Evaluation of Airway Dimensional Changes Before and After Functional Appliance Treatment in Skeletal Class II Patients: A Cephalometric Study.

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Abstract

Background: Skeletal Class II malocclusion, commonly resulting from mandibular retrognathism, not only affects facial esthetics and occlusion but may also compromise pharyngeal airway dimensions, increasing the risk of sleep-disordered breathing. Functional appliance therapy is widely used in growing patients to correct mandibular deficiency and potentially improve airway patency.

Objective: To evaluate changes in the upper and lower pharyngeal airway dimensions in growing skeletal Class II Division I patients before and after functional appliance therapy using lateral cephalometry.

Methods: A retrospective study was conducted on 15 growing patients (8 males, 7 females; age 9–14 years) treated with functional appliances. Pre- and post-treatment lateral cephalograms were traced on lead acetate sheets, and upper and lower pharyngeal widths were measured. Statistical analyses included Shapiro-Wilk test for normality, Wilcoxon signed-rank test for intra-group comparisons, and Mann–Whitney U test for sex-based comparisons.

Results: Significant increases were observed in both upper and lower airway dimensions after functional appliance therapy ($p<0.05$). Sex-wise comparisons revealed that male patients exhibited higher improvements in upper airway dimensions, while females showed non-significant changes. No significant differences were found in lower airway changes between

sexes. Overall, functional appliance therapy effectively enhanced airway dimensions in growing Class II Division I patients.

Conclusion: Functional appliance therapy produces a significant improvement in pharyngeal airway space, particularly in male patients, highlighting its dual role in correcting skeletal discrepancies and supporting airway function.

Keywords: Skeletal Class II, , Functional Appliance, Pharyngeal Airway, Cephalometry

INTRODUCTION

Skeletal class II malocclusion is considered as a prevalent condition among the world population. The malocclusion can be attributed either to maxillary prognathism, mandibular retrognathism or a combination of both. Most of the skeletal class II malocclusions are as a consequence of mandibular retrognathism. Class II condition not only affects the esthetics and the function of the patient but also lead to the compromised airway due to retropositioning of the jaws and tongue. Constriction in the nasopharyngeal region is observed in children with retrognathism of mandible, decreased anterior facial height and steeper mandibular plane. This constriction is one of the causative factor for the development of snoring, upper airway resistance, OSA etc. Further, airway disturbances can lead to a myriad of developmental deformities such as the long face syndrome, anterior and posterior open bites and temporomandibular joint problems. Retroposition of mandible in relation to the anterior cranial base decreases the space between the cervical column and mandibular corpus and leading to posteriorly positioned tongue and soft palate which could also lead to the above mentioned problems. As compared to the subjects with normal occlusion, the nasopharyngeal area and its depth were significantly lower in subjects with class II division I condition and the oropharyngeal airway volume was directly correlated to the length of mandible.

Skeletal class II affects around 30% of population in the world. Literatures have shown the incidence of this skeletal malocclusion to be as high as 15% in the Indian population . According to local study conducted by Gul-e-Erum and Fida[1], 70.5% of patients had angle class II and amongst them 64.7% had class II division I malocclusion. An approximate estimation shows that almost 60% of the skeletal class II malocclusions are due to the consequence of retrognathism.

Normal airway is an important factor for normal growth and development of the craniofacial structures. Smaller airway dimensions during childhood may increase the risk of sleep related breathing problem along with the fat deposition secondarily in the posterior pharyngeal region. In skeletal class II, the problem is likely caused by a posteriorly-oriented mandible that displaces the soft tissues attached to it, impinging on the airway spaces. Obstruction of the nasal passage cause a functional imbalance that would result in an oral breathing pattern leading to a commonly and frequently undiagnosed medical disorder in adults, i.e… Obstructive Sleep Apnoea (OSA) which is characterised by recurrent pharyngeal airway obstruction. According to the studies, subjects with OSA exhibited reduced anteroposterior dimensions, narrowing airways, reduced oropharyngeal and hypopharyngeal areas by an average of 25% which are the consequences of mandibular retrognathism causing skeletal class II division I cases. It has been shown that there is a correlation between the minimum axial cross-sectional area of the oropharyngeal lumen and the oxygen saturation and quantity.

The treatment modalities for skeletal class II malocclusions are dependent on three basic interventions – growth modifications, surgery and dental camouflage which are based on the facial growth and patient's severity of deformity. Studies have shown that skeletal class II malocclusion if diagnosed at an early stage,

use of functional appliances such as Monoblock, Activator, Bionator, Frankel and Twinblock to increase the pharyngeal airway dimension through the forward movement of mandible and hyoid bone and prevents the upper airway collapse during sleep. These appliances work by changing the activity of various muscle groups that influence function and position of mandible . Altering sagittal and vertical mandibular position generates pressure due to stretching of muscles and surrounding soft tissues. The resultant force is transmitted to the underlying dental and skeletal tissues and brings about orthodontic and orthopaedic changes. The study was aimed to evaluate the alterations of pharyngeal airway and related structures following treatment of class II division I malocclusion. Reproducibility of airway dimensions on lateral cephalometry has been studied and found to be highly accurate.They provide us with useful, credible and replicable airway measurements while minimising the patient costs and radiation exposure. Cephalometric measurements provide two– dimensional data and is the reliable method for airway assessment and adenoid size estimation. Limited studies are available on this aspect and the current study was taken up to assess the efficacy of functional appliances in class II division I cases.

