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Assessment of Oropharyngeal Dimensions in Class I Malocclusion with Different Growth Patterns in Iranian Adults

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Abstract:

Introduction:

Any changes in oropharyngeal dimensions during orthodontic treatment or surgery can not only alter the growth path and pattern but also affect treatment stability. Therefore, awareness of normal dimensions in Class I malocclusions is of great importance. This study aimed to investigate oropharyngeal dimensions in Class I malocclusions with different growth patterns.

Materials:

In this descriptive study, 80 adult participants (12 females and 14 males in the Low Angle group, 20 females and 7 males in the Normal Angle group, and 18 females and 7 males in the High Angle group) were selected from the patients who visited the orthodontic department of the Faculty of Dentistry, Islamic Azad University, during 2021-2022. All participants had Class I malocclusion, were within the age range of 18-25 years, had normal respiration, and had no history of orthodontic treatment, orthopedic surgery, or craniofacial anomalies. Lateral cephalometric radiographs were taken for all participants. A total of 37 measurements (12 measurements for evaluating the oropharyngeal airway pathway and 25 measurements for evaluating craniofacial morphology) were assessed. The differences between the groups were statistically evaluated using a one-way ANOVA test.

Results:

According to the ANOVA analysis, 21 out of 25 measurements related to craniofacial morphology showed statistically significant differences among different growth patterns. Among the parameters related to oropharyngeal morphology, the MPT (mouth-throat passage) was found to be greater in the Normal Angle group compared to the High Angle group (P=0.05), and the C3H parameter was greater in the Normal Angle group compared to the Low Angle group (P=0.04). The SPAS (superior airway width) was reported to be lower in the High Angle group compared to the Normal Angle group (P=0.08). These parameters did not show significant differences among the other groups. Additionally, no significant differences were found in tongue dimensions (TGH, TGL), middle and lower airway width (IAS, MAS), and vertical airway height (VAL) among the three groups.

Conclusion:

In samples with Class I malocclusion, different vertical growth patterns influence soft palate thickness, the position of the hyoid bone relative to the third cervical vertebra, and possibly the width of the superior airway passage.

Keywords: oropharyngeal space, Class I malocclusion, growth pattern, adults

Introduction

The effect of oropharyngeal space on craniofacial morphology and vice versa has been a topic of interest among researchers for a long time (1-4).

Changes in the dimensions of the oropharyngeal space during orthodontic treatments and surgery may not only alter the bite and growth pattern (5), but also affect treatment stability (6). Therefore, knowledge of the normal range of these dimensions in malocclusions is of special importance.
On the other hand, studies have shown that any changes in the amount or direction of maxillary bone growth should be done in a way that alters the dimensions of the oropharyngeal airway in the direction of treatment and according to the norms present in that population (7) Gender, age, and ethnicity/heritage are factors that can directly or indirectly influence the formation of teeth, jaws, and the face (8-11).
Some researchers have reported a clear relationship between vertical growth pattern and obstruction of the upper and lower airway (12-14).
Obstruction of the upper airway in patients with sleep apnea leads to changes in their skeletal pattern, including soft tissue changes, which results in a reduction in airway space and airflow (15-18).
Neglecting this issue can lead to complications such as changes in the growth of the facial skeleton, mouth breathing, downward and backward movement of the tongue and mandible, and rotation of the head to the back (19). Changes in these conditions can lead to alterations in dental relationships and growth direction (20-21).
Obstruction of the airway in patients with obstructive sleep apnea leads to a reduction in maxillofacial growth and changes in craniofacial structure, resulting in an increase in the angle between the mandible and maxilla and a decrease in the height of the lower face (22).
The position of the tongue and the hyoid bone, which is influenced by the genioglossus muscles, also affect the upper and lower airway width, as well as the balance between the upper and lower airways and breathing (23-25).
The relationship between malocclusion type and dimensions of the pharyngeal airway has been investigated by various researchers (26). Research has shown a correlation between the dimensions of the pharyngeal airway and the type of malocclusion (27). On the other hand, changes in oropharyngeal space may lead to changes in lung volumes, fat deposition in the upper airway, or the alignment of the upper airway with age and specific head positions in relation to the craniocervical posture (28).
In addition, studies have shown that individuals' growth patterns have different effects on the dimensions of the pharyngeal space, such that these dimensions decrease in individuals with vertical growth patterns and increase in individuals with horizontal growth patterns (29-31).
Given the lack of comprehensive research on the oropharyngeal space in the Iranian population, our study aimed to investigate the dimensions of the oropharyngeal space in Class I malocclusion with different growth patterns in adult Iranians.

