Original Article

Stability of Maxillary Expansion and Tongue Posture

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ABSTRACT

Objective: To evaluate the adaptive changes and the stability in tongue posture following rapid maxillary expansion (RME) in patients without any signs or symptoms of respiratory disturbances.

Materials and Methods: Growing subjects with maxillary constrictions and bilateral buccal crossbites were included in the treatment group (n = 20). A control group (n = 20) comprised subjects with normal dentoskeletal features. RME appliances were used in the treatment group, with an average active expansion of 15 ± 2 days. Cephalometric radiographs were traced and digitized to evaluate static tongue posture before RME and 6.75 ± 0.48 months after RME. Follow-up radiographic evaluations of 17 expansion cases were also performed after an average of 29.25 ± 1.85 months. Independent and paired *t*-tests were conducted to evaluate changes in tongue posture within and between groups.

Results: Results revealed significant reductions of tongue-to-palate ($P < .05$) as well as hyoid bone-to-mandibular plane ($P < .01$) distances following RME. The new tongue posture was found to be stable during the follow-up period.

Conclusions: A higher tongue posture can be obtained with RME in children with no reported respiratory disturbances. (*Angle Orthod.* 2009:79;)

KEY WORDS: Maxillary expansion; Tongue posture; Stability; Respiratory disturbances

INTRODUCTION

The stability of orthodontic treatment results is affected by a wide variety of craniofacial functions, including postural relationships of the head-neck and perioral muscle systems. Therefore, maintenance of posttreatment equilibrium between occlusal, periodontal, gingival, and perioral soft tissue forces and craniofacial growth and development is crucial.[1,2]

Some recent studies of the dental and skeletal effects of maxillary expansion (ME) have shown relatively stable long-term results with this procedure.[3–6] Although the contribution of dentoalveolar and skeletal expansion has varied, clinically acceptable stability has been observed in various age groups. This is somewhat surprising, considering that the increased buccal pressure on the maxillary molars[7] and the decreased tongue pressure[8] have been observed to remain at postexpansion levels for at least 3 months after expansion.

On the other hand, the position of the tongue at rest is considered to have a greater effect on the position of teeth than the short-term pressure of perioral soft tissues.[9] It has been shown that in patients with severe maxillary constriction, the space required to accommodate the tongue close to the roof of the palate is inadequate, and tongue posture is lower than desirable.[10–12] Because ME may create the additional space needed to accommodate the tongue, it may be hypothesized that in patients with stable results, the tongue may be spontaneously positioning itself closer to the roof of the palate. Not only might this result in balanced cheek and tongue pressure on dentition; it could also result in a modification of craniofacial growth and development patterns,[13–15] which would explain the documented stability of ME, at least in those

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Table 1. Distribution of Ages (Years ± SDs) of Patients and Control Subjects According to Time Period*

	T1	T2	T3	C1	C2
Patient age	12.50 ± 1.04	13.10 ± 1.08	15.63 ± 1.38	12.68 ± 1.04	13.16 ± 1.02

* T1 indicates before RME treatment; T2, after RME treatment (without appliance); T3, end of fixed appliance therapy (a mean of 29.25 ± 1.85 posttreatment); C1, beginning of control period; C2, end of control period.

patients with no signs or symptoms of respiratory disturbances (RD).

Therefore, the aims of this study were:

- To determine whether or not tongue posture in children with maxillary constriction and posterior crossbites and no signs or symptoms of RD is lower than tongue posture in controls with normal dental and skeletal characteristics; and
- To evaluate whether or not ME results in stable adaptation of tongue posture in these children.

