PHARYNGEAL DIMENSIONS IN VARIOUS FACIAL PATTERNS - A CEPHALOMETRIC STUDY

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The purpose of this study was to evaluate and compare the nasopharynx, oropharynx and hypopharynx of persons with hyperdivergent, hypodivergent and normodivergent facial patterns and to determine the effects of the pharyngeal size in different facial patterns. The pre-treatment cephalograms of 90 subjects were obtained from the department of orthodontics, faculty of dental sciences, Chhatrapati Shahuji Maharaj Medical University, Lucknow. Sample was divided into 3 groups on the basis of SN – MP angle and 30 subjects were in each group, Group I: SN-MP range – 25-33° (Normodivergent), Group II: SN-MP range - <25° (Hypodivergent), Group III: SN-MP range - >33° (Hyperdivergent). The area measurement of oropharynx was significantly greater for group III when compared to group I [p<0.01] and group II [p<0.05]. Conclusion: **The thickness of the posterior pharyngeal wall in the nasopharynx was more in the hyperdivergent group than the other groups. The oropharynx was observed to be larger in hyperdivergent subjects followed by hypodivergent subjects and then by normodivergent subjects.**

The nasopharynx and the oropharynx have significant locations and functions because both of them form a part of the unit in which respiration and deglution are carried out. As a close relationship between the pharynx and the dentofacial structures exists, a mutual interaction is expected to occur between the pharyngeal structures and the dentofacial pattern, which therefore justifies orthodontic interest. The craniofacial complex is capable of compensatoy changes which may to a certain extent mask some craniofacial anomalies, defects or deficiencies[2]. The compensatory changes present as hypodivergence or hyperdivergence of facial pattern and pharyngeal dimension being a primary factor leading to such compensatory mechanism. It has been hypothesized that chronic nasal obstruction causes hyperdivergent facial growth. Patients exhibiting this pattern typically have 'long face syndrome' characterized by a vertically long lower face height, narrow alae, lip incompetency, a narrow maxillary arch and a greater than normal mandibular plane angle[3,4,5,6].

Influence of breathing or airway obstruction on the malocclusion was demonstrated in 1968. Morrison[29] proposed the existence of a relationship between mouth breathing and facial form. He stated that oral respiration alters normal air currents and pressures through the nasal and oral cavities which cause impaired development of these structures. Kingsley denied a significant relationship between facial morphology and mode of breathing and Emslie[7] reported that the adenoidal facies were not caused by nasal obstruction but were genetically determined. Subtelny[30] stated that the width of the nasopharynx is stable after the age of two years. Gwynne et al[31] stated that mouth breathing does not produce deformities of the jaws and malocclusions and does not result in the development of the adenoidal faces. Bench[11] stated lack of obvious association between structural features of the pharynx and the face when persons with less extreme somato-types or with no additional functional problems were considered. Dunn et al[33] neither support nor refute a possible relationship between upper air way function and dentofacial morphology. Kerr[14] concluded that when no breathing problem or extreme facial growth pattern was present and, the structure and growth of the nasopharynx, especially in sagittal depth, was fairly independent relative to anterior dentofacial dimensions. Athanasiou et al[23] found that the posterior surgical mandibular repositioning does not reduce the airway at the levels of the second and fourth cervical vertebrae.

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Rickets[32] stated that the angle of the soft palate was strongly correlated with the anteroposterior dimension at the bony nasopharynx. In shallow anteroposterior nasopharynx, the soft palate yields an acute angle at the junction with the palate at the posterior nasal spine. Linder – Aronson[3] found that the angle (formed by mandibular line and nasal line) was greater for those patients indicated for surgery due to adenoidal enlargement or recurrent ear infections. Bergland[10] stated that the shape of the cranial base (N-S-Ba) angle influences the pharyngeal depth; an acute angle leads to a more vertical direction of pharyngeal development. An obtuse cranial base angle will open up the anteroposterior dimension of the pharynx. Dunn et al[33] concluded that Bigonial width and gonial angle variation are inversely related to nasopharyngeal air way size variation. Linder Aronson[34] noted that the size of the nasopharyngeal cavity changed in children who switched from mouth to nose breathing after adenoidectony. Koski et al[1] concluded that dorsal rotation of the mandible occurring in association with various pathologic processes could always be primarily a response to an encroachment of the pharyngeal space. Enlow[2] concluded that persons with dolichocephalic growth patterns have tendency toward and obtuse cranial base angle (CBA) because of increasing the depth of the nasopharynx. Tarvonen and Koski[35] found dorsal rotation of the mandibular ramus relative to the palate in patients with enlarged adenoids. Ceylan et al[17] observed that oropharynx area measurements were affected by the change of ANB angle and oropharynx area became smaller with the increase of ANB angle. Eunu-kwon Pae et al[20] concluded that pharyngeal length may be a convenient indicator to diagnose open bite. Akcam et al[36] found that the soft palate length and height showed the largest increase in the subjects with posterior rotation. The purpose of this study was to evaluate and compare the nasopharynx, oropharynx and hypopharynx of persons with hyperdivergent, hypodivergent and normodivergent facial patterns and to determine the effects on the pharyngeal size in different facial patterns.