METHODOLOGY : MATERIALS AND METHODS

The current research is a retrospective study which is planned for skeletal class II patients with a total sample size of 15 patients , both male and female individuals, who have consulted the department of orthodontics for the functional appliance treatment. Approval for this study was obtained from the Ethical Committee of the Institution. These samples were collected from the archives of the Department of Orthodontics and Dentofacial Orthopaedics, Drs. Sudha and Nageswara Rao Siddhartha Institute of Dental Sciences, Chinnaoutapalli, by means of records of the pre treatment

and post treatment lateral cephalograms. Assessment is done by evaluating the pharyngeal airway dimensional changes before and after the treatment with myofunctional appliance therapy. Samples were based on the following

INCLUSION CRITERIA :

1. Subjects dentition diagnosed both clinically and radiographically as skeletal class II with retrognathic mandible .
2. Patients of age range varying from 9 – 14 years with significant growth potential at the beginning of treatment period.
3. Class II incisor, canine and molar relationships.
4. Excessive Overjet $\geq$ 5mm.
5. Compliant patients.

EXCLUSION CRITERIA :

1. Patients with skeletal class I and class III malocclusion.
2. Subjects with any congenital anomalies or syndrome.
3. Noncompliant or non co-operative patients.
4. Subjects with history of orthodontic treatment and permanent teeth extraction before or during Forsus – fixed functional appliance treatment.
5. Cases with cleft lip and palate.
6. Any other systemic disease, respiratory disease or condition.
7. Patients with history of any trauma or surgery of orofacial region.

MATERIALS :

1. 15 pre-treatment and post-treatment lateral cephalograms.
2. Lead Acetate Tracing sheets (250mm x 210mm).
3. Lead pencil (0.3mm).
4. Viewing box.
5. Adhesive tape .
6. Set squares and ruler.

METHODOLOGY :

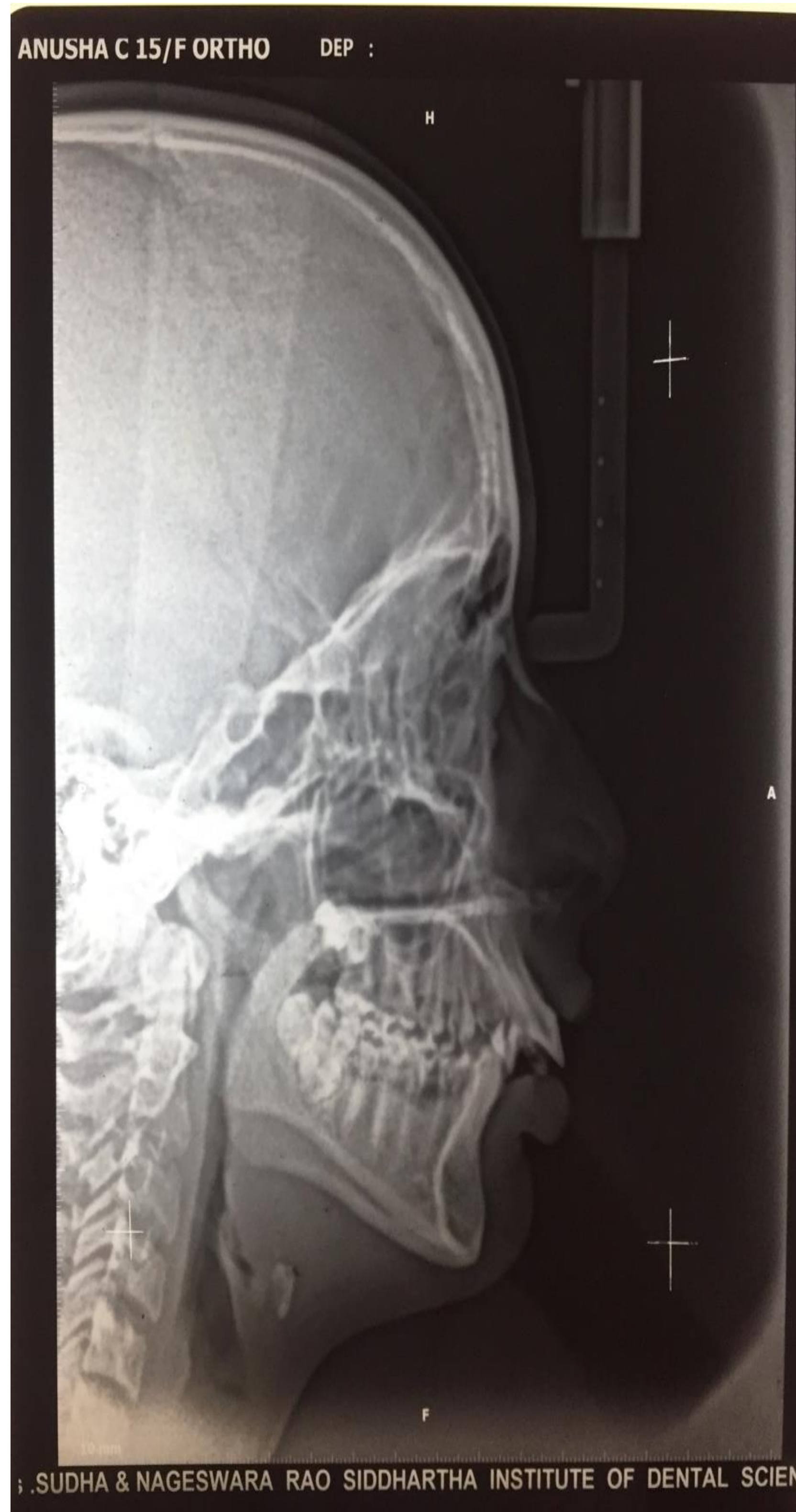
The sheet of lead acetate tracing paper is overlaid on the radiograph and made stable. Both the radiograph and the acetate paper were attached on left side at three different places (upper, middle and lower) with the help of adhesive tape. The orientation cross marks were drawn on the lateral cephalogram and were traced onto the paper for ease of subsequent superimpositioning of the tracing. The hard tissue and soft tissue outlines and landmarks of the radiograph were traced onto the sheet by using 0.3mm lead pencil.

