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An Investigation into the Relationship between the Oropharyngeal and Nasopharyngeal Airway Volume and the Palatal Height in Different Vertical Facial Proportions Using Cone Beam Computed Tomography (CBCT)

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Abstract

Introduction: The proper selection of variations in a variety of face patterns is very important for orthodontic diagnosis and treatment. The classification of facial types is directly associated with the growth of the speech and skull and is divided into three different types: Brachy-Facial, Mesio-Facial and Dolicho-Facial. This study investigated the relationship between oral and nasal airway volume and the palatal height in different vertical facial patterns using CBCT images. **Methods:** In this retrospective study cases of 60 patients who were undergone CBCT scans at the Oral and Maxillofacial Radiology Department of Tabriz Dental School were used to assess the oral and nasal airway volume and palatal height. The sample subgroups were determined by the facial vertical ratio into three equal groups. **Results:** The results of the comparison of the volume of nasal airways in the three facial patterns indicated that there was a statistically significant difference between the three groups (p <0.05). The results of the comparison of the volume of oral airways and palatal height in the coronal and sagittal sections in the three facial patterns indicated that there was a no statistically significant difference between the three groups(P> 0.05) **Conclusion:** The results of the comparison of the volume of nasal airways indicated that the highest volume of nasal airway was seen in individuals with short face pattern, while the lowest volume of nasal airway was observed in the long face pattern.

Keywords: Oral and Nasal Airway Volume, CBCT (Cone Beam Computed Tomography), Vertical Facial Patterns, Palatal Height.

Introduction

The type of a person's face involves changes in skull structure and is associated with genetic and environmental factors(Cassidy et al., 1998; McNamara, 1981). The classification of facial types is directly associated with the growth of the speech and skull and is divided into three different types: Brachy-Facial (horizontal growth), Mesio-Facial (balanced growth) and Dolicho-Facial (vertical growth) (Kageyama et al., 2006). The proper selection of variations in a variety of face patterns is very important for orthodontic diagnosis and treatment because certain techniques that are performed during orthodontic treatment may exacerbate or weaken the facial pattern traits (Barbosa et al., 2015). One of the important components in the diagnosis and treatment planning for orthodontics is the patient's respiratory function. The most important elements involved in breathing are upper airways. The upper airways of the pharynx include

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nasopharynx, oropharynx and hypopharynx which play important roles in breathing and swallowing (Ceylan & Oktay, 1995). There is a close association between the size of the airway space and the facial morphology. It should be pointed out that the airway is influenced by the anterior functional shift, head position, anterior-posterior relation, and vertical growth pattern (Uçar & Uysal, 2011).

De Freitas et al. investigated the association between the upper and lower pharyngeal airways in patients with class I and II malocclusions through vertical and normal growth patterns. The results of this study showed that the width of the upper pharyngeal space in subjects with a vertical growth pattern was lower than those with normal growth pattern, and these changes were statistically significant. It was also found that the type of growth pattern affects the upper pharyngeal space, while it does not affect the lower pharyngeal space (de Freitas et al., 2006). In addition, Pae et al. examined the pharyngeal length in patients without peripheral states. They were able to see the relationship between the airway length and the vertical growth of the face and found that individuals with vertical growth patterns had a longer airway than those with normal growth patterns on average. They also found a significant relationship between hyoid bone distance to mandibular plane and a specific growth pattern. In individuals with a vertical growth pattern, this distance was higher than the average (Pae et al., 1997).

Nowadays, radiographic assessment in dentistry is not limited to conventional and panoramic and intraoral radiography (Sogur et al., 2009). Intraoral radiography provides useful information for determining the presence and location of periradicular lesions, root canal anatomy and the proximity of anatomical structures (Patel et al., 2009), but it also has limitations that can be attributed to the two-dimensional nature of images and anatomical collisions or a combination of these factors (Patel, 2009). Recently, CBCT images have become increasingly important in dentistry, which is able to produce images in various designs that enhance the diagnostic efficiency (Santos et al., 2013). Given the fact that the CBCT imaging provides clear high-contrast images for head and face and is suitable for bone examination, this study aimed to investigate the relationship between oral and nasal airway volume and palatal height in subjects with different vertical facial patterns. The limitations of linear and 2D lateral cephalometric stereotypes as well as the advantages of CBCT, such as three-dimensional images, high resolution, and lower doses compared to CT were taken into consideration (Gröndahl , 2004; Pinsky, 2006).Owing to the fact that the height of hard palate in the patients susceptible for skeletal anchorage by the mini palatal implants is the key to start the surgery, the precise examination of the palatal height is necessary. Since this surgery may cause damage to structures near mini-implants such as nasal floor.This study was conducted to examine the oral and nasal airway volume and the palatal height in different vertical facial patterns in order to increase the accuracy of orthodontic treatments and investigate the physiological changes of the airway.

