Original Article

Uvulo-Glosso-Pharyngeal Dimensions in Different Anteroposterior Skeletal Patterns

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Abstract: The aim of this study was to investigate the uvulo-glosso-pharyngeal dimensions in subjects with different anteroposterior jaw relationship. Cephalometric radiograph of 90 subjects (45 females and 45 males, aged 14–17 years) were divided into three groups according to the ANB angle, ie, group 1, skeletal Class I (ANB angle 1–5); group 2, skeletal Class II (ANB angle >5); and group 3, skeletal Class III (ANB angle <1). In addition, each group was divided into two subgroups according to sex. Statistical analysis was undertaken using analysis of variance and least significant difference test. Pearson's Correlation test was also performed. Sex differences were found in Class I and III subjects. No sex differences were detected in Class II subjects. On average, tongue length was significantly shorter in Class III subjects ($P < .05$), tongue height was reduced in Class II female subjects, the soft palate was thicker in Class III females and the vertical airway length (VAL) was reduced in Class II male subjects ($P < .01$). In Class II subjects, the hyoid bone was closer to the mandible vertically and to C3 horizontally compared with Class I ($P < .01$) and Class III ($P < .001$) male subjects. Anteroposterior skeletal pattern showed a weak, but significant correlation with inferior pharyngeal airway space ($R = -0.24$, $P = .024$), vertical position of hyoid bone in relation to mandibular plane ($R = -0.26$, $P = .014$), and anteroposterior position of hyoid bone in relation to C3 ($R = -0.561$, $P = .000$). In conclusion, uvulo-glosso-pharyngeal dimensions are affected by anteroposterior skeletal pattern. (*Angle Orthod* 2005;76:1012–1018.)

Key Words: Uvulo-glosso-pharyngeal dimensions; Skeletal pattern

INTRODUCTION

Significant relationships between the pharyngeal structures and both dentofacial and craniofacial structures have been reported.[1–7] Skeletal features such as retrusion of the maxilla and mandible and vertical maxillary excess in hyperdivergent patients may lead to narrower anteroposterior dimensions of the airway.[8] On the other hand, the oropharyngeal airway has been claimed to affect the growth of craniofacial structures. To breathe through the mouth, one must maintain an oral airway, and, to accomplish this, the mandible and the tongue are displaced downward and backward and the head is tipped back. These postural changes suggest the possible effect on the relationship of teeth as well as the direction of jaw growth, which may become more downward and backward.[9]

Recently, interest has been focused on uvulo-glosso-pharyngeal dimensions because of a potential relationship between size and structure of upper airway and sleep-induced breathing disturbances.[10,11] It has been shown that Obstructive Sleep Apnea patients have aberrated skeletal and soft tissue patterns that reduce airway space.[10,12] The face and anterior cranial base tend to be retruded,[13,14] the cranial base angle reduced,[15] the mandible short or retrognathic (or both),[16,17] and the lower face height and maxillomandibular planes angle increased.[13,14] Moreover, the hyoid bone is usually located inferior in relation to the mandibular plane, the tongue and soft palate are enlarged,[10,15,18,19] and the posterior airway space is reduced.[17,20]

The hyoid bone and its musculature occupy an important role in the maintenance of the pharyngeal air-

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way.[21] Several studies have shown that changes in hyoid bone position tend to be related to changes in mandibular position.[22–29] Battagel et al[29] reported a more posterior position of the hyoid bone in Class II subjects with a narrower upper airways and Adamidis and Spyropoulos[30] showed that hyoid bone in Class III subjects lay more anteriorly. The effect of the change in anteroposterior position of the mandible on hyoid bone position and the pharyngeal airway space is well documented.[5,29–32] Surgical mandibular advancement resulted in anterior positioning of the hyoid bone and widening of the minimal pharyngeal airway space,[31] whereas surgical mandibular setback was associated with reduction of the saggital dimensions of the oropharyngeal airway space.[32] Moreover, Battagel et al[29] suggested that mandibular advancement with protrusion splint was associated with a proportionate increase in oropharyngeal dimensions.

On the basis of this close relationship between uvulo-glosso-pharyngeal structures and the facial skeleton, a difference in size and position of soft and hard tissue structures of upper airway in different anteroposterior skeletal patterns was hypothesized. This study, using lateral cephalograms, was carried out to determine whether the uvulo-glosso-pharyngeal dimensions of subjects with normal nasal breathing could be affected by the different anteroposterior jaw relationships.

