International Journal of Research in Health and Allied Sciences

Journal home page: www.ijrhas.com

Official Publication of "Society for Scientific Research and Studies" [Regd.]

ISSN: 2455-7803

Original Research

VOLUMETRIC ANALYSIS OF MAXILLARY SINUS IN MOUTH BREATHERS BEFORE AND AFTER RAPID MAXILLARY EXPANSION

Dr. Shubham Sharan[1], Dr. Anu Grover[2], Dr. Shrutika Chand[3], Dr. P. Narayana Prasad[4], Dr. Tarun Kumar[5], Dr. Tarun Sharma[6]

[1]BDS, MDS Orthodontics
[2]Senior Lecturer, Department of Orthodontics & Dentofacial Orthopedics, Seema Dental College & Hospital, Rishikesh
[3]Senior Lecturer, Department of Orthodontics & Dentofacial Orthopedics, Seema Dental College & Hospital, Rishikesh
[4]Professor & Head, Department of orthodontics & Dentofacial Orthopedics, Seema Dental College & Hospital, Rishikesh
[5]Professor, Department of orthodontics & Dentofacial Orthopedics, Seema Dental College & Hospital, Rishikesh,
[6]Professor, Department of orthodontics & Dentofacial Orthopedics, Seema Dental College & Hospital, Rishikesh

ABSTRACT:
Introduction: Rapid maxillary expansion is mostly used in the treatment of narrow maxilla by splitting the mid-palatal suture. Rapid maxillary expansion appliance also causes anterior displacement of maxilla. This study was carried out to evaluate the volumetric changes in paranasal sinus after maxillary expansion therapy in growing patients. **Materials and methods:** Pre (Group T1) and post expansion (Group T2) CBCTs of 15 subjects were considered to evaluate the changes in the dimensions of maxillary sinus. The data obtained was found to be non-normally distributed. So, non-parametric test named Wilcoxn signed-rank test was used. Interclass correlation coefficient between subjects in T1 and T2 was done. The results showed a significant excellent positive correlation between subjects with r value of 0.998 and p value <0.05.Intra-class Correlation of reliability was above 0.8 for all variables. This proves agreement between analysis done at two time frames T1 and T2 which obviates intra-observer error of measurement. **Results:** On comparison of the mean values of maxillary sinus pre (T1) mm^3 and post (T2) mm^3, the mean value of maxillary sinus post expansion is higher with a p value of 0.001which denotes statistically significant changes. **Conclusion:** The rapid maxillary expansion appliances play a significant role in the improvement of maxillary sinus volume, thus decreasing the lower airway resistance. This proves to be very beneficial in mouth breathing patients.
Keywords: Maxillary sinus volume, Rapid Maxillary Expansion, Volumetric changes, CBCT, HYRAX.

Received: 15 October, 2021 Accepted: 1 November, 2021

Corresponding author: Dr. Anu Grover, MDS, Senior Lecturer, Department of Orthodontics & Dentofacial Orthopedics, Seema Dental College & Hospital, Rishikesh, Email – anugrover.11@gmail.com, Contact No. - +91-7983847413

This article may be cited as: Sharan S, Grover A, Chand S, Prasad PN, Kumar T, Sharma T. Volumetric Analysis Of Maxillary Sinus In Mouth Breathers Before And After Rapid Maxillary Expansion. Int J Res Health Allied Sci 2021; 7(6):35-43.

