Original Article

Does the Timing and Method of Rapid Maxillary Expansion Have an Effect on the Changes in Nasal Dimensions?

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Abstract: The aim of this study was to assess the effects of rapid maxillary expansion (RME) and surgical assisted rapid maxillary expansion (SARME) on nasopharyngeal area. The study group consisted of 30 subjects in the permanent dentition who had both maxillary constriction and a posterior cross-bite. The patients were divided into two groups, RME and SARME. The subjects in the RME group consisted of 15 patients (eight girls, seven boys) whose average age was 12.1 ± 1.1 years. The SARME group also consisted of 15 patients (eight boys, seven girls) whose mean age was 18.4 ± 1.4 years. An acrylic bonded RME appliance was used in both groups. Surgery was performed using lateral cortical osteotomies in the SARME group. The nasopharyngeal and respiratory area was determined using a digital planimeter on lateral cephalometric radiographs taken before and after RME. Nasal cavity width was evaluated on postero-anterior radiographs. Nasal dimension was measured using planimeter measurements of the respiratory and nasopharyngeal areas before and after treatment. The data obtained were analyzed using SPSS. Comparisons within the groups were carried out with paired *t*-tests and comparisons between the groups were with a Student's *t*-test. In both groups, the respiratory area and the ratio of the respiratory area to nasopharyngeal (RA/NA) area increased following RME. There were no statistically significant differences between the groups. Nasal cavity width and maxillary width also increased, but the difference between the groups was not significant. Following RME, various differences in both the maxilla and surrounding bones occurred and nasal width increased with a decrease in nasal airway resistance. At the end of treatment there were increases in the width of the nasal floor near the midpalatal suture and nasal cavity. As the maxillary structures separated, the outer walls of the nasal cavity moved laterally resulting in an increase in internasal volume. Nasal resistance decreased and respiratory area increased in patients treated with RME. (*Angle Orthod* 2002;72:118–123.)

Key Words: Rapid maxillary expansion; Surgically assisted rapid maxillary expansion; Nasal dimension; Planimeter

INTRODUCTION

Rapid maxillary expansion (RME) is used in subjects with transverse maxillary deficiencies.[1–3] Angell first introduced the RME method in 1860 and a great deal of research has been carried out since then. In these studies, it has been noted that RME caused not only dentofacial changes, but also craniofacial structural changes.[2–4]

One of the most important factors affecting the success of RME is the age of the patient. The most suitable age for applying this method is the pubertal or prepubertal period.[5,6] Only limited effects occur in adult patients during RME and post-RME therapy; therefore, in adults, RME should be surgically assisted. With surgery, the circummaxillary rigidity is reduced, periodontal health is preserved, the risk of root resorption diminishes, and satisfactory results with long-term stability can be achieved.[7–9]

Eysel studied the effect of RME on nasal cavity function in 1886.[3,10] He found that, in the post-RME period, various changes occurred in the maxilla and adjacent bones and RME caused an opening of the nasal cavity and reduction in nasal airway resistance. In addition, following expansion an increase was found in the nasal cavity width and in the nasal base adjacent to the midpalatal suture. The maxillary sutures separate the external walls of the nasal cavity laterally resulting in an increase in the intranasal capacity.[2,3,5,11,12]

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TABLE 1. The Distribution, Average Ages, Expansion Periods and Retention Periods of the Subjects[a]

	n	Mean Age (year)	Expansion Period (day)	Retention Period (month)
RME group	15	12.1 ± 1.1	26.1 ± 2.2	3.08 ± 0.1
SARME group	15	18.4 ± 1.4	25.2 ± 3.1	3.1 ± 0.2

[a]RME indicates rapid-maxillary expansion; SARME, surgical assisted rapid maxillary expansion.

The shape and the size of nasal cavity and conchae affect the nasal resistance as does septal deviation, polyps, adenoid tissue, the structure of the mucosa, and the shape of the nostrils.[13] To examine the nasal airway and related dentofacial structures, tomography, lateral cephalograms, postero-anterior radiographs, and anterior rhinomanometry methods are used.[14–19]

The aim of this study was to assess the effects of the normal RME and SARME treatments on the nasopharyngeal area.

