South Eur J Orthod Dentofac Res

Orginal Article

SEJODR

Comparison of Transversal Effects of Different Expansion Protocols: Alt-RAMEC versus RME

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ABSTRACT

Introduction: Since there are no studies in the literature comparing the effects of two different expansion protocols in the transverse direction, this is both the first. Most importantly, clinicians will see which of these two protocols is more singular in the treatment of transversal problems.

Aim: The aim of our study was to assess the transversal effects of the Alt-RAMEC (Alternate Rapid Maxillary Expansion and Constriction) protocol on both craniofacial and dentoalveolar structures and to evaluate the transversal effects of the RME (Rapid Maxillary Expansion) protocol.

Materials and methods: The patients selected in our archive were divided into two groups. Group 1 included 22 patients (12 boys, 10 girls, mean age 11.61±2.11 years) treated with five weeks of Alt-RAMEC. Group 2 comprised 21 patients (11 boys, 10 girls, mean age 11.66±1.23 years) who had been treated with one week of RME. Transversal measurements were also performed on the orthodontic cast models pre- (T0) and post-treatment (T1) with a digital caliper. Internasal, interzygomatic, interjugular and intergonial width measurements were made on posteroanterior radiographs. The initial measurements and the mean changes within the groups were analyzed, applying a student's t-test.

Results: According to our study results, when the chronological age, gender distribution and initial values were evaluated, there was no statistically significant difference between the groups. Increases in the widths of intercanine, interpremolar, intermolar and alveolar base with the expansion protocols are statistically significant ($p<0.05$). There was no statistically significant change in the measurements made in the mandible in both groups ($p>0.05$). The changes in maxillary intercanine, interpremolar widths between the group 1 and 2 were statistically significant ($p<0.05$). In the posteroanterior measurements, a significant difference was found between the group1 and 2 in internasal width ($p<0.05$).

Conclusion: Alt-RAMEC and RME treatment protocols are effective in orthodontic treatment with correction of a transverse deficiency in growing subjects. 5-weeks Alt-RAMEC protocol significantly increased intercanine and interpremolar widths compared to 1-week RME.

Kale B, Buyukcavus MH. Comparison of Transversal Effects of Different Expansion Protocols: Alt-RAMEC versus RME. South Eur J Orthod Dentofac Res. 2020;7(2):43-48.

INTRODUCTION

RME treatment is usually used to improve maxillary transversal problems associated with different types of malocclusions, such as patients with Class II, Class III, or open-bite malocclusions or dental crowding.[1-7] When the problem is treated early, it provides orthopedic correction by the separation of circumaxillary sutures. The purpose of correcting maxillary transverse deficiency during mixed dentition is to increase the arch length, provide space for dental crowding, eliminate the maxillary discrepancies, and facilitate face-mask (FM) protraction.[8-10]

RME can be applied for suture mobilization before maxillary protraction, as well as to correct only transversal problems. For this purpose, it has been used for years in the treatment of skeletal Class III subjects together with face-mask.[11] Recently,

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however, it has been reported that approximately 12-15 mm of expansion is required for adequate suture mobilization in the maxilla.[12,13] Such an expansion may irritate the palatal mucosa and non-occlusion between the maxilla and the mandible. Therefore, the researchers developed the Alt-RAMEC protocol.[8]

In 2005, the Alt-RAMEC protocol was introduced by Liou for 7 to 9 weeks, expansion twice daily for 1 week and constriction twice daily for 1 week for next week. With this protocol, Liou stated that more advancement was achieved in the maxilla and more transversal expansion was achieved, which allowed sutural mobilization of the maxilla prior to protraction.[8] Subsequent studies also revealed effects on the maxilla with successful treatment with the Alt-RAMEC protocol. Its popularity is also increasing day by day.

