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Comparison of Equivalency of Volumetric Expansion Between Nasopharynx and Oropharynx in Patients with Class II Malocclusion Subjected to Rapid Maxillary Expansion using Cone Beam Computed Tomography - A Prospective Study.

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Abstract

Objective: The purpose of this study is to analyse the change in the total volume of the oropharynx and nasopharynx after the maxillary expansion done with HYRAX (Hygienic Rapid Expander) and its proportionality with each other. Materials and method: 20 patients were selected for the study. Midline diastema, intermolar width, the volumetric change in the nasopharyngeal and oropharyngeal airway, and McNamara Airway analysis to measure the airway was measured on CBCT Scans before and after expansion. We have evaluated some angular measurements such as saddle angle, articular angle and the gonial angle to evaluate changes in the position of the mandible. Results: Results of paired t-test showed the volume of the nasopharynx has increased with a mean of -3.0200±1.46; p-value =0.001. The volume of the oropharynx has increased with a mean of -7.7600±5.082; p-value =0.001. Increase in the nasal width with mean of -2.0800±0.71642; p-value =0.001. Increase in the intermolar width mean of -4.86000±1.694; p-value = 0.001. McNamara analysis done for upper and lower pharyngeal airways with mean = -1.80100±0.713 p-value = 0.001, mean = -2.37000±0.857 p-value = 0.001 for upper and lower pharyngeal airway respectively. The saddle angle shows a significant reduction with the mean= 3.1000±2.22 p-value=0.001. Articular angle shows an increase (p=0.001) with a mean difference of 3.500±2.60. The Gonial angle decreased with the mean difference=2.40±1.3 p= 0.001. Conclusion: Use of RME results in increase in the volume of oropharynx and nasopharynx, nasal cavity width and the intermolar width which was statistically significant too.

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1. Introduction:

Maxillary expansion is very important treatment for the correction of maxillary transverse deficiency. Rapid maxillary expansion was observed as an important treatment modalities for respiratory problems due to effective effect on maxilla by Angell in the 19th century..[1] Due to the expansion of the arch form, changes in the airway dimensions have been observed. This proved to be beneficial in patients with obstructive sleep apnoea, mouth breathers, or patients suffering from any other breathing disorder[2.] There is also an increase in the malar prominence, which improves the facial aesthetic of the individual. In the contemporary world, a wider smile is considered a signature. Various methods are employed to perform Rapid Maxillary Expansion (RME) but still HYRAX (Hygienic Rapid Expander) remains the gold standard.

Transverse Growth is the first to complete and thus many of transverse problems remain unaddressed. As Maxilla articulates with skull bones through sutures, any changes in the maxilla affect the surrounding structures. Most of the airway changes are measured linearly on lateral cephalograms but a clear idea regarding volumetric expansion cannot be obtained. Use of volumetric changes in the airway can be analysed with the help of cone beam computed tomography (CBCT) in orthodontics. We had conducted the study is to evaluate the change in the total volume of the oropharynx and nasopharynx after the maxillary expansion done with HYRAX and its proportionality with each other.

2. Materials & Method: -

The ethical committee had approved the study and the ethical committee clearance certificate was obtained as per the norms set in by them.

Twenty patients visiting the department for orthodontic treatment meeting the exclusion and inclusion criteria were preferred for the study. Subjects with Class II Skeletal base and dental Class II malocclusion were included. Cephalometric parameters were used for determining skeletal relation (N-S-Ar, S-Ar-Go, Ar-Go-Me, SNA, SNB, ANB, Wits AO-BO). Patients of age 12 -14 years with the high arched palate, constricted maxillary arch with Unilateral or Bilateral Posterior Crossbites and those willing to participate in the study were included. Syndromic or patients with any systemic or metabolic diseases, those suffering from airway obstruction due to nasal stenosis, deviated nasal septum or nasal polyp were excluded.

Pre-Treatment CBCT scans of all patients were recorded for the measurements of nasopharyngeal and oropharyngeal airway volume using in vivo version 5.2. Patients were then subjected to RAPID MAXILLARY EXPANSION following the TIMMS protocol of palatal expansion. Bonded HYRAX appliance was used (Figure 1). Midline Diastema was the clinical key factor in determining the expansion. Also, the intermolar width pre-and post-expansion was measured from CBCT to determine the amount of expansion (Figure 2).

