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Original Research Article

Cephalometric evaluation of pharyngeal airway in different skeletal patterns

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Abstract

Background: Functional examination of respiratory system plays an important role in diagnosis and treatment planning. Any abnormalities or obstruction in the respiratory system may lead to functional imbalance and changes in the craniofacial structures leading to malocclusions**.**

Aims & Objective: The aim of this study is to evaluate if the upper and lower pharyngeal airway dimensions of subjects aged above 18 years will be affected by differentskeletal patterns.

Materials and Methods: Lateral cephalogram of 21 subjects were used for this study **.**Fourteen linear cephalometric airway measurements are used toevaluate the pharyngeal airway dimension at various levels. The Cephalometric variables (measurements) used to measure pharyngeal airway: Ba-ad1 mm, Ba-ad2 mm, Ba-PNS mm, Ptm-ad1 mm, Ptm-ad2 mm,PNS-ppw1 mm, apw2-ppw2 mm, apw3-ppw3 mm, hy-apw2 mm, hy-apw3 mm,Ho□ANS-PNS mm, McNamara's upper and lower pharynx dimension. The values were tabulated and statistical analysis was performed using the ANOVA & post-hoc Bonferroni test.

Result: Statistically not significant in upper and middle pharyngeal width. Statistical significance is seen only in lower pharyngeal width(apw2-ppw2) between Class II and class III groups with the level of significance being (p<0.015).

Conclusion: According to the study only lower pharyngeal dimension was affected in class II and class III pattern. This is probably due to the position of mandible in a retruded or protruded position respectively. We also observed thatthe position of hyoid bone varied in different skeletal patterns which maybe alsobe the reason for variation in pharyngeal dimension for which further studied has to be conducted.

Keywords: Skeletal malocclusion, Pharyngeal airway, Lower pharynx

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1. Introduction

The pharynx is a tube-shaped structure, approximately 12 to 14 cm long, composed of muscles and membranes. It extends from the base of the skull to the sixth cervical vertebra and the lower border of the cricoid cartilage.[1] Located behind the nasal and oral cavities and the larynx, the pharynx is divided into three sections: the nasopharynx, oropharynx, and laryngo-pharynx (**Figure 1**). The nasopharynx, situated behind the nasal cavity and above the soft palate, is connected to the nasal cavity and extends downward into the oropharynx, which runs from the second to fourth cervical vertebra and opens into the oral cavity through an isthmus. The laryngopharynx starts at the level of the pharyngoepiglottic fold and hyoid bone and extends to the sixth cervical vertebra. The pharyngeal airway plays a vital role in deglutition (swallowing), vocalization (speech), and respiration (breathing).[2]

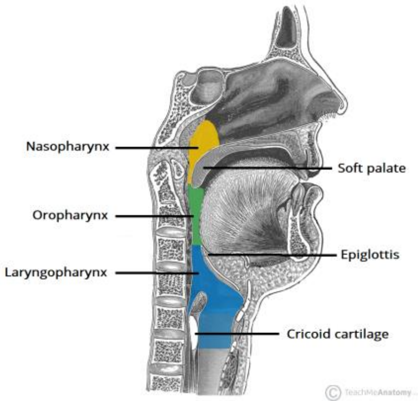

Figure 1: Anatomic structure of pharynx

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Obstructive factors, whether morphologic, physiologic, or pathologic—such as enlarged adenoids and tonsils, chronic or allergic rhinitis, environmental irritants, infections, congenital nasal deformities, nasal trauma, polyps, and tumors can lead to upper airway blockage. This obstruction often causes functional imbalance and shift to mouth breathing, which disrupts normal function and can alter facial structure and dental arch development, leading to malocclusion.[3]

The close relationship between the pharynx and dentofacial structures suggests a mutual interaction between pharyngeal structures and facial development patterns. The association between Class II Division 1 malocclusion and pharyngeal airway obstruction has been well documented, with mouth breathing playing a significant role in altering facial morphology and dental development.[4]

According to Balters' philosophy, Class II malocclusions result from a posterior positioning of the tongue, which disrupts the cervical region and impairs respiratory function near the larynx, leading to improper swallowing and mouth breathing. In contrast, Class III malocclusions are linked to a more anterior tongue position and cervical overdevelopment.[1] Evaluating the airway in patients with different skeletal patterns helps guide appropriate treatment to address both functional and aesthetic concerns.

