Original Article

A Retrospective Evaluation of Conventional Rapid Maxillary Expansion versus Alternate Rapid Maxillary Expansion and Constriction Protocol Combined with Protraction Headgear in the Management of Developing Skeletal Class III Malocclusion

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ABSTRACT

Aims and Objectives: The reverse pull headgear has been widely used to intercept a developing skeletal Class III malocclusion with maxillary deficiency. Rapid maxillary expansion (RME) is recommended along with the reverse pull headgear because there is disruption of the circummaxillary and intermaxillary sutures. This, in turn, expedites the orthopedic effect of the reverse pull headgear. However, studies have shown that the circummaxillary sutures may not be fully disrupted by the use of RME alone. The protocol of alternate RME and constriction (Alt-RAMEC) has been found to produce much more beneficial effects. Hence, this retrospective study was conducted to compare and assess the results obtained in the two methods.

Materials and Methods: This study comprised pre- and post-treatment lateral cephalograms of two groups of nine patients each (total 18 patients – 10 females and 8 males) having skeletal Class III malocclusion (ANB<0°) due to a retrognathic maxilla with or without associated mandibular prognathism treated at the Department of Orthodontics of a teaching institute in Kerala. The patients were treated with either Alt-RAMEC/protraction or RME/protraction. The statistical analysis of the data was done using statistical package SPSS Version 16 software (SPSS Inc., Chicago, IL, USA).

Results: Skeletal, dental, and soft-tissue parameters in Group 2 (Alt-RAMEC group) showed very significant changes with the maxilla moving forward, mandible rotating backward and downward, and proclination of the maxillary incisors when compared to Group 1.

Conclusions: It may be concluded from the results of our study that the Alt-RAMEC protocol and reverse pull headgear might be more effective than conventional RME and the reverse pull headgear to correct a retruded maxilla in a developing skeletal Class III patient.

Keywords: *Alternate rapid maxillary expansion and constriction protocol, rapid maxillary expansion, reverse pull headgear*

Introduction

One of the most perplexing problems faced by orthodontists is the management of developing skeletal Class III malocclusion, and the decision "to or not to" intervene is a common dilemma faced when confronted with a developing Class III malocclusion.[1] Mild-to-moderate cases should be

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intercepted at the earliest to prevent it from becoming more severe. Treatment with the reverse pull headgear has been advocated in the orthopedic management of Class III patients having maxillary deficiency.[2,3]

The main effect of conventional reverse pull headgear therapy is the maxillary forward movement. Rapid maxillary expansion (RME) is recommended along with the reverse pull headgear because there is disruption of the circummaxillary and intermaxillary sutures. This expedites the orthopedic effect of the reverse pull headgear. However, studies have shown that the circummaxillary sutures may not be fully disrupted by the use of RME alone.[4] The protocol of alternate RME and constriction (Alt-RAMEC) has been found to produce much more beneficial effects. Hence, this retrospective study was done in the Kerala population to compare and assess the results obtained in the two methods.

Materials and Methods

Approval from the Institutional Ethics Committee (IEC/16/2015) and informed consent from the patients were obtained. The duration of this study was 1 year and comprised pre- and post-treatment lateral cephalograms of two groups of nine patients each (total 18 patients – 10 females and 8 males) having skeletal Class III malocclusion (ANB<0°) due to a retrognathic maxilla with or without associated mandibular prognathism treated at the Department of Orthodontics of a teaching institution in Kerala. The patients had a mean age of 10.1 years and range of 7.9–12.7 years. The patients were treated with either Alt-RAMEC-protraction or RME-protraction [Figure 1].

A bonded maxillary expander, fabricated in the same orthodontic laboratory with full occlusal acrylic coverage that extended from the deciduous or permanent canine to the first molar, was used in each patient [Figure 2].

In the RME-protraction (Group 1), the activation of screw was done twice daily for 1 week (one turn gave 0.20 mm expansion) resulting in an expansion of 2.8 mm. Following this, expansion was ceased and the patients were directed to use the reverse pull headgear.

In Alt-RAMEC-protraction group (Group 2), the screw was activated for expansion twice daily for 1 week (one turn gave 0.20 mm expansion). Subsequently, the screw was deactivated twice daily for 1 week. This protocol of activation and deactivation was followed for 5 weeks. Following this, the patients were asked to wear the reverse pull headgear.