MATERIALS AND METHODS

This retrospective study was conducted on lateral cephalograms and frontal and hand-wrist radiographs of a treatment group comprised of 20 patients treated with a rapid ME (RME) appliance. All patients were treated at the Ankara University Department of Orthodontics by the same investigators using the same protocol. Selection criteria were as follows:

- Maxillary constriction and bilateral posterior crossbite with all teeth present,
- No signs or symptoms of pediatric RD based on parents' reports,
- Radiographs with clearly visible tongue outlines, and
- Maturation stage between MP3cap and MP3u at the beginning of treatment, indicating adequate growth potential.[16]

No distinctions were made with regard to sagittal and vertical dentoskeletal configurations. The mean patient age at the start of treatment was 12.50 years (age range: 11.5 to 13.1 years) (Table 1).

A control group comprised 20 growing subjects (1977–1984 longitudinal study, Ankara University Department of Orthodontics Archives) who were matched with the treatment group for sex and maturation stage. All control subjects had Angle Class I occlusion with normal overjet and overbite, normal sagittal and vertical skeletal configuration, and all teeth present. None had any reported respiratory problems.

Treatment Protocol

All subjects in the treatment group were initially treated with an acrylic-bonded RME appliance (Figure 1), as described by Toyar Memikoğlu and İşeri[17] (half a turn in the morning and half a turn in the evening, plus retention for 6 months), followed by fixed orthodontic therapy. Four patients required extraction of the first four premolars following RME treatment, and seven patients required high-pull headgear during fixed orthodontic therapy. Maxillomandibular elastics were used in all patients. All patients wore Hawley retainers at the end of orthodontic therapy.

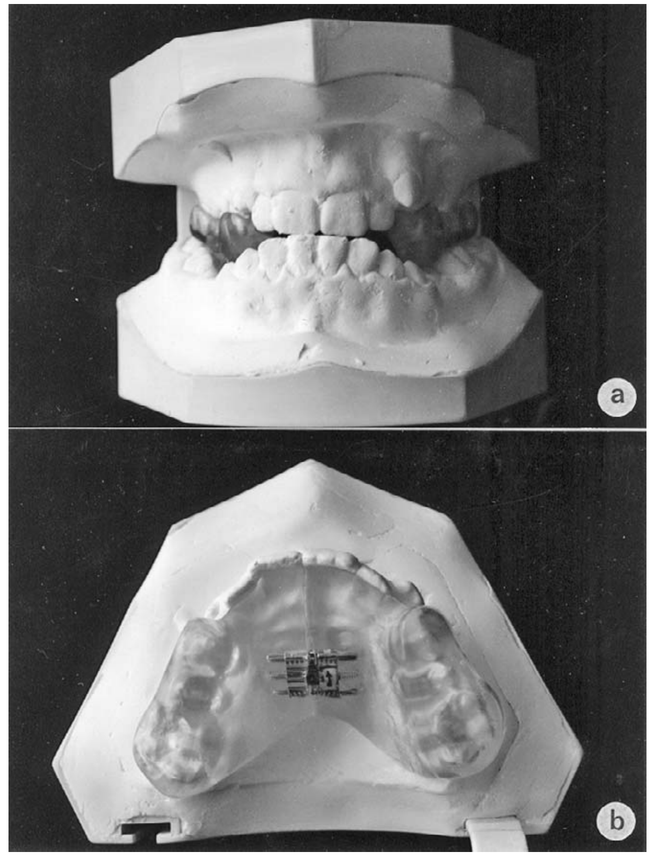

Figure 1. Rigid acrylic bonded rapid maxillary expansion (RME) appliance.

Analysis of Records

Radiographs for the treatment group were taken prior to activation (before RME [T1]; n = 20); after termination of expansion at 6.75 ± 0.48 months, without the appliance (after RME [T2]; n = 20); and at the end of fixed appliance therapy, a mean of 29.25 ± 1.85 months after T2 (end of treatment [T3]; n = 17). Long-term evaluation of three patients (at T3) was not possible because they had discontinued treatment for various reasons.

