Evaluation of two protocol of maxillary protraction in class III adolescent after using (MSE) Alt-RAMEC vs conventional rapid palatal expansion a randomized controlled trial

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Received: 27th Oct, 2025; Revised: 25th Nov, 2025; Accepted: 02h Dec, 2025; Available Online: 12th Feb, 2026

ABSTRACT

Aim of the study:

Comparing two protocols of maxillary protraction in class III adolescents by Alternate Rapid Maxillary Expansion and Constriction (Alt-RAMEC) with two different maxillary skeletal expander (MSE) and conventional rapid palatal expansion (RPE) through cephalometric analysis the goal of this study.

Subjects and Methods:

Using a three-arm, parallel, randomized clinical trial design, 48 Class III late teenage patients (mean age 16.5 ± 1.4 years) with skeletal class III malocclusion were assigned at a 1:1:1 ratio to a single-center, double-blind study (assessors and data analyzers). Patients were randomly splited into three groups: group 1 comprised MSE conventional expansion with facemask (MSE CE + FM, n = 16); group 2 comprised MSE Alt-RAMEC protocol expansion with facemask (MSE Alt + FM, n = 16); and group 3, as a control group (CG) comprised class 3 needs maxillary expansion only with MSE. The FM group used 12–14 hours a day 350–400 g/side elastic traction. The aim was to evaluate the MSE CE + FM regimens' 6.2 ±1.2 months (3D) skeletal effects against MSE Alt + FM.

Results:

In contrast to the controls (1.1± 0.3º), the Alt-RAMEC (2.1± 0.9º) and rapid maxillary expansion with protraction (1.7 ± 0.7º) showed clear maxillary advancement (SNA). This helps to enhance the negative overjet and molar correction when combined with mandibular clockwise rotation. Only the location of the maxillary incisors showed changes between the two expansion methods, since in control one (group 3) was (1.8± 0.8º) while the Alt-RAMEC (1 ± 0.6º) and rapid maxillary expansion with protraction was (0.9 ± 0.5º) indicating maxillary incisor proclination especially in group 3.

Conclusion:

All appliances can help in the management of class 3 cases with improved skeletal anchoring using the Alt-RAMEC technique. MSE alone can control the vertical dimension, through limitation of extrusion and anterior movement of maxillary first permanent molar.

Keywords: Rapid maxillary expansion; Alt-RAMEC; MSE; and Protraction face mask

How to cite this article: Shendy MA, Abouelnour A, EL-Awady AA, El-Din AMB, Hussein AT, AbdelAllah MMA, Gouda WRA, El Hendawey AM, Abdelmoniem MH, Fouad AM, Abdallah KF, Badr AM. Evaluation of two protocol of maxillary protraction in class III adolescent after using (MSE) Alt-RAMEC vs conventional rapid palatal expansion a randomized controlled trial. Int J Drug Deliv Technol. 2026;16(50s): 1636-1654. DOI: 10.25258/ijddt.16.50s.164
Source of support:. None
Conflict of interest: None

Introduction

One of the most challenging dental abnormalities called class III malocclusion is caused by the combination of several environmental and genetic factors during a child's normal growth.[1–3]

Early-onset dentofacial development differences including retrusive maxilla, prognathic mandible, or a combination with higher vertical measurements in most cases, define class III malocclusion.[4] Two possible dentoalveolar compensations are mandibular incisors' retrocline and proclination of maxillary incisors in sagittal direction.[5]

Research concluded that If class 3 is not treated, a distinct development curve will appear, particularly for the mandible, where excesses accumulate with time. Males experienced more growth during the course of the study than females.[6]

The time of pubertal spurt might be longer in mandibular length found in the literature among Class III patients and longer development interval corresponding to the pubertal growth surge (CS3-CS4) than those with normal skeletal connections.[7]

The treatment of rapid maxillary expansion (RME) is well known for the treatment of constricted maxillary arches, mild maxillary crowding, and posterior crossbite via the opening of the mid-palatal suture.[8–12] Including the adults.[13,14]

In some occasions, expansion can be employed even when there is no posterior cross bite; this may be in three conditions. Moderate crowding in class I (3-4 mm) and Class II therapy to restore the molar relationship and minimize mesiopalatal rotation.[15] Third, skeletal expansion is necessary for a compensated posterior cross bite with a narrow maxilla, hence, clinical signs of maxillary insufficiency include dental crowding and crossbite.[16]

Using a maxillary expansion with face mask appliance to improve the protraction effect is the most successful treatment method; nevertheless, this method is still only helpful for primary mixed or deciduous dentition.[17–21]

The concept of circum-maxillary sutures disarticulation that might facilitate maxillary protraction, Liou et al [22] reported a method called "Alternate RME and Constrictions" (Alt-RAMEC), in which the appliance is expanded 1 mm daily and closed 1 mm daily for seven to nine continuous weeks using a special expansion screw with double hinged. Compared to a regular RME, the method allegedly allows complete opening of the circum-maxillary sutures.[23,24]

Examine the differences between the long-term dentoskeletal consequences of early banded or bonded RME -Face Mask protraction treatment and late hybrid-Hyrax during the teenage growth spurt, alt-RAMEC treatment, there was no difference in sagittal and vertical skeletal characteristics, and the overbite, overjet corrections were comparable in both groups. [25] but when compared in younger age in a short period, the skeletal class III correction was shown to be more successful using the Alt-RAMEC approach.[26]

In the late mixed or early permanent dentition period (ages 10–14), effective maxillary protraction using a novel treatment approach that makes use of bone anchors and Class III elastics (bone-anchored maxillary protraction, or BAMP). [27]

The use of cone beam computed tomography is advocated to observe the bone during growth in three dimensions with a novel method.[28]

Despite encouraging indications of the Alt-RAMEC protocol's efficacy in treating individuals with Class III malocclusion, further research is required to validate its efficacy over the long run.[29] and another systematic review showed that there is a risk of bias toward this technique during facemask protraction in class III.[30]

If maxillary protraction in young adults is difficult without surgery, as has been noted in previous literature[30–32], or even the effect of expansion is useless [31,33]Hence the goal of this study was to reduce morbidity and mortality, therefore, it was suggested that MARPE, specifically MSE, can be used to facilitate maxillary protraction with a face mask in this age group instead of using the expansion protocol technique, so this study was directed to compare two protocols of maxillary protraction in class III adolescents using two different maxillary skeletal expander (MSE) protocol Alt-RAMEC versus conventional RPE using cephalometric analysis .

SUBJECTS AND METHODS

Sample size calculation

Based on an earlier study by Isci et al. [34], Buyukcavus et al[35] the sample size was calculated using the free G*Power program (version 3.1.9.4). The study indicated that 48 patients—at least 15 for every group—were required; hence, it was decided to start with 54 patients and work to eliminate any dropouts to meet this target.

Study design

Using a three-arm, parallel, randomized clinical trial design, patients were assigned at a 1:1:1 ratio to a single-center, double-blind study (assessors and data analyzers).

Ethical approval

The ethical committee of the University of Al-Azhar's Faculty of Dental Medicine, Cairo, Boys branch, granted this study approval number (828/220) along with clinical trial registration number (NCT05489302).

Eligibility criteria for participants

Inclusion criteria: -

By considering the initial cephalometric values of SNA, SNB, ANB and Wits, the clinical examination was further validated. Class III malocclusion of the skeletal origin of the retrognathic maxilla since ANB was -1 degrees or less and the Wits was -1mm or less. confirmed by a clinical and cephalometric evaluation. concave profile with a reduced infraorbital rim in certain cases and a midface deficit associated with flat malar bases.

Anterior crossbite, a cervical vertebrae maturation (CVM) Stage of 3–5, a Class III relationship of both permanent molars and canines, and no history of orthodontic or orthopedic treatment or temporomandibular disorder (TMD)

Exclusion criteria: -

Individuals with systemic disorder, poor adherence or compliance, cleft/craniofacial disorders, pseudo class III, class I, or even class II malocclusion, or significant skeletal asymmetry, severe constriction inaccessible for MSE placement, congenital missing of permanent incisors or first molars, normal overjet, a history of orthodontic or surgical treatment, trauma and temporomandibular disorder.

Consent form

All patients, parents, and guardians received explanations of the research process and treatment outcomes, including the possibility of unsuccessful protraction skeletal effect, relapse, and miniscrew failure. Informed consent was obtained

Randomization (random number generation, allocation concealment, implementation)

It was a consecutive selection. All qualified patients and their guardians were invited to participate in the experiment after an intermediary informed them verbally and in writing. Staff members who were not participating in the experiment conducted randomization after consent.