The Petit-type reverse pull headgear was used in both groups. The protraction elastics were attached to the hooks mesial to the maxillary canines on the bonded maxillary expander. The direction of pull was downward and forward at 30° to the occlusal plane. A force of 350 gm on each side was used in both groups for 12–14 hours/day.

Pre- and post-treatment cephalograms were taken. Each radiograph was manually traced by the same investigator [Figure 3] using transparent 0.003" matte-acetate paper and 0.03 mm HB lead pencil.

Figure 1: Correction of overjet with the protraction headgear

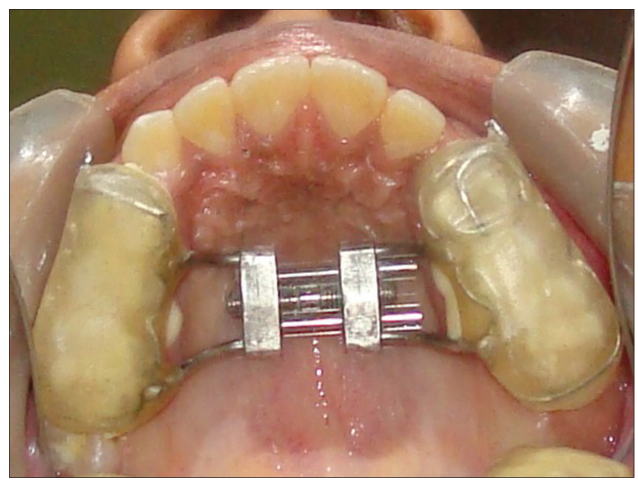

Figure 2: Expansion obtained with rapid maxillary expansion for a constricted maxillary arch

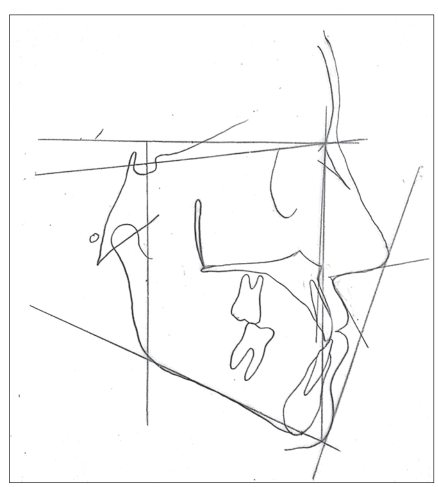

Figure 3: The skeletal and dental parameters measured in the study

The reference planes used include as follows:

1. The horizontal reference line (HRL): This was determined by drawing a line 7° to the sella-nasion plane (S-N) through N
2. The vertical reference line (VRL): A line dropped perpendicular to the HRL at the sella point
3. S-N plane: Anteroposterior extent of anterior cranial base
4. E-line: Line connecting tip of nose and soft-tissue chin
5. Go-Gn: Line connecting Go and Gn signifying the mandibular plane.

Table 1 describes the cephalometric parameters used in the study.

All angular measurements were taken to the nearest 0.5° and linear measurements to 0.5 mm. To identify any intra-examiner error, 10 radiographs were randomly picked up and retraced by the same investigator after 2 weeks. The intraclass correlation coefficient was used to evaluate the level of agreement and showed good agreement. Results were compared and statistical tests were used for analysis of the data.

Results

Assessment using Mann–Whitney U-test was done to ascertain whether the samples in both groups were similar with respect to the parameters selected, and it was found that the samples exhibited no significant differences at T0. The differences between the means were calculated using the Wilcoxon signed-rank test. This was done to evaluate the statistical significance of any differences between the mean values obtained at pretreatment (T0) and posttreatment (T1) in each studied parameter, in the two techniques. The level of significance was kept at $P < 0.05$. Table 2 describes the level of significance of mean changes during 9 months (T1–T0) for Group 1 (RME) and Group 2 (Alt-RAMEC) and also gives a comparison of the changes between the two groups.