INTRODUCTION

Nose breathing associated with the normal functions of chewing and swallowing and posture of tongue and lips provides correct muscular action stimulating adequate facial growth and bone development.[1] Dentofacial morphology can be altered by dysfunctions, such as nasorespiratory obstruction depending on the magnitude, duration and time of occurrence.[1] When nose breathing is disrupted by adenoid and tonsil hypertrophy, rhinitis, nasal septum deviation, among others there is a prevalence of mouth breathing.[2] Mouth breathing may lead to postural changes such as lowered position of the mandible, raised position of the head, low posture of the hyoid bone and anterior inferior position of the tongue. It has also been shown that such postural changes may be related to specific dentofacial characteristics and morphological changes. [2] Several theories have been put forward concerning the physiological role of human paranasal sinuses, but still their function remains an enigma. Enzymes responsible for nitric oxide (NO) production have been demonstrated both in the nose and in the paranasal sinuses. In the sinuses, NO levels have been reported to be several-fold higher than in the nose. This has led to the suggestion that the paranasal sinuses are the main site for NO production within the airways.[3] Nitric oxide also is a strong vasodilator and brain transmitter that increases oxygen transport throughout the body and is vital to all body organs. Nitric oxide is crucial to overall to health and the efficiency of smooth muscles, such as blood vessels and the heart.[4] Mouth breathers have a lower oxygen concentration in their blood than those who have optimal nasal respiration; low oxygen concentration in the blood has been associated with high blood pressure and cardiac failures.[4]

Studies have shown that upper airway obstruction/mouth breathing can cause sleep disorders and sleep apnea.[4] Studies have shown that children with sleep disorders have problems paying attention in school, are often tired, and may exhibit behavior problems; many of these children often are misdiagnosed with attention deficit hyperactivity disorder (ADHD).[4]

Rapid maxillary expansion in growing patients with mouth breathing is beneficial. It produces a significant transversal increase through midpalate suture opening using a Hyrax expanding device. The RME effects have been noted in such neighboring structures as the internasal, naso-maxillary, and fronto-maxillary sutures and even the spheno-occipital synchondrosis in youngsters. Disarticulating these sutures will lead to anatomical changes in the nasal cavity with an increase in the nasal volume, which decreases the nasal airway resistance, establishes predominant nasal respiration, and improves the nasal airway ventilation. This procedure has also been proved to offer an effective method for treating children with obstructive sleep apnea syndrome.[5]

CBCT is a very valuable tool in volumetric analysis. Lulz et al measured the 3D osseous and soft tissue defined volume and surface area of the maxillary sinus. The study showed that the CBCT is suitable for the evaluation of the maxillary sinus volume.[6]The present study aims to evaluate the changes in volume of maxillary sinus after rapid maxillary expansion with CBCT. This CBCT study aimed to evaluate three dimensional changes in paranasal sinus volume after rapid maxillary expansion.

MATERIALS AND METHODS

The present CBCT study was done on untreated Orthodontic patients selected from the subjects who visited to the OPD at Department of Orthodontics and Dentofacial Orthopedics, Seema Dental College and Hospital, Rishikesh and by conducting free camps in various schools of nearby places in and around Rishikesh city. The study comprised total number of 15 subjects in growing age. Treatment protocol was informed and explained to the subjects and the parents prior to intervention. All the pre-and post- expansion records and the maxillary expansion treatment were undertaken with written informed consent.

Inclusion Criteria:

1. Sample should be in a growing age.
2. CVMI Stage between II-IV
3. Mouth breathing
4. Constricted maxillary arch.

Exclusion Criteria:

1. Final stage of growth of growth or adult subjects
2. Cervical Vertebrae Maturation Stage above Stage IV
3. Systemic disease
4. Deviated nasal septum.

The records were categorized into two groups.
Group T1: Pre-expansion CBCT of 15 growing subjects with narrow maxilla
Group T2:Post-expansion CBCT of same subjects after the completion of maxillary expansion.
Both the groups were compared, and the evaluation was done for changes in volumes of maxillary sinus.

Methodology
Total 800 numbers of subjects were screened at the Out-Patients Department of Seema Dental College and Hospital and by examining the general population by conducting camps in various schools of Rishikesh city and adjoining areas.