Allocation concealment method

To make the randomization processes easier, vehicles were tagged and opaque sealed envelopes were sequentially numbered with assigned numbers. In this randomized controlled trial (RCT), research participants were screened at the orthodontic outpatient clinic at the faculty of dental medicine at Al Azhar University in Cairo, Egypt.

Using a three-arm, parallel, randomized clinical trial design, 48 Class III teenage patients (mean age 17 ± 1.8 years) with skeletal class III malocclusion were assigned at a 1:1:1 ratio to a single-center, double-blind study (assessors and data analyzers). Patients were split randomly into three groups: group 1 comprised MSE conventional expansion with facemask (MSE CE + FM, n = 16); group 2 comprised MSE Alt-RAMEC protocol expansion with facemask (MSE Alt + FM, n = 16); and group 3, as a control group (CG) comprised patients advised for maxillary expansion only with MSE. The FM group used 12–14 hours a day 350–400 g/side elastic traction

Blinding

The issue of blindness toward patients or practitioners to the processes was extremely challenging and cannot be completely avoided due to the nature of the clinical work especially in group 3; however, the outcome assessors of cephalometric tracing were unaware of the groups to which the patients belonged.

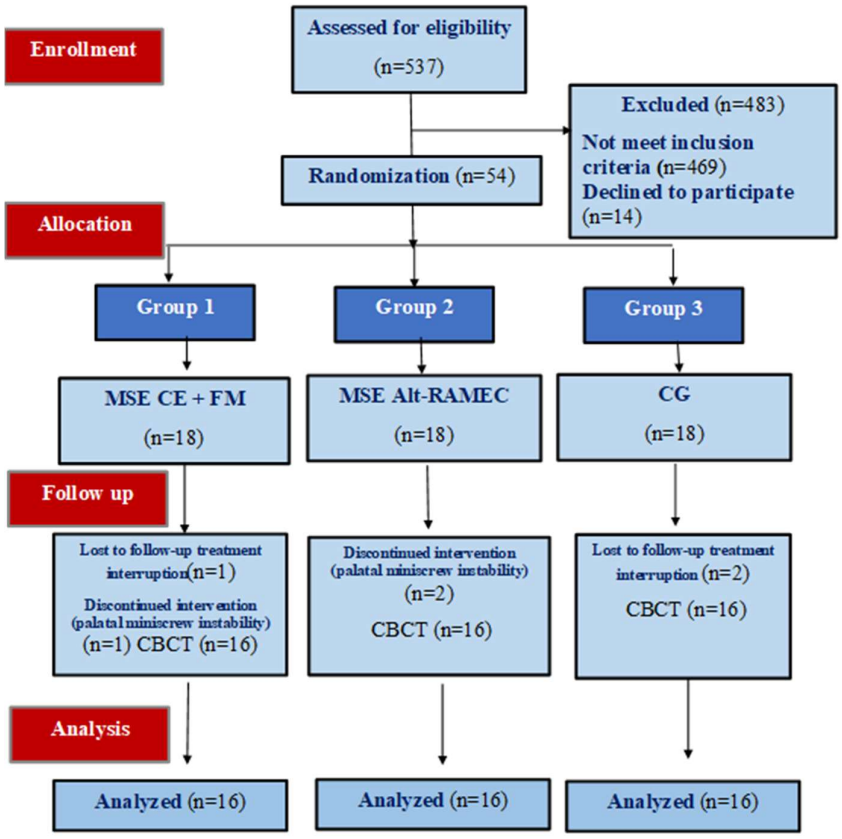

Figure (1): Consolidated Standards of Reporting Trials (CONSORT) flow chart.

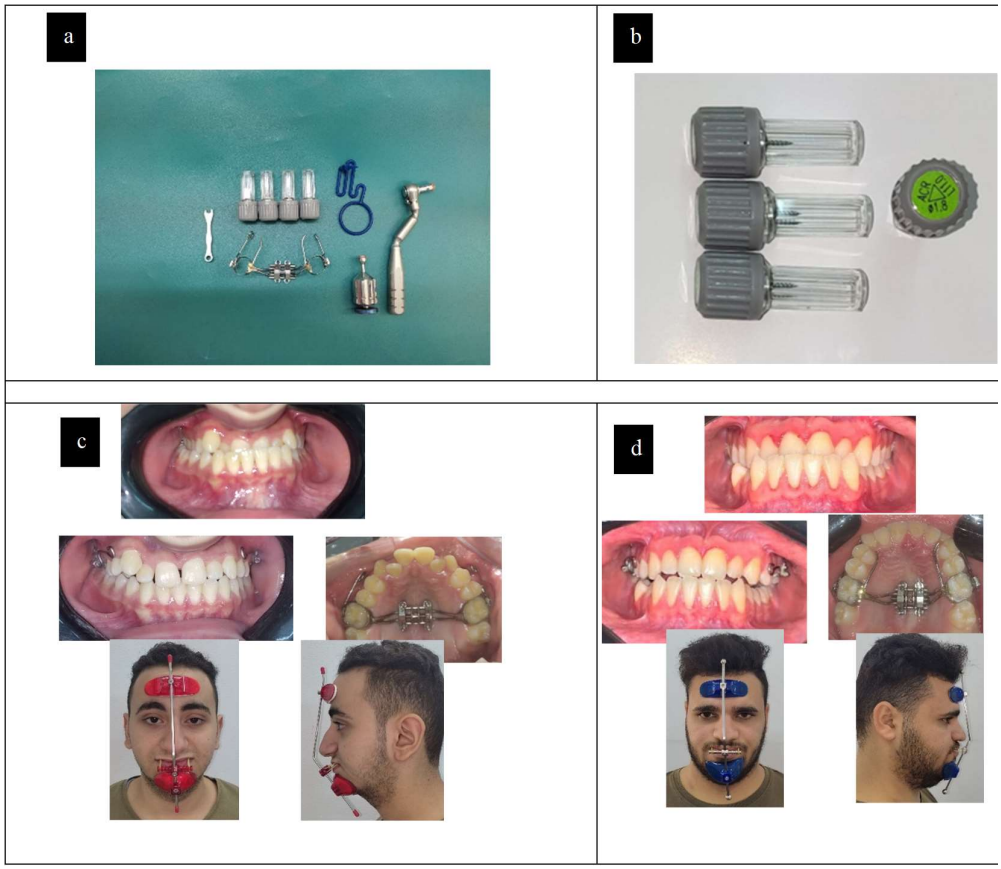

Figure (2): a) MSE b) MSE Minimplants
c) group 1 case d) group 2 case

Interventions for each group

Clinical procedures and Activation protocol:

As regard to the activation period of expansion to minimize bias, it was possible to have a group mimic skeletal pattern to the treated sample act as control and postpone the protraction, since this period is non-significant in the facial growth curve because all of the patients were expected to pass the peak of maxillary growth during this time.[36]

The MSE was constructed with bands around the maxillary permanent first molar supporting the appliance; this design is comparable to that put out by Carlson et al.[37]

The MSE version II-8E appliance contains a central body and four welded holes attached to an expansion screw. Each tube gives pathway for four mini-implants (MI) and has a diameter of 1.8 mm and a length of 2 mm. The diameter and length of each implant are 1.8 mm and 11 mm, respectively. For proper placement of jackscrew, two molar bands are attached to the maxillary first molars as guide. The MI's fit tightly inside the tube, eliminating lateral movement during expansion. The 11 mm MI's bi-cortical engagement through the palate and nasal floor was ensured. (Fig. 2).

Following disinfection with betadine, the precise seating and cementation of MSE are obtained related to M1, then application of palatal local anesthesia, the anterior miniscrews were placed immediately posterior to the level of the third rugae in the paramedian zone, which is 4–6 mm behind the incisive foramen[38], while the posterior one was inserted in their preformed fixed holes.

The use of maxillary protraction with a Petit-type face mask (FM) was in groups 1 and 2 while in group 3, there was no FM till after 7 months from the start.

The elastic force was 400–500 g on each side of the FM protraction regimen, with a direction of 30° downward to the occlusal plane. for a minimum of 12-14 hours every day. There is no need for bite elevation or any other assisting device to open the bite when the elastic is changed once a day. Protraction continued until a positive overjet was obtained.

In group 1, the expansion protocol was 1mm per day in cases associated with posterior crossbite for 1 week while in group 2 the MSE Alt + FM was activated 1mm per day for the first week, then constricted with the same amount the next week, the protocol involved 4 weeks in patient without posterior crossbite while in patient have PC the activation extended to the fifth week by ending with opening the screw about 7 mm. since, as recommended by previous study,[39] The Alt-RAMEC can be safely activated for five weeks as opposed to nine weeks. [40] The patients were given a note schedule calendar like to register the daily protocol achievement.