MATERIAL AND METHODS

This research was conducted on 15 male patients and 15 female patients. The criteria for selection of both groups for rapid expansion treatment were as follows: a posterior cross bite with evidence of significant skeletal involvement as judged clinically by an experienced orthodontist; no evidence of adenoidal blockage of the nasopharynx; and no previous tonsillar, nasal or adenoidal surgery.

The patients were divided into two groups. The first group (RME group) included 15 patients, eight girls and seven boys, whose mean age was 12.1 ± 1.1 years. The second group (SARME group) included 15 individuals, eight boys and seven girls, with an mean age of 18.4 ± 1.4 years. Table 1 shows the distribution, average ages, and average expansion periods of the subjects. In both groups, a modified bonded acrylic rapid maxillary expansion appliance was used in the expansion process (Figure 1).[20]

The RME appliance was cemented in all patients by the same clinician using a glass ionomer cement (Ketac-Cem, Espe Dental AG, Seefeld, Germany). In the RME group, the appliance was activated one-quarter turn twice a day during the expansion period. In the SARME group, a nonsurgical RME was attempted but, if after the fist week the maxillary median suture was not separated, surgical assistance was instituted. The same surgeon carried out all surgery. A Le Fort I osteotomy without a down fracture was used as described by Epker and Fish.[21] A bilateral buccal corticotomy was undertaken from the apertura piriformis towards the pterygoid fissures in an attempt to break the resistance of the maxillary tuberosity and the ties between the maxilla and zygomatic bones. No surgical operation in the median palatal suture was done. Beginning on the seventh postoperative day, the appliance was activated one-quarter turn twice a day during the expansion period.[21] All

