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ORIGINAL RESEARCH

Photographic analysis of orofacial soft tissue alterations related to rapid maxillary expansion in pediatric patients

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Abstract

Maxillary transverse deficiency is widely recognized as one of the most common skeletal issues in orthodontics, and rapid maxillary expansion (RME) is commonly employed as a treatment method. This study aimed to investigate the impact of RME on the soft tissues of the orofacial region in pediatric patients. The study included two groups: an experimental group comprising 30 patients (16 females and 14 males) with maxillary skeletal transverse deficiency who required rapid maxillary expansion (RME), and a control group consisting of patients (10 females and 10 males) who did not require RME or orthodontic treatment. Frontal and profile photographs were taken before and after RME for both groups. Frontal photographs were used to obtain 12 linear measurements, while profile photographs were used to perform 2 linear and 2 angular measurements using the "protractor" and "pixel ruler" software. Burstone-Legan, Steiner and Rickett's analyses were performed to determine the locations of the upper and lower lips. Student *t*-test, paired samples *t*-test and Mann-Whitney U test were used to evaluate the data. In the experimental group, there was a statistically significant increase in nose width and intercommissural distance at the end of the treatment ($p < 0.05$). Similarly, both the experimental and control groups showed a statistically significant increase in the dorsum of nose length at T2 compared to the initial measurement ($p < 0.05$). Furthermore, the male participants in the experimental group exhibited a statistically significantly higher increase in nose length and dorsum of the nose during the T1 and T2 periods compared to the female participants in the experimental group ($p < 0.05$). RME may lead to changes in soft tissues in pediatric patients and was observed to be gender-specific. However, these changes were not clinically noticeable, and long-term follow-up studies are needed to determine the long-term effects of these changes.

Keywords

Orthodontics; Maxillary expansion; Pediatrics; Soft tissue

1. Introduction

The maxilla is connected to several bones, including the frontal, lacrimal, nasal, ethmoid, palatine, vomer, zygoma, inferior nasal concha and sphenoid bones, through sutures to form the pterygopalatine, zygomaticomaxillary, frontomaxillary and palatomaxillary sutures with the facial bones [1, 2]. Maxillary deficiency refers to a narrowing of the maxillary arch, often resulting in a unilateral or bilateral posterior crossbite, which can be attributed to genetic and/or environmental factors [3]. Rapid maxillary expansion (RME) is a commonly used orthodontic treatment for pediatric patients [4–6] involving orthopedically separating the mid-palatal suture [7–9]. During RME, the maxillofacial sutures become tense, the pterygoid processes of the sphenoid bone expand outward, the palatine bones split, and the maxillary base moves forward [10, 11].

RME is often used to correct maxillary transversal skeletal deficiency, especially in young adolescent patients with posterior crossbite, moderate/severe crowding and obstructive sleep apnea. It is also performed on patients experiencing maxillary deficiency in the anterior region during the peak stage, where the growth of the mandible is hindered by the maxillary teeth [10, 12–14].

In addition to its orthopedic effects, the use of RME appliances can lead to orthodontic changes, including buccal tipping and extrusion movements of premolars and molars, as well as lateral rotations of posterior alveolar segments [15, 16]. These movements can cause the mandible to rotate backward and downward, resulting in an increase in facial height. It has been reported that RME can also cause changes in soft tissues due to the movements in the maxillary segments and maxillofacial sutures [16–19]. Furthermore, studies utilizing posteroanterior radiographs have reported increases in nasal, maxillary and zygomatic width following RME, reflecting changes in hard tissues [18, 20, 21]. However, the impact of these alterations in hard tissues on the soft tissues has not been thoroughly investigated [18, 22–24]. Recent orthodontic treatment plans have placed a greater emphasis on enhancing soft tissues rather than solely focusing on tooth alignment, with the primary goal of improving facial esthetics [25–28].

Numerous studies have utilized cone beam computed tomography (CBCT) images and 3D facial scans to assess changes in soft tissue following RME [29–35]. However, the use of 3D imaging systems in pediatric patients is limited, typically reserved for cases involving serious craniofacial anomalies or syndromes due to the high radiation dose associated with these scans [36–38]. Additionally, the cost of 3D imaging devices makes them inaccessible in many orthodontic clinics. Alternatively, orthodontic clinics routinely obtain photographs and radiographs from patients at the beginning, mid-stage and completion of treatment, allowing for clear observation of not only the changes in dentition and skeletal structure but also alterations in soft tissues resulting from orthodontic interventions [23, 24].

This study aimed to investigate the impact of RME on the soft tissues of young adolescents and its potential effects on facial aesthetics. Anthropometric measurements were performed on frontal and profile photographs to assess changes resulting from this commonly applied treatment for pediatric patients with maxillary skeletal deficiency and to explore potential gender differences associated with these changes.

2. Materials and methods

2.1 Subjects

A total of 30 patients with maxillary skeletal transverse deficiency, consisting of 16 females and 14 males, were included in this study. The inclusion criteria for this study were as follows: no history of previous orthodontic treatment, presence of unilateral or bilateral posterior crossbite, the inclusion of maxillary expansion in the treatment plans, and no history of craniofacial or systemic disease. In addition to the experimental group, a control group of 20 individuals (10 females and 10 males) who did not require RME or orthodontic treatment was also included. The mean chronological age for females was 11.23 ± 1.45, while for males, it was 12.13 ± 2.10. The skeletal maturity of both the experimental and control groups was determined using the S, H2 and MP3 cap stages at T1, based on the Greulich-Pyle Atlas, which was used to assess skeletal age. All study participants were from the same geographic region and belonged to the same racial group.

2.2 Sample size

An initial statistical evaluation was conducted to determine the sample size, considering a power of 90%, a two-tailed analysis, and a significance level of 5% (to correct for multiple comparisons), based on the mean of the nose width measurements at post-expansion (T2) (14.9 ± 1.02) and the mean of the measurements at pre-expansion (T1) (13.8 ± 1.12) obtained from a population of 12 patients (our preliminary results). The results indicated a minimum sample size of 22 individuals to obtain reliable comparative analytic results.

2.3 Treatment procedure

The RME devices utilized in this study consisted of an acrylic-cap splint covering only the posterior teeth and a Hyrax expansion screw (Leone Orthodontics, Firenze, Italy) (Fig. 1). The acrylic-cap splint was bonded to the upper teeth using a glass ionomer luting cement called Meron (VOCO, Cuxhaven, Germany). All the RME devices were manufactured by the same qualified technician to ensure consistency. Patients in the experimental group included individuals with mixed or permanent dentition, and no complications related to the stabilization of the RME appliances were reported. The Hyrax screws were activated twice daily (0.25 mm per turn). The activation of the Hyrax screw was performed for 2–3 weeks, aiming for a total expansion of 9–10 mm in accordance with the patient's needs, with a 20% overcorrection. To evaluate the effectiveness of RME, occlusal radiographs were taken both before and after the treatment, allowing for the measurement of the separation of the mid-palatal suture (Fig. 2). Patients with poor oral hygiene and gingival inflammation received oral hygiene training as part of their treatment.