Selection Process:
Total numbers of 22 Subjects with mouth breathing habit were selected for purpose of this study. Among the 22 subjects 4 refused to give consent for treatment. A sample of 18 was finally included in the study. Pre-expansion records i.e. the photographs, impressions and CBCT were taken for all the subjects. Diagnosis and treatment planning were done and 18 patients were included in the study. Treatment protocol was informed and explained to all the subjects. All the records and treatment were undertaken after written informed consent. Three subjects failed to report back to the department. Thus 15 subjects were finally included in the study.

CBCT Image Acquisition and Data Collection
All CBCT images were taken using MYRAY Hyperion X5 machine. Images were taken with a 10 cm x 10 cm field of view (FOV) and apulsed exposure time of 6 seconds set to 110kV.All patients were instructed to occlude into maximum intercuspation, hold their tongue in resting position and avoid swallowing, breathing, or moving their head or tongue during image acquisition. Images captured were exported in Digital Imaging and Communications in Medicine (DICOM)format then imported of volumetric, cross-sectional area, and linear measurements of the maxillary sinus. This is shown in Figure 1.

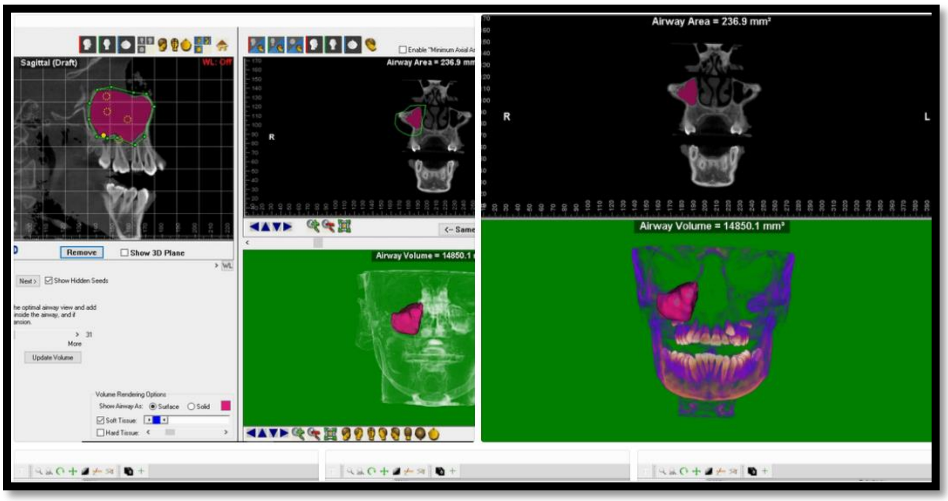

Figure 1: iRYS software for three-dimensional evaluation of Maxillary Sinus
Finishing, Polishing and Delivery of the Appliance:

The HYRAX appliance was finished, polished, and delivered to the subject after required adjustments. Post-delivery instructions were given for adequate wear and care of the appliance and the subject was motivated for scheduled appointments. The visits were scheduled in accordance with the protocol of maxillary expansion and the follow up was done till the end of retentive phase. The mean treatment time was 4 months following which the post treatment records were made.

CBCT Analysis

Thirty sinuses for fifteen patients (out of the original eighteen) were selected for further volumetric analysis of the maxillary sinus. Selection criteria were based on inclusion of all sinus boundaries within the scan. Right and left volumetric measurements were taken for the fifteen patients.

To obtain the width, length, and height of the sinus, the coronal and axial cuts were sequentially reviewed to get maximum height of the sinus [mediolateral dimension] as shown in Figure 2 and 3 respectively and the sagittal cuts were sequentially reviewed to get the maximum sinus base width [antero-posterior dimension] and length [craniocaudal dimension] as shown in figure no 4.