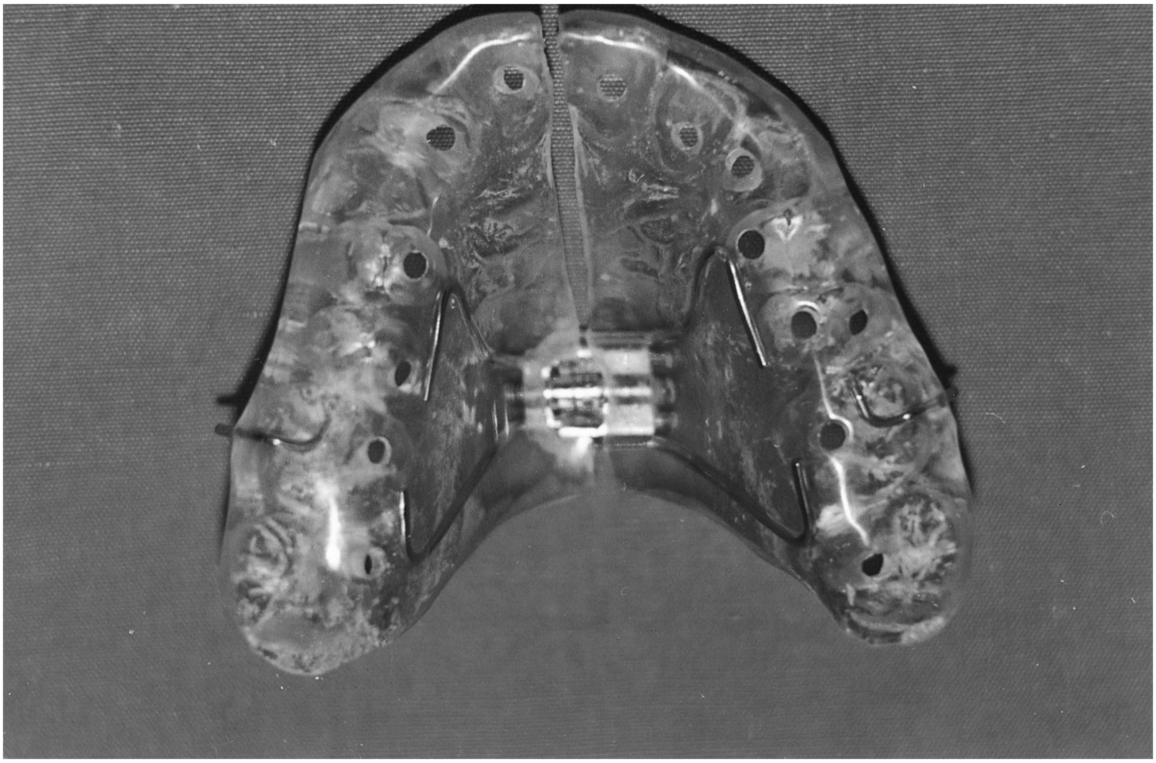

FIGURE 1. Modified acrylic bonded rapid maxillary expansion appliance.

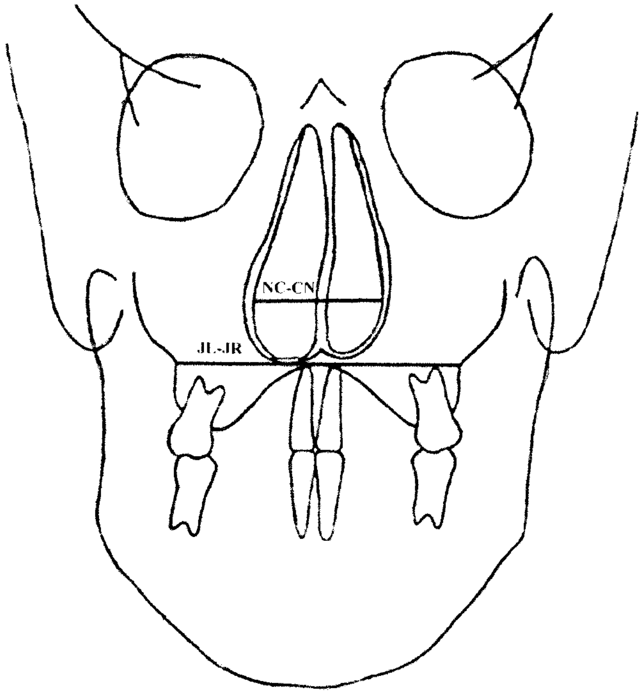

FIGURE 2. Frontal cephalometric measurements: NC-CN, JL-JR.

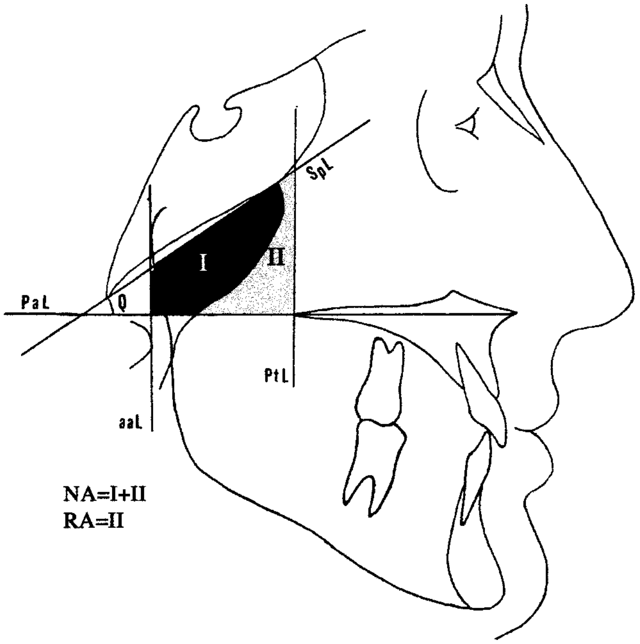

FIGURE 3. Lateral cephalometric measurements: (Nasopharyngeal area [NA], Respiratory area [RA], Q angle).

cross bites were overcorrected so that the palatal cusps of the upper molars were riding up on the buccal cusps of the lowers. When the required expansion was achieved, the RME appliance was removed and the screw locked in position with cold cure acrylic and used as a retainer for three months. All baseline records were repeated after three months. Fixed appliance treatment was started soon after the retention period.

