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ORIGINAL RESEARCH

A Study on the Evaluation of Pharyngeal Size in Different Skeletal Patterns: A Radiographic Study

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ABSTRACT

Aim: The aim of this study was to evaluate the upper and lower pharyngeal airway dimensions were affected by different skeletal malocclusions.

Materials and methods: Lateral cephalograms of 120 subjects were used to measure the pharyngeal airway and were divided into three groups (each group included 40 subjects) according to ANB angle: Class I (ANB angle $2^o \leq ANB \leq 4^o$), Class II (ANB angle(ANB $\geq 6^o$), and Class III (ANB angle $\leq 0^o$). Various linear cephalometric airway measurements (14 measurements) were used to evaluate pharyngeal airway at various levels. Statistical analyses were performed Using the ANOVA and student t-test.

Results: PNS-ppw1 ($p < 0.001$) and McNamara' lower pharynx dimension ($p < 0.05$) showed a statistically significant difference between the groups. Two out of 14 variables ie Ba-PNS and t-ppw showed a statistically significant difference between male and female. In both measurements, the difference is significant only in the Class II group with the level of significance being ($p < 0.001$) in Ba-PNS measurement, and ($p < 0.05$) in t-ppw measurement. In both measurements males have statistically significant higher mean values than the females.

Conclusion: The dimensions of pharyngeal structures were not affected by the changes of the ANB angle. The sagittal skeletal pattern does not seem to influence the variations in the upper airway dimension. There was no significant difference in the dimensions of pharyngeal structures among males and females.

Clinical significance: The upper and lower pharyngeal airway dimensions are affected by different skeletal malocclusions can significantly aid in Orthodontic treatment planning.

Keywords: ANB angle, Cephalometric, Pharyngeal airway and Sagittal.

Abbreviations

1. ANB = A point–Nasion-B point
2. SN-MP = sella nasion to mandibular plane
3. HSD = honestly significant difference
4. PNS = posterior nasal spine

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INTRODUCTION

The pharyngeal airway is a multifunctional structure that is responsible for several different physiologic functions including deglutition, vocalization and respiration. The pharyngeal airway formed by muscles and membranes and pharynx is conventionally divided into three sections the nasopharynx, the oropharynx and the laryngopharynx. Abnormal airway function during the growth spurt period can lead to a profound influence on facial development.[1,2]

In 1872, Tomes[3] hypothesized that maxillary constriction could be caused by enlarged adenoid of the pharynx that caused the incompetent lip and a lower tongue position to maintain the permeability of the airway. Many studies in the literature like Angle,[4] Harvo,[5] Linder-Aronson,[6] and others demonstrated that airway obstruction can determine the abnormal development of dentofacial growth pattern.

Lateral cephalograms are frequently used to assess the pharyngeal airway. They provide a simple method of seeing the outline of the nasopharyngeal soft tissues in relation to the airway and the two-dimensional image correlates well with the size estimated at posterior rhinoscopy (Linder-Aronson and Henrickson, 1973).[7]

Several studies tried to correlate patients with normal airways functions with various malocclusions and airway dimensions. In many studies carried out on subjects, it has been demonstrated that there are statistically significant relationships between the pharyngeal structures and both dentofacial and craniofacial structures at varying degrees.[8,9]

The aim of this study was to evaluate the upper and lower pharyngeal airway dimensions were affected by different skeletal malocclusions.

Therefore, the objective of this study was to evaluate the pharyngeal airway space dimensions in adolescents among different skeletal patterns: ie in Class I, Class II and Class III malocclusions and evaluate sexual dimorphism in soft-tissue airway structures.

MATERIALS AND METHOD

Cephalometric radiographs of 120 patients were selected from the files of patients registered at the Department of of Orthodontics, Regional Dental College, Guwahati.

Subjects in the age range of 13 to 20 years were included in this study. Further screening of subjects for inclusion in this study was done after detailed case history and clinical examination. A written informed consent was obtained from each participant or his or her parents before inclusion in this study.

Based on the degree of sagittal discrepancy between the jaws in relation to the anterior cranial base (i.e ANB angle), all the subjects were divided into three groups –
Group I: having a skeletal Class I malocclusion with ANB angle ranging from 2 ≤ANB ≤4.
Group II: having a skeletal Class II malocclusion with ANB angle equal to or greater than 6 (ANB ≥6).

