Original Article

Stability of surgically assisted rapid maxillary expansion and orthopedic maxillary expansion after 3 years' follow-up

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ABSTRACT

Objective: To evaluate the stability of surgically assisted rapid palatal expansion (SARME) and orthopedic maxillary expansion (OME) after 3 years of follow-up, and compare these changes with a control group.

Materials and Methods: The subjects of the study were divided into three groups. Group 1 was composed of 10 patients (6 males, 4 females) with a mean age of 15.51 years (range: 13.33–17.58 years) and treated with OME, Group 2 comprised 10 patients (7 males, 3 females) with a mean age of 19.01 years (range: 16.25–25.58 years) and treated with SARME. Group 3 was the control group, consisting of 10 untreated, skeletal Class 1 subjects (6 males, 4 females) with a mean age of 15.27 years (range: 13.42–17.00 years) and matched to the OME group for sex and age. Lateral cephalometric and posteroantererior films were taken before expansion (T1), postexpansion (T2), and 3 years after the retention period (T3).

Results: After OME and SARME, significant increases were observed for both dental and skeletal transverse widths ($P < .01$). After 3 years of follow-up, maxillary basal width decreased 1.35 $\pm$ 0.44 mm in the SARME group and 1.19 $\pm$ 0.41 mm in the OME group, while upper molar width decreased 2.23 $\pm$ 1.24 mm in the SARME group and 2.79 $\pm$ 1.01 mm in the OME group.

Conclusions: Both the OME and SARME procedures remained stable after 3 years of follow-up with some amount of postretention relapse, compared with the control group. (*Angle Orthod.* 2010;80:613–619.)

KEY WORDS: Expansion; OME; SARME; Stability

INTRODUCTION

The origin of a constricted maxilla can be skeletal, dental, or combination of both structures. Angell[1] first described maxillary expansion in 1860, and since then it has been used for the treatment of both skeletal and dental posterior cross bites. Rapid maxillary expansion has been used for unilateral and bilateral posterior crossbites,[2–5] skeletal Class II division 1, patients with and without maxillary constriction, skeletal or pseudo Class III patients, cleft lip and palate patients, and patients exhibiting moderate maxillary crowding to gain arch length.[2]

Krebs[6] showed that, with advancing age, more force is required, more dental tipping occurs, and less skeletal expansion can be achieved. Bishara and Staley[2] stated that the optimal age for expansion is before 13 to 15 years of age and that expansion in older patients can yield unpredictable and unstable results. Vanarsdall[7] suggested that, as sutural closure ends, maxillary expansion is generally unsuccessful because of alveolar or dental tipping with little or no basal skeletal movement. Complications such as severe pain, pressure necrosis of soft tissue, tipping and extrusion of maxillary teeth, bending of alveolar bone, uncontrolled relapse, and periodontal complications can also be observed in mature adolescent and adult patients.[7,8]

Many reasons have been suggested for the limitation of orthopedic maxillary expansion (OME) in skeletally mature patients. However, few reports have shown successful findings after nonsurgical maxillary

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Table 1. Mean (D), Standard Deviations (Sd), and Minimum (Min) and Maximum (Max) Values of Subjects' Ages in the SARME[a], OME[b], and Control Groups

Group	N		Chronological Age (year)			
			D	Sd	MIN	MAX
SARME	10	♀: 7 ♂: 3	19.01	1.22	16.25	25.58
OME	10	♀: 6 ♂: 4	15.51	1.09	13.33	17.58
Control	10	♀: 6 ♂: 4	15.27	1.43	13.42	17.00

[a] SARME indicates surgically assisted rapid palatal expansion.
[b] OME indicates orthopedic maxillary expansion.

expansion in adults, as shown in children.[9–11] Surgical procedures such as LeFort osteotomy for segmenting the maxilla to widen it in the transverse dimension and surgically assisted rapid maxillary expansion (SARME) have been suggested to eliminate possible complications after OME in adults.[9] SARME has similar indications for use with conventional expansion, such as maxillomandibular deficiency of more than 5 mm or mild crowding, or to facilitate later treatment of anteroposterior discrepancies.[2,5,12–14]

