Comparison of the Facial Morphologies of Identical Twins Using Three-Dimensional Photography: A Case Report

Sedat Altindis[1], Erdem Hatunoğlu[2], Emine Toptan[1]

[1] Research Assistant, Department of Orthodontics, Faculty of Dentistry, İnönü University, Malatya, Turkey

[2] Assistant Professor, Department of Orthodontics, Faculty of Dentistry, Fırat University, Elazığ, Turkey

Abstract

The facial morphologies of identical twins were compared using the 3dMD three-dimensional (3D) photogrammetry system. 3D images of the faces of 27-year-old identical twins were acquired and then superimposed. The differences were shown in a color histogram generated using 3dMD Vultus software. The faces of the twins differed in the areas of the zygomatic region, lips, and cheeks. There were no prominent differences in other parts of their faces. Differences in the facial morphology of twins can be detected by superimposing 3D photogrammetry generated images and displaying the data as a color histogram.

Keywords: Identical twins, 3dMD, superimposition, color histogram, face analysis

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Corresponding Author*:* Dt. Sedat Altindis, Inonu University, Faculty of Dentistry, Dept of Orthodonti, 44280, Malatya, Turkey
E-mail: dtaltindis@gmail.com **Phone:** +90 532 6945792 **Fax:** +90 442 3411107

Introduction

Quantitative analysis of facial soft tissue is an essential aspect of orthodontics and maxillofacial surgery [1] and is typically performed using cephalometric and photometric methods. However, the use of these techniques to project three-dimensional (3D) images of facial morphology on a two-dimensional plane leads to a loss of information [2].

With the rapid development of imaging technology, advances in 3D imaging processing have allowed the accurate depiction, interpretation, and evaluation of facial structures in 3D [3]. Consequently, 3D images provide the clinician with a virtual patient [4]. Moreover, using the appropriate software, the images can be rotated, translated, enlarged, and manipulated easily, allowing a more detailed evaluation.

There is growing interest in the assessment of facial shape in three dimensions. Wirthlin et al. [5] used 3D photogrammetry to compare the facial morphologies of a Chinese adult population to those of a Caucasian population in Houston, Texas. Kau and Richmond [6] used a 3D laser imaging system to investigate surface changes in facial morphology in healthy children 12–14 years of age. Jayaratne et al. [7] obtained gender-specific normative nasal measurements in Chinese young adults using 3D photogrammetry. Othman et al. [1] used 3D photogrammetry to compare the facial proportions of patients with a repaired unilateral cleft lip and palate with those of a control group with normal lips and palates. In this case report, we extend the application of 3D photogrammetry by comparing the facial morphologies of 27-year-old identical twins.

The Case

The 27-year-old identical twins (one of whom is the senior author of this report) participated in this study voluntarily. Three-dimensional facial images were captured using the 3dMD face system (3dMD, Atlanta, GA) for ear to ear imaging (Figure 1). This system uses a multi-camera configuration, with three cameras (one color and two black-white) positioned on each side of the subject’s head, to capture photo-realistic quality images.

Before its use, the camera was calibrated to define a 3D coordinate system for the 3D photographs. The individual to be photographed was seated in a chair adjusted so that his face was positioned at the level of the camera. Images were captured under standard clinical light conditions. Then, the subject was photographed standing, with his head in a natural position. In this same position, the subject was instructed to relax, holding the lips together if possible without straining and with eyes open. A random flash pattern was projected onto the subject and an image was captured using the three calibrated digital cameras (Figure 2). The image was stored automatically on a connected computer as a .tsb file using the 3dMD Vultus software (3dMD, Atlanta, GA). After digital subtraction of the subject's hair and clothing the images were aligned manually and then superimposed automatically by the software. The differences between the superimposed 3D images were shown as a color histogram (Figure 3). Color histogram revealed that the blue color represents differences between two images of ± 1 mm and therefore very little, or no difference. The green spectrum represents positive changes (up to +3 mm) that are seen to affect cheek and lips. In contrast, the red spectrum (up to -3 mm) corresponds to negative changes as seen in right zygomatic region.

Figure 1. The 3dMD imaging system used this study.

