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RESEARCH ARTICLE

ASSESSMENT OF PHARYNGEAL WIDTH AND LENGTH, POSITION OF HYOID BONE AND SIZE & INCLINATION OF SOFT PALATE IN DIFFERENT SKELETAL MALOCCLUSIONS UTTRAKHAND POPULATION

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ABSTRACT

Background: Uvulo-glosso-pharyngeal dimensions and size and position of associated structures are integral part of Orthodontic treatment planning. Since decades various authors have assessed airway dimensions by different methods and implied the results in diagnosis and treatment planning.
Aims & objectives: The aim of this study was to investigate the uvulo-pharyngeal dimensions and position of hyoid bone in subjects with different anteroposterior jaw relationships.
Method: Cephalometric radiographs of 30 subjects (age 15-25 years of Uttrakhand ethnic origin) were divided into three Groups accorging to ANB and Wits appraisal. Group 1, Skeletal Class I (ANB 1-4 and Wits Appraisal -1 to 0) Group 2, Skeletal Class II (ANB >4 and Wits Appraisal >1) & Group 3, Skeletal Class III (ANB <1 and Wits Appraisal < -1.5). Statistical analysis was undertaken using one-way ANOVA to evaluate the mean and standard deviation in the three Groups and Post hoc Tukey test was done to compare the variables between the three Groups.
Results: On an average, upper airway width was decreased in Group 2 and increased in Group 3 (p=0.028). Lower airway was increased in Group 3 (p=o.005). Velopharyngeal airway was decreased in Group 2 and increased in Group 3(p=0.042).Thickness of soft palate was increased in Group 3(p= 0.0.13). Hyoid bone was positioned poaterioinferiorly in Group 2 and Anterosuperiorly in Group 3(p=0.002).In conclusion, uvulo-pharyngeal airway and position of hyoid bone are affected by anteroposterior skeletal patterns in Uttrakhand population despite of its multiethenicity.

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INTRODUCTION

Pharynx, a tube-shaped structure formed by muscles and membranes, is located behind nasal and oral cavities, and extends from the cranial base to the level of the sixth cervical vertebra (Soheilifer et al., 2014). The pharyngeal airway is the first component of the significant structures, which provides respiration – one of the vital functions of the human body. Because of the close anatomical, structural and functional relationship between the pharynx, soft palate, tongue, epiglottis, hyoid Bone and craniofacial & dentofacial structures such as cranial base, maxilla and mandible, a mutual interaction in terms of growth and function between them is expected (Maghsoudi and Azerbayejani, 2015).

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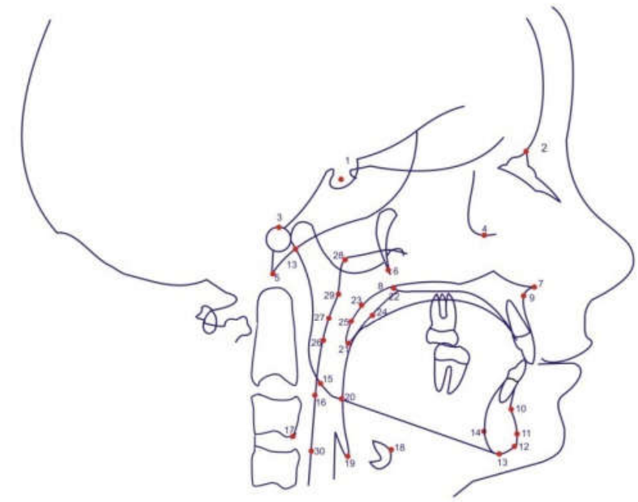
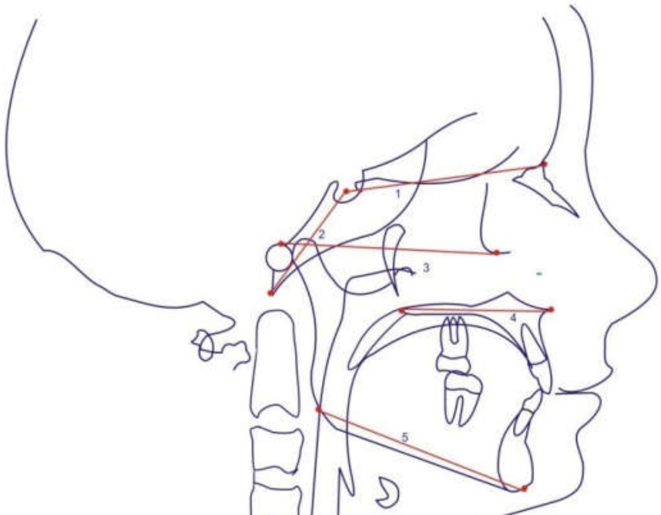
Pharyngeal airway space size is determined primarily by relative growth and size of the soft tissues surrounding the dentofacial skeleton. Studies have shown that the pharyngeal airway space is reduced, than normal in individuals with short cranial base and in cases of retrognathia or micrognathia. Angle showed that Class II Division 1 malocclusion was associated with upper airway obstruction and mouth breathing. Mergen and Jacobs reported that nasopharyngeal depth was significantly larger in patient with normal occlusion than in Class II malocclusion (Soheilifer et al., 2014). In addition, different anatomic features of the maxilla and mandible could change the position of the hyoid and soft palate and lead to decreased dimension of posterior airway space. suprahyoid muscles and infrahyoid muscles and their effect on the shape, growth, external and internal angles of mandible have been less considered.