In postero-anterior cephalometric radiographs, two planes were used and the nasal cavity width and maxillary width were taken (Figure 2). Nasopharyngeal area was established by using four planes on the lateral cephalometric radiographs. The nasopharyngeal area has been limited with the palatal, sphenoid, pterygomaxillary, and anterior axis planes (Figure 3).[22]

- Palatal Plane (PaL): the plane from the ANS to PNS points.
- Sphenoid Plane (SpL): the tangent drawn at the greater wing of the sphenoid bone.
- Pterygomaxillary plane (PtL): the plane formed by drawing a perpendicular line to the Palatal Plane from PNS point.
- Anterior Axis Plane (aaL): the plane formed by drawing a perpendicular line to the palatal plane from aa point (anterior tubercule of the atlas).
- Q angle: the angle between the sphenoid and palatal planes.

The nasopharyngeal and respiratory areas on were measured separately on lateral cephalograms with a ''Placom'' type digital planimeter in mm^2. The respiratory area (RA)/nasopharyngeal area(NA) ratio of Linder-Aronson was also calculated for each patient (Figures 4 and 5).[23]

Statistical analysis

The arithmetic mean and standard deviation (SD) were calculated for the different variables. The paired *t*-test was used to evaluate the treatment changes within each group. To compare the changes observed in both groups, a Student's *t*-test was performed.[24]

For assessment of the combined method error in locating and measuring the changes of the different landmarks, 20 randomly selected lateral and frontal cephalograms were retraced. The following formula was used for the method error calculation: $\sqrt{\Sigma d^2/2n}$, where d is the difference between two measurements of a pair and n is the number of double measurements. The findings were observed to vary between 0.074 and 0.542. Dahlberg's method does not take into account the size of the error in relation to the magnitude of the variable itself; however, the errors of the magnitude in this study are regarded to be relatively low.[25]

RESULTS

The measurement error of Dahlberg, using the formula $\sqrt{\Sigma d^2/2n}$, was established for each measurement and the findings were observed to vary between 0.074 and 0.542. These findings are not significant enough to affect the credibility of the research. The findings of the research are presented in Tables 2, 3, and 4.

The findings related to the nasopharyngeal area revealed that the RA/NA ratio decreased at the level of $P < .001$ in