In addition, maxillary protraction with Alt-RAMEC protocol was three times more effective to displace A-point anteriorly than with RME in adolescent Class III subjects with cleft lip and palate.[8] In other studies comparing Alt-RAMEC and RME, it was reported that Alt-RAMEC was more effective in the sagittal direction. Alt-RAMEC studies in the literature have compared sagittal effects and effects on airways.[14-21] However, no studies examine the transversal effects of the Alt-RAMEC protocol and compare it with the RME.

Our clinical study's goal was to demonstrate the transversal effects of the Alt-RAMEC protocol on both craniofacial and dentoalveolar structures and compare the transversal effects of the RME protocol.

MATERIALS AND METHODS

Ethical approval of this retrospective clinical study was obtained from of the Clinical Research Ethics Committee, Suleyman Demirel University Faculty of Medicine, Isparta, Turkey (28.05.2019/187) and parents of the patients had signed an informed consent form allowing the authors to use their data (images, cephalograms, dental casts etc.) for scientific article or presentation. The sample size was calculated based on a significance level of .05 and a power of 90%. When calculating the sample size, there were no previous transversal measurements on posteroanterior films and no comparison was performed. Yılmaz et al.'s work was taken as a reference.[21] The power analysis showed that 21 patients were needed each group for the study. One of two researchers simultaneously scanned the archives to determine the study samples according to inclusion criteria as follows: (1) presence of transverse maxillary deficiency, (2) treated 1 week RME protocol or 5 weeks Alt-RAMEC protocols, (3) acrylic bonded hyrax appliance used for expansion, (4) posteroanterior radiographs and study models taken before and after treatment, (5) landmarks were identifiable on all of the radiographs.

In our study, patients who used acrylic bonded hyrax appliance for both RME and Alt-RAMEC protocols were selected from the archive in order to eliminate the effects caused by the appliances. For the RME group, individuals with 1-week expansion were preferred. In the original Alt-RAMEC protocol, researchers suggested 7-9 weeks. However, in subsequent studies, it was reported that the effects were similar with the 5-weeks protocol.13 For this reason, a 5-weeks protocol is preferred in our clinic to reduce the treatment time. In our study, patients with post-protocol records for 5 weeks were included in the Alt-RAMEC group. Patients who underwent expansion for more than 1 week, and those with deficiency in their records after expansion, orthodontic treatment history, craniofacial syndromes and treated with different expansion appliances were excluded from our study.

Selected patients were divided into two groups. Group 1 included 22 patients (12boys, 10girls, mean age 11.61 ± 2.11years) who had been treated with 5 weeks of Alt-RAMEC. Group 2 comprised 21 patients (11boys, 10girls, mean age 11.66 ± 1.23years) who had been treated with 1 week of RME. In addition, CVM periods were evaluated by using Lamparski method, one of the lateral cephalometric radiographs (LCR) before treatment. It was observed that all individuals took part in CS2 and CS3 period and their growth development continued.

All patients had been treated by the same clinician (MHB) with bonded type Hyrax expanders with occlusal coverage. The subjects' parents performed to open the Hyarx expander screw (Leone A0620-19, Florence, Italy) twice per day for 1 week and to close it twice per day for the following week (0.20 mm per turn). This protocol was repeated for 5 consecutive weeks in Group 1. In Group 2, the Hyrax expander was opened twice a day for 1 week. After completing the activation, the patients were recorded after the expansion and the retention phase was started. T0 (pre-treatment) and T1 (after expansion protocol) posteroanterior radiographs were obtained using a standard lateral cephalometric X-ray device (Planmeca ProMax 3D Mid, Planmeca Oy, Helsinki, Finland). Transversal measurements were also performed on the study models pre- (T0) and post-treatment (T1).

