Evaluation of the effects of two different Alt-RAMEC procedures: five weeks versus nine weeks

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Objective: To evaluate and compare the skeletal, dentoalveolar and soft tissue effects of two different alternate rapid maxillary expansion (RMEs) and constriction [Alt-RAMEC] procedures.

Material and methods: Thirty-two consecutive patients presenting with a skeletal Class III malocclusion were placed into two comparative groups. Group 1 consisted of 16 patients (5 females and 11 males; mean age: 11.45 ± 1.87 years) who had an Alt-RAMEC procedure for five weeks and Group 2 consisted of 16 patients (6 females and 10 males; mean age: 11.52 ± 1.29 years) who had an Alt-RAMEC procedure for nine weeks. The parents of the patients were instructed to open the screw twice per day for one week and to close it twice per day for the following week (0.20 mm per turn). Nine angular and 20 linear cephalometric variables were measured.

Results: The groups were well matched in relation to patient gender distribution, chronological age and initial cephalometric values. Both Alt-RAMEC procedures showed similar effects with no statistically significant differences. The maxillae moved slightly forward and the mandible moved slightly downward, the changes of which caused an improvement in the maxillo-mandibular relationship in both groups. The overjet slightly increased and the overbite decreased in both groups. The upper lip moved slightly forward during the nine-week treatment Alt-RAMEC group.

Conclusion: Despite the favourable and similar effects of both procedures, neither seems to be sufficient for the complete correction of a skeletal Class III malocclusion.

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Introduction

A Class III malocclusion may be characterised by maxillary retrognathism, mandibular prognathism, protrusion of the maxillary dentition, retrusion of the mandibular dentition or a combination of these characteristics. The prevalence of the malocclusion is reported to be 1–5% in Caucasian populations, and as high as 16.7% in orthodontic populations. Rapid maxillary expansion (RME) is a recommended treatment option in conjunction with face-mask (FM) therapy for disrupting the circum-maxillary sutures and facilitating the skeletal advancement effects of the FM. Therefore, an RME is commonly placed and, following varying protocols, activated for 7–10 days, even in patients presenting without maxillary constriction. However, previous authors have reported that the RME procedure failed to produce beneficial skeletal effects when combined with FM. In addition, there is still no agreement regarding the amount of RME activation necessary for adequate disarticulation of the maxilla. Wang et al. reported that 7 mm of RME activation was not adequate to quantitatively open all circum-maxillary sutures, while the amount of expansion should be at least 12–15 mm according to Haas. Liou described a new protocol called ‘Alternate RME and Constrictions’ (Alt-RAMEC) that is sequentially opened 1 mm per day and closed 1 mm per day for...
seven to nine consecutive weeks using a special double hinged expansion screw. This protocol reportedly allows opening of the circum-maxillary sutures more extensively than a conventional RME. Clinical studies have shown that this method is more successful in protracting the maxillae compared with conventional RME/FM.

Franchi et al. stated that the most significant problem associated with a nine-week Alt-RAMEC protocol was the potential risk of periodontal damage to the anchorage teeth and so a modified Alt-RAMEC protocol for four to five weeks was introduced. It has been reported that this protocol, combined with FM, produced a more effective advancement of the maxillae.

There are few studies of the pure effects of Alt-RAMEC procedure; however, Yilmaz and Kucukkeles evaluated the effects of the Alt-RAMEC procedure using cone beam computed tomography (CBCT) and reported that not only the maxillae was affected, but also other structures of the face. A significant increase in the upper airway was reported.

However, the pure skeletal, dentoalveolar, and soft tissue effects of different Alt-RAMEC protocols remain largely unknown. Therefore, the aim of the present study was to evaluate and compare the facial effects of two different Alt-RAMEC procedures.

**Material and methods**

Ethical approval for the present prospective controlled clinical study was obtained from the Ethics Committee of the Akdeniz University and informed consent was provided by the parents of the patients prior to commencement.

An appropriate sample size was calculated using the formula recommended by Pandis, for a significance level of 0.05, and a power of 80%, to detect clinically meaningful differences between the groups. A power analysis showed that 31 patients were needed for the study.