A number of studies have evaluated the long-term stability of SARME using dental cast measurements for the most part[12,15–18] which, therefore, show only dental changes. Berger et al.[19] and Byloff and Mossaz[20] used PA films to measure transverse skeletal changes and reported on a 1-year follow-up after SARME. Byloff and Mossaz[20] evaluated the skeletal changes only in a SARME group, and Berger et al.[19] compared the SARME group with an OME group, but did not use a control group. Therefore, the aim of our study was to evaluate the stability of SARME and OME after 3 years of follow-up, and compare these changes with a control group.

MATERIALS AND METHODS

The study groups consisted of 20 patients. Ten additional subjects were randomly selected from the longitudinal archive of Ankara University, Faculty of Dentistry and the Department of Orthodontics to serve as the control group. The distribution of the sample is presented in Table 1. Inclusion criteria for the maxillary expansion groups were

—the presence of at least 5 mm of bilateral posterior skeletal cross bite;
—no future orthognathic surgery required;
—no pre-expansion orthodontics performed.[21]

OME Group

The OME group was composed of 10 patients (6 males, 4 females) with a mean age of 15.51 years (range: 13.33–17.58 years) and a minimum skeletal age of 15 years, according to the Greulich and Pyle hand-wrist analysis.[22] Patients in the OME group had completed 99.2% (minimum: 98.61%, maximum: 99.8%) of their growth potential. The pretreatment ANB was –.98° ± 1.30°, indicating a skeletal Class III pattern (Tables 1 and 2).

SARME Group

The SARME group was composed of 10 patients (7 males, 3 females) with a mean age of 19.01 years (range: 16.25–25.58 years) and a minimum skeletal age of 17 years, according to the Greulich and Pyle hand-wrist analysis.[22] Of these 10 patients, 6 patients were older than 17 years and 4 patients were 17 or younger. These four patients were initially treated by OME, but their expansion procedure was continued with surgical assistance owing to discomfort, pain, or resistance to expansion. The patients in the SARME group had completed 99.51% (minimum: 99.1%, maximum: 100%) of their growth potential before treatment.[22] Their pretreatment ANB was 0.08° ± 0.67°, indicating a skeletal Class III tendency (Table 2).

Control Group

The control group consisted of 10 untreated, skeletal Class 1 subjects (6 males, 4 females) matched to the OME group for sex and age (Table 1) in order to assess the effects of normal skeletal growth changes over a 3-year follow-up period.

Surgical Procedure

Surgery was performed under local anesthesia. Bilateral incisions were made at the depth of the vestibule from the first molar area to the distal aspect of the lateral incisor. The mucoperiosteum was elevated, and the maxillary bone exposed from the piriform aperture to the pterygomaxillary fissure. After identifying the infraorbital nerve, an osteotomy was performed horizontally from the piriform aperture to the pterygomaxillary fissure well above the tooth apices. The pterygoid plates were not separated from the maxilla. An additional vertical incision was made parallel to the labial frenulum, and the maxilla was separated by malleting a thin osteotome between the central incisors at a level below the anterior nasal spine. The surgical sites were irrigated and sutured. An anterior nasal pack and pressure bandage were applied for 24 hours; and antibiotics, analgesics, and an oroantral regime were prescribed.[21]

Treatment Protocol

All patients were treated with occlusal-coverage, Hyrax-type expanders (Figure 1). In the OME group, the screws were activated immediately after bonding and in the SARME group after surgery. The activation

Table 2. Mean (D) and Standard Deviations (Sd) of the Cephalometric Values of Subjects Before Treatment in the SARME, OME, and Control Groups

