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Evaluation of Soft Tissue and Airway Changes in Individuals Treated with Mini-Implant Assisted Rapid Palatal Expansion (MARPE)

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ABSTRACT: Introduction: Mini-implant assisted rapid palatal expansion (MARPE) is gradually becoming the treatment of choice to correct the transverse dimension, exceeding the limitations of conventional RME devices. One of the key factors for orthodontic diagnosis and treatment planning apart from a stable occlusion is a balanced and aesthetic facial profile that is influenced by maxillary expansion. Similarly, it also affects the anatomy and physiology of the nasal cavity since nasal airflow is a continuous stimulus for lowering of the palate and for lateral maxillary growth. Hence, there is a need to conduct further research on the effects of MARPE on the facial soft tissues as well as the airway, enabling the orthodontist to reach a more accurate diagnosis as well as aid in the treatment planning process.

Aims and Objectives: This retrospective three-dimensional study was planned and designed with the objective of measuring facial soft tissue and airway changes in individuals treated with mini-implant assisted rapid palatal expansion (MARPE) using CBCT.

Materials and Methods: This study was carried out on CBCT records of 10 patients in the age group of 18–30 years. These records were then imported into Romexis software and calibrated. The facial soft tissue and airway parameters were measured for each individual at selected landmarks and compared before and after expansion.

Result: Statistically significant differences in the soft tissue parameters were observed, which included an increased H-angle, increased soft tissue subnasal to H-line and a decreased soft palate surface area after MARPE.

KEY WORDS: MARPE, CBCT, soft tissue, airway

I. INTRODUCTION

Lee et al.[1] in 2010 made miniscrew assisted rapid palatal expansion (MARPE) appliances available for the treatment of palatal constriction in patients whose midpalatal suture is fused. These help to concentrate expansion forces to the palatal suture with the help of implant-based anchorage. It has been demonstrated that the appliance gets anchorage from the palate, and hence is capable of providing more skeletal than dentoalveolar expansion. Moreover, because of its absolute anchorage, it proves to be a superior alterative to the traditional rapid maxillary expansion methods. Maximization of the skeletal expansion through skeletal anchorage enhancement is done by recruiting both palatal and nasal cortices. At the same time, a support wire connecting the expander to the 1st molars enhances the stability. This is a recent concept and such expanders are referred to as maxillary skeletal expanders (MSE).[2] The effect of the MSE on the soft tissues remains a question asked by both patients and clinicians.

Recent studies have attempted to analyze and quantify the soft tissue facial changes induced by MSE and shown statistically significant changes localized to the circummaxillary region (paranasal, lips, and cheeks) following expansion. Furthermore, these changes seem to be stable even after a retention period of one year.[3,4] In addition, a survey of the literature reveals that MARPE can significantly decrease resistance in the upper airway thereby improving respiratory airflow and ventilation. However, there is limited evidence to suggest a direct influence of this treatment modality on the airway and further research is required.

With advances in three-dimensional (3D) imaging systems, like cone–beam computed tomography (CBCT), and its widespread use in orthodontics, there are greater opportunities for studying the effects of orthodontic treatment on the soft tissues as well as the airway.[4] Moreover, progress in software development now allows for better manipulation and viewing of the CBCT images, which permits the collection of information such as volumetric measurements and morphological evaluation with significant reliability and precision. Therefore, the objective of this study is to highlight the potential use of MARPE in the evaluation of the soft tissue profile and airway changes of individuals using CBCT.

II. METHODOLOGY

This retrospective study included 10 treated cases of mini-implant assisted rapid palatal expansion. These subjects were treated with MARPE for the correction of palatal arch constriction at the Department of Orthodontics and Dentofacial Orthopedics. The study was not funded by NIH. Digital CBCT records were taken pre- (T0) and post-expansion (T1).