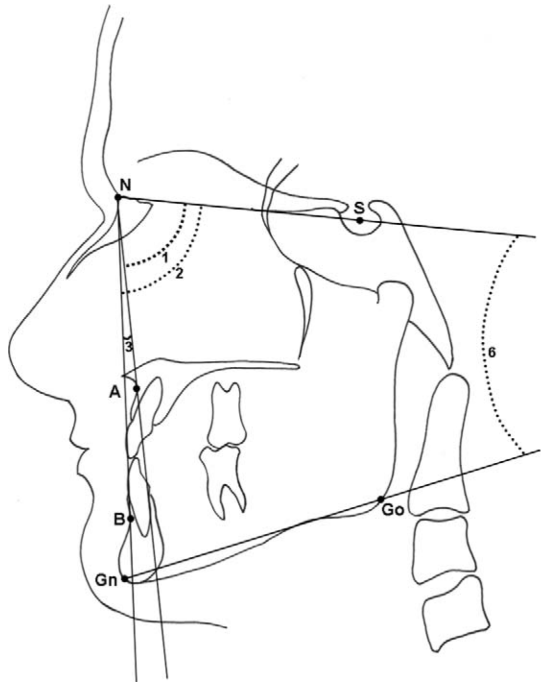

Figure 2. Descriptive lateral cephalometric measurements (angles). 1 indicates SNA; 2, SNB; 3, ANB; 6, SN/GoGn.

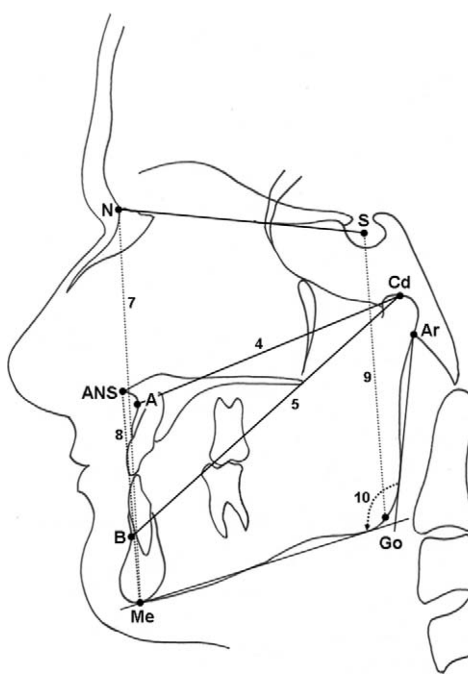

Figure 3. Descriptive lateral cephalometric measurements (lines). 4 indicates Cd-A (the distance between condylion and point A); 5, Cd-B (the distance between condylion and point B); 7, N-Me (anterior face height); 8, ANS-Me (lower anterior face height); 9, S-Go (posterior face height); 10, gonial angle.

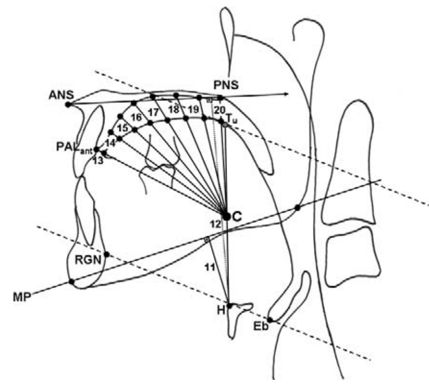

Figure 4. Lateral cephalometric landmarks used to evaluate hyoid bone and tongue. H indicates hyoid bone; Eb, base of epiglottis; PAL_{ant}, palatal curvature; ANS, anterior nasal spine; PNS, posterior nasal spine; T_U, upper tongue point; RGN, retrognathion. Hyoid bone– and tongue posture–related lateral cephalometric measurements: 11 indicates H-MP (the perpendicular distance from hyoid to mandibular plane); 12, H-ANS-PNS (the perpendicular distance from hyoid to palatal plane); 13, TDP1; 14, TDP2; 15, TDP3; 16, TDP4; 17, TDP5; 18, TDP6; 19, TDP7; 20, TDP8.

