Journal of Research in Medical and Dental Science
2018, Volume 6, Issue 5, Page No: 278-283

Available Online at: www.jrmds.in
eISSN No. 2347-2367: pISSN No. 2347-2545

Role of Rapid Maxillary Expansion in Sagittal Correction of Maxilla

Fatih Celebi[1*], Ayse Burcu Kocoglu-Altan[2], Ali Altug Bicakci[1]

[1]Department of Orthodontics, Faculty of Dentistry, Gaziosmanpasa University, Tokat, Turkey
[2]Department of Orthodontics, Faculty of Dentistry, Kocaeli University, Kocaeli, Turkey

ABSTRACT

Objectives: To investigate the sagittal movement of the maxilla due to rapid maxillary expansion (RME) in subjects with Class III malocclusions and compare it to the amount of anterior movement of maxilla obtained with RME/FM (facemask) treatment in order to determine whether RME alone could be satisfactory in correcting particular Class III malocclusions.
Materials and Methods: Sixty-two patients treated with the RME/FM therapy or RME alone were identified from the archives of University, Department of Orthodontics. 31 patients in RME group were initially treated by rapid expansion of the maxilla. 31 patients in the RME/FM group were treated with the same type expander combined with an orthopedic facemask. Following the phase I treatment, comprehensive fixed appliance therapy was continued in both groups. The cephalometric measurements were performed on pretreatment and posttreatment lateral cephalograms of the subjects.
Results: In RME group, point A moved forward 1.70 mm which was statistically significant (P<0.001). In RME/FM group, 3.30 mm of forward movement of point A was observed which was statistically significant (P<0.001). The difference in forward movement of point A was significant between the groups (P<0.001). The angles of SNA ANB, and Wits appraisal increased significantly more in RME/FM group.
Conclusion: The forward movement of point A was significantly more in RME/FM group when compared with RME group. RME without a face mask may provide a spontaneous correction of an edge to edge incisor relationship and resolution of the mild Class III relationship.

Key words: Class III malocclusion, Facemask, RME

HOW TO CITE THIS ARTICLE: Fatih Celebi*, Ayse Burcu Kocoglu-Altan, Ali Altug Bicakci, Role of rapid maxillary expansion in sagittal correction of maxilla, J Res Med Dent Sci, 2018, 6 (5):278-283

Corresponding author: Fatih Celebi
e-mail✉: fatihcelebi5860@gmail.com
Received: 22/09/2018
Accepted: 07/10/2018

INTRODUCTION

Class III malocclusion is one of the most difficult malocclusions for the orthodontists due to compelling treatment approaches. This malocclusion may exhibit a variety of skeletal and dental components, including a protrusive mandible or mandibular dentition, retrusive maxilla or maxillary dentition and combinations of these [1]. Ellis et al. showed that the combination of mandibular protrusion and maxillary retrusion made up a large percentage of Class III patients [2]. Guyer et al. revealed that the sagittal position of the maxilla needs to be treated in quite a lot of subjects with Class III malocclusion [3]. In order to correct this problem, especially in younger patients, McNamara introduced the orthopaedic face mask (FM) with a forehead and chin support in combination with a bonded rapid maxillary expansion (RME) appliance [4]. Over the years, face mask therapy in combination with RME, has become one of the most common orthopedic treatment protocol for Class III malocclusion [5].

RME is commonly utilized in the treatment of patients with Class III malocclusion with an insufficient maxillary arch width. Beside it's efficiency in correcting maxillary transversal dimension, it has been shown to affect the maxilla sagitally which is favoring in Class III correction [6,7]. The anterior movement of point A due to rapid maxillary expansion was firstly introduced by Haas and proved with further studies [6,8,9]. Similarly, Davis et al. found that expansion of the midpalatal suture produced forward repositioning of point A when measured in relation to the posterior boundary of the pterygomaxillary fissure [10]. Additionally, extrusion of upper molars and the outward inclination of the upper alveolar process causing drop of maxilla and posterorotation of the mandible were also presented [11]. Consequently, RME would generally improve patients with skeletal Class III malocclusion [10,12] and it is supposed that RME alone can be beneficial in the treatment of certain types of Class III malocclusion [4]. On the contrary, a number of authors claimed that point A did not move anteriorly

with RME, even a posterior displacement was observed in some subjects [12,13-15].

