Effects of Surgical and Nonsurgical Rapid Maxillary Expansion on Palatal Structures

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Aim: The aim of the present study was to compare the effects of surgical and nonsurgical rapid maxillary expansion (RME) in skeletally mature patients.

Materials and methods: Surgically assisted rapid maxillary expansion (SARME) was used in 18 patients (2 males, 16 females) with a mean age of 19.90 years. Two nonsurgical RME groups were constructed to compare the expansion changes of SARME. Eighteen patients in maximum pubertal peak (12 males, 6 females) with a mean age of 13.04 years comprised the growing RME group, while the nongrowing RME (NG-RME) group consisted of 18 skeletally mature patients (1 male, 17 females) with a mean age of 16.41 years. Thirteen linear and 2 angular measurements were made on the study models taken before expansion (T0) and after 3 months of retention period (T1). Intragroup differences were evaluated with paired *t* test and the intergroup differences were analyzed with 1-way analysis of variance.

Results: All groups showed significant transversal skeletal and dental expansion. The palatal width changes at gingival and midpalate levels were the highest in the NG-RME group (6.85 and 5.84 mm, respectively). The most molar tipping was in the NG-RME group (15.00°) and the palatal vault angle showed the most increase in the SARME group (9.77°). The greatest expansion at the base of palatal vault was in the SARME group (4.42 mm).

Conclusions: The pattern of expansion was rotation of the maxillary halves for SARME and lateral displacement of the dentoalveolar structures for NG-RME. Patients with severe skeletal discrepancy or increased age are good candidates for SARME.

Key Words: Palatal structures, rapid maxillary expansion, surgically assisted rapid maxillary expansion

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Rapid maxillary expansion (RME) is widely used to correct transverse maxillary skeletal or dental deficiency, nasal airway resistance, and skeletal Class II and III patients and to gain arch length in moderate crowding instances.[1–3] Although RME is routinely used during the growth period, the nonsurgical expansion in adult or mature adolescent patients is still questionable in the literature.[4] The studies that evaluated the effects of RME in skeletally mature patients showed more dental and less skeletal response to palatal expansion, so these studies suggested the use of surgery when skeletal expansion of the maxilla is needed.[4–6]

Bishara and Staley stated that the optimal age for expansion is before 13 to 15 years.[5] Melsen histologically showed that after the ages of 15 in girls and 17 in boys, the transverse growth of the midpalatal suture ends and the separation of the maxilla is impossible without fracturing the interdigitated 2 maxillary halves.[6] On the other hand, Malkoç et al[7] evaluated the long-term stability of semi-RME in 14 patients with a mean age of 20.09 ± 2.36 years and found stable dental and skeletal transversal measurements after 5 years of follow-up period. Handelman et al[8] showed successful nonsurgical expansion with the Haas expander in an adult sample with a mean age of 30 years and reported long-term stability of the expansion after 5.9 years of follow-up.

Undesirable side effects or results have been reported after use of RME in skeletally mature patients such as buccal tipping of posterior teeth, extrusion, periodontal tissue recession, fenestration of buccal cortex, necrosis of palatal tissue, failure in opening of midpalatal suture, pain, and relapse of expansion.[9] Surgically assisted rapid maxillary expansion (SARME) has been suggested to achieve successful transverse maxillary expansion without such complications.[3] Patients with skeletal asymmetries or patients having minimum 5 mm of transverse alveolar discrepancy are considered as good candidates for SARME.[10]

Few reports exist in the literature about the effects of nonsurgical RME in adult or skeletally mature patients.[4,7,8,11–15] Generally, transversal skeletal and dental changes are assessed with posteroanterior films and dental models in RME studies. However, these studies are limited to evaluate the changes in the palatal vault area. Contour tracings of study models can show both the level of the expansion at the palatal region and the nature of maxillary expansion.[8,13] To our knowledge, no study has compared the effects of SARME on the palatal area with conventional RME using contour tracings until the time of this writing. Therefore, the aim of our study was to evaluate the effects of SARME on palatal area, and to compare these effects with growing RME (G-RME) and nongrowing RME (NG-RME) patients.

