Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 10, Issue, 05, pp.69012-69019, May, 2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

CORRELATION BETWEEN MALOCCLUSION, SOFT TISSUE PROFILE AND PHARYNGEAL AIRWAY: A CEPHALOMETRIC STUDY IN CENTRAL INDIA POPULATION

*Dr. Saurabh Singh Parihar, Dr. Amit Kalra, Dr. Gaurav Jasoria, Dr. Ashish Jain, Dr. Arun Kumar Gupta, Dr. Ankur Matta, Dr. Apit Shrivastava and Dr. Akanksha Singh

Department of Orthodontics and Dentofacial Orthopaedics, Maharana Pratap College of Dentistry and RC. Gwalior (M.P.), India

ARTICLE INFO

Article History:
Received 14th February, 2018
Received in revised form
29th March, 2018
Accepted 03rd April, 2018
Published online 23rd May, 2018

Key words:
Pharyngeal airway,
Soft tissue profile,
Malocclusion,
Cephalometric Analysis.

ABSTRACT

Introduction & Objective: Cephalometric analysis generates 2D images results which are sufficiently reliable & may be an alternative to 3D imaging in the evaluation of soft tissue and upper airway morphology. In recent years new interrelations between respiratory function and malocclusion have developed. The aim of the study was to evaluate the correlation between hard and soft tissues and upper airway morphology in patients with Angle's Class I, II,and III malocclusion.
Material & Methods: 50 Pre-treatment radiographs were taken. ANB and WITS analysis were used to divide the radiographs into skeletal Class I, II, and III. Rickets E-line , Upper and Lower pharyngeal airway space were also measured on these radiographs..
Results: Spearman's correlation co-efficient was performed to find out the correlation between ANB, Pharyngeal airway space and Ricket's E-line. It was found that there was strong positive correlation between Ricket's E-Line (upper) and Pharyngeal space (lower) in Class I sample ($p<.05$) . In Class II sample there was a negative correlation between Ricket's E-line (upper) and Pharyngeal space (upper)mm($p<.05$) .While in Class III sample it was found that there was strong positive correlation between Ricket's E-line (upper) mm and Ricket's E-line (lower)mm.($p<.05$)
Conclusions: Through this study we conclude that there is a strong positive correlation between Ricket's E-line(upper) & Pharyngeal space (lower) in Class I & negative correlation between Ricket's E-line & Pharyngeal space (upper) in Class II While in Class III samples strong positive correlation between Ricket's E-line (upper &lower) was found.

Citation: Dr. Saurabh Singh Parihar, Dr. Amit Kalra, Dr. Gaurav Jasoria, Dr. Ashish Jain, Dr. Arun Kumar Gupta, Dr. Ankur Matta, Dr. Apit Shrivastava and Dr. Akanksha Singh. 2018. "Correlation between malocclusion, soft tissue profile and pharyngeal airway: a cephalometric study in central india population", *International Journal of Current Research*, 10, (05), 69012-69019.

INTRODUCTION

The functions of the maxillofacial system affect the growth of the face and jaws as well as tooth eruption (Oz, 2013). Prolonged mouth breathing is associated with impaired speech, maxillofacial deformities, tooth malposition, abnormal posture, and even cardiovascular, respiratory, or endocrine dysfunctions (Basheer *et al.*, 2014; Šidlauskienė, 2015). The upper airway is the first component of the significant structure, which provides respiration– one of the vital functions of the human body. Disturbed breathing function could lead to life threatening situations. One of the conditions associated with breathing disturbances is obstructive sleep apnea (OSA), which is characterized by recurrent episodes of upper airway obstruction during sleep resulting in reduced oxygen saturation and is associated with increased morbidity and mortality.

Corresponding author:* **Dr. Saurabh Singh Parihar,
Department of Orthodontics and Dentofacial Orthopaedics, Maharana Pratap College of Dentistry and RC. Gwalior (M.P.), India.

The discussion on the relationship between maxillofacial morphology and upper airway size and resistance has been continuing over a century. Narrowing of the pharyngeal airway passage can be caused by various etiological factors – especially in the nasopharyngeal area – results in mouth breathing (Basheer *et al.*, 2014; Souki *et al.*, 2014). Basheer *et al.* found that the facial profile of patients who had mouth-breathing pattern was more convex than in those who were breathing through the nose (Basheer *et al.*, 2014). Other authors determined a relationship between the size of the upper airways and the severity of malocclusion (Indriksone, 2014). According to various authors, the main features of upper airway obstruction include: increased excessive anterior face height, narrowed upper dental arch, high palatal vault, steep mandibular plane angle, protruding maxillary teeth, and incompetent lip. Orthodontists deal with various kinds of malocclusions, including severe skeletal Class II and III deformities, and advancement and setback operations are standard procedures for correction of the jaw discrepancies.