Correction of anterior crossbite and improvement of molar relationship were found with both expansion protocols. The maxillary apical base (SNA) showed a significant forward movement in the Alt-RAMEC (3.13° ± 1.25°) and RME (1.79° ± 1.03°) groups as evident in the graph [Figure 4]. For intergroup comparisons, the level of significance was set at $P < 0.05$. Other skeletal and dental parameters in Group 2 (Alt-RAMEC group) showed very significant changes as evident in Table 2 with maxillary forward movement, clockwise rotation of the mandible, and proclination of the maxillary incisors.

A highly significant change in the soft-tissue profile was observed ($P < 0.001$) with respect to the subnasale and upper lip in the Alt-RAMEC group. Figures 4-6 are the bar graphs depicting the changes in hard-tissue and soft-tissue parameters in the two groups.

Discussion

Skeletal Class III malocclusion can be attributed primarily to a protrusion of the mandible, retrusion of the maxilla, or a combination of the two.[1] The contribution of retrusion of the maxilla in a Class III malocclusion has been reported in several studies as 19.5%, 25%, 26%, 33%, and 37%.[5]

Protraction of the retruded maxilla is done with the reverse pull headgear. Skeletal and dental changes, in the sagittal as well as vertical dimension obtained, can

Table 1: Cephalometric parameters used in the study

Number	Parameters	Description
1	SNA (°)	Angle between the SN plane and NA line
2	SNB (°)	Angle between the SN plane and NB line
3	ANB (°)	The difference between the angles SNA and SNB
4	VRL-A (mm)	Horizontal distance from point A to the VRL
5	VRL-U1 (mm)	Horizontal distance from the tip of the upper incisor edge to the VRL
6	VRL-B (mm)	Horizontal distance from point B to the VRL
7	VRL-Pog (mm)	Horizontal distance from Pog to the VRL
8	VRL-L1 (mm)	Horizontal distance from the tip of the lower incisor incisal edge to the VRL
9	Ls-E line (mm)	Horizontal distance from E line (line connecting tip of nose and soft tissue chin) to labrale superius
10	Li-E line (mm)	Horizontal distance from E line to labrale inferius
11	VRL-Sn (mm)	Horizontal distance from Sn to the VRL
12	VRL-Ls (mm)	Horizontal distance from Ls to the VRL
13	VRL-Li (mm)	Horizontal distance from Li to the VRL
14	VRL-Pog′ (mm)	Horizontal distance from the soft-tissue Pog’ to the VRL
15	Nasolabial angle (°)	Angle between a line tangent to the base of the nose and a line tangent to the upper lip
16	SN - GoGn (°)	Angle drawn by a line connecting Go and Gn to SN plane

VRL=Vertical reference line, Ls=Labrale superius, Li=Labrale inferius, Sn=Subnasale, Pog=Pogonion

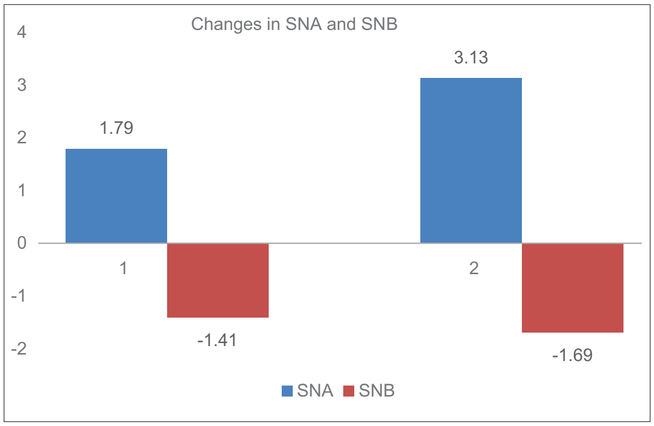

Figure 4: Graph showing mean changes in SNA and SNB in the two groups

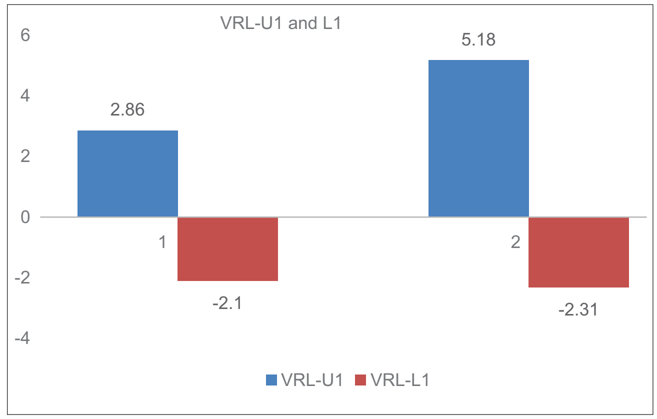

Figure 5: Graph showing mean changes in upper and lower incisal edge to the vertical reference line in the two groups