The objective of this study was to investigate the sagittal movement of the maxilla due to RME in subjects with Class III malocclusions and compare it to the amount of anterior movement of maxilla obtained with RME/FM treatment in order to determine whether RME alone could be satisfactory in correcting particular Class III malocclusions.

MATERIALS AND METHODS

The material of this cephalometric study consisted of the lateral cephalograms of 62 subjects treated in University, Faculty of Dentistry, Department of Orthodontics. Ethical approval was obtained for this study from Research Ethical Committee of University (#2012-02/44). The initial radiographs were obtained before any orthodontic and orthopedic treatment (T1) and the second records after the removal of the fixed orthodontic appliances (T2). For a critical trial with a power of 80% and alpha level of .05, a sample size of 31 patients for each group was considered suitable. The patients included in the groups were selected according to the following criteria:

1. Normal or increased overbite (overbite>1 mm).
2. Angle Class III malocclusion with anterior crossbite or edge to edge incisor relationship.
3. Witts' appraisal of -1 mm or less.
4. Initial ANB angle 0.5 degree or less.
5. Skeletal maturation (CS 2-CS 4) [13].

RME group consisted of 31 patients (16 girls, 15 boys) with a mean age of 12.09 years (± 1.35 years) who were initially treated by rapid expansion of the maxilla by using a bonded type RME device. The 31 patients (15 girls, 16 boys) in the second group (RME/FM) with a mean age of 11.41 years (± 1.9 years) were treated with the same type expander combined with an orthopedic facemask. Following the phase I treatment, comprehensive fixed appliance therapy (.018 Roth System) was continued in both groups.

In the RME group, the parents were instructed to activate the expander twice turns daily one being in the morning and one in the evening until the palatal cusp tips of maxillary posterior teeth come into contact with the buccal cusp tips of the mandibular posterior teeth. The activation period was lasted for 3 to 4 weeks depending on the degree of maxillary constriction, with weekly patient follow-up. After the screw ligation, the RME device was left in place as a retention appliance for 3 months.

In the RME/FM group, vestibular hooks attached to the RME appliance and the parents were instructed to activate the screw once a day until the desired transverse width was achieved. FM wear was continued after RME completed. Elastics were attached from the hooks of the expander to the facemask in a downward and forward direction, producing orthopedic forces of 400-450 g per side. The patients were instructed to wear the facemasks at least 14 hours per day. FM therapy was ended when 5 mm of overjet was maintained.

Cephalometric analysis

All radiographs used in the present study were taken with the same x-ray machine (Planmeca, Proline 2002 CC, Helsinki, Finland). The cephalographs were hand-traced and measured in the same manner by the same person. All linear and angular measurements were carried out with a gauge to the nearest 0.1 mm and recorded exactly as measured without correction for magnification. A previously described basicranial reference system comprising two perpendicular lines was used [16]. The two lines were the stable basicranial line (SBL; passing through the most superior point of the anterior wall of sella turcica at the junction with tuberculum sellae (point T) [17], and tangent to lamina cribrosa of the ethmoid bone) and the vertical T line (VertT; perpendicular to SBL and passing through point T).

The following parameters were evaluated in this study: Angular and linear measurements for assesing sagittal relationships: SNA, SNB, ANB, Wits appraisal, convexity angle, A-VertT, Pr-VertT, Id-VertT, B-VertT, UL-E, LL-E; angular measurements for assesing vertical relationships: FMA, GoGnSN; angular measurements for assessing the inclination of upper and lower incisors: U1-SN, U1-FH, IMPA (Figures 1 and 2).

