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CLINICAL AND 3-DIMENSIONAL RADIOGRAPHIC ASSESSMENT OF NASAL AIRWAY VOLUME IN ADULT ORTHODONTIC PATIENTS FOLLOWING MINI-SCREW ASSISTED RAPID MAXILLARY EXPANSION: A PROSPECTIVE CLINICAL STUDY

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ABSTRACT

Objectives: mini-screw assisted rapid maxillary expansion (MARME) can be clinically acceptable and stable treatment modality for maxillary constriction in adults. **Subjects and methods:** The current study was conducted on 12 orthodontic patients. The mini-screw assisted rapid maxillary expansion appliance consists of two molar bands attached to maxillary first molars and 4 micro-implants to be bi-cortically inserted. Expansion protocol: Initial expansion rate: 2 turns/day. Expansion rate after opening of the diastema: 1 turn/day. CBCT was performed after 3 months after expansion. Data from the CBCT were reconstructed to produce slices for preoperative and postoperative evaluation, Direct assessment of airway dimensions through nasal endoscopy for assessment of nasal airway flow and CBCT of nasal airway dimensions (T0 for preoperative dimension, T1 for dimension at 3 months of expansion and T2 for dimension at 6 months of expansion). **Results:** In the present study, there was a statistically significant increase in nasal volume, pharyngeal volume, and total volume after T1 and T2. There was a statistically significant increase in nasal volume, pharyngeal volume, and total volume at T1 – T2 and T0 – T2. By Nasal endoscopy there was a statistically significant improvement in nasal volume after 3 and 6 months of Expansion. **Conclusion:** After nonsurgical maxillary expansion in young adults, the nasal and pharyngeal volume and mean total volume significantly increased at T1 – T2 and T0 – T2. These results suggest that mini screw assisted rapid maxillary expansion can be a helpful modality to improve breathing in young adults with maxillary constriction.

KEYWORDS: Rapid maxillary expansion, CBCT, Nasal airway volume, Endoscopy.

INTRODUCTION

Transverse maxillary deficit affects 8% to 23% of teenage patients and fewer than 10% of adults, according to research. Unilateral or bilateral cross-bite is the most frequent symptom of transverse maxillary insufficiency [(1)].

Correction of this issue has been linked to beneficial therapeutic benefits on hearing, swallowing, and nasal breathing. Various appliances and treatment regimens can be used to address maxillary transverse deficit, which generally involve maxillary expansion and separation of the mid-palatal

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suture. Rapid Palatal Expansion (RPE), Slow Orthodontic Expansion (SOE), Micro-implant Assisted Rapid Palatal Expansion (MARPE), and Surgically Assisted Rapid Palatal Expansion (SARPPE) are all examples of this (SARPE). All the methods have the same goal of addressing skeletal discord, but they have distinct adverse effects [(2)].

Rapid maxillary expansion (RME) is an orthodontic treatment option for transverse discrepancy correction. It's often utilized to widen the maxillary arch's transverse breadth, correct posterior crossbites, minimize dental crowding, and generate wider grins [(3)].

The most common therapy for individuals with transverse maxillary deficit is surgically aided RPE. Surgically aided RPE, on the other hand, is a more intrusive procedure that can result in lateral rotation of the two maxillary portions with little horizontal translation. Furthermore, surgically aided RPE may be harmful to the periodontium and has been proven to cause a significant amount of bone loss [(4)].

The use of micro screws and an RME device to expand the maxilla was claimed to be successful. According to a recent study, MARME (mini-screw assisted rapid maxillary expansion) can be a clinically acceptable and stable therapeutic option for individuals with maxillary constriction [(5-6)].

Patients with maxillary constriction tend to have narrow airways compared with normal individuals. In earlier research, it was discovered that maxillary expansion by traditional RME helped children with obstructive sleep apnea improve their airway capacity [(7)].

A recent study was conducted to assess the changes in the nasal airway after MARPE in adults. The results demonstrated that the volume and the cross-sectional area of the nasal cavity increased after MARPE and were maintained one year after expansion. Therefore, MARPE may be helpful in expanding the nasal airway [(8)].

The difference between treatment effects of conventional RPE and MARPE is inquired by many orthodontists. In the past, most of the studies focused on conventional RPE, such as Hass expanders and Hyrax expanders [(19)]. Few studies have been done on MARPE treatment so, the difference in the effects between MARPE and conventional RPE on the nasal cavity volume is not fully understood yet because of the lack of the studies and many different designs of MARPE or different expansion protocol were used [(9)].