In order to obtain the required number of patients, one clinician (M.C.) examined the initial data of 40 subjects who presented with a Class III malocclusion and fulfilled inclusion criteria, which identified a skeletal Class III malocclusion due to maxillary retrognathism; a vertically low or normal growth pattern; and a Class III molar and canine relationship with a negative overjet. Exclusion criteria included signs of a functional Class III malocclusion; a history of temporomandibular joint disorder, trauma or congenital anomalies; and previous orthodontic treatment. The patients and their parents were informed of the objectives of the study and the Alt-RAMEC procedures. Finally, 32 patients (11 females and 21 males; mean age: 11.48 ± 1.61) who agreed to participate in the study were placed into two groups. Group 1 consisted of 16 patients (5 females and 11 males; mean age: 11.45 ± 1.87 years) who had an Alt-RAMEC procedure for five weeks and Group 2 consisted of 16 patients (6 females and 10 males; mean age: 11.52 ± 1.29 years) who had an Alt-RAMEC procedure for nine weeks (Figure 1). The parents of the patients were instructed to open the expansion screw twice per day for one week and to close it twice per day for the following week (0.20 mm per turn). This protocol was continually repeated for five weeks in Group 1 and for nine weeks in Group 2. A full-cap bonded RME appliance was fabricated for each patient and the expansion screw (Leone A0620-19, Florence, Italy) was positioned parallel to the midline. Two arms were bent from the appliance framework to the buccal sides of the dentition to form hooks for the maxillary protraction application after the expansion

![Figure 1. Flow diagram of the groups.](image-url)
was completed (Figure 2). All patients were treated in the same clinic by two clinicians (M.C. and M.H.B.). Standardised cephalograms were taken just before the treatment (T1) (within two weeks prior to cementation of the appliance) and immediately after the Alt-RAMEC procedure was completed (T2). On each film, a Horizontal Reference Line (HRL) was constructed passing through tuberculum sella (the intersection point of the lower contours of the anterior clinoid processes and the contour of the anterior wall of the sella) and twing (the intersection of the contour of the ala major with the jugum sphenoidale) points and a perpendicular line passing through the tuberculum sella as a vertical reference line (VRL). One researcher (M.H.B.) traced the cephalograms in a random, blinded order using dedicated software (Dolphin Imaging Version 11.8.06.24 Premium, Chatsworth, CA, USA). Nine angular and 20 linear measurements were taken to evaluate the skeletal, dentoalveolar and soft tissue changes that occurred in both groups (Figures 3–5).
Statistical analyses
To determine the random error, 12 cephalometric films were randomly retraced and remeasured by the same researcher (M.H.B.) two weeks after the first examination. The method error was calculated using the Houston test, which indicated the reliability of the measurements (the coefficients were above 0.916). 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. A comparison of the genders in relation to changes was conducted using a Mann Whitney U test due to few samples, and the data were pooled since no gender difference was found (p > 0.05). 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 a Student’s t-test. All statistical analyses were performed using the SPSS software package program (SPSS for Windows 98, version 10.0, SPSS Inc, IL, USA) at a significance level of p < 0.05.

Results
Table I shows the descriptive data of the patients included in the study. No statistically significant differences were found related to gender distribution and chronological age tested by Pearson chi-square and Student’s t-tests, respectively (p > 0.05).

Descriptive statistics and a comparison of the groups for initial values are shown in Table II. According to the results of the Student’s t-test, no statistically significant differences were identified for the initial values between the groups (p > 0.05). The patients in both groups had a skeletal Class III malocclusion due to the maxillary retrognathism with normal vertical growth patterns.