The upper pharyngeal width was measured which is the smallest distance from the posterior outline of the soft palate to the closest point on the upper pharyngeal wall. This measurement is marked with a horizontal line.

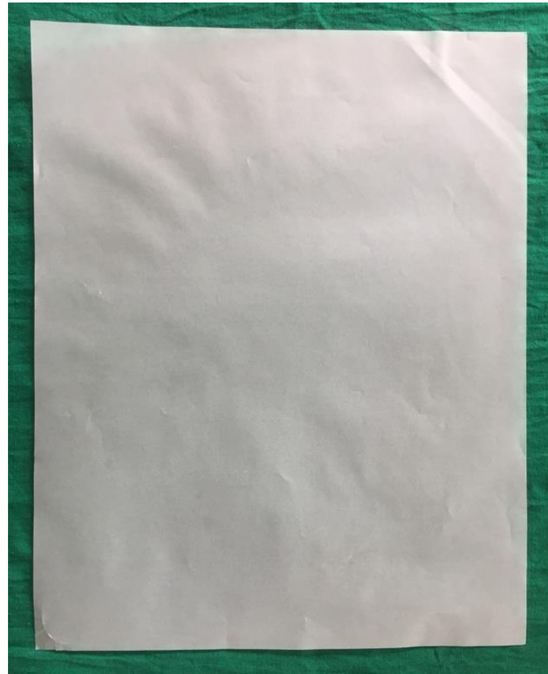
Later, the lower pharyngeal width was measured from the point of intersection of posterior border of the tongue and the inferior border of the mandible to the closest point on the lower pharyngeal wall.

All the cephalograms were assessed in the same manner, measuring and recording the upper pharyngeal dimensions and the lower pharyngeal dimensions.

The differences in the respective recorded values from both the pre-treatment and post-treatment cephalograms were evaluated by the single observer in order to prevent bias. The collected data was statistically analysed using SPSS Version 20.0 (IBM, Armonk).

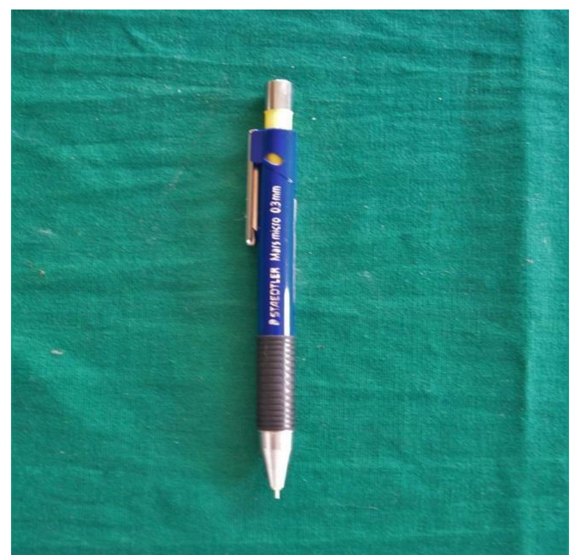


Picture 1 : Lateral cephalogram showing the hard tissue and the soft tissue landmarks