A. Sample Size Derivation

To calculate the sample size, the technique estimation of paired *t*-test is used:

$$n = \frac{\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right)^2}{\Delta^2} + \frac{\left(Z_{1-\frac{\alpha}{2}}\right)^2}{2}$$

where,

$$\alpha = \text{level of significance (5\%)}$$

$$1\text{-}\beta = \text{power of the test (80\%)}$$

$$\Delta = \text{effective size (1)}$$

$$\Rightarrow n = \frac{(1.96 + 0.84)^2}{(1)^2} + \frac{(1.96)^2}{2}$$

$$\Rightarrow n = 10.$$

The inclusion criteria were individuals 18–30 years of age treated with MARPE whose pre- and post-CBCT records can be retrieved from the archives of the Department of Orthodontics.

The exclusion criteria included treated cases of MARPE with incomplete pre- and-post CBCT records; individuals who have undergone orthognathic surgery; individuals with developmental deformities, syndromes, and craniofacial anomalies; and individuals with history of previous orthodontic treatment.

The soft tissue and airway parameters were measured for each CBCT record using planmeca Romexis 4.6.2.R software. Both a lateral view and a postero-anterior view perpendicular to the midsagittal plane was reconstructed, and the relevant landmarks were identified in these images. The airway and soft tissue changes following expansion were measured using the parameters in Fig. 1.

B. Airway Measurements

The first step was to define and select an area containing the entire airway on an axial view. All axial views were checked to ensure that the airway was included in the selected area.

Subsequently, the upper and lower borders in the airway volume area of interest were determined, and the specific borders of the segmented airway were defined manually by tracing the soft tissue–air interface at each 1-mm axial slice with the segmentation tool.

Upper border: A horizontal line passing through the anterior and posterior nasal spine (ANS-PNS) extending backwards to the posterior pharyngeal wall. Lower border: A horizontal line parallel to the upper border passing through the superior point of

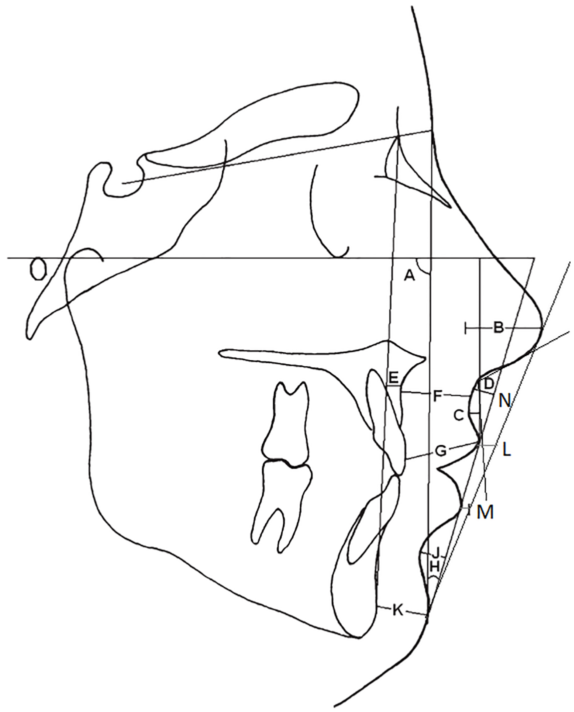

FIG. 1: Soft tissue parameters assessed pre- and post-MARPE. (A) Soft-tissue facial angle: the downward and inner angle formed at a point where the Sella-Nasion line crosses the soft tissue, and a line combining the suprapogonion with the Frankfort horizontal plane. (B) Nasal tip prominence: the dimension between the tip of the nose and a perpendicular line drawn to the Frankfort horizontal plane from the vermillion. (C) Upper lip sulcus depth: the measurement between the upper lip sulcus and a perpendicular line drawn from the vermillion to the Frankfort horizontal plane. (D) Soft tissue subnasal to H-line: measurement from subnasale to the H-line. (E) Skeletal profile convexity: the dimension between point A and facial line. (F) Basic upper lip thickness: the dimension measured approximately 3 mm below point A and the drape of the upper lip. (G) Upper lip thickness: the dimension between the vermillion point and the labial surface of upper incisor. (H) H-angle: the angle formed between the soft- tissue facial plane line and the H-line. (I) Lower lip to H-line: the measurement of the lower lip to the H-line. (J) Upper lip strain: the difference between the basic upper lip thickness and the upper lip thickness (G–H). (K) Soft tissue pogonion thickness: the distance between the hard and soft-tissue facial planes at the level of suprapogonion. (L) Upper lip to E-line: the measurement of the lower lip to the H-line. (M) Lower lip to E-line: the measurement of the lower lip to the H-line. (N) Nasolabial angle: the angle formed by the intersection of the upper lip anterior and columella at subnasal.