Orthognathic procedures are designed to correct dentofacial deformities, but they also inevitably affect the size and the position of the surrounding soft tissues. Although there are a lot of studies reporting changes in the dimensions of the upper airway following surgical repositioning of the mandible and the maxilla, the estimations about the changes in the posterior airway space (PAS) after mandibular setback and advancement surgeries remain controversial (Mattos *et al*., 2011). Despite a few case reports of mandibular setback surgery in skeletal Class III patients inducing OSA associated with airway narrowing (Guilleminault, 1985; Riley *et al*., 1987; Liukkonen *et al*., 2002), prospective studies (Turnbull *et al*., 2000; Hochban, 1996) failed to demonstrate disturbances of respiration during sleep after mandibular setback even though retropalatal airway size was reduced. These findings might be explained by the observation that preoperative airway size in patients with Class III deformity was larger than values in normal population (Hochban *et al*., 1991; Degerliyurt, 2008). Several studies have shown distinct differences between the upper airway dimensions of OSA patients and normal subjects (Pae *et al*., 1994; Johal *et al*., 2007). The posterior airway space (PAS) (space behind the base of the tongue) of patients with OSA is smaller than that of normal individuals (Johal, 2007; Rodenstein, 1990), and their craniofacial morphology is characterized by: short cranial base (Rodenstein *et al*., 1990; Schwab *et al*., 1993), posteriorly positioned maxilla and mandible (Pae *et al*., 1994; Schwab *et al*., 1993), retrognathia or micrognathia (Lowe *et al*., 1994; Lam *et al*., 2004) and increased upper and lower face heights (Bacon *et al*., 1990; Lowe *et al*., 1996). The importance of lateral cephalometric radiographs in the evaluation of the morphology of soft and skeletal maxillofacial tissues and the diagnostics of airway pathology is unquestionable. The aim of the study was to evaluate the relationships between hard and soft tissues and upper airway morphology in patients of skeletal class I, class II and class III malocclusion.

MATERIALS AND METHODS

- Pre treatment lateral cephalograms of 50 orthodontic patients selected randomly between the age of 13 to 30 divided into Class I, Class II and Class III depending on ANB angle & WITS appraisal
- Tracing was done manually by the same operator and all the above mentioned parameters were tabulated along with Rickets E-line, Pharyngeal space (upper & lower)
- To find out association (correlation) between Rickets E-line upper and lower pharyngeal space in all classes of malocclusion

Landmarks used

- Point A-the deepest point on the curve of the bone between the anterior nasal spine and dental alveolus
- Point B-the deepest midline point on the mandible between the infradentale and the pogonion
- Nasion(N)-the most anterior point of the frontonasal suture in the middle
- Sella(S)-the center of the sella turcica
- Pronasale(Prn)-the most protruded point on the nasal apex
- Labiale Superioris (Ls)-midpoint of the upper vermilion line
- Labiale Inferioris (Li)-midpoint of the lower vermilion line

Soft tissue pogonion (Pog‘)-The most prominent or anterior point on the chin on the midsagittal plane

Measurements done

- SNA-Sagittal position of maxilla
- SNB-Sagittal position of mandible
- ANB-Sagittal jaw relationship
- AO-Perpendicular drawn from point A to occlusal plane
- BO-Perpendicular drawn from point B to occlusal plane
- E-LINE-line formed by connecting the Prn and Pog' points
- Ls-E line-distance from upper lip (Ls) to the E line
- Li-E line-distance from the lower lip (Li) to the E line
- UPW(width of the upper pharynx)-measured as the distance from the point of the posterior outline of the soft palate to the closest point on the posterior pharyngeal wall
- LPW(width of the lower pharynx)-measured as the distance from the intersection of the posterior border of the tongue and the inferior border of the mandible to the closest point on the posterior pharyngeal wall

Inclusion criteria for the study

The cases were divided into Skeletal Class I, Class II and Class III depending on the following criteria

- **For a group to be considered in Class I**

- ANB angle between 1° to 3 °
- Wits appraisal between 0 to -1 mm

- **For a group to considered in Class II**

- ANB angle more than or equal to 3 °
- Wits appraisal greater than 0 mm

- **For a group to be considered in Class III**

- ANB angle was less than or equal to 1 °
- Wits appraisal less than -1 mm

Statistical Analysis

Statistical data analysis was performed using the SPSS (IBM SPSS Statistics 22.0) software. Spearman correlation was applied in order to evaluate the strength of the relationship between two quantitative variables that did not meet the conditions of normal distribution.

Correlation analysis of SNA, SNB, and ANB angles as well as the parameters of soft tissues and the airways was performed. The most specific predictors of the decrease in the upper and lower pharyngeal width were assessed using the logistic regression analysis. Differences and interdependence between the attributes were considered to be statistically significant if $P < 0.05$.

RESULTS

A comparison of cephalometric values of soft tissue and airway measurements between Class I class II and class III individuals was performed. It showed that there was a strong positive correlation between Rickets E line (upper lip to E line)and pharyngeal space (lower)mm in the class 1 samples, $r_s(10) = .695, p < .0005$. (Table 4) Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatter plot in Class I individuals.