LANDMARKS USED IN STUDY



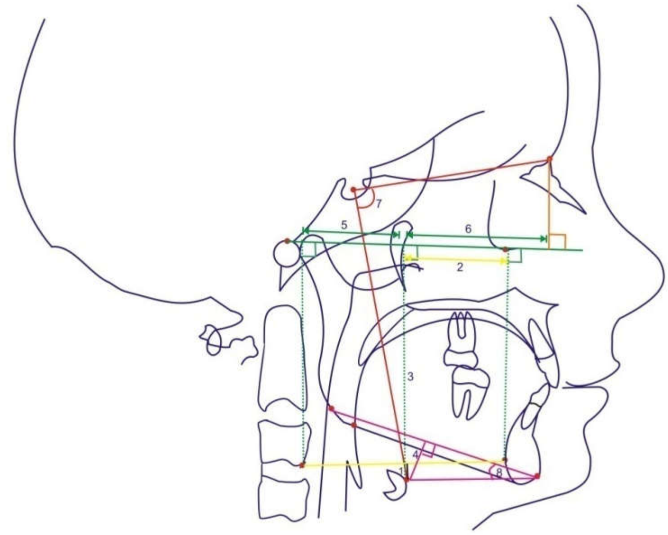
1. Sella
2. Nasion
3. Porion
4. Orbitale
5. Basion
6. Ptm Point
7. ANS
8. PNS
9. Point A
10. Point B
11. Pogonion
12. Gnathion
13. Menton
14. Retrognathion
15. Gonion
16. P0
17. C3 Point
18. H Point
19. Vallecula
20. T Point
21. U
22. U0
23. U1
24. U2
25. U3
26. P Point
27. P1
28. P2
29. P3
30. P4

REFERENCE PLANE USED IN STUDY



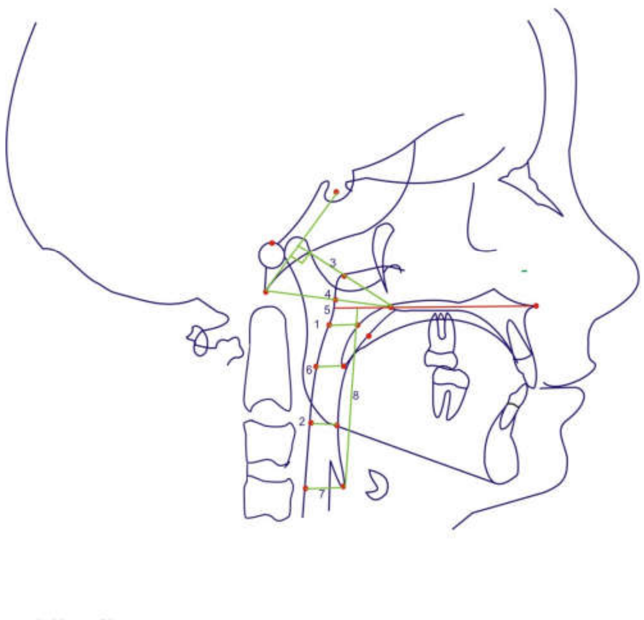
1. Sella Nasion Plane
2. Sella Basion Plane
3. Frankfort Horizontal Plane
4. Palatal Plane
5. Mandibular Plane