the epiglottis. Finally, the oropharyngeal airway was divided into retropalatal and retroglossal airway by creating a horizontal plane, parallel to both the upper and lower borders, passing through the inferior point of the uvula.

Once segmentation was performed, the software automatically computed the retropalatal and retroglossal airway volumes in cubic millimeters. The retropalatal and retroglossal airway lengths were measured at the midsagittal section of the airway volume by using the linear measurement tool (Fig. 2).

C. Statistical Analysis

The data collected was entered in a Microsoft Excel worksheet and analyzed using IBM SPSS version 22. Descriptive statistics of quantitative variables was documented by using mean, standard deviation, and confidence intervals. Descriptive statistics'

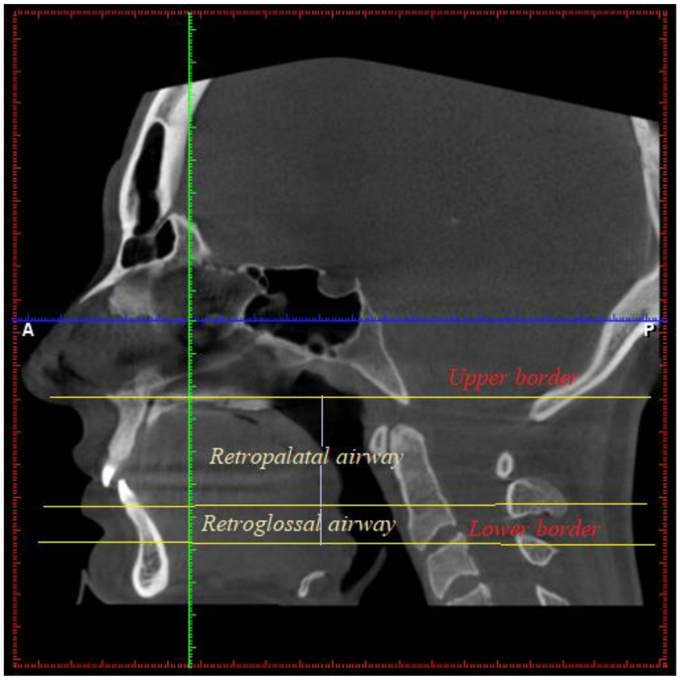

FIG. 2: Airway parameters assessed pre- and post-MARPE

categorical variables were presented using frequency/percentages. Comparison between the mean of two quantitative variables for both soft tissue and airway parameters before and after treatment with mini-implant assisted rapid palatal expansion (MARPE) was done by using paired *t*-test. *P* value < 0.05 was considered as significant.

III. RESULTS

The mean soft tissue facial angle before and after MARPE was 80.48 and 78.46, respectively. By applying paired *t*-test, the difference was found to be nonsignificant (*p* value = 0.10) (Table 1).

Comparing mean nasal tip prominence before and after MARPE was found to be nonsignificant by applying paired *t*-test (*p* value = 0.33). The mean nasal tip prominence before and after treatment was 6.53 and 5.89, respectively (Table 1).

The mean upper lip sulcus depth was found to be 4.30 pre- and 4.32 post-expansion and on applying paired *t*-test, it was found to be nonsignificant post treatment with MARPE (*p* value = 0.97) (Table 1).