Method

This is a descriptive-analytic study. The CBCT images of 60 patients referring to Oral and Maxillofacial Radiology Department of Tabriz School of Dentistry constitute the statistical population of this study. All the calculations related to soft tissue and bone shape and airway volume were performed by computer software. The research data were collected by CBCT images and computer software.

The inclusion criteria included all the patients who referred to this facility for any reason for CBCT imaging. These patients did not have dental and facial asymmetries, Torus Palatinus and anomalies in the head and neck. The exit criteria included individuals with history of malformation or syndrome, trauma in the head and face, frontal sinus surgery, maxillary and mandibular surgery, orthodontic treatment, systemic disease, taking medication which would affect bone density and patients who are just growing teeth.

The data obtained from CBCT (cone beam computed tomography) was inserted in the software NNT viewer version 2.21. Patients' images were reviewed on a Liquid Crystal Display (LCD) Philips (190B) 19-inch desktop computer with a resolution of 1024*1208 and 32 bits.

In order to put individuals in different groups in terms of the shape of the face (normal, long, or short), the lateral views that the device produces as a scout were used. Then, angular assessments were performed. The facial type was determined based on the SN.GoGn angle. According to the obtained SN.GoGn angle, the subjects were classified according to the following criteria: brachyfacial, ≤27°; mesofacial, between 27°and 37° and dolichofacial, SN.GoGn ≥37°.

In order to analyze oral and nasal airway volume Mimics 10.10 software was used. In order to define the volume of nasopharynx,in sagittal view, a vertical line determined from PNS to the height of the pterygomaxillary fissure and a horizontal line determined from PNS to the posterior pharyngeal wall. Finally, area which was limited by these two lines were collected from data. In order to define the volume of the oropharynx, in sagittal view area between hard palate and epiglottis were collected from data. Then, the volume of both airways, measured by Mimics 10.10 software separately.

To measure the palatal height, the bone height in the anterior region of the hard palate was assessed at the level of the maxillary first premolars. First, in the axial view, the mid-sagittal plane of the patient and the maxillary first premolar region were defined, superimposing the sagittal and coronal lines, respectively. The maxillary first premolar region was defined by the plane that overlaps the root canals of both right and left first premolars. For bone height assessment, linear measurements were performed in sagittal and coronal planes, using the ruler tool of the software. In the sagittal view, the measurement was performed between the outer cortical layer of the nasal floor and the cortical layer of the oral hard palate, superimposed to the coronal orientation line. Next, in the coronal view, the palatal bone height of the median and Para median regions were assessed. The median/central site was assessed superimposing the measurement on the orientation line of the sagittal plane. Then, the Para median sites were defined and evaluated 3 mm and 6 mm bilaterally to the central measurement.