MATERIALS AND METHODS

The patients indicated for maxillary expansion were included in this study.

Patient selection criteria were as follows:

1. Bilateral posterior skeletal crossbite
2. The absence of cleft lip and palate or other craniofacial anomalies

TABLE 1. The Mean, Standard Deviations, and Minimum and Maximum Values of the Ages of the Patients in Study Groups

		Chronological Age (y)			
Groups	N	D	SD	Min	Max
G-RME	18; ♀: 6, ♂: 12	13.04	1.02	11.40	14.90
NG-RME	18; ♀: 17, ♂: 1	16.41	0.83	15.40	17.60
SARME	18; ♀: 16, ♂: 2	19.90	2.69	17.50	26.30

D, mean; G-RME, growing rapid maxillary expansion; Max, maximum; Min, minimum; NG-RME, nongrowing rapid maxillary expansion; RME, rapid maxillary expansion; SARME, surgically assisted rapid maxillary expansion; SD, standard deviation.

3. No requirement of future orthognathic surgery
4. Good oral hygiene and healthy periodontal structures
5. No previous history of orthodontic treatment or expansion
6. Good quality of dental casts for pre-expansion and postexpansion evaluation

Three study groups were constructed to evaluate the dentoskeletal changes after RME with and without being surgically assisted (Table 1). No untreated age-matched control group was used due to ethical reasons. Skeletal maturity was determined from hand–wrist films according to Helm et al.[16] Surgically assisted rapid maxillary expansion was applied to the skeletally mature patients having >5-mm transversal skeletal crossbite.

Growing Expansion Group

Eighteen patients (12 males, 6 females) with a mean age of 13.04 ± 1.02 years (range: 11.40–14.90 years) comprised the early RME group. All patients in this group were in MP_3cap stage, indicating that the skeletal maturation was at the peak. A full-coverage bonded expansion appliance with hyrax screw (G&H Wire Company, Franklin, IN) was used for RME (Fig. 1B). The appliance was activated for 2 turns/d, and when the separation of the midpalatal suture was observed from occlusal films, the rate of the expansion was decreased to 1 turn/d. The activation was ceased after enough maxillary expansion was achieved. The expansion appliances were kept in the mouth for retention at least for 3 months, bonded for the first month and removable for the next 2 months.

Nongrowing Expansion Group

Twenty patients were indicated for RME, but 2 patients felt pain and discomfort during RME and were treated with SARME. So, the NG-RME group consisted of 18 patients (1 male, 17 females) with a mean age of 16.41 ± 0.83 years (range: 15.40–17.60 years). All patients were in Ru stage representing the termination of growth. Same expansion appliance and similar expansion and retention protocols of the G-RME group were used for NG-RME patients. As determined from occlusal films, the midpalatal suture was also opened in all patients of this group (Fig. 1D-E).

Surgically Assisted Rapid Maxillary Expansion Group

The SARME group was composed of 18 patients (2 males, 16 females) with a mean age of 19.90 ± 2.69 years (range: 17.50–26.30 years). A tooth-borne, fixed palatal expansion appliance with hyrax screw was used (Fig. 2B). The first premolar and first molar teeth were banded for soldering the arms of the expansion screws, and the appliance was cemented 1 or 2 days before the surgery.

Surgical Procedure

All of the operations were performed by the same surgical team (AA and EK). The surgical protocol was done with piezoosteotomy (Piezosurgery, Mectron Medical Technology, Carasco, Italy) under local anesthesia. Bilateral incisions were made in the depth of the buccal vestibule from the region of the distal aspect of the canine to the mesial aspect of the first molar, and maxillary osteotomies were achieved through the cortical bone from the pyriform rim to the pterygomaxillary fissure. After finishing the incisions of the mucosa between the apices of the central incisors, a sagittal osteotomy was performed interdentally between the roots of the upper central incisors through the posterior nasal spin using a piezosurgical saw tip and with subsequent posterior malleting of an osteotome. A curved osteotome was used to release the pterygoid plates in 8 patients and pterygoid plates were not separated in 10 patients. These 2 groups were compared by the same measurements of this study in a previous study.[17] No statistically significant difference was found between 2 groups, so the data were pooled and a total of 18 patients served as the SARME group of this study.