Table III shows the statistical evaluations of the changes that occurred in each group using the paired t-test. In the five-week Alt-RAMEC group, the maxilla moved slightly forward (A-VRL, 0.93 ± 1.46 mm and p < 0.05; SNA, 1.03 ± 1.01º and p < 0.01) and the mandible moved slightly downward (Pog-HRL, 1.25 ± 1.32 mm and p < 0.01). Those changes in the maxilla and the mandible caused an improvement of the maxillo-mandibular relationships (ANB, 1.16 ± 0.88º and p < 0.001; Convexity, 1.32 ± 1.32º and p < 0.01). In the nine-week Alt-RAMEC group, the maxilla moved slightly forward (A-VRL, 0.85 ± 1.07 mm and p < 0.05; SNA, 1.62 ± 1.17º and p < 0.001) and downward (A-HRL, 1.00 ± 1.28 mm and p < 0.05) and the mandible moved slightly downward (B-HRL, 1.09 ± 1.35 mm and p < 0.05; Pog-HRL, 1.04 ± 1.53 mm and p < 0.05). The changes in the maxilla and mandible produced improvements of the maxillo-mandibular relationships (ANB, 0.93 ± 0.84º and p < 0.01; Convexity, 0.78 ± 0.80º and p < 0.01). The upper (U1-HRL, 0.99 ± 1.61 mm and p < 0.05) and lower incisors (L1-HRL, 1.11 ± 1.21 mm and p < 0.01) moved slightly forward, the lower incisors moved slightly downward (L1-HRL, 1.09 ± 1.35 mm and p < 0.05) and downward (L1-VRL, 0.96 ± 1.26 mm and p < 0.05). The overjet slightly increased (0.38 ± 0.66 mm and p < 0.05; 0.77 ± 0.68 and p < 0.01, respectively) and the overbite decreased in both groups (-1.13 ± 1.13 mm and p < 0.01; -1.07 ± 1.72 mm and p < 0.05, respectively). The upper lip moved slightly forward in the nine-week Alt-RAMEC group (0.91 ± 1.24 mm and p < 0.05).

Table IV shows a comparison of the mean changes that occurred in both groups. There were no statistically significant differences between the groups (p > 0.05).

Table I. Distribution of the chronological ages and genders of the groups.

| Group | Chronological age (years)* | Female/Male+ |
|-------|---------------------------|-------------|
| Group 1 (N = 16) | 11.45±1.87 | 5/11 |
| Group 2 (N = 16) | 11.52±1.29 | 6/10 |
| P | NS | NS |

Group 1: Five weeks of Alt-RAMEC; Group 2: Nine weeks of Alt-RAMEC; N: Number; *: Results of Student t-test; +: Results of Pearson chi-square test; NS: Non significant.
### Table II. Comparison of the initial values between the groups.

| Skeletal measurements | Group 1          | Group 2          | P    |
|-----------------------|------------------|------------------|------|
| SNA (°)               | 77.29 ± 2.49     | 77.08 ± 2.85     | 0.830|
| SNB (°)               | 79.94 ± 2.66     | 80.16 ± 2.86     | 0.828|
| ANB (°)               | -2.65 ± 1.37     | -3.07 ± 1.34     | 0.524|
| Convexity (°)         | -2.99 ± 1.67     | -2.94 ± 1.53     | 0.718|
| SN-MP (°)             | 34.56 ± 5.19     | 35.51 ± 3.46     | 0.548|
| A – VRL [mm]          | 50.98 ± 4.25     | 50.37 ± 7.35     | 0.786|
| B – VRL [mm]          | 49.94 ± 7.34     | 49.12 ± 9.97     | 0.800|
| Pog – VRL (mm)        | 49.41 ± 9.29     | 48.12 ± 10.98    | 0.731|
| A – HRL [mm]          | 50.59 ± 4.50     | 51.27 ± 4.56     | 0.682|
| B – HRL [mm]          | 86.38 ± 5.35     | 86.78 ± 5.79     | 0.842|
| Pog – HRL [mm]        | 97.85 ± 6.23     | 99.00 ± 5.89     | 0.605|

### Dentoalveolar measurements

|       | Group 1          | Group 2          | P    |
|-------|------------------|------------------|------|
| U1 – NA [mm]    | 5.45 ± 2.07      | 5.52 ± 3.05      | 0.944|
| U1 – NA (°)     | 26.08 ± 5.55     | 25.11 ± 7.19     | 0.684|
| L1 – NB [mm]    | 3.33 ± 2.11      | 3.80 ± 1.76      | 0.518|
| L1 – NB (°)     | 19.70 ± 5.42     | 20.72 ± 5.62     | 0.614|
| U1 – VRL (mm)   | 53.79 ± 5.79     | 52.40 ± 9.73     | 0.644|
| L1 – VRL (mm)   | 69.57 ± 5.23     | 70.65 ± 5.84     | 0.592|
| U1 – HRL (mm)   | 53.80 ± 5.79     | 52.73 ± 9.64     | 0.719|
| L1 – HRL (mm)   | 69.55 ± 5.21     | 70.60 ± 5.85     | 0.600|
| Overjet (mm)    | -1.03 ± 1.42     | -1.75 ± 1.87     | 0.238|
| Overbite (mm)   | 0.54 ± 1.83      | 1.40 ± 1.84      | 0.207|