Lastly, for group 3, MSE only, since each turn was equivalent to 0.133 mm, the MSE activation protocol called for four turns per day until a diastema developed; the patient might complain of headache and mild pain in the nasal cavity and palate. Four turns would be equivalent to 0.53 mm, meaning that after 16 days, the total activation would be about 8 mm.

To confirm the appliance's soundness, activation, and force delivery of the facemask group in particular, all patient follow-ups were conducted every three weeks.

To prevent any alteration of the soft tissues, the patients were asked to maintain their teeth in centric occlusion

during the exposure, and special care was taken to ensure that the lips should be in a resting position. cephalometric were taken at the start of the observation period (pretreatment, T1) and at the end (posttreatment, T2) after a positive overjet and/or Class I occlusion was achieved.

Outcome:

PICOS

The PICOS strategy—Population, Intervention, Comparison, Outcome, and Study design was used to proceed with the study question. Adult Class III patient (P); with two different protocols of MSE expansion during protraction face mask (I); treated Class III with MSE only without protraction (C); alterations in dento-skeletal features and facial profile (O); Randomized controlled clinical study (S).

Measurements and landmarks:

1- Cephalometric measurements

Web Ceph software was used for cephalometric measurements, 15 Linear (Table 1) and 15 Angular measurements (Table 2) are as follows:

Linear measurements: -

Table (1) Linear measurements

Linear measurements	Definition
Overbite	The distance of vertical overlap of upper incisor to lower incisor
Overjet	Horizontal distance from Labial surface of lower incisor to palatal surface of maxillary incisor
Wits appraisal	Horizontal distance between perpendicular from point A and B on functional occlusal plane that bisecting posterior occlusion
Upper anterior dental height (UADH)	Vertical perpendicular distance between incisal edge of maxillary incisor and palatal plane
Upper posterior dental height (UPDH)	Vertical perpendicular distance between mesiobuccal cusp tip of maxillary permeant first molar and palatal plane
Maxillary permanent first molar position to pterygoid vertical (M1-Ptv)	Horizontal distance between perpendicular from Ptv to distal surface of maxillary permeant first molar
Maxillary length Co- A	Distance from condylion to subnasale (A point)
Mandibular length Co- Gn	Distance from condylion to gnathion.
A -N Vertical	Horizontal distance from A point to N perpendicular
B – N Vertical	Horizontal distance from B point to N perpendicular
Anterior face height (AFH)	Vertical distance between Nasion and Menton
Posterior face height (PFH)	Vertical distance between Sella and Gonion
Lower anterior face height (LAFH)	Vertical distance between Anterior nasal spine and Menton
Upper lip - E line (ULE)	Horizontal distance between upper lip and Esthetic line (soft tissue line connecting pronasale and pogonion)
Lower lip – E line (LLE)	Horizontal distance between lower lip and Esthetic line (soft tissue line connecting pronasale and pogonion)

Angular measurements: -

SNA, SNB, ANB, Mandibular plane (MP)- palatal plane (PP) angle, SN- MP, Gonial angle (GA), Maxillary incisor with PP (U1-PP), Mandibular incisor with MP (MI-MP) and others (Table 2).

Table (2) Angular measurements

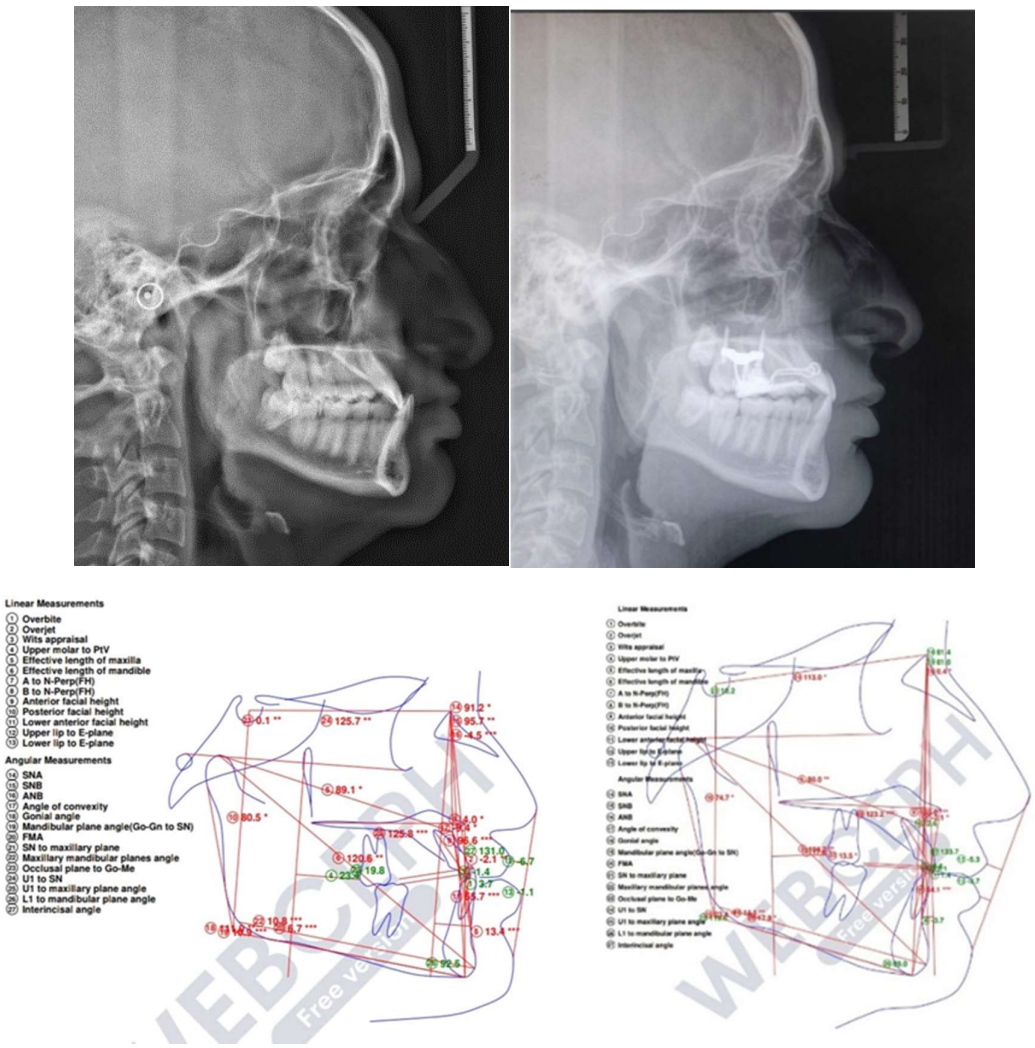

Figure (3): Cephalometric x rays and tracing of pretreatment and post expansion or protraction.

The method error:
The same examiner repeated all cephalometric measures after four weeks, and Concordance Correlation Coefficients were used to calculate the method error. (table 6 and 7)

Statistical analysis:
The data showed a normal distribution after using the Kolmogorov-Smirnov test . For data with a normal distribution, parametric statistics (analysis of variance, ANOVA for comparison among the three groups, while Tukey post hoc test was used when ANOVA was significant; The relationship between pre and post measures (ΔT2-T1) was calculated using Spearman correlation. Changes in dentoskeletal parameters that set the groups apart were found using discriminant analysis. Pearson chi-square test was conducted to verify the gender distribution. The data was merged because no gender variation was noticed ($p > 0.05$).

Results

I-Demographic data

Age and treatment time: The starting mean age was 16.5 ± 1.4 years (range: 14.5-18.5 years),(Table 3 - Fig.4) there was no significant difference in age between groups (p=0.147), and The average treatment time to obtain a positive overjet was 6.7 ± 1.26 months (Table 4 - Fig.5) (range: 5 –8.1 months), There was no significant difference in age between groups (p=0.289).The gender distribution showed in (Table 5 - Fig.6)

Table (3) Descriptive statistics and comparison of age among groups (ANOVA test)

Age (Y)	Mean	SD	Min	Max	P value
MSE CE + FM	16.4	1.03	15.1	17.7	0.147 ns
MSE Alt + FM	17.2	1.3	15.9	18.5	
MSE	15.9	1.4	14.5	17.3	

Significance level p≤0.05, ns=non-significant
(Y) years. (MSE) maxillary skeletal expander, (CE) conventional expansion, (FM) face mask, (Alt) ALTRAMEC, (SD) standard deviation, (Min) minimum, (Max) maximum, and (P) probability.

