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Pharyngeal airways and hyoid bone position in different skeletal patterns based on ANB angle

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Abstract

There is a close relationship between the pharyngeal airway space and position of hyoid bone. Patients`s respiratory function is very important in the orthodontic treatment process. The aim of this study was to evaluate pharyngeal airways and hyoid bone position in different skeletal patterns based on ANB angle. In this retrospective, analytical study 99 digital lateral cephalometeric images were taken in NHP selected from Radiologic department of Dental School of Ahvaz Jundishapur Medical University in 2021-2022.The variables reletad to pharyngeal airway depth, linear and angular measurements of hyoid bone were measured. Data were analyzed by variance test and Tukey HSD by using SPSS software version22. Significance limit was $P \leq 0.05$. There were significant differences in the following variables:1- Depth of the nasopharynx in the cl I and cl III malocclusion 2-Depth of the oropharynx and hypopharynx between skeletal cl III and cl I & II. 3-Distance of H - pp, H -Mp, H-c3 skeletal. H-RGn in the cl III from cl II. 4- LAH- Mp angel in the skeletal cl I&II and skeletal cl III. But there was no significant difference in the LAH_pp angel between skeletal cl I &II and cl III. According to the study:1)Decrease the depth of the nasopharynx and increase the depth of oropharynx and hypopharynx in the skeletal cl III malocclusion,2) decrease hypopharynx depth in skeletal Cl II malocclusion,3) increase nasopharynx depth in the skeletal Cl I.The hyoid bone was more posterior in the skeletal cl II and more inferior and anteriorly in the skeletal cl I. Position of the hyoid bone in the skeletal cl III was more anteriorly than skeletal class I and CL II.

Keywords: Airway space, Hyoid bone, Lateral cephalogram, Malocclusion.

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1. Introduction

One of the most important components in the diagnosis and treatment planning in Orthodontics is the patient's respiratory function [1]. The lateral cephalograms can used for evaluation relationship between craniofacial structures and pharyngeal airways in the patients with different skeletal patterns [2].

The airway spaces of the throat, tongue, and hyoid bone have connection with each other. The hyoid bone is a v-shaped bone in the front of neck and hanging from the tip of styloid proccess in the temporal bone by stylohyoid ligaments. This bone consists of a body and two small lesser horns and two large greater horns [3-10]. The connections of the hyoid bone with the throat, mandible, and cranium were through muscles and ligaments and according to this connection it`s position determines the status of the tongue. It also has an important role for maintaining airway and natural upright position [5-18]. Different craniofacial skeletal patterns have different mandibular position and morphologies, which might be affected by the position of the hyoid bone and depth of the pharyngeal airway [3-5].
During orthodontic treatment, position of hyoid bone may be change, thus evaluation hyoid bone position and it's relation to the tongue is an important factor and in overall the airway must be assessed [6]. The upper airways of the throat include the nasopharynx, oropharynx, and hypopharynx, which play an important role in respiration and swallowing [8]. Cephalometric analysis provides important information about the soft and hard texture of the upper airway [8, 10, 26-32]. By using cephalometry, in addition to reducing the cost and patient exposure, reliable and repeatable information in the field of airway can be obtained. Studies have shown that although the resulting measurements provide two-dimensional information, they are a reliable method for assessing the airway as well as estimating adenoid size [8].The size of the larynx space is determined by the relative growth and size of the soft tissue around the dentofacial skeleton [9,10].The ANB angle is

used to determine the anterior-posterior relationship of the maxilla and mandible [11]. Riedel suggested the use of SNA, SNB and ANB angles and the ANB angle is known as a marker of skeletal sagittal disorder which is the most common measurement criterion for sagittal relationship [12].One of the most important records for presurgical evaluation in Orthognathic surgery is P.A and lateral cephaograms[13].Dental and skeletal relationships, soft tissue analysis and pharyngeal relationships,tongue and hyoid bone positions can be assessed in cephalometric analysis[14]. Most of the new information in craniofacial growth pattern and naso pharyngeal evaluation consist on cephalometric studies [15,16]. The Pharyngeal space divided in three spaces: Nasopharynx, Oropharynx and hypopharynx [17]. Researchers have shown decrease in depth of the airways in the various skeletal anomalies such as retrognathism of the maxilla and mandible. There is a close relationship between the pharyngeal airways and the position of the hyoid bone and importance of patients' respiratory function in orthodontic treatment was obvious [18-25].