Despite the fact that maxillary expansion has a direct effect on the nasal cavity, there is a dearth of three-dimensional (3D) study, and most studies have focused on the pharyngeal airway due to technological challenges in collecting nasal cavity measurements [(10)]. Because it is difficult to assess volumetric dimensions and changes in various cross-sectional regions based on lateral or postero-anterior (PA) cephalograms, the complex structure of the nasal cavity is better seen on three-dimensional (3D) pictures than on two-dimensional (2D) images. Cone beam computed tomography (CBCT) provides multiplanar images with low dose of radiation and high spatial resolution [(11)]. Thus, this study was conducted to investigate the changes in the airway dimensions clinically and by using CBCT after MARME in adult orthodontic patients.

SUBJECTS AND METHODS

Study design:

Prospective clinical study

Study setting and population:

The current study was conducted on 12 orthodontic patients (Power test calculation according to a previous study [(2)]) collected from the outpatient clinic at Orthodontic Department, Faculty of Dental Medicine, Boys, Al-Azhar University, Cairo, Egypt.

Inclusion criteria:

The patients were included in this study if they have: An age ranges from 18 to 30 years, Transverse maxillary deficiency based on the transverse analysis of Andrew's elements [12], No cranio-facial syndromes, Treatment strategies employ using MSE as a part of the treatment plan, Good oral and general health, No previous orthodontic treatment and No airway problems (obstructive sleep apnea, asthma, chronic rhino sinusitis and nasopharyngeal stenosis).

Exclusion criteria:

The patients were excluded from this study if they have: Mental problems, Systemic diseases or taking medications that could interfere with orthodontic treatment, Lack of cooperation, Previous adeno-tonsillectomy, Previous orthognathic surgery, Presence of pathology detectable along the upper airway (nasal polyposis), Movement artifact, Incomplete imaging of required structures or swallowing during scan.

Discontinuation criteria:

1. Repeated missing appointments.
2. Uncooperative patients.
3. Repeated broken appliances.
4. Unwillingness to maintain a good level of oral hygiene throughout the study period.

Ethical considerations: The research protocol was approved by the ethical committee, Faculty of Dental Medicine, Al-Azhar University under ethical code (93/105). The objectives of the study will be discussed with the patients and/or guardians, and informed consent form and a copy of the instructions for the orthodontic patients will be signed before orthodontic treatment.

Observation:

The following were performed before (T0) after 3 months (T1) and after 6 months (T2) of expansions:

A- Standardized orthodontic study models.

B- Standardized extra-oral and intra-oral photography. Figures (1)

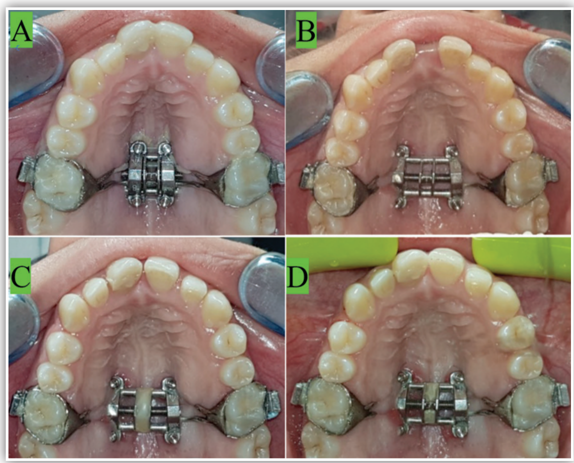

FIG (1) Intraoral photography of MARPE before expansion (A), during expansion (B), after three months of expansion (C) and after six months of expansion (D).

Direct assessment of airway dimensions through:

A- Nasal endoscopy for assessment of nasal airway flow. Figure (2)

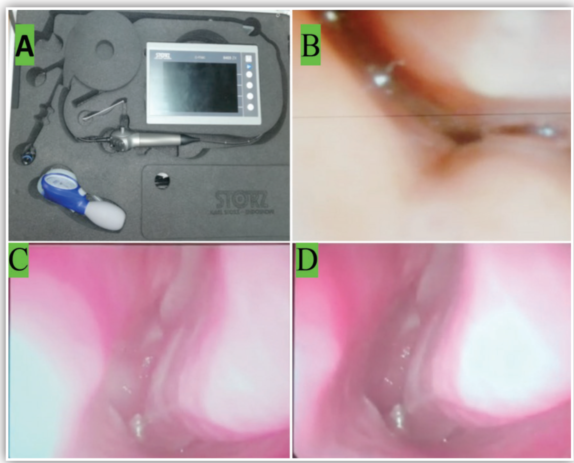

FIG (1) Nasal endoscope (A), Nasal obstruction affecting airway (B), Nasal endoscopy after three months (C) and Nasal endoscopy after 6 months (D)

