Al-Azhar Journal of Dentistry

Volume 6 | Issue 4 Article 3

Pediatric dentistry and orthodontics Issue (Pediatric Dentistry, Orthodontics)

10-1-2019

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How to Cite This Article

mahmoud, manar; Salama, Ahmad; and Ibrahim, Samir (2019) "Comparative Study of Maxillary Expansion by Alternate Rapid Maxillary Expansion and Constriction Versus Hyrax Expansion," *Al-Azhar Journal of Dentistry*: Vol. 6: Iss. 4, Article 3.
DOI: https://doi.org/10.21608/adjg.2019.6137.1054

AL-AZHAR
Dental Journal
For Girls

The Official Publication
of The Faculty of Dental
Medicine For Girls,
Al-Azhar University
Cairo, Egypt.

Print ISSN 2537-0308 • Online ISSN 2537-0316

ADJ-for Girls, Vol. 6, No. 4, October (2019) — PP. 401:408

Comparative Study of Maxillary Expansion by Alternate Rapid Maxillary Expansion and Constriction Versus Hyrax Expansion

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DOI: 10.21608/adjg.2019.6137.1054

ABSTRACT

Purpose: was to evaluate the skeletal and dental effects of maxillary expansion by alternate rapid maxillary expansions and constrictions technique in comparison to conventional RME expansion by Hyrax by using PA cephalometry. **Material and methods:** Twenty patients with constricted maxillary arch represented with an unilateral or bilateral posterior cross bite were selected with ages ranged from 12-15 years. Patients were divided randomly into two equal groups by computer aided randomization according to the protocol of expansion into (Group I): who received alternate rapid maxillary expansions and constrictions (Alt-RAMEC) protocol and (Group II): who received conventional RME protocol. **Results**: Skeletally, the Latero-Nasal Width and the Maxillary width recorded higher mean values in Alt-RAMEC group than RME group with statistical significance. Dentally, all linear and angular measurements recorded higher mean values postoperatively in Alt-RAMEC group than RME group with no statistical significance except upper inter-incisal width mesial. **Conclusions:** Alt-RAMEC protocol produces highly skeletal effects by increasing the nasal width and the maxillary width.

KEYWORDS

Alt-RAMEC protocol, Maxillary expansion, Hyrax.

INTRODUCTION

The maxillary expansion (ME) was introduced for the first time in the 19th century. Reintroduction and popularization of the maxillary expansion was in 1960s [(1)].

Maxillary expansion is utilized in correction of the narrowness of the dental arches or cross bite, elimination of dental crowding and

- Paper extracted from master thesis titled "Comparative Study of Maxillary Expansion by Alternate Rapid Maxillary Expansion and Constriction Versus Hyrax Expansion".

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increasing the size of nasal airway. One of the most popular fixed palatal expander is Hyrax (acronym of Hygienic Rapid Expander). The suggested protocol for the Hyrax expanding device is a daily aperture of 0.5 mm (half turn per day, one activation in the morning (1/4 turn) and another in the night (1/4 turn= 0.25 mm) [1].

A repetitive weekly protocol of alternate maxillary expansions and constrictions (Alt-RAMEC) is a protocol [2] for disarticulation of the circumaxillary sutures. According to this protocol, the maxilla is expanded for 7 consecutive days and constricted for 7 consecutive days for a total 7-9 weeks.[2] Many clinical studies [3,4,5] which combine this technique with facemask were done to evaluate the amount of maxillary protraction after Alt-RAMEC protocol. So the pure effects of Alt-RAMEC could not be evaluated. So, this study was designed to evaluate the pure transverse skeletal and dental effects of Alt-RAMEC protocol in comparison with RME by PA cephalometry.

MATERIAL AND METHOD

This study was conducted over 20 subjects of adolescent patients with bilaterally or unilaterally or bilaterally constricted maxillary arches, the sample contained 11 females and 9 males, with age ranged from 12ys to 15 ys. The sample was divided into two groups, the Alt-RAMEC group (N=10) subjects received Alt-RAMEC protocol. The RME group (N=10) who received the conventional rapid maxillary expansion. In Alt-RAMEC group, the Hyrax was activated 4 times per day (2 times in the morning and 2 times in the evening). The activation was for successive 7 weeks [3,6] of alternating expansion and constriction. In RME group, the Hyrax was activated 2 times per a day (in the morning and in the evening). In both groups, the overcorrection is obtained.

For all subjects taking part in the study postero-anterior cephalometry was done before the maxillary expansion (T1) and immediately after the maxillary expansion (T2).