After activation of the appliance with a total widening of 1.5 mm, symmetric expansion was evaluated and the soft tissues were closed. All of the patients were discharged from the hospital on the same day and were prescribed antibiotic, anti-inflammatory, and analgesic drugs together with chlorhexidine. The expansion was initiated after 5 days of surgery, and the expanders were activated 2 turns/d. When enough expansion was achieved, the appliances remained in situ average for 4 months for retention (Fig. 2).

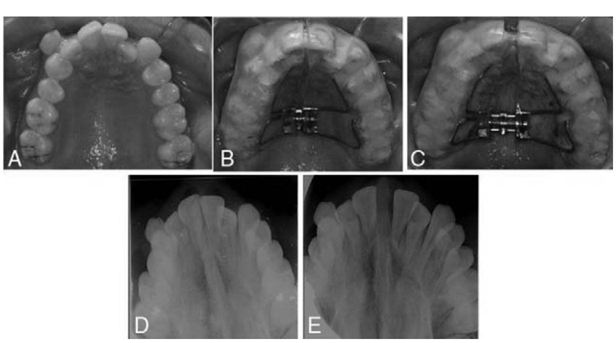

FIGURE 1. Rapid maxillary expansion of a 17-year 4-month-old male patient: (A) before expansion, (B) the full-coverage bonded expansion appliance with hyrax screw, (C) after expansion, (D) occlusal film before expansion, and (E) occlusal film after expansion.

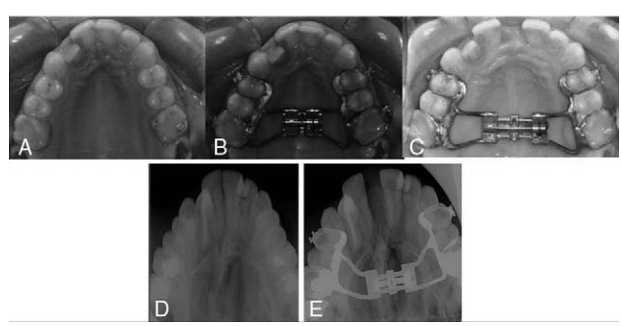

FIGURE 2. Surgically assisted rapid maxillary expansion of a 21-year 3-month-old female patient: (A) occlusal intraoral photograph before expansion; (B) the tooth-borne, fixed palatal expansion appliance with hyrax screw; (C) after expansion; (D) occlusal film before expansion; and (E) occlusal film after expansion.

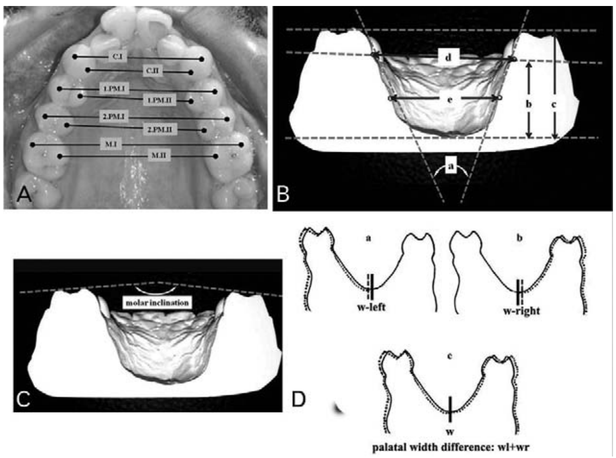

FIGURE 3. (A–D) Measurements on study models.