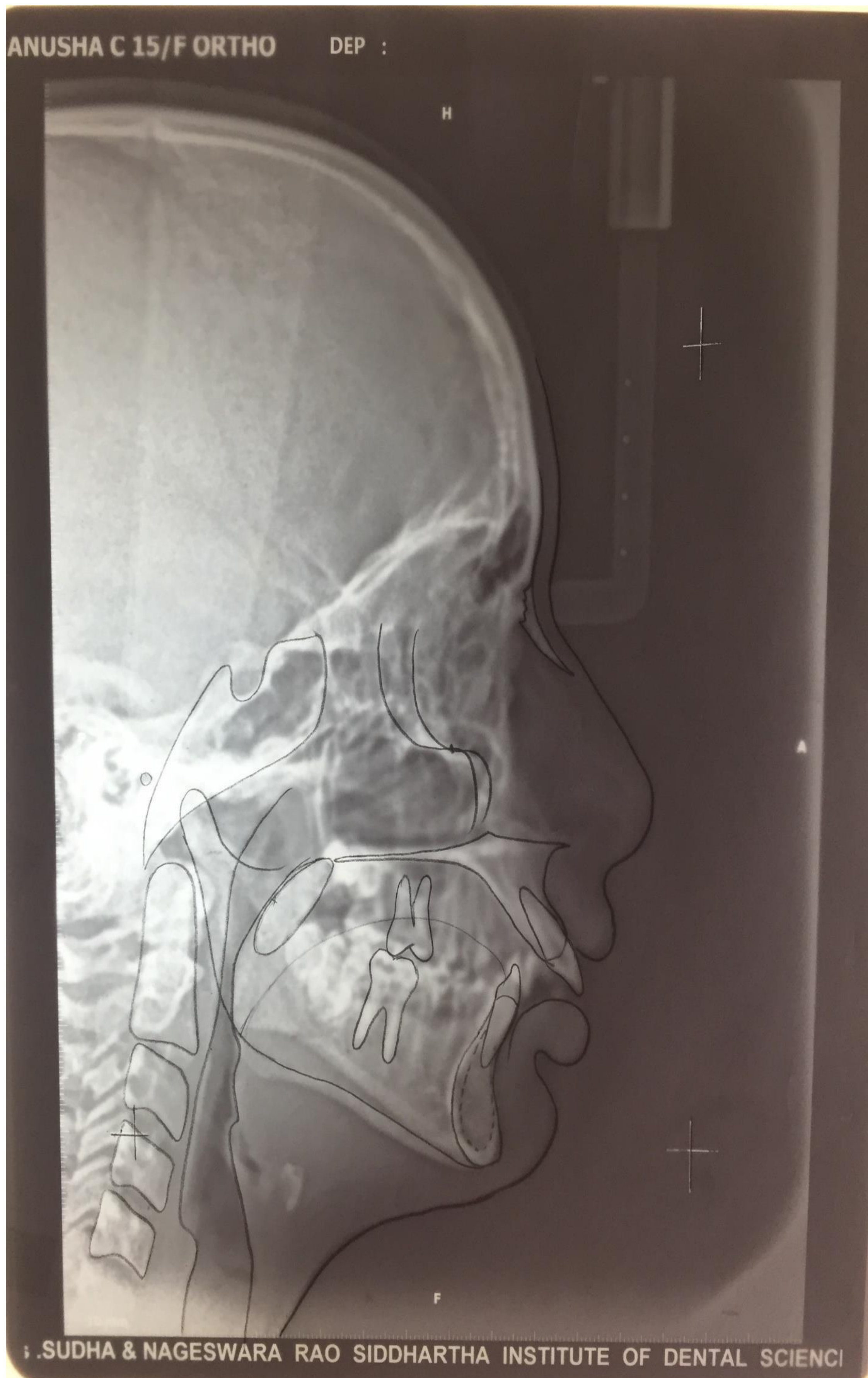


Picture 2 : Lead Acetate Tracing Sheet (250mm x 210mm)