2.4 Photographic assessment

To ensure standardization, all photographs were captured from the same distance of 110 cm using a Nikon d7200 camera equipped with a Sigma 105 macro lens. Frontal and profile photographs, which are commonly taken in orthodontic clinics by professional photograph technicians, were obtained with the patients maintaining their natural head position. Prior to the photographic examination, all accessories were removed to allow for a clear examination of the subjects. For the experimental group, initial photographs (T1) were taken prior to the application of RME. Intermediate phase photographs (T2) were captured immediately after the removal of the RME device. In contrast, the control group consisted of patients who presented to the clinic without prior orthodontic treatment, for whom photographs were taken at the beginning and six months later. The retention phase involved the expansion device being retained for approximately six months. The time interval between T1 and T2, representing the initial and intermediate phases, respectively, was approximately 6.3 months [3, 16, 39].

2.5 Measurements

To ensure the standardization of patient photographs at times T1 and T2, a 30 cm ruler was used for calibration purposes. The ruler was projected and photographed, and the resulting image was adjusted to achieve a 1-to-1 ratio with the actual size of the ruler. For the frontal view measurements, the patient's interpupillary distance was superimposed in both T1 and T2 photographs (Fig. 3). In the profile measurements, the patient's tragus overlaps and lip positions were used as reference points (Figs. 4,5). All measurements were recorded in millimeters (mm).

FIGURE 1. RME device. The occlusal-coverage bonded type RME device with Hyrax screw used in the study is presented.

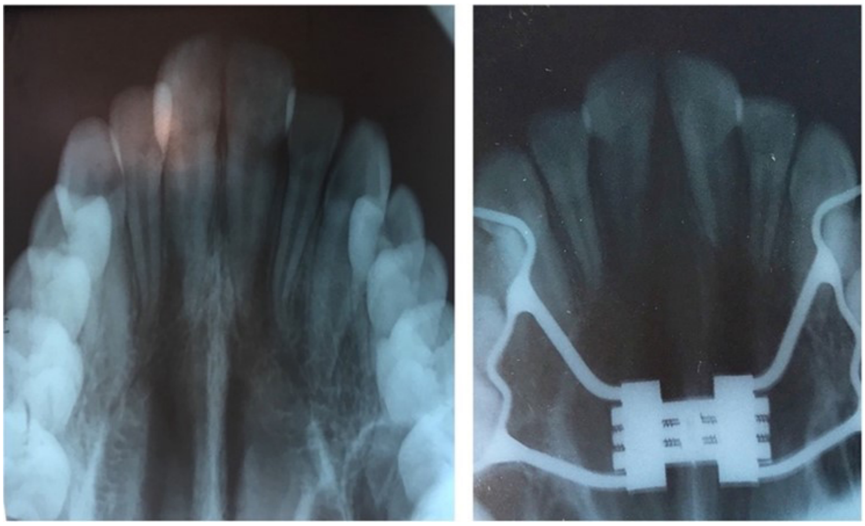

FIGURE 2. Occlusal radiographs. Occlusal radiographs were taken before and after RME, and the separation of the midpalatal suture is presented.

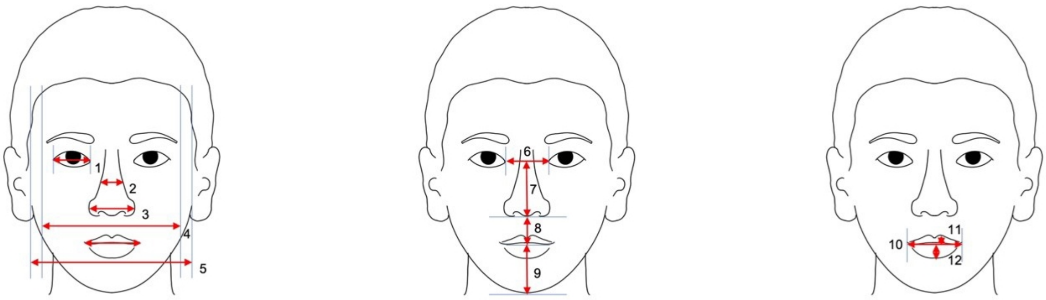

FIGURE 3. Frontal measurements. A schematic diagram of 12 linear measurements made on frontal photographs is presented.

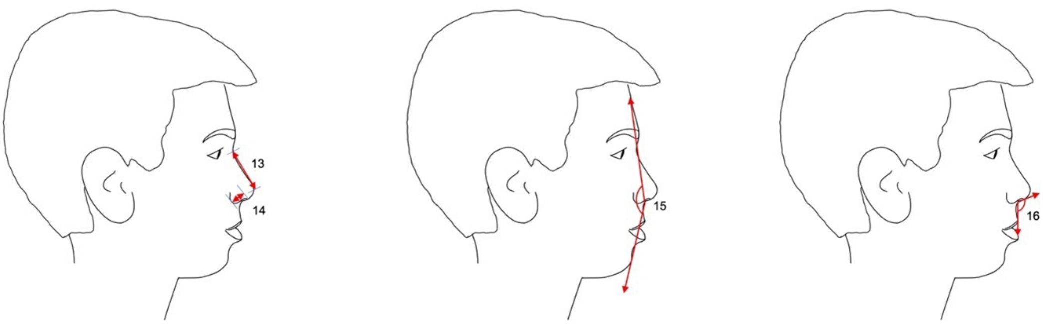

FIGURE 4. Profile measurements. A schematic diagram of 2 linear and 2 angular measurements made on profile photographs is presented.

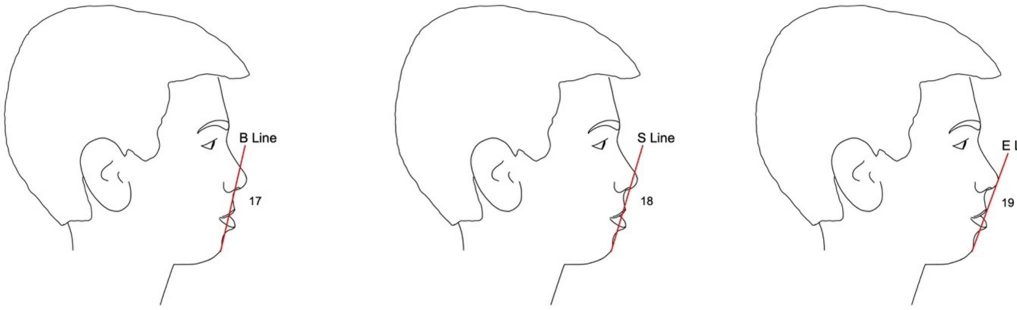

FIGURE 5. Lip position measurements. Lip positions relative to different reference planes are presented.

