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Clinical Paper
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Dentoskeletal parameters related to visual perception of facial asymmetry in patients with skeletal class III malocclusion after orthognathic surgery

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Abstract. The purpose of the study is to explore the critical parameters determining the visual perception of postoperative facial symmetry. This study retrospectively included 24 patients with skeletal class III malocclusion and double-jaw orthognathic surgery (OgS). The patients were classified according to the outcome of subjective visual perception scores (SVPS) based on the postoperative frontal images by 10 orthodontists: symmetrical surgical outcome (S group, $n = 12$) and facial asymmetry after surgery (A group, $n = 12$). The 3D dentofacial measurements from cone beam computed tomography, were compared between the S and A groups. The relationship of all variables in all patients with the SVPS was explored by Spearman correlation coefficient. Significant differences were observed in the midline parameters in the mandible, the B point, gnathion and menton, and the mandibular border axis as well as in the discrepancy of the chin morphology between the two groups ($P < 0.05$). The findings demonstrated that the midline parameter deviation, shape of the mandibular border, and the contour of menton morphology play the major role in the visual perceptions of postoperative asymmetry.

Key words: facial asymmetry; orthognathic surgery; 3D craniofacial analysis; subjective visual perception score.

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The prevalence of facial asymmetry is high. Haraguchi et al. determined that 85% of subjects exhibited skeletal class III malocclusion combined with facial asymmetry in the Asian population[1]. Facial asymmetry results not only from the displacement of the craniofacial structure but also the overgrowth of the cranial base, maxilla, or mandible, which is known as structural asymmetry[2,3]. The symmetry goal of orthognathic surgery (OgS) is to correct the occlusion, align the maxillary midline and chin to the facial midline, level the oral commissure and frontal occlusal plane[4]. Further, adjunctive surgeries or treatments might be applied to improve the contour asymmetry and enhance harmonized and balancing face form.

The development of 3D images has overcome the inherent drawbacks of 2D images, such as structural overlapping and projection distortion[5]. 3D images facilitate the comprehensive assessment of dentofacial deformities in true linear, angular, area, and volumetric measurements for analysis of the craniofacial forms. With the development of computer-assisted 3D surgical simulation and advanced software progression, OgS can be precisely planned and predictably performed to achieve a desired surgical outcome[6].

The 3D images were utilized for analysis of OgS outcome. Several studies examined the OgS improvement of facial symmetry and the results were controversial[7–11]. Some studies showed the improvement of facial asymmetry[7–9]; others showed the surgical outcomes were not with statistical significance compared with preoperative measurement regarding face symmetry[10,11]. Even though the studies address the improvement of face asymmetry after surgery, residual asymmetry still remained postoperatively[8,12].

This study explored the dentoskeletal parameters determining the visual perception outcome of facial symmetry or asymmetry in patients with skeletal class III malocclusion after OgS and analysed the relationship among these parameters.

Subjects and methods

Patients

This retrospective study enrolled 24 patients who underwent OgS and orthodontic treatment from 2011 to 2013 at Chang Gung Memorial Hospital, Taipei, Taiwan. The inclusion criteria for the subjects were as follows: (1) skeletal class III malocclusion, defined as an ANB angle (angle formed from point A, nasion, and point B) less than 0°; (2) complete maxillary dentition, excluding the third molar; (3) the deviation of the menton from the midsagittal plane (MSP) was larger than 4.0 mm preoperatively; (4) underwent double-jaw OgS for dentofacial correction (LeFort I osteotomy and bilateral sagittal split osteotomy); (5) complete cone beam computed tomography (CBCT) data before surgery and on completion of orthodontic treatment; and (6) complete the postoperative photos taken at least 6 months postoperatively (after the facial swelling completely subsided and bone remodelling). Patients with major systemic diseases, genetic syndromes, cleft lip and palate, hemifacial microsomia, congenital muscular torticollis, or craniofacial trauma history were excluded from this study.

Surgical technique

All the patients underwent double-jaw OgS, LeFort I osteotomy, and bilateral sagittal split osteotomy. LeFort I osteotomy was performed to advance, impact, or clockwise rotate the maxilla. If the maxilla is advanced, then the anterior nasal spine (ANS) might be trimmed off during surgery to prevent a procumbent nose.

The bilateral sagittal split osteotomy techniques adopted at our centre were modified from the Hunsuck technique with more anteriorly extended anterior osteotomy cut[13,14]. The medial cortex of the mandibular angle, which can be harvested for a high-quality bone graft or shaved to improve ''square face'', stays with the proximal segment during osteotomy[14].

Genioplasty surgeries were conducted to enhance the chin bottom projection in nine patients in the S group (75%) and seven patients in the A group (58.3%).

Classification of patients

The patients were classified according to subjective visual perception score (SVPS) of facial symmetry/asymmetry after OgS: symmetrical surgical outcome (S group) and facial asymmetry after surgery (A group). The frontal facial images, including static and posed smile of all 24 patients. Every photo was displayed twice for 3 seconds, and images of different patients were displayed at 3-second intervals for scoring. Ten experienced orthodontists (working independently for more than 5 years) in the same orthodontic department participated in patient scoring. The definitions of the SVPS including: 1, obvious asymmetry; 2, moderate symmetry requiring further improvement; 3, acceptable moderate asymmetry; 4, satisfactory mild asymmetry; 5, harmonized symmetry. Ten orthodontists scored every image and the average score on each patient were used for the classification.

3D dentoskeletal measurements

The patients posed in the natural head position and the maximum intercuspation position to enable acquisition of CBCT images (iCAT scanner, Imaging Sciences International, Hatfield, USA). The machine was set at 120 kVp and 36.9 mAs, with a slice thickness of 0.4 mm. The CBCT data were obtained before OgS (T0) and on completion of orthodontic treatment (T1).

The CBCT data of all the patients were exported in the DICOM format and processed using Simplant® O&O software (Materialise Dental, Leuven, Belgium) to reconstruct the 3D craniofacial models, including the cranial and maxillary, mandibular, and dentition segments. Before measurement, craniofacial skeletons were oriented in the natural and upright head positions.

The 3D reference planes were constructed, and the landmarks were identified on the preoperative objects. The horizontal reference plane was the Frankfurt horizontal (FH) plane determined by the bilateral orbitale and the midpoint of the bilateral porion. The MSP was defined as the plane perpendicular to the FH plane and passing through the nasion. The coronal plane (CP) was the plane perpendicular to the FH plane and the MSP, and passing through the basion (Fig. 1).

Table 1 lists the definition of the 3D landmarks and depicts the linear and angular measurements of each landmark relative to the reference planes (Figs. 2–7). The side of the face including the menton, as delineated from the MSP, was defined as the deviated side; the other side was the opposite side. The differences in the presurgical measurement between the S and A groups were compared.

The CBCT images taken at T0 and T1 were superimposed semiautomatically on the anterior cranial base as well as on the frontal and periorbital surface with Geomagic® Studio 12.0 software (3D Systems, South Carolina, USA).

Statistical analyses

To compare preoperative dentofacial differences, the difference between the bilateral landmarks for each pair of parameters was calculated as the distance or the angle

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