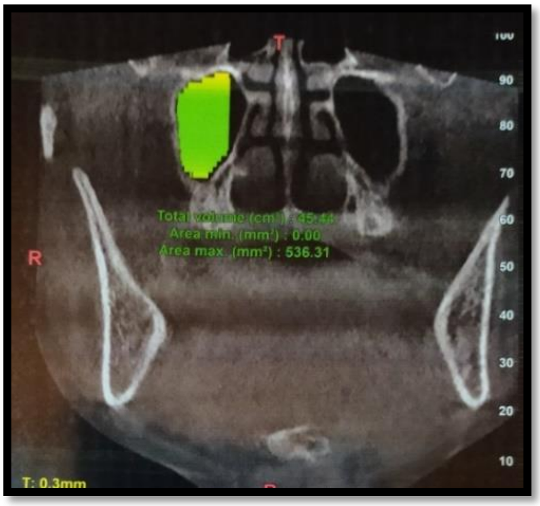

Figure 2 : Coronal Section of CBCT

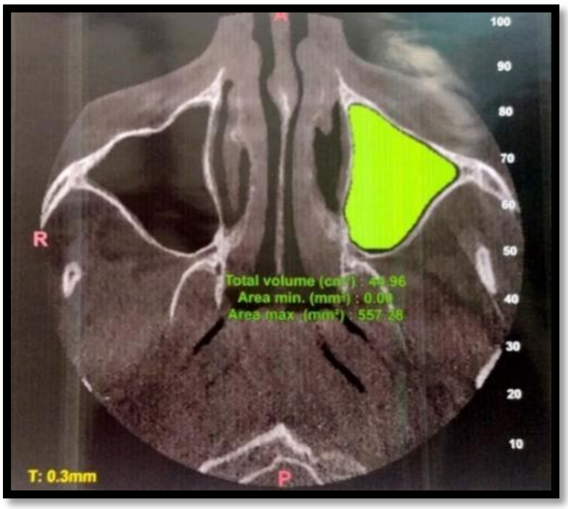

Figure 3 : Axial Section Of CBCT

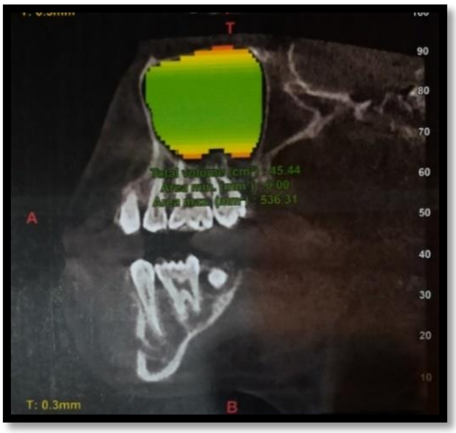

Figure 4 : Sagittal Section of CBCT

RESULTS

The data was compiled in Microsoft excel sheet and transferred to version 20 SPSS software. The data provided shows a non-normal distribution therefore non-parametric analysis was used.

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
T1	.297	15	.001	.736	15	.001
T2	.323	15	.000	.715	15	.000

Table 1: Tests of Normality- Data for 15 subjects was collected and subjected to tests of normality. A non-normal distribution was observed.

The values were subjected to Kolmogorov Smirnov test and Shapiro-Wilk test. Significant difference was observed in Kolmogorov Smirnov test with a Statistical Probability value of 0.000. Significant difference was observed in Shapiro-Wilk test too. The baseline data is represented in a histogram table no 5 and 6. The data represented does not show normal distribution.