Following Expansion, CBCT scans were taken to record the volumetric change in the nasopharyngeal and oropharyngeal airway using in vivo version5.2. (Figure 3 and Figure 4)Airway analysis proposed by McNamara was used to measure the airway (Figure 5)

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Figure 1: HYRAX Expander

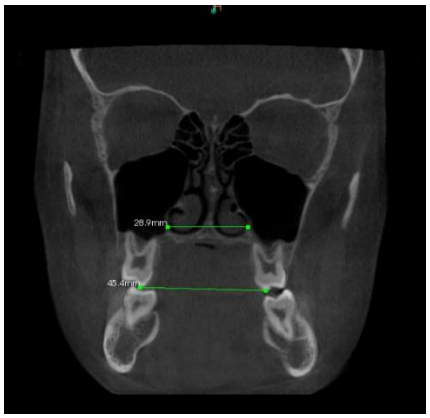

Figure 2: Intermolar Width

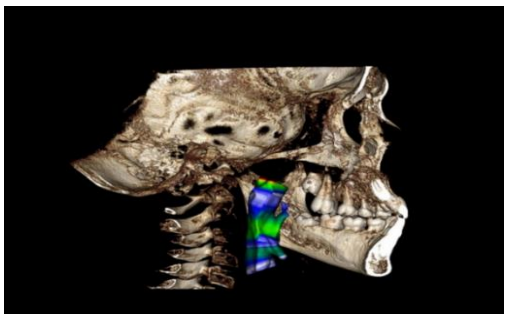

Figure 3

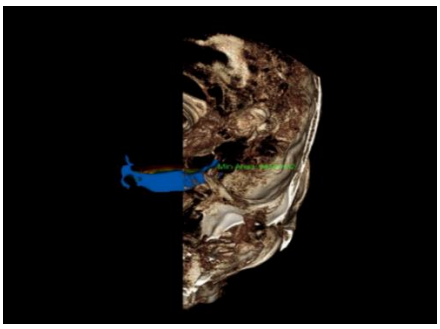

Figure 4

Figure 3: Volumetric Measurement of Nasopharynx and Oropharynx (Lateral View). Figure 4: Volumetric Changes in Nasopharynx and Oropharynx (Coronal View)

The mesiodistal width between the Mesio-palatal cusp of the first molar on both sides of the maxillary arch was measured before and after the expansion. At the same level, the mesiodistal width of the base of the nasal cavity was also measured (Figure 6).

Articular angle, gonial angle and saddle angle were measured. We had also evaluated the change in the position of the mandible before and after the treatment. [Figure 7 (a, b, c)].

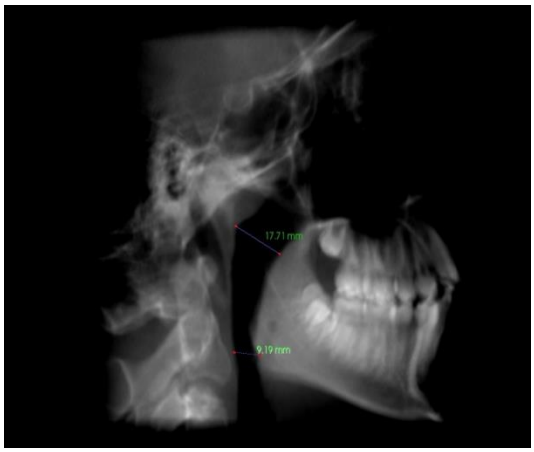

Figure 5

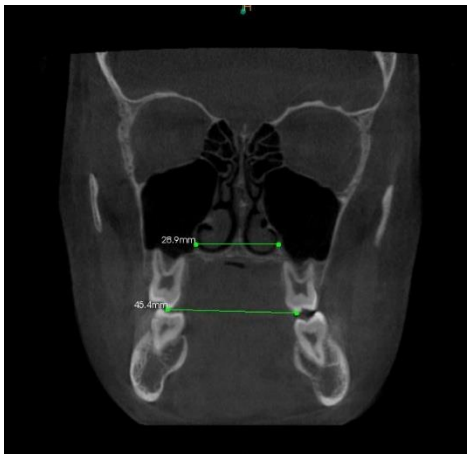

Figure 6

Figure 5: Mcnamara Analysis (Upper and Lower Pharynx). FIGURE 6: Nasal Cavity Width