2.6 Error of the study

The examiner (H.U.) repeated all measurements on 30 frontal and profile photographs of 15 randomly selected patients: five in the female experimental group, five in the male experimental group, and five in the control group to determine method error. The intraclass correlation coefficient (ICC) for all measurements was found to be nearly 1.00, indicating that the measurements could be repeated with negligible error that would not impact the results.

2.7 Statistical analysis

Statistical analysis was performed using SPSS software version 22.0 (SPSS, Chicago, IL, USA). The normal distribution of parameters was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Student's t-test was employed for comparing normally distributed parameters between two groups. Within-group comparisons of normally distributed parameters were conducted using paired samples t-test, the Mann-Whitney U test was used for comparing non-normally distributed parameters, and continuity (Yates) correction was applied for comparing qualitative data. Statistical significance level was set at $p < 0.05$.

3. Results

Table 1 presents the definition of measurements made on the frontal and profile photographs.

The analysis revealed no statistically significant difference between the groups regarding gender ($p > 0.05$), indicating that gender distribution was similar in both the experimental and control groups (Table 2).

Table 3 displays the changes in frontal measurements obtained from the photographs. The results showed that within the experimental group, a statistically significant increase in nose width and intercommissural distance was observed at the end of the treatment ($p < 0.05$).

The nasal width of the middle third in the experimental group at both T1 and T2 was significantly higher than that of the control group ($p < 0.05$). Conversely, the lower face width, intercanthal distance and lower lip vermillion measurements in the experimental group at T1 and T2 were significantly lower than in the control group ($p < 0.05$).

Table 4 presents the changes in profile measurements obtained from the photographs. The dorsum of the nose and soft tissue facial angle in the experimental group at T1 and T2 were significantly higher than those in the control group ($p < 0.05$), while the alar base in the experimental group at T1 and T2 was significantly lower than the control group ($p < 0.05$). Within both groups, there was a significant increase in the dorsum of nose length at T2 ($p < 0.05$). However, there was no significant change in the upper and lower lip positions relative to different reference planes during the T1–T2 period ($p > 0.05$) (Table 5).

Next, we assessed the relationship between the T1–T2 change amounts of the experimental and control groups (Table 6). The results showed that the increase in nose width, intercommissural distance and nasolabial angle measurements in the experimental group during the T1 and T2 period were significantly higher than in the control group, while the increase in the dorsum of nose measurement in the experimental group during the T1 and T2 period was significantly lower than in the control group ($p < 0.05$).

Table 7 presents the relationship between the T1–T2 change amounts of the experimental and control groups in females. The increase in nose width in the experimental group during the T1 and T2 period was significantly higher than in the control group, while the increase in the dorsum of nose measurement in the experimental group during the T1 and T2 period was significantly lower than in the control group in females ($p < 0.05$). In addition, while a decrease in upper lip length was observed in the T1 and T2 period in the experimental group, an increase was observed in the control group in females, and this difference was statistically significant ($p < 0.05$).

Table 8 presents the relationship between the T1–T2 change amounts of the experimental and control groups in males. The increase in nose width, intercommissural distance, dorsum of the nose, and nasolabial angle in the experimental group during the T1 and T2 period were significantly higher than the control group in males ($p < 0.05$).

Lastly, we assessed the relationship between the T1–T2 change amounts of females and males in the experimental groups (Table 9). The results indicated that an increase in nose length and dorsum of the nose in males during the T1 and T2 period was statistically significantly higher than in females ($p < 0.05$). Additionally, there was a significant decrease in upper lip length and upper face width in the T1 and T2 period in females, whereas an increase was observed in males, and the difference was statistically significant ($p < 0.05$).

Conversely, there was no statistically significant change in the relationship between the T1–T2 change amounts in the

TABLE 1. The definition of measurements made on the frontal and profile photographs.

Planes	Landmark Definitions
Frontal Measurements	
1. Eye Width	Distance between the far right and left point of the eye
2. Nasal Width of the Middle Third	Distance between the right and left of the middle third of the nose
3. Nose Width	Distance between the right and left alare
4. Upper Face Width	Distance between the right and left cheekbones
5. Lower Face Width	Distance between the right and left gonion
6. Intercanthal Distance	Distance between the right and left endocanthion
7. Nose Length	Distance between the soft tissue nasion and subnasal point
8. Upper Lip Length	Distance from subnasale to stomion
9. Lower Lip/Chin Length	Distance from stomion to menton
10. Intercommissural Distance	Distance between the right and left commissure
11. Upper Lip Vermillion	Distance from labrale superior to stomion
12. Lower Lip Vermillion	Distance from stomion to labrale inferior
Profile Measurements	
13. Dorsum of the Nose	The length of the nose's external ridge
14. Alar Base	The length of the alar base
15. Soft Tissue Facial Angle	The angle formed by the glabella, subnasale and pogonion soft tissues
16. Nasolabial Angle	The angle formed by columella, subnasale and labrale superior
Lip Positions	
17. B-Line	Shows the Burstone-Legan Analysis
18. S-Line	Shows the Steiner Analysis
19. E-Line	Shows the Rickett's Analysis

TABLE 2. Evaluation of groups in terms of gender.

	Experimental n (%)	Control n (%)	p
Female	16 (53.3%)	10 (50%)	1
Male	14 (46.7%)	10 (50%)	

Continuity (yates) correction.

female and male control groups ($p > 0.05$).

4. Discussion

Numerous studies have established that RME not only affects the hard tissues but also induces changes in the soft tissues of the orofacial region [14, 16, 29, 39, 40]. To evaluate these soft tissue changes resulting from RME, researchers have utilized various methods, including cephalometric radiographs, photographs, and 3D images/facial scans [7, 16, 19, 20, 29, 30, 39]. While CBCT images and 3D face scans offer more precise results and facilitate measurements, their routine use in orthodontic clinics is limited due to the high radiation dose associated with CBCT images and the cost of 3D face scans. In this present study, we opted to perform anthropometric measurements on routinely captured photographs to assess corresponding soft tissue changes.

In a study by Berger *et al*. [39], measurements were taken using only frontal photographs of patients who underwent SARME and orthopedic expansion. During the treatment, they observed changes in upper lip length, chin length, upper and lower face width, and upper and lower lip vermilion measurements. However, there was no statistically significant change between T1 and T2 by the end of the 1-year retention period [39]. Similarly, Truong *et al*. [19] reported that RME initially led to a significant increase in nasal width, but this measurement gradually returned to average levels with growth and development. However, this study was conducted within a time interval of six months. Although an increase in the nose width and intercommissural distance at the end of the treatment was found in the experimental group, a long-term follow-up is needed to determine whether these soft tissue changes are temporary or long-term.

According to literature, the retention period after expansion has been performed in different periods, such as 3 months, 6 months, and 1 year [16, 19, 30, 39, 41]. In this present study, retention was performed for 6 months to decrease the possibility of relapses [3, 16]. It has been determined that

TABLE 3. Intergroup and intragroup evaluation of frontal measurements.