Radiographs of control subjects consisted of annual radiographs taken within the framework of the available longitudinal sample (beginning of control [C1] and end of control [C2]). Patients were instructed to hold their breath and not to swallow while the radiographs were taken. No attempt was made to enhance the outlines of the tongue dorsum.

Measurements

Ten lateral, four posteroanterior, and ten tongue posture cephalometric parameters were assessed (Figures 2 to 5). Anatomic landmarks were identified and digitized on a Houston Hipad digitizer with a resolution of 0.125 mm. Some of the soft tissue points related to the tongue and hyoid bone used in this study have been described by Pae et al.[18]

To establish the original tongue-posture parameters of this study (Figure 4), an upper tongue (T_U) point was identified by drawing a line parallel to points RGN-Eb tangent to the most superior point of the dorsum of the tongue. A line was drawn through points T_U and H, and the midpoint of line T_U-H identified as point C. Lines were then drawn between point C and the intersection of the palatal curvature and central incisor (C-PAL_{ant}), and between point C and PNS (C-PNS). Six additional lines were drawn from point C to divide the angle formed by lines C-PNS and C-PAL_{ant} into six equal angles to form eight lines, including lines C-PNS and C-PAL_{ant}. Eight different tongue-to-palate distances (TPDs 1 through 8) were determined by measuring the distance between the points formed with the lines intersecting the dorsum of the tongue and the palatal curvature.

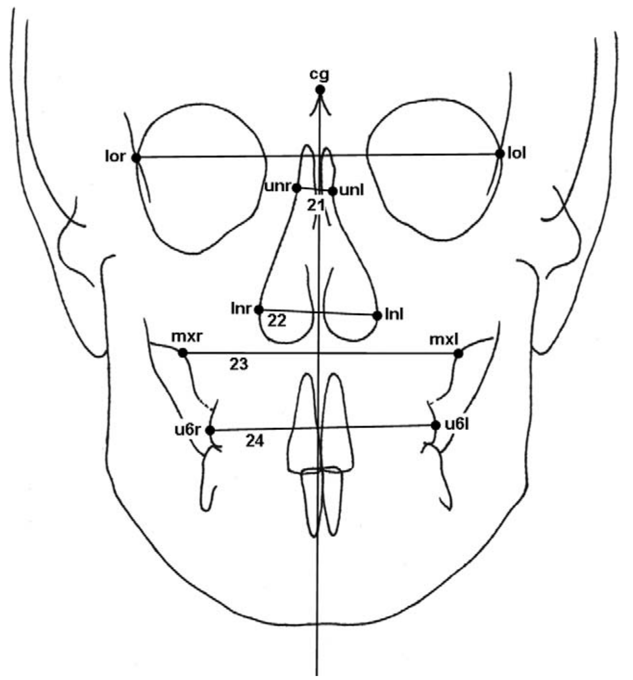

Figure 5. Posteroanterior cephalometric landmarks used in the study. cg (crista galli) indicates the geometric center of crista galli; lor and lol, right and left lateroorbital points, intersections of the inferior borders of the greater wing of the sphenoid bone and lateral orbital margins; unr and unl, right and left upper nasal points, the most inner points on the nasal apertura taken parallel to the HRP; lnr and lnl, right and left lower nasal points, the most lateral points on the nasal apertura taken parallel to the HRP; mxr and mxl, right and left maxillary points, the deepest points on the curvature of the malar process of the maxilla; u6r and u6l, right and left upper first molar points, the midpoint on the buccal surface of the maxillary first molar crown (secondary tooth); HRP, horizontal reference plane, the plane constructed between lor and lol. Posteroanterior cephalometric measurements: 21 indicates UNasW; 22, LNasW; 23, BMaxW; 24, UMolW.

