ORIGINAL ARTICLE

AJO-DO

Evaluation of pharyngeal space and its correlation with mandible and hyoid bone in patients with different skeletal classes and facial types

Yuri Nejaim,[a] Johan K. M. Aps,[b] Francisco Carlos Groppo,[c] and Francisco Haiter Neto[a]

Piracicaba, São Paulo, Brazil, and Seattle, Wash

Introduction: The purpose of this article was to evaluate the pharyngeal space volume, and the size and shape of the mandible and the hyoid bone, as well as their relationships, in patients with different facial types and skeletal classes. Furthermore, we estimated the volume of the pharyngeal space with a formula using only linear measurements. **Methods:** A total of 161 i-CAT Next Generation (Imaging Sciences International, Hatfield, Pa) cone-beam computed tomography images (80 men, 81 women; ages, 21-58 years; mean age, 27 years) were retrospectively studied. Skeletal class and facial type were determined for each patient from multiplanar reconstructions using the NemoCeph software (Nemotec, Madrid, Spain). Linear and angular measurements were performed using 3D imaging software (version 3.4.3; Carestream Health, Rochester, NY), and volumetric analysis of the pharyngeal space was carried out with ITK-SNAP (version 2.4.0; Cognitica, Philadelphia, Pa) segmentation software. For the statistics, analysis of variance and the Tukey test with a significance level of 0.05, Pearson correlation, and linear regression were used. **Results:** The pharyngeal space volume, when correlated with mandible and hyoid bone linear and angular measurements, showed significant correlations with skeletal class or facial type. The linear regression performed to estimate the volume of the pharyngeal space showed an R of 0.92 and an adjusted R^2 of 0.8362. **Conclusions:** There were significant correlations between pharyngeal space volume, and the mandible and hyoid bone measurements, suggesting that the stomatognathic system should be evaluated in an integral and nonindividualized way. Furthermore, it was possible to develop a linear regression model, resulting in a useful formula for estimating the volume of the pharyngeal space. (Am J Orthod Dentofacial Orthop 2018;153:825-33)

Craniofacial growth and occlusion are influenced, among other things, by the respiratory function.[1] An impaired nasal respiratory function is associated with airway inadequacy that can result in the habit of mouth breathing.[2] This change in breathing pattern leads to lowering of the mandible and the tongue, and an extended head posture.[3] Changes in normal airway function during the active facial growth period can have a profound influence on facial development by the time a patient comes for orthodontic treatment.[4,5]

Combined orthodontic and orthognathic surgical treatment has become a common modality for the correction of facial deformities. An important aspect of orthognathic surgery is the effect of skeletal movements in the surrounding structures.[6] Maxillomandibular advancement leads to anterior movements of the soft palate, base of the tongue, hyoid bone, and anterior pharyngeal tissues, resulting in increases in the volumes of the nasopharynx, oropharynx, and hypopharynx, and therefore increasing the posterior airway space.[7] Mandibular setback surgery can cause relative narrowing of the pharyngeal airway and a significant posterior movement of the hyoid bone.[8,9]

The hyoid bone is connected to the pharynx, mandible, and cranium by muscles and ligaments. The hyoid bone and its connecting muscles are also part of the oropharyngeal complex. Without the hyoid bone, our facility for maintaining an airway, swallowing,

[a]Department of Oral Diagnosis, Piracicaba Dental School, State University of Campinas, Piracicaba, São Paulo, Brazil.
[b]Department of Pediatric Dentistry, University of Washington, Seattle, Wash.
[c]Department of Physiological Sciences, Piracicaba Dental School, State University of Campinas, Piracicaba, São Paulo, Brazil.
All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Address correspondence to: Yuri Nejaim, Av. Limeira, 901, Areião, Piracicaba, SP, Brazil, 13414-903; e-mail, ynejaim@hotmail.com.
Submitted, January 2017; revised and accepted, September 2017.
0889-5406/$36.00