MATERIAL AND METHOD

The pre-treatment cephalograms of 90 subjects were obtained from the department of orthodontics, faculty of dental sciences, Chhatrapati Shahuji Maharaj Medical University, Lucknow.

The sample was selected on the following basis:

No history of previous orthodontic treatment

Breathing comfortably though nose

No previous history of trauma to the head and neck regions.

Lateral cephalogram taken in centric occlusion.

Age group range – 15 – 22 years.

GROUPINGS

Sample was divided into 3 groups on the basis of SN – MP angle and 30 subjects were in each group (Schudy)[22]

Group I: SN-MP range – 25-33° (Normodivergent).

Group II: SN-MP range - <25° (Hypodivergent).

Group III: SN-MP range - >33° (Hyperdivergent).

METHODS

The cephalograms obtained were taken with the help of universal counterbalancing type of cephalostat by properly positioning and by keeping the Frankfort horizontal plane parallel to the floor and the teeth in centric occlusion. Kodak X-ray films (8" x 10") were exposed at 70Kvp; 30 mA from a fixed distance of 60 inches for two seconds by following the standard technique employed in the department of Orthodontics, Faculty of Dental Sciences, Chhatrapati Shahuji Maharaj Medical University (upgraded King Goerge's Medical College), Lucknow.

The following cephalometric landmarks, lines, planes, angular, linear and different area measurements were used in the study.

CEPHALOMETRIC LANDMARKS (Fig 1, 2)

N Nasion The anterior most point of the frontonasal suture in the mid sagittal plane[24]

S Sella Midpoint of the hypophyseal fossa[25]

A Subspinale Deepest point between anterior nasal spine and prosthion[25]

B Superamentale Most posterior point in the outer contour of mandibular alveolar process in the median plane between infradentale and pogonion[25]

Me Menton Most caudal point in the Outline of symphysis Regarded as lowest point at the mandible[25]

Gn Gnathion A point located by taking the midpoint between the anterior (pogonion) and inferior (menton) points of the bony chin[24]

Go Gonion A constructed point, the intersection at the line tangent to the posterior margin of ascending ramus and mandibular base[25]

Ba Basion Lowest point on the anterioir margin of the foramen magnum in the median plane[25]

ANS Anterior Tip of the bony a nasal spine anterior nasal spine in the median plane[25]

PNS Posterior nasal Constructed spine radiological point, the intersection of a continuation of anterior wall of the pterygopalatine fossa and the floor of the nose. It marks the dorsal limit of the maxilla[25]

HY Hyoidale The most superior anterior point on the body of the hyoid bone[23]

Ep The most superior and posterior point at the epiglottis[27]

PPWb The intersection point of a line from 'B' through 'Go' and the base of the posterior pharyngeal wall.[26]

Ptm Pterygomaxillary The intersection point between the nasal floor and posterior contour of the maxilla[23]

P Tip of the soft palate[27]

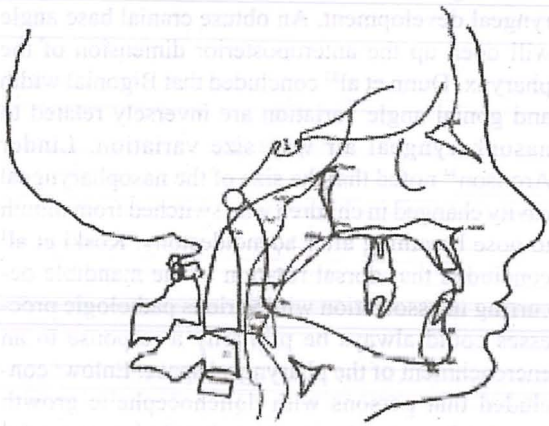
Tb The intersection point of a line from 'B' through 'Go' and the base of the tongue[26]

ad1 The intersection point of the posterior nasopharyngeal wall and the line from "Ptm" to basion[17]

ad2 The intersection point of the posterior nasopharyngeal wall and the line "Ptm" to "SO" where "SO" is the mid point between sella and basion[17]