The mean distance from the soft tissue subnasal to H-line before and after mini-implant assisted rapid palatal expansion was 5.60 and 6.26, respectively. By applying paired *t*-test, comparison of this distance between the two groups was found to be statistically significant (*p* value = 0.01) (Table 1).

The mean skeletal profile convexity before and after mini-implant assisted rapid palatal expansion was evaluated as 0.43 and 1.01, respectively, and after applying paired *t*-test, this change between the two groups was found to be statistically insignificant (*p* value = 0.28) (Table 1).

The mean basic upper lip thickness before and after MARPE was 15.53 and 16.48 respectively. On applying paired *t*-test, this did not change significantly after treatment (*p* value = 0.19) (Table 1).

The mean upper lip thickness before and after MARPE was 12.09 and 12.45, respectively and after applying paired *t*-test, this parameter did not change significantly after treatment (*p* value = 0.54) (Table 1).

The mean upper lip strain before and after treatment was 3.44 and 4.03, respectively. By applying paired *t*-test, this change in the upper lip strain

TABLE 1: Comparison of soft tissue parameters before and after intervention

		N	Mean	SD	Mean Difference	95% Confidence interval of the difference		t	df	*p* value
						Lower	Upper			
Soft tissue facial angle (°)	**Pre**	10	80.48	8.54	2.03	–0.50	4.55	1.82	9	0.10 (NS)
	Post	10	78.46	8.46						
Nasal tip prominence (mm)	**Pre**	10	6.53	2.31	0.64	–0.77	2.05	1.03	9	0.33 (NS)
	Post	10	5.89	3.05						
Upper lip sulcus depth (mm)	**Pre**	10	4.30	1.38	–0.02	–1.13	1.09	–0.04	9	0.97 (NS)
	Post	10	4.32	1.21						
Soft tissue subnasal to H-line (mm)	**Pre**	10	5.60	1.64	–0.66	–1.15	–0.17	–3.03	9	0.01*
	Post	10	6.26	1.68						
Skeletal profile convexity (mm)	**Pre**	10	0.43	1.86	–0.58	–1.71	0.55	–1.16	9	0.28 (NS)
	Post	10	1.01	1.66						
Basic upper lip thickness (mm)	**Pre**	10	15.53	1.66	–0.95	–2.45	0.55	–1.44	9	0.19 (NS)
	Post	10	16.48	1.03						
Upper lip thickness (mm)	**Pre**	10	12.09	1.51	-0.36	–1.64	0.92	–0.64	9	0.54 (NS)
	Post	10	12.45	1.55						
Upper lip strain (mm)	**Pre**	10	3.44	1.29	–0.59	–1.90	0.72	–1.02	9	0.33 (NS)
	Post	10	4.03	1.47						
H-angle (°)	**Pre**	10	14.85	5.72	–2.27	–3.48	–1.06	–4.25	9	0.002*
	Post	10	17.11	5.46						
Lower lip to H-line (mm)	**Pre**	10	1.52	2.82	0.37	–0.17	0.91	1.54	9	0.16 (NS)
	Post	10	1.15	2.90						
Soft tissue pogonion thickness (mm)	**Pre**	10	11.61	2.06	0.51	–0.89	1.91	0.82	9	0.43 (NS)
	Post	10	11.10	3.14						

TABLE 1: (*continued*)

		N	Mean	SD	Mean Difference	95% Confidence interval of the difference		t	df	p value
						Lower	Upper			
Upper lip to E-line (mm)	**Pre**	10	–2.57	3.15	–0.53	–1.31	0.25	–1.53	9	0.16 (NS)
	Post	10	–2.04	2.81						
Lower lip to E-line (mm)	**Pre**	10	0.00	3.47	–0.22	–0.64	0.20	–1.18	9	0.27 (NS)
	Post	10	0.22	3.70						
Nasolabial angle (°)	**Pre**	10	92.86	9.84	–1.62	–6.11	2.88	–0.81	9	0.44 (NS)
	Post	10	94.48	10.00						

Note: Paired t-test.
*$p < 0.05$ statistically significant.
$p > 0.05$ nonsignificant (NS).

between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.33) (Table 1).