Analysis of Data

Posteroanterior radiographs and study models were used to assess the transversal effects of two different expansion protocols. Posteroanterior radiographs was analyzed with Dolphin 3D software (Version 11.8, Dolphin Imaging & Management Solutions, Chatsworth, California, ABD) by the single author (BK), who was blinded to the type of protocols. Internasal, interzygomatic, interjugular and intergonial width measurements were made on posteroanterior radiographs (Figure 1) (Table1). On the study models, intercanine, intermolar, interpremolar distances and base width and arch

length in maxilla and mandible were measured with a digital caliper (Figure 2) (Table1). Intercanine width was measured from the incisal margin, and interpremolar and intermolar widths were measured from central fossas. The alveolar base's width was measured 5 mm below the gingival margin of the first molar tooth.

Statistical Analysis

Fifteen randomly selected posteroanterior radiographs were traced by the same researcher (BK) 15 days after the first evaluation. The method error was calculated using the Houston test[22], which indicated the reliability of the measurements (r≥0.961). In addition, the results of a paired t-test showed that the data were free of systematic error (p>0.05). The gender distribution in each group was tested using a Pearson chi-square test. The Shapiro-Wilks test showed normally distributed variables (p>0.05) and thus parametric tests were used for further comparisons. The changes observed in each group were analysed using the paired t-test, and the initial measurements and the mean changes within the groups were analysed using the student's t test. All statistical analyses were performed using the SPSS software package program (SPSS for Win, ver 21.0; SPSS Inc, Chicago, Ill, USA) at a significance level of p < 0.05.