Parameter		SARME		OME		Control	
		D	±Sd	D	±Sd	D	±Sd
Lateral Cephalometric Measurements							
Maxilla							
1. SNA	deg	75.28	0.94	74.57	0.96	8.020	3.21
2. N-ANS	mm	57.50	0.97	60.08	1.94	58.63	1.01
3. SN/Palatal plane	deg	10.99	0.94	11.83	1.11	11.04	1.23
Mandible							
4. SNB	deg	75.20	1.32	77.56	1.07	77.55	3.31
Maxillomandibular relations							
5. ANB	deg	0.08	0.67	−2.98	1.30	2.65	0.75
6. SN/GoMe	deg	44.09	1.91	43.77	1.14	36.80	2.62
7. Overjet	mm	1.92	0.82	−1.82	1.67	2.05	0.86
8. Overbite	mm	−1.61	1.48	1.15	0.52	2.10	1.39
Posteroanterior Cephalometric Measurements							
9. MXR-MXL	deg	66.79	2.16	62.80	0.56	70.83	1.58
10. UMOLR-UMOLL	deg	54.88	2.38	55.04	0.93	61.23	1.74
11. LMOLR-LMOLL	mm	61.60	1.46	58.62	1.46	60.88	1.24
12. MxR/cg/mXl	mm	50.61	1.24	48.93	1.41	52.71	2.01

protocol for both expansion groups was two turns a day (0.25 mm per turn). In all 20 patients, the opening of the midpalatal suture was followed using occlusal radiographs. After the desired expansion was achieved, the expander was kept on the teeth as a passive retainer for an average of about 90 days. Fixed appliance treatment was not initiated until after the postexpansion radiographs were taken so as not to affect the dentoalveolar measurements. Immediately after the expander was removed, fixed straightwire appliances were placed, and transpalatal arches were used for the remainder of the conventional orthodontic treatment period. At the end of fixed orthodontic treatment, the transpalatal arches were removed and a Hawley plate was used full time for 6 months and only at night for 6 months for a total of 12 months. The treatment then was finished.

Cephalometric Measurements

Lateral and posteroanterior cephalograms and hand-wrist films were obtained for each patient at preexpansion (T1), postexpansion (T2) and after a time period including fixed appliance treatment, a retention period of 12 months, and 3 years without retention (T3). Eight lateral cephalometric (Figure 2) and four posteroanterior (Figure 3) measurements were performed at T1, T2, and T3.

Statistics

Analysis of variance and Duncan's tests were used, respectively, to compare the cephalometric measurements of patients at T1, T2, and T3. Paired *t*-tests were also performed to analyze changes within the observation periods.

Error Study

All cephalograms were retraced 1 month later by the same examiner. No significant differences were found, and the reliability coefficients (r) ranged between 0.91 and 0.96.

RESULTS

OME-SARME-Control Group Comparison at T1–T2

Sagittal measurements. The maxilla showed posterior rotation in the SARME group (SN/palatal plane), and anterior rotation in the OME group, and the difference was significant ($P < .01$). The difference between the OME and the control group was also significant ($P < .01$) (Table 3). The most anterior displacement of the maxilla (SNA) was measured in the OME group ($2.18^\circ \pm 1.60^\circ$) ($P < .05$); this displacement was significantly different from the SARME ($P < .05$) and control groups ($P < .05$).

The SARME group exhibited significant vertical downward maxillary displacement (N-ANS) ($P < .01$), and the OME group showed vertical upward movement, which may explain the maxillary rotations in both groups. The differences among the three groups were significant (Table 3).

Bite opening (SN/GoMe) was observed both in the SARME ($P < .05$) and the OME ($P > .05$) groups, and the difference was significant between the SARME and the control groups ($P < .01$).

