

Three-Dimensional Measurements of Pharynx Structures in Malocclusion

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ABSTRACT

Background/Objectives: The present study was conducted to examine differences between malocclusion the pharynx by reconstructing 3D images from CBCT data using the Mimics program, which allows actual measurement values to be acquired that are not affected by image distortion.

Method/Statistical Analysis: The subjects were analyzed by dividing them into malocclusion of classes I, II, and III (with each group comprising five participants) according to their facial skeletal forms. DICOM images were 3-dimensional ones manufactured by using the 3-D image program(Mimics 17, Materialise, Leuven, Gelgium). Upper airways in subjects of class I,II and III were divided into rhinopharynx, oropharynx and laryngopharynx.

Findings: The volume of the nasopharynx was 11521.9600 for class I, 11925.5850 for class II, and 13167.2800 for class III; the corresponding values for the oropharynx were 10946.0500, 8547.6125, and 12126.3125, respectively, indicating no significant differences. The volume ratio of the nasopharynx was 51.0534 for class I, 58.1387 for class II, and 51.9762 for class III; the corresponding values for the oropharynx were 48.9466, 41.8613, and 48.0238, respectively, also indicating no significant differences

Improvements/Applications: However, the present 3D measurements based on data measured in two dimensions are expected to facilitate future studies and provide basic data for them.

Keywords: *pharynx, malocclusion, 3D, Pharyngeal, CBCT*

Introduction

The respiration function has a huge impact on maxillofacial growth and development, with the environmental factor of mouth breathing known to be closely related to malocclusion¹⁻². Mouth breathing is likely to result in problems related to occlusion, such as palatal stricture, posterior crossbite, and anterior open bite, and it also may increase the anterior facial height and lower the position of the tongue by affecting the skeletal structure³. These features have led to considerable interest in the relationship between mouth breathing and facial form, and the number of studies evaluating pharynges based on the skeletal form has been

increasing¹⁻¹¹. Mouth breathing and airway obstruction have been reported to be related to malocclusion of Angle class 2 and division 1⁴. Some studies have evaluated the pharynges according to malocclusion, with recent ones examining the relationship between breathing during sleep and the pharynx¹²⁻¹⁸.

A representative case is snoring sometimes being accompanied by sleep apnea and obstructive sleep apnea¹⁶. Such obstructive sleep apnea occurs as the pharyngeal airway is narrowed during sleep due to macroglossia, a posterior position of the mandible, and a receding chin¹⁷. Previous studies have found a high incidence of obstructive sleep apnea in malocclusion of Angle class 3¹⁹⁻²⁰. Sleep apnea may therefore seem to be significantly affected by the pharyngeal size, depending on the severity of the Angle malocclusion. Although previous studies have tended to measure the pharyngeal form using cephalometric images, recent studies have observed pharyngeal forms by building three-dimensional (3D) images based on CT and MRI¹⁻¹¹.

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However, there are some limitations when establishing pharyngeal forms based on constructing 3D images based on CT and MRI²¹. The present study was conducted to examine differences between malocclusion of classes I, II, and III and the pharynx by reconstructing 3D images from CBCT data using the Mimics program (version 17, Materialise, Leuven, Belgium), which allows actual measurement values to be acquired that are not affected by image distortion.

Materials and Method

Subjects: CBCT data of 15 male adults without missing or asymmetric teeth or psychological disorders from among orthodontics patients at Danguk University Dental Hospital were provided by the Department of Oral and Maxillofacial Radiology. The subjects were analyzed by dividing them into malocclusion of classes I, II, and III (with each group comprising five participants) according to their facial skeletal forms. This study was approved by the institutional review board of Danguk University Dental Hospital (approval no. DUDH IRB 2015-12-022).

Method

Reconstruction of Three-Dimensional Images: CBCT data of the subjects were obtained in DICOM format using a CBCT scanner (Alphard 3030, Asahi, Kyoto, Japan), and CT scanning was carried out with the following parameters: slice increment, 0.39 mm; slice thickness, 0.39 mm; and matrix, 512 px * 512 px.

The DICOM images were 3D images that were reconstructed using 3D image processing software (Mimics version 17, Materialise). The nasopharynx, oropharynx, and laryngopharynx parts of the upper airways of the subjects were categorized into malocclusion of classes I, II, and III.

Reference Points: The following reference points were measured [Figure. 1, Figure. 2, Figure. 3]:

1. **Nasopharynx:** from the posterior bone of the hard palate to the border below the sphenoid bone underneath the sinus.
2. **Oropharynx:** from the posterior end border of the soft palate to the middle and anterior borders of the second cervical vertebrae.
3. **Laryngopharynx:** from the posterior border of the hyoid bone to the low and anterior borders of the third cervical vertebrae.