### Soft tissue measurements

|       | Group 1          | Group 2          | P    |
|-------|------------------|------------------|------|
| UL – VRL [mm] | 67.12 ± 5.44    | 65.76 ± 8.15    | 0.598|
| LL – VRL [mm] | 66.28 ± 6.54    | 66.04 ± 9.18    | 0.934|
| UL – HRL [mm] | 64.16 ± 5.56    | 65.46 ± 5.96    | 0.536|
| LL – HRL [mm] | 76.44 ± 7.44    | 77.55 ± 6.88    | 0.672|
| Pog(s) – VRL (mm) | 60.52 ± 9.10    | 58.93 ± 11.55   | 0.678|
| Pog(s) – HRL (mm) | 97.27 ± 5.82    | 97.86 ± 6.28    | 0.787|
| Facial convexity (°) | 174.25 ± 3.39 | 173.08 ± 3.47 | 0.353|
| Nasolabial angle (°) | 113.27 ± 6.13  | 116.13 ± 9.13  | 0.327|

Group 1: Five weeks of AlRAMEC; Group 2: Nine weeks of AlRAMEC; P: Results of Student t-test comparing the initial values of the groups; SD: Standard deviation.
### Table III. Comparison of the changes observed in each group.

| Skeletal measurements | (T1) Mean ± SD | (T2) Mean ± SD | P     | (T1) Mean ± SD | (T2) Mean ± SD | P     |
|------------------------|----------------|----------------|-------|----------------|----------------|-------|
| SNA (°)                | 77.29 ± 2.49   | 78.33 ± 2.95   | 0.001 | 77.08 ± 2.85   | 78.71 ± 2.24   | 0.000 |
| SNB (°)                | 79.94 ± 2.66   | 79.82 ± 2.72   | 0.586 | 80.16 ± 2.86   | 80.86 ± 2.62   | 0.120 |
| ANB (°)                | -2.65 ± 1.37   | -1.49 ± 1.38   | 0.000 | -3.07 ± 1.34   | -2.15 ± 1.60   | 0.001 |
| Convexity (°)          | -2.99 ± 1.67   | -1.68 ± 1.99   | 0.001 | -2.94 ± 1.53   | -2.16 ± 1.69   | 0.003 |
| SN-MP (°)              | 34.56 ± 5.19   | 35.08 ± 5.82   | 0.160 | 35.51 ± 3.46   | 35.65 ± 4.01   | 0.114 |
| A – VRL (mm)           | 50.98 ± 4.25   | 51.91 ± 4.27   | 0.019 | 50.37 ± 7.35   | 51.22 ± 7.39   | 0.011 |
| B – VRL (mm)           | 49.94 ± 7.34   | 50.18 ± 7.63   | 0.422 | 48.12 ± 10.98  | 49.64 ± 10.47  | 0.243 |
| Pog – VRL (mm)         | 49.41 ± 9.29   | 49.47 ± 9.41   | 0.870 | 49.12 ± 9.97   | 49.64 ± 10.47  | 0.187 |
| A – HRL (mm)           | 50.59 ± 4.50   | 51.05 ± 4.29   | 0.307 | 51.27 ± 4.56   | 52.27 ± 4.51   | 0.012 |
| B – HRL (mm)           | 86.38 ± 5.35   | 87.07 ± 4.99   | 0.052 | 86.78 ± 5.79   | 87.88 ± 5.96   | 0.010 |
| Pog – HRL (mm)         | 97.85 ± 6.23   | 99.10 ± 5.83   | 0.001 | 99.00 ± 5.89   | 100.04 ± 6.31  | 0.024 |