Method error

All radiographs were retraced and remeasured by the same investigator 1 month after the initial analysis. Reproducibility coefficients were found greater than 0.92

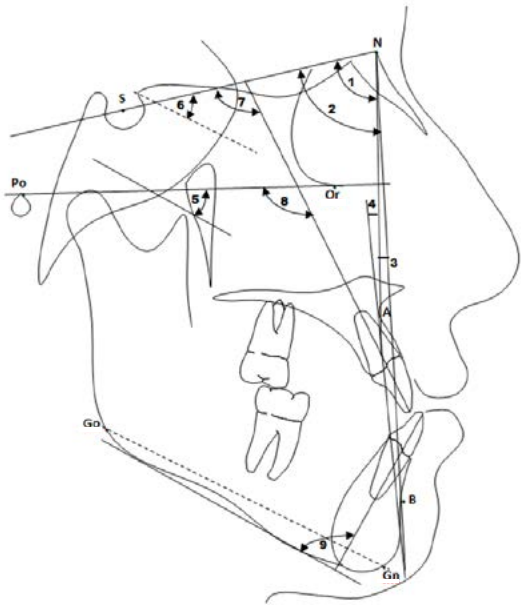

Figure 1: Angular measurements, 1) SNA; 2) SNB; 3) ANB; 4) Convexity angle; 5) FMA; 6) GoGN-SN; 7) U1-SN; 8) U1-FH; 9) IMPA

for both linear and angular measurements which did not reveal any measurement error.

Statistical analysis

Data were statistically processed by SPSS for Windows, version 14.0. Descriptive statistics were calculated for all cephalometric measures at T1 and T2 for both groups. A paired t-test was used to determine the differences within the groups and independent t-test to compare the differences between the groups. Significance for all statistical tests was predetermined at p<0.05.

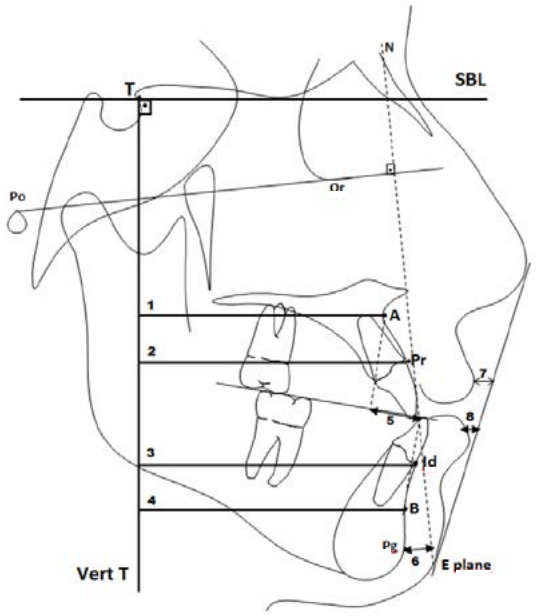

Figure 2: Linear measurements. Point T (T): Most superior point of the anterior wall of sella turcica at the junction with tuberculum sellae; SBL: Stable basic cranial line; Vertical reference line (VertT), 1) point A-VertT distance; 2) Pr-VertT distance; 3) Id-VertT distance; 4) B-VertT distance; 5) Witts appraisal; 6) Nv-Pog distance; 7) Upper lip-Eplane distance; 8) Lower lip-E plane distance

RESULTS

There was no difference for the ages and gender of the subjects between the two groups (P=0.11; P=0.79, respectively). The groups did not represent any difference by means of the sagittal position of maxilla (SNA, A-VertT), vertical growth (SN-GoGn, FMA), upper and lower incisor inclinations and lip positions at the beginning of treatment (T1) while the SNB, ANB and convexity angles, and NV-Pg, Wits, Id-VertT and B-VertT measurements were found significantly different (Table 1).

In RME group, point A moved forward 1.70 mm which was statistically significant (P<0.001). ANB and convexity angles, and the linear measurements Pr-VertT, Id-VertT, B-VertT, and Witts appraisal increased significantly (P<0.001) at the end of the overall treatment (T2). The proclination of upper incisors and the change in vertical dimension were found statistically nonsignificant (Table 2).