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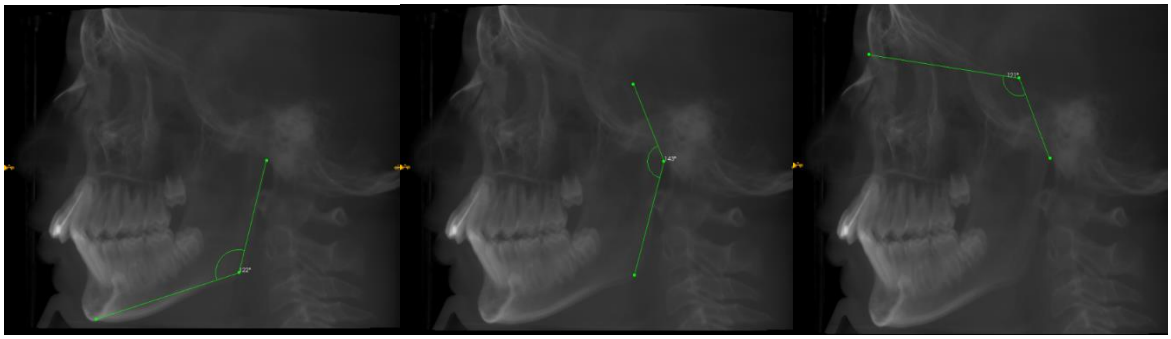

Figure 7a **Figure 7b** **Figure 7c**

Figure 7a: GONIAL ANGLE (Ar-Go-Me). Figure 7b: ARTICULAR ANGLE(S-Ar-Go). Figure 7c: SADDLE ANGLE (N-S-Ar)

3. Results:

The volumetric change in the nasopharynx and oropharynx was determined by paired t-test, Intermolar Width changes, Nasal Width changes and Pharyngeal width changes (McNamara) before and after rapid maxillary expansion.

Pearson's correlation test was carried out to determine the correlation between the volumetric changes in the nasopharynx & the oropharynx, the intermolar width and nasal width.

Results of paired t-test showed a high statistically significant mean difference before and after the expansion of the maxilla. Volume of the nasopharynx has increased with a mean of -3.0200±1.46; p-value =0.001. (TABLE I). The volume of the oropharynx has increased with a mean of -7.7600±5.082; p-value =0.001(TABLE I). Increase in the nasal width with mean of -2.0800±0.71642; p-value =0.001 (TABLE II). Increase in the intermolar width mean of -4.86000±1.694; p-value = 0.001 (TABLE II). McNamara analysis done for upper and lower pharyngeal airways with mean = -1.80100±0.713 p-value = 0.001, mean = -2.37000±0.857 p-value =0.001 for upper and lower pharyngeal airway respectively (TABLE III). The saddle angle (N-S-Ar) shows a statistically significant reduction with the mean= 3.1000±2.22 p-value=0.001. The pre-treatment mean was 119.7±5.08 and the post-treatment mean is 116.60±4.08 which suggests that there is an anterior shift of the Ar point and thus the forward shift of the mandible. (TABLE IV). However, the Articular angle (S-Ar-Go) shows a significant increase (p=0.001) in the mean value statistically, with a mean difference of 3.500±2.60. (TABLE IV). The Gonial angle (Ar-Go-Me) as a result of compensation is found to decrease with a statistically significant decrease of mean difference=2.40±1.3 p= 0.001 (TABLE IV). Statistical significant change was noted in volume of the oropharynx and nasopharynx and the change in the nasal cavity width with the change in the intermolar distance. P-value = 0.002 for the volumetric change of pharyngeal airway (TABLE V) and P-value = 0.003 for intermolar width and nasal cavity. (TABLE VI)

Table I: Paired t-test for oropharynx and nasopharynx

Parameters	Mean difference	Std. deviation	Std. error	95%confidence interval of the difference		T value	Df	p value
				Lower	Upper			
Nasopharynx	-3.02000	1.46381	0.32732	-3.70508	-2.33492	-9.227	19	0.001
Oropharynx	-7.76000	5.08293	1.13658	-10.13889	-538111	-6.828	19	0.001

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Table II: Paired t test for inter molar width and nasal width

Parameters	Mean difference	Std. deviation	Std. error	95%confidence interval of the difference		T value	Df	p value
				Lower	Upper			
Inter molar width	-7.76000	5.08293	1.13658	-10.13889	-5.38111	-6.828	19	0.001
Nasal width	-2.08000	0.71642	0.16020	-2.41530	-1.74470	-12.984	19	0.001