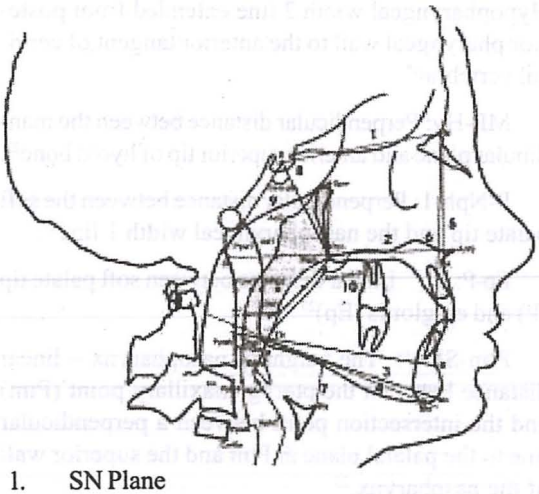
SPW The intersection point between a perpendicular line to the palatal plane at Ptm and the superior wall of the nasopharynx[23]

FIG 1: CEPHALOMETRIC POINTS USED IN THE ANALYSIS



N	Nasion
S	Sella
A	Subspinale
B	Supramentale
Me	Menton
Gn	Gnathion
Go	Gonion
Ba	Basion
ANS	Anterior Nasal Spine
PNS	Posterior Nasal Spine
Hy	Hyoidale
C_3	Thrid Cervicalvertebrae
Ep	Tip of the Epiglottis
Ptm	Pterygo maxillary point
P	Tip of the soft palate

FIG 2: CEPHALOMETRIC LINES, PLANES AND ANGULAR VARIABLES USED IN THE ANALYSIS



1. SN Plane
2. Palatal Plane
3. Mandibular Plane (Go-Gn)
4. Mandibular Plane (Go-Met)
5. NA Plane
6. NB Plane
7. MP-hy
8. N-S-P tm
9. Ptm-S-Ba
10. ANS-PNS-P

FIG 3: LINEAR VARIABLES USED IN THE ANALYSIS

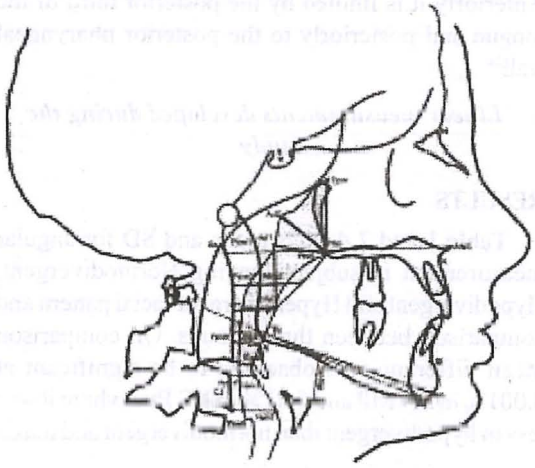
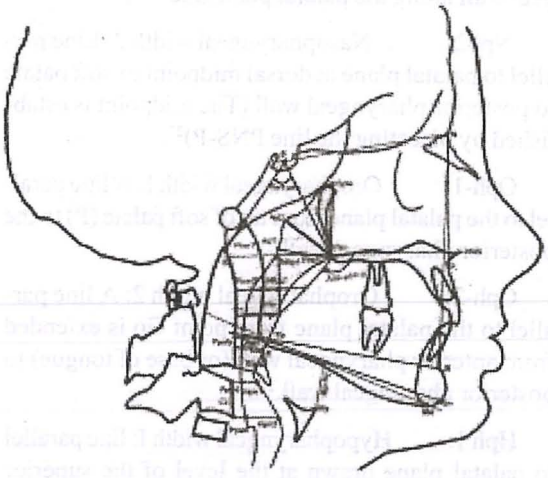


FIG 4: LINEAR AND AREA MEASUREMENT VARIABLES USED IN THE ANALYSIS



CEPHALOMETRIC ANGLES (Fig. 2, 3, 4)

SNA[25] , SNB[25] , ANB[25] , SN-MP[25]

N-S-Ptm: The shape of the bony nasopharyngeal space-angle between the line N-S and S-Ptm[23]

Ptm-S-Ba: The shape of the bony nasopharyngeal space – angle between the lines Ptm-S and S-Ba.[23]

ANS-PNS-P: Palatal angle; that is the angle at intersection of palatal plane and soft palatal plane.[23]

LINEAR MEASUREMENTS (Fig 2, 3, 4)

Ba-PNS: Dimension of the bony pharynx-linear distance between point Ba and PNS[17].

