A 2-Year Follow-Up of Changes After Bimaxillary Surgery in Patients With Mandibular Prognathism: 3-Dimensional Analysis of Pharyngeal Airway Volume and Hyoid Bone Position

Je-Hwa Shin, DDS, MSD, Min-Ah Kim, DDS, MSD,† In-Young Park, DDS, MSD,‡ and Yang-Ho Park, DDS, MSD, PhD§*

Purpose: The aims of this study were to use 3-dimensional cone-beam computed tomography (CBCT) to evaluate how the upper airway and hyoid bone position changed after orthognathic surgery in patients with skeletal Class III malocclusions and to analyze the relations among upper airway changes, the change in the position of the hyoid bone, and postsurgical stability.

Materials and Methods: CBCT scans were obtained from 15 patients with mandibular prognathism before surgery (T0), 6 months after surgery (T1), 1 year after surgery (T2), and 2 years after surgery (T3). Positional displacement of the hyoid bone was assessed using the coordinates at T0, T1, T2, and T3. In addition, the volume of each patient's pharyngeal airway was measured. Differences in CBCT scans at the established time points were determined by the Wilcoxon signed rank test. The Spearman correlation coefficient was used to determine the relations among changes in hyoid bone position, airway volume, and skeletal reference points.

Results: The hyoid bone moved backward at 6 months after surgery (T0 to T1), and the total volume of the pharyngeal airway was considerably decreased at the same time points. At 1 year after surgery (T1 to T2), although the hyoid moved more posteriorly and the total volume of the pharyngeal airway was decreased, the changes were not major. At 2 years after surgery, the hyoid bone moved anteriorly and the size of the upper pharyngeal airway was increased (T2 to T3).

Conclusion: The hyoid bone moved posteriorly and the pharyngeal airway volume was decreased at 6 months after bimaxillary surgery. These measurements had a tendency to recover at 2 years postoperatively. The decrease in pharyngeal airway volume was not correlated with positional changes of the hyoid bone.

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The pharyngeal upper airway has drawn attention because narrowing of the upper airway is caused by external factors relative to orthognathic surgery. If the upper airway becomes narrow, it increases airflow resistance and leads to a decrease in airflow.[1-3]

Because of variations in the location and degree of constriction of the airway, facial morphology can vary widely among patients.[4] A smaller nasopharyngeal area has been observed more often in patients with Class II and Class III malocclusions than in those

*Resident, Department of Orthodontics, Kangdong Sacred Heart Hospital, Hallym University Medical Center, Seoul, Korea.

†Resident, Department of Orthodontics, Kangdong Sacred Heart Hospital, Hallym University Medical Center, Seoul, Korea.

‡Clinical Assistant Professor, Department of Orthodontics, Hallym Sacred Heart Hospital, Anyang, Korea.

§Professor, Department of Orthodontics, Kangdong Sacred Heart Hospital, Hallym University Medical Center, Seoul, Korea.

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Address correspondence and reprint requests to Dr Y.-H. Park: Department of Orthodontics, Kangdong Sacred Heart Hospital, Hallym University Medical Center, Gil-dong 445, Gangdong-gu, Seoul 134-701, Republic of Korea,; e-mail: dentpark64@hanmail.net

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with Class I malocclusion.[5] Mandibular setbacks in patients with skeletal Class III malocclusions have been reported to lead to major pharyngeal narrowing.[6-8]

Orthognathic surgery for skeletal deformities alters the oropharyngeal complex and the position of the hyoid bone.[9] The position of the hyoid bone and the size of the pharyngeal airway have been reported to change after mandibular setback surgery.[10] The alteration in position of the hyoid bone after surgery could relax the tension of the suprahyoid musculature. Subsequently, muscle tension, which is related to skeletal relapse, might increase over time.[11-13]

Based on previous studies, posterior and inferior movement of the hyoid bone was found after surgery over the short-term.[14] However, this bone had a tendency to return to its original position over the long-term.[12]

The effects of mandibular setback surgery on the pharyngeal airway space have been investigated in Class III skeletal deformities.[9] Some studies have shown that physiologic adaptation of surrounding soft tissues occurs with time, and the airway tends to be restored to its presurgical dimensions.[10,12,15] However, Eggensperger et al[16] reported that the upper airway narrowed immediately after surgery, and it did so consistently over time.