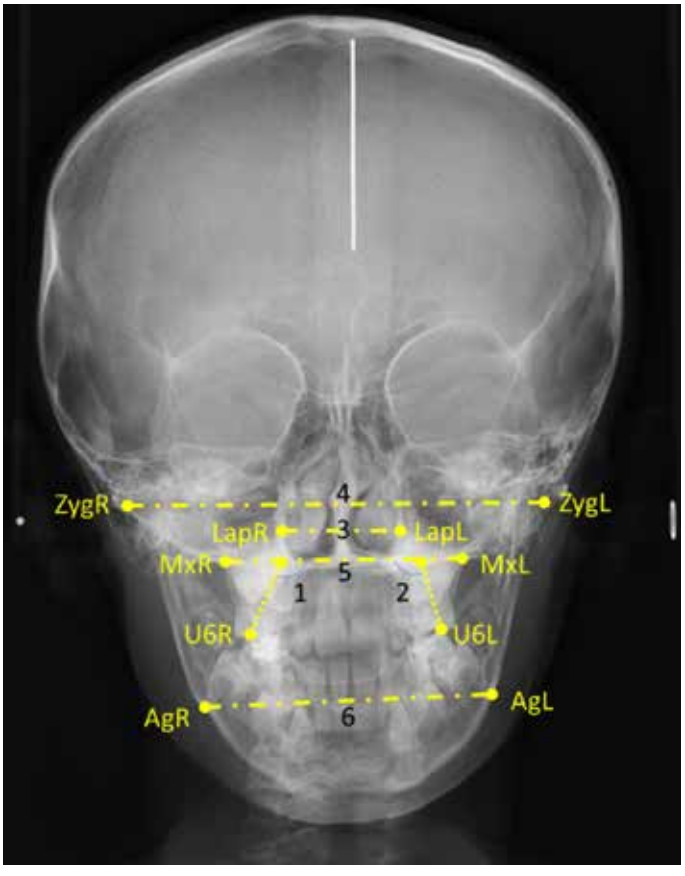

Figure 1. *Transverse measurements on posteroanterior radiographs*

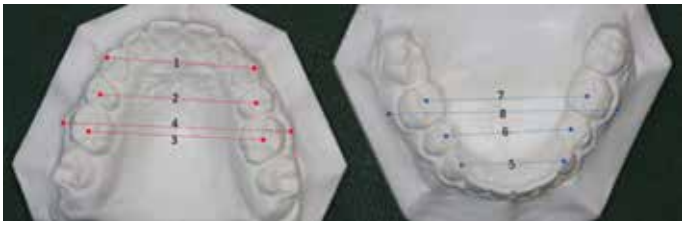

Figure 2. *Transverse measurements on study models*

Table 1. *Summary of Measurements and Definitions*

POSTERO-ANTERIOR MEASUREMENTS	
1- 16 Inclination	Angle between the long axis of the upper right molar and the palatal plane.
2- 26 Inclination	Angle between the long axis of the upper left molar and the palatal plane.
3- Internasal width (LapR– LapL)	The distance between the left and right most lateral points of nasal cavity.
4- Interfacial width (ZygR– ZygL)	The distance between the left and right Zygion points.
5- Maxillary width (MxR–MxL)	The distance between the left and right deepest points of lateral maxillary contours.
6- Mandibular width (AgR–AgL)	The distance between the left and right deepest points of antegonial notches.
DENTOALVEOLAR MEASUREMENTS	
1- Maxillary Intercanine Width	The distance between the cusp tips of the right and left upper canine teeth.
2- Maxillary Interpremolar Width	The distance between central fossae of the right and left first maxillary premolars.
3- Maxillary Intermolar Width	The distance between central fossae of the right and left first maxillary molars.
4- Maxillary Alveolar Width	The distance between the alveolar regions of maxillary first molars (5 mm above the most apical points of gingival margin).
5- Mandibular Intercanine Width	The distance between the cusp tips of the right and left lower canine teeth.
6- Mandibular Interpremolar Width	The distance between the buccal cusp tips of the right and left first premolar teeth.
7- Mandibular Intermolar Width	The distance between the medio-buccal cusp tips of the right and left first molar teeth.
8- Mandibular Alveolar Width	The distance between the alveolar regions of mandibular first molars (5 mm above the most apical points of gingival margin).

RESULTS

The number of patients and gender and chronological age distribution in the groups, are shown in Table 2. In the group 1, there were 22 individuals (12 boys and 10 girls) with a mean age of 11.61 ± 2.11 years. In the group 2, there were 21 individuals (11 boys, 10 girls) with a mean age of 11.66 ± 1.23 years. When the age and gender distribution between the groups were evaluated, no statistically significant difference was found (p>0.05).

The initial values of the groups in our study are shown in Table 3. When the results were examined, no statistically significant difference was found between the two groups in both the dentoalveolar measurements in the study models and the measurements on the posteroanterior radiographs (p>0.05).

Table 2. *Comparison of the chronological ages and gender distributions between the groups.*

	Gender distribution (Male/Female)	Chronological age (years)
Group 1 (N=22)	12/10	11.61±2.11
Group 2 (N=21)	11/10	11.66±1.23
P	.785*	.922†

*Group 1: Five weeks of Alt-RAMEC; Group 2: RME (1-week); N: Number; *: Results of Pearson chi-square test; †: Results of Student's t-test.*

As a result, both groups were similar in terms of skeletal and dentoalveolar features.

Assessment of the changes in each group is shown in Table 4. The expansion protocols showed a statistically significant increase in the widths of intercanine, interpremolar, intermolar and alveolar base widths in the maxilla ($p<0.05$). When the dentoalveolar changes in the mandible were examined, no statistically significant changes were observed in both groups ($p>0.05$). In posteroanterior measurements, there was no statistically significant change in the amount of buccal tipping of the maxillary first molar teeth in both groups on the right and left ($p>0.05$). In addition, there was no statistically significant change in the interfacial width, examining the distance between the zygomas and the mandibular width examining the distance between the antegonial notches ($p>0.05$). There was a statistically significant increase in maxillary and internasal widths in both groups ($p<0.05$).