Fig. 1: Cephalometric radiographic unit

Group III: having a skeletal Class III malocclusion with ANB angle less than or equal to 0. (ANB ≤0).

In order to increase the homogeneity of the sample, subjects with ANB angle between 0 < ANB > 2; and between 4 < ANB > 6 were excluded from the study and only those samples were selected who were in the normal angle range of SN-MP angle i.e., between 26 to 38 : according to Isaacson et al.[10] (Table 1). The final sample size in each group included 40 subjects who met the criteria (Tables 2 and 3). In addition, each group was also divided into subgroups according to sex (20 male and 20 female subjects). The lateral cephalometric radiographs of all the subjects selected were done with same magnification, all the radiographs being taken with same machine and by the same operator (Figs 1 and 2). The radiographs were traced and digital Caliper for measuring the distance between the points accurate to 0.01 mm was used (Figs 3 to 6).

Cephalometric variables (measurements) used to measure pharyngeal airway:

- Ba-adl mm
- Ba-ad2 mm
- Ba-PNS mm

Table 1 : Characteristics of the subjects in each group

	Group I			*Group II*			*Group III*		
Variables	*Male*	*Female*	*Total*	*Male*	*Female*	*Total*	*Male*	*Female*	*Total*
No. of Subjects	20	20	40	20	20	40	20	20	40
Age (years)	15.96 ± 2.46	15.60 ± 2.06	15.78 ± 2.24	15.18 ± 2.37	16.00 ± 2.39	15.60 ± 2.39	15.43 ± 2.64	15.06 ± 2.51	15.25 ± 2.55
SNA angle (in degrees)	82.6 ± 3.23	83.90 ± 4.34	83.25 ± 3.83	84.28 ± 3.37	84.55 ± 3.89	84.41 ± 3.59	80.20 ± 3.17	80.45 ± 4.58	80.33 ± 3.90
SNB angle (in degrees)	79.75 ± 3.52	80.75 ± 4.22	80.25 ± 3.87	77.00 ± 3.43	76.70 ± 4.04	76.85 ± 3.70	82.80 ± 3.42	83.45 ± 4.50	83.12 ± 3.96
ANB angle (in degrees)	3.15 ± 0.81	2.85 ± 0.87	3.00 ± 0.84	7.85 ± 1.59	7.25 ± 1.16	7.55 ± 1.38	-3.00 ± 1.48	-2.60 ± 1.60	-2.80 ± 1.54
SN-MP angle (in degrees)	33.05 ± 4.01	33.05 ± 3.63	33.05 ± 3.78	31.05 ± 4.26	32.80 ± 3.90	31.92 ± 4.12	32.30 ± 3.40	32.50 ± 3.66	32.40 ± 3.49

Fig. 2: Natural head position

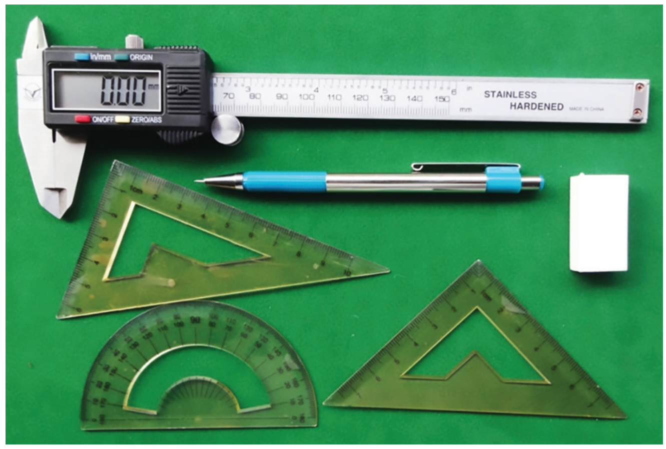

Fig. 3 : Material and equipment: digital caliper, a 3H hard lead pencil, eraser, a pair of set squares and protractor.