A lateral cephalogram is a crucial diagnostic tool for orthodontists, as it offers detailed information about dental and skeletal relationships along with insights into airway anatomy. The McNamara airway analysis is a widely used method for assessing airway dimensions; however, it has been noted for its limited sensitivity in detecting subtle airway obstructions or variations.[5]

The aim of the study was to evaluate the upper, middle and lower pharyngeal airway dimensions of subjects aged above 18 years with different skeletal patterns.

2. Materials and Methods

The study was conducted at the Department of Orthodontics and Dentofacial Orthopedics, Navodaya College of Dental Sciences, Hospital and Research Centre, Raichur, Karnataka. The study was approved by Institutional Ethics Committee.

2.1. Inclusion criteria

1. Patients with class I, II and III skeletal malocclusion
2. Patient without skeletal malformations

2.2. Exclusion criteria

1. Patients who had undergone orthodontic treatment.
2. Patients with nasal obstruction.
3. Patients with history of enlarged adenoids or ENT infections.
4. Patients with habits –mouth breathing & tongue thrusting
5. Deglutition disorder.
6. Wound, burn and scar tissue in the neck region.

2.3. Sample size

A power analysis was established by G*power, version 3.0.1. A sample size of 21 (7 per group) would yield 80% power at confidence level 95%. 21 patients were selected for the study.

2.4. Method

A total of 21 individuals, aged 18-25, were selected from the Department of Orthodontics. The subjects were positioned with the Frankfurt horizontal plane parallel to the floor and their teeth in centric occlusion on the X-ray machine ORTHOPHOS XGS (SIRONA), and a lateral cephalogram was taken. The X-rays were printed using standard Fujifilm Medical Dry Imaging film (8*10 inches in size) and the Fujifilm Dry Pix Plus printer.

Cephalograms were manually traced on acetate paper of .003 thickness and 8x10 inches dimension. Tracings were done by a single operator.

Based on SNA, SNB and ANB angles, the cephalograms were divided into Class I, Class II and class III. An ANB angle of 2- 3° was classified as Class I, ANB angle ≥ 4° as Class II and ANB ≤ 0° as Class III.

The cephalograms were marked with 18 cephalometric landmarks to measure the pharyngeal airway (**Figure 2**).

The cephalometric landmarks marked were:

1. Basion(ba) –lowest point of ant margin of foramen magnum
2. Sella(s) - midpoint of Sella turcica.
3. Hormion (Ho)-inf pt of Sphenooccipital synchondrosis.
4. Pterygomaxillary fissure (Ptm)- inf point of pterygomaxillary fissure
5. ad1- point of intersection of posterior pharyngeal wall and line from Ptm -Ba.
6. ad2- point of intersection of posterior pharyngeal wall and Ptm to S-Ba line
7. ANS- Anterior nasal spine
8. PNS- Posterior nasal spine
9. ppw- Posterior pharyngeal wall intersecting occlusal plane
10. Cv2ia- inferoanterior point on 2nd cervical vertebrae
11. Cv3ia- inferoanterior point on 3rd cervical vertebrae
12. Ppw1- ppw intersecting the palatal plane.
13. Ppw2- ppw along line intersecting cv2ia and hy
14. Ppw3- ppw along line intersecting cv3ia and hy
15. Apw3-Anterior pharyngeal wall along line intersecting cv3ia and hyoid bone
16. Apw2 –ant pharyngeal wall along line intersecting cv2ia and hyoid bone

17. t- tongue surface intersecting occlusal plane
18. Hy- superior & anterior part of body of hyoid

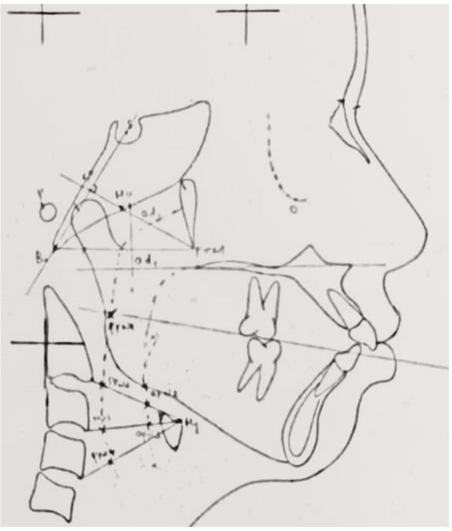

Figure 2: Cephalometric landmarks

2.5. Parameters for evaluation of pharyngeal airway

Fourteen linear cephalometric airway measurements were used to evaluate the pharyngeal airway dimension at various levels.