Methods and Materials:

In this descriptive study, out of 400 individuals who visited the orthodontic department of the Faculty of Dentistry, Islamic Azad University, Tehran, a total of 80 eligible participants were selected. These patients sought orthodontic treatment, and all of their cephalograms were obtained from a single center under standard conditions. In all cases, the Frankfort plane was parallel to the horizontal plane, the teeth were in centric occlusion, and the oropharyngeal muscles were at rest. Individuals who had completed their growth, with an age range between 18 and 25 years, were included to eliminate the influence of ongoing growth. Moreover, all samples had Class I malocclusion, bilateral Class I molar and canine relationships, and normal overjet and overbite. The ANB angle varied from 1 to 4 degrees.
The exclusion criteria of this study included systemic or local diseases, a history of trauma, cleft lip and palate, orthodontic or orthopedic treatment, any respiratory disease such as (large tonsils, large adenoids, chronic allergy, nasal polyps, asthma and respiratory disorders during sleep), and craniofacial anomalies that could affect the study results (32-33).

Based on the mandibular plane angle (SN-MP) of 80 samples, they were divided into 3 groups: < 26 low angle ,
<38-26< normal angle, and <38 high angle. Lateral cephalometric radiographs were manually traced for all samples, and a total of 37 measurements were taken, including 12 linear measurements to evaluate the oropharyngeal airway pathway (Figure 1), 14 angular measurements (Figures 2 and 3), and 11 linear measurements (Figure 4) to assess the craniofacial morphology in this study. Then, 10 cephalograms were randomly selected from all cephalograms, and after 2 weeks, all parameters were measured by the same person, and the reliability of the numbers between the two times was assessed by the intraclass correlation coefficients (ICC) index.

Parameters investigated in the study:
Linear parameters related to oral-pharyngeal morphology (Figure 1):

1. TGL: a line extending from the most anterior point of the tongue (tt) to the base of the epiglottis (Eb), indicating the length of the tongue.
2. TGH: a line perpendicular to the line connecting Eb to tt, passing through the posterior part of the tongue, indicating the volume of the tongue.
3. PNSP: formed by the distance between two points, PNS (posterior nasal spine) and P (soft palate endpoint), indicating the length of the soft palate.
4. MPT: a line perpendicular to PNSP, passing through the thickest part of the soft palate, indicating the thickness of the soft palate.
5. MPH: a line perpendicular to the mandibular plane (MP), passing through the most anterior part of the hyoid bones (H), indicating the vertical position of the hyoid bones.
6. HH1: the vertical distance between H and a line connecting C3 to RGN (retro gnathion), indicating the vertical position of the hyoid bones.
7. HRGN: the distance between two points, H and RGN, indicating the anterior-posterior position of the hyoid bones.
8. C3H: the distance between H and the anterior limit of the third cervical vertebra (C3), indicating the anterior-posterior position of the hyoid bones.
9. SPAS: the smallest distance between the posterior border of the soft palate and the posterior pharyngeal wall parallel to the Go-B line (line connecting Gonion to point B), indicating the width of the upper airway.
10. MAS: the width of the mid-airway parallel to the Go-B line, drawn from point P.
11. IAS: the width of the lower airway along the Go-B line.
12. VAL: the distance between PNS and Eb (epiglottic base), indicating the vertical height of the airway.

