ARCHIVES OF ORAL BIOLOGY 59 (2014) 1391–1399

Available online at www.sciencedirect.com

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Morphological differences of facial soft tissue contours from child to adult of Japanese males: A three-dimensional cross-sectional study

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ARTICLE INFO

Article history:
Accepted 11 August 2014

Keywords:
Facial soft tissue
Children
Three-dimensional
Optoelectronic system

ABSTRACT

Objective: To evaluate morphological differences of the facial soft tissue surface between male Japanese adults and children.

Design: 20 adult Japanese males (average age 28 years) and 20 Japanese boys (average age 5.5 years) with normal occlusion were selected for this study. The images of the subjects' facial surface were obtained with a 3-D laser scanner. To evaluate the three-dimensional morphological differences of the facial soft tissue, we transformed the coordinates of 16 facial landmarks to a new reference plane and compared the adults' and children's facial form drawn to the same scale in the same coordinate system.

Results: The morphological difference ratio of the lower facial area was higher than in the upper facial area, and the nose and lower face changed more forward than downward. The morphological difference ratio of the mid face width was smaller than other areas.

Conclusion: Our study suggests that the morphological facial soft tissue differences between Japanese adults and children are more forward and downward than laterally, manifesting in a facial form of adults that is deeper and narrow.

1. Introduction

Craniofacial morphological development is of interest to pedodontists and orthodontists because they engage in occlusal guidance and orthodontic treatment professionally, and their treatment can influence facial skeletal and soft tissue growth.[1,2] Although there have been a substantial number of studies about facial morphological changes from child to adult, most of these used measurements in only two-dimensions,[3,4] and few have used three-dimensional measurements.[5,6] Furthermore, compared to the number of studies of the facial skeleton, there have been few studies of the facial soft tissue.

Three-dimensional measuring technology has improved during the last few years, and newer techniques support

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http://dx.doi.org/10.1016/j.archoralbio.2014.08.004

measurement of the facial surface. For example, direct measurement methods such as moiré techniques, stereophotogrammetry, computerized tomography, and so on are now available.[7,8] In recent years, methods to capture facial images using a laser scanner have become a mainstream method because of their ease of use and high accuracy.[9,10] All of these three-dimensional methods of measuring distances and analyzing angles of the face have been used to evaluate clinical outcomes of treatment, cross-sectional growth change, and normative population values.[5,11] However, the morphological evaluation of facial soft tissue in the reference coordinates system obtained by these methods, like an analysis of facial skeletal differences by using cephalograms, is insufficient.

It is well known that there is a strong relationship between facial soft-tissue form and the underlying bony structure.[2,12] For example, the form of facial soft tissue can be altered by changing orientation of the teeth and position of the facial skeleton by clinical orthodontic treatment and orthognathic surgery. Additionally, the patients and the people around them evaluate the success of treatment or changes in growth mainly by changes of the facial surfaces. Because the facial soft tissue has a three-dimensional configuration the morphological analysis should be carried out three-dimensionally. Moreover, a three-dimensional coordinate system is not only useful for evaluating changes of maxillomandibular relations and growth by angles and distances but also by direction. The purpose of this study was to consider the three-dimensional contour differences of the facial surface between adults and children.

2. Materials and methods

2.1. *Human subjects*

20 Japanese adult males (average age 28 years; SD 5 years) and 20 Japanese boys who were highly cooperative (average age 5.5 years; SD 4 months) participated in this study. The total number of screened children was 26. Only those children who could maintain a resting state with their eyes open during scanning were selected for scanning. Children who cried or moved with fear and had a playful attitude were judged ‘‘poor cooperators’’ and were not used. As the result of screening, 20 children were selected as analysis objects. Subjects had no obvious signs or symptoms of temporomandibular joint dysfunction or asymmetry of the face, and their occlusion was normal. None had a history of orthodontic treatment. Informed consent to participate in this study was obtained from all subjects and parents of all children. Prior to beginning the study, approval by the clinical ethics committee of Kagoshima University Hospital had been obtained (No. 378).

2.2. *Three-dimensional imaging system*

Three-dimensional laser scans were taken with a Vivid® 910 laser scanner (Konica Minolta, Tokyo, Japan) that operates as a stereo-pair and has an accuracy of 0.3 mm. This camera emits an eye-safe Class I type laser beam (rated safe for eyes by the US Food and Drug Administration, maximum 30 mW, 690 nm) with an object to scanner distance of 0.6 m–2.5 m and a fast-mode scan time of 3.0 s. The laser scanner automatically focused on the subject, and a middle lens (focal distance $f = 14$ mm) was used. The system used a one-half-frame transfer CCD and acquired 307,000 data points. The scanner's output data was 640 $\times$ 480 pixels for three-dimensional data. Data was recorded on a desktop workstation. The scanner was controlled with Polygon Editing Tool (Konica Minolta, Tokyo, Japan) and data coordinates were saved in a Vivid® file format. Coordinate data was transferred to 3D-Rugle software (Medic Engineering Corporation, Tokyo, Japan), which manipulated the facial image.

2.3. *Data capture technique*

During the scanning, subjects sat relaxed in a revolving chair with their heads in a natural head position. The subject-to-scanner distance was set at 1.5 m. The scanning procedures were performed in a room under four fluorescent lights. The subjects were instructed to keep their jaw in the intercuspal position just before the scans were taken. The total scan time was approximately 3.0 s.

To test the scan error due to possible movement by the children during the scan, scans of the 20 boys were repeated after 1 week by the same person, and Dahlberg's formula was used for the calculation of the acquisition accuracy:

$$\text{acquisition accuracy} = \sqrt{\frac{\text{sd}^2}{2\text{n}}}$$

where d is the difference between the first and second scans and n is the number of subjects. The errors ranged from 0.29 to 0.87 mm (mean, 0.61 mm), corresponding to 0.77% of the total variance, indicating that these errors were negligible.

2.4. *Date preparation*

2.4.1. *Transformation to new reference plane*

To evaluate morphological differences of facial soft tissue form, we transformed the facial coordinates to a new reference plane. First, the three-dimensional coordinates of the 16 facial landmarks (Table 1; Fig. 1) were established and identified on the three-dimensional facial image by a single investigator (D.M.) using the 3D-Rugle programme. The coordinates from each subject were then transformed to a standardized plane (Fig. 2) using our custom-made programme written in Microsoft Visual C++® (Microsoft, Redmond, Seattle, USA). The direction of the X-axis was defined as lateral, the Y-axis as anterior-posterior, and Z-axis as vertical. A regression line, obtained from the X and Z coordinates of points N, Prn, Sn, Ls, Li and Pog, defined the midline (sagittal reference plane (Fig. 2B)). The coronal reference plane was established parallel to the regression plane defined by the points Acr, Acl and N (Fig. 2C). The axial reference plane was defined as perpendicular to both the sagittal and coronal reference planes. All coordinates were then transformed to a reference plane in which the midpoint between right and left endocanthions (Enr and Enl) was the origin. Finally, the transformed coordinate values (X, Y, Z) of each landmark were transferred to Microsoft Excel®.