Statistical Analysis

Intraclass correlation coefficients were used to assess the reliability of landmark identification, digitization, and calculation of measurements. Independent and paired *t*-tests were used to assess changes between and within the groups. Repeated-measures analyses and Duncan tests were used to assess treatment changes. Statistical analysis was performed using the Minitab for Windows Statistical Package.

Table 3. Descriptive Statistics (Means ± SDs) of the Treatment and Control Groups and Intragroup Differences

Parameter	Treatment Group at T1 (n = 20)	Control Group at C1 (n = 20)	*P*
1 SNA	76.85 ± 0.91	81.20 ± 0.54	<.001
2 SNB	76.35 ± 0.89	78.26 ± 0.58	NS
3 ANB	0.50 ± 0.95	2.94 ± 0.44	<.05
4 Cd-A	82.74 ± 1.08	89.43 ± 0.91	<.001
5 Cd-B	102.51 ± 1.35	105.28 ± 0.78	NS
6 Go-Gn.SN	38.36 ± 0.76	32.06 ± 0.90	<.001
7 N-Me	121.39 ± 1.23	120.21 ± 1.18	NS
8 ANS-Me	68.35 ± 0.92	67.68 ± 1.00	NS
9 S-Go	74.02 ± 1.07	77.93 ± 1.04	<.01
10 Gonial angle	132.53 ± 0.87	127.61 ± 0.91	<.001

NS = Non Significant.

RESULTS

The reliability of measurements was tested by repeating all tracing, landmark identification, and digitization procedures on 20 randomly selected cephalograms. Reliability was found to be within clinically acceptable limits (Table 2). Descriptive statistics of the treatment and control groups and a statistical evaluation of intergroup differences at T1/C1 are given in Table 3.

Intragroup and Intergroup Differences in Tongue Posture and Hyoid Bone Position at T1/C1 and T2/C2

Hyoid bone-to-mandibular plane distance (H-MP) was significantly greater in subjects with maxillary constriction when compared to subjects in the control group (Table 4). TPDs were also greater at all points in the treatment group when compared to the control group; however, only the differences in the distances at the posterior parts of the tongue (TPD1 to TPD3)

Table 2. Reliability of the Measurements

Descriptive Lateral Cephalometric Measurements			Hyoid Bone- and Tongue Posture-Related Lateral Cephalometric Measurements			Posteroanterior Cephalometric Measurements		
1	SNA	0.9982	11	H-MP	0.9822	21	UNasW	0.9888
2	SNB	0.9840	12	H-ANS-PNS	0.9712	22	LNasW	0.9812
3	ANB	0.9971	13	TPD1	0.9876	23	BMaxW	0.9777
4	Cd-A	0.9876	14	TPD2	0.9834	24	UMolW	0.9834
5	Cd-B	0.9849	15	TPD3	0.9789			
6	Go-Gn.SN	0.9977	16	TPD4	0.9799			
7	N-Me	0.9903	17	TPD5	0.9824			
8	ANS-Me	0.9878	18	TPD6	0.9798			
9	S-Go	0.9877	19	TPD7	0.9766			
10	Gonial angle	0.9865	20	TPD8	0.9775			

Table 4. Hyoid Bone and Tongue Posture Changes (Means ± SDs) in Treatment and Control Groups and Statistical Evaluation of Intragroup and Intergroup Differences