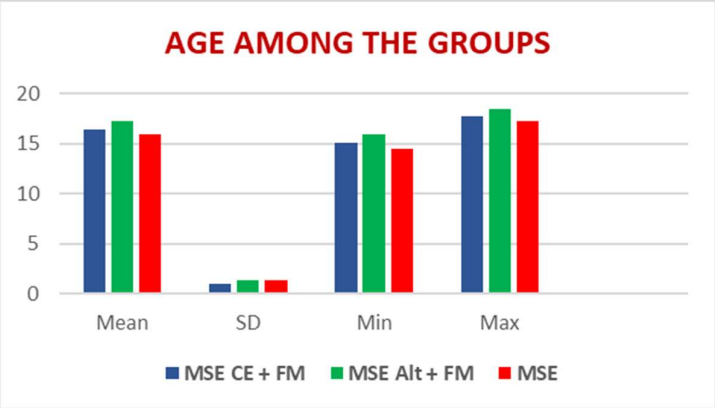

Figure (4): Bar chart for age distribution

Table (4) Descriptive statistics and comparison of the treatment duration among groups (ANOVA test)

Treatment duration (M)	Mean	SD	Min	Max	P value
MSE CE + FM	6.8	1.3	5.5	8.1	0.289 ns
MSE Alt + FM	6.9	1.1	5.8	8	
MSE	6.4	1.4	5	7.8	

Significance level p≤0.05, ns=non-significant
(M) months, (MSE) maxillary skeletal expander, (CE) conventional expansion, (FM) face mask, (Alt) ALTRAMEC, (SD) standard deviation, (Min) minimum, (Max) maximum, and (P) probability.

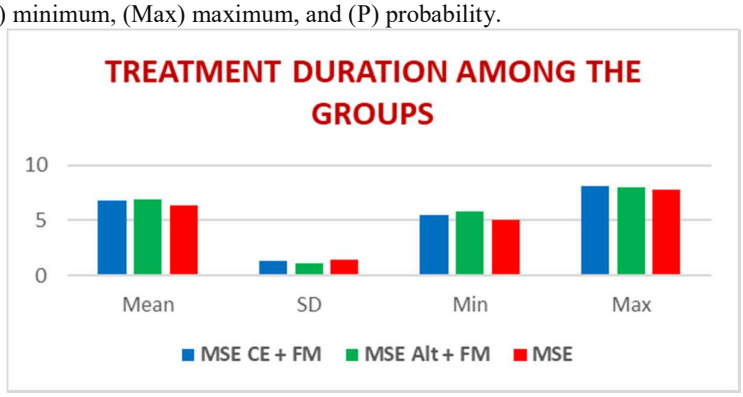

Figure (5): Bar chart for treatment duration

Table (5) Descriptive statistics and comparison of the gender distribution and CVM among groups (ANOVA test)

Gender & CVM	Male	Female	CVM 5	CVM 6	P value
MSE CE + FM	10	6	7	9	0.274 ns
MSE Alt + FM	7	9	6	10	
MSE	8	8	5	11	

Significance level p≤0.05, ns=non-significant
(CVM) cervical vertebral maturation, (MSE) maxillary skeletal expander, (CE) conventional expansion , (FM) face mask, (Alt) ALTRAMEC, and (P) probability.

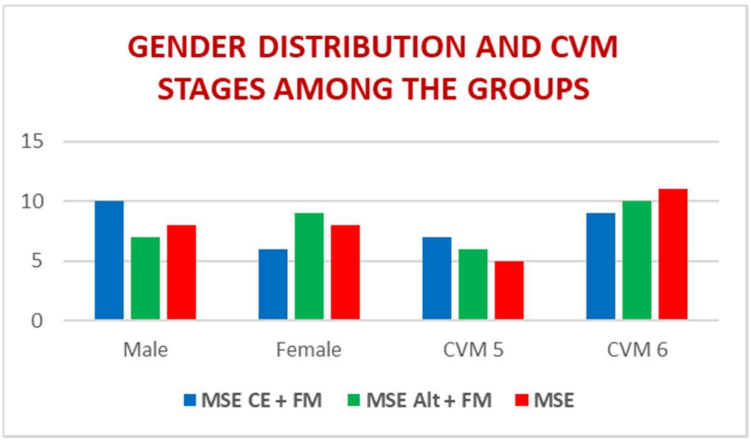

Figure (6): Bar chart for gender and CVM distribution

Table (6) Concordance Correlation Coefficients (CCCs) for the Intraobserver and Interobserver Reliability of the Linear Measurements Used in the

Linear Measurements	Interobserver Reliability Scores		Intraobserver Reliability Scores	
	CCC	95% Confidence Limits	CCC	95% Confidence Limits
Overbite	0.942	0.933-0.976	0.962	0.951-0.973
Overjet	0.963	0.944-0.971	0.972	0.941-0.991
Wits appraisal	0.971	0.969-0.987	0.987	0.965-0.991
UADH	0.962	0.944-0.979	0.989	0.981-0.994
UPDH	0.957	0.927-0.995	0.978	0.975-0.991
M1-Ptv	0.972	0.931-0.993	0.986	0.932-0.993
Co-A	0.958	0.921-0.983	0.987	0.979-0.991
Co-Gn	0.973	0.942-0.986	0.989	0.972-0.996
A-N v	0.962	0.923-0.976	0.978	0.965-0.988
B-N v	0.957	0.921-0.974	0.973	0.957-0.984
AFH	0.983	0.931-0.991	0.992	0.945-0.996
PFH	0.986	0.935-0.993	0.992	0.944-0.995
LAFH	0.978	0.938-0.957	0.993	0.956-0.996
ULE	0.971	0.936-0.998	0.984	0.947-0.992
LLE	0.972	0.931-0.997	0.986	0.958-0.991

(CCCs) Concordance Correlation Coefficients, (UADH) upper anterior dental height, (UPDH) upper posterior dental height, (M1-Ptv) maxillary permanent first molar position to pterygoid vertical, (Co- A) maxillary length, (Co- Gn) mandibular length , (V) vertical, (AFH) anterior face height, (PFH) posterior face height, (LAFH) lower anterior face height, (ULE) upper lip - E line, (LLE) lower lip - E line .

Table (7) Concordance Correlation Coefficients (CCCs) for the Intraobserver and Interobserver Reliability of the Angular Measurements Used in the

Angular Measurements	Interobserver Reliability Scores		Intraobserver Reliability Scores	
	CCC	95% Confidence Limits	CCC	95% Confidence Limits
SNA	0.975	0.931-0.989	0.984	0.952-0.991
SNB	0.976	0.923-0.987	0.989	0.961-0.993
ANB	0.996	0.986-0.998	0.997	0.992-0.999
NA-Pog A	0.868	0.842-0.888	0.913	0.884-0.944
Ar-Go-Me	0.895	0.814-0.943	0.934	0.892-0.975
SN- MP	0.987	0.952-0.989	0.991	0.972-0.995
FMPA	0.913	0.899-0.932	0.963	0.921-0.984
SN- PP	0.982	0.951-0.993	0.986	0.932-0.993
MP- PP	0.977	0.931-0.985	0.987	0.979-0.991
MP- OP	0.973	0.952-0.982	0.989	0.972-0.996
U1-SN	0.992	0.973-0.998	0.978	0.965-0.988
UI-PP	0.987	0.941-0.991	0.993	0.967-0.997
IMPA	0.986	0.939-0.989	0.991	0.972-0.996
U1-L1	0.965	0.943-0.987	0.987	0.927-0.992
N' Sn Pog'	0.987	0.969-0.992	0.992	0.977-0.996

(CCCs) Concordance Correlation Coefficients , (NA-Pog A) Angle of convexity, (Ar-Go-Me) gonial angle, (SN-MP) mandibular plane with anterior cranial base, (MP-PP) mandibular plane- palatal plane, (MP-OP) mandibular plane- occlusal plane, (U1-SN) upper incisor- SN plane, (UI-PP) upper incisor with palatal plane, (IMPA) lower incisor- mandibular plane, (U1-L1) interincisal angle and (N'Sn Pog') soft tissue profile.