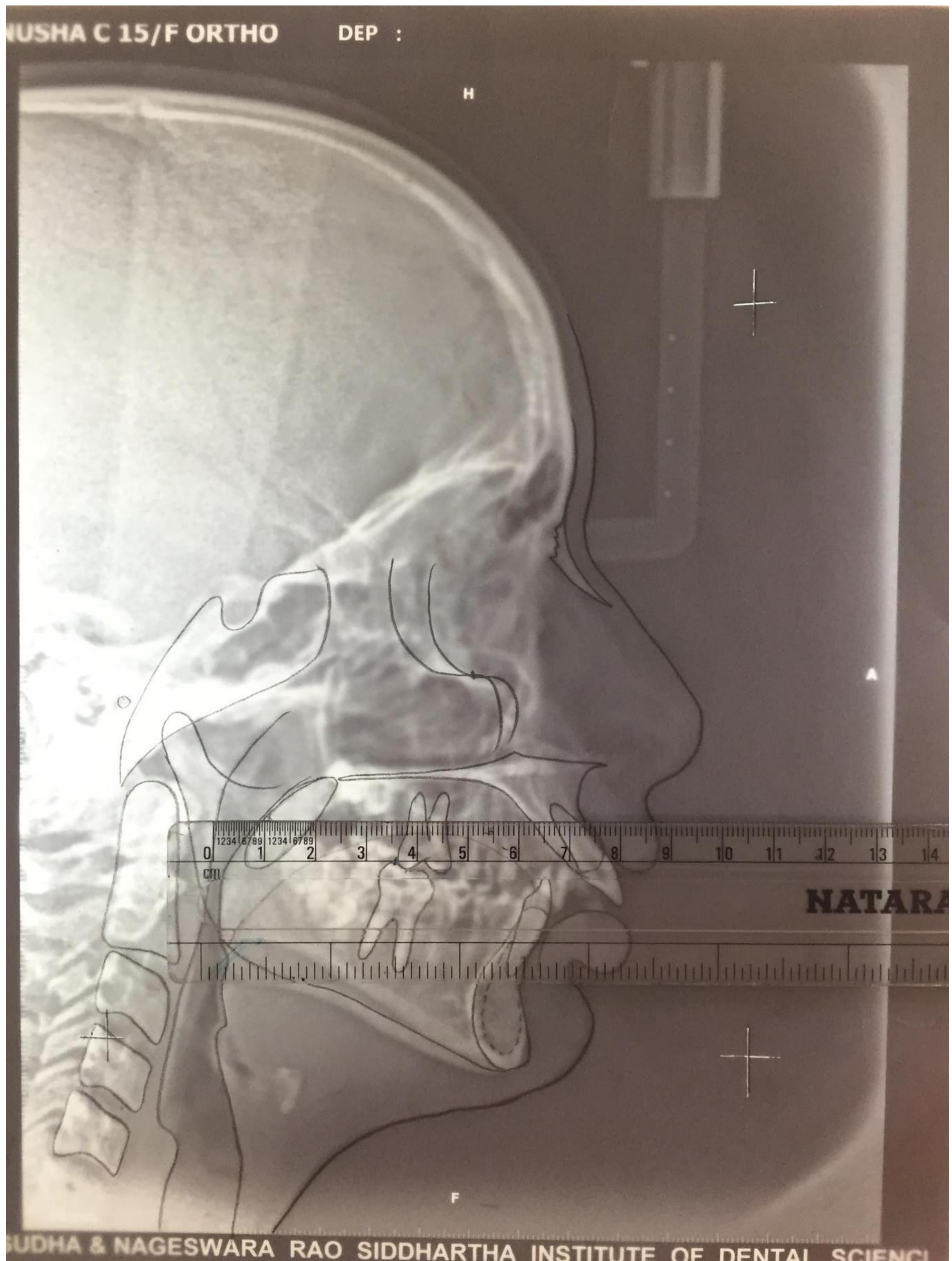
Picture 3 : Set squares and ruler



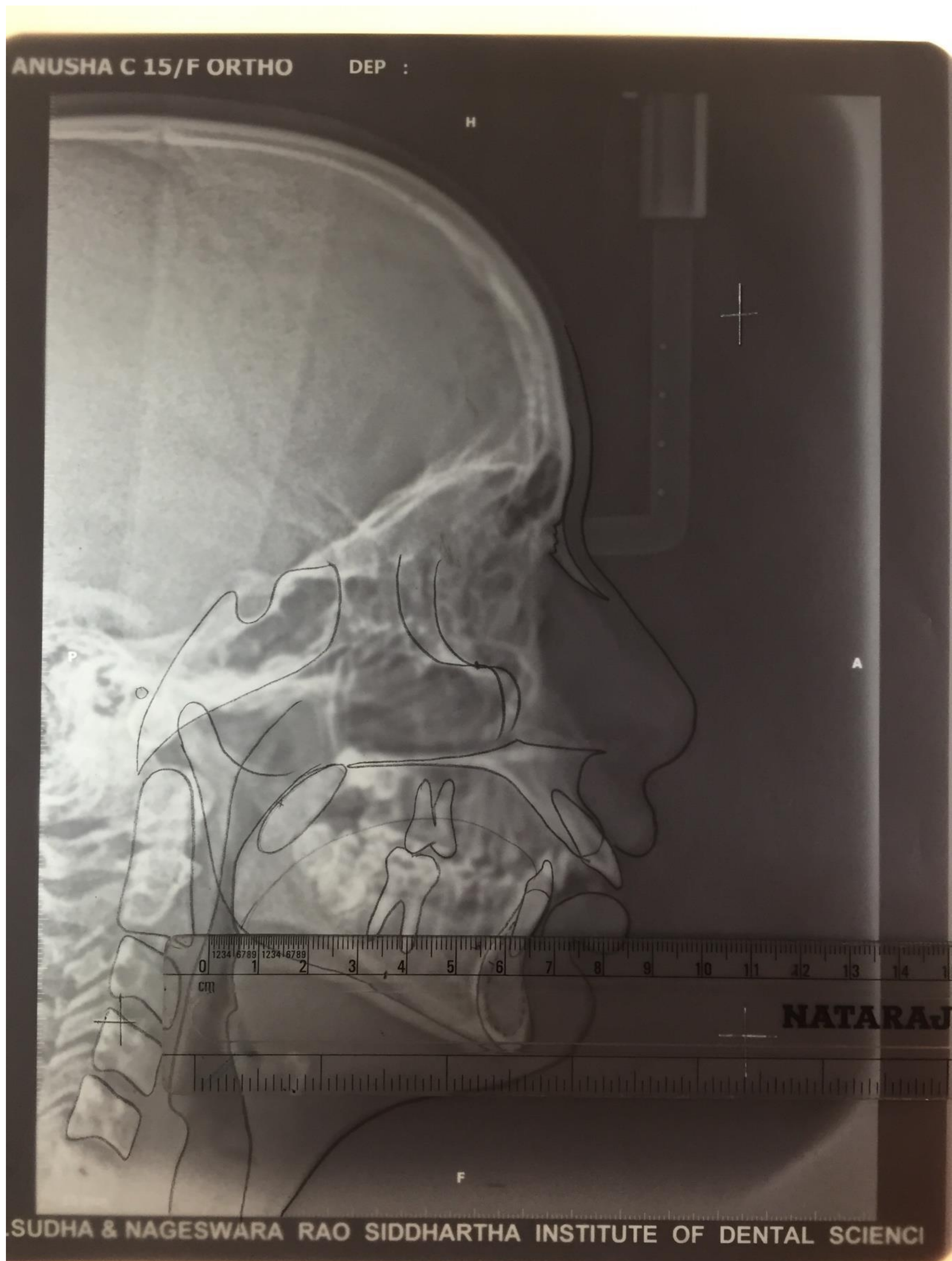
Picture 4 : 0.3 mm lead pencil



Picture 5 : Tracing the hard tissue and soft tissue outlines and landmarks .



Picture 6 : Measuring the upper pharyngeal dimensions



Picture 7 : Measuring the lower pharyngeal dimensions .

OBSERVATION AND RESULTS

The collected data was statistically analysed using SPSS Version 20.0 (IBM, Armonk).

The data is checked for the normality using Shapiro Wilk test ($p<0.001$) and it showed

that the data is of non-normal distribution. Descriptive statistics were calculated followed by Wilcoxon signed rank test was conducted for intra-group comparison and Mann-Whitney U test is performed to compare upper and lower in males and females.

Table 1: Comparison of pre and post upper and lower airway in the participants with Wilcoxon signed rank test.