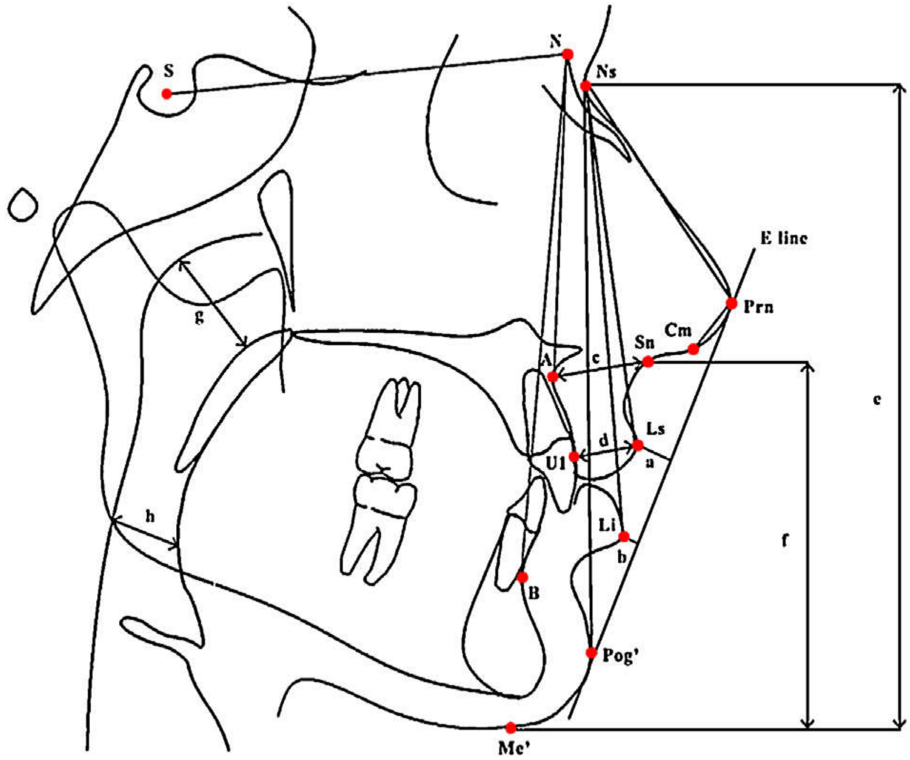


Table 1. skeletal class I

S.NO.	ANB(0)	WITS (mm)	PHARYNGEAL SPACE (mm)		RICKET'S E-LINE (mm)	
			UPPER	LOWER	Ls-E line	Li-E line
1	1.5	-0.5	11	11	2	1
2	2	O	14	12	2	3
3	2	0	16	10	3	4
4	2	6	12	8	-3	3
5	2	0	14	9	1	2
6	2	1.6	13	9	-1	-1
7	1	-1	15	18	3	2
8	2	1.6	13	7	0	2
9	1	-1	14	7	-3	-3
10	3	1.6	12	12	3	4
11	2	-1	17	10	4	2
12	2	1	12	12	1	0

Table 2. class II

S.NO.	ANB(0)	WITS (mm)	PHARYNGEAL SPACE (mm)		RICKET'S E-LINE (mm)	
			UPPER	LOWER	Ls-E line	Li-E line
1	7	9	8	4	4	5
2	6	10	13	8	1	7
3	5	5	17	12	0	6
4	8	4	14	9	2	5
5	2	4	8	7	2	3
6	6	2	12	12	.5	3
7	5	3	12	8.5	2	4
8	11	8.5	10.5	9	2	2
9	5	5	8	12	1	1
10	2	3	13	8	0	1
11	3	1	11	8	1	5
12	6	2	7	10	1	6
13	4	4	7	7	5.5	6
14	8	7	11	8	2	1
15	7	4	9	11	2	3
16	6	4	12	6	1	4
17	6	4	10	11	1	4
18	7	8	16	6	3	1
19	6	4	13	9	-1.5	-1
20	6	5	15	5	-1	0
21	3	3	15	13	0	0
22	7	5	11	10	3	5
23	2	4	10	12	3	0
24	9	6	6	6	5	6

Table 3. Class III

S.NO.	ANB(0)	WITS (mm)	PHARYNGEAL SPACE (mm)		RICKET'S E-LINE (mm)	
			UPPER	LOWER	Ls-E line	Li-E line
1	-9	-9	8	11	-5	3
2	0	-1.5	13	7	2	3
3	9	-8	11	4	0	5
4	3	-4.5	9	8	4	2
5	-.5	-4	18	11	-4	-1
6	.5	-8	5	6	-1	5
7	-1.5	-1.5	17	6	-5	-3
8	-3	-4.5	19	6	-2	3
9	0	-3	15	11	-8	5
10	-4	-7	15	7	-3	1
11	-4	-4	10	10	-2	2

