The Influential Bony Factors and Vectors for Predicting Soft Tissue Responses After Orthognathic Surgery in Mandibular Prognathism

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Purpose: We sought to identify the hard tissue points and vectors that have the greatest effect on soft tissue movement after orthognathic surgery in patients with mandibular prognathism.

Patient and Methods: The present retrospective study involved patients who had undergone mandibular setback surgery with or without maxillary advancement. Multiple linear regression models were adapted to evaluate the association between the 8 hard tissue landmark (predictor variables) changes and 11 soft tissue responses (outcome variables) using the x and y coordinates assessed from superimposed pre- and postoperative 3-dimensional computed tomography images.

Results: A total of 50 patients (42 patients had undergone 2-jaw surgery; 8 patients had undergone 1-jaw surgery; mean age 23 $\pm$ 4 years) were included in the present study. Our statistical models demonstrated that the horizontal hard tissue changes had a greater influence on the soft tissue responses than did the vertical changes, and these changes were more notable in the lower facial area (lower lip contour and chin profile) than the midfacial area (nasal profile, upper lip contour, upper lip length, and nasolabial angle). In the horizontal soft tissue response model, the soft tissue A point/A point ratio was 0.86:1 (95% confidence interval [CI] 0.674-1.049); the soft tissue B point/B point ratio was almost 1:1 (95% CI 0.919-1.071); and the soft tissue pogonion/pogonion ratio was 0.88:1 (95% CI 0.805-0.963).

Conclusions: Horizontal or vertical bone tissue changes affected both the horizontal and vertical soft tissue changes in most areas. Our study demonstrated that the soft tissue response is not linear but a more complicated and dynamic reaction.

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The main purpose of orthognathic surgery is to restore a patient's maxillomandibular function. However, the esthetic facial appearance that results from surgery is also an important part that should not be ignored. Although orthognathic surgery is limited to the skeleton only, patient satisfaction with esthetics is ultimately determined from the soft tissue profile. At present, many surgeons depend on computer-assisted photographic imaging techniques to predict the postoperative soft tissue response in surgical planning. However, these technques have limitations because they cannot accurately reflect actual changes.[1-5] Thus, it is important for surgeons to be aware of the factors that can affect the soft tissue changes.

The soft tissue responses after orthognathic surgery have been studied in 2-dimensional (2D) lateral cephalograms. Despite this issue, the association between the hard tissue and soft tissue movements related to orthognathic surgery has not yet been clearly verified.

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Most studies have been limited to results obtained using the relative ratios of soft tissue to hard tissue changes using the mean values of responses in a simple correlation or linear regression.[6-11] In addition, these studies overlooked the 1-dimensional movement of points of a particular bone tissue that could cause a 2D change in the soft tissue, as reflected by the *x* and *y* coordinates. Above all, the analyses based on a 2D lateral cephalogram have fundamental limitations regarding the image, because it is difficult to set major landmarks accurately, such as the anterior nasal spine (ANS), A point, and dental outline on the image because of image burnout, blurring, or overlapping anatomic structures. Furthermore, variation in an image can occur, depending on a patient's posture or the adjustment values of the machine at the time when the image was obtained. In addition, it is difficult to obtain true lateral images. Analysis involving computed tomography (CT) can overcome these limitations, allowing for actual length measurements and changes that could not be observed on a lateral cephalometric image.

The purpose of the present study was to identify the significant skeletal landmarks for predicting the soft tissue changes resulting from orthognathic surgery. We hypothesized that the soft tissue response is represented by the movement of various bony landmarks rather than by the movement of 1 point and that horizontal or vertical bone tissue changes simultaneously affect both the horizontal and the vertical soft tissue changes. The specific aims of the present study were to analyze the extent to which hard tissue movements influence soft tissue changes in clinical practice using *x* and *y* coordinates.

Patients and Methods

PATIENT SELECTION

To address the research purpose, we designed and implemented a retrospective cohort study. The study population included all patients who had undergone orthognathic surgery for the surgical correction of mandibular prognathism in the Department of Oral and Maxillofacial Surgery at Seoul National University Dental Hospital (Seoul, Korea) from 2006 to 2014. The inclusion criteria were as follows: Korean nationality, bilateral sagittal split ramus osteotomy (BSSRO), and setback surgery with or without Le Fort I osteotomy or genioplasty. The exclusion criteria were condylar hyperplasia, cleft lip and palate, craniofacial syndrome, and a history of physical trauma or surgical intervention in the maxillofacial region. The institutional review board (IRB) of the Seoul National University School of Dentistry approved the study (IRB no. S-D20160008), which was conducted according to the tenets of the 1964 Declaration of Helsinki and its later amendments. All procedures were conducted by a single surgeon (B.M.S.).

SURGICAL TECHNIQUE AND POSTOPERATIVE CARE

All patients underwent a modified BSSRO with or without a standard Le Fort I osteotomy involving rigid internal fixation. Standard alar cinch suturing was performed using 2-0 polydioxanone suture without bone anchorage. The wound was closed with an interrupted suture and <SS>V</SS>-<SS>Y</SS> advancement on the upper lip mucosa to achieve the ideal incisor exposure of 2 mm. A suction drain was inserted into the mandibular bony lateral surface. A pressure dressing was applied after surgery and maintained for 2 weeks. Mouth opening was allowed from postoperative day 1. At 1 week after surgery, the patients were advised to perform active physiotherapy involving the application of a hot pack and mouth-opening exercises. Postoperative orthodontic treatment was begun approximately 4 to 6 weeks after surgery.

RADIOGRAPHIC AND IMAGING ANALYSES

All patients underwent 3-dimensional (3D) CT scanning (Somatom Sensation 10; Siemens AG, Erlangen, Germany) as part of their clinical examinations at the pre- and postoperative follow-up appointments (3 to 4 months postoperatively). With the patient in a supine position, the maxillofacial regions were scanned using a tube voltage of 120 kVp, a tube current of 80 mA, a scan time of 33 seconds, and table movement of 1.5 mm/rotation. Axial images with 0.75-mm-thick slices with no interslice gap were reconstructed from the volume image data. InVivo dental software (Anatomage, San Jose, CA) was used to create 3D reconstructed models. The 3D models were reoriented using Frankfort horizontal (FH) and mid-sagittal planes as reference planes. The FH plane was defined as the plane that passes through both porions and the midpoint of the line connecting both infraorbitales. The midsagittal plane was a plane perpendicular to the FH plane that passed through the midpoint of the line connecting both infraorbitales. The 2D images were obtained by capturing 3D images. Superimposition based on the cranial bone of the preoperative and postoperative 2D images and landmarks measurements was conducted using Photoshop CS, version 3.0 (Adobe Systems, San Jose, CA; Fig 1). We designated 9 hard tissue and 11 soft tissue landmark points as *x* and *y* coordinates, and 3 landmark angles and 1 landmark length (upper lip length) were measured on the pre- and postoperative images (Table 1, Fig 2). On the *x* coordinate, advancement and setback changes are represented as positive and negative values, respectively. On the *y* coordinate, downward and upward changes are represented as