Airway		N	Mean±SD	Std. Error Mean	Sig.
	UPPER	15	1.80±0.862	0.223	p<0.003*
	LOWER	15	0.67±0.450	0.116	

*statistical significance level set as **p<0.05***

Table 1 showing the Comparison of pre and post upper and lower airway in the participants with Wilcoxon signed rank test. From the above results, it is observed that there is high significance between pre and post measurements pertaining to functional upper and lower airways, when all the participants were considered, where the statistical significance level set as **p<0.05***

Table 2: Comparison of pre and post upper airway in the participants with Mann –Whitney U test

Airway		N	Mean±SD	Std. Error Mean	Sig.
	Female	7	1.43±0.535	0.202	p<0.129
	Male	8	2.13±0.991	0.350	

*statistical significance level set as **p<0.05***

Table 2 showing the Comparison of pre and post upper airway in the participants with Mann–W hitney U test. From the above results, it is observed that there is no statistical significance for pre and post measurements pertaining to functional upper airway where male and female patients were considered, where the statistical significance level set as **p<0.05***

Table 3: Comparison of pre and post lower airway in the participants with Mann –Whitney U test

Airway		N	Mean±SD	Std. Error Mean	Sig.
	Female	7	0.64±0.476	0.18	p<0.867
	Male	8	0.69±0.458	0.162	

*statistical significance level set as **p<0.05***

Table 3 showing the Comparison of pre and post lower airway in the participants with Mann–Whitney U test. From the above results, it is observed that there is no statistical significance for lower airway changes between males and females, where the statistical significance level set as **p<0.05***

Table 4: Comparison of upper and lower airway in female participants with Wilcoxon signed rank test.

Airway		N	Mean±SD	Std. Error Mean	Sig.
	Upper	7	1.43±0.535	0.202	p<0.06
	Lower	7	0.64±0.476	0.162	

*statistical significance level set as **p<0.05***

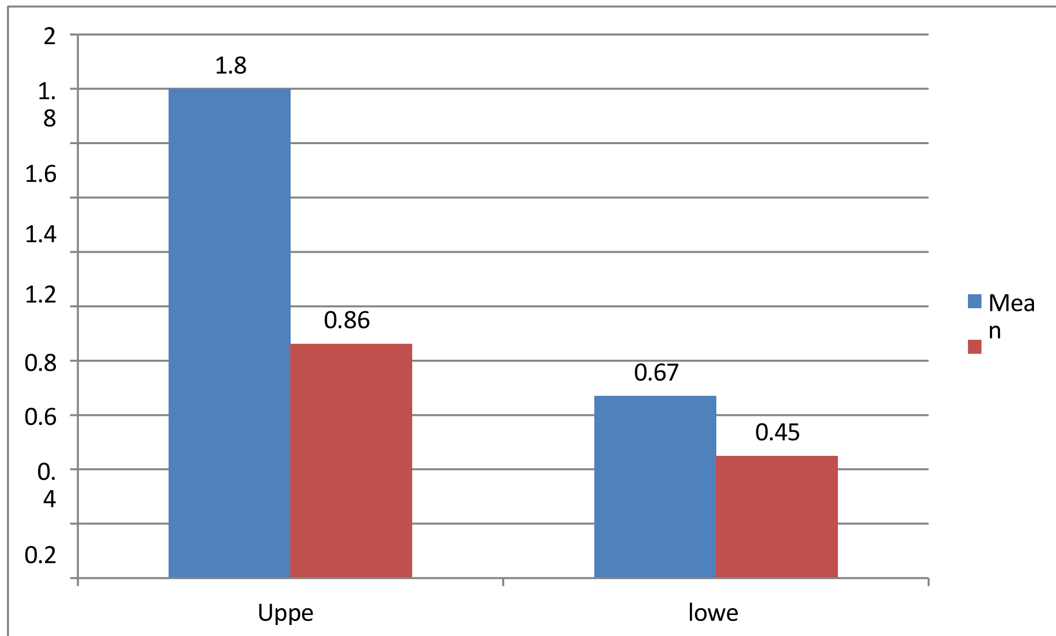
Table 4 showing the Comparison of upper and lower airway in male participants with Wilcoxon signed rank test. From the above results, it is observed that there is no statistical significance between upper and lower airway among female participants, where the statistical significance level set as **p<0.05***

Table 5: Comparison of upper and lower airway in male participants with Wilcoxon signed rank test.

Airway		N	Mean±SD	Std. Error Mean	Sig.
	Upper	8	2.13±0.991	0.350	p<0.016*
	Lower	8	0.69±0.458	0.162	

*statistical significance level set as **p<0.05***

Table 5 showing the Comparison of upper and lower airway in male participants with Wilcoxon signed rank test. From the above results, it is observed that there is high statistical



significance between upper and lower airway among male participants, where the statistical significance level set as **p<0.05* Chart representing upper and lower mean values of airway in the participants**

Chart representing the comparison between males and females for upper and lower airway dimensions. .