In this study, we evaluated the pharyngeal airway space and the position of the hyoid bone in 3 skeletal classification based on the ANB angle. Our question was: Is there relation between nasopharyngeal airways and skeletal malocclusions?

2. Materials and methods

This study was performed by using 99 digital lateral cephalometric images (range of 18 to 25 years) selected from archive of the Radiologic department of Dental School of Ahvaz Jundishapur Medical University in 2021-2022. All radiographs were taken in the NHP and with the same machine (Planmeca scara3, finland). The inclusion criterias were:1) Normal anatomy of the head and neck area (absence of congenital or syndromic diseases),2) Absence of pathological lesion, 3) No history of orthodontic and surgical treatment, 4) Proper quality of stereotypes. To ensure the desired quality and standard of the stereotypes, selection of radiographs was evaluated under the supervision of an orthodontist (corresponding author) and maxillofacial radiologist.

The Wits appraisal was used to determine the horizontal relationship of the jaws and the Steiner analysis for assessment the ANB angle. For each stereotype, three measurements were performed to determine the depth of the nasopharynx, oropharynx and hypopharynx. To determine the depth of the nasopharynx: we use a line from PNS (posterior nasal spine) to Upper pharyngeal wall, and for depth of oropharynx: a line from uvula to Middle pharyngeal wall and to determine the depth of hypopharynx: We drew a line from vallecula to Lower pharyngeal wall and measured in millimeters.

For assess the hyoid bone in the lateral cephalogram 6 linear and angular measurements were used by Audax Ceph Ultimate v6.1.4.3951 software. The variables were used in the study:

1) H-MP: Vertical distance from the superior-anterior point on the body of the hyoid bone (Hyoidal: H) to the mandibular plane (MP).

2) H-PP: Vertical distance from H(hyoidal) to the palatal plane (PP).

3)H-C3: Distance from H to the most inferior and anterior point of the 3rd cervical vertebra (C3).

4) H-RGn: Distance from H to the most posterior point of the mandibular symphysis (Retro-gnathion (RGn)).

5) LAH-MP: Angle formed between the long axis of the hyoid bone (LAH) and the mandibular plane (MP).

6) LAH-PP: Angle formed between the long axis of the hyoid bone (LAH) and the palatal plan (PP).

The reference points, lines and plans used in the lateral cephalogram were described in fig1. All data were recorded and assessed by statistical analysis.

3. Results and discussions

According to the one-way analysis of variance (ANOVA) there were significant differences between the means of nasopharyngeal, oropharyngeal and hypopharyngeal depth in all of skeletal classifications (I, II and III) (p <0.001) (Table 1). Due to the significance of ANOVA test, LSD post hoc test was used to compare the two skeletal classes studied in pairs (Figure 1).

Table 1. Mean, standard deviation and ANOVA test results for comparison of three skeletal classes in nasopharyngeal depth

depth	Class III skeletal	Class II skeletal	Class I skeletal	*p*.value
	M ± SD	M ± SD	M ± SD	
Nasopharyngeal (mm)	33.75 ± 4.48	35.37 ±4.83	40.22 ± 4.04	<0.001
oropharynx (mm)	12.80 ± 4.11	9.54 ± 1.91	10.19 ± 2.95	<0.001
hypopharynx (mm)	16.56 ± 5.42	12.76 ± 2.5	13.35 ± 3.15	<0.001
Note. M=Mean, SD=Std. Deviation				

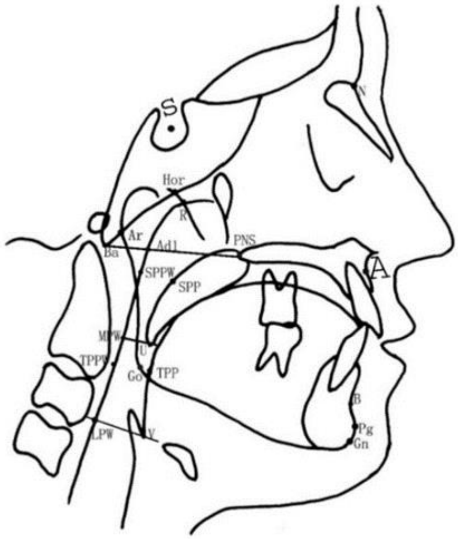

Figure 1a. Landmarks used in the study [18].