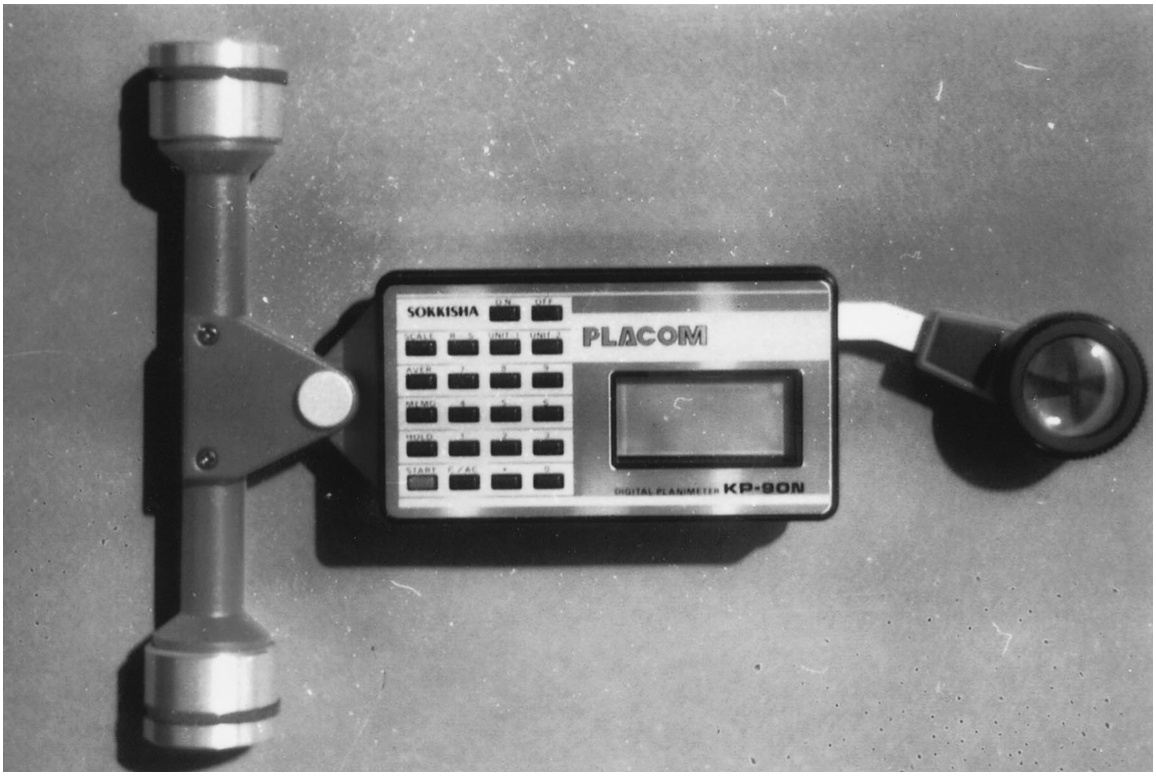

FIGURE 4. Placom type digital planimeter.

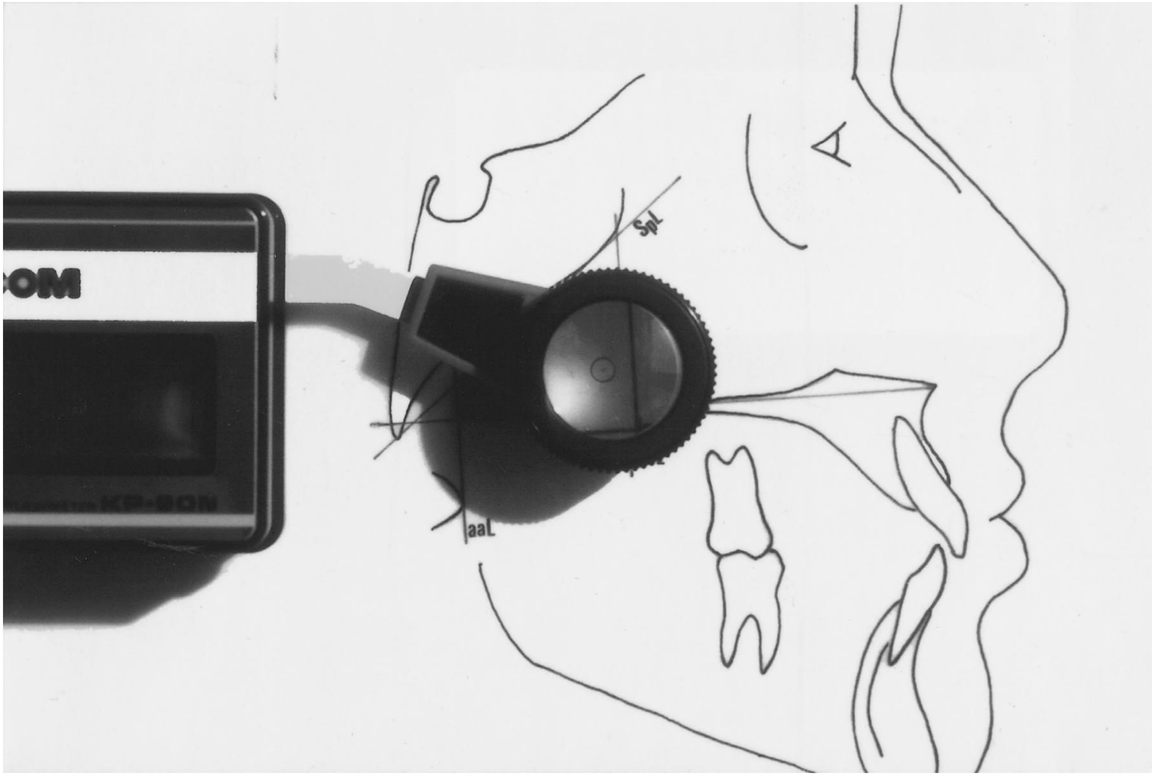

FIGURE 5. Nasopharyngeal and respiratory area measurement with planimeter.