Measurements

The study models were obtained before expansion (T0) and after at least 3 months of retention period (T1). Thirteen linear and 2 angular measurements were made. Direct measurements on the study models were taken to the nearest 0.1 mm with vernier calipers. All measurements were performed by 1 author (BK). Maxillary dental arch widths of canine, first and second premolar, and first molar teeth were measured between left and right vestibular and palatal cusp tips (Fig. 3A). Palatal contour tracings were achieved as described by Handelman[8,13] previously (Table 2) (Fig. 3B-D).

Statistical Analysis

All statistical analyses were performed using the Statistical Package for Social Sciences software package (for Windows 98, version 10.0; SPSS Inc, Chicago, IL). For each variable, the arithmetic mean and standard deviation were calculated. When the P value was <0.05, the statistical test was determined to be significant. Intragroup differences were evaluated with paired t test

TABLE 2. Description of the Measurements and Contour Tracings Used for This Study (Fig. 3)

Measurements	Description
(a) Palatal vault angle (Fig. 3B)	The intersecting lines tangent to the middle two-thirds of the right and left palatal surfaces
(b) Palatal depth from the gingival height (Fig. 3B)	The shortest distance between the midpalatal raphe and the line connecting the points on the gingival crest of the first molars
(c) Palatal depth from the molar cusp (Fig. 3B)	The shortest distance from the midpalatal raphe to a line connecting the occlusal surfaces of the first molars
(d) Palatal width at the gingival height (Fig. 3B)	The distance between the first molars at the level of the palatal gingiva
(e) Palatal width at midpalate (Fig. 3B)	The distance between the halfway points of the gingival height line and the deepest point of the palatal vault
Maxillary first molar axial angulation (Fig. 3C)	The angle formed between the intersecting lines of the mesial buccal and mesial lingual cusp tips of both the right and left first molars
Palatal width difference (Fig. 3D)	The palatal contour tracings of T0 and T1 initially were superimposed on the left palatal outline and then on the right palatal outline while remaining parallel to the occlusal plane. The displacements of the midpalatal raphe for right and left sides were summed and the total amount of palatal width difference was measured

and the intergroup differences were analyzed with 1-way analysis of variance.

Method Error

All measurements were repeated by the same investigator 1 month later. Reliability coefficients were found to yield sufficient reliability for both linear and angular (0.90–0.97) measurements.

RESULTS

No paresthesia, sinus healing complications, root resorption, or loss of tooth vitality was observed in the study groups. A minor postoperative nosebleed occurred in only 1 SARME patient with pterygomaxillary disjunction. Postoperative pain was minimal in all patients, and none of the patients reported excessive discomfort.

Surgically assisted rapid maxillary expansion patients exhibited significantly lower dental and skeletal transversal dimensions than RME patients before expansion (Table 3). All expansion groups showed significant increases at all transversal and angular measurements ($P < 0.001$) (Table 4).

Comparison of Growing Rapid Maxillary Expansion, Nongrowing Rapid Maxillary Expansion, and Surgically Assisted Rapid Maxillary Expansion Differences After Expansion

Dental Measurements

The highest dental transversal width increases were found in SARME patients (Table 5). All differences between expansion groups were statistically significant ($P < 0.05$), except the distances between left and right palatal cusp tips of canine and molar teeth. The most significant molar tipping was measured in the NG-RME group ($15.00^\circ \pm 11.25^\circ$), followed by SARME patients ($11.28^\circ \pm 8.35^\circ$), while RME in growing patients caused the least molar inclination ($9.95^\circ \pm 4.85^\circ$). The differences between expansion groups were significant ($P < 0.05$).

Skeletal Measurements

The highest palatal width changes after maxillary expansion at both the gingival height and midpalate levels were found in the NG-RME group (6.85 ± 3.20 and 5.84 ± 3.11 mm, respectively).

The palatal vault angle showed the most significant increase in the SARME group ($9.77^\circ \pm 5.95^\circ$), while $6.55^\circ \pm 2.61^\circ$ increase in G-RME patients indicates more parallel displacement of maxillary halves compared with other groups following expansion. The amount of vertical molar teeth displacement between expansion groups was nonsignificant.