	Experimental (n = 30) Mean ± SD (median)	Control (n = 20) Mean ± SD (median)	[1]p
Eye Width			
T1	12.54 ± 1.39	12.04 ± 1.23	0.199
T2	12.57 ± 1.36	12.04 ± 1.23	0.169
[2]p	0.379	0.330	
Nasal Width of The Middle Third			
T1	7.49 ± 1.22	6.72 ± 0.67	0.013*
T2	7.50 ± 1.20	6.73 ± 0.65	0.012*
[2]p	0.482	0.166	
Nose Width			
T1	14.00 ± 1.89	13.43 ± 1.28	0.211
T2	14.91 ± 1.80	13.44 ± 1.27	0.001*
[2]p	0.001*	0.106	
Upper Face Width			
T1	55.87 ± 5.55	58.04 ± 3.41	0.095
T2	55.90 ± 5.52	58.12 ± 3.45	0.086
[2]p	0.813	0.163	
Lower Face Width			
T1	48.30 ± 5.43	54.38 ± 3.96	0.001*
T2	48.47 ± 5.39	54.46 ± 4.01	0.001*
[2]p	0.198	0.185	
Intercanthal Distance			
T1	12.67 ± 1.64	13.67 ± 1.65	0.041*
T2	12.70 ± 1.67	13.67 ± 1.65	0.049*
[2]p	0.161	1.000	
Nose Length			
T1	18.69 ± 1.72	18.80 ± 0.89	0.757
T2	18.86 ± 1.71	18.88 ± 0.93	0.960
[2]p	0.097	0.024*	
Upper Lip Length			
T1	8.78 ± 1.67	9.47 ± 0.72	0.054
T2	8.77 ± 1.68	9.48 ± 0.69	0.044*
[2]p	0.883	0.278	
Lower Lip-Chin Length			
T1	17.39 ± 3.27	18.29 ± 1.44	0.192
T2	17.58 ± 3.36	18.30 ± 1.43	0.301
[2]p	0.093	0.010*	
Intercommissural Distance			
T1	19.04 ± 2.03	18.40 ± 1.16	0.167
T2	19.73 ± 2.02	18.43 ± 1.17	0.006*
[2]p	0.001*	0.231	
Upper Lip Vermillion			
T1	3.37 ± 0.78	3.69 ± 0.69	0.140
T2	3.36 ± 0.71	3.70 ± 0.69	0.098
[2]p	0.879	0.287	
Lower Lip Vermillion			
T1	4.30 ± 0.76	5.03 ± 0.74	0.001*
T2	4.35 ± 0.78	5.03 ± 0.73	0.004*
[2]p	0.168	0.525	

[1]*Student t test.* [2]*Paired Samples t test.* *$*p < 0.05$. SD: Standard Deviation.*

TABLE 4. Intergroup and intragroup evaluation of profile measurements.

	Experimental (n = 30) Mean ± SD (median)	Control (n = 20) Mean ± SD (median)	[1]p
Dorsum of the Nose			
T1	14.82 ± 1.57	13.13 ± 1.12	0.001*
T2	15.07 ± 1.50	13.92 ± 1.19	0.006*
[2]p	0.001*	0.001*	
Alar Base			
T1	5.37 ± 0.93	6.63 ± 0.69	0.001*
T2	5.37 ± 0.93	6.63 ± 0.75	0.001*
[2]p	0.932	0.935	
Soft Tissue Facial Angle			
T1	162.94 ± 5.06	158.67 ± 3.06	0.001*
T2	162.38 ± 4.37	158.63 ± 3.04	0.002*
[2]p	0.317	0.242	
Nasolabial Angle			
T1	114.93 ± 9.68	118.00 ± 10.94	0.301
T2	115.70 ± 9.33	117.93 ± 10.96	0.443
[2]p	0.184	0.482	

[1]*Student t test.* [2]*Paired Samples t test.* *$*p < 0.05$. SD: Standard Deviation.*

TABLE 5. Intergroup and intragroup evaluation of upper and lower lip measurements.

	Experimental (n = 30) Mean ± SD (median)	Control (n = 20) Mean ± SD (median)	[1]p
B-Line—Upper Lip			
T1	1.03 ± 0.82	1.18 ± 0.44	0.402
T2	1.20 ± 0.73	1.19 ± 0.44	0.930
[2]p	0.056	0.093	
B-Line—Lower Lip			
T1	0.99 ± 1.02	1.46 ± 0.61	0.069
T2	0.98 ± 0.90	1.46 ± 0.61	0.061
[2]p	0.895	0.202	
S-Line—Upper Lip			
T1	−0.12 ± 0.80	0.00 ± 0.54	0.563
T2	0.01 ± 0.80	0.03 ± 0.57	0.931
[2]p	0.148	0.235	
S-Line—Lower Lip			
T1	−0.02 ± 1.02	−0.13 ± 0.67	0.653
T2	−0.03 ± 0.94	−0.12 ± 0.65	0.715
[2]p	0.897	0.268	
E-Line—Upper Lip			
T1	−1.05 ± 1.28	−1.35 ± 0.41	0.242
T2	−0.85 ± 1.42	−1.35 ± 0.40	0.077
[2]p	0.346	0.836	
E-Line—Lower Lip			
T1	−0.74 ± 1.04	−0.47 ± 0.98	0.345
T2	−0.89 ± 0.92	−0.44 ± 0.96	0.101
[2]p	0.060	0.077	

[1]*Student t test.* [2]*Paired Samples t test.* *$*p < 0.05$. SD: Standard Deviation.*

TABLE 6. Evaluation of the experimental and control groups in terms of T1–T2 change amounts.