- Ptm-adl mm
- Ptm-ad2 mm
- PNS-ppwl mm
- apw2-ppw2 mm
- apw3-ppw3 mm
- hy-apw2 mm
- hy-apw3 mm
- Ho ANS-PNS mm
- McNamara's upper pharynx dimension
- McNamara's lower pharynx dimension
- t-ppw

RESULTS

All statistical analyses were performed using the (SAS 9.3 English). According to ANOVA, a majority of the variables (i.e. 12) out of 14 variables do not show any statistically significant difference between the groups: i.e., between Class I, Class II, Class III. Two out of 14 variables ie. PNS-ppw1 ($p < 0.001$) and McNamara' lower pharynx dimension ($p < 0.05$) showed statistically significant difference between the groups. Multiple comparisons of the groups via Tukey HSD for linear measurements showed that in PNS-ppw1 significant difference exists between Class I and Class II; and between Class II and Class III, while in McNamara' lower pharynx dimension significant difference exists between Class I and Class III; and between Class II and Class III. The mean values of PNS-ppw1 and McNamara' lower pharynx dimension was found to be highest in Class III, followed by Class I and Class II.

The results of the t-test shows that a majority of the variables (ie 12) out of 14 variables donot show any statistically significant difference between male and female in each group. Two out of 14 variables ie Ba-PNS and t-ppw showed statistically a significant difference between

Table 2: Cephalometric landmarks used in the cephalometric analysis to study pharyngeal dimensions

S.No.	*Cephalometric landmark*	*Definition*
1.	Ba (Basion)	Lowermost point on anterior margin of foramen magnum.
2.	S (Sella point)	Midpoint of sella turcica.
3.	Ho (Hormion)	Most inferior point of sphenooccipital synchondrosis. It is located at the intersection between the perpendicular line to S-Ba from PNS and the cranial base[37].
4.	Ptm (Pterygom-axillary fissure)	Most inferior point on average of right and left outlines of pterygomaxillary fissure.
5.	ad1	Point of intersection of posterior pharyngeal wall and line Ptm to Ba.
6.	ad2	Point of intersection of posterior pharyngeal wall and line from Ptm as normal perpendicular to S-Ba.
7.	ANS	Anterior nasal spine: tip of anterior nasal spine.
8.	PNS	Posterior nasal spine: tip of posterior spine of palatine bone in hard palate
9.	Ppw	Posterior pharyngeal wall intersecting occlusal plane.
10.	ppw1	Posterior pharyngeal wall intersection with ANS-PNS line
11.	ppw2	Posterior pharyngeal wall along line intersecting cv2ia and hy.
12.	ppw3	Posterior pharyngeal wall along line intersecting cv3ia and hy
13.	apw2	Anterior pharyngeal wall along line intersecting cv2ia and hy
14.	apw3	anterior pharyngeal wall along line intersecting cv3ia and hy.
15.	cv2ia	Most inferoanterior point on body of second cervical vertebra
16.	cv3ia	Most inferoanterior point on body of third cervical vertebra
17.	t	Tongue surface intersecting occlusal plane
18.	hy	Most superior and anterior point on body of hyoid bone.

Table 3: Cephalometric variables (measurements) used to measure pharyngeal airway:

S.No.	*Cephalometric measurement*	*Definition*
1.	Ba-adl mm	Adenoid thickness; defined as the soft-tissue thickness at the posterior nasopharynx through the Ptm-Ba line (ad1).
2.	Ba-ad2 mm	Adenoid thickness : Distance from Ba to the nearest adenoid tissue measured along the line through Ptm perpendicular to the sella-basion line (ad2).
3.	Ba-PNS mm	Total lower sagittal depth of the bony nasopharynx.
4.	Ptm-adl mm	Nasopharyngeal airway thickness at Ptm-ad1 level; distance between Ptm and the nearest adenoid tissue measured through the Ptm-Ba line (ad1).
5.	Ptm-ad2 mm	Nasopharyngeal airway thickness at Ptm-ad2 level; distance between Ptm and the nearest adenoid tissue measured through a perpendicular line to S-Ba from Ptm (ad2).
6.	PNS-ppwl mm	Airway thickness at the level of the palatal plane.
7.	apw2-ppw2 mm	Airway thickness at the level of the base of second cervical vertebrae.
8.	apw3-ppw3 mm	Airway thickness at the level of the base of third cervical vertebrae.
9.	hy - apw2 mm	Distance between the anterior pharyngeal wall and the hyoid bone at the level of the base of second cervical vertebrae.
10.	hy – apw3 mm	Distance between the anterior pharyngeal wall and the hyoid bone at the level of the base of third cervical vertebrae.
11.	Ho⊥ANS-PNS mm	Height of nasopharynx.
12.	McNamara's upper pharynx dimension	Minimum distance between the upper soft palate and the nearest point on the posterior pharynx wall.
13.	McNamara's lower pharynx dimension	Minimum distance between the point where the posterior tongue contour crosses the mandible and the nearest point on the posterior pharynx wall.
14.	t-ppw	Oropharyngeal depth at the level of the occlusal plane.