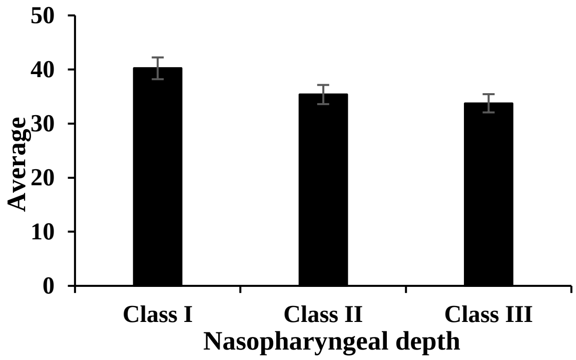

Figure 1b. Averages of nasopharyngeal depth in three skeletal classes

LSD test results showed a comparison of two skeletal classes; the mean depth of class I skeletal nasopharynx was significantly higher than class II skeletal type (4.84 mm) and significantly higher than class III skeletal 6.46 mm ($p < 0.001$). There was no significant difference between the means of class II skeletal nasopharyngeal depth compared to class III skeletal ($p = 0.145$). Due to the significance of ANOVA test, LSD post hoc test was used to compare the two skeletal classes in the depth of the oropharynx (Figure 2). The results of LSD test by comparing two skeletal classes showed; There was no significant difference between the mean of orthopharyngeal depth of skeletal class I compared to class II skeletal ($p = 0.399$) but was significantly lower than skeletal class III (2.62 mm) ($p = 0.001$). The mean depth of skeletal class II oropharynx was significantly lower by 3.26 mm compared to class III skeletal ($p < 0.001$).

Due to the significance of ANOVA test, LSD post hoc test was used to compare the two skeletal classes in depth of hypopharynx (Figure 3).

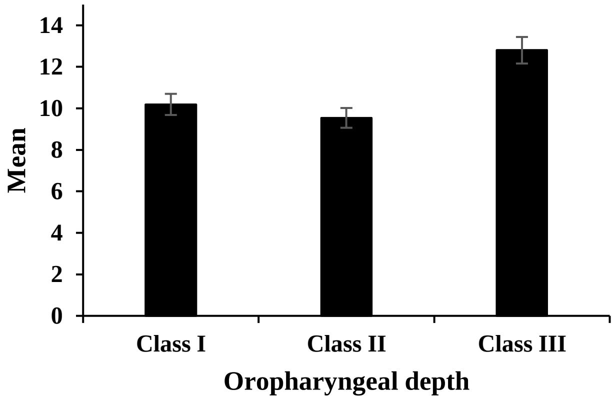

Figure 2. Mean of oropharyngeal depths in three skeletal classes

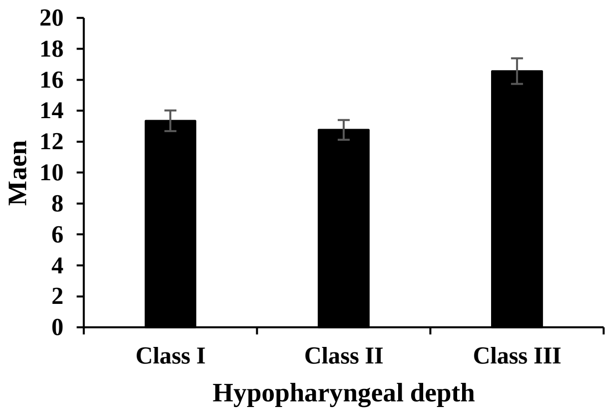

Figure 3. Means of hypopharyngeal depth in three skeletal classes

The results of LSD test by comparing two skeletal classes showed; There was no significant difference between the means of skeletal hypopharyngeal depth of class I compared to class II skeletal ($p = 0.539$). The mean depth of skeletal class I hypopharynx was significantly less than 3.21 mm compared to class III skeletal ($p = 0.001$). The mean depth of skeletal hypopharynx of class II skeletal compared to class III skeletal was significantly lower by 3.80 mm ($p < 0.001$).

The results of ANOVA test showed that there was a significant difference between the means of distance H to Mp, distance H to pp, distance H to c3 and distance H to RGn in three skeletal classes I, II and III ($p < 0.05$) (Table 2). Due to the significance of ANOVA test, LSD post hoc test was used to compare the two skeletal classes in distance between H to Mp, distance H to pp, distance H to c3 and distance H to RGn (Table 3).