Ptm-ad1: Distance between the posterior nasal spine and ad1[17]

Ptm-ad2: Distance between the posterior nasal spine and ad2[17]

PAS: Posterior airway space: That is the distance between the base of the tongue (tb) and the posterior pharyngeal wall (PPwb) along a line extended from 'B' point to 'Go'[26].

PNS-P: Distance between posterior nasal spine and soft palate tip[26].

Nph1: Nasopharyngeal width-I is measured from posterior nasal spine to posterior pharyngeal wall along the palatal plane line[27]

Nph2: Nasopharyngeal width 2: Line parallel to palatal plane at dorsal midpoint of soft palate to posterior pharyngeal wall (The midpoint is established by bisecting the line PNS-P)[27].

Oph-1: Oropharyngeal width I: A line parallel to the palatal plane from tip of soft palate (P) to the posterior pharyngeal wall[27].

Oph-2: Oropharyngeal width 2: A line parallel to the palatal plane from point Go is extended from anterior pharyngeal wall (or base of tongue) to posterior pharyngeal wall.[27]

Hph 1: Hypopharyngeal width I: line parallel to palatal plane drawn at the level of the superior border of C3 and measured from Anterior Pharyngeal wall (base of tongue) to posterior pharyngeal wall[27]

Hph-2: Hypopharyngeal width 2: a line parallel to the palatal plane at the level of inferior border of "C3" measured from anterior pharyngeal wall to posterior pharyngeal wall[27].

PPW 1: Posterior pharyngeal wall 1: Nasopharyngeal width-1 line extended from posterior pharyngeal wall to the anterior tangent of cervical vertebrae[27].

PPW-2: Posterior pharyngeal wall 2: nasopharyngeal width 2 line extended from posterior pharyngeal wall to the anterior tangent of cervical vertebrae[27].

PPW-3: Posterior pharyngeal wall 3: oropharyngeal width 1 line extended from posterior pharyngeal wall to the anterior tangent of cervical vertebrae[27].

PPW-4: Posterior pharyngeal wall 4: oropharyngeal width 2 line extended from posterior pharyngeal wall to the anterior tangent of cervical vertebrae*.

PPW-5: Posterior pharyngeal wall 5: Hypopharyngeal width 1 line extended from posterior pharyngeal wall to the anterior tangent of cervical vertebrae*.

PPW-6: Posterior pharyngeal wall 6: Hypopharyngeal width 2 line extended from posterior pharyngeal wall to the anterior tangent of cervical vertebrae*.

MP-Hy: Perpendicular distance between the mandibular plane and anterior superior tip of hyoid bone[23].

P-Nph-1: Perpendicular distance between the soft palate tip and the nasopharyngeal width 1 line[27].

Ep-P: Linear distance between soft palate tip (P) and epiglottis (Ep)[27]

Ptm-SPW: The height of nasopharynx – linear distance between the pterygomaxillary point (Ptm) and the intersection point between a perpendicular line to the palatal plane at Ptm and the superior wall of the naspharynx.[23]

AREA – Boundaries (as described in Gray's Anatomy) Nasopharyngeal area: Superior it starts from the lower border of the soft palate and inferiorly it extends upto the upper margin of the epiglottis. Anterior it is limited by the posterior third of the tongue and posteriorly it is limited by pharyngeal wall[28].