Table (8) Descriptive statistics and test of significance (ANOVA) or Kruskal–Wallis test (†) for the pre-treatment Linear measurements in all groups

Measurement (mm)	Mean	SD	Min	Max	F	*P Value*
Overbite						
MSE CE + FM	2.2	0.9	0.56	3.5	1.31	0.642
MSE Alt + FM	1.9	1.1	0.62	3.4		
MSE	2.3	1.2	0.83	3.6		
Overjet						
MSE CE + FM	-2.5	0.5	-4.1	0.9	0.76	0.489
MSE Alt + FM	-2.4	0.6	-3.9	0.7		
MSE	-2.2	0.7	-3.5	1.3		
Wits appraisal						
MSE CE + FM	-8.2	1.8	-4.8	-11.1	1.32	0.637
MSE Alt + FM	-7.7	1.7	-4.2	-10.6		
MSE	-7.1	2.1	-4.7	-10.2		
UADH						
MSE CE + FM	27.3	2.5	23.2	31.2	0.368	0.964
MSE Alt + FM	26.8	2.7	21.5	30.3		
MSE	27.2	2.3	23.5	31.5		
UPDH						
MSE CE + FM	21.5	2.2	18.1	27.3	1.146	0.384
MSE Alt + FM	22.6	1.9	17.5	26.4		
MSE	22.3	2.1	17.6	28.2		
M1-Ptv						
MSE CE + FM	15.4	2.3	12.1	17.4	2.426	0.003
MSE Alt + FM	14.9	2.1	11.2	18.2		
MSE	15.5	1.9	12.4	18.6		
Co- A						
MSE CE + FM	64.5	2.9	60.3	69.3	1.75	0.096
MSE Alt + FM	63.2	3.5	58.2	68.1		
MSE	62.3	3.7	56.1	67.4		
Co- Gn						
MSE CE + FM	119.4	4.2	113.2	125.2	2.45	0.094
MSE Alt + FM	120.5	3.8	114.4	124.1		
MSE	121.4	3.5	115.3	126.6		
A -N Vertical						
MSE CE + FM	-3.4	3.1	-0.1	-7.2	2.22	0.736
MSE Alt + FM	-3.6	2.9	-0.4	-7.5		
MSE	-3.3	2.8	-0.3	-7.1		
B -N Vertical						
MSE CE + FM	1.5	2.1	-0.9	4.2	3.59	0.653
MSE Alt + FM	1.4	2.2	-1.1	4.5		
MSE	1.6	1.9	-1.3	4.8		
AFH						
MSE CE + FM	111.3	8.7	91.5	131.3	1.64	0.732
MSE Alt + FM	114.6	9.1	93.4	129.5		
MSE	115.7	8.4	92.6	127.8		
PFH						
MSE CE + FM	69.5	4.4	59.8	78.5	0.171	0.426
MSE Alt + FM	74.26	4.6	62.6	83.8		
MSE	72.61	5.2	60.41	85.4		
LAFH						
MSE CE + FM	46.5	7.5	38.1	51.2	1.632	0.571
MSE Alt + FM	47.9	7.3	39.6	56.3		
MSE	44.2	6.9	36.9	53.7		
ULE						
MSE CE + FM	-1.6	1	-0.8	0.5	2.733	0.482
MSE Alt + FM	-1.9	0.9	-0.9	0.7		
MSE	-1.4	0.6	-0.7	0.9		

LLE						
MSE CE + FM	3.8	1.3	0.8	5.7	1.839	0.388
MSE Alt + FM	3.4	1.5	0.9	6.1		
MSE	3.2	1.4	0.9	5.9		

95% Confidence Interval for Mean, (mm) millimeter, (SD) standard deviation, (Min) minimum, (Max) maximum, (P) probability, (MSE) maxillary skeletal expander,(CE) conventional expansion , (FM) face mask, (Alt) ALTRAMEC , (UADH) upper anterior dental height, (UPDH) upper posterior dental height, (M1-Ptv) maxillary permanent first molar position to pterygoid vertical, (Co- A) maxillary length, (Co- Gn) mandibular length , (V) vertical, (AFH) anterior face height, (PFH) posterior face height, (LAFH) lower anterior face height, (ULE) upper lip - E line, (LLE) lower lip - E line .

Table (9) Descriptive statistics and test of significance (ANOVA) or Kruskal–Wallis test (†) for the pre-treatment Angular measurements in all groups

Measurement (0)	Mean	SD	Min	Max	F	*P Value*
SNA						
MSE CE + FM	78.7	3.2	75.5	82.3	2.72	0.127
MSE Alt + FM	78.8	3.4	75.4	82.8		
MSE	79.1	2.8	76.3	82.9		
SNB						
MSE CE + FM	81.3	2.7	78.3	83.2	5.24	0.684
MSE Alt + FM	80.5	3.2	77.1	83.7		
MSE	80.4	3.1	77.8	84.1		
ANB						
MSE CE + FM	-2.1	1.8	-3.5	1.2	2.37	0.354
MSE Alt + FM	-1.9	1.7	-3.4	1.3		
MSE	-1.8	1.6	-3.1	0.9		
NA-Pog A						
MSE CE + FM	182	3.4	175.3	190.2	1.39	0.636
MSE Alt + FM	181	3.1	172.8	187.3		
MSE	180	2.8	173.5	189.4		
Ar-Go-Me						
MSE CE + FM	123	5.3	116.2	137.4	0.023	0.863
MSE Alt + FM	125	5.1	118.6	136.9		
MSE	122	5.8	115.7	134.5		
MP- SN						
MSE CE + FM	34.7	5.21	27.4	42.9	1.12	0.373
MSE Alt + FM	35.4	6.5	28.6	43.4		
MSE	34.5	3.71	28.1	41.8		
FMPA						
MSE CE + FM	27.4	5.2	20.4	33.6	2.95	0.482
MSE Alt + FM	28.2	4.7	21.7	34.5		
MSE	27.2	4.8	20.8	35.2		
SN-PP						
MSE CE + FM	9.6	3.3	4.4	13.3	2.47	0.737
MSE Alt + FM	8.4	2.4	5.9	14.2		
MSE	10.6	2.5	6.7	15.4		
MP-PP						
MSE CE + FM	24.5	4.4	19.8	31.3	3.48	0.637
MSE Alt + FM	23.5	3.7	18.3	29.6		
MSE	25.3	5.1	19.2	33.3		
MP-OP						
MSE CE + FM	14.5	3.1	10.1	20.6	1.42	0.421
MSE Alt + FM	13.9	2.96	9.6	18.8		
MSE	15.2	2.72	11.7	21.7		
U1-SN						
MSE CE + FM	103.2	4.5	92.5	112.2	2.32	0.563
MSE Alt + FM	102.3	5.3	93.4	110.4		
MSE	100.5	5.1	94.1	111.9		
U1-PP						
MSE CE + FM	101	5.2	93.4	109.3	1.38	0.324
MSE Alt + FM	99.2	4.8	92.1	107.4		
MSE	98.2	6.2	91.3	106.2		
IMPA						
MSE CE + FM	84.3	5.2	76.3	91.4	2.33	0.623

MSE Alt + FM	86.1	4.3	77.7	92.8		
MSE	85.6	4.1	78.3	93.2		
U1-L1						
MSE CE + FM	145	5.7	137.8	152.3	2.13	0.679
MSE Alt + FM	143	6.2	135.6	152.7		
MSE	147	4.3	139.2	155.1		
N' Sn Pog'						
MSE CE + FM	175.1	2.1	168.4	178.2	1.39	0.385
MSE Alt + FM	174.3	2.6	168.7	177.4		
MSE	176.1	2.3	167.1	178.4		

95% Confidence Interval for Mean, (0) degree, (SD) standard deviation, (Min) minimum, (Max) maximum, (P) probability, (MSE) maxillary skeletal expander,(CE) conventional expansion , (FM) face mask, (Alt) ALTRAMEC , (NA-Pog A) Angle of convexity, (Ar-Go-Me) gonial angle, (SN-MP) mandibular plane with anterior cranial base, (MP-PP) mandibular plane- palatal plane, (MP-OP) mandibular plane- occlusal plane, (U1-SN) upper incisor- SN plane, (UI-PP) upper incisor with palatal plane, (IMPA) lower incisor- mandibular plane, (U1-L1) interincisal angle and (N'Sn Pog') soft tissue profile.

Skeletal, dental, and soft tissue changes:

Significant decrease in SNB, minus overjet in groups 1and 2, while there was a significant increase in SNA, ANB, the angle of convexity, and Wits appraisal in groups 1 and 2, resulting in obtaining positive overjet and convex or straight facial profile.

Table (10) Cephalometric linear variables pre-treatment (T1) and post-expansion or protraction (T2) and mean difference (T2-T1) Wilcoxon test.