Angular parameters related to craniofacial morphology (Figures 2 and 3):

1- SNA: Angle formed by the intersection of three points, Sella, Nasion, and point A, indicating the position of the maxilla relative to the anterior cranial base.
2- SNB: Angle formed by the intersection of three points, Sella, Nasion, and point B, indicating the position of the mandible relative to the anterior cranial base.
3- ANB: Angle formed by the intersection of three points, A, Nasion, and B, indicating the position of the maxilla and mandible relative to each other.
4- (SN-Ar) saddle/sella angle: Angle between the lines connecting Nasion, Sella, and Articular.
5- (S-Ar-Go) Articular angle: Angle between the lines connecting Sella, Articular, and Gonion.
6- (Ar-Go/MP) Gonial/jaw angle: Angle between the Ar-Go line and the mandibular plane.
7- Mandibular plan angle (SN-MP): Angle between the line connecting Sella to Nasion and the mandibular plane (MP).
8- (PP-GoGn) palatal-Mand angle: Angle between the palatal plane (PP) and the mandibular plane (MP).
9- Y-axis: Angle between the line connecting Sella to Gnathion and the SN plane.
10- SN-Npog: Angle between the line connecting Nasion to Pogonion and the SN plane.

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11- (convexity) NA-Apog: Angle between the line connecting point A to Pog and the line connecting point A to Nasion.
12- FMA: Angle between the Frankfurt plane and the mandibular plane (MP).
13- (ANS-PNS to SNpn) inclination angle: Angle between the line connecting ANS to PNS and the line perpendicular to the SN plane at point N'.
14- MP-OP: Angle between the mandibular plane (MP) and the occlusal plane (OP).

Linear parameters related to craniofacial morphology (Figure 4):

1- A to N perp: The distance between point A and the perpendicular Nasion line.
2- Pog to N perp: The distance between Pogonion and the perpendicular Nasion line.
3- Upper incisor to NA: The distance between the line that reaches point A from Nasion and the longitudinal axis of the maxillary incisor.
4- Lower incisor to NB: The distance between the line that reaches point B from Nasion and the longitudinal axis of the mandibular incisor.
5- (S-Go) posterior Facial Height: The distance between the two points Sella and Gonion.
6- (Na-Me) Anterior Facial Height: The distance between the two points Nasion and Menton.
7- (Cd to A point) Effective length of Maxilla: The distance from the most posterior point on the condyle of the head to point A.
8- (Cd to B point) Effective length of Mandible: The distance from the most posterior point on the condyle of the head to point B.
9- (LAFH) Lower Anterior facial height: The distance between Subnasal and Menton.
10- (Cd to Go) Ramus height: The distance from the most posterior point on the condyle of the head to Gonion.
11- (Go to pog) Body of Mandible length: The distance between Gonion and Pogonion.