Conventionally, postoperative changes in the upper airway have been analyzed using 2-dimensional lateral cephalograms.[6,8-10,12,13,16-20] Although the lateral cephalogram has been used extensively as a diagnostic tool in the study of craniofacial morphology, it does not offer unique potential for 3-dimensional (3D) airway anatomy. Cone-beam computed tomography (CBCT) can distinguish the boundaries between the soft tissue and the airway space, with the advantages of lower cost and lower radiation doses. Lenza et al[21] insisted that CBCT-based 3D analysis could more accurately represent the anatomic characteristics of the airways than single linear measurements performed on cephalograms. There have been few long-term follow-up studies of the relations between the changes in the upper airway and hyoid bone with the application of 3D images.

The aims of this study were to evaluate how the upper airway and hyoid bone position changed after orthognathic surgery in patients with skeletal Class III malocclusions and to analyze the relations among upper airway changes, the change in the position of the hyoid bone, and postsurgical stability using 3D CBCT. The null hypothesis was that the postoperative change (6 months after surgery) in hyoid bone position and pharyngeal airway volume would be maintained at up to 1 year and 2 years after surgery.

Materials and Methods

PATIENTS

Fifteen consecutive patients with skeletal Class III malocclusion (8 men, 7 women; mean age, 27.04 ± 6.08 yr; range, 21.0 to 33.1 yr) who underwent bimaxillary surgery at Kangdong Sacred Heart Hospital from February 2009 to January 2011 were included in this retrospective study. The ethics review committees at the Kangdong Sacred Heart Hospital (Seoul, Korea) and the Hallym University Medical Center (Anyang, Korea) approved the study protocol (IRB14-1-09). The diagnostic inclusion criteria were an overjet no larger than 0 mm, a unilateral or bilateral Angle Class III molar relation, and an ANB no larger than 0°. All patients had fully developed permanent dentition from second molar to second molar. Patients who had craniofacial syndromes, such as cleft lip and palate, and those with symptoms related to pharyngeal pathologies or with severe facial asymmetry were excluded. Severe facial asymmetry was determined by maxillary canting greater than 3 mm, measured at the upper first molars in reference to the Frankfort horizontal (FH) plane, which was constructed from the right and left poria and the right orbitale, or a mandibular menton deviation greater than 3 mm from the midsagittal plane, constructed by the crista galli (the most superior point of the crista galli of the ethmoid bone), anterior nasal spine (ANS; the most anterior point of the premaxillary bone in the sagittal plane), and opisthion (the most posterior point on the posterior margin of the foramen magnum).[22] In addition, patients who had degenerative disease in the temporomandibular area were excluded. All patients had pre- and postoperative orthodontic treatment.

The surgical procedure consisted of conventional Le Fort I osteotomy and bilateral sagittal split ramus osteotomy. After Le Fort I osteotomy, the posterior maxilla was impacted (mean, 2.75 mm; range, 2 to 4 mm) by rotating it clockwise with a center of rotation at the upper incisal tip and then rigidly fixated. The mandible was set back with bilateral sagittal split ramus osteotomy. After the setback movement, the desired occlusion was fixed with stainless steel intermaxillary wires with a thin interocclusal acrylic splint (surgical wafer) in place. Then, the proximal segment was stabilized by semirigid fixation. Titanium miniplates were used for fixation of the fragments. The proximal fragments were positioned into the proper position in the fossa. The miniplates were bent, positioned passively against the bone fragments, and fixed with at least 2 monocortical 5- or 7-mm screws on each side of the osteotomy. Six patients also underwent advancement genioplasty as an adjunct procedure.