In RME/FM group, point A moved 3.30 mm forward which was statistically significant (P<0.001). SNA, ANB and convexity angles, and the measurements of Pr-VertT, Id-VertT, B-VertT and Witts appraisal increased; while the LL-E decreased significantly. The upper incisors were found to be proclined significantly. The change in vertical dimension was found insignificant (Table 2).

Significantly greater forward movement of point A was found in RME/FM group when compared with RME group (P<0.001). The angles of SNA, ANB and convexity, LL-E distance, and Witts appraisal changed significantly more in RME/FM group. No significant difference was found in vertical dimension (GoGnSN and FMA), and inclination of upper and lower incisors between the groups (Table 2).

Table 1: Comparison of initial cephalometric values between RME and RME+FM groups

Measurement	RME GROUP		RME-FM GROUP		P	Sig
	Mean	SD	Mean	SD		
SNA (°)	77.63	1.62	77.47	2.58	0.774	NS
SNB (°)	78.56	2.11	80.15	2.44	0.008	**
ANB (°)	-0.9	1.28	-2.7	1.35	0	***
NV-Pg (mm)	-3.43	4.97	0.29	6.52	0.014	*
Witts (mm)	-3.84	1.68	-5.8	2.15	0	***
Convexity (°)	-3.24	3.79	-5.55	4.29	0.028	*
FMA (°)	26.38	3.2	25.02	3.56	0.121	NS
SN-GoGn (°)	33.48	4.96	31.57	3.86	0.097	NS
u1-SN (°)	100.58	5.02	101.42	5.1	0.513	NS
u1-FH (°)	110.11	4.62	110.85	4.87	0.545	NS
IMPA (°)	85.55	4.95	84.8	5.46	0.571	NS
LL-E (mm)	-1.42	2.65	-0.46	2.13	0.122	NS
UL-E (mm)	-5.14	2.36	-5	2.25	0.801	NS
A-VertT (mm)	52.43	5.63	50.89	2.62	0.171	NS
Pr-VertT (mm)	54.12	5.55	52.57	2.38	0.156	NS
Id-VertT (mm)	50.91	5.78	53.7	2.86	0.02	*
B-VertT (mm)	48.88	7.08	52.19	3.14	0.021	*

Independent Samples Test; SD, Standard Deviation; NS, Not Significant; *P<0.05, **P<0.01, ***P<0.001

Table 2: Intragroup (paired t-test) and intergroup (independent t-test) comparisons of mean changes during treatment duration (T2–T1) for the RME and RME+FM groups

Measurement	RME GROUP			Sig	RME+FM GROUP			Sig	P (†)	Sig
	Mean	SD	P (Ω)		Mean	SD	P (Ω)			
SNA (°)	1.55	0.82	0	***	2.98	1.63	0	***	0	***
SNB (°)	0.23	0.8	0.167	NS	0.48	1.51	0.101	NS	0.436	NS
ANB (°)	1.4	0.83	0	***	2.78	1.15	0	***	0	***
NV-Pg (mm)	-0.16	3.94	0.801	NS	-0.32	4.77	0.719	NS	0.885	NS
Witts (mm)	2.53	1.72	0	***	3.93	2	0	***	0.005	**
Convexity (°)	2	1.95	0	***	3.82	3.6	0	***	0.016	*
FMA (°)	0.05	2.52	0.794	NS	-0.18	2.73	0.72	NS	0.733	NS
SN-GoGn (°)	-0.43	2.53	0.392	NS	-0.71	2.77	0.164	NS	0.682	NS
u1-SN (°)	1.8	6.12	0.059	NS	3.49	5.59	0.002	**	0.262	NS
u1-FH (°)	1.85	5.14	0.077	NS	3.43	7.65	0.015	*	0.346	NS
IMPA (°)	-0.15	7.8	0.925	NS	0.36	5.85	0.763	NS	0.771	NS
LL-E (mm)	-0.43	2	0.238	NS	-1.71	2.47	0.002	**	0.029	*
UL-E (mm)	-0.58	1.74	0.07	NS	-0.42	2.01	0.261	NS	0.722	NS
A-VertT (mm)	1.7	0.92	0	***	3.3	1.04	0	***	0	***
Pr-VertT (mm)	1.86	1.46	0	***	3.79	1.4	0	***	0	***
Id-VertT (mm)	1.87	1.17	0	***	1.55	1.43	0	***	0.016	*
B-VertT (mm)	1.62	1.97	0	***	1.44	1.74	0	***	0.039	*