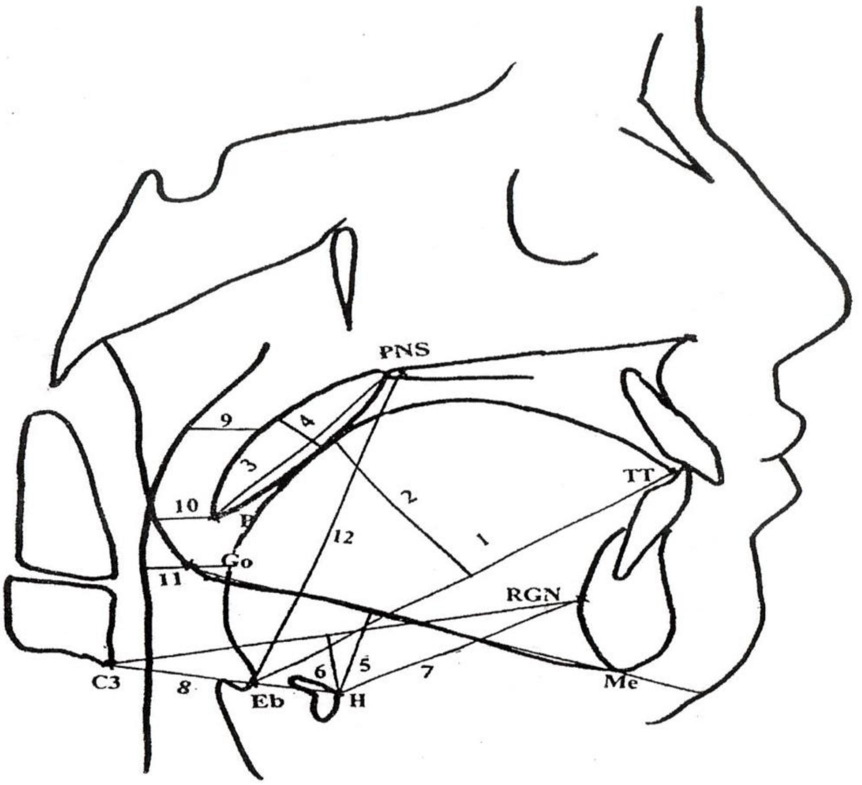

Figure 1: Linear parameters related to oral-pharyngeal morphology

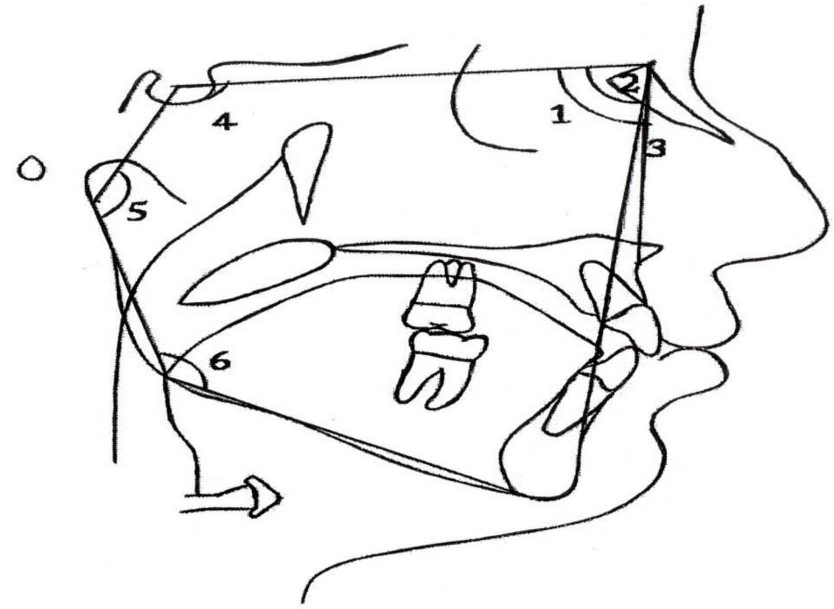

Figure 2: Angular parameters related to craniofacial morphology

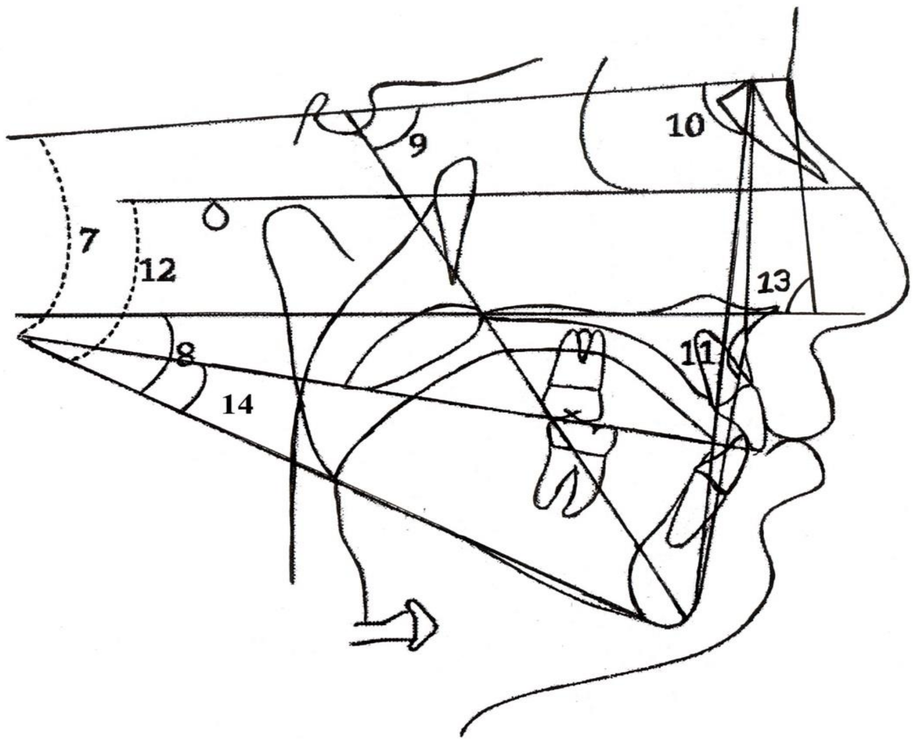

Figure 3: Angular parameters related to craniofacial morphology

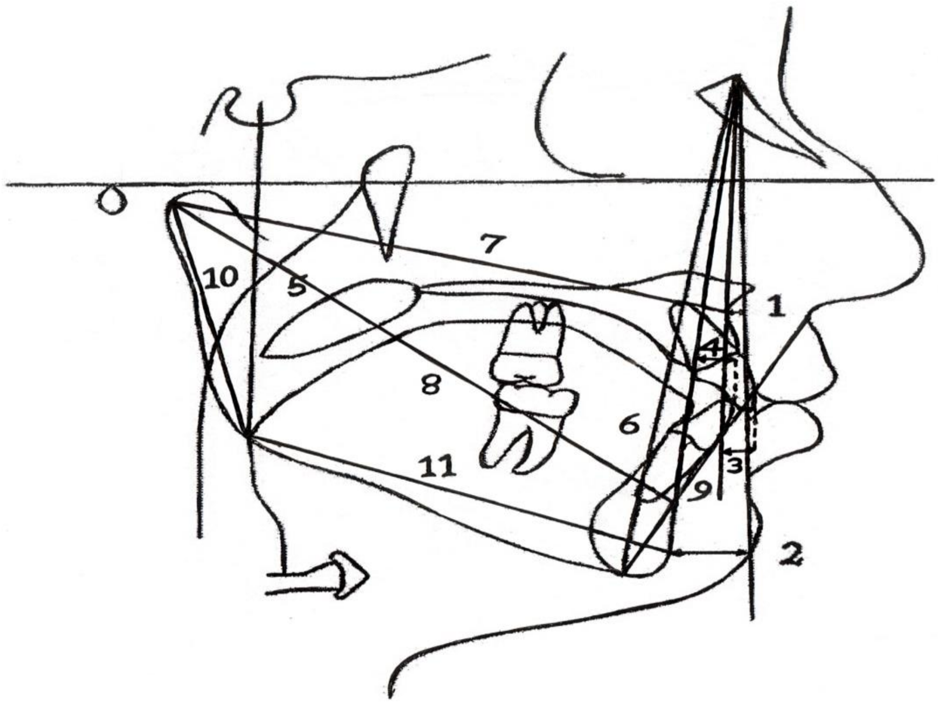

Figure 4: Linear parameters related to craniofacial morphology

Findings:

A study was conducted on 80 patients with Class I malocclusion who matched the entry and exit criteria and were divided into 3 groups: the first group was Low Angle consisting of 26 individuals (12 girls and 14 boys), the second group was Normal Angle consisting of 28 individuals (20 girls and 7 boys), and the third group was High Angle consisting of 26 individuals (18 girls and 7 boys).

Measurements related to the oropharyngeal morphology by growth pattern type are presented in Table 1, and measurements related to the craniofacial morphology are presented in Table 2. The ICC between the two operators for the measured parameters was between 0.999-0.906, and since a correlation coefficient of 0.75 or higher is considered to indicate good correlation, the values examined in this study were highly reliable.

Table 1: Distribution of examined individuals based on the measured parameters related to the oral-pharyngeal morphology, categorized by vertical growth pattern type.