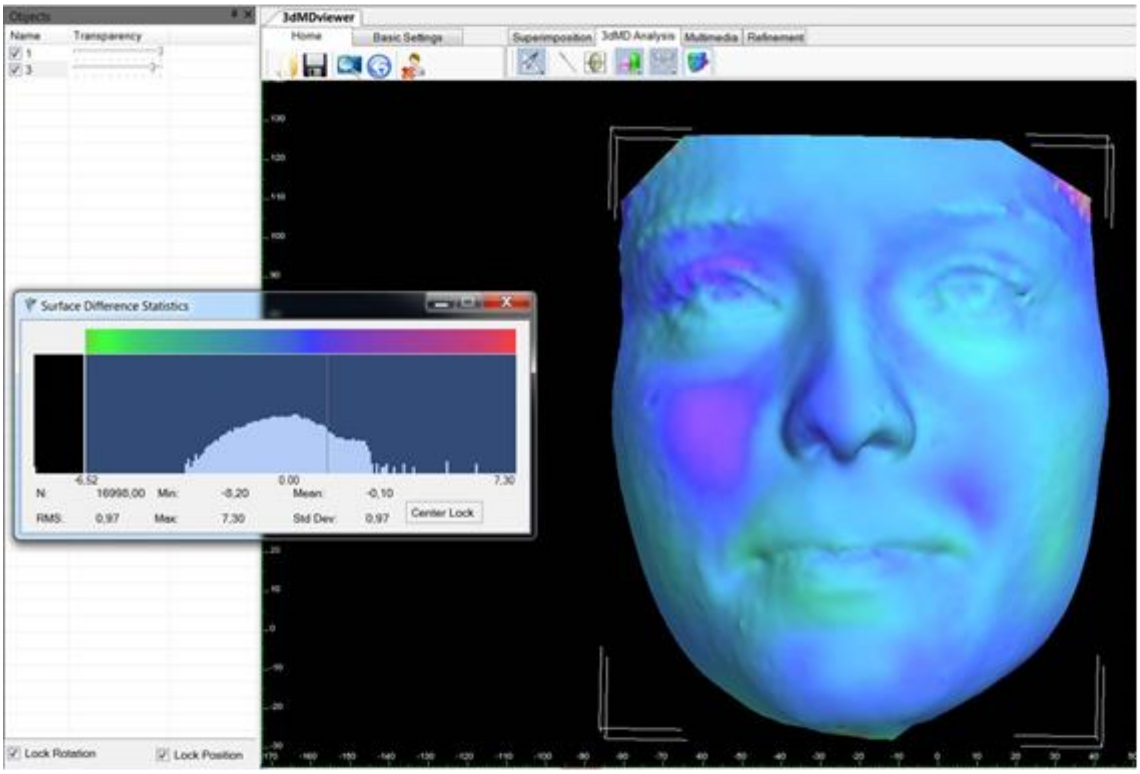

Figure 2. Images from different angles of identical twins.