Oropharyngeal area: Superiorly it starts from the lower border of the soft palate and inferiorly it extends upto the upper margin of the epiglottis. Anteriorly it is limited by the posterior third of the tongue and posteriorly to the posterior pharyngeal wall[28]

Linear measurements developed during the study

RESULTS

Table 1 and 2 depicts mean and SD for angular measurement in subjects having Normodivergent, Hypodivergent and Hyperdivergent facial pattern and comparison between three groups. On comparison mean differene was observed to be significant at 0.001% in SN MP and 0.01% in NS Ptm where it was less in hypodivergent than normodivergent and maxi-

TABLE 1: ANGULAR MEASUREMENTS OF DIFFERENT GROUPS

S. No.	Variable	Group I (SN-MP+25°-33°) Normodivergent	Group II (SN-Mp<25°) Hypodivergent	Group III (SN-MP<33°) Hyperdivergent
1.	SN-MP	29.13±1.89	20.80±2.81	38.23±3.29
2.	SNA	82.37±2.67	82.07±4.06	79.17±3.29
3.	SNB	77.97±3.77	78.10±4.12	74.80±2.87
4.	ANB	4.73±3.25	3.97±2.67	4.40±2.39
5.	N-S-Ptm	68.87±3.73	66.00±3.46	71.07±3.46
6.	Ptm-S-Ba.	60.73±4.27	64.27±5.33	62.57±6.53
7.	ANS-PNS-P	133.87±6.67	135.87±7.02	136.20±6.94

TABLE 2: COMPARISON OF ANGULAR MEASUREMENTS IN DIFFERENT GROUPS

S. No.		I vs. II			I vs. III			II vs. III		
		t	P	Remark	t	P	Sig.	t	P	Sig.
1.	SNA	0.34	NS	NS	4.14	p<0.001	S↑I	3.04	<p0.01	S↑II
2.	SNB	0.13	NS	NS	3.66	p<0.001	S↑I	3.60	p0.01	S↑II
3.	ANB	0.98	NS	NS	0.44	NS		0.66	NS	
4.	SN-MP	13.47	p<0.001	S↑I	13.14	p<0.001	S↑III	22.06	p<0.001	S↑III
5.	N-S-Ptm	3.09	p<0.01	S↑I	2.37	p<0.05	S↑I	5.68	p<0.001	S↑III
6.	Ptm-S-Ba	2.84	p<0.01	S↑II	1.29	NS		1.10	NS	
7.	ANS-PNS-P	1.31	NS	NS	1.33	NS		0.18	NS	

mum in hyperdivergent than hypodivergent. Angle SNA & SNB exhibited significant difference in comparison between group 1 and 3; 2 and 3. Meaning there by that the maxilla and mandible were posteriorly places in group 3.

Table no. 3 and 4, are showing that linear dimension in Hypodivergent group was significantly more in Ptm-ad1, NPh1, Nph2 and PPW6 in comparison to Normodivergent. Mean significant difference observed in linear measurement of NPh2 and EP-P which was significantly more in Hyperdivergent group than in Normodivergent and when Hypodivergent group was compared to Hyperdivergent, the mean difference was observed to be statistically significant which was more in Ptm ad1, Ptm-ad2, NPh1, OPh2 in Hypodivergent than Hyperdivergent, however the mean measurement of PPw1 and MPhy was more in Hyperdivergent than Hypodivergent. These differences were found to be statistically significant at 5% level of significance.

Table 5 & 6 reveal that an insignificant difference is seen in mean value of nasopharyangeal area between normodivergent, hypodivergent and hyperdivergent cases. Whereas the orophayryngeal mean area was statistically more in hyperdivergent than normodivergent and hypodivergent. The differ-

Table 3: LINEAR MEASUREMENTS OF DIFFERENT GROUPS

S. No	Variables	Group I Normodivergent (n=30)	Group II Hypodivergent (n=30)	Group III Hyperdivergent (n=30)
1.	Ba-PNS	46.70±3.63	48.77±3.23	48.33±4.79
2.	Ptm-adl	24.63±5.76	28.37±3.46	24.07±6.55
3.	Ptm-ad2	19.80±7.01	2188±4.81	18.07±4.39
4.	PAS	7.90±3.91	6.98±3.80	8.20±4.72
5.	PNS-P	32.20±3.13	32.13±4.07	32.33±3.16
6.	Nphl	25.43±5.04	28.83±4.09	25.23±5.86
7.	Nph2	18.67±2.56	20.15±2.24	20.07±2.74
8.	OphI	9.72±2.38	10.18±2.51	9.60±3.72
9.	Oph2	9.73±1.87	9.88±3.65	7.35±2.57
10.	Hphl	6.93±2.90	6.48±2.55	6.30£3.12
11.	Hph2	8.93±3.91	8.85±4,68	8.90±3.52
12.	PPw1	15.57±4.58	14.90±4.22	18.13±6.28
13.	PPw2	9.87±2.01	10.03±2.61	10.93±3.69
14.	PPw3	5.70+1.91	6.20+1.74	6.58+1.94
15.	PPw4	3.67±1.30	3.75±1.19	3.98±1.33
16.	PPw5	4.30±0.95	4.18±0.91	4.30+1.02
17	PPw6	3.43±0.77	3.88±0.91	3.45±1.40
18.	MP-Hy	11.00±7.40	9.07±4.36	12.03±5.10
19.	P-NIIP1	23.50±3.52	22.5±4.09	22.60±3.01
20.	EP-P	21.93±5.19	24.10±5.75	26.77±5.89
21.	Ptm-Spw	26.87±4.23	24.93±3.16	26.45±3.05