PARAMETERS USED FOR ASSESSMENT OF HYOID BONE

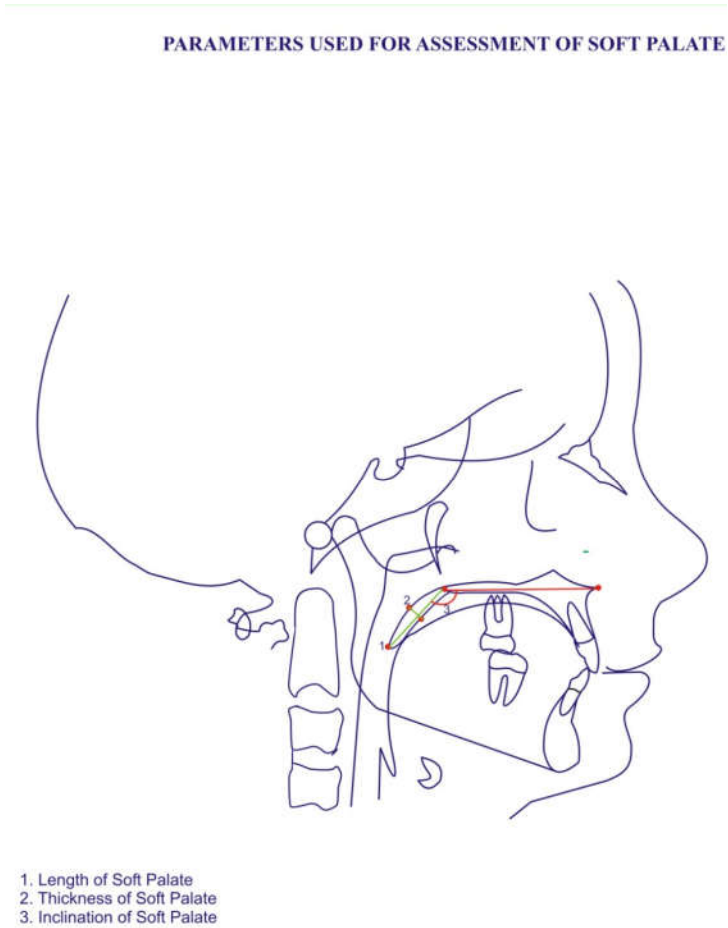


1. C3-RGn / H
2. H - RGn
3. H- FH
4. MP-H
5. C3-H
6. H/N-FHP
7.NSH
8. MPH

PARAMETERS USED FOR ASSESSMENT OF PHARYNGEAL AIRWAY



1. Upper Airway
2. Lower Airway
3. Upper Airway Width
4. Lower Airway Width
5. Nasopharyngeal Airway Depth
6. Oropharyngeal Airway Depth
7..Velopharyngeal Airway Depth
8. Vertical Pharyngeal Length



STATISTICAL ANALYSIS TO EVALUATE THE PARAMETERS BY ONE-WAY ANOVA

Table 1.a Parameters to assess anteroposterior skeletal relationship of the subjects in

PARAMETERS	GROUPS	N	Mean	Std. Deviation	Statistics/ mean squares	df2(welch) / F(Anova)	ANOVA P VALUE
ANB	CLASS I	10	2.2	1.2517	155.465	16.788	≤0.001
	CLASS II	10	7	1.8257			
	CLASS III	10	-3.45	0.896			
	Total	30	1.917	4.5431			
WA	CLASS I	10	0.85	0.8182	262.8	163.965	≤0.001
	CLASS II	10	5.05	1.3427			
	CLASS III	10	-5.15	1.5284			
	Total	30	0.25	4.429			

Hyoid bone as a link between suprahyoid and infrahyoid muscles has a significant role in orientation and even in function of these muscles which should not be disregarded (Gray, 2007). Significant difference in position of hyoid bone was found between Class I, Class II and Class III malocclusions (Amayeri et al., 2013). It is further documented that soft palate length, thickness, and inclination is associated with various skeletal malocclusions (Allhaija and Al-Khateeb, 2005). Since Orthodontists deal with various kinds of malocclusions, including severe skeletal Class II and III deformities and the standard procedures for correction of these discrepancies, it has therefore become mandatory to consider Pharyngeal Airway in Diagnosis and Treatment Planning to eliminate the disturbances in respiration, as disturbed breathing function could lead to life threatening situations such as obstructive sleep apnea (OSA), which is characterized by recurrent episodes of upper airway obstruction during sleep resulting in reduced oxygen saturation and systemic disorders such as Cor pulmonale, thus associated with increased morbidity and mortality (Indriksone and Jakobsone, 2014).As the relationship between the Pharyngeal Airway and changes in facial morphology has been extensively debated in the literature and still remained controversial, therefore in view of the need to uncover new evidences to contribute to and assist in addressing this complex issue, this study was carried out by tracing certain reference points, lines and angles on digitalized lateral cephalograms to evaluate the variations in pharyngeal airway spaces, position of hyoid bone and size and inclination of soft palate in skeletal Class I, Class II and Class III malocclusions in Uttrakhand population and to derive clinical implications of study as applicable to Orthodontic treatment planning.