Table III: Paired t test for McNamara analysis done for upper and Lower pharyngeal airway

Parameters	Mean difference	Std. deviation	Std. error	95%confidence interval of the difference		T value	Df	p value
				Lower	Upper			
Upper airway	-1.80100	0.71304	0.15944	-2.13471	-1.46729	-11.296	19	0.001
Lower airway	-2.37000	0.85723	0.19168	-2.77120	-1.96880	-12.364	19	0.001

TABLE IV: Paired t test for saddle angle, articular angle, gonial angle

Parameters	Mean difference	Std. deviation	Std. error	95%confidence interval of the difference		T value	Df	p value
				Lower	Upper			
Saddle angle	3.1000	2.22190	0.4968	2.06012	4.13988	6.240	19	0.001
Articular angle	-3.5000	2.64575	0.59161	-4.73825	-2.26175	-5.916	19	0.001
Gonial angle	2.4000	1.39170	0.3119	1.74866	3.05134	7.712	19	0.001

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Table V: Volumetric correlation between oropharynx and nasopharynx

Parameters	Mean	Std. deviation	N	Pearson's corerleation value
Nasopharynx	3.1600	1.27089	20	0.002
Oropharynx	5.9300	1.43860	20	0.002

Table VI: Correlation of linear measurements of nasal width and intermolar width

Parameters	Mean	Std. deviation	N	Pearson's correlation value
Nasal width	2.0800	0.71642	20	0.003
Inter molar width	4.4200	0.98173	20	0.003

4. Discussion

The maxilla is the most adaptable entity in the transverse dimension. The narrow maxilla was first diagnosed by Hippocrates a thousand years ago. E.H. Angle stated that rapid maxillary expansion is said to be one of the most important treatment modalities for the constricted maxilla [3] ·In the early 1900 maxillary expansion was very popular in the field of Rhinology. G.V.I Brown a rhinologist noted that nasal permeability increased with the opening of maxillary sutures.

Widening of arches, removal of unnecessoary force from developing dentition, and up-righting of the teeth can be achieved with the help of passive expansion with vestibular shields. Due to the constricted and high palate, the nasal airway resistance increases.[4] Nasal airway obstruction leads to difficulty in breathing, so the patient develops a habit of mouth breathing or faces difficulty in breathing while sleeping also known as obstructive sleep apnoea.[5] Orthopedic expansion is used to decrease the resistance of airway by using lateral force against the posterior maxillary dentition through separation of midpalatal sutute. With the help of orothopedic expansion area of the nasal fossa can be increased too. Banded appliance is very comfortable to the patients and it can reduce the number of appointments.It also help in restriction of of the buccal tipping of molars and prevents extrusion of maxillary molars. This will prevent more backward tipping of the mandible. So the bonded appliance was preferred over the banded appliance in this study.[6]

The maxilla after expansion goes downwards and forward in fan shape pattern which also leads to the opening of the articular angle.[3] According to Sarver and Johnson, it was stated that bonded appliance is preferred for class II patients as the posterior aspect of the maxilla moves superiorly and does not allow the maxilla to shift anteriorly which is supposed to be taken care of in class II patients. It is also helpful for cases, especially where posterior expansion is needed.[7,8] Wertz (1968) claimed that the suture opens wider anteriorly.

A highly significant change was found in the nasal cavity width dimensions after expansion. According to Edna Namiko et al, increase in the nasal width is as a result of expansion of the mid- palatal sutute due to enlargement of the nasal cavity.[9]Jing jing Zeng et al also stated in their study that there is a direct relation of change in the nasal width, as the mid palatal suture opens up in a fan shape, more anteriorly and less posteriorly, which is directly in correlation with the nasal floor.[10,11] Riberio et al stated that the maximum effect was seen in nasal cavity in lower third region. The above study also states that there is a direct correlation between the intermolar width change and the change in the nasal cavity width. The widening of choancae was

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quantified by increased inter-hamular width which suggested an increase in the area of the nasopharynx. This increase in the width of the nasal cavity is more in the inferior region & decreases towards the superior aspect. A similar incline is found in the antero-posterior direction with the greatest amount of expansion in the anterior region. As stated earlier the palate also acts as a nasal floor, so any change in the palate will be directly correlated to the change in the nasal floor. The intermolar width specifies the amount of expansion that has taken place.