Table 3. *Comparison of the initial dentoalveolar and posteroanterior values between the groups.*

		Group 1 (Mean±SD)	Group 2 (Mean±SD)	P
DENTOALVEOLAR MEASUREMENTS	Maxillary Intercanine Width	32.71±2.06	32.13±3.08	.496
	Maxillary Interpremolar Width	38.13±4.25	36.86±2.76	.274
	Maxillary Intermolar Width	45.26±3.43	43.97±3.22	.233
	Maxillary Alveolar Width	57.45±4.02	55.79±3.27	.166
	Mandibular Intercanine Width	26.76±1.37	26.71±1.48	.902
	Mand. Interpremolar Width	33.81±2.26	33.06±1.71	.247
	Mandibular Intermolar Width	42.00±2.57	41.42±2.29	.465
	Mandibular Alveolar Width	58.12±1.98	57.94±2.83	.819
POSTEROANTERIOR MEASUREMENTS	16 Inclination	103.5±4.09	104.93±4.31	.296
	26 Inclination	99.91±3.03	100.59±3.67	.152
	Internasal Width	26.73±2.41	26.35±2.35	.624
	Interfacial Width	95.66±9.00	93.45±10.91	.498
	Maxillary Width	58.18±3.12	57.95±3.93	.408
	Mandibular Width	80.00±6.26	77.90±3.72	.209

Group 1: Five weeks of Alt-RAMEC; Group 2: RME (1 week); SD: Standard deviation; P: Results of Student's t-test.

Table 4. *Assessment of the changes in each group.*

	Group 1			Group 2		
	T0 (Mean±SD)	T1 (Mean±SD)	P	T0 (Mean±SD)	T1 (Mean±SD)	P
Dentoalveolar Measurements						
Maxillary Intercanine Width	32.71±2.06	35.65 ± 2.27	.000	32.13±3.08	34.09 ± 3.06	.000
Maxillary Interpremolar Width	38.13±4.25	40.27 ± 4.22	.000	36.86±2.76	38.29 ± 2.99	.000
Maxillary Intermolar Width	45.26±3.43	47.25 ± 3.54	.000	43.97±3.22	45.2 ± 3.12	.000
Maxillary Alveolar Width	57.45±4.02	59.67 ± 3.91	.000	55.79±3.27	57.88 ± 3.78	.000
Mandibular Intercanine Width	26.76±1.37	27.03 ± 1.42	NS	26.71±1.48	27.21 ± 1.67	NS
Mand. Interpremolar Width	33.81±2.26	33.87 ± 2.28	NS	33.06±1.71	33.16 ± 2.15	NS
Mandibular Intermolar Width	42.00±2.57	42.10 ± 2.49	NS	41.42±2.29	41.81 ± 2.09	NS
Mandibular Alveolar Width	58.12±1.98	57.90 ± 2.32	NS	57.94±2.83	57.62 ± 2.97	NS
Posteroanterior Measurements						
16 Inclination	103.5±4.09	105.95±4.63	NS	104.93±4.31	107.76±4.13	NS
26 Inclination	99.91±3.03	102.11 ± 3.56	NS	103.59±3.67	106.13 ± 3.58	NS
Internasal Width	26.73±2.41	28.46 ± 2.52	.000	26.35±2.35	27.54 ± 2.51	.000
Interfacial Width	95.66±9.00	96.47 ± 9.56	NS	93.45±10.91	94.18 ± 10.99	NS
Maxillary Width	58.18±3.12	60.10 ± 3.18	.000	54.95±3.93	56.84 ± 4.34	.000
Mandibular Width	80.00±6.26	80.40 ± 6.23	NS	77.90±3.72	78.03 ± 3.95	NS

Group 1: Five weeks of Alt-RAMEC; Group 2: RME (1 week); SD: Standard deviation; P: Results of Paired t-test.