The expansion at the level of the palatal vault was 4.38 ± 1.28 mm for the G-RME group, 3.17 ± 1.35 mm for the NG-RME group, and 4.42 ± 1.23 mm for the SARME group, and the differences between NG-RME patients and other RME groups were significant ($P < 0.05$).

DISCUSSION

Different methods can be used to evaluate skeletal maturity, such as dental development and eruption, cervical vertebral maturation, and skeletal maturation of hand–wrist films, as used for our study. All patients in NG-RME and SARME groups were in Ru stage indicating termination of growth in height according to Helm et al,[16] and for the G-RME group, all patients were in MP_3cap stage representing maximum growth spurt. As few studies were found in the literature about RME in nongrowing or adult patients, no study exists in the literature that compares the effects of SARME on

TABLE 3. Comparison of Study Groups Before Expansion

Measurements	G-RME (T0)		NG-RME (T0)		SARME (T0)		Test	G-RME Versus NG-RME	G-RME Versus SARME	NG-RME Versus SARME
	Mean	SD	Mean	SD	Mean	SD				
C.I (mm)	33.54	2.04	34.78	4.17	30.84	2.77	**	NS	**	**
C.II (mm)	27.91	2.14	28.43	3.43	24.88	2.26	***	NS	***	***
1.PM.I (mm)	39.06	2.91	39.05	3.92	35.89	3.15	**	NS	**	**
1.PM.II (mm)	28.98	2.80	28.66	3.30	26.07	2.99	*	NS	*	*
2.PM.I (mm)	44.59	3.29	44.21	3.94	41.38	3.56	*	NS	*	*
2.PM.II (mm)	34.44	3.33	33.79	3.62	31.87	3.89	NS	NS	NS	NS
M.I (mm)	49.55	3.45	50.89	4.21	46.81	3.41	**	NS	**	**
M.II (mm)	38.31	3.40	39.59	4.20	35.61	2.80	**	NS	**	**
a (°)	64.72	5.02	60.22	9.71	64.27	11.66	*	*	NS	*
b (mm)	15.18	2.03	17.11	1.40	15.72	2.46	*	*	NS	*
c (mm)	19.98	2.13	20.36	1.27	19.43	2.03	NS	NS	NS	NS
d (mm)	32.44	3.35	34.44	5.01	30.72	3.04	*	NS	NS	*
e (mm)	21.53	2.99	27.21	7.15	20.00	4.00	***	***	NS	***
Molar inclination (°)	160.83	7.00	165.83	7.52	161.66	11.49	NS	NS	NS	NS

G-RME, growing rapid maxillary expansion; NG-RME, nongrowing rapid maxillary expansion; NS, nonsignificant; RME, rapid maxillary expansion; SARME, surgically assisted rapid maxillary expansion; SD, standard deviation.

*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

the palatal area with those of conventional RME using contour tracings. Therefore, this study was aimed to evaluate and to compare the dentoskeletal changes after surgical and nonsurgical rapid expansion at the palate.

Maxillary Expansion at Different Stages of Growth

Age has been utilized generally as a basic criterion for indicating the patients for the use of SARME or RME in the correction of transversal constriction of the maxilla,[9] or for considering the prognosis of the expansion in the long term.[11] Histological examination of the midpalatal suture showed that in the adolescent stage (13 and 14 years of age), the suture was wavier with increased interdigitation, and in the adult stage, the suture showed synostosis and numerous bony bridge formations.[6,18,19] Because the midpalatal suture begins to fuse with advanced age and becomes rigid in mature patients, general opinion for ideal timing to obtain maximum skeletal and stable expansion is before maximum growth spurt.