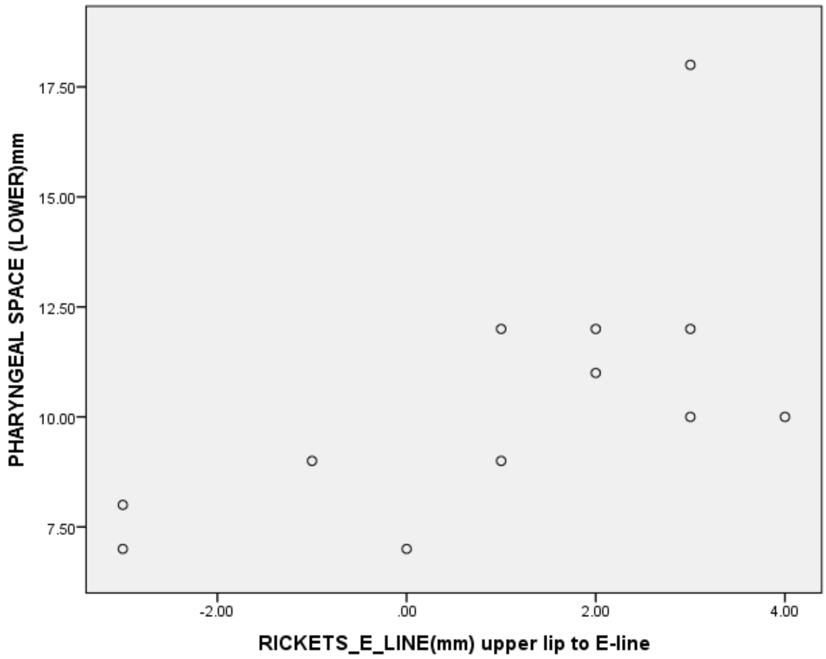


Figure 1. Scatterplot denoting the monotonic relationship between Rickets E line (upper lip to E line)

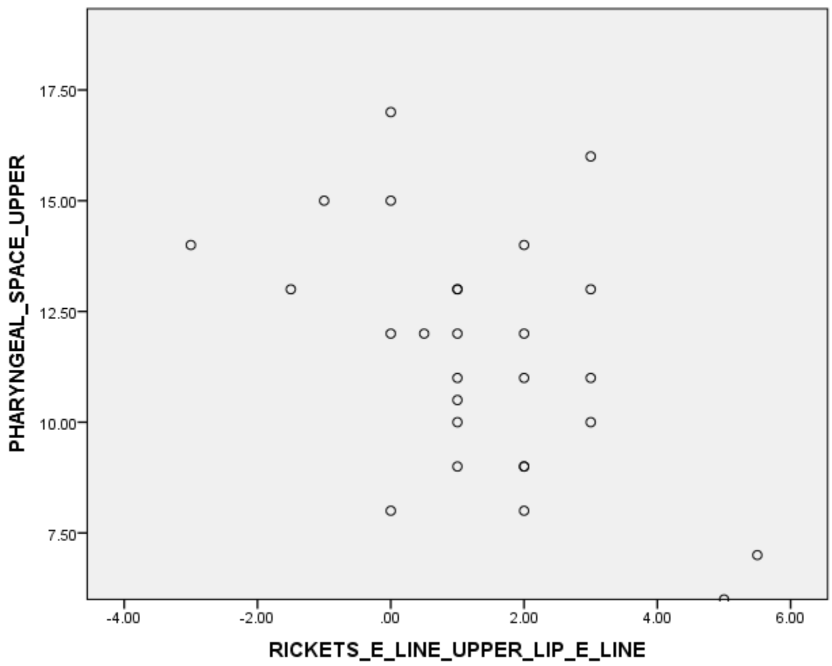


Figure 2. Scatterplot denoting the monotonic relationship between Rickets E line (upper lip to E line) and Pharyngeal space (upper)mm

Table 4. Spearman Correlation between the various variables of Class 1 samples

			Anb(degree)	Pharyngeal space (upper)mm	Pharyngeal space (lower)mm	Rickets_e_line (mm) upper lip to e-line	Rickets_e_line (mm) lower lip to e-line
Spearman's rho	ANB(DEGREE)	Correlation Coefficient	1.000	-.203	.051	.171	.569
		Sig. (2-tailed)	.	.526	.876	.595	.054
		N	12	12	12	12	12
	PHARYNGEAL SPACE (UPPER)mm	Correlation Coefficient	-.203	1.000	.002	.410	.129
		Sig. (2-tailed)	.526	.	.996	.186	.690
		N	12	12	12	12	12
	PHARYNGEAL SPACE (LOWER)mm	Correlation Coefficient	.051	.002	1.000	.695*	.275
		Sig. (2-tailed)	.876	.996	.	.012	.387
		N	12	12	12	12	12
	RICKETS_E_LINE(mm) upper lip to E-line	Correlation Coefficient	.171	.410	.695*	1.000	.486
		Sig. (2-tailed)	.595	.186	.012	.	.109
		N	12	12	12	12	12
	RICKETS_E_LINE(mm) lower lip to E-line	Correlation Coefficient	.569	.129	.275	.486	1.000
		Sig. (2-tailed)	.054	.690	.387	.109	.
		N	12	12	12	12	12

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5. Spearman Correlation between the various variables of Class 2 samples