1. Ba-ad1 mm- soft tissue thickness at the post nasopharynx through Ptm-Ba line(ad1)
2. Ba-ad2 mm- distance from basion to the nearest adenoid tissue measured along the line through Ptm ⊥to S-Ba line(ad2)
3. Ba-PNS mm- total sagittal depth of nasopharynx
4. Ptm-ad1mm- distance between Ptm and the nearest adenoid tissue measured through Ptm-Ba line(ad1)
5. Ptm-ad2 mm- distance between Ptm and the nearest adenoid tissue measured through a perpendicular line to S-Ba from Ptm(ad2)
6. PNS-ppwI mm- airway thickness at the level of palatal plane
7. apw2-ppw2 mm- airway thickness at the level of the base of CV2
8. apw3-ppw3 mm - airway thickness at the level of base of CV3
9. hy-apw2 mm- distance between apw and hyoid bone at the level of CV2
10. hy-apw3 mm- distance between apw and hyoid bone at the level of CV3
11. Ho-ANS-PNS(mm)- height of nasopharynx
12. McNamara’s upper pharynx dimension- minimum distance between soft palate and nearest point on ppw
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 ppw.
14. t-ppw- oropharyngeal depth at the level of occlusal plane

2.6. Statistical analysis

Data was entered in the excel spread sheet and SPSS IBM Version 22 was used for data analysis with data represented in the form of mean and standard deviation

ANOVA test was used to compare the mean pharyngeal size among the groups & post-hoc Bonferroni test used for inter group comparison.

The level of significance is set at 5%.

3. Results

The upper pharyngeal airway measurement was made using McNamara's upper pharyngeal dimension. In the class I group the mean width was 13.86±1.68, in class II it was11.57±1.90 and in class III it was 11.86 ±2.4. The upper airway measurements made at ptm-ad1 showed 21.14±3.72 in class I, 24.86±3.93 in class II and 21.29±3.04 in class III groups. (**Table 1**)

The middle pharyngeal airway measurement was made using ‘t-ppw’ which showed a mean width of 11±2.08 in class I, 11±3.87 in class II and 9.57±0.79 in class III.

The lower pharyngeal airway measurements were made using McNamara's lower pharyngeal dimension. In class I the mean width was 12±1.41, in class II it was 10.71±1.98 and in class III was 13.14±1.77. There were statistically significant changes in the mean lower pharyngeal width on measuring apw2-ppw2 (**Table 2**) which showed 13.29±1.6 in class I, 11.86±2.41 in class II and 15.29±1.98 in class III groups with the level of significance being ($p<0.015$) (**Figure 3**).

Table 1: Comparison of the cephalometric findings among the groups using anova

Parameters	Groups	N	Minimum	Maximum	Mean	S.D	p value
SNA	Class I	7	76.0	89.0	82.86	4.14	0.081
	Class II	7	82.0	92.0	85.86	3.29	
	Class III	7	76.0	87.0	81.00	3.96	
SNB	Class I	7	77.0	86.0	80.86	3.02	0.059
	Class II	7	73.0	83.0	78.00	3.79	
	Class III	7	78.0	89.0	83.57	5.06	
ANB	Class I	7	1.0	3.0	2.29	0.95	0.001*
	Class II	7	5.0	11.0	7.86	2.48	