Certain bilateral cephalometric landmarks were used in PA tracing [7]:

Skeletal landmarks

1. Lateronasal width (Ln-Ln):__The distance between 2 lateronasal points (the most lateral points on the nasal cavity).
2. Maxillary width (Mx-Mx): It is a distance the distance between 2 points located at the depth of the concavity of the lateral maxillary contour.

Dental linear landmarks

1. Maxillary inter-molar width (Um-Um): It is a distance between 2 points located laterally at the most prominent point on the buccal surface of the maxillary first permanent molars.
2. Mandibular inter-molar width (Lm-Lm): It is a distance between 2 points located at the most laterally located point on the buccal surface of the lower first molars.
3. Upper inter-incisal width mesial (Uim): The distance between the 2 most mesial points of the crowns of the maxillary central incisors.
4. The maxillary incisor width apex (Uia): It is a distance between the tips of the apex of the roots of upper central incisors.

Dental angular landmarks

1. Maxillary incisal angle (Mia) It is located between the axes of the 2 upper central incisors.
2. The maxillary right first molar-laterorbital width: It is an angle between the tangent to the maxillary right first molar and the laterorbitale width.
3. The maxillary left first molar-laterorbital width: It is an angle between the tangent to the maxillary left first molar and the laterorbital width.
4. The upper first molar angle: It is located between the tangents of the 2 upper first molars.

Statistical Analysis

The statistical analysis was done by a software program (SPSS 18; SPSS, Chicago, IL, USA).

As data was parametric, the independent t test was used to estimate the significant difference between the 2 groups.

The comparison between the pre-operative and post-operative values for each group was done by the Paired t test.

The percentage of change was calculated by the following formula:

$$\frac{\text{Value after-value before}}{\text{Value before}} \quad \text{X } 100$$

RESULTS

Results revealed a significant increase in the nasal width and the maxillary width after treatment in both the Alt-RAMEC (P=0.000 & 0.000 respectively) and RME (P= 0.000 &0.000 respectively) groups. Regarding the percent change, greater percent changes of the nasal width and the maxillary width were noted in Alt-RAMEC group which were statistically significant (P = 0.048 & 0.011 respectively).(Table 1&2)

Regarding all dental linear measurements, there was a significant increase after treatment in both the Alt-RAMEC group and the RME group. Regarding the percent change, greater percent changes were noted in Alt-RAMEC group which were statistically insignificant except the upper inter-incisal width mesial (Table 3&4).

Regarding the dental angular measurements, a significant increase was recorded in the Maxillary right first molar Later orbitale width (UR6^LO), Upper left First molar Later orbitale Width (UL6^LO) and Maxillary first molar Angle and a significant decrease in the Maxillary Incisal Angle after treatment in both groups. Regarding the percent change, greater percent a greater percent increase was recorded in the Upper right first molar Later orbitale width (UR6^LO), Upper left First molar Later orbitale Width (UL6^LO) and Maxillary first molar Angle with no significant difference. And a greater percent decrease was recorded in the Maxillary Incisal Angle with no significant difference (Table 5&6).

Table (1) *Comparison of pre-operative and post-operative values in group I & II regarding skeletal linear measurements (mm), (Paired t test).*

			Mean	**Std. Dev SD**	**Std. Error Mean**	**t**	**P**
1-Latero-Nasal Width (Ln-Ln)	Alt-RAMEC	Pre	25.65	1.03	.33	13.08	.000*
		Post	27.55	1.09	.35		
	RME	Pre	25.35	1.03	.33	15.377	.000*
		Post	27.05	.83	.26		
2-Maxillary Width (Mx-Mx)	Alt-RAMEC	Pre	57.85	1.27	.40	27.000	.000*
		Post	60.10	1.31	.41		
	RME	Pre	57.65	1.31	.42	17.335	.000*
		Post	**59.50**	**1.33**	**.42**		

M: *Mean value*, **SD:** *Standard Deviation*, *Significance level p<0.05, *significant*

Table (2) *Comparison between both groups regarding percent change in skeletal linear measurements (%), (Independent t test).*

		Mean	Std. Dev	Std. Error Mean	t	P
1-Latero-Nasal Width (Ln-Ln)	Alt-RAMEC	6.89	1.58	.50	0.85	.048*
	RME	6.31	1.37	.43		
2-Maxillary Width (Mx-Mx)	Alt-RAMEC	3.74	0.43	.13	.853	.011*
	RME	3.11	0.65	.18		

Table (3) *Comparison of pre-operative and post-operative values in group I & II regarding dental linear measurements (mm), (Paired t test).*