TABLE 4. Comparison of Pre-Expansion and Postexpansion Measurements of the Patients in the Study Groups

Measurements	G-RME (T0)		G-RME (T1)		Test	NG-RME (T0)		NG-RME (T1)		Test	SARME (T0)		SARME (T1)		Test
	Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
C.I (mm)	33.54	2.04	39.06	2.30	***	34.78	4.17	39.31	4.41	***	30.84	2.77	35.28	2.66	***
C.II (mm)	27.91	2.14	32.87	2.20	***	28.43	3.43	33.24	3.65	***	24.88	2.26	29.47	2.44	***
1.PM.I (mm)	39.06	2.91	44.92	3.40	***	39.05	3.92	45.45	4.83	***	35.89	3.15	43.45	2.51	***
1.PM.II (mm)	28.98	2.80	35.11	3.37	***	28.66	3.30	34.80	4.60	***	26.07	2.99	34.14	3.35	***
2.PM.I (mm)	44.59	2.30	50.78	3.98	***	44.21	3.94	50.97	4.61	***	41.38	3.56	49.03	2.76	***
2.PM.II (mm)	34.44	3.33	40.94	3.99	***	33.79	3.62	40.58	4.50	***	31.87	3.89	39.86	3.85	***
M.I (mm)	49.55	3.45	55.52	3.76	***	50.89	4.21	57.24	4.47	***	46.81	3.41	54.37	2.98	***
M.II (mm)	38.31	3.41	45.04	3.75	***	39.59	4.20	46.69	3.99	***	35.61	2.80	43.05	2.44	***
a (°)	64.72	5.02	71.27	5.20	***	60.22	9.71	67.50	12.90	***	64.27	11.66	74.06	12.61	***
b (mm)	15.18	2.03	14.82	2.05	NS	17.11	1.40	17.31	1.51	NS	15.72	2.46	16.11	2.39	NS
c (mm)	19.98	2.13	19.24	2.12	NS	20.36	1.27	20.40	1.53	NS	19.43	2.03	18.86	2.22	**
d (mm)	32.44	3.35	38.06	3.88	***	34.44	5.01	41.30	4.67	***	30.72	3.04	36.50	3.07	***
e (mm)	21.53	2.99	26.69	3.71	***	27.21	7.15	33.06	7.76	***	20.00	4.00	24.03	4.42	***
Molar inclination (°)	160.83	7.00	150.89	8.68	***	165.83	7.52	150.83	13.42	***	161.66	11.49	150.39	17.66	***

G-RME, growing rapid maxillary expansion; NG-RME, nongrowing rapid maxillary expansion; NS, nonsignificant; RME, rapid maxillary expansion; SARME, surgically assisted rapid maxillary expansion; SD, standard deviation.

**$P < 0.01$.
***$P < 0.001$.

TABLE 5. Comparison of Expansion Differences Between Study Groups

	G-RME (T0)		NG-RME (T0)		SARME (T0)					
Measurements	Mean	SD	Mean	SD	Mean	SD	Test	G-RME Versus NG-RME	G-RME Versus SARME	NG-RME Versus SARME
C.I (mm)	5.51	1.66	4.52	3.07	4.43	1.38	*	*	*	NS
C.II (mm)	4.96	2.11	4.80	2.88	4.58	1.41	NS	NS	NS	NS
1.PM.I (mm)	5.86	1.69	6.40	3.10	7.55	2.51	*	NS	*	*
1.PM.II (mm)	6.12	1.68	6.13	3.33	8.06	2.94	*	NS	*	*
2.PM.I (mm)	6.18	1.87	6.75	3.37	7.65	1.82	*	NS	*	*
2.PM.II (mm)	6.50	1.55	6.79	3.37	7.98	3.23	*	NS	*	*
M.I (mm)	5.96	1.92	6.34	3.58	7.55	1.91	*	NS	*	*
M.II (mm)	6.73	1.89	7.09	3.06	7.44	2.53	NS	NS	NS	NS
a (°)	6.55	2.61	7.27	6.71	9.77	5.95	*	NS	*	*
b (mm)	−0.35	1.37	0.19	0.72	0.39	1.23	NS	NS	NS	NS
c (mm)	−0.73	1.50	0.03	0.87	−0.58	0.98	NS	NS	NS	NS
d (mm)	5.62	1.37	6.85	3.20	5.77	2.31	NS	NS	NS	NS
e (mm)	5.15	2.86	5.84	3.11	4.03	1.82	*	NS	*	*
Molar inclination (°)	−9.95	4.85	−15.00	11.25	−11.28	8.35	*	*	*	*
Palatal width (mm)	4.38	1.28	3.17	1.35	4.42	1.23	*	*	NS	*

G-RME, growing rapid maxillary expansion; NG-RME, nongrowing rapid maxillary expansion; NS, nonsignificant; RME, rapid maxillary expansion; SARME, surgically assisted rapid maxillary expansion; SD, standard deviation.
*$P < 0.05$.