			Anb	Pharyngeal_space_upper	Pharyngeal_space_lower	Rickets_e_line_upper_lip_e_line	Rickets_e_line_lower_lip_e_line
Spearman's rho	Anb	Correlation Coefficient	1.000	-.050	-.187	.215	.057
		Sig. (2-tailed)	.	.805	.351	.281	.777
		N	27	27	27	27	27
	Pharyngeal_space_upper	Correlation Coefficient	-.050	1.000	.090	-.443*	-.226
		Sig. (2-tailed)	.805	.	.656	.021	.256
		N	27	27	27	27	27
	Pharyngeal_space_lower	Correlation Coefficient	-.187	.090	1.000	-.132	-.170
		Sig. (2-tailed)	.351	.656	.	.513	.396
		N	27	27	27	27	27
	Rickets_e_line_upper_lip_e_line	Correlation Coefficient	.215	-.443*	-.132	1.000	.248
		Sig. (2-tailed)	.281	.021	.513	.	.212
		N	27	27	27	27	27
	Rickets_e_line_lower_lip_e_line	Correlation Coefficient	.057	-.226	-.170	.248	1.000
		Sig. (2-tailed)	.777	.256	.396	.212	.
		N	27	27	27	27	27

*. Correlation is significant at the 0.05 level (2-tailed).

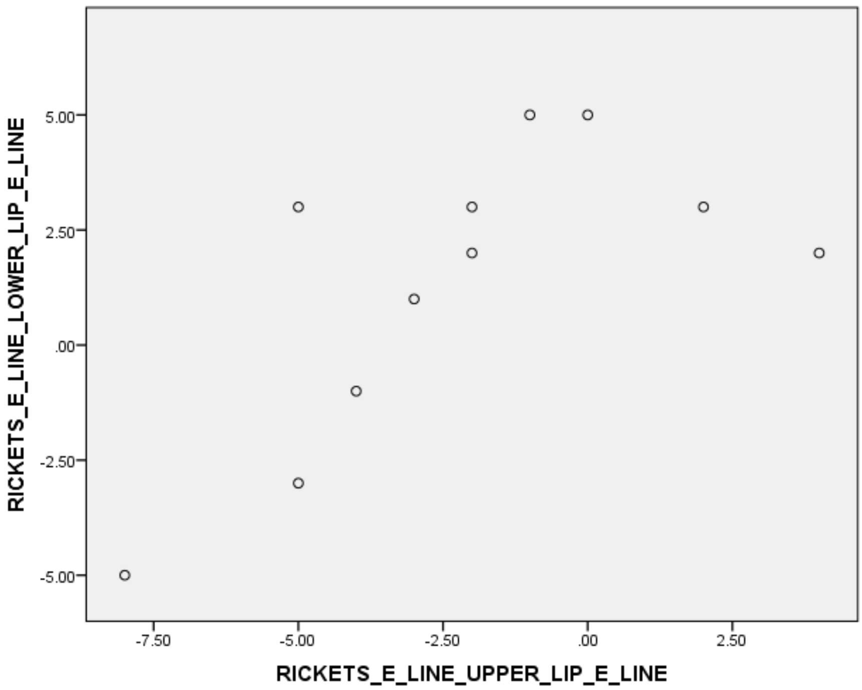
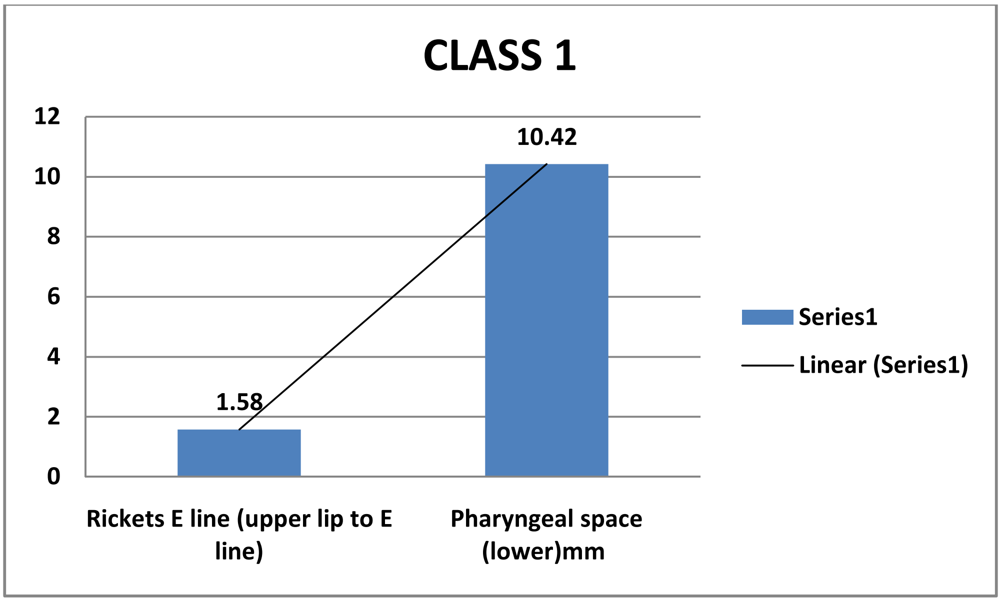
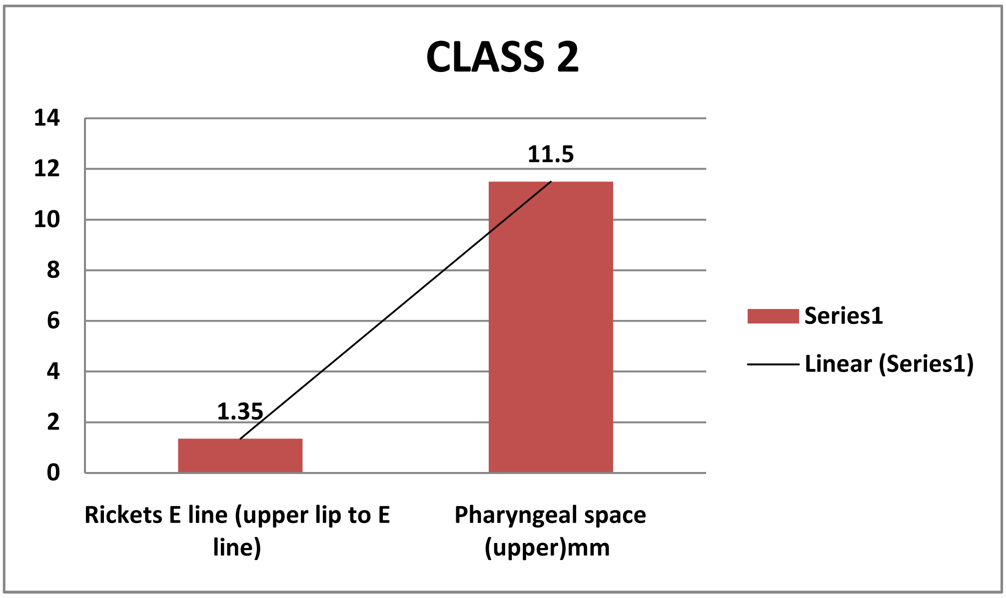