Group 1, Group 2 and Group 3 by One-way ANOVA

Table 1.b Parameters to assess Pharyngeal airway of the subjects in group 1, group 2 and group 3 by One-way ANOVA

PARAMETERS	GROUPS	N	Mean	Std. Deviation	Statistics/ mean squares	df2(welch) / F(Anova)	ANOVA P VALUE
Linear Measurements							
UA	CLASS I	10	11.75	2.486	7.234	13.045	0.032
	CLASS II	10	11	2.041			
	CLASS III	10	13.3	0.483			
	Total	30	12.02	2.057			
LA	CLASS I	10	7.65	1.886	21.1	6.101	0.007
	CLASS II	10	9.25	2.475			
	CLASS III	10	10.55	0.832			
	Total	30	9.15	2.162			
UAW	CLASS I	10	15.55	3.166	0.758	0.143	0.867
	CLASS II	10	15.85	1.959			
	CLASS III	10	15.3	1.418			
	Total	30	15.57	2.231			
LAW	CLASS I	10	20.5	2.369	5.658	0.781	0.468
	CLASS II	10	20.6	2.923			
	CLASS III	10	19.25	2.751			
	Total	30	20.12	2.671			
NAD	CLASS I	10	20.2	2.474	1.608	0.277	0.76
	CLASS II	10	20.55	2.179			
	CLASS III	10	19.75	2.563			
	Total	30	20.17	2.35			
OAD	CLASS I	10	8.1	2.951	12.233	1.915	0.167
	CLASS II	10	9	2.357			
	CLASS III	10	10.3	2.214			
	Total	30	9.13	2.606			
VAD	CLASS I	10	11.8	3.889	4.64	13.982	0.007
	CLASS II	10	16.6	3.836			
	CLASS III	10	12.9	1.197			
	Total	30	13.77	3.75			
Angular Measurements							
VPL	CLASS I	10	48.05	3.444	9.158	0.297	0.746
	CLASS II	10	46.2	6.889			
	CLASS III	10	46.7	5.774			
	Total	30	46.98	5.421			

Table 1.c Parameters to assess position of Hyoid bone in the subjects in group 1, group 2 & group 3 by One-way ANOVA

PARAMETERS	GROUPS	N	Mean	Std. Deviation	Statistics/ mean squares	df2(welch)/ F(Anova)	ANOVA P VALUE
Linear Measurements							
C3/RGs - H	CLASS I	10	0	4	19.308	0.57	0.572
	CLASS II	10	2.15	6.3336			
	CLASS III	10	-0.45	6.7472			
	Total	30	0.567	5.7336			
H-RGs	CLASS I	10	30.65	5.972	1.908	0.061	0.941
	CLASS II	10	30.4	3.526			
	CLASS III	10	29.8	6.746			
	Total	30	30.28	5.402			
MP-H	CLASS I	10	-6.6	3.1693	13.733	0.561	0.577
	CLASS II	10	-8.8	5.1381			
	CLASS III	10	-8.4	6.0773			
	Total	30	-7.933	4.8703			
C3-H	CLASS I	10	30.4	3.6878	10.033	0.504	0.61
	CLASS II	10	30	5.1208			
	CLASS III	10	31.9	4.4585			
	Total	30	30.767	4.384			
H/N-FHP	CLASS I	10	43.05	6.379	174.925	4.231	0.025
	CLASS II	10	48.1	7.989			
	CLASS III	10	39.8	4.417			
	Total	30	43.65	7.11			
Angular Measurements							
NSH	CLASS I	10	87.45	5.014	71.858	4.125	0.027
	CLASS II	10	90.8	4.104			
	CLASS III	10	85.5	3.206			
	Total	30	87.92	4.602			
MPH	CLASS I	10	14.9	5.071	2.533	0.048	0.953
Angle	CLASS II	10	15.9	6.154			
	CLASS III	10	15.5	9.744			
	Total	30	15.43	7.027			
FH-H	CLASS I	10	67.3	4.00832	6.175	0.233	0.794
	CLASS II	10	65.85	6.12849			
	CLASS III	10	67.1	5.10338			
	Total	30	66.75	5.01506			