https://doi.org/10.1016/j.ajodo.2017.09.018

Table I. Measurements

Measurement	*Description*	*Reconstruction*	*Figure*
Pharyngeal space dimensions:			
Anterior nasal spine-posterior nasal spine distance	Line from the most anterior to the most posterior point of hard palate	Sagittal	1A
Shortest distance	Horizontal line on the greatest constriction of pharyngeal space	Sagittal	1B
C1- latero-lateral distance	Horizontal line on the greatest latero-lateral dimension of pharyngeal space oriented at the level of the most inferior point of C1	Axial	2A
C1-anteroposterior distance	Vertical line on the greatest anterior-posterior dimension of pharyngeal space oriented at the level of the most inferior point of C1	Axial	2A
C2-latero-lateral distance	Horizontal line on the greatest latero-lateral dimension of pharyngeal space oriented at the level of the most inferior point of C2	Axial	2B
C2-anteroposterior distance	Vertical line on the greatest anteroposterior dimension of pharyngeal space oriented at the level of the most inferior point of C2	Axial	2B
C3-latero-lateral distance	Horizontal line on the greatest latero-lateral dimension of pharyngeal space oriented at the level of the most inferior point of C3	Axial	2C
C3-anteroposterior distance	Vertical line on the greatest anteroposterior dimension of pharyngeal space oriented at the level of the most inferior point of C3	Axial	2C
Epiglottis-latero-lateral distance	Horizontal line on the greatest latero-lateral dimension of pharyngeal space oriented at the level of the most concave point of epiglottis base	Axial	2D
Epiglottis-anteroposterior distance	Vertical line on the greatest anteroposterior dimension of pharyngeal space oriented at the level of the most concave point of epiglottis base	Axial	2D
Mandible dimensions:			
Anterior-posterior angle of mandible	Angle between the most posterior point of the mandibular condyle, the gonion point and the most inferior border of the mandible body	Sagittal (MIP)	1C
Transverse angle of mandible	Angle between the most anterior point of the mandibular symphysis and the gonion point on right and left sides of the mandible	Axial	3A
Latero-lateral distance of mandible	Line between the right and left gonion points	Axial	3B
Anteroposterior distance of mandible	Perpendicular line from the most anterior point on the lingual surface of the symphysis to a line between the right and left gonion points	Axial	3C
Hyoid bone dimensions:			
Transverse angle of hyoid bone	Angle between the projections of the lines crossing the lesser and greater horns of right and left sides of hyoid bone	Axial	4A
Latero-lateral distance of hyoid bone	Line between the right and left greater horns	Axial	4B
Anteroposterior distance of hyoid bone	Perpendicular line from the most anterior point in the concavity of the body of the hyoid bone to a line between the right and left greater horns	Axial	4C

preventing regurgitation, and maintaining the upright postural position of the head could not be controlled as carefully.[10]

The use of 3-dimensional (3D) imaging in dentistry, more specifically cone-beam computed tomography (CBCT), has increased considerably in the last years, making possible the evaluation of anatomic structures and analysis of pharyngeal space morphology.[11] Because of its high spatial resolution, adequate contrast between the soft tissues and empty space, and the relatively low radiation dose compared with multislice computed tomography, CBCT is an important tool in the study of craniofacial development.[12,13]

Due to the close relationship between the pharynx, mandible, and hyoid bone and the fact that orthodontic or orthognathic interventions may affect the pharyngeal space,[14] information regarding the influence of skeletal classes and facial types on these structures would improve the diagnosis and treatment of orthodontic patients.

The aim of this study was to correlate the volume of the pharyngeal space, the size and shape of mandible and the hyoid bone in patients with different facial types and skeletal classes. Furthermore, we estimated the volume of the pharyngeal space with a formula using only linear measurements.

MATERIAL AND METHODS

This study was approved by the research ethics committee of Piracicaba Dental School, State University of Campinas, in Brazil with protocol number 092/2014.

This retrospective study was performed on a batch of previously taken CBCT volumes (i-CAT Next Generation; Imaging Sciences International, Hatfield, Pa) at 120 kV, 5 mA, 23 × 17-cm field of view, 0.4-mm voxel, and 40-second scanning time, with indication for orthodontic treatment or orthognathic surgery planning. The CBCT examinations were made with each subject sitting upright, and with the Frankfort horizontal plane parallel