Baccetti et al evaluated the effects of RME in patients that were before and after the skeletal maturation peak.[18] Similar with the literature, the authors found more pronounced transverse skeletal changes at the skeletal level in both maxillary and circummaxillary structures when RME was used before the peak in skeletal growth. After the pubertal growth spurt, maxillary response to expansion changed from the skeletal to the dentoalveolar level.[18] However, some studies in the literature demonstrated successful nonsurgical maxillary expansion in adults.[7,8,11,14] Malkoç et al observed suture opening determined from occlusal films in a mature sample after semi-RME with a mean age of 20.09 ± 2.36 years and dental and skeletal changes were still stable after 5 years of follow-up.[7] Handelman et al presented the results of nonsurgical expansion in 47 adult patients (mean age 30 years) and no relapse was observed after 5.9 years of retention period in 21 patients of the adult group.[8]

Handelman et al compared adult expansion patients (mean 30 years) with a child RME group (mean age 9.4 ± 1.2 years) and found similar results among their study groups.[8] Transversal width increases were 4.6 ± 2.8 mm for the molars and 5.5 ± 2.4 mm for the second premolars in the adult expansion group, while the child expansion group exhibited 5.7 ± 2.4 mm expansion for the molars and 5.7 ± 2.5 mm for the premolars. Similar with the results of Handelman et al, the growing and nongrowing expansion patients showed insignificant differences in dental transversal width changes in our study.[8] All transversal width changes of this study after expansion were higher than the results of Handelman et al, because maxillary posterior teeth were overexpanded for both NG-RME and G-RME groups, while Handelman et al obtained postexpansion material after lingual adjustment of the posterior teeth that settled to normal transversal occlusion.[8] On the other hand, all postexpansion dental transversal increases for SARME patients were significantly higher than for RME groups for molar and premolar measurements. The SARME group had the lowest transarch dimensions among study groups before treatment, so higher molar and premolar expansion values can be attributed to the more need for expansion to correct the maxillary constriction in SARME patients, compared with RME groups.

Altug-Atac et al evaluated and compared the dental and skeletal changes during RME (mean age 15.51 years) and SARME (mean age 19.01 years), and concluded that only difference between the groups was the indication for RME or SARME, depending on the age and skeletal maturation of the patient.[12] Baydas et al showed significant metabolic activity changes in the maxillofacial area during RME in young adult females (mean age 17.3 ± 0.86 years), meaning that RME has also skeletal effects on young adult patients.[15] The highest metabolic activity increases were found in the midpalatal suture, at right and left maxillary regions.[15] The results of our study supported the similar findings that nonsurgical successful maxillary expansion in young adults can be achieved with an acrylic expander covering the palatal region.

Pattern of Maxillary Expansion

Growing patients showed the least molar tipping (9.95° ± 4.85°) and the least increase in palatal vault angle (6.55° ± 2.61°) among the expansion groups. The midpalatal suture opening (4.38 ± 1.28 mm) of this group was more than that of skeletally mature patients (3.17 ± 1.35 mm), which indicates more parallel movement of maxillary halves than in the nongrowing expansion group. The most molar tipping among 3 study groups was measured in skeletally mature patients (15.00° ± 11.25°) and the most amount of midpalatal distraction was found in the SARME group (4.42 ± 1.23 mm). These results showed that mature patients with severe transversal inadequacy, increased vertical dimensions, and buccally inclined upper molars before treatment are indicated for SARME.