	Experimental (n = 30)	Control (n = 20)	
T1–T2 Difference	Mean ± SD (median)	Mean ± SD (median)	*p*
Frontal Measurements			
Eye Width	0.03 ± 0.18 (0)	0 ± 0 (0)	0.501
Nasal Width of The Middle Third	0.01 ± 0.08 (0)	0.01 ± 0.03 (0)	0.335
Nose Width	0.91 ± 0.47 (1)	0.01 ± 0.03 (0.01)	0.001*
Upper Face Width	0.02 ± 0.54 (0)	0.09 ± 0.27 (0)	0.381
Lower Face Width	0.17 ± 0.71 (0)	0.08 ± 0.26 (0.01)	0.967
Intercanthal Distance	0.03 ± 0.10 (0)	0 ± 0 (0)	0.243
Nose Length	0.18 ± 0.56 (0)	0.08 ± 0.14 (0.03)	0.444
Upper Lip Length	−0.01 ± 0.40 (0)	0.02 ± 0.07 (0.01)	0.642
Lower Lip-Chin Length	0.19 ± 0.59 (0)	0.01 ± 0.02 (0.01)	0.917
Intercommissural Distance	0.69 ± 0.93 (0.18)	0.02 ± 0.08 (0)	0.006*
Upper Lip Vermillion	−0.01 ± 0.21 (0)	0.01 ± 0.05 (0)	0.681
Lower Lip Vermillion	0.06 ± 0.22 (0)	0 ± 0.03 (0)	0.898
Profile Measurements			
Dorsum of Nose	0.24 ± 0.37 (0)	0.79 ± 0.45 (1.02)	0.001*
Alar Base	0 ± 0.04 (0)	0 ± 0.16 (0)	0.960
Soft Tissue Facial Angle	−0.56 ± 3.01 (0)	−0.04 ± 0.16 (0)	0.429
Nasolabial Angle	0.77 ± 3.10 (0.08)	−0.07 ± 0.45 (0)	0.003*
Upper and lower lip			
B-Line—Upper Lip	0.18 ± 0.49 (0)	0.01 ± 0.03 (0)	0.546
B-Line—Lower Lip	−0.04 ± 0.52 (0)	0 ± 0.01 (0)	0.865
E-Line—Upper Lip	0.20 ± 1.14 (0)	0 ± 0.06 (0)	0.695
E-Line—Lower Lip	−0.14 ± 0.40 (−0.01)	0.03 ± 0.06 (0)	0.038*
S-Line—Upper Lip	0.12 ± 0.45 (0.01)	0.02 ± 0.08 (0)	0.357
S-Line—Lower Lip	−0.01 ± 0.57 (0)	0.01 ± 0.06 (0)	0.300

*Mann Whitney U test. *p < 0.05. SD: Standard Deviation.*

TABLE 7. Evaluation of the experimental and control groups in terms of T1–T2 change amounts in females.

	Experimental (n = 16)	Control (n = 10)	
T1–T2 Difference (Female)	Mean ± SD (median)	Mean ± SD (median)	*p*
Frontal Measurements			
Eye Width	−0.01 ± 0.03 (0)	0 ± 0 (0)	0.429
Nasal Width of The Middle Third	−0.01 ± 0.05 (0)	0 ± 0.01 (0)	0.058
Nose Width	0.82 ± 0.41 (0.94)	0.02 ± 0.03 (0)	0.001*
Upper Face Width	−0.19 ± 0.56 (0)	0.11 ± 0.34 (0)	0.029*
Lower Face Width	0.04 ± 0.76 (0)	0.01 ± 0.02 (0.01)	0.583
Intercanthal Distance	0.03 ± 0.10 (0)	0 ± 0 (0)	0.429
Nose Length	0.06 ± 0.40 (0)	0.05 ± 0.10 (0.02)	0.661
Upper Lip Length	−0.09 ± 0.50 (0)	0.04 ± 0.07 (0.01)	0.032*
Lower Lip-Chin Length	0.19 ± 0.67 (0)	0.02 ± 0.03 (0.02)	0.578
Intercommissural Distance	0.63 ± 0.93 (0.1)	0.04 ± 0.11 (0)	0.062
Upper Lip Vermillion	−0.04 ± 0.29 (0)	0.01 ± 0.03 (0)	0.458
Lower Lip Vermillion	0.10 ± 0.29 (0)	−0.01 ± 0.04 (0)	0.974
Profile Measurements			
Dorsum of Nose	0.16 ± 0.38 (0)	0.80 ± 0.48 (0.96)	0.004*
Alar Base	−0.01 ± 0.05 (0)	0 ± 0.08 (0)	0.253
Soft Tissue Facial Angle	−1.12 ± 3.96 (−0.63)	−0.05 ± 0.18 (0)	0.081
Nasolabial Angle	0.55 ± 3.87 (0)	−0.21 ± 0.50 (0)	0.053
Upper and lower lip			
B-Line—Upper Lip	0.19 ± 0.57 (0)	0.02 ± 0.04 (0)	0.535
B-Line—Lower Lip	0 ± 0.67 (0)	0.01 ± 0.01 (0)	0.284
E-Line—Upper Lip	0.38 ± 1.55 (0)	−0.02 ± 0.08 (0)	0.863
E-Line—Lower Lip	−0.14 ± 0.51 (0)	0.04 ± 0.08 (0.03)	0.261
S-Line—Upper Lip	0.12 ± 0.57 (0)	0.02 ± 0.06 (0)	0.803
S-Line—Lower Lip	−0.08 ± 0.74 (0)	0.02 ± 0.06 (0)	0.227

*Mann Whitney U test. *p < 0.05. SD: Standard Deviation.*

TABLE 8. Evaluation of the experimental and control groups in terms of T1–T2 change amounts in males.

	Experimental (n = 14)	Control (n = 10)	
T1–T2 Difference (Male)	Mean ± SD (median)	Mean ± SD (median)	*p*
Frontal Measurements			
Eye Width	0.07 ± 0.27 (0)	0 ± 0 (0)	0.160
Nasal Width of The Middle Third	0.04 ± 0.11 (0)	0.02 ± 0.05 (0)	0.942
Nose Width	1.02 ± 0.53 (1.03)	0 ± 0.02 (0.01)	0.001*
Upper Face Width	0.27 ± 0.42 (0.08)	0.06 ± 0.18 (0.01)	0.311
Lower Face Width	0.32 ± 0.64 (0.06)	0.14 ± 0.36 (0.01)	0.570
Intercanthal Distance	0.03 ± 0.11 (0)	0 ± 0 (0)	0.398
Nose Length	0.30 ± 0.69 (0.34)	0.11 ± 0.18 (0.03)	0.088
Upper Lip Length	0.08 ± 0.23 (0.03)	−0.01 ± 0.06 (0.01)	0.105
Lower Lip-Chin Length	0.19 ± 0.52 (0.01)	0.01 ± 0.01 (0.01)	0.438
Intercommissural Distance	0.76 ± 0.97 (0.5)	0.01 ± 0.01 (0)	0.039*
Upper Lip Vermillion	0.03 ± 0.06 (0)	0.01 ± 0.07 (0)	0.252
Lower Lip Vermillion	0.01 ± 0.01 (0)	0 ± 0 (0)	0.804
Profile Measurements			
Dorsum of Nose	0.34 ± 0.35 (0.28)	0.78 ± 0.44 (1.03)	0.012*
Alar Base	0.01 ± 0.03 (0)	0 ± 0.22 (0)	0.279
Soft Tissue Facial Angle	0.08 ± 1.17 (0.02)	−0.03 ± 0.14 (0.01)	0.548
Nasolabial Angle	1.03 ± 2.00 (0.33)	0.07 ± 0.35 (0)	0.022*
Upper and lower lip			
B-Line—Upper Lip	0.17 ± 0.40 (0)	0 ± 0 (0)	0.794
B-Line—Lower Lip	−0.08 ± 0.28 (0.01)	0 ± 0.01 (0)	0.330
E-Line—Upper Lip	−0.01 ± 0.22 (0)	0.01 ± 0.03 (0.01)	0.441
E-Line—Lower Lip	−0.15 ± 0.25 (−0.06)	0.01 ± 0.03 (0)	0.080
S-Line—Upper Lip	0.13 ± 0.28 (0.1)	0.02 ± 0.09 (0.01)	0.290
S-Line—Lower Lip	0.06 ± 0.30 (0)	0.01 ± 0.05 (0)	0.944

*Mann Whitney U test. *p < 0.05. SD: Standard Deviation.*

TABLE 9. Evaluation of the female and male experimental groups in terms of T1–T2 change amounts.