ence in mean was significant between hypodivergent and hyperdivergent cases.

Table 7 & 8 demonstrate that mean pharyngeal area was significantly less in normodivergent than hyperdivergent and hypodivergent whereas insignificant difference existed between hypo divergent and hyperdivergent group.

DISCUSSION

Normal respiration denotes that the nasal and pharyngeal structures are being used sufficiently

TABLE 4: COMPARISON OF LINEAR MEASUREMENTS AMONG DIFFERENT GROUPS

S. No.		I vs. II			I vs. III			II vs. III		
		t	P	Sig.	t	P	Sig.	t	P	Sig.
1.	Ba-PNS	2.33	p<0.05	S↑I	1.49	N.S.	N.S.	0.42	N.S.	N.S.
2.	Ptm-ad1	3.46	p<0.01	S↑II	0.35	N.S.	N.S.	3.56	p<0.01	S↑II
3.	Pum-ad2	1.34	N.S.	N.S.	1.15	N.S.	N.S.	3.20	P<0.01	S↑II
4.	PAS	0.93	N.S.	N.S.	0.27	N.S.	N.S.	1.11	N.S.	N.S.
5.	PNS-P	0.07	N.S.	N.S.	0.16	N.S.	N.S.	0.21	N.S.	N.S.
6.	Nph1	2.87	p<0.01	S↑II	0.14	N.S.	N.S.	2.76	P<0.01	S↑II
7.	Nph2	2.38	p<0.05	S↑II	0.014	p<0.05	S↑III	0.13	N.S.	N.S.
8.	Oph1	0.73	N.S.	N.S.	0.15	N.S.	N.S.	0.64	N.S.	N.S.
9.	Oph2	0.76	N.S.	N.S.	0.20	N.S.	N.S.	3.10	P<0.01	S↑II
10.	Hph1	0.64	N.S.	N.S.	0.81	N.S.	N.S.	0.24	N.S.	N.S.
11.	Hph2	0.07	N.S.	N.S.	0.03	N.S.	N.S.	0.04	N.S.	N.S.
12.	PPw1	0.59	N.S.	N.S.	1.80	N.S.	N.S.	2.34	p<0.05	S↑III
13.	PPw2	0.27	N.S.	N.S.	1.38	N.S.	N.S.	1.09	N.S.	N.S.
14.	PPw3	1.06	N.S.	N.S.	1.77	N.S.	N.S.	0.80	N.S.	N.S.
15.	PPw4	0.25	N.S.	N.S.	0.91	N.S.	N.S.	0.71	N.S.	N.S.
16.	PPw5	0.50	N.S.	N.S.	0	N.S.	N.S.	0.48	N.S.	N.S
17.	PPw6	2.06	p<0.05	S↑II	0.06	N.S.	N.S.	1.41	N.S.	N.S.
18.	MP-Hy	1.23	N.S.	N.S.	0.62	N.S.	N.S.	2.2	p<0.05	S↑III
19.	P-NPH1	1.02	N.S.	N.S.	1.06	N.S.	N.S.	1.06	N.S.	N.S.
20.	EP-P	1.53	N.S.	N.S.	3.88	p<0.01	S↑III	1.78	N.S.	N.S.
21.	Ptm-Spw	2.01	N.S.	N.S.	0.44	N.S.	N.S.	1.90	N.S.	N.S.