Oropharyngeal evaluation	Low Angle		Normal Angle		High Angle		ANOVA	Combined comparison using sheffe's method		
Linear measurement(mm)	SD	Mean	SD	Mean	SD	Mean	Sig	Low vs. Normal	Low vs. High	Normal vs. High
TGL	/236	80/3	/975	8/140	/326	77/8	0/26	NS	NS	NS
TGH	/164	3/969	/313	3/759	/823	3/079	0/67	NS	NS	NS

PNSP	/63 4	3/34 8	/49 4	3/75 8	/25 5	37/3	0/52	NS	NS	NS
MPT	/47 1	9/57	/51 2	1/32 0	/58 1	9/03	0/05*	NS	NS	*
MPH	4/8	1/57 1	/24 4	10/1	/35 5	13	0/09	NS	NS	0/09
HH_1	/58 5	8/46	/09 4	5/71	/71 4	6/07	0/08	NS	NS	NS
HRGN	/01 6	4/92 2	/08 5	4/25 2	/61 5	3/84 9	0/11	NS	NS	NS
C_3H	/05 4	3/38 8	/42 4	3/78 5	/88 3	3/88 5	0/04*	*	NS	NS
SPAS	/67 3	1/57 4	/35 3	1/17 5	/37 2	1/11 3	0/08	NS	NS	0/08
MAS	/57 3	1/92 0	/97 2	1/85 0	/86 3	1/88 0	0/99	NS	NS	NS
IAS	/91 3	1/03 2	3/3	1/03 2	/17 3	1/34 2	0/93	NS	NS	NS
VAL	/57 7	7/19 1	5/7	68/5	/06 9	6/07 8	0/27	NS	NS	NS

*p< 0/05 : has statistical significance. NS: Not statically significant.

Table 2: Distribution of the study participants based on the measured parameters related to craniofacial morphology by vertical growth pattern.

Craniofacial evaluation	Low Angle		Normal Angle		High Angle		ANOVA	Combined comparison using sheffe's method		
Angular measurement(degrees)	SD	Mean	SD	Mean	SD	Mean	Sig	Low vs. Normal	Low vs. High	Normal vs. High
SNA	2/91	82/07	2/69	81/39	2/67	77/26	0/0001*	NS	*	*
SNB	2/61	79/42	2/78	78/14	2/51	74/34	0/0001*	NS	*	*
ANB	1/44	2/65	1/28	3/6	1/44	3/07	0/04*	*	NS	NS
SN-Ar	3/57	124/62	4/15	126/79	6/28	128/12	0/03*	NS	*	NS
S-Ar-Go	5/24	146/77	6/1	146/14	7/24	145/46	0/75	NS	NS	NS
Ar-Go/Mp	4/86	113/23	3/87	119/71	6/45	128/12	0/0001*	*	*	*
SN-MP	2/5	24/03	2/92	32/14	3/51	41/23	0/0001*	*	*	*
PP-GOGn	3/3	16/46	3/57	22/64	5/07	31/34	0/0001*	*	*	*
Y-axis	2/16	64/88	2/03	69/14	2/13	73/34	0/0001*	*	*	*
SN-Npog	2/32	81/26	2/6	78/78	2/25	74/76	0/0001*	*	*	*
NA-Apog	4/1	178/46	3/57	174/04	3/91	174/54	0/0001*	*	*	NS
FMA	3/32	17/65	3/18	22/6	4/46	30/03	0/0001*	*	*	*
ANS-PNS to SNPn	2/33	81/07	3/91	80/17	3/74	79	0/09	NS	NS	NS

