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Volumetric comparison of maxillofacial soft tissue morphology: computed tomography in the supine position versus three-dimensional optical scanning in the sitting position

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Objective. Three-dimensional (3-D) surgical simulation has become popular, but the accuracy of such simulation is difficult to assess. Because maxillofacial soft tissue profiles vary with posture, we compared such profiles obtained in the supine and sitting positions.

Study Design. In total, 28 patients with skeletal Class III jaw deformities underwent computed tomography in the supine position and 3-D optical scanning in the sitting position. The 2 sets of 3-D data were superimposed, and linear and volumetric differences were calculated. We evaluated the cheeks, the subauricular and infraorbital regions, the nose, the lips, and the chin. Statistical analyses were performed by using paired Student's t tests. Differences with $P < .05$ were considered significant.

Results. Patients were divided into 3 groups based on body mass index. The facial profiles of the cheeks and subauricular areas differed significantly between the sitting and supine positions. The extent of variation increased with body mass index.

Conclusions. When a patient moves from the sitting position to the supine position, maxillofacial soft tissue migrates from the cheeks to the subauricular regions. Thus, simulations for surgery based on supine computed tomography alone do not accurately model the cheeks and subauricular areas. (Oral Surg Oral Med Oral Pathol Oral Radiol 2018;■■:■■–■■)

The purpose of orthognathic surgery is to create an ideal occlusion and facial profile. Prediction of postoperative outcomes is important for successful orthognathic surgery. Thus, surgical planning must be based on accurate hard and soft tissue evaluations.[1]

The location of maxillofacial soft tissue is affected by gravity.[2-5] Surgeons must consider the posture and position of patients at all stages of evaluation. Cephalometric radiographs are taken with the patient in the standing position and facial photographs in the standing or sitting position. Three-dimensional (3-D) optical scans are obtained with the patient in the standing or sitting position. However, multislice computed tomography scans are obtained with the patient in the supine position, and this position is used for surgery as well.

Conventionally, hard and soft tissue evaluations before orthognathic surgery are based on 2-dimensional (2-D) data (cephalometric analysis and facial photography).[2,3] However, 2-D evaluation of radiographs is sometimes inaccurate, especially for patients with facial asymmetry because lateral cephalometric images contain double points and because of the lines representing the right and left anatomic structures. Thus, conventional cephalometry has limitations in predicting the postoperative 3-D face, especially in patients with facial asymmetry.

Recently, 3-D computed tomography (CT) and optical scanners have been used in surgical simulations. However, the accuracy of 3-D CT simulation is difficult to assess because multislice computed tomography scans are obtained with the patient in the supine position.

Soft tissue variations with patient position have been evaluated in 2 dimensions on facial photographs,[2,3] and in 3 dimensions with a 3-D optical scanner.[4,5] All study measurements have been linear.[2-5] However, this approach does not adequately consider variation in soft tissue caused by patient position. Thus, instead of 2-D linear measurements, volumetric measurements and 3-D evaluation are required. Our purpose was to explore volumetric variations occurring with changes in patient positions. For comparison with other reports,[2-5] we also obtained linear measurements.

MATERIALS AND METHODS

Patients

The study included 28 patients with jaw deformities undergoing Le Fort I osteotomy and/or sagittal split ramus osteotomy and/or genioplasty at the Division of Oral and Maxillofacial Surgery, Department of Oral Medicine and

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Statement of Clinical Relevance

The soft tissue facial profile is affected by both posture and body mass index; surgeons must consider this when simulating surgical outcomes for patients with jaw deformities.

Surgery, Tohoku University Hospital, Sendai, Miyagi, Japan, between April 2012 and March 2016.

The inclusion criteria were skeletal class III status and no facial scarring. Patients with trauma, cleft-related deformities, congenital syndromes, Class II malocclusion, and/or severe asymmetry (>4 mm deviation from the tooth midline to the facial midline) were excluded. Patients were divided into 3 groups based on body mass index (BMI), following the criteria of the Japan Society for the Study of Obesity. Those with BMIs less than 18.5 kg/m^2 were considered to be underweight, those with BMIs 18.5 kg/m^2 or greater and those with BMIs less than 25 kg/m^2 were considered to be of normal weight, and those with BMIs 25 kg/m^2 or greater were considered to be overweight.

Methods

CT in the supine position. Two months before surgery, 3-D CT images were obtained, with all patients in the supine position. The head was positioned horizontally and at a right angle to the Frankfort horizontal plane; the patient's eyes were closed, and the lips were relaxed. CT was performed with a Somatom Emotion 6 (Siemens, Erlangen, Germany) operating at 130 kV and 80 mA (slice thickness, 0.1 mm). The data were downloaded to a DICOM (Digital Imaging and Communications in Medicine) platform and converted into stereolithographic (STL) files using Osirix MD (Pixmeo SARL, Bernex, Switzerland).