Measurement (mm)	T1		T2		T2 – T1		
	Mean	SD	Mean	SD	Mean	SD	*P Value*
Overbite							
MSE CE + FM	2.2	0.9	1.5	0.7	-0.7	0.2	0.018
MSE Alt + FM	1.9	1.1	0.7	0.6	-1.2	0.3	0.004
MSE	2.3	1.2	1.2	0.7	-1.1	0.5	0.003
Overjet							
MSE CE + FM	-2.5	0.5	3.3	0.8	5.8	0.3	0.001
MSE Alt + FM	-2.4	0.6	4.3	0.7	6.7	0.4	0.003
MSE	-2.2	0.7	2.2	0.6	4.4	0.2	0.005
Wits appraisal							
MSE CE + FM	-8.2	1.8	-3.7	1.6	4.5	0.8	0.002
MSE Alt + FM	-7.7	1.7	-2.3	1.8	5.4	0.6	0.003
MSE	-7.1	2.1	-4.3	1.1	2.8	0.4	0.005
UADH							
MSE CE + FM	27.3	2.5	26.5	2.3	-0.8	0.4	0.002
MSE Alt + FM	26.8	2.7	25.5	2.2	-1.3	0.6	0.001
MSE	27.2	2.3	27.6	1.9	-0.4	0.2	0.135
UPDH							
MSE CE + FM	21.5	2.2	21.9	1.8	0.4	0.2	0.284
MSE Alt + FM	22.6	1.9	23.3	2.1	0.7	0.3	0.341
MSE	22.3	2.1	22.6	1.7	0.3	0.1	0.168
M1-Ptv							
MSE CE + FM	15.4	2.3	17.3	1.7	1.9	0.8	0.001
MSE Alt + FM	14.9	2.1	17.2	1.9	2.3	0.9	0.001
MSE	15.5	1.9	16.3	1.2	0.8	0.3	0.043*
Co- A							
MSE CE + FM	64.5	2.9	66.6	1.5	2.1	0.9	0.001
MSE Alt + FM	63.2	3.5	66.5	1.7	3.3	0.9	0.001
MSE	62.3	3.7	63.5	1.4	1.2	0.4	0.042*
Co- Gn							
MSE CE + FM	119.4	4.2	117.5	2.5	-1.9	1.1	0.002*
MSE Alt + FM	120.5	3.8	117.7	2.6	-2.8	1.2	0.001
MSE	121.4	3.5	120.6	1.8	-0.8	0.4	0.158
A -N Vertical							
MSE CE + FM	-3.4	3.1	-1.8	2.3	1.6	0.8	0.001
MSE Alt + FM	-3.6	2.9	-1.6	1.5	2	0.9	0.001
MSE	-3.3	2.8	-2.7	0.8	0.3	0.1	0.158
B -N Vertical							
MSE CE + FM	1.5	2.1	1.3	1.9	-0.2	0.1	0.147
MSE Alt + FM	1.4	2.2	1.1	1.7	-0.3	0.2	0.231

MSE	1.6	1.9	2.1	1.5	0.5	0.2	0.001*
AFH							
MSE CE + FM	111.3	8.7	113.2	6.2	1.9	0.3	0.432
MSE Alt + FM	114.6	9.1	116.3	5.7	1.7	0.2	0.257
MSE	115.7	8.4	119.2	5.8	3.5	0.8	0.001*
PFH							
MSE CE + FM	69.5	4.4	70.3	4.6	0.8	0.3	0.426
MSE Alt + FM	74.2	4.6	74.9	5.1	0.7	0.2	0.362
MSE	72.6	5.2	73.9	4.3	1.3	0.5	0.001*
LAFH							
MSE CE + FM	46.5	7.5	48.3	4.2	1.8	0.4	0.372
MSE Alt + FM	47.9	7.3	46.3	3.6	1.6	0.3	0.153
MSE	44.2	6.9	47.5	4.9	3.3	0.7	0.001*
ULE							
MSE CE + FM	-1.6	1	-0.8	0.5	0.8	0.3	0.001*
MSE Alt + FM	-1.9	0.9	-0.9	0.7	1	0.5	0.001*
MSE	-1.4	0.6	-1.1	0.9	0.3	0.1	0.432
LLE							
MSE CE + FM	3.8	1.3	2.2	0.9	1.6	0.7	0.002*
MSE Alt + FM	3.4	1.5	1.6	0.8	1.8	0.6	0.002*
MSE	3.2	1.4	1.2	0.7	2	0.5	0.001*

(mm) millimeter, (SD) standard deviation, (P) probability, (MSE) maxillary skeletal expander,(CE) conventional expansion , (FM) face mask, (Alt) ALTRAMEC , (UADH) upper anterior dental height, (UPDH) upper posterior dental height, (M1-Ptv) maxillary permanent first molar position to pterygoid vertical, (Co- A) maxillary length, (Co- Gn) mandibular length , (V) vertical, (AFH) anterior face height, (PFH) posterior face height, (LAFH) lower anterior face height, (ULE) upper lip - E line, (LLE) lower lip - E line .

Table (11) Cephalometric angular variables pre-treatment (T1) and post-expansion or protraction (T2) and mean difference (T2-T1) Wilcoxon test.

Measurement (0)	T1		T2		T2 – T1		P Value
	Mean	SD	Mean	SD	Mean	SD	
SNA							
MSE CE + FM	78.7	3.2	80.9	1.24	1.72	0.7	0.002*
MSE Alt + FM	78.8	3.4	75.4	82.8	2.1	0.9	0.001
MSE	79.1	2.8	76.3	82.9	1.1	0.3	0.158
SNB							
MSE CE + FM	81.3	2.7	80.1	1.9	1.2	0.6	0.384
MSE Alt + FM	80.5	3.2	79.6	1.7	0.9	0.5	0.523
MSE	80.4	3.1	78.7	1.6	1.7	0.4	0.002*
ANB							
MSE CE + FM	-2.1	1.8	2.2	1.3	4.3	0.9	0.002*
MSE Alt + FM	-1.9	1.7	2.7	1.2	4.6	1.1	0.001
MSE	-1.8	1.6	1.1	0.7	2.9	0.8	0.003
NA-Pog A							
MSE CE + FM	182	3.4	177	2.5	-5	1.9	0.002*
MSE Alt + FM	181	3.1	178	2.7	-3	2.1	0.001
MSE	180	2.8	185	2.6	5	2.8	0.003
Ar-Go-Me							
MSE CE + FM	123	5.3	123.9	3.9	0.9	0.5	0.002*
MSE Alt + FM	125	5.1	126.3	4.2	1.3	0.7	0.001
MSE	122	5.8	124.2	3.7	2.2	1.1	0.003
MP- SN							
MSE CE + FM	34.7	5.21	35.5	3.4	0.8	0.4	0.134
MSE Alt + FM	35.4	6.5	36.1	3.3	0.7	0.3	0.246
MSE	34.5	3.71	36.3	2.8	1.8	0.9	0.001
FMPA							
MSE CE + FM	27.4	5.2	28.4	3.8	1	0.8	1.67
MSE Alt + FM	28.2	4.7	29.4	3.9	1.2	0.7	3.15
MSE	27.2	4.8	29.7	2.7	2.5	1.2	0.001
SN-PP							
MSE CE + FM	9.6	3.3	10.4	3.5	0.8	0.4	2.58
MSE Alt + FM	8.4	2.4	9.1	4.1	0.7	0.3	0.178
MSE	10.6	2.5	10.9	3.8	0.3	0.1	3.69
MP-PP							

MSE CE + FM	24.5	4.4	26.3	4.2	1.8	0.9	0.023
MSE Alt + FM	23.5	3.7	25.2	3.8	1.7	0.7	0.013
MSE	25.3	5.1	28.1	4.3	2.8	1.3	0.001
MP-OP							
MSE CE + FM	14.5	3.1	15.1	2.8	0.6	0.3	3.93
MSE Alt + FM	13.9	2.96	14.3	2.7	0.4	0.2	2.63
MSE	15.2	2.72	16.9	2.4	1.7	0.8	0.033
U1-SN							
MSE CE + FM	103.2	4.5	104.1	5.1	0.9	0.5	0.296
MSE Alt + FM	102.3	5.3	103.3	4.8	1	0.6	1.537
MSE	100.5	5.1	102.3	4.9	1.8	0.8	0.024
U1-PP							
MSE CE + FM	112.6	5.7	113.7	4.8	1.1	0.6	2.35
MSE Alt + FM	110.6	4.9	111.8	5.3	1.2	0.5	1.98
MSE	110.1	5.4	112.3	5.6	2.2	1.2	0.042
IMPA							
MSE CE + FM	84.3	5.2	83.9	4.8	-0.4	0.2	0.346
MSE Alt + FM	86.1	4.3	85.6	4.6	-0.5	0.2	1.483
MSE	85.6	4.1	86.4	4.9	0.8	0.3	3.245
U1-L1							
MSE CE + FM	145	5.7	143.5	4.6	-1.5	0.5	0.0124
MSE Alt + FM	143	6.2	142.2	4.3	-0.8	0.2	0.035
MSE	147	4.3	145.1	3.8	-1.9	0.9	0.001
N' Sn Pog'							
MSE CE + FM	175.1	2.1	171.3	1.9	-3.8	1.8	0.001
MSE Alt + FM	174.3	2.6	171.6	1.4	-2.7	1.7	0.023
MSE	176.1	2.3	173.5	1.7	-2.6	1.5	0.033

(0) degree, (SD) standard deviation, (P) probability, (MSE) maxillary skeletal expander,(CE) conventional expansion , (FM) face mask, (Alt) ALTRAMEC , (NA-Pog A) Angle of convexity, (Ar-Go-Me) gonial angle, (SN-MP) mandibular plane with anterior cranial base, (MP-PP) mandibular plane- palatal plane, (MP-OP) mandibular plane- occlusal plane, (U1-SN) upper incisor- SN plane, (UI-PP) upper incisor with palatal plane, (IMPA) lower incisor- mandibular plane, (U1-L1) interincisal angle and (N'Sn Pog') soft tissue profile.

