The airway implications in treatment planning two-jaw orthognathic surgery: The impact on minimum cross-sectional area

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The impact of orthognathic surgery on the pharyngeal airway supported by cone-beam computed tomography (CBCT) technology has been the topic of many recent studies. The minimum cross-sectional area (MCA) has also been evaluated but not with respect to vertical position changes of the MCA with movement of the facial skeleton. Vertical position changes and shape changes of 71 patients after orthognathic treatment of Class II and Class III malocclusions were evaluated with CBCT images and Invivo5 software. The vertical changes were found not to be significant for Class II and Class III patients (5.0 mm and 0.2 mm respectively, $p = 0.31$). In addition, the vertical changes of the MCA with individual skeletal movement were also not significant. The shape changes were not consistent relative to individual Angle classification. Vertical changes of the MCA after orthognathic surgery could not be associated with Angle's classification or skeletal movement while shape changes were not predictable. Orthognathic surgical planning is a complex process in which the patient's occlusion, facial balance, and harmony are considered. The purpose of this article is to provide surgical insight into obtaining the best possible results when considering the multifactorial nature of orthognathic surgical treatment planning. Original research on the changes in MCA will be presented. (Semin Orthod 2016; 22:18–26.)

Introduction

Advances and availability of cone-beam computed tomography (CBCT) imaging and related software have allowed for the pharyngeal airway to be accurately evaluated. Several software programs are capable of measuring both volume and minimum cross-sectional area (MCA). In addition, several studies[1–3] have shown the accuracy of the volumetric airway measurements as well as the accuracy of the software in evaluating the MCA. It has been shown that changes in the pharyngeal airways are difficult to quantify using conventional two- and three-dimensional images. Lateral cephalograms do not capture the changes in the lateral airway that can be seen with CBCT imaging.[4] Gonçales et al.[5] demonstrated an increase in the lateral dimension of the airway at three separate vertical points with maxillary advancement, mandibular advancement, and maxillomandibular advancement. Interestingly, the maxillary advancement group with mandibular setback also demonstrated an increase in the lateral dimensions of the airway at the vertical position of the posterior nasal spine and vellecula with a small decrease in lateral dimension at the uvula.

Other studies[2,4,6–8] have looked at the volumetric changes associated with orthognathic surgery utilizing existing software programs and have found that there are predictable volumetric increases or decreases of the pharyngeal airway, depending upon the type of movement that was performed surgically. A more recent study[9] has evaluated the changes in airway volume after orthognathic surgery as it relates to specific

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skeletal movement, with certain movement in the horizontal mandible and vertical position of the posterior nasal spine (PNS) causing significant differences in airway volume and MCA.

Similarly, there have been numerous publications[10–13] concerning both the position of the MCA and the changes in area following orthognathic surgery. However, the vertical position of the MCA has not been evaluated with respect to the millimetric skeletal changes with orthognathic surgery. Such evaluation is important because airway obstruction tends to occur at two vertical areas, either at the level of the soft palate or at the tongue base.[13,14] If specific skeletal movement changes are found to predict the vertical position of the MCA, the orthodontic setup and surgical movement can be planned to improve upon or at least minimize negative effects on the airway.

Materials and methods

IRB approval was obtained from the University of Oklahoma (OU). The patient pool obtained from the OU Oral and Maxillofacial Surgery Department used in this study was also used in a recently published article on the pharyngeal airway and orthognathic surgery.[9] This retrospective study included 71 total subjects that met the inclusion criteria of 35 Class II patients and 36 Class III patients as determined cephalometrically. The patients' preoperative lateral cephalograms were used for classification. Class II patients had positive overjet and ANB and Class II posterior buccal segments. Class III patients had negative overjet and ANB and Class III posterior buccal segments. Positive overjet was defined as the anterior maxillary dentition anterior to the mandibular anterior dentition and negative overjet defined as the mandibular anterior dentition anterior to the maxillary anterior dentition. Class II buccal segments were defined as any maxillary molar position anterior to a Class I designation. Class III buccal segments were defined as the maxillary molar position posterior to a Class I designation. The average age of the 31 male and 40 female patients was 18 years 8 months. Preoperative and postoperative CBCT scans were taken on them after two-jaw orthoganthic surgery using either an Iluma Ultra Cone Beam CT scanner (IMTEC, Ardmore, OK) with a 19 × 22 cm^2 field of view and voxel size of 0.3 mm or a ProMax 3D CT scanner (Planmeca, Roselle, IL) with a field of view of 17 × 20 cm^2 and a voxel size of 0.2 mm. The images included the entire oropharynx, extending at least to the inferior border of C3. Exclusion factors included those without sufficient preoperative or postoperative records, open bites, craniofacial anomalies, and patients not in intercuspation at either time when the scans were made. The same surgeon performed the orthognathic surgery for all patients.

The postsurgical CBCT images were taken from 4 to 14 months postsurgery to allow for decrease of soft tissue inflammation. All scans were performed at 3.8 mA for 40 s at 120 kV (Iluma), or a variable 1–14 mA for 27 s at 90 kV (Planmeca). The patients were instructed to breathe lightly without swallowing while in maximum intercuspation with their head positions standardized (held in the Frankfort Horizontal (FH) plane, parallel to the floor) while they either sat (Iluma) or stood (Planmeca). The scans were reconstructed at 0.3 mm and exported in the Digital Imaging and Communications in Medicine (DICOM) format.

The DICOM files were then loaded into Invivo 5 software for evaluation. The same examiner performed all CBCT data analysis for bony measurements pre- and postoperatively,[9] and a second examiner performed the data analyses for measurement of MCA and vertical position of the MCA as well as changes in its shape. The patient's 3D images were oriented to FH utilizing the software's orientation widget. This served as a reference plane as previously described (Fig. 1).[9] Once oriented, skeletal measurements were performed. For the maxilla, Point A was measured vertically and horizontally. The transverse maxilla was measured from the inner most curvature as well as the vertical position of the PNS. The mandible included both horizontal and vertical measurements at Point D, which is the midpoint of the mandibular symphysis. Point D more accurately represents the vertical and sagittal movement of the bony chin than does Point B, which may not change with rotational movement of the mandible. For the nine patients that underwent genioplasty, Point B was used due to the difficulty in determining Point D after this procedure.

The airway volume measurement option in the Invivo software was used to calculate the MCA