3-D optical scanning in the sitting position. 3-D Images were obtained 1 day before surgery by using an Artec Eva imaging system (Data-design, Aichi, Japan). The patient's head was in a natural position, with eyes closed and lips relaxed. Three skilled examiners, each with experience of greater than 100 scans, obtained the images. The output STL files were evaluated using Artec Studio software.

Volumetric and linear analysis of STL data. STL data were analyzed with the aid of 3 D-Rugle software (Medico-Engineering, Kyoto, Japan). A vertical plane through the patient's nose and forehead was constructed with reference to the Frankfort horizontal plane in each STL data set. Next, the 2 STL data sets (from the different evaluations) were superimposed by reference to the T zone,[6] defined as the area from the forehead to the root of the nose. Data sets were superimposed with 3 D-Rugle using the iterative closest point algorithm. The software calculated volumetric changes in defined regions by summing up the areas of difference between 3-D CT and 3-D optical scanning images for each slice. The areas evaluated were the cheeks, the subauricular and infraorbital regions, the nose, the lips, and the chin.

The cheek area was defined by a circle 100 mm in diameter, tangential below the line connecting the alar base to the lower margin of the tragus (Figure 1A). The subauricular area was defined by a rectangle of 30 × 40 mm (vertical, horizontal), of which the upper boundary was the lower margin of the tragus and the posterior boundary was the posterior margin of the ear (Figure 1B). The infraorbital area was defined by a rectangle of 40 × 30 mm (vertical, horizontal), of which the upper margin was the lower eyelid and the lower margin was the medial canthus

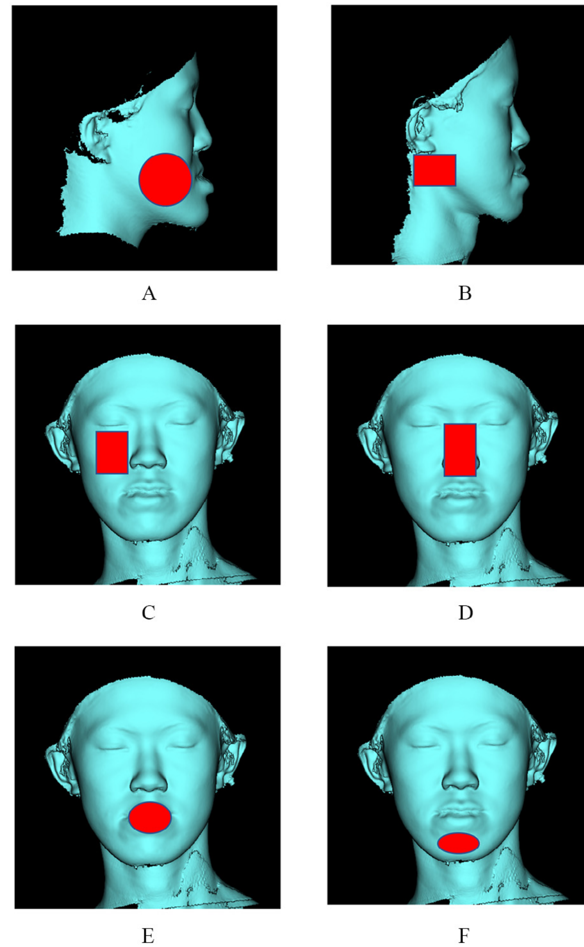

Fig. 1. Areas evaluated. **(A)** The cheek area. The cheek area was a circle, 100 mm in diameter, tangential above to the line connecting the alar base to the lower margin of the tragus. **(B)** The subauricular area. The subauricular area was a rectangle of 30 × 40 mm (vertical, horizontal) of which the upper bound was the lower margin of the tragus, and the posterior bound was the posterior margin of the ear. **(C)** The infraorbital area. The infraorbital area was a rectangle of 40 × 30 mm (vertical, horizontal) of which the upper margin was the lower eyelid, and the lower margin was the medial canthus. **(D)** The nose area. The nose area was a rectangle of 50 × 30 mm (vertical, horizontal) of which the upper margin was the line connecting the medial canthuses, and the midline was the midline of the face. **(E)** The lips. The lip area was an ellipse with axes of 30 and 40 mm centered on the lips. **(E)** The chin. The chin area was an ellipse with axes of 20 and 40 mm. The upper margin was the margin of the lower lip, and the midline was the lip midline.