The mean value of H-angle before and after mini-implant assisted rapid palatal expansion was 14.85 and 17.11, respectively. On applying paired t-test, comparison of this angle between the two groups was found to be statistically significant (p value = 0.002) (Table 1).

The mean distance from the lower lip to H-line before and after treatment was 1.52 and 1.15, respectively. By applying paired t-test, change in this distance between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.16) (Table 1).

The mean soft tissue pogonion thickness before and after treatment was 11.61 and 11.10, respectively. By applying paired t-test, change in this parameter between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.43) (Table 1).

The mean distance from the upper lip to H-line before and after treatment was –2.57 and –2.04, respectively. By applying paired t-test, change in this distance between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.16) (Table 1).

The mean distance from the upper lip to H-line before and after treatment was 0.00 and 0.22, respectively. By applying paired t-test, change in this distance between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.27) (Table 1).

The mean value of the nasolabial angle before and after treatment was 92.86 and 94.48, respectively. By applying paired t-test, change in this angle between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.44) (Table 1).

The mean retropalatal airway length before and after treatment was 30.09 and 30.08, respectively. By applying paired t-test, change in this length between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.99) (Table 2).

The mean retroglossal airway length before and after treatment was 17.63 and 19.69, respectively. By applying paired t-test, change in this length between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.28) (Table 2).

The mean total airway length before and after treatment was 47.72 and 49.77, respectively. By applying paired t-test, change in this length strain between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.30) (Table 2).

The mean retropalatal airway volume before and after treatment was 14.42 and 12.91, respectively. By applying paired t-test, change in this volume between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.15) (Table 2).

The mean retroglossal airway volume before and after treatment was 7.83 and 6.29, respectively. By applying paired t-test, change in this volume between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.44) (Table 2).

The mean total airway volume before and after treatment was 22.25 and 19.20, respectively. By applying paired t-test, change in this volume between both the groups, was found to be statistically insignificant after treatment with MARPE (p value = 0.44) (Table 2).

The mean soft palate surface area before and after treatment was 654.20 and 575.90, respectively. By applying paired t-test, change in this parameter between both the groups, was found to be statistically significant after treatment with MARPE (p value = 0.04) (Table 2).

The mean alar base width before and after treatment was 23.75 and 26.76, respectively. By applying paired t-test, change in this width between both the groups, was found to be statistically significant after treatment with MARPE (p value < 0.001) (Table 2).

IV. DISCUSSION

Numerous studies have been published describing the skeletal and dentoalveolar effects of rapid maxillary expansion, particularly MARPE; however, very few have considered its effects on the facial

TABLE 2: Comparison of airway parameters before and after intervention

		N	Mean	SD	Mean difference	95% Confidence interval of the difference		t	df	*p* value
						Lower	Upper			
Retropalatal airway length (mm)	**Pre**	10	30.09	5.30	0.01	–4.15	4.17	0.01	9	0.99 (NS)
	Post	10	30.08	5.37						
Retroglossal airway length (mm)	**Pre**	10	17.63	6.73	–2.06	–6.08	1.97	–1.16	9	0.28 (NS)
	Post	10	19.69	6.93						
Total airway length (mm)	**Pre**	10	47.72	5.15	–2.05	–6.21	2.12	–1.11	9	0.30 (NS)
	Post	10	49.77	4.13						
Retropalatal airway volume (cm^3)	**Pre**	10	14.42	5.69	1.51	–0.65	3.67	1.58	9	0.15 (NS)
	Post	10	12.91	4.36						
Retroglossal airway volume (cm^3)	**Pre**	10	7.83	7.64	1.54	–2.72	5.80	0.82	9	0.44 (NS)
	Post	10	6.29	4.42						
Total airway volume (cm^3)	**Pre**	10	22.25	11.71	3.05	–1.59	7.69	1.49	9	0.17 (NS)
	Post	10	19.20	8.03						
Soft palate surface area (mm^2)	**Pre**	10	654.20	136.30	78.30	1.30	155.30	2.30	9	0.04*
	Post	10	575.90	111.98						
Alar base width (mm)	**Pre**	10	23.75	2.16	–3.01	–4.15	–1.87	–5.95	9	< 0.001*
	Post	10	26.76	2.04						