Table (12) Comparison of mean linear parameters changes among the three groups (T2-T1)

Measurement (mm)	MSE CE + FM	MSE Alt + FM	MSE	P Value	Post-hoc Tukey test		
					1-2	1-3	2-3
Overbite	-0.7	-1.2	-1.1	0.001	NS	0.001	0.003
Overjet	5.8	6.7	4.4	0.002	NS	0.001	0.012
Wits appraisal	4.5	5.4	2.8	0.011*	NS	0.002*	0.013*
UADH	-0.8	-1.3	-0.4	0.231	-	-	-
UPDH	0.4	0.7	0.3	0.425	-	-	-
M1-Ptv	1.9	2.3	0.8	1.35	-	-	-
Co- A	2.1	3.3	1.2	0.003*	NS	0.001*	0.012*
Co- Gn	-1.9	-2.8	-0.8	2.76	-	-	-
A-N Vertical	1.6	2	0.3	0.5	NS	0.011*	0.022*
B-N Vertical	-0.2	-0.3		5.23	-	-	-
AFH	1.9	1.7	3.5	0.001*	NS	0.002*	0.001*
PFH	0.8	0.7	1.3	0.002*	NS	0.002*	0.001*
LAFH	1.8	1.6	3.3	0.001*	NS	0.002*	0.001*
ULE	0.8	1	0.3	0.003*	NS	0.001*	0.0001*
LLE	1.6	1.8	2	0.352	-	-	-

(mm) millimeter, (SD) standard deviation, (P) probability, (MSE) maxillary skeletal expander,(CE) conventional expansion , (FM) face mask, (Alt) ALTRAMEC , (UADH) upper anterior dental height, (UPDH) upper posterior dental height, (M1-Ptv) maxillary permanent first molar position to pterygoid vertical, (Co- A) maxillary length, (Co- Gn) mandibular length , (V) vertical, (AFH) anterior face height, (PFH) posterior face height, (LAFH) lower anterior face height, (ULE) upper lip - E line, (LLE) lower lip - E line .

Table (13) Comparison of mean angular parameters changes among the three groups (T2-T1)

Measurement (0)	MSE CE + FM	MSE Alt + FM	MSE	P Value	Post-hoc Tukey test		
					1-2	1-3	2-3
SNA	1.72	2.1	1.1	0.001	NS	0.001	0.003
SNB	1.2	0.9	1.7	0.002*	NS	0.002*	0.001*
ANB	4.3	4.6	2.9	0.001	NS	0.012*	0.001*
NA-Pog A	-5	-3	5	0.356	-	-	-

Ar-Go-Me	0.9	1.3	2.2	0.003	NS	0.002*	0.001*
MP- SN	0.8	0.7	1.8	0.001*	NS	0.002*	0.001*
FMPA	1	1.2	2.5	0.002*	NS	0.002*	0.001*
SN-PP	0.8	0.7	0.3	0.001*	NS	0.001*	0.0001*
MP-PP	1.8	1.7	2.8	0.003*	NS	0.002*	0.013*
MP-OP	0.6	0.4	1.7	0.147	-	-	-
U1-SN	0.9	1	1.8	0.001*	NS	0.001	0.003
U1-PP	1.1	1.2	2.2	0.002*	NS	0.001	0.012
IMPA	-0.4	-0.5	0.8	0.001*	NS	0.002*	0.013*
U1-L1	-1.5	-0.8	-1.9	0.471	-	-	-
N' Sn Pog'	-3.8	-2.7	-2.6	0.164	-	-	-

(0) degree, (SD) standard deviation, (P) probability, (MSE) maxillary skeletal expander,(CE) conventional expansion , (FM) face mask, (Alt) ALTRAMEC , (NA-Pog A) Angle of convexity, (Ar-Go-Me) gonial angle, (SN-MP) mandibular plane with anterior cranial base, (MP-PP) mandibular plane- palatal plane, (MP-OP) mandibular plane- occlusal plane, (U1-SN) upper incisor- SN plane, (UI-PP) upper incisor with palatal plane, (IMPA) lower incisor- mandibular plane, (U1-L1) interincisal angle and (N'Sn Pog') soft tissue profile.

Table (14) Pearson correlation coefficients between cephalometric variables (T2-T1) in all groups.

Variable 1	Variable 2	R	P	Significance
SNA	Overjet			
MSE CE + FM		0.32	0.004	s
MSE Alt + FM		0.47	0.021	s
MSE		0.83	0.230	ns
SNA	NA-Pog A			
MSE CE + FM		0.34	0.0001	s
MSE Alt + FM		0.41	0.0321	s
MSE		0.93	1.94	ns
SNA	M1-Ptv			
MSE CE + FM		-0.26	0.001	s
MSE Alt + FM		-0.23	0.026	s
MSE		-0.72	3.28	ns
SNA	OB			
MSE CE + FM		-0.021	0.003	s
MSE Alt + FM		-0.034	0.002	s
MSE		-0.83	0.67	ns
SNA	ULE			
MSE CE + FM		0.52	0.006	s
MSE Alt + FM		0.62	0.002	s
MSE		0.134	0.68	ns
U1-SN	ULE			
MSE CE + FM		0.324	0.003	s
MSE Alt + FM		0.567	0.021	s
MSE		-0.12	0.46	ns
SNA	Co- A			
MSE CE + FM		0.47	0.036	s
MSE Alt + FM		0.62	0.043	s
MSE		0.92	2.70	ns
SNB	SN-MP			
MSE CE + FM		-0.37	0.0041	s
MSE Alt + FM		-0.83	0.0032	s
MSE		-0.46	1.46	ns

T1, pre-treatment; T2, post treatment; R, Pearson correlation coefficient; S, significance; NS, not significant P ≤0.05; (MSE) maxillary skeletal expander, (CE) conventional expansion, (FM) face mask, (Alt) ALTRAMEC, (NA-Pog A) Angle of convexity, (SN-MP) mandibular plane with anterior cranial base, (U1-SN) upper incisor- SN plane, (IMPA) lower incisor- mandibular plane angle and (N'Sn Pog') soft tissue profile. (M1-Ptv) maxillary permanent first molar position to pterygoid vertical, (Co- A) maxillary length, (ULE) upper lip - E line.

Discussion

There is ongoing debate regarding the stability of dentofacial orthopaedic treatment for Class III correction, since relapse is unavoidable when patients are tracked over time due to the net skeletal changes caused by therapy being lost.[41,42] while another study saw the opposite.[43]

Even though some researches[44–46] have found no discernible variation in maxillary advancement with or without RPE, in the current sample group 1 and 2

showed a significant result in comparison to group 3 only.

Because the pterygomaxillary buttress bone is a primary resistance component in maxillary growth, this site was chosen to exert lateral stresses against it, so the screw was positioned at the first molar for this reason.[37]The only evaluation in the current study through using cephalometric analysis rather than CBCT to respect the principle of ALARA (as low as reasonably achievable)

The Orthopedic forces on the mandible and maxilla appear to have been more beneficial and successful in the early stages of protraction than in the latter stages.[47]

Patients with cleft palates were able to use FM in conjunction with the Alt-RAMEC concept, which involved a 5.8 mm anterior movement of point A.[22] In contrast to the RME group (2.33 mm), Isci et al.[34] noted that the Alt-RAMEC group's anterior movement of point A was virtually identical (4.13 mm).

Using the Alt-RAMEC approach, Kaya et al.[48] evaluated the outcomes of FM treatment supported with miniplates without a control group, while Cevidanes et al,[49] found more skeletal protraction effect with the use of miniplates.

The effects of maxillary protraction initiated concurrently and following the Alt-RAMEC technique were compared by CanturK et al[50]they found that it is not mandatory to wait for Alt-RAMEC technique while RPE only can give the same effect. And for protraction group the maxillary plane directed up anteriorly this was in accordance with Cordasco et al[45,51]

Buyukcavus et al,[35] recommended that quick maxillary movement can be achieved by applying the face mask utilizing TADs in conjunction with the altered Alt-RAMEC procedure carried out prior to reverse headgear.