MATERIALS AND METHODS

Lateral cephalometric radiographs were selected from the files of orthodontic patients at the orthodontic department, Jordan University of Science and Technology Dental Teaching Centre. Records for 1520 orthodontic patients were screened and 90 subjects (45 females and 45 males, ages 14–17 years) were included with the following criteria: no history of orthodontic treatment; breathing comfortably through the nose; normal vertical occlusal relationship (Max/Man planes angle 25.5° ± 5).

Cephalometric radiographs were taken with a Siemens Orthophos-5 machine (Siemens AG, Munich, Federal Republic of Germany) using a standardized technique and a fixed anode-midsaggital plane distance. The subjects were asked not to swallow, not to move their heads and tongues, and to contact their teeth lightly while the radiographs were being exposed. The magnification of the radiographic machine, which was not corrected, was 11.3.

Lateral skull radiographs were traced on acetate paper and 10 hard and soft tissue cephalometric points were registered yielding 12 linear measurements (Figure 1). The measurements were performed manually using a ruler to the nearest 0.1 mm.

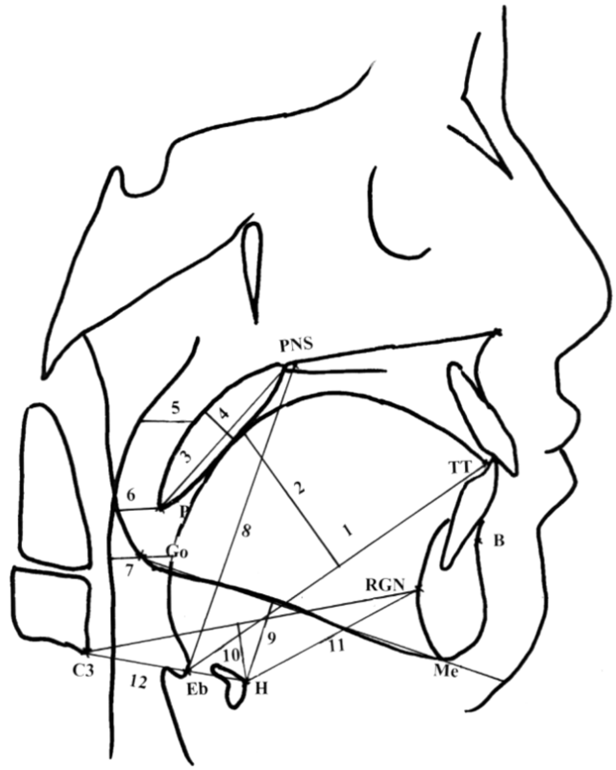

FIGURE 1. Cephalometric points, lines, and linear variables used in the cephalometric analysis. TT, tongue tip; Eb, base of epiglottis; P, tip of soft palate; PNS, posterior nasal spine; Me, menton; Go, gonion; B, point B; RGN, retrognathion; H, hyoidale; C3: Anteroinferior limit of third cervical vertebra. Mandibular plane: Go-Me, Go-B line. (1) TGL, tongue length (Eb-TT); (2) TGH, tongue height (maximum height of tongue along perpendicular line of Eb-TT line to tongue dorsum); (3) PNSP, soft palate length (PNS-P); (4) MPT, soft palate thickness (maximum thickness of soft palate measured on line perpendicular to PNS-P line); (5) SPAS, superior posterior airway space (width of airway behind soft palate along parallel line to Go-B line); (6) MAS, middle airway space (width of airway along parallel line to Go-B line through P); (7) IAS, inferior airway space (width of airway space along Go-B line); (8) VAL, vertical airway length (distance between PNS and Eb); (9) MPH, perpendicular distance from hyoid bone to mandibular plane; (10) HH1, perpendicular distance from hyoid bone to the line connecting C3 and RGN; (11) HRGN, distance between hyoid bone and RGN; (12) C3H, distance between hyoid bone and C3.

The films were divided into three groups according to the ANB angle:

- group 1, skeletal Class I (ANB angle 1–5)
- group 2, skeletal Class II (ANB angle >5)
- group 3, skeletal Class III (ANB angle <1).