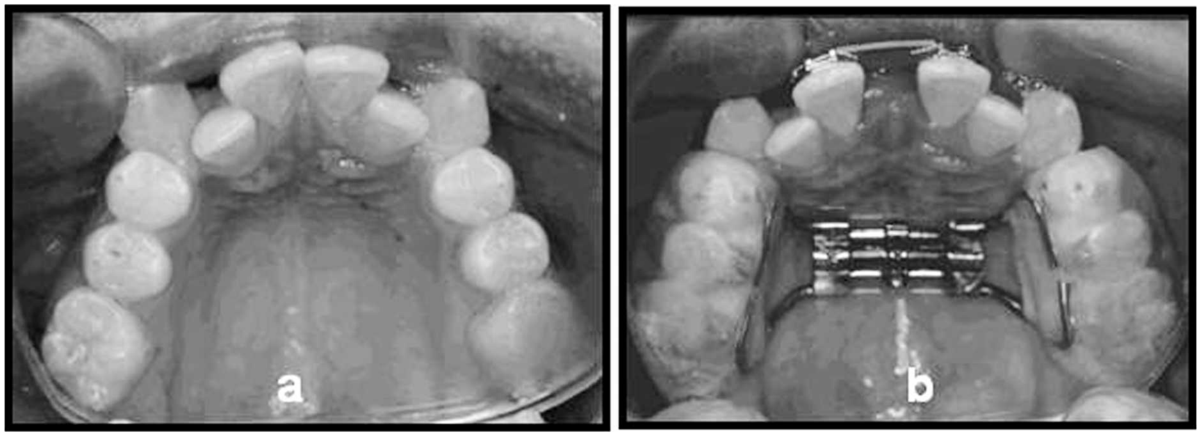

Figure 1. Intraoral photograph of the occlusal-coverage, Hyrax-type expander.

Significant decrease in SNB ($P < .05$) in the SARME group and insignificant increases were measured in both the OME and control groups. The ANB angle showed a significant increase in the OME group ($P < .05$) because of an increase in the SNB angle, and the differences in the SARME and control groups in ANB were insignificant. The significant increase in the ANB angle caused a significant increase in the overjet measurement in the OME group ($P < .05$).

Transverse measurements. The maxillary width (MxR-MxL) increased significantly in both the SARME and OME groups ($P < .01$), and both expansion groups showed significant differences compared with the control group ($P < .01$). The maxillary posterior segment exhibited significant transverse tipping (MxR/cg/MxL) in both the SARME and OME groups compared with the control group ($P < .01$). The most tipping ($P < .01$) was observed in the SARME group ($3.28^\circ \pm 0.75^\circ$) (Table 3).

The upper first molar width (UmolR-UmolL) showed significant increases in both treatment groups ($P < .01$), and the differences between the control group are significant ($P < .001$). Lower molar width (LmolR-LmolL) increased significantly in the OME group ($P < .05$).

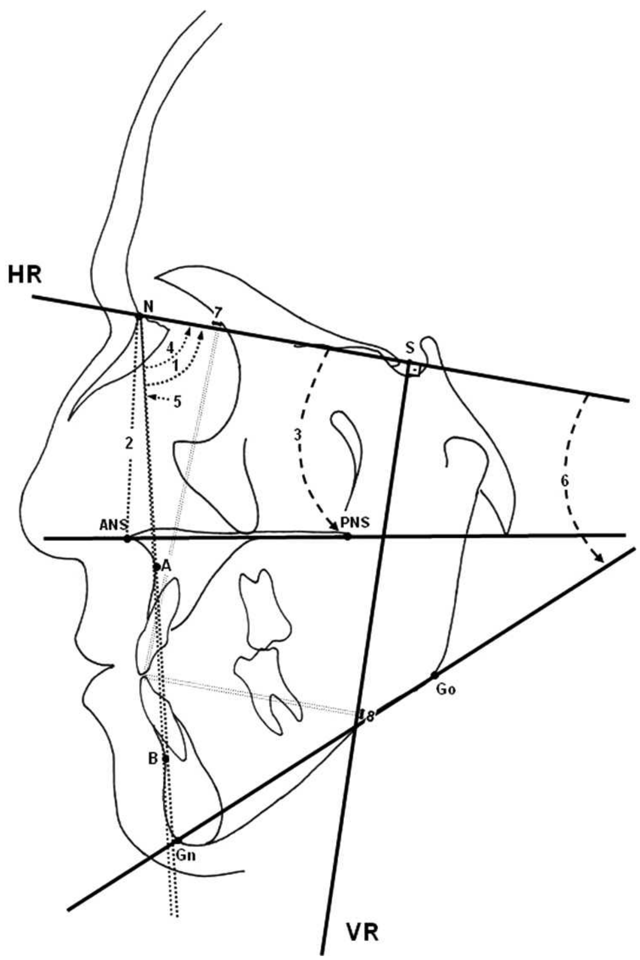

Figure 2. Lateral cephalometric measurements: SNA, SNB, ANB, N-ANS, SN/palatal plane, SN/mandibular plane, in degrees; overjet and overbite, in mm.