Table 1.d Parameters to assess the size and inclination of soft palate in the subjects in group 1, group 2 and group 3 by One-way ANOVA

PARAMETERS	GROUPS	N	Mean	Std. Deviation	Statistics/ mean squares	df2(welch) / F(Anova)	ANOVA P VALUE
Linear Measurements							
LSP	CLASS I	10	27.2	3.393	0.951	15.745	0.28
	CLASS II	10	26.2	1.619			
	CLASS III	10	25.05	3.444			
	Total	30	26.15	2.977			
TSP	CLASS I	10	7.4	0.568	6.358	4.972	0.015
	CLASS II	10	6.3	1.567			
	CLASS III	10	7.85	1.029			
	Total	30	7.18	1.276			
Angular Measurements							
ISP	CLASS I	10	124.25	6.957	239.925	3.292	0.053
	CLASS II	10	132.5	9.629			
	CLASS III	10	123.8	8.804			
	Total	30	126.85	9.187			

STATISTICAL ANALYSIS OF THE PARAMETERS TO COMPARE THE VARIABLES OF AIRWAY BETWEEN GROUP 1, GROUP 2 AND GROUP 3 BY POST HOC TUKEY TEST

Table 2.a Parameters to compare anteroposterior skeletal relationship in group 1, group 2 and group 3 by poat hoc tukey test

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P Value
	CLASS I	CLASS II	-4.8000*	0.6166	≤0.001
ANB		CLASS III	5.6500*	0.6166	≤0.001
	CLASS II	CLASS III	10.4500*	0.6166	≤0.001
	CLASS I	CLASS II	-4.2000*	0.5662	≤0.001
WA		CLASS III	6.0000*	0.5662	≤0.001
	CLASS II	CLASS III	10.2000*	0.5662	≤0.001

Table 2.b Parameters to compare pharyngeal airway in group 1, group 2 and group 3 by post hoc tukey test.

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P Value
Linear Measurements					
UA	CLASS I	CLASS II	0.75	0.84	0.649
		CLASS III	-1.55	0.84	0.174
	CLASS II	CLASS III	-2.300*	0.84	0.028
LA	CLASS I	CLASS II	-1.6	0.832	0.151
		CLASS III	-2.900*	0.832	0.005
	CLASS II	CLASS III	-1.3	0.832	0.279
UAW	CLASS I	CLASS II	-0.3	1.029	0.954
		CLASS III	0.25	1.029	0.968
	CLASS II	CLASS III	0.55	1.029	0.855
LAW	CLASS I	CLASS II	-0.1	1.203	0.996
		CLASS III	1.25	1.203	0.559
	CLASS II	CLASS III	1.35	1.203	0.509
NAD	CLASS I	CLASS II	-0.35	1.078	0.944
		CLASS III	0.45	1.078	0.909
	CLASS II	CLASS III	0.8	1.078	0.741
OAD	CLASS I	CLASS II	-0.9	1.13	0.709
		CLASS III	-2.2	1.13	0.145
	CLASS II	CLASS III	-1.3	1.13	0.493
VAD	CLASS I	CLASS II	-4.800*	1.444	0.007
		CLASS III	-1.1	1.444	0.729
	CLASS II	CLASS III	3.700*	1.444	0.042
Angular Measurements					
VPL	CLASS I	CLASS II	1.85	2.485	0.74
		CLASS III	1.35	2.485	0.851
	CLASS II	CLASS III	-0.5	2.485	0.978

MATERIALS AND METHODS

The present cephalometric study was done on untreated Orthodontic patients Uttrakhand ethnicity selected from the subjects who visited to the OPD at Department of Orthodontics and Dentofacial Orthopaedics, Seema Dental College and Hospital, Rishikesh. The study comprised of 30 subjects aged between 15-25 years, breathing comfortably through nose. All digital Cephalometric radiographs were taken in NHP and patients were asked to swallow while shooting for cephalogram. All Cephalograms were taken using Kodak 8000C Panoramic & Cephalometric unit at Tube voltage of 60-

Table 2.c Parameters to compare the position of hyoid bone in group 1, group 2 and group 3 by post hoc tukey test