	Female (n = 16)	Male (n = 14)	
T1–T2 Difference (Experimental)	Mean ± SD (median)	Mean ± SD (median)	*p*
Frontal Measurements			
Eye Width	−0.01 ± 0.03 (0)	0.07 ± 0.27 (0)	0.163
Nasal Width of The Middle Third	−0.01 ± 0.05 (0)	0.04 ± 0.11 (0)	0.079
Nose Width	0.82 ± 0.41 (0.94)	1.02 ± 0.53 (1.03)	0.212
Upper Face Width	−0.19 ± 0.56 (0)	0.27 ± 0.42 (0.08)	0.010*
Lower Face Width	0.04 ± 0.76 (0)	0.32 ± 0.64 (0.06)	0.257
Intercanthal Distance	0.03 ± 0.10 (0)	0.03 ± 0.11 (0)	0.923
Nose Length	0.06 ± 0.40 (0)	0.30 ± 0.69 (0.34)	0.020*
Upper Lip Length	−0.09 ± 0.50 (0)	0.08 ± 0.23 (0.03)	0.025*
Lower Lip-Chin Length	0.19 ± 0.67 (0)	0.19 ± 0.52 (0.01)	0.685
Intercommissural Distance	0.63 ± 0.93 (0.1)	0.76 ± 0.97 (0.5)	0.558
Upper Lip Vermillion	−0.04 ± 0.29 (0)	0.03 ± 0.06 (0)	0.178
Lower Lip Vermillion	0.10 ± 0.29 (0)	0.01 ± 0.01 (0)	0.612
Profile Measurements			
Dorsum of Nose	0.16 ± 0.38 (0)	0.34 ± 0.35 (0.28)	0.021*
Alar Base	−0.01 ± 0.05 (0)	0.01 ± 0.03 (0)	0.070
Soft Tissue Facial Angle	−1.12 ± 3.96 (−0.63)	0.08 ± 1.17 (0.02)	0.055
Nasolabial Angle	0.55 ± 3.87 (0)	1.03 ± 2.00 (0.33)	0.227
Upper and lower lip			
B-Line—Upper Lip	0.19 ± 0.57 (0)	0.17 ± 0.40 (0)	0.543
B-Line—Lower Lip	0 ± 0.67 (0)	−0.08 ± 0.28 (0.01)	0.439
E-Line—Upper Lip	0.38 ± 1.55 (0)	−0.01 ± 0.22 (0)	0.874
E-Line—Lower Lip	−0.14 ± 0.51 (0)	−0.15 ± 0.25 (−0.06)	0.817
S-Line—Upper Lip	0.12 ± 0.57 (0)	0.13 ± 0.28 (0.1)	0.687
S-Line—Lower Lip	−0.08 ± 0.74 (0)	0.06 ± 0.30 (0)	0.232

*Mann Whitney U test. *p < 0.05. SD: Standard Deviation.*

long-term retentions are usually made in cases with surgically-assisted expansion [21, 39]. Berger *et al.* [39] performed mid-term measurements without removing the bonded-type device, which may cause differences in values. In our study, all the measurements were performed before RME and after removing the RME device, but still, changes were determined in the experimental group measurements, which indicates a change in soft tissues immediately after RME in pediatric patients.

Berger *et al.* [39] reported a 2 mm increase in nose width following RME. In contrast, Gül *et al.* [29] found that although nose width increased, no significant changes were observed in bizygomatic width, philtrum width and upper vermillion height after RME. Torun examined soft tissue alterations in pre-adolescent and post-adolescent patients before and after RME and reported the highest increase in cheek projection in the prepubertal group. In addition, they observed statistically significant alterations in columella height, nasal vestibulum, philtrum diameter, upper lip length and columella diameter, while no significant changes were observed in nostril height, alar base, nasolabial angle or nostril width [16]. Comparatively, in this current study, we found that nose width and intercommissural distance increased at T2 only in the experimental group, while the dorsum of the nose length increased at T2 in both the experimental and control groups, indicating that nose length increases with growth and development, whereas nose width and intercommissural distance may expand due to RME. Although the nasal width of the middle third, lower face width, intercanthal distance and lower lip vermillion of the experimental group differed significantly from those of the control group, there were no changes within the groups at T1 and T2. We hypothesized that these results might be attributed to anatomical variations among the investigated patients.

Dos Santos *et al.* [11] used cephalometric radiographs to evaluate changes in soft tissue profiles after RME. By conducting various analyses such as Ricketts, Steiner, Legan-Burstone, Holdaway and McNamara analyses, the researchers found that although there was an initial forward movement of the upper lip immediately after expansion, it returned to its original position at the end of the 6-month retention period. Similarly, while the lower lip showed forward movement immediately after expansion, no statistically significant difference was observed at the end of the retention period. Comparatively, in this current study, the positions of the upper and lower lips at T1 and T2 were assessed using B, S and E lines. It was expected that the position of the lips would change due to the forward movement of the A point and the downward and backward rotation of the mandible following RME [4, 9, 17, 42]. However, no statistically significant change in the lip position was observed, which might be attributed to the study's inability to employ 3D scans. As in growing patients, soft tissue changes can also occur during prosthetic procedures [43–47].

It is well recognized that females and males can exhibit variations in growth and developmental patterns, as well as differences in anatomical and bone structures, despite having the same chronological age [12, 31]. The results of this study indicate that there were no statistically significant changes in the relationship between the T1–T2 change amounts of the female and male control groups. However, it was observed that the increase in nose length, dorsum of the nose, upper face width and upper lip length in males from the experimental group during the T1 and T2 periods was significantly higher than that of females from the experimental group, suggesting that RME may have a more pronounced effect on soft tissue alterations in males than in females.

Kokich *et al.* [48] examined the perceptions of orthodontists, general dentists, and laypeople regarding minor variations in the size and alignment of anterior teeth and their relationship to the surrounding soft tissues. They reported that general dentists and laypeople were unable to detect a 4 mm midline deviation, and laypeople were unable to detect an incisal plane asymmetry until it was 3 mm [48]. Silva *et al.* [49] determined laypersons' perceptions of dental and facial asymmetries and found that chin deviations of 6 mm or less were not noticed and did not have a statistically significant impact on the perception of facial attractiveness. Naini *et al.* [50] evaluated the differences in the aesthetic perception of soft tissue profile and concluded that a 4 mm protrusion or retrusion was frequently unnoticed regardless of the observer's profession. According to the findings of this present study, although changes occurred in soft tissues after RME, these changes were observed to be less than 2 mm. Based on the existing literature, such small changes may not be clinically significant and might be undetectable by both professionals and laypeople.