OME-SARME-Control Group Comparison at T2–T3

Sagittal measurements. After 3 years of follow-up, most of the lateral cephalometric measurements showed similar changes among the three groups. The SN/palatal plane angle showed a significant increase in the OME group ($2.12^\circ \pm 1.21^\circ$) ($P < .01$), and a comparison of the SARME and OME groups with the control group displayed significant differences ($P < .05$) (Table 4).

Opening of the bite continued in both expansion groups, and the differences between the SARME and OME groups and the control group were significant ($P < .05$). Overbite changes in the expansion groups were significant compared with the control group after 3 years, which might be due to compensation for the bite opening during fixed orthodontic treatment after rapid maxillary expansion.

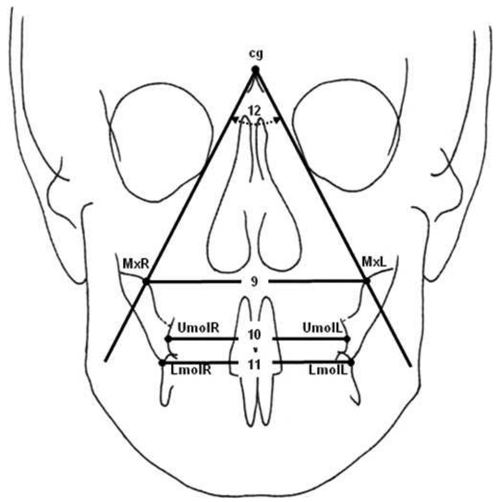

Figure 3. Posteroanterior cephalometric measurements: basal maxillary width (MxR-MxL), maxillary dentoalveolar width (UmolR-UmolL), in millimeters; mandibular dentoalveolar width (LmolR-LmolL), angles between crista galli and maxillary base points (MxR/cg/MxL).

Transverse measurements. The achieved increase in maxillary bony width (MxR-MxL) was reduced insignificantly within both expansion groups, and the amount of relapse was also not statistically significant (Table 4), but the differences between the expansion groups and the control group were significant ($P < .05$).

Relapse of the transverse tipping of maxillary halves was insignificant and similar in both expansion groups (MxR/cg/MxL), and the control group showed significant changes compared with the expansion groups ($P < .01$).

The SARME and OME groups exhibited decreases in upper molar widths, and the changes in the OME group were significant ($P < .05$). The differences between the OME group and the SARME group were significant ($P < .05$). Also, the expansion groups showed significant changes when compared with the control group ($P < .001$).

Lower molar width (LmolR-LmolL) also relapsed significantly in the OME group ($P < .05$), and insignificantly in the SARME group; the differences among the three groups were statistically significant ($P < .05$) (Table 4).

DISCUSSION

PA films were used to evaluate the transverse skeletal changes pre-expansion, postexpansion, and after 3 years of follow-up in our study. Betts et al.[14] suggested that posteroanterior cephalograms are available and reliable tools to identify and evaluate transverse skeletal discrepancies between the maxilla and the mandible. Lateral cephalometric films were also used to measure sagittal changes during the follow-up periods. Studies assessing the stability of the SARME procedure mostly used dental measurements to evaluate the long-term changes.[12,15–18] Few studies used PA films for evaluating long-term skeletal changes,[19,20] so the number of studies showing skeletal stability of SARME is limited.