Handelman et al stated that the nature of expansion in adults is a result of displacement of the alveolar process that carries the teeth buccally.[8] Contour tracings of the palate used for our study confirm the findings of Handelman et al, which state that skeletal maxillary expansion is a combination of skeletal opening of midpalatal suture and lateral expansion of palatal–alveolar structures, and this lateral movement of dentoalveolar complex is more obvious in skeletally mature patients. The NG-RME group showed the most molar tipping among expansion groups, and the increases of the palatal width at both midpalatal and gingival levels were higher than those in the G-RME group. The palatal vault angle increase in the NG-

RME group (7.27° ± 6.71°), representing the buccal tipping of maxillary dentoalveolar structures, was more than the patients in maximum pubertal peak (6.55° ± 2.61°), and was similar with the adult group of Handelman et al (7.9° ± 7.8°). Işeri and Özsoy used metallic markers to evaluate the effects of maxillary expansion in older adolescents and adults (mean age 14.57 years), and the authors stated that the expansion of the maxilla is primarily due to the expansion of the maxillary dentoalveolar structures.[11] In the SARME group, the most lateral tipping of the maxillary halves (9.77° ± 5.95°) was measured among expansion groups; the first upper molars intruded 0.58 mm and buccal tipping of upper first molars was more than that in the G-RME group. These findings showed that expansion with SARME is mainly a lateral rotation of the 2 maxillary halves.

Expansion Appliance

The expansion appliances used in nonsurgical and surgical patients had different designs (full-coverage acrylic and tooth-borne banded, respectively). The banded full metal expander is more hygienic and comfortable for the surgically assisted expansion instances than full-coverage acrylic appliance, and using a full palatal coverage appliance can be contraindicated in most of SARME patients due to the extent of the surgical cuts. Koudstaal et al evaluated stability, tipping, and relapse after SARME with bone-borne and tooth-borne expanders at 12-month follow-up.[19] The transpalatal distractor and Rotterdam palatal distractor were used for bone-borne group, and, similar with our study, a fixed palatal expansion appliance with hyrax screw soldered to bands of first premolar and first molars was utilized as a tooth-borne expander. The authors found no significant difference between bone-borne and tooth-borne appliances and the tipping of the maxillary segments and changes in the retention period were equal in both groups in the long-term follow-up.[19]

Clinical Implications

Complications such as pain, swelling, edema, ulceration, gingival recession, and bite opening, and limitations such as insufficient expansion and relapse in the long term have been reported in the literature after maxillary expansion of nongrowing or adult patients.[4] Capelozza Filho et al observed pain, edema, and ulceration frequently after rapid expansion of the maxilla in nongrowing young adults.[14] Two of the 20 patients of the RME group felt pain and discomfort during expansion in our study, so these patients were indicated for SARME. On the other hand, many complications such as pain, infection, hemorrhage, gingival recession, root resorption, maxillary nerve injury, vitality loss of teeth, and sinus infection, and also some rare complications such as orbital compartment syndrome causing permanent blindness were reported in the literature after SARME.[9] Patients with severe maxillary transverse deficiency and advanced gingival recession or periodontal bone loss can be good candidates for SARME.[8] So, the orthodontist and the surgeon should make a cost-effectiveness analysis, and possible options can be shared with the patient.

CONCLUSIONS

1. Significant increases in dental and skeletal transversal dimensions were recorded in all expansion groups.
2. The nature of orthopedic maxillary expansion in skeletally mature patients is a combination of distraction of the midpalatal suture and lateral expansion of palatal–alveolar structures. Mature patients having increased molar tipping or increased vertical dimensions are contraindicated for RME.
3. Rapid maxillary expansion can be used in young adults effectively, but in severe skeletal instances or after unsuccessful expansion, SARME is the only option for the clinicians.
4. Although maxilla is expected to expand skeletally by parallel opening of the midpalatal suture with no or minimum molar tipping after surgically assisted RME, the results of this study showed that maxillary expansion with SARME is a lateral rotation of the 2 maxillary halves with some amount of molar tipping.

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