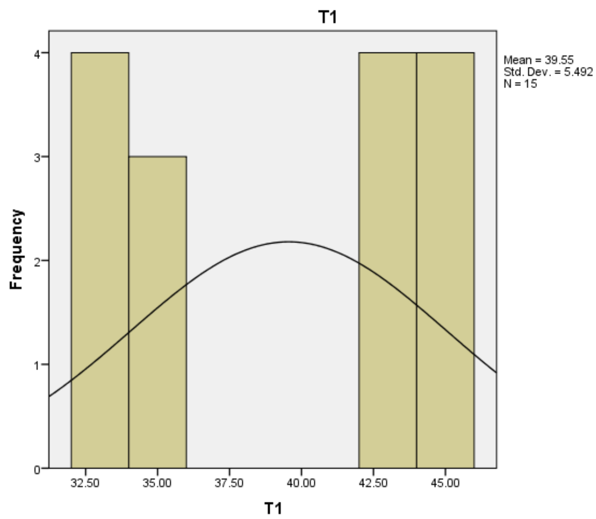

Figure 5: Non- Normal frequency distribution in T1 Group

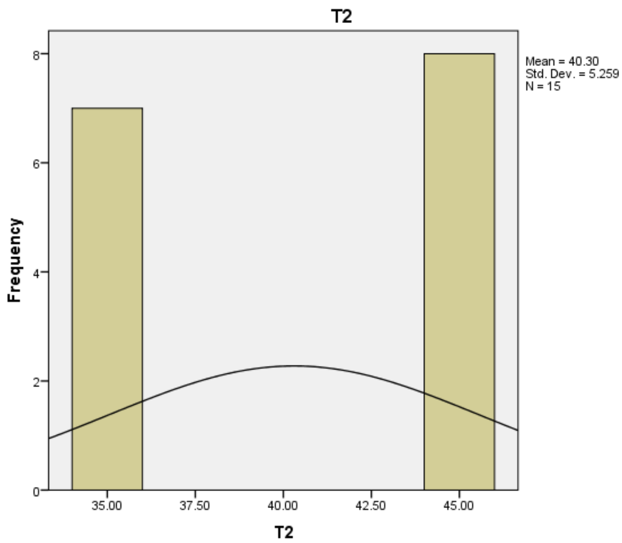

Figure 6: Non- Normal frequency distribution in T2 Group

Mean and Standard Deviation Between Pre and Post-Expansion

Group	N	Mean	Std. Deviation	Minimum	Maximum
T1	15	39.55	5.49	33.59	45.44
T2	15	40.30	5.25	34.44	45.53

Table 02- Mean and Standard Deviation Between Pre and Post-Expansion shows descriptive statistics with mean value of 39.55± 5.4 in T1 and 40.30± 5.25 in T2 respectively.

Comparison Between Pre and Post Group Using Wilcoxin Signed Rank Test

		N	**Mean Rank**	**Sum of Ranks**	**Z value**	**p value**
T2 - T1	**Negative Ranks**	0a	0	0	-3.43	0.001**
	Positive Ranks	15b	8	120		
	Ties	0c				

a- T2 < T1, b- T2 > T1, c- T2 = T1

Table 03 - Comparison Between Pre and Post Group Using Wilcoxin Signed Rank Test shows inferential statistics with all subjects in positive rank in T2. Therefore, there is significant difference between groups with a p value of 0.001 and z value of -3.43.

Maxillary Sinus Volume:

As shown in table number 02, the mean value for maxillary sinus volume in group T1 was 39.55 ±5.49mm^3 and in group T2 was 40.30± 5.25mm^3. On comparison of the mean values of maxillary sinus pre (T1) $mm^3$and post (T2) mm^3, the mean value of maxillary sinus post is higher with a p value of 0.001which denotes statistically significant changes.

Interclass Correlation Coefficient Using Pearson Correlation Test

Correlations		**T1**	**T2**
T1	**Pearson Correlation**	1	.998**
	Sig. (2-tailed)		0.001
	N	15	15
T2	**Pearson Correlation**	.998**	1
	Sig. (2-tailed)	0.001	
	N	15	15

Table 04 :Interclass Correlation Coefficient Using Pearson Correlation Test shows inferential statistics of interclass correlation coefficient between subjects in T1 and T2. The results show a significant excellent positive correlation between subjects with r value of 0.998 and p value <0.05.

Inter- observer and Intra- observer Errors

Table 05: **Interclass Correlation Coefficient To Eliminate Error**shows inferential statistics of intraclass correlation coefficient between examiners. The results show an Intraclass Correlation value of > 0.8 and p value <0.05.