male and female. In both measurements, the difference is significant only in the Class II group with level of significance being ($p < 0.001$) in Ba-PNS measurement and ($p < 0.05$) in t-ppw measurement. In both measurements, males have statistically significant higher mean values than the females.

DISCUSSION

Abnormal development of the upper airway is related to airway constriction, and the relationship relevance between reduced respiratory function and craniofacial growth has long been of interest to orthodontists. But this interaction is still controversial. Analyzing these results the present study reveals that the pharyngeal structures were not affected by the changes of the ANB angle. Our findings are similar to those of Solow et al,[9] Allhaija et al.,[11] McNamara[8] in which no statistically significant relationship between the pharyngeal size and the antero-posterior jaw relationship can be obtained.

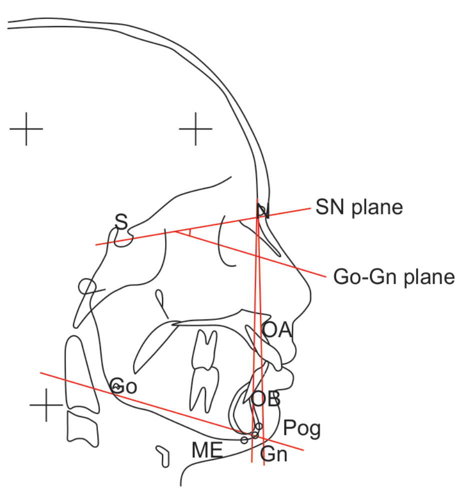

Fig 4: Cephalometric measurement (1st)

Mergen and Jacobs[12] compared normal occlusion subjects with Class II occlusion. They concluded that the midsagittal nasopharyngeal depth is significantly larger in subjects with normal occlusion than in subjects with Class II malocclusion. The reason for difference could be due to the difference in the criterion for the selection of the subjects like the samples were not classified based on skeletal patterns.

However, Sosa et al. [13] could find no relationship when they compared nasopharyngeal dimension (Ba-PNS) in Angle's Class I and Class II division 1 malocclusions. Although in this study sample selection was not based on skeletal patterns. Most recently, Freitas et al[14] measured the dimensions of the upper and lower oropharynx in between Class I and Class II malocclusions and found no significant difference between Class I and Class II malocclusions. Although that study classified its sample by molar relationships, which differed from the present classification by skeletal pattern subgroups, the results were similar.

In the present study both, PNS-ppw ($p < 0.001$) and McNamara' lower pharynx dimension ($p < 0.05$) showed statistically significant difference between the groups. This was due to higher mean values of McNamara' lower pharynx dimension in Class III group (12.41 ± 3.00) in comparison to Class I (10.79 ± 2.96) and Class II group

Code	Cephalometric Measurement
M1	Ba-adl mm
M2	Ba-ad2 mm
M3	Ba-PNS mm
M4	Ptm-adl mm
M5	Ptm-ad2 mm
M6	PNS-ppwl mm
M7	apw2-ppw2 mm
M8	apw3-ppw3 mm
M9	hy - apw2 mm
M10	hy – apw3 mm
M11	Ho⊥ANS-PNS mm
M12	McNamara's upper pharynx dimension
M13	McNamara's lower pharynx dimension
M14	t-ppw