	Class III	7	-6.0	-1.0	-2.57	2.07	
Ba-ad1	Class I	7	16.0	28.0	21.00	3.65	
	Class II	7	16.0	21.0	18.71	1.70	
	Class III	7	16.0	28.0	19.29	4.07	0.422
Ba-ad2	Class I	7	16.0	32.0	25.86	6.99	
	Class II	7	25.0	29.0	28.29	1.50	0.626
	Class III	7	23.0	35.0	26.71	3.90	
Ba-PNS	Class I	7	38.0	45.0	41.71	2.36	
	Class II	7	39.0	46.0	43.43	2.37	
	Class III	7	40.0	45.0	42.00	2.52	0.384
Ptm-ad1	Class I	7	14.0	25.0	21.14	3.72	
	Class II	7	18.0	30.0	24.86	3.93	
	Class III	7	15.0	24.0	21.29	3.04	0.118
Ptm-ad2	Class I	7	13.0	21.0	17.14	2.67	
	Class II	7	12.0	25.0	19.43	4.79	0.529
	Class III	7	12.0	23.0	18.57	3.51	
McNamara Upper pharyngeal width	Class I	7	11.0	16.0	13.86	1.68	
	Class II	7	9.0	14.0	11.57	1.90	
	Class III	7	10.0	17.0	11.86	2.41	0.097
McNamara lower pharyngeal width	Class I	7	11.0	15.0	12.00	1.41	
	Class II	7	8.0	13.0	10.71	1.98	
	Class III	7	10.0	15.0	13.14	1.77	0.055
PNS-ppw	Class I	7	27.0	39.0	31.86	4.14	
	Class II	7	29.0	38.0	32.71	3.35	
	Class III	7	29.0	37.0	32.86	2.61	0.841
apw2-ppw2	Class I	7	11.0	16.0	13.29	1.60	
	Class II	7	8.0	14.0	11.86	2.41	0.018*
	Class III	7	13.0	19.0	15.29	1.98	
Apw3-ppw3	Class I	7	10.0	16.0	13.57	1.81	
	Class II	7	10.0	16.0	12.71	2.36	
	Class III	7	11.0	17.0	14.14	1.95	0.441
hy-apw2	Class I	7	11.0	25.0	19.00	4.76	
	Class II	7	14.0	24.0	18.86	3.58	0.833
	Class III	7	17.0	24.0	20.00	2.94	
Hy-apw3	Class I	7	10.0	20.0	15.71	3.40	
	Class II	7	14.0	20.0	16.57	2.70	
	Class III	7	15.0	20.0	17.71	1.70	0.397
Ho ⊥ANS-PNS	Class I	7	11.0	21.0	16.86	3.72	
	Class II	7	11.0	20.0	15.86	3.34	
	Class III	7	12.0	19.0	16.00	2.71	0.828
T ppw	Class I	7	9.0	15.0	11.00	2.08	
	Class II	7	6.0	18.0	11.00	3.87	0.502
	Class III	7	9.0	11.0	9.57	0.79	

*significant

Table 2: Inter-group comparison using post-hoc bonferroni

Parameters	Groups	Mean Difference	p value	95% ConfidenceInterval	
				LowerBound	UpperBound
SNA	Class I Vs Class II	-3.00	0.47	-8.38	2.38
	Class I Vs Class III	1.86	1.00	-3.52	7.24
	Class II Vs Class III	4.86	0.09	-0.52	10.24
SNB	Class I Vs Class II	2.86	0.61	-2.85	8.56
	Class I Vs Class III	-2.71	0.68	-8.42	2.99
	Class II Vs Class III	-5.57	0.06	-11.28	0.14
ANB	Class I Vs Class II	-5.57	0.001*	-8.31	-2.83
	Class I Vs Class III	4.85	0.001*	2.12	7.60

	Class II Vs Class III	10.42	0.001*	7.69	13.17
Ba-ad1	Class I Vs Class II	2.29	0.64	-2.38	6.95
	Class I Vs Class III	1.71	1.00	-2.95	6.38
	Class II Vs Class III	-0.57	1.00	-5.24	4.09
Ba-ad2	Class I Vs Class II	-2.43	1.00	-9.06	4.20
	Class I Vs Class III	-0.86	1.00	-7.49	5.77
	Class II Vs Class III	1.57	1.00	-5.06	8.20
Ba-PNS	Class I Vs Class II	-1.71	0.60	-5.12	1.70
	Class I Vs Class III	-0.29	1.00	-3.70	3.12
	Class II Vs Class III	1.43	0.85	-1.98	4.84
Ptm-ad1	Class I Vs Class II	-3.71	0.20	-8.77	1.34
	Class I Vs Class III	-0.14	1.00	-5.20	4.91
	Class II Vs Class III	3.57	0.24	-1.48	8.63
Ptm-ad2	Class I Vs Class II	-2.29	0.81	-7.59	3.02
	Class I Vs Class III	-1.43	1.00	-6.73	3.87
	Class II Vs Class III	0.86	1.00	-4.45	6.16
	Class I Vs Class II	2.29	0.15	-0.56	5.13