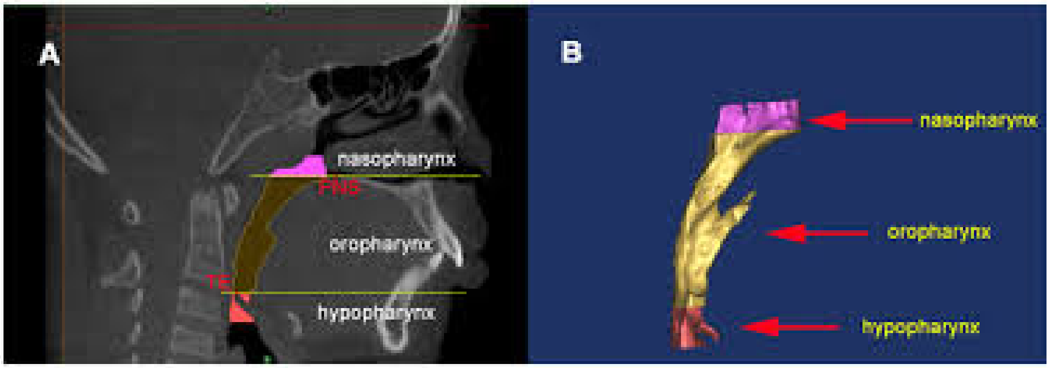

Fig. 1: Upper Airway Volume

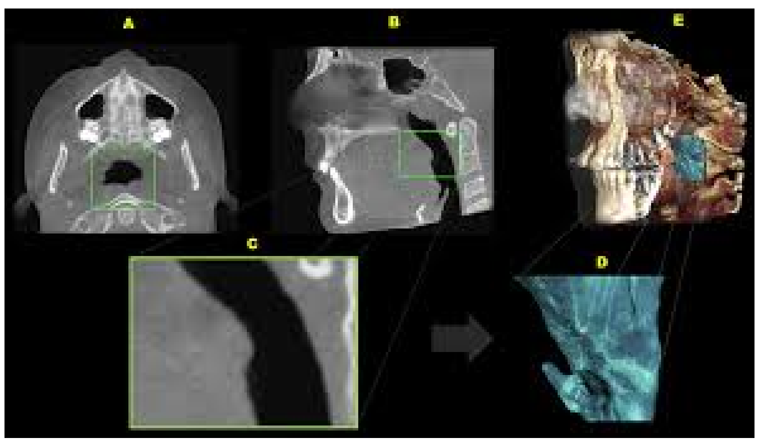

Fig. 2: Oropharyngeal Airway Volume

Fig. 3: Palatal Height in Coronal and Sagittal view

The data were reported using descriptive statistical methods (mean ± standard deviation and frequency). In order to compare the volume of the airway between three types of facial shapes, one-way variance and analysis was used in the case of normal distribution of data. However, Kruskal-Wallis test was used in the case of abnormal distribution of data. The normality of data was analyzed using

Kolmogorov-Smirnov test. Statistical analysis was performed using SPSS 17 software. In all cases, the significance level (P) was less than 0.05.

Results

This retrospective study was descriptive and analytical in which the cases of 60 patients with CBCT images was studied. In this study, 34 women (56.7%) and 26 men (43.3%) participated. The number of individuals with a short face, a normal face and a long face pattern was equal and 20 people were selected in each group. The mean age of the patients was 4.54 ± 28.45 years. The youngest and oldest participants were 20 and 35 years old, respectively. The mean oropharynx volume, the mean volume of nasopharynx, the mean height of the palate in the coronal section and the mean height of the palate in the sagittal section were respectively 16923.47 ± 7145.41, 6702.77 ± 2035.78, 6.702, 7.37 ± 2.58 and 7.24 ± 2.36.

At first, the Kolmogorov-Smirnov test was used to evaluate the normality of the data. It was found that all indices have a normal distribution. One-way variance and analysis was used to compare the volume of oral and nasal airways in three types of facial patterns. It was found that there was no statistically significant difference between the volume of oral airway in three types of facial patterns (P-value = 0.912). The highest and lowest mean oral airway volume was found in the Short Face group and the Long face group, respectively. There was a statistically significant difference between the volume of nasal airway in three types of facial patterns (P-value = 0.009) (Table 1). Tukey's test was utilized to compare these two groups, given the homogeneity of the variance of this variable in the groups (P-value = 0.064). The results indicated that there was a significant difference between the volume of the airway between the two long face and short face patterns (P-value = 0.007). The highest and lowest volume of nasal airway was observed in individuals with a short facial pattern and in those with long facial pattern, respectively.

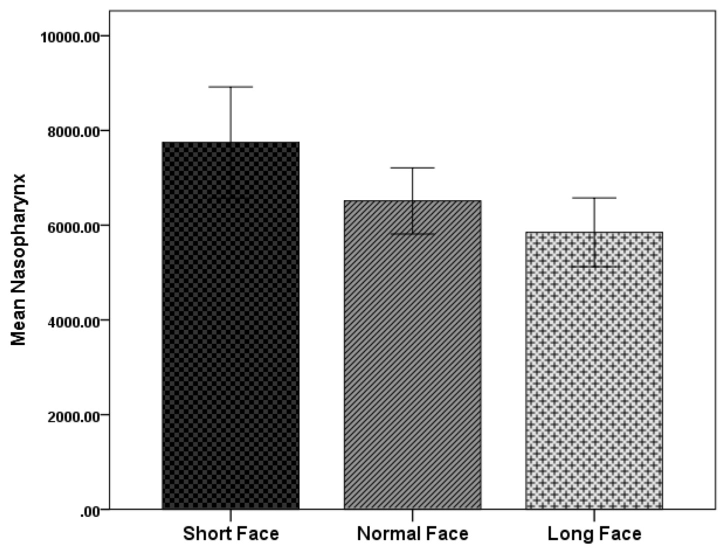

Chart. 1: Comparison of Nasal Airway Volume in Three Types of Facial Patterns

Furthermore, the comparison of the palatal height in the coronal section in three types of facial patterns revealed that there was no statistically significant difference between the palatal height in the coronal section in the three types of facial patterns (P-value = 0.101). The highest and lowest palatal height in the coronal section was observed in individuals with normal facial pattern and those with long facial pattern, respectively. Finally, the palatal height was compared in sagittal section in three types of facial patterns by one-way analysis of variance. It was found that there was no significant difference between the palatal height in sagittal section in the three types of facial patterns (P-value = 0.135). The highest and lowest palatal height in the sagittal section was observed in individuals with short facial pattern and long facial pattern, respectively.