In the current study the overjet improved by 5.8.4 ± 0.3 mm in group 1 and 6.7 ± 0.4 mm in the Alt-RAMEC (group 2), while in group 3 the mean difference was 4.4 ± 0.2 mm indicating a positive overjet especially in group 2.

The point A moves forward and upward in protraction face mask group 1 and 2 1.6 ± 0.8 mm and 2 ± 0.9 mm respectively, while in group 3 the advancement of A point was less 0.3 ± 0.1 mm this was confirmed by increase in SNA angle in contrast to the controls by (1.1± 0.3º), the Alt-RAMEC was (2.1± 0.9º) and rapid maxillary expansion with protraction was (1.7 ± 0.7º) showed clear maxillary advancement. This helps to enhance the negative overjet and molar correction when combined with mandibular clockwise rotation. Only the location of the maxillary incisors showed changes between the two expansion methods, since in control one (group 3) was (1.8± 0.8º) while the Alt-RAMEC (1 ± 0.6º) and rapid maxillary expansion with protraction was (0.9 ± 0.5º) indicating maxillary incisor proclination especially in group 3.

The WITs appraisal was 4.5, 5.4 and 2.8 mm in group 1,2 and 3 respectively, also a counterclockwise rotation of the palatal plane (0.8, 0.7 and 0.3 degree) was unavoidable, even if the protraction elastics were oriented 30-40 degrees with the occlusal plane, which was in concomitance with previous findings.[52–57] And was in discordance with Liou et al[22] and Shanker et al[58]

Liou et al[22] found 5.8 mm protraction of point A, this might be using a continuous active spring 24 hours while the time of wearing protraction face mask in the present study was nearly 12 ± 2.1 hours per day.

While Shanker et al[58] found that the movement of point A was forward and downward this might be attributed to a different expander design. While other studies[59,60] found little rotation of no significance after protraction with FM, these different actions depends on multifactorial process including individual soft and hard tissue response, age, gender, force application, the expander's design and the miniscrew's location, this affect the geometric alterations in the maxilla that came about as a result of the midpalatal suture opening. On the other hand, in group 3 RPE only the A point moves forward and downward 0.3 mm, as confirmed by increase in positive overjet by 4.4 ± 0.2 mm SNA by 1.1 ± 0.3 degree, and Wits appraisal was 2.8 ± 0.4 mm this agreed with previous studies,[58,61,62].

Compared to RME-FM therapy, Isci et al.[34] saw an improvement in overjet, particularly with Alt-RAMEC-FM. were 7.13 ± 2.09 mm and 4.97 ± 2.07 mm, respectively, following 12 months, with no change in the lower incisors and more proclination of maxillary anterior, this was in agreement with our study but nearly with half the amount due to different age in both studies.

The effect of protraction face mask on mandible in the present study was of no statistical value since little growth was expected but the B point might show significant decrease due to backward and downward rotation of the mandible as indicated by decrease in SNB angle in group 3.

In group 1 and 2 the vertical dimension showed little change in comparison to group 3 which evidenced by noticeable increase in FMPA and FH with PP, this indicated by a good control of protraction force direction in comparison to expansion alone, this was in approval with previous studies [62–64]And in disapproval with Saleh et al[65] this might be due to different expander design and age group, since they used banded hyrax in 6-12 years patients, while in the present study the use of MSE in late teen groups.

As regard to the effect of RPE on maxilla the result showed that there is no significant maxillofacial sagittal and vertical changes at the maxillary position similar to the results of systematic review done by Lagravere etal[66] who conducted a thorough study on the lasting skeletal changes in patients undergoing RME therapy and concluded that there were no significant sagittal and vertical changes even during growth period. Da Silva Filho et al.[33] also investigated the midterm outcomes for RME and did not observe any significant anterior movement/translation of the maxilla.

Comprehensive orthodontic treatment can sometimes help to correct bone-related issues that happen with RME, for example, it can address the backward rotation of the lower jaw or an anterior open bite. Once this adjustment is made, no further changes are expected because it fits with how the body normally grows.[67]

The Class III malocclusion was corrected as a result of notable, favorable sagittal alterations, despite the fact that only a small portion of the groups wore their FMs for ten hours or more, as shown by reasonable studies.[68,69]These findings caused the vertical measures to rise as a result and aligned with the conclusions of earlier researches [50,70,71] in addition it might be brought on by the maxilla and/or maxillary teeth moving vertically[72] or by the retracting strain on the chin.

While in the protraction group there was little mandibular backward rotation due to less extrusion, counterclockwise rotation of maxilla, concomitant with

previous studies.[49,52,73] as presented by increase in lower anterior height in group 3 and noticeable decrease in SNB angle 1.2, 0.9 and 1.7 degree found in group 1, 2 and 3 respectively, and these results was in disagree with Buyukcavus et al[35], since they used adifferent hybrid appliance while in the present study the 4 miniscrews of the MSE might have role in controlling molar extrusion and hence less mandibular backward rotation.

Although the use of skeletal anchorage and the application of the Alt-RAMEC protocol have been demonstrated to be effective methods for increasing maxillary protraction, the choice of appliance anchorage which may be tooth-borne or skeletal is more significant than the expansion method (RME or Alt-RAMEC).[74]

The upper incisor inclination was 0.9 ± 0.5º, 1 ± 0.6º and (1.8± 0.8º) in group 1, 2 and 3 respectively, this results showed decrease in upper incisor inclination in the protraction FM groups while in group 3 RPE only was increased this was in discordance with previous studies, [74,75] this can be attributed to different methodology with less dentoalveolar compensation in the protraction MSE groups. And this can explain no differences in overjet, since in group 3 the overjet improved by both compensation of upper incisors in addition to backward and downward rotation of the mandible, as regard the change in overbite group 3 showed decrease -1.1 mm while in group 1 and 2 showed little change -0.7 and 0.6 mm respectively was observed, these agreed with D0-delatour et al[61]

In the current study, the mandibular incisor in the RPE group showed a significant drop 0.8 compared to the protraction groups, whereas the lower incisor inclination in ALTRAMEC was -0.5 and group 1 was -0.4. This was in line with the findings of earlier researches,[48,74,75] and at odds with earlier research by Rongo et al [76] this could be related to age group changes, the harmony with the protraction rate, which could be impacted by lower upper molar extrusion and forward tongue balance in the protraction groups.

For the upper lip and soft tissue pogonion, both groups' soft tissue effects were more pronounced than for the lower lip. The underlying skeletal and dentoalveolar modifications may be the cause of the upper lip's forward movement and the lower lip's and the soft tissue pogonion's backward motions, as indicated by the upper lip to E line 0.8, 1 and 0.3 in group 1, 2 and 3 respectively. These modifications were consistent with the findings of earlier research.

But in comparison to the growing patient in a previous study[77] this was distinguished by the correction of the relative mandibular prognathism and an increase in the fullness of the infraorbital area, but in the current study the effect on the infraorbital area with no of value.

A systematic review showed there is little to moderate evidence that Class III patients' soft tissues benefit from early therapy. These findings, however, are predicated on a two-dimensional examination of cephalometric pictures, which could not offer comprehensive or precise data. Consequently, more RCTs employing thorough 3D analysis are required to validate these findings.[78]

In the current study, the patient compliance toward hygiene or activation protocol and or facemask wear was accepted, since only 6 patients were lost in this study.

Conclusion

1- All appliances can help in the management of class 3 cases with improved skeletal anchoring using the Alt-RAMEC technique.
2- MSE alone can control the vertical dimension, through limitation of extrusion and anterior movement of maxillary first permanent molar.
3- Alt-RAMEC protocol showed encouraging results with no statistical difference but of clinical value.
4- Upper incisor extrusion is expected in RPE alone with downward and forward rotation of maxilla.

Limitation

The impact of Bolton tooth size, patient compliance, and treatment adherence was omitted. 2D evaluation for the issue of radiation protection ALADA, hence sutural maturation stage cannot be evaluated. Transversal inconsistencies were not the main emphasis. Sutural activation can be important, particularly in expansion groups with or without protraction, even if this is not an issue with the Alt-RAMEC technique. Some growth along the ramus may have been retained by some patients. Including the group with only face masks, or a group without an appliance for growth comparison, was considered, but we cannot for ethical reasons; this age group might have no benefit from face masks only. The medium-term outcomes of this randomized, prospective study are one of its drawbacks; assessing the long-term results in a subsequent investigation is crucial.

Conflicts of interest

All the authors have no conflict of interest.

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