As shown in Table no. 5 the Intraclass Correlation of reliability was above 0.8 for all variables. This proves agreement between evaluations and measurements done by observer 1 (O1) and observer 2 (O2) which obviates interobserver error of measurement.

DISCUSSION

Nasorespiratory function and its relation to craniofacial growth is of great interest today. Discussions on this topic have appeared in the literature for over a century. Recent renewed interest is based on the accumulating finding of the relationship between breathing patterns and craniofacial growth.[1]
The literature has shown a correlation between mouth breathing and abnormal facial growth in humans. McNamara found a relationship between upper airway obstruction and deviant facial growth. Bresolin et al studied 45 North American Caucasians (30 chronic mouth breathers and 15 nasal breathers) of both sexes (ranging in age from 6–12 years) and found that mouth breathers had longer faces with a narrower maxilla and retrognathic jaws. Trask et al studied 64 children medically, dentally, and cephalometrically: 25 allergic children who were mouth breathers, 25 nasal breathing siblings, and 14 nasal breathing control subjects. The authors found that the allergic children had longer and more retrusive faces than the control group.[4]

In addition to various types of abnormal facial growth and dental malocclusions, many other medical problems can be attributed to mouth breathing. First and foremost, nasal respiration (which is produced in the nasal sinuses) is essential for the production of nitric oxide. Nitric oxide inhaled via nasal respiration has been shown to increase oxygen exchange efficiency and increase blood oxygen by 18%, while improving the lungs' ability to absorb oxygen. Nitric oxide also is a strong vasodilator and brain transmitter that increases oxygen transport throughout the body and is vital to all body organs. Nitric oxide is crucial to overall health and the efficiency of smooth muscles, such as blood vessels and the heart.[4]

Nasal respiration provides the most efficient mechanism for introducing oxygen into the lungs and body for overall health. Mouth breathers have a lower oxygen concentration in their blood than those who have optimal nasal respiration; low oxygen concentration in the blood has been associated with high blood pressure and cardiac failures.[4]

Several theories have been put forward concerning the physiological role of human paranasal sinuses, but still their function remains an enigma. Enzymes responsible for nitric oxide (NO) production have been demonstrated both in the nose and in the paranasal sinuses. In the sinuses, NO levels have been reported to be several-fold higher than in the nose. This has led to the suggestion that the paranasal sinuses are the main site for NO production within the airways.[3]

Wright's study of 30 patients with nasal respiratory insufficiency in 1911 treated by RME showed, by measuring the width of the nasal cavity with pre- and post-expansion cephalograms, a mean 6.5 mm increase in width following the expansion procedure. Using occlusal radiographs to assess 40 cases treated with maxillary expansion, Thorne in 1960 found that the increase in nasal width ranged from 0.4 to 5.7 mm (mean - 17 mm) at the end of the procedure. This author also noted that a two-month retention period was required for stability of the increased width.[7]

Anatomically the nasal cavity increases in width immediately after maxillary expansion, particularly of the nasal floor close to the midpalatal suture. Haas made this statement in 1961 based on animal studies, after which he undertook a clinical trial in human beings. Ten patients with nasal insufficiency and maxillary atresia, aged between 9 and 18 years were selected and subjected to RME. Analysis of CBCTs, photographs and subjective questionnaires answered by patients was done. These authors found that the width of the nasal cavity increased by 2.0 to 4.5 mm, and concluded that improved nasal breathing depended on the severity of the nasal cavity narrowing before maxillary expansion.[7]

The present study evaluated the volumetric changes in maxillary sinus after rapid maxillary expansion. Growing patient with CVMI III & IV were selected for this study as more pronounced change are evident after maxillary expansion not only on volumetric aspect but also on behavioural aspect.[4] In the field of orthodontics, CBCT has added value when upper airway definitions are required for diagnosis and treatment planning. Moreover, the use of software reconstruction in three dimensions enabled the manipulation of images in a three-plane space. These features enhance studies aiming to assess upper airway volume and morphology with respect to craniofacial growth, as well as maxillofacial surgical and orthodontic interventions.[8] Awareness of the possibility of increasing upper airway dimensions to prevent or relieve OSA symptoms in both adults and children led to an increase in the number of studies evaluating the outcomes of RME in terms of nasal cavity dimensions and upper airway patency via CBCT.