If anatomy is considered the pharyngeal airway especially the upper pharynx i.e. the nasopharynx is directly correlated to the of the nasal and the oral cavity 9posterior endings). According to Timms, during expansion, the maxilla moves downward and laterally. Which increases the overall area of the nasopharynx which also increases the volume. Juam Palmo et al stated that a two-fold increase in nasopharyngeal volume is found in the patients subjected to rapid palatal expansion. This also reduces the airway resistance which in turn improves the patient's lifestyle.[12,13]Andrew woo et al found that there was a forward displacement of the maxilla due to rapid palatal expansion assisted by surgery. Davis et al stated that with mid-palatal suture opening there are also changes in the posterior part of the maxilla which also affects the pharyngeal airway.[9,14] The present study also shows a highly statistical and clinical significance of the volumetric increase in the nasopharynx after rapid expansion. Okan Ackman also found in a study stating that the nasopharyngeal volume increased in cases where there was a posterior rotation of the mandible. This supports the above study.

The oropharyngeal airway also showed a significant change in post-expansion. Annelise Ribeiro et al stated in their study that change in the volume of the oropharynx due to rapid palatal expansion was significant. The change can be related to the tongue position and head posture. In the present study, all the CBCTs were recorded in the natural head position in proper posterior occlusion avoiding any rotation of the mandible.[15] As the palate expands the tongue position also changes. Tomonori Iwasaki et al stated in their study that rapid maxillary expansion changed the posture of the tongue along with relieving airway obstruction.[16] Ozbek et al reported less respiratory problems and high tongue positions in children with narrow maxilla. This result indicates that the tongue posture changes when intermolar width is expanded.[17] The rapid maxillary expansion changes the tongue position which in turn changes the area of the lower pharynx. This is one of the reasons for the increase in the oropharyngeal volume and the lower pharynx linear measurement. According to Filho et al due to movements maxilla and rotation of mandible a change in the nasopharyngeal and oropharyngeal area was found.[18] Though the movement of the mandible may lead to a negative effect, but according to Baccetti as the posterior constriction opens up due to expansion in the transverse direction, it may also lead to positive anteroposterior positioning of the mandible and the mandible does get carry forward in its normal position. Carolina Bartieri et al performed a study showing rapid palatal expansion effect on the mandible. It stated that the mandible does shift downwards, which leads to a vertical increase in the area of the oropharynx.[19] In follow-up period of three months, it stated the forward shifting in mandible leading to the increase in the area of the oropharynx in the anteroposterior direction. This leads to an increase in volume. According to S. Arvind et al, one of the effects of expansion on the mandible is that it could lead to simultaneous expansion of the mandibular arch as much as 4mm in the canine region and 6mm in the molar region.[20] Forward positioning of the mandible in retention period occurs due to widening of maxilla to over-expanded position was noted by James McNamara et al.[21] The mandible shifted in the anterior direction by rapid maxillary expansion which was confirmed by the wit's appraisal. In the present study, the forward positioning of the mandible was confirmed by reduce in the saddle angle and the gonial angle. In the previous study, the forward shifting of the mandible has resulted in correction of the class II molar relation and increased overjet.

In the present study the saddle, articular and gonial angles were also measured for determining any change in the position of the mandible. The saddle angle had reduced as the Ar point (articulate) had shifted forward. As mentioned earlier after expansion the mandible gets free space for gliding forwardly, which was previously blocked due to the constricted maxilla. The Articular angle had increased as a result of backward rotation and the

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Gonial angle had reduced, justifying the compensatory rotation of the mandible at the gonion. The forward positioning of the Ar point suggests the forward positioning of the mandible, which increases the area of the oropharynx. Iwasaki et al stated in their study that rapid palatal expansion had a direct relation with the increase in the oropharyngeal volume. Carolina Barrater stated in the study that the rapid maxillary expansion allowed the mandible to shift forward.

A highly significant correlation was found in the changes in the volume of the nasopharynx and oropharynx. Due to anatomic interrelation of the nasal cavity, maxilla, oral cavity, nasopharynx and oropharynx with each other, any change or increase in the nasopharynx will be reflected in its lower half, the oropharynx.

5. Conclusion:

- Statistically significant difference was observed in the volume of the oropharynx and nasopharynx, intermolar width and nasal cavity was found as a result of RME.
- Reduction in the Saddle angle, change in the articular angle (increase) and compensatory reduction in the Gonial angle suggests forward positioning and counter-clockwise rotation of mandible.

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