SD, Standard deviation; NS, not significant

P (Ω) Intragroup comparison, paired t-test *P<0.05, **P<0.01, ***P<0.001

P (†) Intergroup comparison,independent t-test *P<0.05, **P<0.01, ***P<0.001

DISCUSSION

FM combined with RME is a frequently used modality in treatment of Class III patients and produces approximately 1.5 mm to 2.4 mm of maxillary advancement with 6 to 12 months of wear [1,18]. However, this modality could not be a valid treatment option for some patients while FM was effective at early ages and for an extended duration [19,20]. Moreover, this treatment protocol could cause lack of self-esteem and requires high patient compliance.

Although there have been some studies comparing the effects of FM and RME/FM combination [21-24], interestingly no information about how much anterior movement of maxilla is derived from RME in RME/FM combination therapy is available. In this study, the sagittal effects of RME on maxilla was compared with the effects of RME/FM followed by fixed appliance therapy to reveal the contribution of RME on forward movement of maxilla in RME/FM treatment and whether particular Class III malocclusions could be treated by RME alone.

RME is an intraoral treatment method which is generally used in correcting maxillary transverse deficiency. However, it also affects the sagittal position of maxilla as moving it anteriorly, which can be determined as an additional or adverse effect due to the clinician's point of view. Although a few studies showed that the maxilla remained stable in sagittal plane during RME [12-15], the anterior movement of maxilla due to RME was presented many times since early 1960's [8,14,25,26].

The groups in this study didn't show any statistically significant difference in terms of the sagittal position of the maxilla, the upper and lower incisor inclinations, vertical growth and lip projections at the beginning of the treatment. However, mandibular prognatism was significantly greater in RME/FM group reasonably, while the severity of Class III malocclusion had been more in the RME/FM group so they had undergone RME/FM therapy actually.

In the literature, a forward movement of point A, ranging from 1.5 mm to 2.4 mm was reported at the end of RME/FM therapy [1,18]. In their study, Arman et al. continued with a second phase of fixed appliance therapy and observed an additional 1.27 mm of forward movement of point A between the end of RME/FM and fixed appliances therapy which can be attributed to the growth of the maxilla [1]. They reported an overall anterior movement of point A as 3.34 mm which was very close with the results of the present study (3.3 mm).

The anterior movement of point A due to RME therapy was firstly introduced by Haas, in 1961 [8]. Afterwards, anterior movement of maxilla was confirmed by hundreds of studies. Being in accordance with the majority of the studies performed in order to evaluate the sagittal movement of maxilla due to RME, we found 1.70 mm of forward movement of point A in the RME group which was statistically significant. On the contrary, a few studies are also available in the literature that present a backward movement or stationary position of the maxilla during RME [12-15]. In one of the study da Silva Filho et al., found that the maxilla did not move sagittally but

moved downward after RME, displaying a downward and backward rotation in the palatal plane [12].

Why does the maxilla move sagitally during expansion? It is known that the displacement of the two halves of the maxilla is an angular or wedge-shaped displacement due to the fact that anterior margin of the maxilla is free while at the posterior margin there is continuous articulation [6,8,9,27]. According to Biederman, this angular displacement can occur in two ways depending on the location of center of rotation being in the midline or somewhere at posterior lateral parts of the maxilla [25]. In the first circumstance, the posterior lateral points must move backward which would entail the resorption of bone and backward movement of point A. The author claimed that this was a consequence which would not likely occur in so short a time as 2 weeks. In the other circumstance, when the center of rotation locates at posterior lateral part of the maxilla, point A moves forward as several authors observed [27]. The age, actually the level of skeletal maturation might affect the location of center of rotation during the expansion of the maxilla. The difference in anterior movement of maxilla may depend on this factor. Additionally, another factor that affects the forward movement of maxilla was explained in two studies by Gardner et al. and Leonardi et al., [28,29]. The investigators showed that RME induces not only opening of the circummaxillary sutures but also sphenooccipital synchondrosis which would result in forward displacement of the maxilla [28].