Maxillary Sinus Volume: There is a mean increase of 0.80 mm^3 between pre and post expansion values. The mean value for maxillary sinus volume in group T1 was 39.55 ±5.49mm^3 and in group T2 was 40.30± 5.25mm^3. On comparison of the mean values of maxillary sinus pre (T1) mm^3 and post (T2) mm^3, the mean value of maxillary sinus post expansion is higher with a p value of 0.001which denotes statistically significant changes.

These results coincide with study done by **Pamporakis et al in 2014** that also suggests significant increase in the maxillary sinus volume following RME.[9]

Another CBCT study by **Bouserhal et al in2014** showed that there were volumetric increases of different components of the nasomaxillary complex following RME. The total volume increased by 2.81 mm^3, or 12%, including increases in the nasal volume of 0.85 mm^3 and in the maxillary volume of 1.96 mm^3, which are equivalent, respectively, to 17% and 10.6%.[5]

Rapid maxillary expansion in growing patients with mouth breathing is beneficial. It produces a significant transversal increase through midpalate suture opening using a Hyrax expanding device.

CONCLUSION

This descriptive analytical study was done on 15 growing subjects to evaluate changes in the volume of paranasal sinus in mouth breathers after rapid maxillary expansion therapy. Mean treatment time was 4 months and the pre-treatment and post treatment CBCTs were evaluated to assess the changes. The results indicated that rapid maxillary expansion therapy plays a significant role in the improvement of maxillary sinus volume and hence decreasing the resistance of the airway.

Follow up studies are further needed to assess the stability of maxillary sinus volume after a period of 5 years and 10 years. Moreover, three dimensional studies with the increased sample size would be a conclusive one to predict the efficacy of rapid maxillary expansion as an adjunct to the treatment of reduced airway space in growing children.

ACKNOWLEDGEMENT

I would like to thank 'The Almighty' for his grace, the wisdom he bestowed upon me, the strength, and his blessings at every step of this mortal journey. Heartfelt thanks to all who participated in this study. They are the unsung heroes. A special vote of thanks to all friends and family. I shall forever remain indebted to them.

REFERENCES

1. Mc Namara Jr, Influence of respiratory pattern on craniofacial growth, Angle orthodontist, Vol 51; No 4 Oct 1981
2. Timo Peltomaki, The effect of mode of breathing on craniofacial growth-revisited, Eur. J. Orthod. Vol 29; no.1; Sept2007: p 426-429
3. J.O.N. Lundberg et al, High nitric oxide production in human paranasal sinus, Nature medicine, Vol 1; No 4, April 1995
4. Yosh Jefferson, Mouth breathing: Adverse effects on facial growth, health, academics and behaviour; Genereal Dentistry. 2010 Jan-Feb
5. Joseph Bouserhal et al.,Three-dimensional changes of the naso-maxillary complex following rapid maxillary expansion, Angle Orthod; 2013
6. Julia Luz et al,3D evaluation of the maxillary sinus in cone beam computed tomography. Int. J. Implant Dent., Vol 4, No. 17, 2018

7. Tatiana Ramires et al., Nasal cavity changes and the respiratory standard after maxillary nexpansion; Braz J Otolaryngol. 2008Sept-Oct;74(5):763-769
8. Gabriele DiCarlo et al., Rapid maxillary expansion and upper airway morphology: A systemic review on the role of cone beam computed tomography. Bio Med Research International, Vol 2017
9. Paschalis Pamporakis et al, Three dimensional alterations in pharyngeal airway and maxillary sinus volumes in class III maxillary deficiency subjects undergoing orthopedic facemask treatment. Angle Orthod, Vol 84, No 4, 2014: 701-707