Table 2. Mean, standard deviation and ANOVA test results for comparison of three skeletal classes

Distance (mm)	Class III skeletal	Class II skeletal	Class I skeletal	*p*.value
	M ± SD	M ± SD	M ± SD	
H to Mp	11.39 ± 4.65	4.60 ± 2.85	7.55 ± 3.05	<0.001
H to pp	57.72 ± 7.39	41.02 ± 6.27	51.24 ± 5.24	<0.001
H to c3	37.61 ± 5.44	28.60 ± 2.86	30.61 ± 4.22	<0.001
H to RGn	30.01 ± 3.33	39.83 ± 5.42	36.00 ± 6.75	<0.001
Note. M=Mean, SD=Std. Deviation				

Table 3. Double comparisons of three skeletal classes in the distance R to Mp

Distance (mm)	Class (I)	Class (J)	Class Differences (I-J)	SE	*p*.value
H to Mp	Class I	Class II	2.95	0.89	<0.001
	Class I	Class III	-3.84	0.89	<0.001
	Class II	Class III	-6.79	0.89	<0.001
H to pp	Class I	Class II	10.21	1.57	<0.001
	Class I	Class III	-6.48	1.57	<0.001
	Class II	Class III	-16.69	1.57	<0.001
H to c3	Class I	Class II	2.01	1.07	0.063
	Class I	Class III	-7.00	1.07	<0.001
	Class II	Class III	-9.01	1.07	<0.001
H to RGn	Class I	Class II	-3.84	1.32	0.005
	Class I	Class III	5.99	1.32	<0.001
	Class II	Class III	9.82	1.32	<0.001

Table 4. Mean, standard deviation and ANOVA test results for comparison of three skeletal classes in angle

Degree	Class III skeletal	Class II skeletal	Class I skeletal	*p*.value
	M ± SD	M ± SD	M ± SD	
LAH angle up to Mp	-3.30 ± 9.69	4.06 ± 2.68	5.61 ± 4.20	<0.001
LAH angle up to pp	18.25 ± 8.92	20.60 ± 7.79	14. 78 ± 6.24	0.012
Note. M=Mean, SD=Std. Deviation				

Table 5. Double comparisons of three skeletal classes in angle

angle	Standard Error	Class I-) Differences (J	Class (J)	Class (I)	*p*.value
LAH up to Mp	1.56	1.56	Class II	Class I	0.322
	1.56	8.91	Class III	Class I	<0.001
	1.56	7.35	Class III	Class II	<0.001
LAH up to pp	1.92	-5.82	Class II	Class I	0.003
	1.92	-3.74	Class III	Class I	0.074
	1.92	2.25	Class III	Class II	0.221

The results of LSD test by comparing two skeletal classes showed; The average distance H to Mp of skeletal class I was significantly 2.95 mm higher than skeletal class II (p = 0.001) and significantly less than 3.84 mm of skeletal class III (p <0.001). The mean distance H to Mp of skeletal class III was significantly 6.79 mm longer than class II skeletal (p <0.001). The mean distance H to pp of skeletal class I was significantly 10.21 mm longer than class II skeletal (p <0.001) and was significantly less than 6.48 mm compared to skeletal class III (p <0.001). The mean distance from H to pp of skeletal class III was significantly 16.16 mm longer than class II skeletal (p <0.001). There was no significant difference between the means of distance H to c3 of skeletal I class compared to skeletal class II (p = 0.063) but it was significantly 7 mm less than skeletal class III (p <0.001). The mean distance from H to c3 of skeletal class III was significantly greater than that of class II skeletal 9.01 mm (p <0.001). The mean distance from H to RGn of skeletal class I was significantly less than 3.84 mm of skeletal class II (p = 0.005) but it was significantly 5.99 mm longer than class III skeletal (p <0.001). The mean distance from H to RGn of skeletal class III was significantly less than 9.82 mm compared to class II skeletal (p <0.001). According to Table 4, the means angle of LAH to Mp in skeletal class I, II and III were 5.61, 4.06, -30.30 degrees, respectively.

The results of ANOVA test showed there is significant difference between the means of LAH to Mp angle in skeletal classes I, II and III (p <0.001) and the average angle of LAH to pp was 14.78, 20.6 and 18.25 degrees in skeletal class I, II and III respectivly and there was significant difference between the means of LAH to pp angle in all of clasifications(p = 0.012).Due to the significance of ANOVA test, LSD post hoc test was used to compare the two skeletal classes in the angle of LAH to Mp and LAH to pp (Table 5).