Parameter	Treatment Group at T1 (n = 20)	Control Group at C1 (n = 20)	*P*	Difference in Treatment Group (T2 − T1)	Difference in Control Group (C2 − C1)	*P*
11 H-MP	17.50 ± 1.19	12.06 ± 0.98	<.001	−1.90 ± 0.84*	−0.11 ± 0.79	NS
12 H-ANS-PNS	62.77 ± 1.43	61.20 ± 1.22	NS	0.17 ± 0.92	1.51 ± 0.69*	NS
13 TPD1	12.80 ± 0.45	11.04 ± 0.694	<.05	−1.30 ± 0.63*	0.63 ± 0.56	<.05
14 TPD2	10.51 ± 0.55	8.55 ± 0.70	<.05	−2.02 ± 0.63**	0.61 ± 0.48	<.01
15 TPD3	10.27 ± 0.72	8.24 ± 0.72	<.05	−2.52 ± 0.70**	0.41 ± 0.52	<.01
16 TPD4	10.58 ± 0.77	8.63 ± 0.77	NS	−2.81 ± 0.82**	0.34 ± 0.62	<.01
17 TPD5	10.79 ± 0.78	9.26 ± 0.81	NS	−2.65 ± 0.86**	0.60 ± 0.74	<.01
18 TPD6	9.35 ± 0.70	8.43 ± 0.77	NS	−2.20 ± 0.91*	0.66 ± 0.70	<.05
19 TPD7	6.43 ± 0.51	5.98 ± 0.66	NS	−1.72 ± 0.72*	0.05 ± 0.59	NS
20 TPD8	4.75 ± 0.38	4.00 ± 0.43	NS	−0.66 ± 0.51	0.01 ± 0.37	NS

* *P* < .05; ** *P* < .01. NS = Non Significant.

Table 5. Results of Repeated-Measures Analysis and Duncan Test in the Treatment Group

Parameter	T1 (n = 20)	T2 (n = 20)	T3 (n = 17)	F test	1–2	1–3	2–3
Hyoid bone- and tongue posture-related lateral cephalometric measurements							
11 H-MP	17.50 ± 1.19	15.60 ± 1.23	15.68 ± 1.92	*	*	NS	NS
12 H-ANS-PNS	62.77 ± 1.43	62.94 ± 1.77	66.14 ± 2.59	*	NS	*	NS
13 TPD1	12.80 ± 0.45	11.50 ± 0.64	10.68 ± 1.16	*	*	NS	NS
14 TPD2	10.51 ± 0.55	8.49 ± 0.68	8.11 ± 1.23	**	**	*	NS
15 TPD3	10.27 ± 0.72	7.75 ± 0.72	7.73 ± 1.27	**	**	*	NS
16 TPD4	10.58 ± 0.77	7.77 ± 0.73	8.23 ± 1.29	**	**	NS	NS
17 TPD5	10.79 ± 0.78	8.14 ± 0.69	8.74 ± 1.26	**	**	NS	NS
18 TPD6	9.35 ± 0.70	7.15 ± 0.74	7.42 ± 1.05	*	*	NS	NS
19 TPD7	6.43 ± 0.51	4.71 ± 0.73	4.70 ± 0.65	*	*	*	NS
20 TPD8	4.75 ± 0.38	4.09 ± 0.65	2.92 ± 0.33	***	NS	***	NS
Posteroanterior measurements							
21 UNasW	4.86 ± 0.40	5.15 ± 0.48	5.24 ± 0.37	NS	NS	NS	NS
22 LNasW	30.14 ± 0.46	31.80 ± 0.72	31.29 ± 0.76	**	**	**	NS
23 BMaxW	62.44 ± 1.01	66.41 ± 1.04	66.19 ± 0.88	**	**	**	NS
24 UIMolW	53.66 ± 0.82	58.96 ± 1.11	59.66 ± 0.85	**	**	**	NS

* P < .05; ** P < .01; *** P < .001. NS = Non Significant.

were statistically significant ($P < .05$). H-MP was observed to have decreased significantly ($P < .05$) in the treatment group. All TPD parameters, except for TPD8, also decreased significantly ($P < .05$ to $P < .01$) because of treatment.

Changes in Tongue Posture and Hyoid Bone Position in Treatment Group

H-MP decreased significantly in the treatment group from pretreatment to posttreatment and remained constant throughout the fixed appliance phase. No systematic changes were observed in the control group (Table 5).