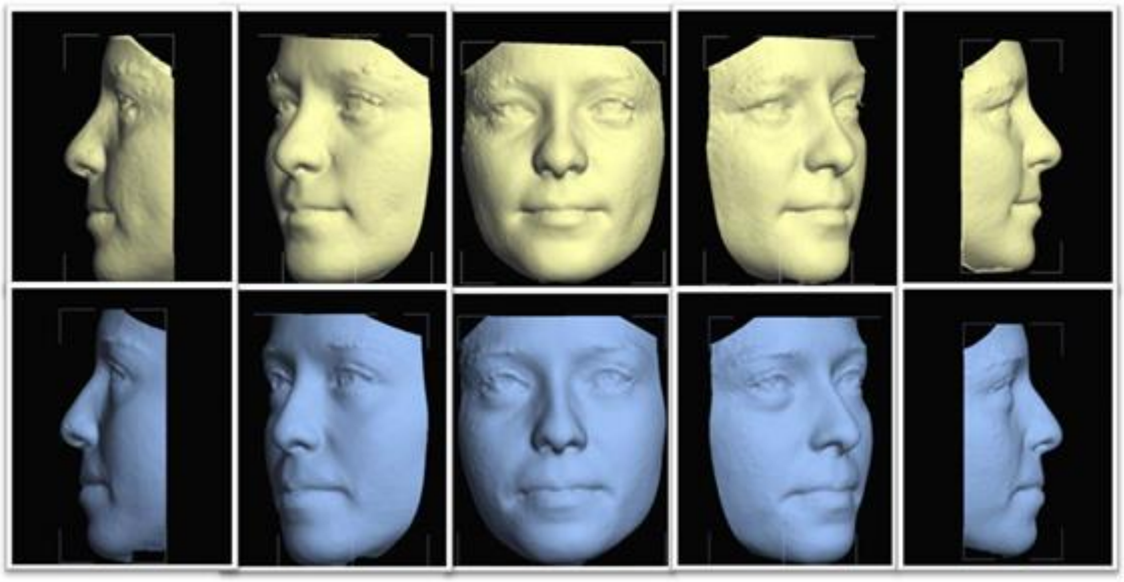

Figure 3. The color histogram indicates the areas of differences (green and red) and the areas of similarities (blue).

Discussion

In the analysis of facial morphology, 3D imaging systems have played an increasingly important role over last decade [8], based on the rapidly improving technology. The 3D devices described in the recent literature include cone beam computed tomography (CBCT), lasers, structured light techniques, and 3D photogrammetry.

CBCT overcomes several of the limitations of conventional CT devices. The total radiation is approximately 20% of that of conventional CT and equivalent to a full-mouth periapical radiographic exposure [9]. Three-dimensional measurements of a computer-generated soft-tissue model created from a CT slice are accurate and show excellent reproducibility [10]. CBCT images yield a nearly exact 1-to-1 image-to-reality ratio when used with appropriate algorithms [11]. However, its disadvantages in facial soft-tissue imaging are the long scanning time and the radiation exposure [12].

Laser facial scanning acquires a 3D image of the facial soft tissues without exposing the subject to any ionizing radiation [12]. Kau et al. [13] investigated the accuracy of laser scans of the same individual acquired at different times. The mean registration error was < 0.4 mm and the error was within a range of 0.85 mm for 90% of the registration. However, the long scanning time causes image distortion and the subject's eyes can be exposed to the laser beam, which is particularly detrimental in young, growing subjects [8].

The use of structured light involves photographing the subject with a camera calibrated according to the specifics of the projected light pattern [14]. When the light illuminates the surface of the subject, the light pattern distorts and bends. The reflected and distorted pattern is captured by a system of cameras positioned at a defined angle and known distance from the subject. Shape data are generated and pertinent color and texture information is registered automatically [12]. The structured light system uses white light, which can be viewed with the naked eye safely.

In 3D photogrammetry, or stereophotogrammetry, a 3D image is captured using two or more cameras set at a predefined distance from each other. Two images of the same object are used to create a stereo pair and combined with depth measurements to generate a 3D image [14]. The advantages of 3D photogrammetry are the rapid, non-invasive image capture, which minimizes distortion, the ability to store the images easily, high-resolution color representation, and the absence of radiation exposure, which facilitates the recruitment of untreated subjects for a control group without ethical concerns [15].

Quantifying the soft tissues of the face requires an objective, accurate, and reliable system, which supported our choice of 3D photogrammetry and, specifically, the 3dMD face system. Aldridge et al. [16] used the 3dMD face system to investigate the precision, error, and repeatability associated with the acquisition of anthropometric landmark coordinate data. The results showed that the measurements were highly repeatable and precise and that the average error associated with placement of the landmarks was < 1 mm. Lubbers et al. [17] evaluated data acquisition and the resulting data of the 3dMD face system. They found the system to be reliable, with a mean global error of 0.2 mm for mannequin head measurements. Plooij et al. [18] used the 3dMD face system in their study of the reproducibility and reliability of soft-tissue landmarks and showed that the intra- and inter-observer reproducibility of the landmarks was high.

In this study, differences in the facial morphology of identical twins were evaluated quantitatively using a histogram generated following the superimposition of 3D photogrammetry images. The same method can be used in the same individual to evaluate the effects of treatment or to compare structural changes in multiple images acquired over time.

Conclusion

The facial morphologies of identical twins were evaluated quantitatively by superimposing two 3D images. The results were displayed in the form of a color histogram. A maximum difference of 3 mm was recognized, confirming the essentially identical facial morphologies of the identical twins.

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