In addition, each group was divided into two subgroups according to sex.

Method error

Twenty randomly selected films were retraced and measured and method errors calculated as recommended by Dahlberg[33] and Houston.[34] The Dahlberg

TABLE 1. Means, Standard Deviations and *P* Values for Sex Differences in Each of the Three Skeletal Groups[a]

Variable	Skeletal Class I: Females (n = 15) Mean SD	Skeletal Class I: Males (n = 15) Mean SD	Skeletal Class I: Total (n = 30) Mean SD	Sex Difference *P* Value	Skeletal Class II: Females (n = 15) Mean SD	Skeletal Class II: Males (n = 15) Mean SD	Skeletal Class II: Total (n = 30) Mean SD	Sex Difference *P* Value
Tongue								
TGL (mm)	81.1 ± 5.8	81.2 ± 5.2	81.1 ± 5.4	.974	79.4 ± 4.3	79.1 ± 3.8	79.3 ± 4.0	.877
TGH (mm)	35.8 ± 3.9	37.2 ± 4.8	36.5 ± 4.3	.397	34.9 ± 4.8	34.7 ± 5.6	34.8 ± 5.1	.944
Soft palate								
PNSP (mm)	36.7 ± 3.7	37.0 ± 4.3	36.8 ± 4.0	.823	37.2 ± 4.6	36.8 ± 3.2	37.0 ± 4.0	.783
MPT (mm)	7.1 ± 1.2	7.7 ± 1.3	7.4 ± 1.3	.197	7.4 ± 1.1	7.4 ± 1.7	7.4 ± 1.4	.901
Upper airway								
SPAS (mm)	13.7 ± 2.8	12.5 ± 2.3	13.1 ± 2.6	.181	13.8 ± 3.3	14.3 ± 4.3	14.0 ± 3.8	.724
MAS (mm)	9.7 ± 3.5	9.6 ± 2.7	9.7 ± 3.1	.885	10.1 ± 3.0	10.1 ± 2.7	10.1 ± 3.1	.977
IAS (mm)	12.9 ± 5.2	11.7 ± 3.4	12.3 ± 4.4	.460	14.3 ± 4.1	11.6 ± 3.3	12.9 ± 3.9	.059
VAL (mm)	63.7 ± 11.2	69.9 ± 6.5	66.8 ± 9.5	.074	64.2 ± 5.2	61.6 ± 9.5	62.9 ± 7.7	.368
Hyoid								
MPH (mm)	16.4 ± 3.5	19.9 ± 4.6	18.2 ± 4.4	.024*	16.5 ± 5.0	15.0 ± 4.6	15.8 ± 4.8	.398
HH1 (mm)	5.4 ± 4.2	12.2 ± 4.6	8.8 ± 5.5	.000***	6.3 ± 4.4	7.2 ± 5.0	6.8 ± 4.6	.602
HRGN (mm)	45.7 ± 4.9	40.5 ± 7.0	43.1 ± 6.5	.025*	44.4 ± 3.9	43.1 ± 6.3	43.7 ± 5.2	.492
C3H (mm)	35.5 ± 4.5	36.8 ± 3.2	36.1 ± 3.9	.377	33.2 ± 4.2	32.1 ± 3.0	32.6 ± 3.6	.403

[a] TGL indicates tongue length; TGH, tongue height; PNSP, soft palate length; MPT, soft palate thickness; SPAS, superior posterior airway space; MAS, middle airway space; IAS, inferior airway space; VAL, vertical airway length; MPH, perpendicular distance from hyoid bone to mandibular plane; HH1, perpendicular distance from hyoid bone to the line connecting C3 and retrognathion (RGN); HRGN, distance between hyoid bone and RGN; C3H, distance between hyoid bone and C3.

* $P < .05$, ** $P < .01$, *** $P < .001$.

error varied from 0.21 mm for IAS to 0.45 mm for PNS-Eb. Houston's coefficient of reliability was above 0.90 for all variables.

Statistical analysis

Descriptive statistics including the mean and standard deviation for each group were computed using SPSS PC+ (SPSS Inc., Chicago, Ill). The differences between males and females were tested using Student's *t*-test. Analysis of variance was used to determine whether significant differences existed between the groups. Least significant difference multiple comparison test was applied to identify which of the groups were different. Pearson's correlation coefficient test was used to detect any relationship between ANB angle and other variables.