MP-OP	2/83	12/84	3/85	16/57	4/75	21/8	0/0001*	*	*	*
Linear measurement(mm)										
A to N prep	2/18	4/69	1/79	3/14	1/55	4/42	0/006*	*	NS	*
Pog to N prep	2/02	10/03	2/4	11/39	2/45	13/88	0/0001*	NS	*	*
Upper incisor to NA	3/09	4/65	2/13	4/42	2/34	6/73	0/002*	NS	*	*
Lower incisor to NB	3/01	4/84	2/39	7/46	1/86	7/96	0/0001*	*	*	NS
S-Go	9/74	89/42	5/65	83/64	6/24	78/5	0/0001*	*	*	*
Na-Me	9/81	123	7/66	126/89	7/83	131/69	0/002*	NS	*	NS
Cd to A point	5/53	95/11	5/85	95/28	6/06	91/88	0/06	NS	NS	NS
Cd to B point	6/7	108/46	7/78	109/89	5/82	109/08	0/74	NS	NS	NS
LAFH	6/79	68/03	5/7	71/28	4/59	74/88	0/0001*	NS	*	0/07
Cd to Go	6/47	65/23	4/54	61/75	6/06	58/46	0/0001*	NS	*	NS
Go to Pog	6/34	84/96	7/49	82/07	5/33	79/76	0/01*	NS	*	NS

*p< 0/05 : has statistical significance. NS: Not statically significant.

The normal values of parameters related to the oropharyngeal morphology in 3 different growth patterns are presented in Table 1. Among these parameters, only the soft palate thickness (MPT) and the distance from hyoid bone to C3 vertebrae showed statistically significant differences between groups ($p < 0.05$). Specifically, MPT was greater in the Normal Angle group compared to the High Angle group ($p = 0.05$) and C3H was greater in the Normal Angle group compared to the Low Angle group ($p = 0.04$). Other groups did not show statistically significant differences in the values of these 2 variables.

Regarding the angular parameters related to craniofacial morphology, a statistically significant difference was found between the groups in terms of the measured indices of SNA, SNB, ANB, SN-Ar, Ar-Go/MP, SN-MP, PP-GoGn, Y-axis, SN-Npog, NA-Apog, FMA, and MP-OP ($p<0.05$). In pairwise comparisons between the groups using the Sheffe method, SNA and SNB were found to be lower in the High Angle group compared to other groups ($p=0.001$), ANB was lower in the Low Angle group compared to the Normal Angle group ($p=0.04$), and SN-Ar was lower in the Low Angle group compared to the High Angle group ($p=0.03$). Additionally, Ar-Go/MP, SN-MP, PP-GoGn, Y-axis, FMA, and MP-OP increased from the Low Angle group to the Normal Angle group and to the High Angle group, respectively ($p=0.001$).

Regarding the linear parameters related to craniofacial morphology, a statistically significant difference was found between the groups in terms of the measured indices of A to N perp, Pog to N prep, Lower incisor to NB, upper incisor to NA, Na-Me, S-Go, LAFH, Cd to Go, and Go to pog ($p<0.05$). In pairwise comparisons between the groups using the Sheffe method, A to N prep was lower in the Normal Angle group compared to other groups ($p=0.006$), Pog to N prep and LAFH were higher in the High Angle group compared to other groups ($p=0.002$), Na-Me was higher in the High Angle group compared to the Low Angle group ($p=0.002$), Cd to Go was higher in the Low Angle group compared to other groups ($p=0.001$), and Go to pog was higher in the Low Angle group compared to the High Angle group ($p=0.01$). Additionally, S-Go increased from the High Angle group to the Normal Angle group and to the Low Angle group, respectively ($p=0.001$).

No significant differences were found between the three groups for other parameters

Discussion and Conclusion:

This study was conducted on individuals with normal occlusion and vertical and horizontal growth patterns. So far, no comprehensive and complete research has been done on evaluating the oral-pharyngeal space in an Iranian population.