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P Value
Linear Measurements					
	CLASS I	CLASS II	-2.15	2.6031	0.69
C3/RGs - H		CLASS III	0.45	2.6031	0.984
	CLASS II	CLASS III	2.6	2.6031	0.584
	CLASS I	CLASS II	0.25	2.498	0.994
H-RGs		CLASS III	0.85	2.498	0.938
	CLASS II	CLASS III	0.6	2.498	0.969
	CLASS I	CLASS II	2.2	2.2118	≤0.001
MP-H		CLASS III	1.8	2.2118	0.586
	CLASS II	CLASS III	-0.4	2.2118	0.698
	CLASS I	CLASS II	0.4	1.995	0.978
C3-H		CLASS III	-1.5	1.995	0.735
	CLASS II	CLASS III	-1.9	1.995	0.613
	CLASS I	CLASS II	-5.05	2.875	0.203
H/N-FHP		CLASS III	3.25	2.875	0.504
	CLASS II	CLASS III	8.300*	2.875	0.02
Angular Measurements					
	CLASS I	CLASS II	-3.35	1.867	0.19
NSH		CLASS III	1.95	1.867	0.556
	CLASS II	CLASS III	5.300*	1.867	0.022
	CLASS I	CLASS II	-1	3.251	0.949
MPH		CLASS III	-0.6	3.251	0.981
Angle	CLASS II	CLASS III	0.4	3.251	0.992
	CLASS I	CLASS II	1.45	2.30462	0.805
FH-H		CLASS III	0.2	2.30462	0.996
	CLASS II	CLASS III	-1.25	2.30462	0.851

Table 2.d Parameters to compare the size and inclination of soft palate in group 1, group 2 and group 3 by post hoc tukey test

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P Value
Linear Measurements					
	CLASS I	CLASS II	1	1.316	0.73
		CLASS III	2.15	1.316	0.249
LSP	CLASS II	CLASS III	1.15	1.316	0.661
	CLASS I	CLASS II	1.1	0.506	0.094
		CLASS III	-0.45	0.506	0.651
TSP	CLASS II	CLASS III	-1.550*	0.506	0.013
Angular Measurements					
	CLASS I	CLASS II	-8.25	3.818	0.097
		CLASS III	0.45	3.818	0.992
ISP	CLASS II	CLASS III	8.7	3.818	0.076

90kVp, Digital censor CCD with 1360X1840 Pixels and magnification of 1:1%. Lateral cephalometric radiographs were traced on acetate paper and 26 hard tissue and 14 soft tissue reference points were registered yielding 4 angular and 17 linear measurements. Sample was divided into three groups with 10 subjects in each group

- Group 1, Skeletal Class I (ANB 1-4 and Wits Appraisal -1 to 0)
- Group 2, Skeletal Class II (ANB >4 and Wits Appraisal >1)
- Group 3, Skeletal Class III (ANB <1 and Wits Appraisal < -1.5)
-

To minimise the error, all the cephalograms were manually traced and analysed by a single observer. Three radiographs from each group were randomly selected and revaluated by the same observer to reduce Intra-observer error.

INCLUSION CRITERIA

- Age should be in the range of 15 to 25 years with mean Age being 20 years
- Native Uttrakhand population based upon history and domicile obtained from the parents in the form of a questionnaire format.
- Skeletal Class I, Class II and Class III malocclusion. – Evaluated by cephalometric analysis.
- Subjects able to breath comfortably through nose.

Subjects with history of tonsilitis and pharyngitis, major trauma to craniofacial region, orthognathic surgery,mouth breathing and previous orthodontics treatment. Were excluded. Cephalometric landmarks, reference lines, parameters to assess pharyngeal airway, soft palate and position of hyoid bone are given in Diagram 1,2,3,4 & 5 respectively.

STATISTICAL ANALYSIS

Descriptive statistics including mean and standard deviation for each Group were computed using one-way ANOVA to determine whether significant differences exist between the three groups. The subgroup Analysis between Class I and Class II, Class I and Class III, Class II and Class III was done using Post hoc Tukey test.

RESULTS

Dahlberg and Houston analysis showed that systematic error was not significant (P = 0.321); therefore, the measurements were highly reproducible. The results of the statistical analysis with mean, Standard deviation, and p values are shown in the (Table 1.a-d and Table 2.a-d) and (Graph a).Results statistically significant for Upper Airway between Group 2 and Group 3 but no significance was found when Group 1 was compared to Group 2 and Group 3. It was found to be increased in Group 3(13.3mm) and decreased in Group 2 (11mm) (p=0.028). However statistical significance of Lower Airway was found to be decreased in Group 1(7.76mm) and increased in Group 3(10.55mm) (p=.005) and no positive statistical significance existed when Group 2 was compared to Group 1 and Group 3.