Dentoalveolar measurements

| U1 – NA (mm)           | 5.45 ± 2.07    | 5.11 ± 2.23    | 0.204 | 5.52 ± 3.05    | 4.92 ± 2.50    | 0.045 |
| U1 – NA (°)            | 26.08 ± 5.55   | 25.06 ± 6.14   | 0.972 | 25.11 ± 7.19   | 25.40 ± 6.40   | 0.535 |
| L1 – NB (mm)           | 3.33 ± 2.11    | 3.50 ± 2.23    | 0.248 | 3.80 ± 1.76    | 4.15 ± 1.66    | 0.002 |
| L1 – NB (°)            | 19.70 ± 5.42   | 19.89 ± 5.53   | 0.621 | 20.72 ± 5.62   | 21.94 ± 5.18   | 0.039 |
| U1 – VRL (mm)          | 53.79 ± 5.79   | 54.21 ± 5.58   | 0.316 | 52.40 ± 9.73   | 53.21 ± 10.06  | 0.085 |
| L1 – VRL (mm)          | 69.57 ± 5.23   | 70.55 ± 4.77   | 0.109 | 70.65 ± 5.84   | 71.79 ± 5.74   | 0.011 |
| U1 – HRL (mm)          | 53.80 ± 5.79   | 54.24 ± 5.58   | 0.282 | 52.73 ± 9.64   | 53.72 ± 9.96   | 0.039 |
| L1 – HRL (mm)          | 69.55 ± 5.21   | 70.52 ± 4.79   | 0.006 | 70.60 ± 5.85   | 71.72 ± 5.83   | 0.004 |
| Overjet (mm)           | -1.03 ± 1.42   | -0.65 ± 1.36   | 0.027 | -1.75 ± 1.87   | -0.98 ± 2.02   | 0.001 |
| Overbite (mm)          | 0.54 ± 1.83    | -0.59 ± 1.70   | 0.001 | 1.40 ± 1.84    | 0.33 ± 1.81    | 0.036 |

Soft tissue measurements

| UL – VRL (mm)          | 67.12 ± 5.44   | 67.37 ± 5.37   | 0.402 | 65.76 ± 8.15   | 66.68 ± 8.38   | 0.016 |
| LL – VRL (mm)          | 66.28 ± 6.54   | 66.43 ± 6.60   | 0.698 | 66.04 ± 9.18   | 66.67 ± 9.79   | 0.181 |
| UL – HRL (mm)          | 64.16 ± 5.56   | 64.88 ± 5.53   | 0.567 | 65.46 ± 5.96   | 66.10 ± 6.07   | 0.283 |
| LL – HRL (mm)          | 76.44 ± 4.44   | 77.42 ± 6.78   | 0.091 | 77.55 ± 6.88   | 78.53 ± 6.87   | 0.092 |
| Pog(s) – VRL (mm)      | 60.52 ± 9.10   | 60.82 ± 9.53   | 0.053 | 58.93 ± 11.55  | 59.65 ± 12.41  | 0.087 |
| Pog(s) – HRL (mm)      | 97.27 ± 5.82   | 97.95 ± 5.67   | 0.077 | 97.86 ± 6.28   | 98.47 ± 5.84   | 0.318 |
| Facial convexity (°)   | 174.25 ± 3.39  | 173.51 ± 3.79  | 0.052 | 173.08 ± 3.47  | 172.87 ± 3.35  | 0.667 |
| Nasolabial angle (°)   | 113.27 ± 6.13  | 113.45 ± 9.38  | 0.908 | 116.13 ± 9.13  | 116.32 ± 9.35  | 0.890 |

Group 1: Five weeks of Alt-RAMEC; Group 2: Nine weeks of Alt-RAMEC; P: Results of paired t-test; SD: Standard deviation.
Table IV. Statistical evaluation of the changes obtained in five and nine-weeks Alt-RAMEC groups.