In a finite element study, Gautam et al. investigated the skeletal response to maxillary protraction with and without maxillary expansion and found that with maxillary protraction alone, point A moved anteriorly 0.33 μm, while this movement was 0.15 mm (nearly 500 times more) when maxillary protraction was combined with maxillary expansion [23]. The authors concluded that the anterior structures of the maxilla were displaced more anteriorly with maxillary protraction and expansion than with maxillary protraction alone. Consequently, the additional effect of RME in forward movement of maxilla has been proven by clinical and laboratory researches. In the present study, the maxilla moved significantly in a forward direction with RME alone. However, this movement was observed as being more when RME combined with FM.

Both RME and RME/FM treatment modalities affect upper incisor position. It is an important point because of the fact that incisor position could affect the position of point A. Ngan et al. found 2.0 mm forward movement of point A after 6 months of maxillary protraction and attributed this finding to the 4.2 mm forward movement of the maxillary incisors [30]. Similarly, Shanker et al. concluded that 75% of the total forward movement of A point (1.8 mm of 2.4 mm) was due to skeletal maxillary protraction and 25% (0.6 mm of 2.4 mm) was localized remodeling during RME/FM treatment [18]. The authors claimed that forward movement of maxillary incisors that has been reported with maxillary protraction was the reason of this remodeling. Moreover, in a recent study about the correlation between upper incisor movement and point A response, it was presented that point A follows the movement of upper incisors' root in a half amount [31]. In the present study, the upper incisors moved significantly 1.87 mm and 3.79 mm forward in RME and RME/FM groups respectively and the difference of 1.92 mm between the groups was also found significant. While the point A follows upper incisor roots nearly in a half amount [30,31], we may conclude that 1.92 mm of more protrusion of upper incisors in RME/FM group resulted in nearly 1 mm forward movement of point A. Consequently, 1 mm of 1.6 mm of difference in forward movement of point A between the groups might occur due to more protrusion of upper incisors in RME/FM group. The residual 0.6 mm of movement could be determined as the skeletal effect of FM therapy. Although it's limited effect on anterior movement of the maxilla, FM is a useful appliance in achieving parallel protrusion of upper incisors which is very important in treatment of functional Class III patients.

CONCLUSION

Under the limitations of this study, it was observed that RME without face mask may provide a spontaneous correction of an edge to edge incisor relationship and resolution of the mild Class III relationship.

CONFLICT OF INTEREST

All authors declare that there is no conflict of interest.

REFERENCES

1. Arman A, Toygar TU, Abuhijleh E. Evaluation of maxillary protraction and fixed appliance therapy in Class III patients. Eur J Orthod 2006; 28:383-92.
2. Ellis E, McNamara JA. Components of adult Class III open-bite malocclusion. Am J Orthod 1984; 86:277-90.
3. Guyer EC, Ellis III EE, McNamara Jr JA, et al. Components of Class III malocclusion in juveniles and adolescents. Angle Orthod 1986; 56:7-30.
4. McNamara JJ. An orthopedic approach to the treatment of Class III malocclusion in young patients. J Clin Orthod 1987; 21:598-608.
5. Ja Jr M, Brudon Wl. Orthodontics and Dentofacial orthopedics. Ann Arbor Mich: Needham Press Inc 2001; 73:256-62.
6. Haas AJ. Palatal expansion: Just the beginning of dentofacial orthopedics. Am J Orthod 1970; 57:219-55.
7. Bishara SE, Staley RN. Maxillary expansion:

Clinical implications. Am J Orthod Dentofacial Orthop 1987; 91:3-14.
8. Haas AJ. Rapid expansion of the maxillary dental arch and nasal cavity by opening the midpalatal suture. Angle Orthod 1961; 31:73-90.
9. Haas AJ. The treatment of maxillary deficiency by opening the midpalatal suture. Angle Orthod 1965; 35:200-17.
10. Davis WM, Kronman JH. Anatomical changes induced by splitting of the midpalatal suture. Angle Orthod 1969; 39:126-32.
11. Velázquez P, Benito E, Bravo LA. Rapid maxillary expansion. A study of the long-term effects. Am J Orthod Dentofacial Orthop 1996; 109:361-7.
12. de Silva Fo OG, Boas CV, Capelozza LF. Rapid maxillary expansion in the primary and mixed dentitions: A cephalometric evaluation. Am J Orthod Dentofacial Orthop 1991; 100:171-9.
13. Sarver DM, Johnston MW. Skeletal changes in vertical and anterior displacement of the maxilla with bonded rapid palatal expansion appliances. Am J Orthod Dentofacial Orthop 1989; 95:462-6.
14. Wertz RA. Skeletal and dental changes accompanying rapid midpalatal suture opening. Am J Orthod 1970; 58:41-66.
15. Wertz R, Dreskin M. Midpalatal suture opening: A normative study. Am J Orthod 1977; 71:367-81.
16. Franchi L, Baccetti T, Tollaro I. Predictive variables for the outcome of early functional treatment of Class III malocclusion. Am J Orthod Dentofacial Orthop 1997; 112:80-6.
17. Viazis AD. The cranial base triangle. J Clin Orthod 1991; 25:565.
18. Shanker S, Ngan P, Wade D, et al. Cephalometric A point changes during and after maxillary protraction and expansion. Am J Orthod Dentofacial Orthop 1996; 110:423-30.
19. Kapust AJ, Sinclair PM, Turley PK. Cephalometric effects of face mask/expansion therapy in Class III children: A comparison of three age groups. Am J Orthod Dentofacial Orthop 1998; 113:204-12.
20. Kim JH, Viana MA, Graber TM, et al. The effectiveness of protraction face mask therapy: A meta-analysis. Am J Orthod Dentofacial Orthop 1999; 115:675-85.
21. Angelieri F, Ruellas AC, Yatabe MS, et al. Zygomaticomaxillary suture maturation: Part II-The influence of sutural maturation on the response to maxillary protraction. Orthod Craniofac Res 2017; 20:152-63.
22. Hino CT, Cevidanes LH, Nguyen TT, et al. Three-dimensional analysis of maxillary changes associated with facemask and rapid maxillary expansion compared with bone anchored maxillary protraction. Am J Orthod Dentofacial Orthop 2013; 144:705-14.
23. Gautam P, Valiathan A, Adhikari R. Skeletal response to maxillary protraction with and without maxillary expansion: a finite element study. Am J Orthod Dentofacial Orthop 2009; 135:723-8.
24. Tortop T, Keykubat A, Yuksel S. Facemask therapy with and without expansion. Am J Orthod Dentofacial Orthop 2007; 132:467-74.
25. Biederman W. Rapid correction of Class III malocclusion by midpalatal expansion. Am J Orthod 1973; 63:47-55.
26. Chen LL, You QL, Yang YM. Non-extraction treatment in borderline class III malocclusion. Shanghai Kou Qiang Yi Xue 2011; 20:82-7.
27. Krebs A. Expansion of the midpalatal suture, studied by means of metallic implants. Acta Odontol Scand 1959; 17:491-501.
28. Gardner GE, Kronman JH. Cranioskeletal displacements caused by rapid palatal expansion in the rhesus monkey. Am J Orthod 1971; 59:146-55.
29. Leonardi R, Cutrera A, Barbato E. Rapid maxillary expansion affects the spheno-occipital synchondrosis in youngsters: A study with low-dose computed tomography. Angle Orthod 2010; 80:106-10.
30. Ngan P, Hägg U, Yiu C, et al. Treatment response to maxillary expansion and protraction. Eur J Orthod 1996; 18:151-68.
31. Bicakci AA, Cankaya OS, Mertoglu S, et al. Does proclination of maxillary incisors really affect the sagittal position of point A? Angle Orthod 2013; 83:943-7.