Statistically significant values were found in Velopharyngeal Airway Depth between Group 1(11.8mm) and Group 2(16.6mm) and between Group 2(16.6mm) and Group 3(12.9mm) however no statistical significance was seen between Group 1 and Group 3. It was found to be decreased in Group 1 & Group 3 and increased in Group 2 (p=.007) (p=0.042) respectively. Thickness of soft palate was found to be decreased in Group 2(6.3mm) and increased in Group 3(7.85mm) (p=.015) , however no statistical significant values were found when Group 1 was compared to Group 2 and Group 3. The highly significant values were found in MP-H between Group 1(-6.6mm) and Group 2 (-8.8mm) (p=0.001) and it was found that hyoid bone was inferiorly positioned in relation to Mandibular plane in Group 2, however statistically no significance existed when Group 1 was compared to Group 2 and Group 3 and when Group 2 and Group 3 were compared. The values for H/N-FHP were found to be statistically significant between Group 2 and Group 3 with increase in Group 2(48.1mm) and decreased in Group 3(39.8mm) (p=0.02). NSH was found to be increased in Group 2 (90.8 degrees) and decreased in Group 3 (85.5degrees) (p=0.02). No statistical significance existed in H/N-FH & NSH values when Group 1 was compared to Group 2 and Group 3. No statistical significance was found in relation of UAW, LAW, NAD, OAD, VPL, LSP, ISP, C3/RGs-H, H-RGs, MP-H, C3-H, MPH and FH-H to various sagittal skeletal malocclusions.

DISCUSSION

Uttrakhand, the 27th state of Republic of India is on an average 2,084 mts above sea level. Voluntary hyperventilation and breath holding at high altitudes has been documented. Voluntary hyperventilation and breath holding produce respiratory and cardiac changes. The great variation has been found in the pattern of breathing and respiratory indices in the population residing at high altitudes.[7] Therefore Uttrakhand population was choosen for the study to evaluate whether any airway changes with the change in ANB in this very population is similar to those of documented earlier or any deviation exists.

Cephalogram is a standardized lateral radiograph of head and neck used to examine upper airway, craniofacial and soft tissue structures all togather. Lateral cephalometry is widely available, easily performed and much less expensive than CT Scanning and MRI with least radiation exposure to the subjects. Posterior airway space, as measured by lateral cephalograms, was highly correlated with measurements using 3D - CT scan, with 92% accuracy in predictability (Samman et al., 2003). ANB and Wits Appraisal as the indicators of sagittal divergence were used to divide the sample into three Groups. ANB is the most commonly used and most accurate and reliable measurement for appraising anteroposterior disharmony of the jaws as per studies conducted by Oktay and Ishikawa et al. The reference points can easily be located on a cephalogram and repeatedly reproduced (Oktay, 1991; Ishikawa et al., 2000). Wits Appraisal was used as adjunctive measurement of anteroposterior jaw relations in order to obviate the shortcomings of ANB such as unstable anteroposterior position of nasion and rotational growth of the jaws as per studies conducted by Jacobson, Hussel and Nanda (Jacobson, 1975; Hussel and Nanda, 1984). Since Wits appraisal includes functional occlusal plane as reference line which was traditionally being used by all phases of dentistry including Angle and it intimately related to Point A and point B and to the masticatory forces, thus holding a firm importance in sampling. The nasopharyngeal dimensions continue to grow rapidly until 13 years of age and then slowly until adulthood. In this study the age range was 15-25 years with the mean age of 20 years to ensure that the oropharyngeal structures had reached adult size (Allhaija and Al-Khateeb, 2005). As it has been suggested that the head posture influence the dimensions of pharyngeal airway, so all the cephalometric radiographs of the subjects were recorded with the head in NHP (Natural Head Position) (Solow et al., 1984). A normal nasal airway is dependent on sufficient anatomical dimensions of airway. Experimental studies using primates carried out by Harvold and associates also showed varied dentofacial forms and malocclusions, resulting after establishment of mouth breathing. On the other hand it has been mentioned in the literature that malocclusion type does not influence pharyngeal width (Watson et al., 1968; de Freitas et al., 2006; Alves et al., 2008).[14] Since the correlation of facial morphology to that of airway dimensions is still a controversy therefore the present study was conducted to find whether any changes are evident in pharyngeal airway, position of hyoid bone and dimensions and inclination of soft palate in relation to various anteroposterior skeletal malocclusions in Uttrakhand population.