RESULTS

The results of the statistical analysis are shown in Tables 1 through 3. In Class I, sex differences were detected in the vertical position of the hyoid bone in relation to the mandibular plane and in relation to a line connecting retrognathion to C3 ($P < .05$ and $P < .001$, respectively), and in the anterior-posterior position of hyoid bone relative to retrognathion ($P < .05$). In Class III subjects, sex differences were found in the vertical airway length (VAL) ($P < .01$), the vertical po-

TABLE 2. The *F* Values for Comparisons of the Three Skeletal Patterns in Females, Males, and Total Group Using ANOVA[a]

Variable	Females	Males	Total
Tongue			
TGL (mm)	1.33	2.11	2.98
TGH (mm)	2.35	1.02	0.45
Soft palate			
PNSP (mm)	1.34	1.03	2.12
MPT (mm)	2.22	1.18	0.06
Upper airway			
SPAS (mm)	0.21	1.21	0.86
MAS (mm)	0.63	0.10	0.50
IAS (mm)	0.66	0.64	1.05
VAL (mm)	0.02	6.01**	2.77
Hyoid			
MPH (mm)	0.44	7.91***	3.42*
HH1 (mm)	0.76	6.05**	1.17
HRGN (mm)	1.44	0.67	0.65
C3H (mm)	5.42**	10.67***	15.73***

[a] ANOVA indicates analysis of variance; TGL, tongue length; TGH, tongue height; PNSP, soft palate length; MPT, soft palate thickness; SPAS, superior posterior airway space; MAS, middle airway space; IAS, inferior airway space; VAL, vertical airway length; MPH, perpendicular distance from hyoid bone to mandibular plane; HH1, perpendicular distance from hyoid bone to the line connecting C3 and retrognathion (RGN); HRGN, distance between hyoid bone and RGN; C3H, distance between hyoid bone and C3.

* $P < .05$, ** $P < .01$, *** $P < .001$.

TABLE 1. Extended

Skeletal Class III			
Females (n = 15) Mean SD	Males (n = 15) Mean SD	Total (n = 30) Mean SD	Sex Difference *P* Value
77.9 ± 5.8	70.4 ± 25.7	74.2 ± 18.7	.275
38.0 ± 3.4	32.4 ± 14.1	35.2 ± 10.4	.145
34.7 ± 4.7	33.4 ± 12.5	34.0 ± 9.3	.690
7.9 ± 1.0	6.6 ± 2.7	7.3 ± 2.1	.083
12.9 ± 5.4	12.7 ± 3.4	12.8 ± 4.4	.904
11.4 ± 5.6	9.8 ± 3.2	10.6 ± 4.5	.354
14.9 ± 5.4	12.9 ± 3.5	13.9 ± 4.6	.227
64.2 ± 3.1	70.3 ± 6.9	67.2 ± 6.1	.004**
16.1 ± 3.7	21.5 ± 4.9	18.8 ± 5.0	.002**
4.3 ± 4.5	11.8 ± 3.4	8.1 ± 5.5	.000***
47.6 ± 6.5*	42.1 ± 4.7*	44.9 ± 6.2	.013*
38.3 ± 4.0	39.1 ± 5.9	38.7 ± 5.0	.643

sition of hyoid bone in relation to mandibular plane and in relation to a line connecting retrognathion to C3 ($P < .01$ and $P < .001$, respectively), and the anterior-posterior position of hyoid bone relative to retrognathion ($P < .05$). No sex differences were found in Class II subjects.

Females

In females, the tongue was significantly thicker in Class III subjects compared with Class II subjects ($P < .05$). Such a difference was not detected between Class I and Class II or between Class I and Class III. The soft palate was thinner in Class I subjects compared with Class II and Class III. A significant level has been only reached between Class I and Class III ($P < .05$). In Class II subjects, hyoid bone was closer to C3. A significant difference was evident between Class II and Class III ($P < .01$).

Males

On average, VAL was significantly reduced in Class II males compared with Class I ($P < .01$) and Class III ($P < .01$) male subjects.