Table 2: Significance of mean changes during nine months (T1-T0) for Group 1 (rapid maxillary expansion) and Group 2 (alternate rapid maxillary expansion and constriction) and comparison of these changes between the two groups

Number	Variables	Group 1			Group 2			*P*
		Mean	SD	*P*	Mean	SD	*P*	
1	SNA (°)	1.79	1.03	***	3.13	1.25	***	**
2	SNB (°)	−1.41	0.79	***	−1.69	0.82	***	Ns
3	ANB (°)	3.28	1.05	***	4.67	1.43	***	**
4	VRL-A (mm)	2.01	1.26	***	3.32	1.27	***	**
5	VRL-U1 (mm)	2.86	1.95	***	5.18	1.38	***	***
6	VRL-B (mm)	−2.43	2.32	**	−3.04	2.35	***	Ns
7	VRL-Pog (mm)	−2.61	2.13	**	−3.19	2.38	***	Ns
8	VRL-L1 (mm)	−2.1	1.81	**	−2.31	1.51	***	Ns
9	Ls-E line (mm)	1.91	2.45	*	3.55	1.79	***	*
10	Li-E line (mm)	−0.25	1.27	Ns	−0.04	1.38	Ns	Ns
11	VRL-Sn (mm)	1.68	1.64	**	3.18	2.65	**	Ns
12	VRL-Ls (mm)	1.62	2.01	*	3.39	1.45	***	**
13	VRL-Li (mm)	−1.37	2.73	Ns	−0.71	1.38	Ns	Ns
14	VRL-Pog′ (mm)	−2.89	2.28	***	−2.87	2.27	***	Ns
15	Nasolabial angle (°)	1.26	5.15	Ns	−0.31	7.89	Ns	Ns
16	SN-GoGn (°)	2.27	1.68	***	2.09	2.14	**	Ns

*P<0.05, **P<0.01, ***P<0.001. SD=Standard deviation, Ns=Not significant, VRL=Vertical reference line, Ls=Labrale superius, Li=Labrale inferius, Sn=Subnasale, Pog=Pogonion

be attributed to a combination of forward movement of the maxilla, downward and backward rotation of the mandible, and proclination of the maxillary incisors. Benefits attributed to an early orthopedic management include greater orthopedic and functional correction and a marked improvement in the facial esthetics, thereby reducing the potential for future orthognathic surgery.[6]

Studies with the reverse pull headgear without RME have revealed a noteworthy amount of forward movement of the maxilla.[7,8] Maxillary expansion has been recommended even in the absence of maxillary constriction or crowding [Figure 2]. The primary benefits of palatal expansion include expansion of a narrow maxilla and loosening of the circummaxillary sutures, which causes a downward and forward movement of the maxilla.[8,9] In patients who do require maxillary expansion, activation of the maxillary expansion appliance depends on the amount of expansion needed for the constricted maxilla.[9,10]

Liou in 2005 proposed a weekly protocol of repetitive Alt-RAMEC for disarticulation of the circummaxillary sutures.[11] He observed that 5 weeks of Alt-RAMEC significantly increased the opening of frontomaxillary, zygomaticomaxillary, internasal, zygomaticotemporal, and nasofrontal suture by 1.5–1.8 times when compared to 1 week of conventional RME. In addition to the changes in the maxilla, there was anterior displacement of nasal bones also in the Alt-RAMEC group.[11] Liou and Tsai reported a maxillary advancement in the Alt-RAMEC group which was two to three times greater than that with RME and reverse pull headgear and this change was attributed by them to the fact that the circummaxillary sutures were separated and stretched to a greater degree with the Alt-RAMEC expansion protocol than with RME alone.[12]