B- CBCT (iCAT Next Genration scanner, Kavo, Germany) of nasal airway dimensions. Mimics software (Materialise, Belgium) was utilized for volumetric measurement. Figure (3)

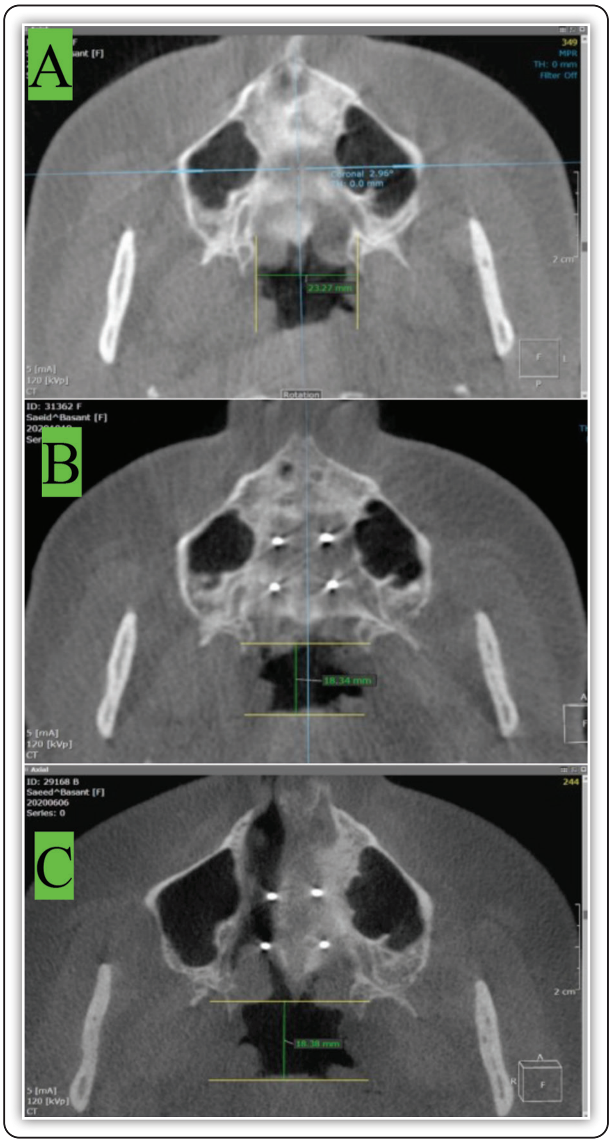

FIG (3) CBCT (A) Preoperative, (B) after three months and (C) after six months

Intervention:

1. The MSE appliance consists of two molar bands attached to maxillary first molars and 4 micro-implants inserted bi-cortically into the palate.

2. Expansion protocol: Initial expansion rate: 2 turns/day. Expansion rate after opening of the diastema: 1 turn/day [13].

3. CBCT will be performed after 3 months after expansion.

4. Data from the CBCT will be reconstructed to produce slices for preoperative and postoperative evaluation.

5. Observation through nasal endoscopy for assessment of nasal airway flow.

6. Data from CBCT will be used to assess the changes in the nasal airway:

   - Nasal cavity volume: the nasal cavity is defined as the region bound superiorly by the Frankfort Horizontal plane, anteriorly by the Anterior Nasal Spine -perp. Plane (Perpendicular to the Frankfort Horizontal plane and passing through Anterior Nasal Spine), laterally by the orifice of the maxillary sinus, and posteriorly by the choanae plane (The plane along the choanae) [14].

   - Nasopharynx volume: the nasopharynx is bound superiorly by the choanae plane and inferiorly by the C3 plane, the plane tangent to the most inferior and anterior point on the body third cervical vertebra and Parallel to the FH plane and passing through C3 [15].

7. Neither brackets, nor wires will be used till the end of the expansion process.

Statistical analysis of the data: The IBM SPSS software program version 20.0 was used to examine the data that was input into the computer. (IBM Corporation, Armonk, NY). The Kolmogorov-Smirnov test was performed to ensure that the distribution was normal. Range (minimum and maximum), mean, standard deviation, and median were used to characterize quantitative data. The significance of the acquired results was assessed at a 5% level.