Vertical position of hyoid bone in relation to mandibular plane differed significantly between the three groups. In Class II subjects, the vertical position of hyoid bone was closer to the mandibular plane and to a line connecting retrognathion and C3 compared with both Class I ($P < .01$ and $P < .01$, respectively) and Class III subjects ($P < .001$ and $P < .01$, respectively). In the anteroposterior dimension, the hyoid bone was closer to C3 in Class II subjects compared with Class I ($P < .01$) and Class III ($P < .001$). No statistically significant differences were found in the position of the hyoid bone to C3 in Class I and III.

TABLE 3. Mean Differences (in mm) Between Class I, Class II and Class III in Females, Males and Total Groups and Level of Significance Using LSD Test[a]

	Females			Males			Total		
Variable	Cl (I&II)	Cl (I&III)	Cl (II&III)	Cl (I&II)	Cl (I&III)	Cl (II&III)	Cl (I&II)	Cl (I&III)	Cl (II&III)
Tongue									
TGL (mm)	1.73	3.17	1.43	2.03	10.81	8.77	1.88	6.99*	5.10
TGH (mm)	0.93	−2.20	−3.13*	2.43	4.76	2.33	1.68	1.28	−0.40
Soft palate									
PNSP (mm)	−0.53	1.93	2.47	0.20	3.65	3.45	−0.17	2.79	2.96
MPT (mm)	−0.37	−0.87*	−0.50	0.30	1.08	0.78	−0.03	0.11	0.14
Upper airway									
SPAS (mm)	−0.03	0.80	0.83	−1.80	−0.27	1.53	−0.92	0.27	1.18
MAS (mm)	−0.37	−1.63	−1.27	−0.50	−0.23	0.27	−0.43	−0.93	−0.50
IAS (mm)	−1.37	−2.03	−0.67	0.01	−1.17	−1.27	−0.63	−1.60	−0.97
VAL (mm)	−0.43	−0.43	0.00	8.33**	−0.33	−8.67**	3.95	−0.38	−4.33*
Hyoid									
MPH (mm)	−0.13	0.30	0.43	4.93**	−1.57	−6.50***	2.40	−0.63	−3.03*
HH1 (mm)	−0.90	1.07	1.97	4.97**	0.33	−4.63**	2.03	0.70	−1.33
HRGN (mm)	1.33	−1.87	−3.20	−2.53	−1.60	0.93	−0.60	−1.73	−1.13
C3H (mm)	2.30	−2.77	−5.07**	4.70**	−2.37	−7.07***	3.50**	−2.57*	−6.07***

[a] LSD, least significant difference; Cl, Class; TGL, tongue length; TGH, tongue height; PNSP, soft palate length; MPT, soft palate thickness; SPAS, superior posterior airway space; MAS, middle airway space; IAS, inferior airway space; VAL, vertical airway length; MPH, perpendicular distance from hyoid bone to the line connecting C3 and retrognathion (RGN); HRGN, distance between hyoid bone and RGN; C3H, distance between hyoid bone and C3.

* $P < .05$, ** $P < .01$, *** $P < .001$.

Total group

Tongue length was significantly shorter in Class III compared with Class I subjects. Class I and Class II subjects did not differ in tongue length. VAL was significantly reduced in Class II subjects compared with Class III ($P < .05$) subjects. No difference was detected between Class I and Class II subjects nor Class I and Class III subjects. The vertical position of the hyoid bone in relation to mandibular plane differed significantly between Class II and Class III subjects only ($P < .05$). The anteroposterior position of hyoid bone in relation to C3 differed significantly between the three groups. The hyoid bone was more anteriorly positioned in Class III subjects compared with Class I ($P < .05$) and Class II ($P < .001$) subjects. In Class II subjects, it was closer to C3 compared with the Class I subjects ($P < .01$).

Skeletal configuration (ANB) showed a weak but significant correlation with the inferior pharyngeal airway space ($R = -0.24$, $P = .024$), vertical position of hyoid bone in relation to mandibular plane ($R = -0.26$, $P = .014$) and anteroposterior position of hyoid bone in relation to C3 ($R = -0.056$, $P = .000$).

DISCUSSION

The nasopharyngeal dimensions continue to grow rapidly until 13 years of age[35] and then slows until adulthood.[36,37] In this study, the age range was 14–17 years to ensure that the oropharyngeal structures had reached adult size.