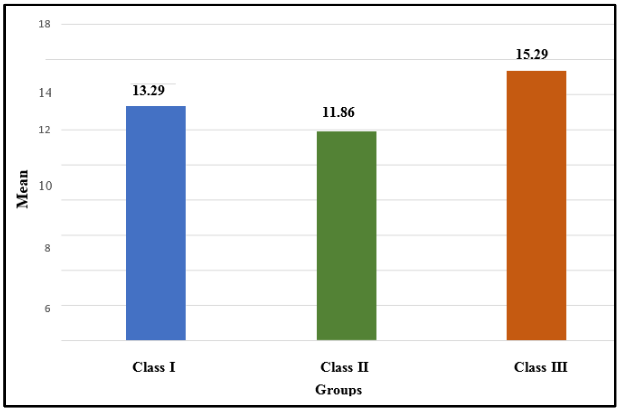

Figure 3: Mean apw2-ppw2 values

4. Discussion

Normal respiration is dependent on sufficient anatomical dimensions of the airway.[3] A mutual association is expected to exist between the pharyngeal structures and the dentofacial pattern in the common population. Solow et al., presumed that airway adequacy was related to the size and position of the mandible rather than maxillary variables.[6]

The present study sought to assess the effect of craniofacial morphology on the upper airway dimension with a sufficient sample size and to control for interactions between sagittal and vertical patterns.

The ANB angle was chosen to divide the sample into Class I, Class II, and Class III skeletal patterns because it is a widely used method for assessing the anteroposterior relationship between the maxilla and mandible. However, this angle can be affected by factors such as the anteroposterior position of the nasion relative to Points A and B.[7,8,9] Some researchers suggest that assessing these discrepancies should involve multiple methods. Despite its limitations, the ANB angle was used in this study, as using more than one criterion does not always provide consistent results. Several studies have found negative correlations between oropharyngeal volume and the ANB angle.[10,11,12]

The age range in this study was chosen to examine airway differences in growing adolescents with varying skeletal patterns. Schendel et al. noted that airway dimensions continue to increase until around age 20, after which they tend to stabilize moderately.[13]

Analyzing the result of our study, it can be inferred that lower pharyngeal airway width had a significant impact on class II & class III skeletal patterns. It is following a study conducted by Ismail et al., which showed a difference in hy-apw4 and t-ppw (oropharynx)[1]. Heeralal et al., found a significant change in the lower pharyngeal dimension which correlates with our present study where there was a change in apw2-ppw2 (lower pharynx) for class II & class III.

The mean upper pharyngeal airway dimension was decreased in Class I and Class III compared to Class II. This reduction may be due to a normally sized but retro-positioned maxilla, which can cause narrowing of the nasopharynx.[14]

The mean lower pharyngeal airway dimension was increased in class III and decreased in class II this may be attributed to the anteroposterior position of the mandible. This was in accordance with study conducted by T Muto et al., where the group with mandibular prognathism had the largest pharyngeal airway diameter, followed by those with a normal mandible, and then the group with mandibular retrognathism.[15]

Solow et al,[6] and Wenzel et al.[16] found no statistically significant relationship between pharyngeal size and anteroposterior jaw relationship, which contradicts the findings of the study conducted. Pallavi et al., evaluated pharyngeal width in skeletal class I & Class II and concluded that skeletal pattern does not influence pharyngeal width.[17]

The reason for the difference in results could be due to the difference in the selection of criteria and the sample size.

In our study, it was also noted that the position of hyoid bone varied in the three groups which is in accordance with study conducted by Mortazavi et al.,[18] (**Figure 4**) which could also be the reason for varied lower pharyngeal dimensions for which further studies are required.

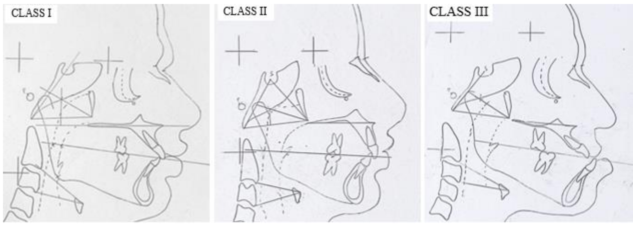

Figure 4: Variation in hyoid bone

5. Conclusion

The pharyngeal airway can be varied by the alteration in anterioposterior relation of the maxilla and mandible.

1. The Class II skeletal malocclusion group had a smaller lower pharyngeal width when compared to Class I and Class III groups.
2. The Class III skeletal malocclusion group had a larger lower pharyngeal width when compared to Class I and Class II groups.

6. Source of Funding

None.

7. Conflict of Interest

None.

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