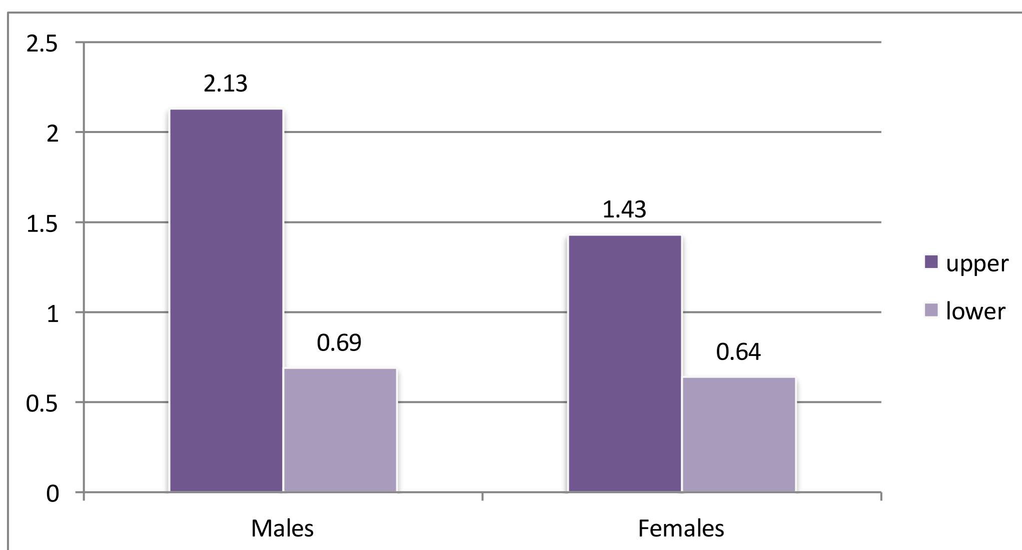
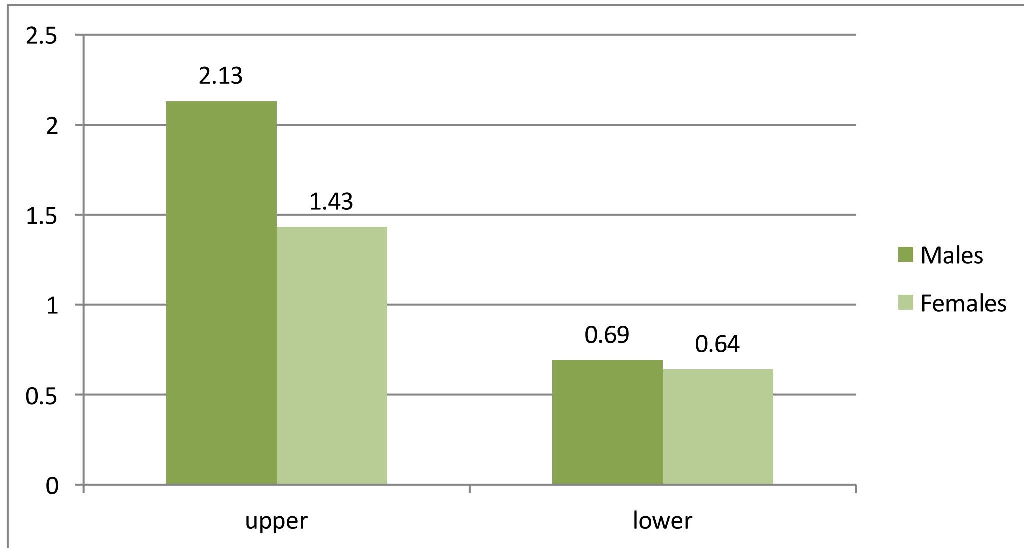


Chart representing the comparison of upper and lower airway mean values between males and females.



DISCUSSION

Physical attractiveness plays a vital role in social interaction and in dealing with the people in the society. The face is the first structure to be noticed and the people with well proportionated and attractive faces are perceived as being more outgoing, friendly, socially competent, optimistic and confident. The synchrony of ideal health and facial development is based on the accurate posture of tongue and nasal breathing. Orthodontia being one of its kind speciality has always aimed at correcting the dento–facial esthetics which involves the achievement of: ideal jaw relationship, normal oral function, proximal and occlusal contact of the teeth. But the core aspect of function and performance has been taken up by the function of respiration or breathing which is in fact the top most important function for humans. Therefore, the recent protocols be it Preventive, Interceptive or Corrective Orthodontics, factoring the dire need of pharyngeal airway space improvement in addition to improvement in smile and facial appearance.

The pharyngeal airway is an anatomical space divided into the

nasopharynx, oropharynx and laryngeal pharynx. Individuals with impaired nasopharyngeal airways may tend to exhibit mouth breathing due to the enlargement of the adenoid tissue . Associated factors may also induce mouth breathing, among which are constriction of the nasal passage, a narrowed or obstructed nasopharynx, hypertrophic nasal membranes, enlarged turbinates, hypertrophic palatine or pharyngeal tonsils, nasal septal deviation, choanal atresia and pathology in the nose or nasopharynx. The other etiological factors contributing to the effect of upper airway dimensions are posture, gender, age, obesity and body mass index.

The function of respiration is highly relevent to orthodontic diagnosis and treatment planning. Significant relationships between pharyngeal, craniofacial as well as dentofacial structures have been reported in several studies. Many authors have emphasized that constricted airway and associated symptoms can be cured with correction of either skeletal or dental problems or both. Zhong *et al.*[20] found that the sagittal skeletal pattern may be a contributory factor in variations in the inferior part of the upper airway. One of the kind of malocclusion which interferes with the function of respiration or breathing is the Skeletal Class II malocclusion. In this study, subjects with skeletal class II division I are considered which are typically present with an increased overjet, lower lip trapped behind maxillary incisors and an unfavourable facial profile. Class II malocclusion can manifest in various combinations of skeletal and dental disharmony that effect the overlying soft tissue facial profile. However, the majority of the patients have anteroposterior deficiency of mandible which is known as the mandibular retrognathism. Literature supports the hypothesis that mandibular deficiency is analogous to a narrower pharyngeal airway space . Although orthodontia at the present juncture , recognizes the importance of evaluating and treating airway, sleep disorders, there are yet tremendous scope untouched.