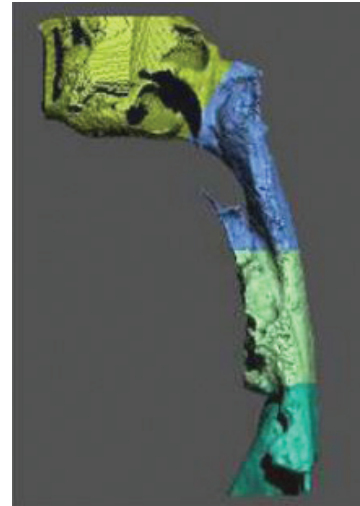


Figure 1: Three –Dimensional measurement of pharyngeal structures in malocclusion case (Class I)



Figure 2: Three–Dimensional measurement of pharyngeal structures in malocclusion case (Class II)



Figure 3: Three–Dimensional measurement of pharyngeal structures in malocclusion case (Class III)

Measurement Items

The following parameters were measured:

1. Nasopharynx volume.
2. Oropharynx volume.
3. Nasopharynx volume ratio.
4. Oropharynx volume ratio.

Statistical Analysis

The measurement items were analyzed using SPSS (version 23.0, SPSS, Chicago). The presence of significant differences was tested using a regularity test, and one-way ANOVA was applied due to a small number of the subjects. The average differences according to each class was tested by conducting a posttest with a 95% confidence interval ($p=0.05$).

Results and Discussion

The volume of the nasopharynx was 11521.9600 for class I, 11925.5850 for class II, and 13167.2800 for class III; the corresponding values for the oropharynx were 10946.0500, 8547.6125, and 12126.3125, respectively, indicating no significant differences. The volume ratio of the nasopharynx was 51.0534 for class I, 58.1387 for class II, and 51.9762 for class III; the corresponding values for the oropharynx were 48.9466, 41.8613, and 48.0238, respectively, also indicating no significant differences [Table 1].

The breathing function is one of the environmental factors of malocclusion that plays an important role in maxillofacial growth and development, and is also known to be closely related to the occurrence of malocclusion⁸⁻⁹. Lee et al.² reported that the presence of more-serious mandibular protrusion in patients with class III malocclusion resulted in a larger laryngopharyngeal width. Lee et al.¹¹ reported that maxillofacial growth can be affected by maxillary retrusion and mandibular posteroinferior rotation when mouth breathing is present.

In addition, pharynges related to the respiratory and digestive systems are also closely associated with maxillofacial growth and occlusal disorder, since they

are connected inside the mouth and to adjacent skeletal structures⁷. Ricketts⁸ reported that the pharyngeal effects on the skeletal structure may vary depending on size, and mouth breathing can occur if the adenoid of the nasopharynx is large. In addition, Lixa et al.¹⁴ reported that the size of the pharynx is associated with stroke, and Yun et al.¹⁴ also indicated that the size of the pharynx affects sleep apnea.

While many studies have investigated the pharynx, quantitative measurements have been lacking. Most of the preliminary studies measured the size of the pharynx using lateral cephalometric radiography, CT, or MRI¹⁻¹⁸. The present study therefore used the Mimics program in an attempt to identify differences between the pharynges in 3D images obtained from CBCT data and in the presence of malocclusion of classes I, II, and III.

This study found that the rhinopharynges are larger in malocclusion of class I than in classes II and III, whereas Lee et al.² reported that the rhinopharynges are larger in malocclusion of classes II and III than in class I. These discrepancies could have been due to errors in the measurements made on cephalometric radiographs²¹. The results of the present study are similar to those of Kim et al.¹, who found that the oropharynx was larger in class III than in class I, probably due to mandibular protrusion being more serious in class III skeletal structures¹¹. The present results are also similar to Fakhri et al.⁵ finding that the nasopharynx was larger in class II than in the other two classes, probably due to greater maxillary protrusion¹¹. Finally, the present study found that volume ratios of the oropharynx were higher in class I than in class III, whereas Kim et al.¹⁰ obtained the opposite result, probably due to errors.

The size of the pharynges appears to vary between skeletal structures of classes I, II, and III, and hence further studies are needed to clarify the situation. This study is considered to have been limited by the small number of subjects resulting in no statistically significant differences between the size of pharynges among classes I, II, and III. However, the present 3D measurements based on data measured in two dimensions are expected to facilitate future studies and provide basic data for them.

Table 1: Comparison of Pharynges According to Malocclusion Class

	Class I Mean (SD)	Class II Mean (SD)	Class III Mean (SD)	P*
Nasopharynx	11521.9600 (3595.04708)	11925.5850 (1306.05734)	13167.2800 (2089.73790)	0.643
Oropharynx	10946.05500 (2755.05117)	8547.6125 (539.30330)	12126.3125 (1689.51491)	0.067
Volume ratio of nasopharynx	51.0534 (2.46665)	58.1387 (3.97881)	51.9762 (5.33349)	0.074
Volume ratio of oropharynx	48.9466 (2.46665)	41.8613 (3.97881)	48.0238 (5.33349)	0.074

Conclusion

This study examined the size of the pharynges according to different classes of malocclusion by comparatively analyzing the pharyngeal forms in patients with malocclusion of classes I, II, and III by reconstructing images derived from CBCT into 3D ones. The results can be summarized as follows:

1. The size of the nasopharynx was 11521.9600 for class I, 11925.5850 for class II, and 13167.2800 for class III, with no significant differences ($p>0.05$).
2. The size of the oropharynx was 10946.0500 for class I, 8547.6125, for class II, and 12126.3125 for class III, with no significant differences ($p>0.05$).
3. The volume ratio of the nasopharynx was 51.0534 for class I, 58.1387 for class II, and 51.9762 for class III, with no significant differences ($p>0.05$).
4. The volume ratio of the oropharynx was 48.9466 for class I, 41.8613 for class II, and 48.0238 for class III, with no significant differences ($p>0.05$).

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Source of Funding: Self

Conflict of Interest: Nil

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