LSD test results showed a comparison of two skeletal classification. There was no significant difference between the means of LAH to Mp angle of skeletal class I and skeletal class II (p = 0.322) but it was significantly 8.91 degrees higher than skeletal class III (p <0.001). The average angle of LAH to Mp in skeletal class II was significantly 7.35 degrees higher than skeletal class III (p <0.001). The mean angle of LAH to pp of skeletal class I was significantly lower than class II skeletal class (5.5) (p = 0.003) but no significant difference found in comparison to skeletal class III (p = 0.074). There was no significant difference between the means of LAH angle to pp of skeletal class II in comparison to skeletal class III (p = 0.221).

Cephalometric analysis is important for assessing craniofacial growth pattern as well as for Orthodontic diagnosis and treatment planning. It provides important information about the soft and hard texture of the upper airway, so it can be a reliable method of assessing the airway. But in cephalometric studies there are often different interpretations of the description of different types of facial expressions that may lead to different therapeutic approaches and consequently different results. Changes in the normal function of the upper airways during the active period of facial growth can potentially affect craniofacial growth pattern. However, it is unclear whether an altered growth pattern may affect upper airway size [34]. Hyoid bone has no bony articulation with the other bones and is hung by the balanced muscles and ligaments in place and any disturbance in this balance can change the position of the bone [35].

In this study, the specimens were divided into 3 skeletal groups of class I, II, and III. According to our findings, the mean depth of nasopharynx in skeletal class I was significantly (6.46 mm) greater than skeletal class III (p <0.001). The mean depth of skeletal orpharynx and hypopharynx of skeletal class I and II were significantly lesser than class III (p <0.001). It was also observed that the mean distances between H -PP, H - c3 and H -Mp of skeletal class III were significantly greater than class II (p <0.001). The mean H - RGn distance in skeletal class III was significantly lesser than class II (p <0.001). The mean LAH-Mp angle of skeletal class I and II were significantly greater than class III (p <0.001), but there was no significant differences between the mean of LAH -pp angle in skeletal class I and II in comparison to class III (p = 0.221).

Mortazavi et al. [28]. by using 110 lateral cephalograms (59 females and 51 males) that divided in 3 skeletal patterns of class I, class II and class III according to the ANB angle evaluate the position of the hyoid bone by MicroDicom software. Consistent with the present study, the hyoid bone position varies in different skeletal patterns. They founded Class II skeletal has more postrior and class I has more forward and lower position of hyoid bone. For sex dimorphism the position of the hyoid bone in women was more posterior than men. In a similar study, Majeed et al. [34] evaluation the upper and lower airways in Pakistanian patients with class I and II malocclusions with normal in vertical facial hieght. Consistent with the present study, depth of the nasopharynx is greater in the class I patients, but this difference is not statistically significant. Ashish Chauhan et al. [29] compared the dimensions of the airways of the throat, tongue and hyoid position based on ANB angle by using lateral cephalograms of 61 specimens (29 class I and 32 class II) in 11 to 19 years of old, there were no significant difference in the dimensions of the anteroprostrior airway of the throat and the position of the hyoid bone and tongue between class ll and class I. But according to our findings there were different hyoid bone positions in class II and class I skeletal patterns. Racial differences, small sample size and more young samples can be the reasons for these differences.

In Islamian et al. [8], they evaluated the depth of the upper airway in a variety of horizontal and vertical facial skeletal abnormalities. Consistent with the present study, the greatest nasopharyngeal depth was in the skeletal class I and the least depth was related to the skeletal class III and the greatest hypopharyngeal and oropharyngeal depth were related to class III and the lowest was for class II.

4. Conclusions

According to study these results are statistically significant: Skeletal Class III jaw relationship reduces depth of the nasopharynx space and increases depth of the oropharynx and hypopharynx. Skeletal class II decreases depth of the hypopharynx and in Class I individuals there were increases in depth of the nasopharynx.

Hyoid bone has a more posterior position in skeletal class II patterns and in a lower and anterior position in skeletal class I patterns. Also, the hyoid bone was in more anterior position in skeletal class III in comparison to classes II and I.

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Conflict of interest*:* There is no conflict of interest.

Suggestion: The authors suggested a more extensive study with more sample in other religion and comparison with this study for establish better validity.

Ethical approval*:* This study was performed according to the ethical standards of institutional and national research committee and with the 1964 Helsinki declaration.

Data availability*:* All data is available.

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