			Mean	Std. Dev SD	Std. Error Mean	t	P
1-Upper Inter-molar Width (Um-Um)	Alt-RAMEC	Pre	57.25	1.21	.38	23.211	.000*
		Post	64.70	1.20	.38		
	RME	Pre	57.25	1.21	.38	18.500	.000*
		Post	64.55	1.13	.36		
2-Lower Inter-molar Width (Lm-Lm)	Alt-RAMEC	Pre	58.40	1.10	.35	5.511	.000*
		Post	59.30	1.27	.40		
	RME	Pre	58.45	1.14	.36	4.881	.001*
		Post	59.20	1.23	.39		
3-Upper Inter-incisal Width mesial (Uim-Uim)	Alt-RAMEC	Pre	.80	.34	.17	-4.392	.002*
		Post	1.55	.40	.25		
	RME	Pre	.95	.30	.19	-3.772	.004*
		Post	1.65	.42	.26		
4-Upper Inter-incisal Width apex (Uia-Uia)	Alt-RAMEC	Pre	5.30	1.25	.40	5.218	.001*
		Post	6.65	1.23	.39		
	RME	Pre	5.85	1.03	.33		.000*
		Post	7.15	1.11	.35		

Table (4) *Comparison between both groups regarding percent change in dental linear measurements (%), (Independent t test).*

		Mean	Std. Dev	Std. Error Mean	t	P
1-Upper Inter-molar Width (Um-Um)	Alt RAMEC	11.43	1.46	.46		
	RME	11.37	1.85	.59	.085	.933 ns
2-Lower Inter-molar Width (Lm-Lm)	Alt RAMEC	1.26	.45	.27		
	RME	0.51	.41	.26	.667	.513 ns
3-Upper Inter-incisal Width mesial (Uim-Uim)	Alt RAMEC	48.38	31.07	8.12		
	RME	42.38	24.74	11.61	3.41	.046 *
4-Upper Inter-incisal Width apex (Uia-Uia)	Alt RAMEC	20.38	6.53	3.64		
	RME	18.14	6.14	2.57	.503	.622 ns

Table (5) *Comparison of pre-operative and post-operative values in group I & II regarding dental angular measurements (mm), (Paired t test).*

			Mean	Std. Dev	Std. Error Mean	t	P
1-Maxillary Incisal Angle	**Alt-RAMEC**	**Pre**	7.50	2.80	1.20	-3.223	.000*
		Post	3.4	2.48	.79		
	RME	**Pre**	7.85	2.80	.83	-1.684	.000*
		Post	3.95	2.63	1.20		
2-Upper right first molar Later orbitale width UR6^LO	**Alt-RAMEC**	**Pre**	92.65	2.51	.79	10.37	.000*
		Post	95.35	2.53	.80		
	RME	**Pre**	91.50	2.69	.85	7.64	.000*
		Post	93.85	2.84	.90		
3-Upper left First molar Later orbitale Width UL6^LO	**Alt-RAMEC**	**Pre**	91.95	2.63	.83	14.000	.000*
		Post	94.75	2.41	.76		
	RME	**Pre**	92.50	2.75	.87	10.24	.000*
		Post	95.15	2.82	.89		
4-Maxillary first molar Angle (Mfma)	**Alt-RAMEC**	**Pre**	7.20	1.60	.51	11.329	.000*
		Post	10.90	2.26	.71		
	RME	**Pre**	7.25	2.02	.64	16.602	.000*
		Post	10.75	2.28	.72		

Table (6) *Comparison between both groups regarding percent change in dental angular measurements (%), (Independent t test).*

		Mean	Std. Dev	Std. Error Mean	t	P
1-Maxillary Incisal Angle	Alt RAMEC	-54.66	9.14	10.74		
	RME	-49.68	8.36	9.39	.675	.051 ns
2-Upper right first molar Later orbitale width UR6^LO	Alt RAMEC	2.82	.68	.22		
	RME	2.54	.87	.27	.799	.435 ns
3-Upper left First molar Later orbitale Width UL6^LO	Alt RAMEC	3.06	.62	.20		
	RME	2.83	.70	.22	.777	.448 ns
4-Maxillary first molar Angle (Mfma)	Alt RAMEC	33.24	5.26	1.66		
	RME	32.25	6.14	1.94	.002	.998ns

DISCUSSION

The maxillary constriction and the accompanying posterior cross-bite is a very common dento-skeletal problems [8]. RME has skeletal and dental effects. Skeletally, the separation of the midpalatal suture is not the only effect of RME, but also involve the circumzygomatic and circumaxillary sutures [9]. Dentally, tipping of teeth is one of the common dental effects of RME. The Alt-RAMEC protocol of maxillary expansion is a modification of the conventional RME. This protocol can open the sagittally and coronally running circumaxillary sutures significantly more than RME [6].