5. Conclusions

In conclusion, the study revealed that RME treatment significantly increased nose width and intercommissural distance. Additionally, gender differences were observed, with males exhibiting a higher increase in nose length and dorsum of the nose compared to females. However, it is important to note that these changes were not clinically noticeable. Further long-term follow-up studies are necessary to assess the persistence and clinical significance of these soft tissue changes over time.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

AM and HU—designed the research study. HU—performed the research. GC—analyzed the data. MC, MMM and GM—wrote the manuscript. All authors contributed to the editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was carried out in accordance with the Helsinki Declaration, and the protocol was approved by the Ethics Committee of the University of Aldent, Tirana, Albania (Protocol number: 843/2022, Date: 7/11/2022). All patients and their parents gave written informed consent for participation.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Giuseppe Minervini is serving as one of the Editorial Board members of this journal. We declare that Giuseppe Minervini had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to MAM.

REFERENCES

[1] Masucci C, Franchi L, Franceschi D, Pierleoni F, Giuntini V. Post-pubertal effects of the Alt-RAMEC/FM and RME/FM protocols for the early treatment of Class III malocclusion: a retrospective controlled study. European Journal of Orthodontics. 2022; 44: 303–310.

[2] Büyükçavuş MH. Alternate rapid maxillary expansion and constriction (Alt-RAMEC) protocol: a comprehensive literature review. Turkish Journal of Orthodontics. 2019; 32 47–51.

[3] Chamberland S, Proffit WR. Short-term and long-term stability of surgically assisted rapid palatal expansion revisited. American Journal of Orthodontics and Dentofacial Orthopedics. 2011; 139: 815–822.e1.

[4] Iwasaki T, Papageorgiou SN, Yamasaki Y, Ali Darendeliler M, Papadopoulou AK. Nasal ventilation and rapid maxillary expansion (RME): a randomized trial. European Journal of Orthodontics. 2021; 43: 283–292.

[5] Lo Giudice A, Ronsivalle V, Lagravere M, Leonardi R, Martina S, Isola G. Transverse dentoalveolar response of mandibular arch after rapid maxillary expansion (RME) with tooth-borne and bone-borne appliances. The Angle Orthodontist. 2020; 90: 680–687.

[6] Alqahtani HM, Togoo RA, Ain TS, Alshahrani AS, Asiri RM, Alkahtani ZM, *et al*. Correlation between head circumference and mesio-distal width of the maxillary central incisor: a cross sectional study among three different population groups. Journal of Clinical Pediatric Dentistry. 2023; 47: 59-63.

[7] Minervini G, Franco R, Marrapodi MM, Fiorillo L, Cervino G, Cicciù M. Economic inequalities and temporomandibular disorders: a systematic review with meta-analysis. Journal of Oral Rehabilitation. 2023; 50: 715–723.

[8] Lagravere MO, Major PW, Flores-Mir C. Long-term dental arch changes after rapid maxillary expansion treatment: a systematic review. The Angle orthodontist. 2005; 75: 155–161.

[9] Lanteri V, Cossellu G, Gianolio A, Beretta M, Lanteri C, Cherchi C, *et al*. Comparison between RME, SME and leaf expander in growing patients: a retrospective postero-anterior cephalometric study. European Journal of Paediatric Dentistry. 2018; 19: 199–204.

[10] Qazi N, Pawar M, Padhly PP, Pawar V, D'Amico C, Nicita F, *et al*. Teledentistry: Evaluation of Instagram posts related to bruxism. Technology and Health Care. 2023; 31: 1923-1934.

[11] dos Santos BM, Stuani AS, Stuani AS, Faria G, Quintao CC, Sasso Stuani MB. Soft tissue profile changes after rapid maxillary expansion with a bonded expander. The European Journal of Orthodontics. 2012; 34: 367–373.

[12] Kanomi R, Deguchi T, Kakuno E, Takano-Yamamoto T, Roberts WE. CBCT of skeletal changes following rapid maxillary expansion to increase arch-length with a development-dependent bonded or banded appliance. The Angle Orthodontist. 2013; 83: 851–857.

[13] Minervini G, Franco R, Marrapodi MM, Ronsivalle V, Shapira I, Cicciù M. Prevalence of temporomandibular disorders in subjects affected by Parkinson disease: a systematic review and metanalysis. Journal of Oral Rehabilitation. 2023: 50: 877–885.

[14] Akan B, Gökçe G, Şahan AO, Veli İ. Tooth-borne versus tooth-bone-borne rapid maxillary expanders according to a stereophotogrammetric evaluation of facial soft tissues: a randomized clinical trial. Orthodontics & Craniofacial Research. 2021; 24: 438–448.

[15] Chung C, Font B. Skeletal and dental changes in the sagittal, vertical, and transverse dimensions after rapid palatal expansion. American Journal of Orthodontics and Dentofacial Orthopedics. 2004; 126: 569–575.

[16] Torun GS. Soft tissue changes in the orofacial region after rapid maxillary expansion: a cone beam computed tomography study. Journal of Orofacial Orthopedics. 2017; 78: 193–200.

[17] Farfel V, Morea GC, Ferreira LM, Pereira MD. Evaluation of sagittal and vertical changes in maxillary dental, skeletal, and soft tissue following surgically assisted rapid maxillary expansion: a retrospective longitudinal study. The Journal of Craniofacial Surgery. 2022; 33: e398–e401.

[18] Lanteri V, Gianolio A, Gualandi G, Beretta M. Maxillary tridimensional changes after slow expansion with leaf expander in a sample of growing patients: a pilot study. European Journal of Paediatric Dentistry. 2018; 19: 29–34.

[19] Truong CT, Jeon HH, Sripinun P, Tierney A, Boucher NS. Short-term and long-term effects of rapid maxillary expansion on the nasal soft and hard tissue. The Angle Orthodontist. 2021; 91: 46–53.

[20] Aras I, Ölmez S, Akay MC, Günbay T, Aras A. The effects of maxillary expansion on the soft tissue facial profile. Journal of Istanbul University Faculty of Dentistry. 2017; 51: 1–10.

[21] Nada RM, van Loon B, Maal TJJ, Bergé SJ, Mostafa YA, Kuijpers-Jagtman AM, *et al*. Three-dimensional evaluation of soft tissue changes in the orofacial region after tooth-borne and bone-borne surgically assisted rapid maxillary expansion. Clinical Oral Investigations. 2013; 17: 2017–2024.

[22] Gao J, Wang X, Qin Z, Zhang H, Guo D, Xu Y, *et al*. Profiles of facial soft tissue changes during and after orthodontic treatment in female adults. BMC Oral Health. 2022; 22: 257.

[23] Nedeljkovic N, Cubrilo D, Hadzi-Mihailovic M. Changes in soft tissue profile following the treatment using a Herbst appliance: a photographic analysis. Vojnosanitetski Pregled. 2014; 71: 9–15.

