P < 0.05$, one-sample t-test). Thus, Kinect showed good precision and reasonable accuracy, and appears to be an interesting and promising resource for facial analysis.

Key words: imaging; three-dimensional; photogrammetry; anatomy.

Accepted for publication 28 March 2018

Analysis of the facial soft tissues is of great importance in dentistry, in particular in orthodontics[1–3] and surgery[4–6]. With recent technological developments, facial scanning methods have flourished, allowing a comprehensive analysis of three-dimensional (3D) facial features without the use of ionizing radiation[7–9]. This technology makes it possible to analyse growth, soft tissue changes, perform treatment simulations, aid appliance design, and access treatment effects in three dimensions[8]. In addition, the assessment of outcomes of surgery, showing its importance to the patient, makes facial scanning an important tool[10].

Among the various methods, stereophotogrammetry (SPG) is the most commonly used in dentistry[11–14]. Systems based on this methodology are commercially available for different applications, for example the three-dimensional surface capture system DI3D, which is used in film and entertainment, as well as in healthcare, research, and education[14–16]. The main disadvantage of such SPG systems is the high cost, limiting their routine use by most professionals[11].

At the end of 2010, Microsoft released the Kinect device, which allows the user to play video games without the need for a remote control. Player recognition is made possible through laser scanning[17]. The Kinect basically consists of an infrared light projector, an infrared camera, a common RGB camera, a set of microphones, and a motor[18]. The main advantages of Kinect are its affordable price and its open software development kit (SDK), which allows the creation of programs by other individuals and companies to expand hardware applications in different situations[19]. Several studies using the Kinect scanner in health have been conducted[19–23].

The aim of this study was to evaluate the technical feasibility (precision and accuracy) of using an inexpensive scanner (Microsoft Kinect), compared to an SPG scanner (DI3D) for facial analyses.

Materials and methods

This project was approved by the institutional ethics review board. Informed consent was obtained from all participants.

A sample size calculation was performed considering a power of hypothesis test of 80% and a level of significance of 0.05, to detect a difference in measurements of 2 mm with a standard deviation of 2.03. The sample size calculation showed that at least eight volunteers would be needed for this research.

Ten patients were selected, five male and five female, who had their faces scanned with the DI3D system and with the Kinect system. For the evaluation of the accuracy of Kinect, each subject was scanned twice (once using each method). The patients were instructed not to wear makeup, earrings, glasses, facial products, or any accessories during the acquisition of the scans. In addition, the head was kept still, with the Frankfort plane parallel to the floor. When scanning with Kinect, the procedure was started with Kinect positioned in front of the patient; it was then moved in an arc path to the left side of the patient and then moved to the right side passing in front of the patient again (Fig. 1A). The 3D model acquired with DI3D is illustrated in Fig. 1B, and the 3D model of the same patient acquired with Kinect is presented in Fig. 1C.

To verify the accuracy of Kinect, another patient was selected and scanned 11 times at the same visit and in the same position. The same instructions were given to this subject as to the other participants.

All subjects were adults. Patients with fixed orthodontic appliances, syndromes, possessing a beard or moustache, or with any craniofacial deformity were excluded.

Comparison of the methods

DI3D capture version 5.2.3.1859 was the software used by DI3D for image acquisition (Dimensional Imaging Ltd, Glasgow, Scotland, UK). The patients were scanned using the two methods on the same day, with an interval of less than 12 hours between scans, to reduce the influence of weight gain/loss and changes in the soft tissues. After scanning, stereolithography (STL) models were generated.

Geomagic Qualify software 2013 (3D Systems Inc., Research Triangle Park, NC, USA) was used to record the images. The best-fit superimposition of the two models was done manually by marking five random matching points on the surfaces to be superimposed (Fig. 2A).

Following this, the virtual models were cut using the ‘trim with plane’ tool, and the areas that would not be assessed were excluded in order to obtain two models with a homogeneous shape. A global best-fit was then performed: the software was used to calculate the shortest possible distances between the points on the two surfaces, and the best fit for the two images was determined automatically (Fig. 2A).

Subsequently, these models were converted to .IV file format (SGI Open Inventor) using the binary executables STL2Meta and MetaToIV, which are part of the SPHARM-PDM package (https://www.nitrc.org/). These images in IV format were imported into Craniomaxillofacial Application (CMF Application; University of Bern, Switzerland, under the funding of the Co-Me network; now available at http://cmf.slicer.org/) so that qualitative and quantitative comparisons could be performed by 3D mapping of the differences between the two surfaces.

CMF Application graphically demonstrates the differences between scans using colour-coded maps. The contouring line tool (Isoline) was used to visualize the main differences between the methods for each anatomical region of interest (ROI) (Fig. 2B). The face was analysed as a whole and then divided into anatomical ROI, which were analysed individually. The following ROI were used: tip of the nose (TN), right ala–nostril sill (RAN), left ala–nostril sill (LAN), dorsal nose (DN), upper lip philtrum (ULP), mentolabial fold (MF), mental region (MR), right

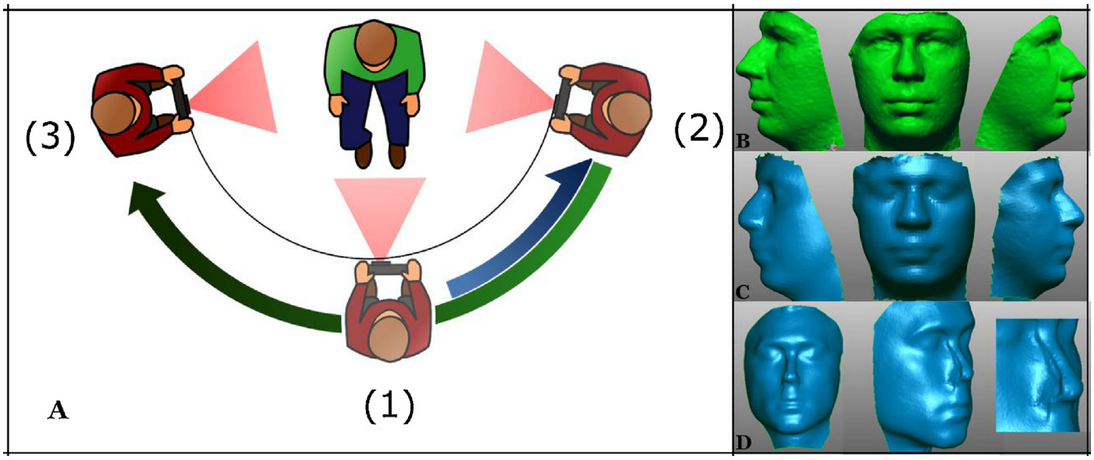

Fig. 1. (A) Scheme illustrating the Kinect scanning procedure: (1) position of the initial Kinect scan (in front of the patient); (2) Kinect moved to the left of the patient; (3) Kinect moved to the right side, passing in front of the patient again. (B) Images acquired with the DI3D scanner. (C) Images acquired with the Kinect device. (D) Images acquired with the Kinect device but excluded from the sample due to distortion of the nose.

Please cite this article in press as: Maués CPR, et al. Three-dimensional surface models of the facial soft tissues acquired with a low-cost scanner, *Int J Oral Maxillofac Surg* (2018), https://doi.org/10.1016/j.ijom.2018.03.028