Figure 3. Scatterplot denoting the monotonic relationship between Rickets E line (upper lip to E line) mm and Rickets E line (lower lip to E line)mm


CLASS 1
12
10
8
6
4
2
0
10.42
1.58
Rickets E line (upper lip to E line)
Pharyngeal space (lower)mm
Series1
Linear (Series1)


CLASS 2
14
12
10
8
6
4
2
0
11.5
1.35
Rickets E line (upper lip to E line)
Pharyngeal space (upper)mm
Series1
Linear (Series1)


CLASS 3
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1.36
-2.18
Rickets E line (upper lip to E line) mm ;
Rickets E line (lower lip to E line)mm
Series1
Linear (Series1)

Table 6. Spearman Correlation between the various variables of Class 3 samples

			anb	pharyngeal_space_upper	pharyngeal_space_lower	rickets_e_line_upper_lip_e_line	rickets_e_line_lower_lip_e_line
Spearman's rho	ANB	Correlation Coefficient	1.000	-.192	-.491	.562	.262
		Sig. (2-tailed)	.	.571	.125	.072	.437
		N	11	11	11	11	11
	PHARYNGEAL_SPACE_UPPER	Correlation Coefficient	-.192	1.000	.344	-.366	-.527
		Sig. (2-tailed)	.571	.	.300	.268	.096
		N	11	11	11	11	11
	PHARYNGEAL_SPACE_LOWER	Correlation Coefficient	-.491	.344	1.000	-.396	-.306
		Sig. (2-tailed)	.125	.300	.	.228	.360
		N	11	11	11	11	11
	RICKETS_E_LINE_UPPER_LIP_E_LINE	Correlation Coefficient	.562	-.366	-.396	1.000	.637*
		Sig. (2-tailed)	.072	.268	.228	.	.035
		N	11	11	11	11	11
	RICKETS_E_LINE_LOWER_LIP_E_LINE	Correlation Coefficient	.262	-.527	-.306	.637*	1.000
		Sig. (2-tailed)	.437	.096	.360	.035	.
		N	11	11	11	11	11

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7. Descriptive Statistics

	CLASS 1	CLASS 2	CLASS 3
ANB(DEGREE)	1.88 ± 0.53	5.63 ± 2.15	-0.86 ± 4.54
PHARYNGEAL SPACE (UPPER)mm	13.50 ± 1.78	11.50 ± 2.76	12.73 ± 4.50
PHARYNGEAL SPACE (LOWER)mm	10.42 ± 3.00	9.06 ± 2.24	8.82 ± 3.37
RICKETS_E_LINE(mm) upper lip to E-line	1.00 ± 2.34	1.35 ± 1.81	-2.18 ± 3.40
RICKETS_E_LINE(mm) lower lip to E-line	1.58 ± 2.07	3.11 ± 2.42	1.36 ± 3.17
N	12	27	11

In Class II individuals there was a moderate correlation between Rickets E line (upper lip to E line)and Pharyngeal space (upper)mm, $r_s(25) = .695$. $p < .0005$. (Table 5) While in Class III individuals there was a strong positive correlation between Rickets E line (upper lip to E line)and Rickets E line (lower lip to E line)mm , $r_s(9) = .637$. $p < .0005$ (Table 6).