Paired *t*-test.
*$p < 0.05$ statistically significant.
$p > 0.05$ nonsignificant (NS).

soft tissues or on the airway, leading to a limited database of evidence of these changes subsequent to maxillary expansion.[5]

In the recent era, cone–beam computed tomography (CBCT) has acquired widespread popularity as the imaging modality of choice, allowing for minimal distortion and greater resolution.[6] Therefore, in the present study, soft tissue and airway changes were evaluated adult patients with maxillary transverse discrepancy after treatment with miniscrew assisted rapid palatal expansion (MARPE) with the help of CBCT.

Kiliç et al.[7] reported that the H-angle had a highly significant increase after RME, in addition to being stable long term; this was attributed to the anterior movement of the upper lip, clockwise mandibular rotation or a combination of both, turning out to be favorable for Class III and unfavorable for Class II patients.[7,8]

In another study,[9] increase in the H-angle post-RME was found to be statistically significant, which meant that the upper lip became more prominent relative to the overall soft tissue profile.[9] This is in concordance with our current study wherein the change in H-angle after MARPE is found to be statistically significant.

A study carried out by Kiliç[7] reported that the distance from the soft tissue subnasal to the H-line did not show a significant increase post-RME. However, these results were not in agreement with the current study where the change in this parameter turned out to be statistically significant, which can be attributed to the downward and backward rotation of the mandible following MARPE.

Qiming et al. recently put forward the concept that the location and shape of the soft palate might be subject to change due to the horizontal expansion of the hard palate.[10] Therefore, the current study attempted to determine the surface area of the soft palate post-expansion to discover if MARPE has a direct effect on this parameter, and found it be statistically significant.

In a 2012 study evaluating immediate soft tissue changes after RME, an increase in the alar base width was reported.

Similarly, Lee et al.,[11] in a 2020 study, noted a statistically significant increase (mean 1.214 mm) in the alar base width post-MARPE that is in accordance with the current study, portraying a similar statistically significant increase in this parameter after active expansion.[8,11]

In a study by Kilic et al.,[7] the effects of rapid maxillary expansion on the facial soft tissues were measured and they noted a statistically significant reduction in the facial angle.[7] The current study also reports a similar reduction in the soft tissue facial angle owing to the clockwise rotation of the mandible post-MARPE, however, it was found to be statistically insignificant.

Altorkat et al., in a study reported a flattening of the tip of the nose, which was in contrast to Basciftci,[12] who noted a forward movement of the nasal tip (mean 2.53 mm) post-RME. Moreover, Magnusson et al.[13] found mild but statistically significant findings exhibiting a forward movement of the nose after tooth borne SARME. However, according to Aras et al.,[9] RME had no effect on the nasal tip prominence, analogous to the results given by Kılıç et al.,[7] Silva Filho,[14] and the current study, suggestive of a negative correlation between RME and nasal morphology.

Kilic et al.[7] reported an expected increase in the skeletal profile convexity owing to an anterior maxillary movement along with a clockwise mandibular rotation. These outcomes were in accordance with previous studies conducted by Haas,[15] Wertz,[16] and Karaman.[17] Aras et al. in 2017 noted a statistically significant reduction in the soft tissue facial profile post-expansion[9]; however, Huang et al.[25] stated that there were notable yet insignificant changes in the skeletal profile convexity after rapid palatal expansion. This was attributed to the flattening of the nose being compensated by forward maxillary movement and growth. The results of this study were in conjunction with our current study with no statistically significant change in the skeletal profile convexity post-MARPE.

Huang et al.[8] also noted a statistically significant change in the distance between the lower lip to the E-line post expansion; however, it did not exceed 1 mm, and relapsed during the retention period, which may have been associated with the movement and rotation of the maxilla and the mandible. Similarly, in the current study, the distance from the lower lip to the E-line did not show a statistically significant change.