In the present investigation, anterior movement of Point A of 2.01 ± 1.26 mm with respect to the VRL in the RME group is in agreement with the results of previous studies.[13,14] Merwin *et al*. reported an anterior movement of Point A of 2.1 mm for 9–12-year-old patients treated with RME and reverse pull headgear. Forward movement of Point A with respect to the VRL in the Alt-RAMEC group in the present study was highly significant (3.32 ± 1.27 mm) when compared with the observations of Merwin *et al.* and Kapust *et al.*[13,14]

Wang *et al*. in 2009 reported similar findings and concluded that the circummaxillary sutures were opened

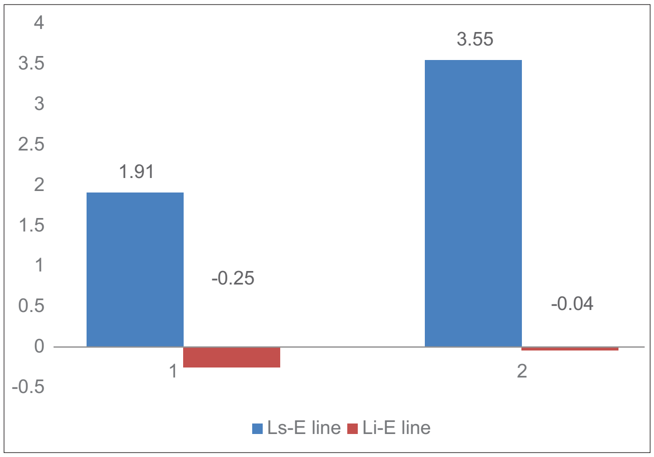

Figure 6: Graph showing mean changes in labrale superius and labrale inferius to the E-line in the two groups

significantly with five weeks of Alt-RAMEC than one week of RME protocol. They concluded that the sagittally running sutures were opened significantly more (94.4%–100.0%) than those running coronally (56.9%–58.3%), irrespective of whether they articulated directly or indirectly to the maxilla.[15]

Posterior rotation of the mandible and the increase of anterior face height were observed for both groups in the present study. The posterior rotation of the mandible and the increase of anterior face height could be due to a combination of maxillary vertical movement, maxillary molars extrusion, and chin cup effect of reverse pull headgear. Celikoglu and Buyukcavus[16] in their study with two different Alt-RAMEC protocols reported similar findings of a significant increase in the maxillary growth, inhibition of mandibular growth, and clockwise rotation of the mandible, leading to an improvement of the maxillomandibular relationship in both groups.

ANB angle showed a notable increase in the Alt-RAMEC group (4.67° ± 1.43°) in comparison with the RME group (3.28° ± 1.05°) at T1. The results showed no significant posterior movement of Point B. The decrease of SNB angle showed no significant difference between the two groups, but the increase of SNA angle showed a significant difference. Thus, from the present study, it can be interpreted that the greater anterior movement of Point A (deduced from an increase of SNA angle) can be the reason for the pronounced increase of ANB angle in the Alt-RAMEC group.

At T1, both groups showed an improvement of the soft-tissue profile. The profile improvement could be explained by the anterior movement of the upper lip and a posterior movement of the lower lip and soft-tissue Pog point.[17] In the Alt-RAMEC group, there was more pronounced anterior movement of the upper lip (3.55 ± 1.79 mm) compared to the RME group (1.91 ± 2.45 mm), and this could be due to the significant maxillary skeletal and dental changes seen in the Alt-RAMEC group.

Isci *et al*. in 2010 obtained similar results with the present study and found that the anterior movement of Point A for the Alt-RAMEC group was approximately twice that of the RME group. The backward movement of the mandible as well as anterior face height showed no significant difference between the two groups.[18]

The results of the study by Do-deLatour *et al*. demonstrated an increased forward movement of the maxilla in the RME group, which may be attributed to the higher level of compliance in this group than in the Alt-RAMEC group. They observed that Alt-RAMEC protocol as on itself does not increase the amount of forward movement of the maxilla, but other factors including the age of patient, duration of facemask wear, and duration of treatment may have to be considered in the future studies.[19]

Kaya *et al.*[20] and Tagawa *et al.*[21] in their cephalometric studies also concluded that the Alt-RAMEC protocol along with reverse pull headgear treatment was advantageous in the correction of mild-to-moderate maxillary retrusion in Class III patients. Their studies showed that the forward movement of the maxilla was without maxillary incisor movement.