Discussion

Determining changes in the various face patterns appropriately is very important for orthodontics diagnosis and treatment because the special methods performed during orthodontics treatment may intensify or weaken the face pattern characteristics. Morphologic changes may occur in the different structures such as hardpalate, the complex structure of maxillofacial that are involved in the all stages of craniofacial development and evolution (Barbosa et al., 2015)

CBCT technique has been demonstrated as an accurate method to measure bone dimensions related to the palatal regions and determining bone density in the Hounsfield units. Also it has been found that height and width of bones can be measured easily through the technique, then the most appropriate treatment can be chosen. Therefore, considering the findings,the CBCT method can be used to measure quality and quantity of palatal block . Given the musculoskeletal and anthropometric differences among different ethnicities, in this retrospective descriptive-analytic research the relations between palatal height, volume of oral and nasal airway with face patterns in different patients was examined through cone beam computed tomography scanning (CBCT). In this method instead of linear measurements, the surface three dimensional visual models were used to compute airway volume. Subgroups of the samples were determined by the vertical jaw relationships.

Results concerning the oral airway volume in the three face pattern types showed that there isn't statistically significant difference among the three groups (0.05<p-value) and the highest average belong to the shorts face group and the smallest average belong to the long face group.

Moreover, results concerning to comparison of nasal airway volume also determined that there is statistically significant difference among the three under study groups, such that the most of the nasal airway volume belong to individuals with short face pattern and the smallest belong to individuals with ling face pattern. In the study of Shahidi et al. who compared the airway volume between individuals with cleft palate and lip and normal people through CBCT images, the average volume of upper airways and palate in the cleft palate was significantly lower than non-cleft group, but the lower airway volume didn't show a significant difference between the two groups. Also findings determined that upper and lower airway volume has significant difference with each other in the cleft group.

Results of Dan Grauer et al. in 2009 demonstrated the relationship between lower airway volume and dimensions of anterior-posterior jaw. As in this study there was a significant relation between airway volume and face size and gender, whilst no difference was observed between airway volume and vertical facial proportions. These results shows that volume and shape of airways volume and shape are variable in patients with different of anterior-posterior jaw relations; but among individuals with different vertical facial proportions, different volumes not observed.

Moreover, previous studies have found that depending on the type of face, palate shape can be deep and narrow in dolicofacial individuals while in brachifacial individuals is shallow. Therefore, it can be expected that based on the palate form, the volume of oral and nasal airway is different among different people.

In this study also palate height in the coronal section in the three facial patterns was compared that results didn't show any significant difference between palate heights in coronal section in the three facial patterns. The most palate height in the coronal section was for normal facial pattern and the smallest was for long facial pattern. Also following the measurement of palate height in coronal section, in this study the palatal height in sagittal section was measured that no significant difference was observed among the three study group in this case as well. Yet the most palatal height in the sagittal section was for short facial pattern and the smallest was for individuals with long facial pattern. In 2015, Rezende Barbosa GL et. al. performed measurements in the sagittal and coronal views in the median and Para median regions and no statistically significant difference was observed among the palatal bone height in the first premolar region and different type of faces (Barbosa et al., 2018)

In the Freitas et. al. study it was found that upper throat space width in individuals with vertical growth was less than individuals with normal growth pattern and these changes was significant statistically and these results showed that the type of development pattern influences on the upper throat space and doesn't influence on the throat lower space (de Freitas et al., 2006). Also Pae et. al. could show the relationship of airway length with vertical growth of face and found that individuals with vertical growth pattern have an average airway length larger than individuals with normal growth pattern. They also found that in individuals with vertical growth pattern, the Hyoid bone distance to Mandibular plan is higher on average (Pae et al., 1997).

Given the results of different studies, contradictory results are observed regarding the throat space dimensions and craniofacial structures. Some of them have pointed to dimensions of airway in the variety of posterior-anterior skeletal relations and others have pointed to existence of a relation between vertical growth pattern and upper and lower airway obstruction (. In view of these findings can refer to an anatomical factor of the palate and ducts of the respiratory tract as a predisposing factor to respiratory tract obstruction. Therefore, in people with a long face pattern the oral and nasal airway volume have been reduced compared to other people. (Pae et al., 1997).

Final Conclusion

1. Findings of this study show that palatal height in sagittal and coronal sections as well as oral and nasal airway volume is different in individuals with different facial patterns.
2. The results of the comparison of the volume of nasal airways in the three facial patterns indicated that there was a statistically significant difference between the three groups. The highest volume of nasal airway was seen in individuals with short face pattern, while the lowest volume of nasal airway was observed in the long face pattern.
3. The results of the comparison of the volume of oral airways in the three facial patterns indicated that there was a no statistically significant difference between the three groups
4. The results of the comparison of palatal height in the coronal and sagittal sections showed that there was no statistically significant difference between the palatal height in the coronal and sagittal sections in the three types of facial pattern

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