TABLE 2. Comparisons of Pre- and Post-Treatment Values Between and Within the Groups[a]

	RME Group							SARME Group							Group Difference Student's *t*-test
	Pre-treatment		Post-treatment		Difference		Paired *t*-test	Pre-treatment		Post-treatment		Difference		Paired *t*-test	
	Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD		
RA/NA ratio	0.55	0.14	0.62	0.12	0.07	0.05	.000***	0.54	0.09	0.61	0.09	0.07	0.05	.000***	NS
Q angle	29.33	5.14	29.33	5.49	0.00	1.31	NS	30.67	5.63	30.93	5.57	0.27	0.80	NS	NS
Nasal cavity width	30.53	2.77	34.00	2.76	3.47	1.04	.000***	32.93	3.20	35.87	3.40	2.93	0.73	.000***	NS
Maxillary width	61.53	3.40	66.27	3.26	4.73	1.33	.000***	59.47	3.60	63.33	3.24	3.87	1.25	.000***	NS

[a]RME indicates rapid maxillary expansion; SARME, surgical assisted rapid maxillary expansion; RA, respiratory area; NA, nasopharyngeal area; SD, standard deviation; and NS, not significant.

*** $P < .001$.

both groups (nonsurgical RME and SARME) (Tables 2 and 3).

The differences between pretreatment and post-treatment measurements in these groups were not statistically significant ($P > .05$) (Table 4). The Q angle in all assessments was not statistically significant ($P > .05$) (Tables 2, 3, and 4). When the frontal cephalometric films in both groups were evaluated, a significant increase in the width of the nasal cavity and the maxilla was seen $P < .001$.

DISCUSSION

When an RME is used in the separation of the midpalatal suture, some expansion occurs between the maxillary bones and in the lower part of the nostrils. Therefore, individuals having some problems in the frontal and lower parts of their nasal structure have had much more relaxed respiration following RME.[3,12,26–29]

Through the use of RME, there was an increase in nasal cavity dimensions, a decrease in nasal obstruction, and a relief in the respiration canals. However, in the treatment of asthma (allergic rhinitis patients), an RME is said to be not efficient enough and, therefore, is only a supplementary treatment in solving the problem.[3,26,28]

Lateral cephalometric radiographs have been used for examining dentofacial structures, nasal airway, and related areas.[17–19] Although there is no clear connection between the oropharyngeal and hypopharyngeal areas, it is claimed that there is a direct relation between the two-dimensional cephalometric film measurement of tongue, palate, and nasopharyngeal areas and their three-dimensional computed tomography measurements. However, orthodontists do not advise three-dimensional computerized tomography as the patient is exposed to high doses of radiation and it causes a waste of time and money.[30] The measurement of the nasopharyngeal area was made with a planimeter similar to that of many other studies.[22,31–33] In this study, the dentofacial structure of the patients treated with RME and SARME have been examined. In both groups, Placom-type digital planimeter lateral and postero-anterior cephalometric films were used.

Handelman and Osborne[22] maintained that the Q angle between the sphenoid plane and the palatal plane that they used in determining the nasopharyngeal area did not change from the age of one year until the age of 18 years. Our study also shows the stability of the Q angle in both groups ($P > .05$), indicating the credibility of the planes in determining the nasopharyngeal area.

Planimetric measurements taken on lateral cephalograms showed that respiration areas in both groups enlarged and the RA/NA ratio increased ($P < .001$). These results suggest that nasal respiration passages are opened and the respiration process relieved. In both groups, RA/NA ratio increased 12%. In addition, when normal RME was compared to SARME, no statistically significant difference was observed between these groups ($P > .05$).