Kim et al.[18] in their study observed an immediate decrease in the upper lip thickness after RME; however this reduction was not seen by Aras et al.,[9] the probable explanation being that the radiographs acquired in the latter were 85 days post-MARPE in contrast to the former who made their measurements just after the appliance was fully activated. However, they found small yet significant alterations in the upper lip thickness at the vermillion border in the SARPE group; it was their assumption that these findings were due to a possible stretching of the lip caused by higher skeletal expansion of the maxillary segment (bone-borne SARPE) as compared to tooth-borne RME; the current study, however, reports an insignificant but mild increase in the upper lip thickness post-MARPE, which seems to be in disagreement with previous studies.[19,20] Hence, this can be a point of further research, possibly employing various ethnic and racial populations, similar to the current study where the Indian population was assessed, thus justifying the contrasting results seen in this study. According to Kilic et al.,[7] there was not a statistically significant change in the soft tissue pogonion thickness post-RME. In another study by Aras et al.,[9] a decrease in the soft tissue chin prominence was noted in the RME group. In the current study, we found this change to be statistically insignificant, which is in agreement with the previous studies.

Torun[21] found a mild decrease in the nasolabial angle post-expansion that was statistically insignificant. Similarly, in another study by Altorkat et al.,[22] the nasolabial angle decreased post-RME and was reported as insignificant.

Karaman[17] and Sierra,[23] however, found a statistically significant increase of 5.4 and 7.0 degrees respectively, in the nasolabial angle after SARPE. According to the authors, segment tilting occurring in the anterior and inferior segment of the maxilla post-expansion[24] modified the lip projection as well as the nasolabial angle causing it to increase.[25] Thus, these findings were consistent with the current study where the nasolabial angle has increased post-MARPE though it is statistically insignificant.

Oliveira De Felippe et al.[26] found a noteworthy 30.12% increment in the volume of the nasal cavities after rapid maxillary expansion, thereby decreasing the nasal resistance and improving ventilation.[27,28] Kawaiah et al.[5] explored how mini-implant assisted rapid palatal expansion impacts individuals with OSA, and concluded that it can be a highly effective treatment modality for OSA patients.

Their findings suggested a definite improvement in the condition of OSAS with the use of the MARPE technique, which was in accordance with previous studies in the literature demonstrating how MARPE improves airflow and decreases upper airway resistance. Smith et al. noted a marked 16.2% increase in the nasopharyngeal airway volume whereas the oropharyngeal airway volume decreased, though not significantly, and the author ascribed it to the lowering of the palatine vault.[29]

In contrast, Ribeiro et al.[30] reported an increase of 239 mm^3 in the oropharyngeal airway volume with no change observed in the nasopharyngeal airway volume, which could possibly be attributed to a lack of standardized position of the head and tongue at the time of image acquisition according to the author.[31]

The current study shows a statistically insignificant reduction in the total airway length as well as volume post-MARPE, which highlights the limitations of CBCT imaging especially in accurately assessing the volume of the morphologically complex and anatomically intricate airway. To overcome this, technological advancements in the CBCT software, along with a standardized position of the head and the tongue, need to be established at the time of image acquisition, in order to ensure interobserver reliability for analysis of airway volumes.[32]

This study may have a few limitations; one being that the changes were recorded immediately after expansion not taking into account the possibility of relapse, due to lack of a long term follow up period. Furthermore, there may be absence of control over the position of the tongue while the CBCT images were being taken, which is an important anatomic factor affecting the size and shape of the oropharyngeal airway volume.

V. CONCLUSION

In this retrospective study, evaluating soft tissue and airway changes post-treatment with mini implant assisted rapid palatal expansion (MARPE), significant soft tissue changes were observed including an increased H-angle, an increased soft tissue subnasal to H-line, and a decreased soft palate surface area. Notable changes in the airway were also reported, especially the alar base width, which showed a significant increase.

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