DISCUSSION

- There is widespread & growing interest in facial esthetics which has become one of the goals of contemporary orthodontic treatment. A patient's respiratory function is an important factor in diagnostics & treatment planning, and it has a direct correlation with the size of upper airways.
- Zhang *et al* found that cephalometric facial analysis data did not have any significant differences among other techniques while in analysing upper airway patency 3D images have greatest accuracy, yet the disadvantage of this technique are high radiation exposure & high costs therefore cephalometric 2D images which are simple, sufficiently informative and cost effective technique are used as an alternative for airway measurement.
- Basheer *et al* found that mouth breathers have more convex faces compared to nasal breathers. Gulsen *et al* stated that the convexity of facial soft tissues is related to the position of the jaws. Loptiene *et al* compared cephalometric values of soft tissue and airway measurements and found that there is significant negative correlation between width of upper pharynx and ANB angle, the ANB angle was decreasing with an increasing width of upper pharynx. The airways showed a stastically significant negative correlation between the width of lower pharynx and the distance from the upper and lower lips to the E- line.

In this study all classes of malocclusion were studied and it was found that in Class I individuals there was strong positive correlation between Ricket's E- line (upper) and lower pharyngeal space at p value<.05, In Class II individuals there was negative correlation between Ricket's E- line (upper) and upper pharyngeal space at P value <.05 i.e as the lip prominence increase width of upper pharynx decreases while in Class III individuals there was strong positive correlation between upper and lower Ricket's E-line.

Conclusion

During critical period of growth and development of the maxillofacial system, the patients with oral functional functional disturbances such as obstructive sleep apnoea, snoring and other airway disorders can be diagnosed using a 2D cephalometric radiography in routine clinical practice. Through this study we conclude that in Class I patients with prominent upper lips there is decreased lower pharyngeal space which may be attributed to snoring, In Class II individuals with prominent upper lips have a decreased lower pharyngeal space while in Class III both the lips are prominent. As such this study is not directly related to the Obstructive sleep apnoea (OSA) but considering the factors involved in the etiology and serious concerns about Obstructive sleep apnoea as well as its investigative procedures are on the rise. A narrow upper airway and other predisposing or etiological factors, such as craniofacial deformity, mandibular retrognathia or micrognathia, tongue position, sleep posture etc have been reported. Planning successful treatment for the correction of anatomic abnormalities of upper airway by surgically advancing mandible depends on extensive knowledge of pharyngeal airway space and tongue position and the changes induced by the advancement surgery in the said structures.

Conflict of interest statement: None

Funding Statement: None

REFERENCES

Armalaitė J, Lopatienė K. 2016. Lateral teleradiography of the head as a diagnostic tool used to predict obstructive sleep apnea. *Dentomaxillofac Radiol.,* 45(1):20150085

Bacon WH, Turlot JC, Krieger J, Stierle JL. 1990. Cephalometric evaluation of pharyngeal obstructive factors in patients with sleep apneas syndrome. *Angle Orthod.,* 60:115-22

Banno K, Kryger MH. 2007. Sleep apnea: clinical investigations in humans. *Sleep Med* 8:400-26

Basheer B, Hegde KS, Bhat SS, Umar D, Baroudi K. Influence of mouth breathing on the dentofacial growth of children: a cephalometric study. J Int Oral Health 2014;6(6):50–5.

Degerliyurt K, Ueki K, Hashiba Y, Marukawa K, Nakagawa K, Yamamoto E. 2008. A comparative CT evaluation of pharyngeal airway changes in class III patients receiving bimaxillary surgery or mandibular setback surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.,* 105:495-502

Guilleminault C, Riley R, Powell N. 1985. Sleep apnea in normal subjects following mandibular osteotomy with retrusion. *Chest.,* 88:776-8.

Hochban W, Schürmann R, Brandenburg U. 1996. Mandibular setback for surgical correction of mandibular hyperplasia - does it provoke sleep-related breathing disorders? *Int J Oral Maxillofac Surg.,* 25:333-8.

Ikävalko T, Närhi M, Lakka T, Myllykangas R, Tuomilehto H, Vierola A, *et al*. 2015. Lateral facial profile may reveal the risk for sleep disordered breathing in children. *Acta Odontol Scand.,* 73(7):550–5.

Indriksone I, Jakosone G. 2014. The Upper Airway dimensions in different saggital craniofacial patterns: a systematic review. *Stomatogija Baltic Dental and Maxillofacial Journal,* Vol.16, No.3:109-117.

Indriksone I, Jakobsone G. 2014. The upper airway dimensions in different sagittal craniofacial patterns: a systematic review. Stomatologija16(3):109–17.

Jakobsone G, Urtane I, Terauds I. 2006. Soft tissue profile of children with impaired nasal breathing. Stomatologija, 8(2):39–43.

Johal A, Patel SI, Battagel JM. 2007. The relationship between craniofacial anatomy and obstructive sleep apnoea: a casecontrolled study. *J Sleep Res.,*16:319-26.

Kula K, Jeong AE, Halum S, Kendall D, Ghoneima A. 2013. Three dimensional evaluation of upper airway volume in children with different dental and skeletal malocclusions. *J Biomed Graph Comput.,* 3(4):116–26.