| Skeletal measurements | Group 1 Mean ± SD | Group 2 Mean ± SD | P  |
|-----------------------|-------------------|-------------------|----|
| SNA (°)               | 1.03 ± 1.01       | 1.62 ± 1.17       | 0.146 |
| SNB (°)               | -0.13 ± 0.96      | 0.69 ± 1.56       | 0.100 |
| ANB (°)               | 1.16 ± 0.88       | 0.93 ± 0.84       | 0.376 |
| Convexity (°)         | 1.32 ± 1.32       | 0.78 ± 0.80       | 0.180 |
| SN-MP (°)             | 0.52 ± 1.45       | 0.14 ± 1.15       | 0.398 |
| A – VRL (mm)          | 0.93 ± 1.46       | 0.85 ± 1.07       | 0.863 |
| B – VRL (mm)          | 0.23 ± 1.18       | 0.51 ± 1.57       | 0.577 |
| Pog – VRL (mm)        | 0.05 ± 1.32       | 0.67 ± 1.80       | 0.296 |
| A – HRL (mm)          | 0.46 ± 1.79       | 1.00 ± 1.28       | 0.337 |
| B – HRL (mm)          | 0.68 ± 1.34       | 1.09 ± 1.35       | 0.405 |
| Pog – HRL (mm)        | 1.25 ± 1.24       | 1.04 ± 1.53       | 0.691 |

Dentoalveolar measurements

| U1 – NA (mm)          | -0.34 ± 1.06      | -0.60 ± 1.01      | 0.496 |
| U1 – NA (°)           | -0.01 ± 2.01      | 0.28 ± 1.68       | 0.651 |
| L1 – NB (mm)          | 0.17 ± 0.58       | 0.35 ± 0.34       | 0.297 |
| L1 – NB (°)           | 0.19 ± 1.54       | 1.22 ± 1.99       | 0.114 |
| U1 – VRL (mm)         | 0.41 ± 1.64       | 0.80 ± 1.60       | 0.513 |
| L1 – VRL (mm)         | 0.38 ± 0.93       | 0.56 ± 0.71       | 0.553 |
| U1 – HRL (mm)         | 0.44 ± 1.63       | 0.99 ± 1.61       | 0.355 |
| L1 – HRL (mm)         | 0.96 ± 1.26       | 1.11 ± 1.21       | 0.740 |
| Overjet (mm)          | 0.38 ± 0.66       | 0.77 ± 0.68       | 0.083 |
| Overbite (mm)         | -1.13 ± 1.13      | -1.07 ± 1.72      | 0.915 |

Soft tissue measurements

| U1 – VRL (mm)         | 0.24 ± 1.15       | 0.91 ± 1.24       | 0.129 |
| LL – VRL (mm)         | 0.14 ± 1.47       | 0.63 ± 1.66       | 0.394 |
| Pog(s) – VRL (mm)     | 0.29 ± 2.07       | 0.71 ± 2.38       | 0.898 |
| UL – HRL (mm)         | 0.71 ± 1.63       | 0.64 ± 1.32       | 0.994 |
| LL – HRL (mm)         | 0.98 ± 1.93       | 0.97 ± 1.96       | 0.604 |
| Pog(s) – HRL (mm)     | 0.68 ± 1.49       | 0.61 ± 2.19       | 0.914 |
| Facial convexity (°)  | -0.74 ± 1.21      | -0.21 ± 1.82      | 0.364 |
| Nasolabial angle (°)  | 0.17 ± 6.16       | 0.19 ± 5.11       | 0.994 |

Group 1: Five weeks of Alt-RAMEC; Group 2: Nine weeks of Alt-RAMEC; P: Results of Student t-test comparing the groups; SD: Standard deviation.

Discussion

A bibliographic search in Medline using the keywords ‘Alt-RAMEC’, ‘Alternate rapid maxillary expansion and construction’ and ‘RME’ showed that a limited number of studies21 had previously focused on the effects of the Alt-RAMEC procedure. Although different Alt-RAMEC protocols had been described, no previous study compared the effects of those procedures. The duration of the Alt-RAMEC procedures ranged from four weeks to nine weeks.12,15-17,23 Because of the potential risk to the periodontium of the anchorage teeth during an extended Alt-RAMEC procedure, it was suggested that a shorter activation time was...
preferable. It had been previously reported that positive clinical findings were achieved in two patients treated by five weeks of Alt-RAMEC activation followed by maxillary protraction but more detailed studies with larger samples were needed to confirm the effects of the innovative treatment protocol. Masucci et al. evaluated the effects of four weeks of Alt-RAMEC activation followed by maxillary protraction compared with conventional RME/FM and reported significantly favourable effects leading to the correction of the Class III malocclusion in both groups. However, the Alt-RAMEC/FM protocol produced a more effective advancement of the maxilla (SNA, 1.2°) and greater inter-maxillary change (ANB, 1.7°) compared with the RME/FM protocol. There was no apparent comparison of the sole effects of the different Alt-RAMEC procedures. Therefore, the present prospective clinical study aimed to assess the skeletal, dentoalveolar, and soft tissue effects of different Alt-RAMEC procedures to add new information to the literature.