It has been demonstrated that the reproducibility and accuracy of measuring tongue dimensions, hyoid bone position, and pharyngeal airway space from lateral cephalograms is very high (34).
In this study, all parameters indicating the level of vertical growth, including Y-axis, FMA, mandibular plan angle, and palatal-mandibular angle, increased significantly (P<0.05) from Low Angle individuals to Normal Angle and High Angle individuals. This finding is consistent with Ucar et al. research, and according to ANOVA, only 4 out of 25 craniofacial measurements showed significant statistical differences among the three groups (35).
The present study showed that the tongue length and height (TGH, TGL) did not differ significantly among the three groups with horizontal, normal, and vertical growth patterns. Although individuals with vertical growth pattern had shorter tongue length, this finding was not statistically significant. This result is consistent with Ucar et al.'s research (35).
The length and thickness of the soft palate (PNSP, MPT) decreased in order from individuals with Normal Angle to Low Angle and High Angle, although this decrease was statistically significant only for the thickness of the soft palate (MPT) between individuals with Normal Angle and High Angle (P=0.05) (35-36).
The upper airway width (SPAS) was lower in individuals with high angle compared to those with normal angle (P=0.08)، but there was no significant statistical difference in other groups. This finding was similar to study of Alfawzan. In the Class I high-angle group, both the upper and lower pharyngeal widths were significantly narrower compared to the normal-angle and low-angle groups (37)
However, the middle and lower airway widths (IAS, MAS) also did not show any significant statistical differences among these three groups. This finding was consistent with the results of the studies by Freitas et al. and Joseph et al (3, 38).
The results of the study by Ucar et al (35) were consistent with the findings of the present study, with the difference that in their study, the reduction in upper pharyngeal airway width was statistically significant only between Low Angle and High Angle individuals (p<0.05). This difference in results may be attributed to differences in age range and sample size between the two studies. Similarly, Zhang et al. stated in their study that in samples with a normal sagittal pink pattern, the dimensions of the upper airway (nasopharyngeal and oropharyngeal) decrease with an increase in the mandibular plane angle (39). Additionally, Akcam et al. reported that the airway width decreases in individuals with mandibular retrognathism(40).
In the present study, the vertical airway length (VAL) decreased in the order of low angle to normal angle and high angle individuals, although this decrease was not statistically significant.
The findings of the present study were inconsistent with those of the study by Pae et al., who investigated the role of airway length in sleep apnea. They reported that individuals with vertical growth patterns have a higher average airway length compared to those with normal growth patterns. (41) The difference between these theories may be due to the age range of the samples, which can cause changes in the dimensions of the pharyngeal space from childhood to adulthood (42-43).
In this study, the hyoid bone (H) distance in the anteroposterior direction relative to the third cervical vertebra (C3) and retrognathion (RGN) was greater in individuals with a horizontal growth pattern than in other groups, although this difference was statistically significant only for the distance from this bone to the third cervical vertebra (C3H) and only between individuals with low angle and normal angle (p> 0.05). This finding indicates a more anterior position of this bone in individuals with a low angle.
Jipal's study also found that the hyoid bone had a more inferior and posterior position in individuals with a horizontal growth pattern, similar to the previous study (44).
The distance between the hyoid bone and the mandibular plane (MPH), which indicates the vertical position of this bone, was greater in individuals with a high angle compared to other groups (p = 0.09), which is consistent with the findings of the study by Pae et al. and colleagues (41).
Moreover, the distance between the hyoid bone and the line connecting the third cervical vertebra to the retrognathion (HH1) was less in individuals with a vertical growth pattern compared to those with a horizontal growth pattern, although this finding was not statistically significant (45).

In this study, the lower airway did not show a statistically significant difference between different growth patterns. This finding suggests that there is no meaningful correlation between the lower airway and the craniofacial growth pattern.

The position of the hyoid bone can be influenced by the size of the airway. If there is narrowing in the oropharyngeal area, the hyoid bone moves downwards (due to the stronger inferior muscles of the hyoid bone compared to the superior and anterior muscles) to increase the dimensions of the airway in the oropharyngeal region (46). This can lead to an increase in the distance between the hyoid bone and the mandibular plane over a long period of time. Therefore, the increase in this distance in individuals with a high angle may be due to the smaller dimensions of the upper pharynx (47).

Since lateral cephalometry is measurable in the anterior-posterior and vertical dimensions, the transverse dimension was not examined in this study and requires a 3D device for investigation (48).

Conclusion:

Since this study was conducted on individuals with normal occlusion and vertical and horizontal growth patterns, the cephalometric measurements available in this study can be used as a norm for the oral-pharyngeal space.

Different vertical growth patterns in Class I malocclusion samples, soft palate thickness, the position of the hyoid bone relative to the third cervical vertebra, and possibly the width of the upper airway are affected.

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