The mean ANB in the OME group was $-2.98^\circ \pm 1.30^\circ$, indicating a skeletal Class III pattern, and in the SARME group, $0.08^\circ \pm 0.67^\circ$, indicating a skeletal

Table 3. Comparison of SARME, OME, and Control Groups Between T2 and T1 by Analysis of Variance (ANOVA) and Duncan Tests

Parameters		SARME		OME		Control			SARME vs	OME vs	SARME vs
		D	±Sd	D	±Sd	D	±Sd	Test	OME	Control	Control
Lateral Cephalometric Measurements											
Maxilla											
1. SNA	deg	0.18	0.36	2.18*	1.60	0.56	0.67	**	*	*	
2. N-ANS	mm	1.21**	0.28	−0.22	0.31	0.84	1.77	**	**	*	**
3. SN/Palatal Plane	deg	0.65	0.33	−1.09*	0.44	1.01	0.42	**	**	**	
Mandible											
4. SNB	deg	−0.93*	0.34	0.52	0.34	0.67	1.38	*	*		*
Maxillomandibular relations											
5. ANB	deg	1.11	0.59	1.66*	0.50	−0.11	0.77	**	*	**	**
6. SN/GoMe	deg	0.90*	0.34	0.15	0.60	−0.79	1.84	**			**
7. Overjet	mm	0.26	0.42	1.64*	0.56	−0.38	0.72	**		**	
8. Overbite	mm	1.51	1.07	0.42	0.60	−0.14	1.12				
Posteroanterior Cephalometric Measurements											
9. MxR-MxL	mm	2.45**	0.52	2.22**	0.51	0.36	0.16	***		***	***
10. UmolR-UmolL	mm	7.81**	1.01	7.38**	1.01	1.32	0.44	***		***	***
11. LmolR-LmolL	mm	0.27	0.43	1.61**	0.37	0.75	0.33	*	*	*	*
12. MxR/cg/MxL	deg	3.28**	0.75	1.08**	0.20	0.69	0.26	***	*	***	***

* $P < .05$; ** $P < .01$; *** $P < .001$; D, mean of the differences; Sd, standard deviation of mean of the differences.

Table 4. Comparison of SARME, OME, and Control Groups Between T3 and T2, by Analysis of Variance (ANOVA) and Duncan Tests

Parameter		SARME		OME		Control					
		D	±Sd	D	±Sd	D	±Sd	Test	SARME vs OME	OME vs Control	SARME vs Control
Lateral Cephalometric Measurements											
Maxilla											
1. SNA	deg	0.13	0.23	0.20	0.10	−0.12	0.11				
2. N-ANS	mm	0.17	0.13	0.11	0.14	0.13	0.07				
3. SN/Palatal plane	deg	1.15	1.18	2.12*	1.21	−0.81	0.32	*	*	*	*
Mandible											
4. SNB	deg	0.29	0.21	0.78	0.22	0.17	0.11				
Maxillomandibular relations											
5. ANB	deg	−0.11	0.17	−0.24	0.09	−0.21	0.35				
6. SN/GoMe	deg	0.63	0.28	0.35	0.44	−0.39	0.31	*		*	*
7. Overjet	mm	0.15	0.13	0.50	0.35	0.28	0.32				
8. Overbite	mm	0.29	0.27	0.55	0.21	−0.23	0.20	*		*	*
Posteroanterior Cephalometric Measurements											
9. MxR-MxL	mm	−1.35	0.44	−1.19	0.41	0.15	0.07	**		**	**
10. UmolR-UmolL	mm	−2.23	1.24	−2.79*	1.01	1.08	0.24	***	*	***	***
11. LmolR-LmolL	mm	−0.07	0.03	−0.82*	0.32	0.23	0.11	*	*	*	*
12. MxR/cg/MxL	deg	−2.17	0.34	−2.08	0.30	0.48	0.36	**		**	**

* $P < .05$; ** $P < .01$; *** $P < .001$; D, Mean of the differences; Sd, standard deviation of mean of the differences.

Class III tendency. The control group comprised skeletal Class I cases and did not match with the expansion groups by means of skeletal features, for ethical reasons.