[24] Jaiswal P, Gandhi A, Gupta AR, Malik N, Singh SK, Ramesh K. Reliability of photogrammetric landmarks to the conventional cephalogram for analyzing soft-tissue landmarks in orthodontics. Journal of Pharmacy and Bioallied Sciences. 2021; 13: S171–S175.

[25] Londoño A, Assis M, Fornai C, Greven M. Premolar extraction affects mandibular kinematics. European Journal of Dentistry. 2022. [Preprint].

[26] Mora-Zuluaga N, Soto-Llanos L, Aragón N, Torres-Trujillo K. Relationship of malocclusions with disorders of the temporomandibular joint in children of CALI—Colombia. European Journal of Dentistry. 2022; 16: 781–786.

[27] Soh J, Wang ZD, Zhang WB, Kau CH. Smile attractiveness evaluation of patients selected for a U.S.—based board certification examination. European Journal of Dentistry. 2021; 15: 630–638.

[28] Tiro A, Nakas E, Arslanagic A, Markovic N, Dzemidzic V. Perception of dentofacial aesthetics in school children and their parents. European Journal of Dentistry. 2021; 15: 13–19.

[29] Gül A, de Jong MA, de Gijt JP, Wolvius EB, Kayser M, Böhringer S, *et al*. Three-dimensional soft tissue effects of mandibular midline distraction and surgically assisted rapid maxillary expansion: an automatic stereophotogrammetry landmarking analysis. International Journal of Oral and Maxillofacial Surgery. 2019; 48: 629–634.

[30] Öztürk SA, Malkoç S, Yolcu Ü, İleri Z, Güler ÖÇ. Three-dimensional soft tissue evaluation after rapid maxillary expansion and mandibular midline distraction osteogenesis. The Angle Orthodontist. 2021; 91: 634–640.

[31] Nguyen H, Shin JW, Giap H, Kim KB, Chae HS, Kim YH, *et al*. Midfacial soft tissue changes after maxillary expansion using micro-implant-supported maxillary skeletal expanders in young adults: a retrospective study. Korean Journal of Orthodontics. 2021; 51: 145–156.

[32] Spagnuolo G. Cone-beam computed tomography and the related scientific evidence. Applied Sciences. 2022; 12: 7140.
[33] Kochhar AS, Sidhu MS, Prabhakar M, Bhasin R, Kochhar GK, Dadlani H, *et al*. Intra- and interobserver reliability of bone volume estimation using OsiriX software in patients with cleft lip and palate using cone beam computed tomography. Dentistry Journal. 2021; 9: 14.
[34] Dindar M, Açıkgöz-Alparslan E, Tekbaş-Atay M. Radiographic evaluation of marginal bone height and density around overhanging dental restorations. The International Journal of Periodontics & Restorative Dentistry. 2022; 42: 401–408.
[35] Büyükgöze Dindar M, Tekbaş Atay M. The effect of toothbrush abrasion on wear and surface roughness of direct and indirect composite laminate veneer restorations. Surface Topography: Metrology and Properties. 2020; 8: 035007.
[36] Lo AL, Hallac RR, Chen SH, Hsu KH, Wang SW, Chen CH, *et al*. Craniofacial growth and asymmetry in newborns: a longitudinal 3D assessment. International Journal of Environmental Research and Public Health. 2022; 19: 12133.
[37] Erten O, Yilmaz BN. Three-dimensional imaging in orthodontics. Turkish Journal of Orthodontics. 2018; 31: 86–94.
[38] Marcu M, Hedesiu M, Salmon B, Pauwels R, Stratis A, Oenning ACC, *et al*. Estimation of the radiation dose for pediatric CBCT indications: a prospective study on ProMax3D. International Journal of Paediatric Dentistry. 2018; 28: 300–309.
[39] Reddy LKV, Madithati P, Narapureddy BR, Ravula SR, Vaddamanu SK, Alhamoudi FH, *et al*. Perception about Health Applications (Apps) in Smartphones towards Telemedicine during COVID-19: A Cross-Sectional Study. Journal of Personalized Medicine. 2022; 12: 1920.
[40] Shetty A, Ratti S, Nakra P, Shetty S, Mohammed A, Saidath K. Evaluation of soft tissue and airway changes in individuals treated with mini-implant assisted rapid palatal expansion (MARPE). Journal of Long-Term Effects of Medical Implants. 2022; 32: 7–18.
[41] Rathi S, Chaturvedi S, Abdullah S, Rajput G, Alqahtani NM, Chaturvedi M, *et al*. Clinical Trial to Assess Physiology and Activity of Masticatory Muscles of Complete Denture Wearer Following Vitamin D Intervention. Medicina (Kaunas). 2023; 59: 410.
[42] Akbulut S, Yilmaz S, Yagci A. Comparison of the short-term effects of facemask therapy preceded by conventional rapid maxillary expansion or by an alternate rapid maxillary expansions and constrictions protocol: a retrospective study. Journal of Orofacial Orthopedics. 2022. [Preprint].
[43] Sfondrini MF, Gallo S, Pascadopoli M, Licari A, Marseglia GL, Gandini P, *et al*. The knowledge of orthodontic and craniofacial growth amongst Italian Pediatric Medical Residents for early diagnosis in growing patients: a cross-sectional study. Journal of Clinical Pediatric Dentistry. 2023; 47: 64-73.
[44] D'Addazio G, Xhajanka E, Cerone P, Santilli M, Rexhepi I, Caputi S, *et al*. Traditional removable partial dentures versus implant-supported removable partial dentures: a retrospective, observational oral health-related quality-of-life study. Prosthesis. 2021; 3: 361–369.
[45] Arnould A, Hendricusdottir R, Bergmann J. The complexity of medical device regulations has increased, as assessed through data-driven techniques. Prosthesis. 2021; 3: 314–330.
[46] Pugliese A, Cataneo E, Fortunato L. Construction of a removable partial denture (RPD): comparison between the analog procedure and the selective laser melting procedure. Prosthesis. 2021; 3: 428–436.
[47] Lee J, Bae SR, Noh HK. Commercial artificial intelligence lateral cephalometric analysis: part 2-effects of human examiners on artificial intelligence performance, a pilot study. Journal of Clinical Pediatric Dentistry. 2023; 47: 130-141.
[48] Kokich VO, Asuman Kiyak H, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. Journal of Esthetic and Restorative Dentistry. 1999; 11: 311–324.
[49] Silva B, Jimenez-Castellanos E, Martinez-de-Fuentes R, Greenberg J, Chu S. Laypersons' perception of facial and dental asymmetries. The International Journal of Periodontics & Restorative Dentistry. 2013; 33: e162–e171.
[50] Naini FB, Donaldson ANA, McDonald F, Cobourne MT. Assessing the influence of chin prominence on perceived attractiveness in the orthognathic patient, clinician and layperson. International Journal of Oral and Maxillofacial Surgery. 2012; 41: 839–846.

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