The anteroposterior skeletal relationship was determined using Jordanian norms[38] of the ANB angle (ANB $= 3 \pm 2°$). ANB angle is considered the most commonly used cephalometric measurement for evaluation of anteroposterior jaw relationship.[39,40] The validity of this measurement has been investigated by several researchers. Jacobson[41] showed that ANB angle does not provide adequate assessment of jaw relationship because rotational growth of the jaws and the anteroposterior position of nasion influence the ANB angle. Furthermore, Hussels and Nanda[42] reported that the vertical lengths from nasion to point B and from point A to point B are usually affected. On the other hand, Oktay[39] and Ishikawa et al[43] reported that ANB angle is one of the most reliable and accurate measurements of the anteroposterior jaw relationship.

Mouth breathing results in a number of postural changes, such as downward and forward tongue position and head extension.[2,4,24,26,44] Because the mode of breathing affects mandibular position, inclination of the mandibular plane, and head posture, only subjects with a normal breathing pattern were included in this study. Because head posture has been suggested to influence the dimensions of the oropharyngeal airway,[45–47] cephalometric radiographs of the subjects were recorded with the head in a natural position.[47,48]

Long face subjects have backward growth direction expressed in an increase in face height and gonial angle. It has been found that adenoid obstruction is most common among long face subjects.[49,50] Opdebeeck et al[24] reported smaller nasopharyngeal cavities in long face subjects compared with short face ones. In our study, only subjects with normal vertical skeletal relationship were included to eliminate any effect on nasopharyngeal airway caused by changes in the vertical plane.

Sex differences were not detected in tongue and soft palate dimensions. Pharyngeal dimensions were not affected by sex except in Class III subjects where VAL was longer in males. These findings are in agreement with those reported in the literature,[4,6,7,36] which suggest that sex differences in the pharyngeal dimensions are not present. However, vertical and anteroposterior position of the hyoid bone showed sex differences in Class I and III subjects only, which may reflect a sex difference in neck thickness.

Hyoid bone position is of great clinical interest because it plays an important role in maintaining the upper airway dimensions.[51] In this study, the hyoid bone position was different in the different skeletal patterns. In Class II subjects, hyoid bone was located in an upward and backward position, whereas it was located in downward and forward position in Class III subjects. These findings were in agreement with those reported by others.[52–54] Yamaoka et al[52] found that tongue root was situated more posterior in Angle's Class II compared with Angle's Class III females.

Our study revealed that anteroposterior pharyngeal airway dimensions were not affected by the changes of the ANB angle. This was in agreement with earlier studies suggesting that the anteroposterior dimension of the upper airway is usually maintained by adaptation of both tongue and hyoid bone.[23,25] Because the hyoid bone is located more posterior in Class II skeletal pattern, the genioglossus, the main protruder of the tongue, generates upper airway dilating forces to maintain upper airway patency.[54]

However, Kerr[5] reported that Class II subjects had a larger nasopharyngeal area than Class I subjects with malocclusion. On the other hand, the VAL was affected by the change in the anteroposterior jaw relationship and Class II subjects had short VAL compared with Class III subjects. Pae et al[55] reported that as hyoid bone position moves inferiorly, the pharyngeal length become longer because the hyoid bone and epiglottis are in a close anatomical relationship. The hyoid bone position detected in Class II and Class III in this study explains the difference in upper airway length in Class II and Class III subjects.

Our findings regarding the relationship between uvulo-glosso-pharyngeal structures and anteroposterior skeletal pattern are inconsistent with those that reported no relationship between pharyngeal structures and the ANB angle.[4,7,56,57] However, the variables used to measure pharyngeal airway in the previous studies differed from those used in this investigation, which makes the comparison more difficult.

Although significant correlation was found in this study between anteroposterior skeletal relationship and airway dimensions, it was a low correlation, which was in agreement with that reported by Kerr.[5] The position of the hyoid bone and width of inferior pharyngeal space were correlated with the change in ANB angle. As the ANB increases, the inferior pharyngeal space is reduced and the hyoid bone moves upward and backward.

CONCLUSIONS

- Sex differences in the pharyngeal dimensions were found in Class I and Class III skeletal patterns.
- The position of hyoid bone and the width of inferior pharyngeal space had a significant but weak correlation with the change in ANB angle.

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