The groups were well matched in relation to gender distribution, chronological age and initial cephalometric values. All patients assessed had a retrusive maxilla and upper lip, a protrusive mandible and lower lip, retroclined lower incisors and a reduced overjet. These pretreatment findings matched those of similar relevant studies performed on Class III patients. According to Wang et al., the amount of maxillary expansion should be over 7 mm to open all circum-maxillary sutures. However, this level of expansion might produce a problem related to the co-ordination of the maxillary and mandibular arches in Class III patients who do not possess a posterior crossbite. Therefore, it was suggested that a longer Alt-RAMEC procedure was required to increase the opening of the coronally-orientated circum-maxillary sutures in cats. The procedure of opening and closing the expansion screw at a rate of 1 mm per week was suggested by Liou and Liou and Tsai; however, several clinicians limited the activation to 0.5 mm per week in alternative studies. In the present study, it was decided to perform the procedure as 0.5 mm per day because of the possible risk of periodontal damage and root resorption of the anchor teeth.

A single study using CBCT images that evaluated the sole effects of nine weeks of Alt-RAMEC procedure reported slightly forward (0.89 ± 0.93 mm) and downward (0.92 ± 1.62 mm) movement of A point.

In the present study, similar amounts of forward movement of A point (0.93 ± 1.46 mm and 0.85 ± 1.07 mm, respectively) were found in both groups. The downward movement of A point was found to be similar in the nine-week Alt-RAMEC group (1.00 ± 1.28 mm), while it was found to be slightly less in the five-week Alt-RAMEC group (0.46 ± 1.79 mm). The differences in the design of the appliance used for Alt-RAMEC, the screws used for expansion and the amount of expansion per day might be possible reasons for the slight differences between the present findings and others.

A slight forward (0.23 ± 1.18 mm and 0.51 ± 1.57 mm, respectively) and downward (0.68 ± 1.34 mm and 1.09 ± 1.35 mm, respectively) movement of B point was found in both groups. Since the mandibular effects of the Alt-RAMEC procedure were not evaluated by previous studies, comparisons could not be performed. However, a recently published systemic review showed that an increase in the SNB angle after RME therapy did not reach clinical significance. The present study revealed that minor changes in the upper and lower incisor positions and inclinations and the spatial variations of the jaws caused slight changes in the overjet measurement. A significant change was observed in the anterior movement of the upper lip in the nine-week Alt-RAMEC group (0.91 ± 1.24 mm and p < 0.05). The present comparison of the Alt-RAMEC groups showed similar findings with no statistically significant differences. The identified changes in both Alt-RAMEC groups seem to be insufficient to correct the skeletal Class III malocclusions and the slight changes may have limited clinical utility, as previously indicated by Yilmaz and Kucukkeles. Therefore, the effects of alternative Alt-RAMEC procedures on maxillary protraction should be investigated in future prospective clinical studies.

CBCT imaging has been reported to present more accurate data when compared with conventional films and the failure to use CBCT imaging may be seen as a potential limitation of the present study. Despite the advantages of CBCT scans, the ethical dilemma of obtaining CBCT images of patients for a period of five or nine weeks of Alt-RAMEC comparison remains real. While no CBCT images were taken in the present study, the reliability of the findings were supported by the Houston test.
Conclusion

The maxilla moved slightly forward and the mandible moved slightly downward, which produced an improvement in the maxillo-mandibular relationships in both groups.

Both Alt-RAMEC procedures showed similar effects without statistically significant differences.

Five weeks of Alt-RAMEC activation can be safely performed rather than a nine-week procedure. This would have the likely benefit of reducing the possibility of periodontal damage to anchor teeth.

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