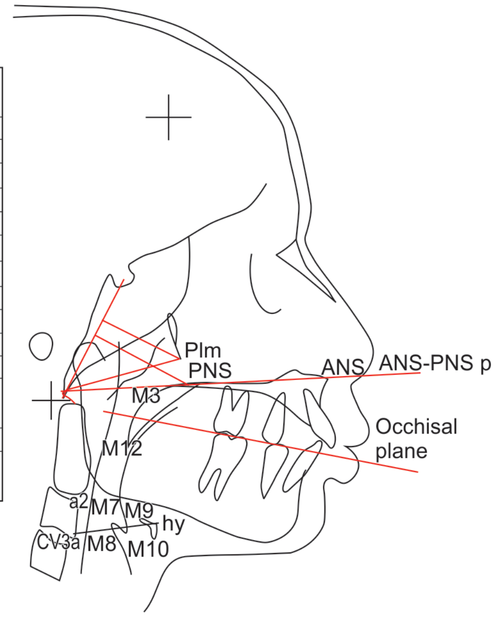

Fig 5: Cephalometric measurement (2nd)

(10.69 ± 2.74). The findings of the present study in relation to McNamara' lower pharynx dimension is in accordance with the study done by Yoshihiko Takemoto et al.[15] who compared McNamara' lower pharynx dimension in prognathic and normal occlusion girls. They concluded that prognathic girls had a significantly wider lower pharyngeal airway compared with those with normal occlusion (p = 0.01) (Table 2).

The fact that only two measurements, Ba-PNS and t-ppw, from the 14 parameters showed significant difference between the sexes, indicates that pharyngeal structures have not been affected by sex at this age group. This finding agrees with the results of Solow et al.,[11] Handelman and Osborne[16] in which no statistically significant relationship between the males and females were observed regarding the pharyngeal airway size measurements.

Cephalo metric landmark	Code:
Ba	1
S	2
Ho	3
Ptm	4
ad1	5
ad2	6
ANS	7
PNS	8
Pp w	9
ppw1	10
ppw2	11
ppw3	12
apw2	13
apw3	14
cv2ia	15
cv3ia	16
t	17
hy	18

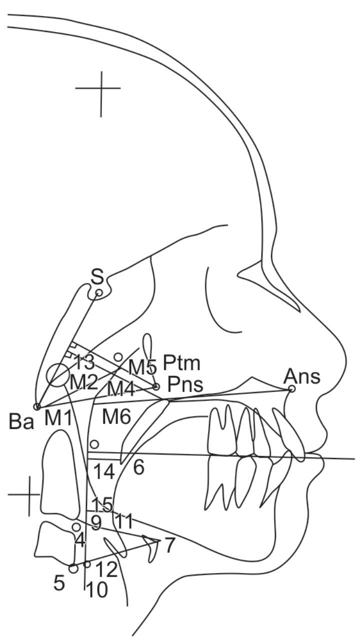

Fig 6: Cephalometric measurement (3rd)

Martin et al.[17] reported a statistically significant difference (p < 0.05) between the sexes for these variables: ad1-Ba, ad2-H, PNS-H, N-H (H is Hormion and other symbols were same as that of current study) They suggested that men with excellent occlusions have larger adenoid tissue areas than women. Men also showed greater sagittal thickness of the upper airway. These results were in contrast to the present study.

Allhaija et al.[11] measured sagittal pharyngeal airway dimension in three different vertical levels in different anteroposterior skeletal patterns. They did not found any sexual dimorphism at all three vertical levels in all three skeletal patterns. This is in accordance with the present study.

One of the critical limitations of this study might be that the three-dimensional upper-airway was evaluated based on a two-dimensional cephalometric measurement. Further studies may be aimed at evaluating pharyngeal airway with three-dimensional imaging.

There are different ethnic groups in this part of the country. So further studies pertaining to ethnic specific or inter-ethnic comparison may be carried out.

CONCLUSION

Based on the findings of this study, the following conclusions could be drawn:

The dimensions of pharyngeal structures were not affected by the changes of the ANB angle. The sagittal skeletal pattern does not seem to influence the variations in the upper airway dimension.

There was no significant difference in the dimensions of pharyngeal structures among males and females.

CLINICAL SIGNIFICANCE

The upper and lower pharyngeal airway dimensions are affected by different skeletal malocclusions can significantly aid in Orthodontic treatment planning.

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