RESULTS

Mean change in nasal volume at T0 – T1 was 2.53±1.53, at T1 – T2 was 0.28±1.10 and at T0 – T2 was 2.81 ± 1.66. there was a statistically significant increase in nasal volume (CC) ($<0.001^{*}$) at T1 – T2 and T0 – T2. Mean change in pharyngeal volume at T0 – T1 was 1.74 ± 1.41, at T1 – T2 was 0.34 ± 0.49and at T0 – T2 was 2.08 ± 1.73. there was a statistically significant increase in pharyngeal volume (<0.014*) at T1 – T2 and T0 – T2. Mean change in total volume at T0 – T1 was 4.28 ± 1.45, at T1 – T2 was 00.62 ± 1.13 and at T0 – T2 was 4.89 ± 1.76. there was a statistically significant increase in total volume (<0.014*) at T1 – T2 and T0 – T2. Mean change in MD linear at T0 – T1 was 2.79 ± 2.99, at T1 – T2 was 0.86 ± 0.82 and at T0 – T2 was 3.64 ± 3.62. there was a statistically significant increase in MD linear (<0.014*) at T1 – T2 and T0 – T2. Mean change in AP linear at T0 – T1 was 2.08 ± 1.37, at T1 – T2 was 0.37 ± 0.37 and at T0 – T2 was 2.44 ± 1.22. there was a statistically significant increase in AP linear (<0.014*) at T1 – T2 and T0 – T2, Table (1).

Regarding Expansion by nasal endoscopy, there was a statistically significant improvement in nasal volume after 3 and 6 months of Expansion (p=0.001*), Table (2).

TABLE (1) Comparison between the different time periods in each group.

	Change in nasal volume (CC)			p
	T0 – T1	**T1 – T2**	**T0 – T2**	
Change in Nasal volume (CC)	2.53 ± 1.53	0.28 ± 1.10	2.81 ± 1.66	0.001*
p_0		0.025*	0.239	
Change in Pharyngeal volume	1.74 ± 1.41	0.34 ± 0.49	2.08 ± 1.73	0.014*
p_0		0.157	0.157	
Change in Total volume (CC)	4.28 ± 1.45	0.62 ± 1.13	4.89 ± 1.76	0.001*
p_0		0.045*	0.099	
Change in MD Linear (mm)	2.79 ± 2.99	0.86 ± 0.82	3.64 ± 3.62	0.001*
p_0		0.045*	0.099	
Change in AP Linear (mm)	2.08 ± 1.37	0.37 ± 0.37	2.44 ± 1.22	0.002*
p_0		0.126	0.059	

p: p value for comparing between the studied periods

p_0: p value for comparing between **T0 – T1** *and each other period*

**: Statistically significant at p ≤ 0.05*

TABLE (2): Comparison between the different time periods according to expansion by nasal endoscopy.

	Expansion			p value
	Preoperative	**3 months**	**6 months**	
Expansion				
No improvement	8 (88.9%)	0 (0.0%)	1 (11.1%)	
Mild to moderate improvement	1 (11.1%)	7 (77.8%)	4 (44.4%)	0.001*
Moderate to high improvement	0 (0.0%)	2 (22.2%)	4 (44.4%)	
p_0		0.003*	0.002*	

p value for comparing between preoperative and each other period

**: Statistically significant at p ≤ 0.05*

DISCUSSION

Transverse maxillary deficiency has been reported to affect 8% to 23% of adolescent patients and less than 10% of adults. The most common finding in transverse maxillary deficiency is unilateral or bilateral cross-bite [16-19]. Correction of this issue has been linked to beneficial therapeutic benefits on hearing, swallowing, and nasal breathing. Various appliances and treatment regimens can be used to address maxillary transverse deficit, which generally involve maxillary expansion and separation of the mid-palatal suture. This includes Rapid Palatal Expansion (RPE), Slow Orthodontic Expansion (SOE), Micro-implant Assisted Rapid Palatal Expansion (MARPE), and Surgically Assisted Rapid Palatal Expansion (SARPE). All techniques, share the same objective to address the skeletal disharmony with different side effects [20-21].

Rapid maxillary expansion (RME) is an orthodontic treatment modality for correcting transverse discrepancy. It has been commonly used to increase the transverse width of the maxillary arch, to correct posterior crossbites, to reduce dental crowding, and to create broader smiles [22,23]. Successful expansion of the maxilla using mini screws combined with an RME device was reported. According to a recent study mini screw assisted rapid maxillary expansion (MARME) can be a clinically acceptable and stable treatment modality for maxillary constriction in adults [24,25]. Melsen's histology investigations have led to a consensus that the use of traditional RPE should be restricted to patients under the age of 15 [26,27]. Although effective palatal expansion has been recorded in young people above the age of 15 with traditional RPE, most physicians feel that MARPE has enhanced the rate of success in young adults in separating the midpalatal suture. It is evident from the published research reports that MARPE had approximately 84% to 87% success rate [28-30]. the present study was to evaluate the clinical and 3-dimensional radiographic assessment of nasal airway volume in adult orthodontic patients following mini-screw assisted rapid maxillary expansion: a prospective clinical study.