In 2014, Wilmes *et al*. too observed that the combination of the Hybrid Hyrax, Facemask, and Alt-RAMEC protocol provided a longer-lasting "RPE effect," probably due to the repeated opening of the midpalatal sutures with the Alt-RAMEC protocol.[22]

Masucci *et al*. in 2014 also concluded that a modified Alt-RAMEC/Facemask protocol produced a more effective advancement of the maxilla and greater intermaxillary changes as compared to the RME/Facemask protocol in developing Class III patients.[23]

Yilmaz and Kucukkeles in 2015 noted that Point A exhibited a slight forward movement with the Alt-RAMEC protocol. They observed an increase in the upper airway volume with the expansion of the maxilla and other structures of the face, along with significant changes occurring in the paranasal area.[24]

Rathi *et al*. in their case report noted that reverse pull headgear therapy with bonded RME appliance following Alt-RAMEC protocol corrected the anterior crossbite and improved facial profile by protruding the maxilla and inhibiting the forward growth of the mandible.[25]

Pithon *et al*. in their systematic review concluded that the use of Alt-RAMEC protocol is effective in early treatment of Class III malocclusion patients, but no conclusion on stability was made, due to the lack of studies designed to assess the issue of stability.[4]

Stocker *et al*. in their case report introduced a novel approach for tracking the duration of wear of a protraction facemask, by incorporating a "FaceMon" sensor along with a modified Alt-RAMEC protocol and intermittent application of a Hybrid Hyrax-protraction Facemask combination. The average wear time of the facemask was measured at 10.8 h per day. The importance of this can be attributed to the fact that patient response to treatment may be calibrated in relation to compliance.[26]

Al-Mozany *et al.* in their study, using a hybrid mini-implant supported RME appliance along with the Alt-RAMEC protocol, found significant protraction of the maxilla although the mandibular base was redirected posteriorly.[27]

Gökalp[28] in his case report described how an intraoral protraction spring combined with Alt-RAMEC treatment improved skeletal relationships in an adolescent patient with Class III malocclusion with maxillary deficiency and minimal dentoalveolar compensation.

The primary outcome of this study may be summarized with the observations similar to previous studies in that the Alt-RAMEC protocol appears to be more effective than conventional RME when used along with the reverse pull headgear to bring about protraction of retruded maxilla. The correction achieved in the anterior crossbite and molar relationship may be due to a forward movement of the maxilla and downward and backward rotation of the mandible.

Limitations

A limitation of this study was that no untreated controls were used. Further studies with a larger sample size for detailed assessment of the skeletal, dental, and soft-tissue changes obtained with the two methods of expansion along with the protraction headgear would be useful to standardize the nature and extent of changes obtained by this interceptive orthodontic procedure. Furthermore, three-dimensional imaging could have been used to assess the changes in skeletal and dentoalveolar regions.

Conclusions

According to the envelope of discrepancy, developing skeletal malocclusions which are mild may be corrected with growth modification procedures during the period of growth. Orthopedic forces are an integral part of growth modification techniques. An intraoral orthopedic appliance (RME) and an extraoral orthopedic appliance (protraction headgear) are used in tandem for the correction of the developing skeletal Class III malocclusions. The present study supports previous studies in the conclusion that Alt-RAMEC protocol appears to be more effective than conventional RME when used along with Facemask to bring about protraction of retruded maxilla although significant sagittal and vertical changes were encountered with both expansion protocols. The reason may be that Alt-RAMEC tends to open the sagittally and coronally running circummaxillary sutures more quantitatively than with conventional RME. The anterior crossbite and molar relationship were corrected mostly due to a forward movement of the maxilla and downward and backward rotation of the mandible. Hence, it may be concluded from the results of our study that the Alt-RAMEC and protraction headgear protocol might be more effective than conventional RME and protraction headgear protocol to correct a retruded maxilla in a developing skeletal Class III patient.

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Conflicts of interest

There are no conflicts of interest.

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