Many authors accept patient age in choosing between the OME and SARME.[9] However, conflicting suggestions are found in the literature regarding when the OME or SARME should be used for achieving successful skeletal expansion. Timms and Vero[23] accepted 25 years as an upper limit for applying OME. Epker and Wolford[24] recommended SARME in patients over 16 years of age. Mommaerts[25] stated that OME is indicated for patients younger than 12 years and, for those over 14 years, corticotomy-assisted expansion is needed. Some of the patients in the OME group were adults or young adults, but they still had growth potential, so successful expansion was achieved in these patients. Results in the OME group support Suri and Taneja,[9] who stated that successful OME can be achieved in chronologically advanced—but skeletally immature—patients. On the other hand, OME might be unsuccessful in chronologically younger patients with advanced skeletal maturity.

Statistically significant forward displacement of the maxilla was observed only in the OME group. Altug-Ataç et al.[21] stated that this forward displacement could be explained by the occlusal coverage of the expanders, which helped unlock the occlusion and set the maxilla free in the OME patients who had a negative ANB value initially. Similar maxillary movement was observed both in the SARME and control groups after expansion. Insignificant sagittal maxillary displacement in the SARME group could be due to minimal or no growth potential of the patients. Byloff and Mossaz[20] concluded that maxillary skeletal expansion with the SARME is mainly a lateral rotation of the two maxillary halves with minimum horizontal translation, which supports our findings. All three groups showed insignificant maxillary movements in the long term.

Similar transverse maxillary skeletal increase was found in the SARME and OME groups after expansion (2.45 ± 0.52 mm and 2.22 ± 0.51 mm, respectively). In the long-term follow-up, both expansion groups exhibited 50% of skeletal maxillary relapse, and these transverse decreases were significant compared with the control group. The main maxillary skeletal transverse difference between expansion groups was maxillary transverse rotation. The SARME group showed significant lateral rotation of the maxillary halves compared with the OME group ($3.28^\circ \pm 0.75^\circ$ and $1.08^\circ \pm 0.20^\circ$, respectively), and this finding supports the idea that skeletal expansion with SARME is mainly a lateral rotation of the two maxillary halves.[20] The decrease in the transverse angular measurement was insignificant after 3 years in both expansion groups. Although some relapse was observed in the expansion groups, the total amount of skeletal transverse changes in both expansion groups exceeded that in the control group in the long term.

Different relapse rates have been reported for SARME in the literature, from 5% to about 25%,[9,18,19,25]; reported relapse rates for OME is much higher, and can be as high as 63%.[2,9,26,27] Both groups exhibited 50% decrease of skeletal maxillary transverse dimension after 3 years. Also in our study, the pterygoid plates were not separated from the maxilla and no midpalatal osteotomy was performed. Bays and Greco[18] and Northway and Meade[17] suggested not separating the maxilla from the pterygoid plates to avoid invading the pterygomaxillary junction. The authors stated that such a separation requires extreme force and usually causes the plates to fracture.[17]

The SARME and OME groups showed similar maxillary molar width increases after expansion (7.81 $\pm$ 1.01 mm and 7.38 $\pm$ 1.01 mm, respectively). Both expansion groups showed 30% decreases in transverse molar width after a follow-up period; changes in the OME group were significant. Magnusson et al.[12] concluded that relapse is most pronounced during the first 3 years after treatment and suggested retention during this period. Byloff and Mossaz[20] found a one-third decrease in lateral tipping of the molars during the retention period. Magnusson et al.[12] concluded that pterygoid detachment could not fully eliminate the posterior resistance and that buccal tipping of the molars can still be observed. Wertz[5] stated that flaring or tipping of the maxillary molars was a demonstrable and expected response to expansion. Although dental relapse in the OME group was statistically significant, both expansion groups maintained most of their transverse dental width stability after 3 years compared with the control group.

CONCLUSIONS

- Although invasive surgical protocols such as pterygoid detachment and palatal separation were not used, both skeletal and dental widths were stable after 3 years' follow-up, with some relapse.
- Overexpansion is suggested for both SARME and OME for more stable results.
- Results of this study confirm the idea that expansion with SARME is mainly a lateral rotation of the two maxillary halves.
- Increased follow-up periods may be more effective for assessing long-term changes after expansion procedures.

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