Lam B, Ooi CGC, Peh WCG, Lauder I, Tsang KW, Lam WK, *et al*. 2004. Computed tomographic evaluation of the role of craniofacial and upper airway morphology in obstructive sleep apnea in Chinese. *Respir Med.,* 98:301-7.

Liukkonen M, Vahatalo K, Peltomaki T, Tiekso J, Happonen RP.2002. Effect of mandibular setback surgery on the posterior airway space. *Int J Adult Orthod Orthognath Surg.,* 17:41-6

Lopatiene K, Sidlauskas A, Vasiliaukas A,Ceycte L, Svalkauskiene V, Sidlauskas M. 2016. Relationship between malocclusion,soft tissue profile and pharyngeal airway: A cephalometric study. MEDICINA 52.: 307-314

Lowe AA, Ono T, Ferguson KA, Pae EK, Ryan F, Fleetham JA. 19996. Cephalometric comparisons of craniofacial and upper airway structure by skeletal subtype and gender in patients with obstructive sleep apnea. *Am J Orthod Dentofac Orthop.,* 110:653-64.

Mattos CT, Vilani GNL, Sant'Anna EF, Ruellas ACO, Maia LC. 2011. Effects of orthognathic surgery on oropharyngeal airway: a meta-analysis. *Int J Oral Maxillofac Surg.,* 40:1347-56.

Muto T, Yamazaki A, Takeda S. 2008. A cephalometric evaluation of the pharyngeal airway space in patients with mandibular retrognathia and prognathia, and normal subjects. *Int J Oral Maxillofac Surg.,* 37(3):228–31.

Oz U, Orhan K, Rubenduz M. Two-dimensional lateral cephalometric evaluation of varying types of Class II subgroups on posterior airway space in postadolescent girls: a pilot study. J Orofac Orthop 2013;74(1):18–27.

Pae EK, Lowe AA, Sasaki K, Price C, Tsuchiya M, Fleetham JA. 1994. A cephalometric and electromyographic study of upper airway structures in the upright and supine positions. *Am J Orthod Dentofac Orthop.,*106:52-9.

Pirilä-Parkkinen K, Löppönen H, Nieminen P, Tolonen U, Pääkkö E, Pirttiniemi P. 2011. Validity of upper airway assessment in children: a clinical, cephalometric, and MRI study. *Angle Orthod.,* 81(3):433–9.

Riley RW, Powell NB, Guilleminault C, Ware W. 1987. Obstructive sleep apnea syndrome following surgery for mandibular prognathism. *J Oral Maxillofac Surg.,* 45:450.

Rodenstein DO, Dooms G, Thomas Y, Liistro G, Stanescu DC, Culée C, *et al*. 1990. Pharyngeal shape and dimensions in healthy subjects, snorers, and patients with obstructive sleep apnoea. *Thorax* 45:722-7.

Ryu HH, Kim CH, Cheon SM, Bae WY, Kim SH, Koo SK, *et al*. 2015. The usefulness of cephalometric measurement as a diagnostic tool for obstructive sleep apnea syndrome: a retrospective study. Oral Surg Oral Med Oral Pathol Oral Radiol):20–31.

Samdani D, Saigal A, Garg E. 2015. Correlation of morphological variants of soft palate and types of malocclusion: A digital lateral cephalometric study. *J Indian Acad Oral Med Radiol.,* 27:366-71.

Schwab RJ, Gefter WB, Hoffman EA, Gupta KB, Pack AI. 1993. Dynamic upper airway imagining during awake respiration in normal subjects and patients with sleep disordered breathing. *Am Rev Respir Dis.,*148:1385-1400.

Šidlauskienė M, Smailienė D, Lopatienė K, Čekanauskas E, Pribuišienė R, Šidlauskas M. Relationships between malocclusion, body posture, and nasopharyngeal pathology in pre-orthodontic children. *Med Sci Monit.,* 21:1765–73.

Silva NN, Lacerda RH, Silva AW, Ramos TB. 2015. Assessment of upper airways measurements in patients with mandibular skeletal Class II malocclusion. *Dental Press J Orthod.,* 20 (October (5)):86–93.

Souki BQ, Lopes PB, Veloso NC, Avelino RA, Pereira TB, Souza PE, *et al*. 2014. Facial soft tissues of mouth-breathing children: do expectations meet reality? *Int J Pediatr Otorhinolaryngol.,* 78(7):1074–9.

Sutherland K, Schwab RJ, Maislin G, Lee RW, Benedikstdsottir B, Pack AI, *et al*. 2014. Facial phenotyping by quantitative photography reflects craniofacial morphology measured on magnetic resonance imaging in Icelandic sleep apnea patients. Sleep., 37(5):959–68.

Tangugsorn V, Skatvedt O, Krogstad O, Lyberg T. 1995. Obstructive sleep apnoea: a cephalometric study. Part I. Cervico-craniofacial skeletal morphology. *Eur J Orthod.,* 17:45-56.

Turnbull NR, Battagel JM. 2000. The Effects of orthognathic surgery on pharyngeal airway dimensions and quality of sleep. *J Orthod.,* 27:235-47

****