The pharyngeal airway has always been an area of interest for orthodontists because of the role played in the growth and development of the craniofacial and orodental complex and their primary functions in maintaining patent airway. Many previous studies have shown a possible relationship among pharyngeal airway and skeletal structures, soft tissues and musculature[21&22]. Accordingly, the purpose of the present study was to evaluate the upper pharyngeal airway and lower pharyngeal airway dimensions in skeletal class II subgroup i.e., division I condition in which the lower incisal edges lie posterior to the cingulum plateau of the

upper incisors, the overjet (OJ) is increased and the upper incisors are normally inclined or proclined.

From the days of Edward Angle, a frequently debated area in orthodontics has been the efficacy of various modalities in treating patients with Class II malocclusion with a retruded mandible. According to him, when a normal function is established, the adaptation of the craniofacial morphology subsequently follows it[21]. Growth modifications are attempted to alter a developing skeletal class II relationship in young children, predominantly during the growth phase by modifying the patients' remaining facial growth to a favourable size or position of the jaws using the functional appliances. These appliances enhance the proprioceptive sensory feedback mechanisms of various perioral musculatures that control the function and position of the mandible and transmit the generated forces to the dentition and basal bone. This modifies the growth of the mandible and maxilla , guiding them into a favourable relationship.

McNamara[23] stated that 60 % of the skeletal appliances in the form of functional appliances are used in the dentofacial orthopaedic treatment of growing children with hypoplastic and/or retrognathic mandible. However, there is a significant modification of the oropharyngeal airway dimension is observed in most of the studies.

Hypothesis could be presumed that , the dentoalveolar modifications occurring after functional appliance treatment , guides the tongue to a more forward position, enlarging the posterior airway space (PAS). The improvement in the dimension of oropharynx was more with removable functional appliance (Twin block) compared to the fixed functional appliance (Forsus).

Correction achieved by Twin block appliance therapy is due to an improved functional environment provided by the appliance, leading to muscular adaptation and favourable skeletal and dental changes. Twin block appliance is constructed in a protrusive bite that effectively modifies the occlusal inclined plane, which causes the forward growth of the mandible and in turn increases upper airway dimension (UAD). Many studies have shown that Twinblock appliance therapy is one of the most efficient treatment modalities available for the improvement of the upper airway for growing patients.

In the era of airway centric orthodontics, the effect of any orthodontic appliance, especially myofunctional appliance therapy on the airway, should be evaluated. It is important to determine and evaluate the minimum area that is an area of maximum constriction.

The introduction of cephalometry to the world of orthodontics was by Broadbent[24] and Hofrath[25] in the 1930s. The cephalometric technique has been regarded as a most important tool for orthodontists and maxillo-facial surgeons engaged in studying dental malocclusions and underlying discrepancies. Applications for cephalometric analysis include case diagnosis, treatment planning, prediction of growth and evaluation of treatment results.

The method used for the cephalometric analyses is McNamara Analysis which is one of the most popular methods, developed by San Francisco native James A. McNamara Jr [26]. It combines the anterior reference plane, the plane that runs parallel to

the Frankfurt horizontal through the nasion with a description of the length of the patient's jaw and the relationship between them. There are three main advantages of the McNamara analysis. Firstly, that it depends largely on linear measurements rather than angles. It analyzes the interarch relationship in the vertical plane as well as sagittal making them into one single integrated unit . Lastly, it helps to diagnose external condition in the airway.

The upper pharyngeal width is the smallest distance from the posterior pharyngeal wall to anterior half of the soft palate outline. The normal upper airway dimensions for an adult is 17$\pm$ 4mm.

The lower pharyngeal width is measured on the mandibular plane from the posterior tongue to posterior pharyngeal wall. The normal lower airway dimensions for an adult women is 11.3$\pm$4mm, while for an adult male is 13.5$\pm$4mm. Value less than 15mm suggest that

the anterior positioning of the tongue is either postural or there's an enlargement of tonsils.

The analysis in the current study revealed that there is high significance between the dimensions of upper airway and lower airway space changes. It was also evident that there is no considerable significance of the pre and post treatment upper airway measurements when analysed between the males and females. Similarly, the lower pharyngeal airway spaces have shown the same that there no significance. However, there was observed significance in male individuals when compared to female individuals before and after the treatment.

Only limited studies were conducted in the area of Orthodontics and further studies can be done regarding the efficacy of the appliances. As the obstruction in the airway can be considered as the predisposing factor for many problems , further studies can also consider this condition as a research to be done. The volumetric changes

in the three-dimensional view can also be done regarding the pharyngeal airway spaces.

CONCLUSION AND SUMMARY

A retrospective study was done by collecting 15 pre treatment and post treatment cephalograms , out of which, 8 were male and 7 were female growing patients. Both the upper airway and lower airway dimensions were measured and evaluated before and after the myofunctional appliance therapy.

From the analysis, the conclusions are as follows :

- High significance between the dimensions of upper airway and lower airway spaces of the patients before and after the functional appliance therapy.
- No statistical significance was observed for pre and post measurements pertaining to upper airway changes between male and female patients.
- No statistical significance was observed for pre and post measurements pertaining to lower airway changes between male and female patients.
- It was also observed that there is no statistical significance between upper and lower airway among female patients.
- High statistical significance between upper and lower airway among male patients was observed before and after the functional appliance therapy.
- Considerable change in both the upper pharyngeal width and lower pharyngeal width after the treatment was observed more in male patients than female patients.

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