In the present study, mean nasal volume at T0 was 20.81 ± 3.23, at T1 was 23.34 ± 2.97 and at T2 was23.62 ± 2.85. There was a statistically significant increase in nasal volume (CC) (<0.001*) after T1 and T2. Mean change in nasal volume at T0 – T1 was 2.53 ± 1.53, at T1 – T2 was 0.28 ± 1.10 and at T0 – T2 was 2.81 ± 1.66. there was a statistically significant increase in nasal volume (CC) (<0.001*) at T1 – T2 and T0 – T2. Mean pharyngeal volume at T0 was 38.62 ± 7.06, at T1 was 40.36 ± 7.13 and at T2 was 40.70 ± 7.10. there was a statistically significant increase in pharyngeal volume (<0.006*) after T1 and T2. Mean change in pharyngeal volume at T0 – T1 was 1.74 ± 1.41, at T1 – T2 was 0.34 ± 0.49and at T0 – T2 was 2.08 ± 1.73. There was a statistically significant increase in pharyngeal volume (<0.014*) at T1 – T2 and T0 – T2. Mean total volume at T0 was 59.43 ± 7.43, at T1 was 63.71 ± 7.39 and at T2 was 64.32 ± 6.53. There was a statistically significant increase in total volume (<0.006*) after T1 and T2. Mean change in total volume at T0 – T1 was 4.28 ± 1.45, at T1 – T2 was 00.62 ± 1.13 and at T0 – T2 was 4.89 ± 1.76. There was a statistically significant increase in total volume (<0.014*) at T1 – T2 and T0 – T2.

In the present study, the volume of the nasal cavity and nasopharynx increased after mini screw assisted rapid maxillary expansion and was maintained during the retention period. Mini screw assisted rapid maxillary expansion has been proven effective for skeletal and dental expansion in young adults, and the skeletal changes were maintained even after removal of the appliance[31-33]. Nonsurgical maxillary expansion was shown to enhance the volume and cross-sectional area of the nasal airway in young adults in the current investigation. The nasal cavity's volume and area grew the most.

Kim et al. studied the effects of nonsurgical minis crew-assisted rapid maxillary expansion (MARME) on nasal airway capacity and cross-sectional area in young individuals. At T1 and T2, the nasal cavity volume grew considerably, but the nasopharynx volume only increased at T2. At T1 and T2, the front and middle cross-sectional areas rose considerably, but the posterior cross-sectional area remained unchanged throughout the observation period. They discovered that one year after MARME, the volume and cross-sectional area of the nasal cavity increased and stayed constant. As a result, MARME may help to expand the nasal airway. The extra growth during the retention phase appears to be the consequence of adaptation of the nasal cavity's lateral walls, which were shifted shortly after expansion. It should be observed that the nasal cavity had a larger increase in volume than the nasopharynx. This is most likely because the appliance's position, which was below the nasal cavity, would have had a direct impact on alterations in the nasal cavity [34]. The effects on the airway in patients undergoing mini-screw-assisted fast palatal expansion were studied by Mehta et al [35] (MARPE). In comparison to the control group, MARPE generated a statistically significant increase in the airway after expansion. With MARPE, total airway volume, total airway area, and minimum cross-sectional area increased significantly soon after expansion. However, MARPE resulted in a large long-term rise in nasopharyngeal volume. Nasal endoscopy was performed postoperatively to evaluate the effect of surgically assisted rapid maxillary expansion on the nasal airways after 3 and 6 months of Expansion. There was a statistically significant improvement in nasal volume after 3 and 6 months of Expansion. These results agree with the data reported by other investigators [36–40]. Because RME corrected posterior crossbite and also the lateral growth of the nasomaxillary complex, we observed that after 6 months.

CONCLUSION

In conclusion, after nonsurgical maxillary expansion in young adults, the nasal and pharyngeal volume and mean total volume significantly increased at T1 – T2 and T0 – T2. These results suggest that mini screw assisted rapid maxillary expansion can be a helpful modality to improve breathing in young adults with maxillary constriction. According to the results of the study, it could be stated that Nasal endoscopy has a good role in evaluation of nasal airways with rapid maxillary expansion.

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