Table 5. *Statistical comparison of the mean changes between the groups.*

		Group 1 (Mean±SD)	Group 2 (Mean±SD)	P
DENTOALVEOLAR MEASUREMENTS	Maxillary Intercanine Width	2.94±1.14	1.96±1.09	.021
	Maxillary Interpremolar Width	2.14±1.04	1.43±0.97	.040
	Maxillary Intermolar Width	1.98±0.84	1.23±1.07	.227
	Maxillary Alveolar Width	2.22±1.30	2.08±1.17	.736
	Mandibular Intercanine Width	0.27±0.95	0.50±0.61	.871
	Mandibular Interpremolar Width	0.05±0.74	0.10±0.92	.876
	Mandibular Intermolar Width	0.10±0.08	0.39±0.13	.606
	Mandibular Alveolar Width	-0.21±0.81	-0.32±1.23	.754
POSTEROANTERIOR MEASUREMENTS	16 Inclination	2.44±1.47	2.83±1.43	.647
	26 Inclination	2.19±1.55	2.54±1.44	.923
	Internasal Width	1.73±1.20	1.19±1.10	.047
	Interfacial Width	0.81±3.69	0.72±2.04	.243
	Maxillary Width	1.92±1.12	1.88±1.05	.920
	Mandibular Width	0.40±0.98	0.13±0.29	.199

Group 1: Five weeks of Alt-RAMEC; Group 2: RME (1 week); SD: Standard deviation; P: Results of Student's t-test.

The mean and statistical comparison changes that occurred in the groups are shown in Table 5. In the comparison between the groups, the changes in maxillary intercanine and maxillary interpremolar widths were statistically significant ($p<0.05$). Other dentoalveolar measurements were statistically similar between the two groups ($p>0.05$). In the posteroanterior measurements, a statistically significant difference was found between the groups in internasal width ($p<0.05$). Other posteroanterior measurements were statistically similar between the two groups ($p>0.05$).

DISCUSSION

Rapid Maxillary Expansion (RME) is the process of opening the midpalatal suture by applying force exceeding the tooth movement limits in the lateral direction to the tooth or palatal mucosa. RME has an important role in maximizing the transverse deficiency of the maxilla in dentofacial therapy. RME is used for increasing maxillary arch length, correcting dental crowding and posterior cross-bite and facilitating protraction before face-mask treatment.[23]

RME has been used for years in the therapy of skeletal Class III patients with face-mask for suture mobilization prior to maxillary protraction.[11] Recently, however, it has been reported that approximately 12-15 mm expansion is required for adequate suture mobilization in the maxilla. Such an expansion may cause irritation of the palatal mucosa and non-occlusion between the maxilla and mandible.[12] Therefore, the researchers developed the Alt-RAMEC protocol. Alt-RAMEC protocol was introduced by Liou with 7 to 9 weeks, a two-day expansion for 1 week and two-week contraction for 1 week.[8] With this protocol, Liou said that further progress was achieved in the maxilla and further expansion was achieved, allowing the suture mobilization of the maxilla before protraction.[8] Subsequent studies have also demonstrated the effects on the maxilla with successful treatment with the Alt-RAMEC.[14-19] The present study evaluated the transversal effects of a 5-weeks Alt-RAMEC treatment protocol according to the conventional RME protocol in adolescent subjects.

In the literature, RME and Alt-RAMEC protocols have been compared several times. However, in most of these studies, their effects on maxillary protraction or sagittal effects before maxillary protraction were compared to both cone-beam computed tomography (CBCT) and LCRs. Most studies have been reported that the Alt-RAMEC protocol provides more mobilization in circummaxillary sutures than the RME, the advancement in the maxilla was approximately twice that of the Alt-RAMEC groups.[14,15,18,19.] Airway studies comparing these two protocols are also available.[21,24] In these groups, it was reported that the changes in the upper airway were greater in the Alt-RAMEC groups before maxillary protraction treatment. To our knowledge, no previous studies have analyzed the transversal effects of Alt-RAMEC and RME protocols. Therefore, our study is the first and it is a pilot study for the following studies. Since a similar study in our study is not available in the literature, our study's findings will be compared with the studies performed with the transverse effects of previous RME and RME/FM studies.