The patency of the mid palatal suture was not concerned during patient selection because the mid-palatal suture does not represent the main resistance to the palatal expansion but the remaining maxillary articulations [10].

In the present study, the banded Hyrax expander was used because it has many advantages such as superior hygiene, more comfort and prevention of lesion to the palatal tissues in addition to its controlled expansion without the need of the patient's cooperation [11].

In RME group, the appliances were activated with 1/4 turn twice per day. In Alt-RAMEC group, the duration of activation and deactivation protocol was 7 weeks as it was [6] recommended that the duration of Alt-RAMEC protocol not to be less than 5 weeks because after 5 weeks of Alt-RAMEC protocol the sutures would not be opened quantitavely enough so, 7-9 weeks of Alt-RAMEC was necessary.

A diastema between the central incisors was found in all patients of RME group. In Alt-RAMEC group, the diastema appeared after the first, third, fifth and the seventh week of expansion and disappeared after the second, fourth and the sixth week of constriction.

In RME group, the maxillary width was significantly increased by (a mean value of 1.85mm). Previous studies of RME which [12] stated that the width of the maxilla was increased by a 1.11 mm in 13.4-year-old patients, whereas in another study it was [13] found that the increase was 2.81 mm in patients of 5 to11-years-old.

In Alt-RAMEC group, the maxillary width was significantly increased by (a mean value of 2.25mm). This result agrees with:

1. A study [6] was done in 2014 on a cat model,which stated that "By the increase of the expansion-rate, the Alt-RAMEC opens the circumaxillary sutures that run in a sagittal and coronal directions quantitavely more than RME".
2. A study done in 2014 [14] on a rat model which compared the pure histological effects of Alt-RAMEC protocol versus RME.

Regarding the nasal width (Ln-Ln), the mean value of the nasal width was significantly increased after treatment in both RME and Alt-RAMEC groups by (1.7, 1.9mm respectively) which agrees with other studies [15-16] . This is in agreement with the results of previous studies that recorded (1.4mm) [17] and (1.9mm) [18] increase in the nasal width. And also supported with the studies [19,20] which stated that rapid maxillary expansion is an effective approach in breathing problems as obstructive sleep apnea and it reduced the mean apnea-hypopnea index.

The increase in the mean value of the nasal width was higher in Alt-RAMEC group than RME group which agrees with the results of previous studies [21].

The (Uim-Uim) and the (Uia-Uia) increased in RME group by (0.7, 1.3mm respectively) and in Alt-RAMEC group by (0.75, 1.35mm respectively). These results mean that the dislocation of the incisors was not bodily. The lateral movement of the root apices was more than that of the crowns and thus the (Maxillary incisal angle) was decreased by (3.9°) in RME group and by (4.1°) in Alt-RAMEC group.

This was in agreement with the previous results in literature [1]. The gingival fibers (especially the

transeptal fibers) tend to keep the proximity of the crowns of the central incisors. So, the displacement of the central incisors was due to the orthopedic and orthodontic tooth movement. In both RME and Alt-RAMEC groups, there was a statistically significant increase in the mean value of the upper inter-molar width (UIM) by (7.3mm and 7.45mm respectively). These results were in agreement with the previous studies in literature [22, 23] that stated that the average of the transverse increase is 6.7mm.

It is important to mention that the maxillary halves usually do not expand in a symmetrical way. Instead, the expansion of the teeth is more widely than the expansion of bone above [24].

In RME group, *UR6^LO* was increased by 2.35° and UL6^LO was increased by 2.65°. In Alt-RAMEC group, UR6^LO was increased by 2.7° and UL6^LO was increased by 2.8°. These results agree with the other findings in literature that stated that the increase of the molar inclination could be from 1° to 24° [25].

As the results of the increase in *UR6^LO* and *UL6^LO*, the increase in *(*Mfma) is a normally expected result. It increased by (3.5°) in RME group and by (3.7°) in Alt-RAMEC group. This result is in agreement with the result of a previous study [26] that stated an increase in Mfma of about 4.15° after RME. In a previous systematic review [27] ,it was stated that at the end of expansion the buccal inclination of the anchored teeth was increased by using a heavy force.

CONCLUSION

Depending on the results of the present study, the following conclusions could be extracted:

1. The increase in the nasal width after treatment was higher in Alt-RAMEC group than RME group with a clinical significance.
2. The increase in the maxillary width after treatment was higher in Alt-RAMEC group than RME group with a clinical significance.
3. Alt-RAMEC protocol was tolerated by most of the patients in spite of the higher rate of screw opening during expansion.

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