TABLE 5: NASOPHARYNGEAL AND OROPHARYNGEAL AREA MEASUREMENTS OF DIFFERENT GROUPS

S. No.	Pharyngeal Area	Group I (SNMP=25°33°) Normodivergent	Group II (SN-Mp<25°) Hypodivergent	Group HI (SN-MP> 330) Hyperdivergent
1.	Nasopharyngeal area	615.00 ± 154.34	660.80 ± 100.11	640.10 ± 161.93
2.	Oropharyngeal area	164.40 ± *55.56*	181.90 ± 94.35	234.63 ± 102.77

TABLE 6: COMPARISON OF ANGULAR MEASUREMENTS IN DIFFERENT GROUPS

S. No.	Area	I vs. II			I vs. III			II vs. III		
		't'	'p'	Rem.	't'	'p'	Rem.	't'	'p'	Rem.
1.	Nasopharyngeal	1.36	NS	NS	0.61	N.S.	S↑I	0.60		
2.	SNB	0.88	NS	NS	3.29	p<0.01	S↑III	2.07	p<0.05	S↑III

TABLE 7: PHARYNGEAL (NASO + ORO) AREA MEASUREMENTS OF DIFFERENT GROUPS

Groups	Mean±SD
I	779.40±114.95
II	842.70±107.43
III	874.73±158.42

(Subtelny). A normaly nasal airway is dependent on sufficient anatomical dimension of the nasal passage. In addtion, the size of nasopharynx is of particular importance in determining whether the mode of breathing is nasal or oral. Therefore, in this study, any factors affecting the normal nasal breathing & pharynx size were excluded and only subjects with the normal breathing pattern were included.

The material consisted of pre-treatmnet cephalograms of 90 patients. All the patients were 15 years or above at the time of obtaining the lateral cephalograms. Sample selection was based on the fact that the human subjects do not show any appreciable growth changes after the age of 17 years with regards to the pharyngeal dimensions. This was also supported by the study done by King[8] the anteroposterior growth of the pharynx (pharyngeal depth) is almost complete by 12 years of age. The vertical growth of the pharynx however continues throughout the growth period. The soft palate also completes most of its growth in the early years of life and the growth curve reaches a plateau at 10-12 years of age. Jeans et al[17] have reported that the nasopharyngeal airway area increases rapidly until 13 years of age. And after this period the growth slows down. As no significant differences between males and females were observed in this study hence the data were combined. The present study was carried out in order to determine the differences in size of nasopharynx, oropharynx and the hypopharynx in patients with different types of facial pattern.

Sample was studied for angular variables namely N-S-Ptm, which indicates the anterior positioning of the pharyngeal wall. The hyperdivergent (Group III) shows significantly larger value (71.07±3.46) than the

TABLE 8: COMPARISON OF PHARYNGEAL (NASO + ORO) AREA IN DIFFERENT GROUPS

Groups	't'	p	Remark
I (Normodivergent) vs II (Hypodivergent)	3.26	<0.05	Significantly higher in II
I (Normodivergent) vs II (Hypodivergent)	2.68	<0.05	Significantly higher in III
I (Normodivergent) vs II (Hypodivergent)	0.92	N.S.	High in III but not statistically significant

normodivergent (Group I) which in turn was significantly greater than hypodivergent (Group II) indicating a more retroposition maxilla and hence a more posteriorly located anterior wall of the pharynx which in turn means a smaller antero-posterior dimension of the naso-pharynx in hyperdivergent patients (Emsile et al[7], Bjork 1955[9], Bergland, 1963[10]). Linear measurment Ba-PNS indicating an antero-posterior size of the nasopharynx and thickness of the posterior pharyngeal wall was larger for normodivergent (Group I) when compared to hypodivergent (Group II) being significant at level of $p<0.05$. This finding is supported by study of Linder-Aronson and Woodside[18], in which they found that sagittal depth of the bony nasopharynx is a relatively independent variable in its relation to other dimensions of the facial complex.

The linear measurments Nph1 and Nph2 were larger for Group II (hypodivergent) as compared to the Group I (hyperdivergent) and Group II (normodivergent) show a more antero-posterior dimension of nasopharynx in hypodivergent subjects. These indicate a smaller antero-posterior dimension in hyperdivergent subject which are similar to the findings of Koski et al[1] and Opdebeek et al[12]. They stated that nasopharyngeal depth (the distance of PNS to the posterior pharyngeal wall) is significantly shorter in the LFS than in the small face syndrome (SFS), which is characterized by extreme euryprosopy, even through the CBA is larger in the former. This would be due to a retrognathic position of the whole maxilla relative to the SN. The PNS and the anterior nasal spine (ANS) are in more distal position, whereas the SNA angle remains unchanged. This finding is supported by the study of Taylor et al[18] in which they found that the distance between the anterior border of the atlas (ATA) and PNS did not change after age 12, while two soft tissue measurments (PNS-pharyngeal wall(Ph W2) (19.3 to 25.6 mm) and posterior soft palate to pharyngeal wall (PhW3) (8.2 to 11.1 mm) increased.