In our study, dentoalveolar measurements on study models showed a significant difference only between maxillary intercanine and interpremolar widths between the two groups. According to the other studies in the literature, it can be thought that it provides more sutural mobilization with the Alt-RAMEC protocol and consequently widening transversally. Fischer et al. compared Alt-RAMEC/FM group with RME/FM group on CBCT.[25] As a result of the study, intercanine distance, interorbital and interzygomatic distances were compared. In the Alt-RAMEC group, interzygomatic and intercanine measurements were increased; in the RME group, the increase in interorbital width was higher. However, these increases were not statistically significant. In this study, the effects of Alt-RAMEC after protraction rather than pure effect were compared.[25] Therefore, unlike our study, the change in intercanine width may not be significant.

In posteroanterior measurements, only the internasal width was statistically significant increase in the Alt-RAMEC group compared to the RME group. In other transversal measurements, the amount of expansion in both groups was similar. According to this result, differences between the amount of expansion in both protocols were not observed on posteroanterior radiographs. The expansion remained mostly at the dentoalaveoler level.

Baratieri et al. compared the control group with maxillary alveolar and basal widths and maxillary molar angulations in CBCT studies in which they examined the transversal effects of RME.[26] At the end of the study, they found a significant difference in maxillary alveolar width, but they did not find a difference in maxillary basal width. The increase in right and left molar angulations was found to be significant in the groups when compared with the control group, a significant difference was found in right maxillary molar angulation.[26] In our study, no significant difference was found in the comparison between both groups in upper molar angulations. This result may have been effective in the design of the appliance used in our study. Because our appliance that completely covers the buccal and palatinal surfaces of acrylic molar teeth is used, the buccal tipping amount of the molars may be reduced and no statistically significant difference may occur. In the same study, a significant difference was found in internasal width compared to the control group.

Yılmaz et al. found a statistically significant increase in interzygomatic width of 0.75 mm and interjugular width of 1.61 mm with the 9-weeks Alt-RAMEC protocol[21]. In our study, the interzygomatic (interfacial) distance in the RME group was 0.72 mm, and the increase in the Alt-RAMEC group was 0.41 mm. The interjugular (maxillary) width was 1.88 mm in the RME group and 1.92 mm in the Alt-RAMEC group.

Lemos Rinaldi et al. compared the different appliances of the RME and the different daily screw activation protocols with the Alt-RAMEC protocol.[23] In their study on CBCT, they evaluated alveolar bone thickness, root resorption and tooth lengths. Similar to our study, they measured intermolar width in maxilla at the crown and root level. As a result of the study, no significant difference was found between the intermolar width Alt-RAMEC group with the Haas group and hyrax groups with 2 and 4 activations per day. The intermolar width at the root level was significantly increased in the Alt-RAMEC group compared to the Hyrax group with 2 activations per day.[23]

Limitations

Cone-beam computed tomography (CBCT) has been developed for maxillofacial imaging, which can provide accurate and reliable orthodontics measurements. CBCT images have several advantages over conventional lateral cephalometric films that it has been reported in previous studies. However, posteroanterior radiographs were preferred in our study due to the high radiation dose of CBCT, its expensive and ethical problems in its routine use. Therefore, the findings of this retrospective clinical study should be considered within the limits of the two-dimensional radiographic design used for evaluation.

Another limitation of our study was the absence of a control group. The study should include a control group in order to differentiate the treatment of clinical trials from changes in growth and development. However, since transversal deficiency are often severe malocclusions in orthodontics that require early treatment, it is unethical to wait for these patients for the control group only.[27] Therefore, our study did not include a control group.

CONCLUSION

- Alt-RAMEC and RME protocols are important treatment protocols for the correction of a transverse deficiency in growing subjects.
- Alt-RAMEC and RME protocols showed similar skeletal and dentoalveolar effects in a transverse direction.
- 5-weeks Alt-RAMEC protocol significantly increased intercanine and interpremolar widths compared to 1-week RME in study models. 5-weeks Alt-RAMEC protocol significantly increased internasal widths compared to 1-week RME in posteroanterior radiographs.

CONFLICT OF INTEREST

The authors of the present article declare no conflicts of interest.

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