Warren et al[28] found that nasal area increased 45% after the RME and 55% following the SARME. The expansion became particularly effective in increasing nasal valve size and the area width. Researchers suggested that an RME would not be useful by itself in cases with turbine hypertrophy, nasal polyps, enormous adenoids, or septal deviations.

In our study, the nasal cavity width and maxillary width, measured from postero-anterior cephalograms, increased statistically in both groups ($P < .001$). Moreover, the nasal cavity width increased at the level of 3.47 mm in the normal RME group and 2.93 mm in the SARME group. These findings are greater than Krebs[34] (1.4 mm), Wertz[12] (1.9 mm) and the average nasal cavity width (2.087 mm) found by Da Silva Filho, et al.[35]

Haas[36], however, claimed that this measure varied between 2 to 4.5 mm. The reasons for the difference is in the age variation of the subjects, differences in how the appliance was used in the expansion and the variance of expansion amounts applied on the patients. Our findings agree with previous research showing an increase in maxillary width and nasal cavity width with the use of RME.[23,26,27]

Linder-Aronson and Aschan[37] claimed that measurements taken after one year showed no change in the nasal resistance, which came to normal levels after the RME. Hershey et al[27] came to the conclusion that no changes occurred in the new capacity of nasal resistance after a three-year period.

In our study, RME with or without surgical aid was effective in patients with nasal respiration problems and maxillary transversal deficiency. However, while planning the treatment, the localization of etiologic factors should be considered.