A greater dimension of oph2 for Group II (9.88±3.65) when compared to Group III (7.35±2.56) and Group I (9.73±1.87) coincides with the study of Trenouth et al[21] in which they found that the oropharyngeal area (OPA) also increases as the cranial base angle (NHBa) opens up.

A greater value (18.13±6.28) of PPW1 for Group III indicates a greater thickness of the wall of pharynx in the region of nasopharynx is a result of greater adenoidal activity and this increased thickness may be due to larger size of the adanoids in this group. Solow et al[13] found that larger carniocervical angulation was associated with small mandibular dimension, mandibular retrognathism and a large mandibular inclination and retroclination of the upper incisors, however, the nasopharyngeal airway was obstructed. Emslie et al[7] found those childern with long narrow faces, high gonial angles, and narrow arches showed a high incidence of adenoidal obstruction of the nasopharynx because the nasopharynx was narrow as was the rest of the face, and thus was easily blocked.

A larger dimension of PPW6 (3.88±0.91) for Group II indicates a greater thickness of the pharyngeal wall in the hypopharyngeal region and this could be due to increased horizontal growth vector in the hypodivergent group as stated by Treanouth et al[21]

A greater value of MP-hy for Group III (12.03+5.10) indicates vertical tendency of structural growth in hypodivergent group. Bench RW[11] who stated that euryprosopy is characterized by minimal vertical increase in the vertebral and by only a forward movement of the hyoid bone, whereas in the vertical growth pattern, cervical vertical growth is considerable and is assoiciated with a concomitant downward movement of the hyoid bone.

A greater Ep-p value (26.77±5.89) indicates increased length of the oropharynx in the Group III, which is a result of greater oro-pharyngeal stimulation and general growth trend[11].

There was a non-significant difference in the nasopharyngeal area measurement in all the three groups. This finding is similar with the study of Kerr[14] who found that when no breathing problem or extreme facial growth pattern is present, the structure

and growth of the nasopharynx, especially in sagittal depth, is fairly independent relative to anterior dentofacial dimensions.

As shown in table 6 the area of oropharynx was significantly larger for the Group III (234±102.77) which again supports the view of the growth trend of associated structures. This finding coincides with the study of Tourne[16] in which he found that the pharynx increases its capacity predominantly by a vertical expansion which indicates the amount and direction of growth at the sphenooccipital synchondrosis and the cervical vertebrae.

As shown in table 8 the pharyngeal area (naso and oro) was larger in Group II (842.70±107.43) and Group III (875.73± 158.42) as compared to the Group I(779.40±107.43) which shows that alteration in the facial pattern alters the dimensions of the pharynx. Ternouth et al[21] supports an association between a short mandible and small oropharyngeal airway in the context of obstructive sleep apnea syndrome, the same could not be said for the relationship of the oropharyngeal airway to long face syndrome. They also found that the oropharyngeal airway (OPA) also increases as the cranial base angle (NSBa) opens up. This could be explained as a more posterior positioning of the temporo mandibular loint requiring a larger mandibular to maintain a normal relation with the maxilla thereby increaseing the OPA. This finding is also supported by the study of Eung-Kwon et al[20] in which they concluded that respiratory efficiency may be associated with anterior open bite. This finding is also supported by Wenzel et al[15] in which they found that changes in nasopharyngeal airway size were not correlated to any changes in morphology apart from maxillary prognathism, nor to changes in postrure. Carroll et al[19] also revealed similar results. They found that lip posture, sagittal airway size, and tonsil size represent three different and unrelated phenomena with respect to their effects on craniofacial growth and form.

CONCLUSION

Following conclusion have been drawn from this study.

i. Hyperdivergent faces demonstrate pronounced increased posterior pharyngeal wall thickness in nasopharynx.

ii. Oropharyngeal area was significantly increased in hyperdivergent than hypodivergent and normodivergent cases.

iii. Nasopharyngeal height and nasopharygeal area were unaffected in different facial patterns.

iv. Hyoid bone was placed relatively low in the hyperdivergent faces.

v. Horizontal growth vector was dominant in the hypodivergent while vertical growth in hyperdivergent faces.

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