The present study showed that the upper pharyngeal airway was found to be decreased in Class II subjects and increased in Class III subjects, which was statistically significant. This was in accordance with the study of Kem et al, Angle and Kirjavainen et al who showed decrease in Upper pharyngeal width in Class II Subjects (Yadav et al., 2015). As the space between Cervical vertebrae and mandible decreases it causes obstruction in the upper airway thus reducing the width of upper pharyngeal space anteroposteriorly. Mergen and Jacobs reported that nasopharyngeal depth was significantly larger in patient with normal occlusion than in Class II malocclusion.[4] Thus it can be concluded that as the mandible advances into more anterior position, the upper pharyngeal width also increases. Thus with the increase in ANB there is subsequent decrease in upper pharyngeal width and Vice-versa.

Adenoids also referred to as nasopharyngeal tonsils, is a part of Waldeyers ring which is situated in the nasopharyngeal area. Adenoids are classified under lymphoid tissues, which show the growth regression after particular period of time according to Scammons growth curve (Yadav et al., 2015). Upper aerial width and lower aerial width determines the dimensions of adenoidal space, with no significant correlation to any changes in ANB. This might be the cause of fact that the sample that was choosen for the study were between the age of 15-25 years in which the nasopharynx has already achieved the adult size and by time the adenoid tissue growth is also regressed to achieve the average upper pharyngeal space dimensions. Lower pharyngeal airway was found to be increased in Class III malocclusion. It was found to be normal in Class II malocclusion as the functional adaptation to reduced upper airway otherwise the posterior oropharyngeal and laryngeal spaces might get encroached. This was in accordance with the study conducted by Tourne in 1991 who showed increase in lower airway space in Class III subjects (Tourne, 1991). The vertical position of hyoid bone in relation to mandibular plane was found upward in Class I subjects and Class III subjects and downwards in class II malocclusion As the upper airway is compromised in Class II subjects the downward position of hyoid bone is the anatomic adaptation to maintain the stability and patency of the pharyngeal airway. The anteroposterior distance between nasion and hyoid bone when measured on Frankfort horizontal plane, was found to be increased in Class II subjects and reduced in Class III subjects, signifying anteriorly positioned hyoid bone in Class III subjects and posteriorly postioned hyoid bone in Class II subjects.
NSH angle was found to be increased in Class II malocclusion and decreased in Class III malocclusion which signifies posterioly positioned hyoid bone in Class II malocclusion and anterior positioning of hyoid bone in Class III malocclusion. Both the finding were in accordance with the study done by Ceylan and Oktay 1995 who showed that with an increase in ANB angle, the distance between fourth cervical vertebra and hyoid bone decreased i.e posteriorly positioned hyoid bone in Class II malocclusion (Ceylan and Oktay,1995). According to the study done by Kurdo et al, 1966 the body of hyoid bone was located backward in Class II samples and forward in Class III samples in comparison to control group.[17] Adamidis and Spyropoulos,1992 reported a more anterior position and decreased inclination of the hyoid bone in Class III group thus supporting the results of the present study (Adamidis and Spyropoulos, 1992).

Significant increase in thickness of soft palate was seen in Class III group and reduced in Class II group. The backward position of the tongue in subjects with retrognathic mandible pushed the soft palate posterior and decreased the dimension of upper airway. Reduced thickness of soft palate is because of the forces exerted by the tongue over the soft palate. Reduction in the thickness of soft palate will further maintain the patent airway in upper pharyngeal space which is otherwise reduced in Class II group as per statistics. This was in accordance with the study conducted by Elham & Susan and Jena AK, 2010 in which they showed the decrease in the thickness of soft palate with the increase in ANB (Allhaija and Al-Khateeb, 2005). No significant changes were seen in the inclination of soft palate with the changes in ANB. This could be due to the functional adaptation of the tongue position along with the change in position of mandible associated with various skeletal malocclusions, thus nullifying the difference associated with various skeletal malocclusions.

Thus in the present study a significant correlation was found between uvulopharyngeal airway and position of hyoid bone in different anteroposterior skeletal patterns.

Conclusion

Upper pharyngeal airway width was reduces with the increase in ANB. Lower pharyngeal airway width increases with the decrease in ANB. Velopharyngeal airway increases with the increase in ANB. Hyoid bone was found to be positioned posteriorly and inferiorly in with the increase in ANB. Thickness of soft palate was decreases with the increase in ANB. Therefore, the pharyngeal airway dimensions, thickness of soft palate and position of hyoid bone have a significant correlation with the changes in ANB in Uttrakhand population. Futher study is suggested to assess whether new norms for pharyngeal airway and fot the position and size of adjacent structures should be established for this very population to consider the values during diagnosis and treatment planning.

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