REFERENCES

1. Bell RA. Review of maxillary expansion in relation to rate of expansion and patient's age. *Am J Orthod.* 1982;81:32–37.
2. Haas AJ. The treatment of maxillary deficiency by opening the midpalatal suture. *Angle Orthod.* 1965;35:200–217.
3. Haas AJ. Rapid expansion of the maxillary dental arch and nasal cavity by opening the mid palatal suture. *Angle Orthod.* 1961;31:73–90.
4. Graber TM. *Current Orthodontic Concepts and Techniques.* Philadelphia, Penn: WB Saunders; 1975.
5. Bishara SE, Staley RN. Maxillary expansion: clinical implications. *Am J Orthod.* 1987;91:3–14.
6. Epker BN, Wolford C. *Dentofacial Deformity, Surgical-Orthodontic Correction.* St Louis, Mo: CV Mosby; 1980.
7. Betts NJ, Vanarsdall RL, Barber HD, Higgins-Barber K, Fonseca RJ. Diagnosis and treatment of transverse maxillary deficiency. *Int J Adult Orthodon Orthognath Surg.* 1995;10:75–96.
8. Lines PA. Adult rapid maxillary expansion with corticotomy. *Am J Orthod.* 1975;67:44–56.
9. Pogrel MA, Kaban LB, Vargerik K, Baumrind S. Surgically assisted rapid maxillary expansion in adults. *Int J Adult Orthodon Orthognath Surg.* 1992;7:37–41.
10. Timms DJ. The soft underbelly or RME revisited. *Am J Orthod.* 1986;89:443–445.
11. Timms DJ. Some medical aspects of rapid maxillary expansion. *Br J Orthod.* 1973;1:127–132.
12. Wertz RA. Skeletal and dental changes accompanying rapid midpalatal suture opening. *Am J Orthod.* 1970;58:41–66.
13. Turvey TA, Hall DJ, Warren DW. Alterations in nasal airway resistance following superior repositioning of the maxilla. *Am J Orthod.* 1984;85:109–115.
14. Linder-Aronson S, Lindgren J. The skeletal and dental effects of rapid maxillary expansion. *Br J Orthod.* 1979;6:25–29.
15. Montgomery W, Vig PS, Staab EV, Matteson SR. Computed tomography: a three-dimension study of the nasal airway. *Am J Orthod.* 1979;6:363–375.
16. Ricketts RM. Respirotory obstruction syndrome. *Am J Orthod.* 1968;54:495–507.
17. Bacon WH, Turlet JC, Krieger J, Stierle JL. Craniofacial characterictics in patients with obstructive sleep apnea syndrome. *Cleft Palate Journal.* 1988;25:374–378.
18. Lowe AA, Gionhaku N, Takeuchi K, Fleetham JA. Three-dimensional CT reconstructions of tongue and airway in adult subjects with obstructive sleep apnea. *Am J Orthod.* 1986;90:364–374.
19. Berry Borowiecki B, Kukwa A, Blanks RHI, Irvine CA. Cephalometric analysis for diagnosis and treatment of obstructive sleep apnea. *Laryngoscope.* 1988;98:226–234.
20. Başçiftçi FA. *Modifiye akrilik bonded rapid maksiller ekspansiyon apareyi ve vertikal çeneliğin dentofasiyal yapılar üzerine etkileri* [master's thesis]. Konya, Turkey: University of Selcuk; 2001.
21. Epker BN, Fish LC. Transverse maxillary deficiency. In: Epker BN, Fish LC, eds. *Dentofacial Deformities: Integrated Orthodontic and Surgical Correction.* Vol II. St Louis: CV Mosby Co; 1986:818–675.
22. Handelman CS, Osborne G. Growth on nasopharynx and adenoid development from one to eighteen years. *Angle Orthod.* 1976;46:243–258.
23. Linder-Aronson S. Adenoids. Their effect on mode of breathing and nasal airflow and their relationship to characteristics of the facial skeleton and the denition. A biometric, rhino-manometric and cephalometro-radiographic study on children with and without adenoids. *Acta Otolaryngol Suppl.* 1970;265:1–132.
24. Sokal RR, Rohlf FS. *Biometry.* San Francisco, Calif: WH Freeman Company; 1981.
25. Battagel JM. A comparative assessment of cephalometric errors. *Eur J Orthod.* 1993;15:305–314.
26. Hartgerink DV, Vig PS, Abbot DW. The effect of rapid maxillary expansion on nasal airway resistance. *Am J Orthod.* 1987;92:381–389.
27. Hershey HG, Stewart BL, Warren DW. Changes in nasal airway resistance associated with rapid maxillary expansion. *Am J Orthod.* 1976;69:274–284.
28. Warren DW, Hershey HG, Turvey TA, Hinton VA, Hairfield WM. The nasal airway following maxillary expansion. *Am J Orthod.* 1987;91:111–116.
29. Wertz RA. Changes in nasal air flow incident to rapid maxillary expansion. *Angle Orthod.* 1968;38:1–11.
30. Lowe AA. Can we predict the success of dental appliance therapy for the treatment of obstructive sleep apnea based on anatomic considerations. *Sleep.* 1993;16:93–95.
31. Güray E, Aytan S. Nazal obstrüksiyonun belirlenmesinde rinomanometre ve planimetre. *Hacettepe Dişhekimliği Fakültesi Dergisi.* 1987;11:25–28.
32. Holmberg H, Linder-Aronson S. Cephalometric Radiographs as a means of evaluating the capacity of the nasal and nasopharyngeal airway. *Am J Orthod.* 1979;76:479–490.
33. Güray E, Karaman Aİ. Adenoidektomi operasyonunun dentofasiyal yapılar üzerine etkisi (6 yıllık longitüdinal çalışma). *Türk Ortodonti Dergisi.* 1994;7:151–164.
34. Krebs A. Expansion of the midpalatal suture studied by means of metallic implants. *Acta Odontol Scand.* 1959;17:491–501.
35. Da Silva Filho OG, Prado Montes LA, Torelly LF. Rapid maxillary expansion in the deciduous and mixed dentition evaluated through posteroanterior cephalometric analysis. *Am J Orthod Dentofacial Orthop.* 1995;107:268–275.
36. Haas AJ. Palatal expansion: just the beginning of dentofacial orthopedics. *Am J Orthod.* 1970;57:219–255.
37. Linder Aronson S, Aschan G. Nasal resistance to breathing and palatal height before and after expansion of the median palatine suture. *Odontol Rev.* 1963;14:254–270.