All TPD distances except for TPD8 decreased significantly in the treatment group and remained constant until the removal of the fixed appliances at T3. No systematic changes were observed in the control group.

Changes in Transverse Maxillary Dimensions in Treatment Group

All transverse maxillary dimensions except for upper nasal width (UNasW) increased significantly ($P < .01$) in the treatment group from pretreatment to posttreatment and remained constant until the removal of fixed appliances at T3 (Table 5).

DISCUSSION

Tongue posture and habits related to tongue function have been associated with the etiology of malocclusions as well as posttreatment stability.[19–26] "Atypical tongue function" has been associated with relapse following a variety of treatment regimens for different orthodontic problems.[27–29] Huang et al suggested that stability following crib therapy treatment of anterior open bite might be a result of a modification in tongue posture.[30] It has also been suggested that the functional and/or mechanical ‘‘unlocking’’ of transverse maxillary deficits to establish proper tongue posture and control tongue habits is a vital component in the stability of treatment results.[31]

Our results confirm that TPD and H-MP are larger in subjects with narrow maxillae and posterior crossbites and no signs or symptoms of RD versus the same distances in subjects with normal dentoskeletal characteristics. They also suggest that spontaneous and stable reduction of the distance between the dorsum of the tongue and the palate following ME is possible in these patients.

Our findings are in line with those of a study by Okhiba and Hanada[11] that examined the stability of ME results in individuals with cleft palate. Whereas the cleft palate subjects showed no tongue-palate contact with the tongue at rest and only brief tongue–hard palate contact during swallowing prior to ME, following expansion, the tongue was observed to demonstrate sustained contact with all areas of the hard palate and the lingual surface of the maxillary dentition, and this new relationship was maintained after 3 months of retention.

According to the equilibrium theory, increased buccal pressure following ME must be balanced by pressure from the opposite direction, namely tongue pressure, to achieve stability.[9,32] Mew and Meredith[14] have stated that, ‘‘while the assumed relationship between a firm tongue-to-palate swallow and the pump action of the palatine aponeurosis appears to be reduced in long-faced adenoidal children, clinical evidence suggests that it may be regenerated by early Orthotropics (growth guidance) and aimed at directing facial growth forward instead of downward.’’ Moreover, the functional matrix theory also suggests that the width of the maxillary palatal complex is influenced by the location of the tongue.[33] Our findings, in conjunction with these theories, may explain, at least in part, the long-term stability of ME in selected cases without RD.

In line with these theories, it may be suggested that normalization of tongue posture following ME in growing subjects might enhance ME stability by balancing buccal pressure. Normalization of tongue posture might also break a cycle of low tongue posture and nonharmonious growth and replace it with one of high tongue posture and harmonious growth, resulting in normalization of the maxillary growth pattern and hence stable expansion (Figure 6).

However, in light of other data found in the literature, we must remain cautious before generalizing these conclusions.

First, it should be noted that, because of the retrospective design of this study, a longitudinal control sample was used, in which no special attempt had been made to obtain radiographs in the natural head posture and/or tongue posture. Another important factor to be considered is the individual’s ‘‘respiratory needs,’’ which may influence head, jaw, and tongue posture, thereby altering equilibrium and dentofacial morphology.[9,12,25,34–42] Seto et al[42] demonstrated that maxillary constriction may occur more commonly in patients with obstructive sleep apnea than in the nonsnoring, nonapneic population. Low tongue posture has also been associated with chronic upper airway obstruction.[12,35–38,41] Children with enlarged tonsils have been found to have extended head posture, an inferiorly positioned hyoid bone, and anteroinferior tongue posture.[38] Therefore, it may be unrealistic to expect spontaneous correction of tongue posture after ME in a child with enlarged tonsils and an RD that is severe enough to result in an abnormally low tongue posture in the first place. Such children are likely to experience relapses in any changes brought about by ME therapy. In these cases, an interdisciplinary approach with the otorhinolaryngological surgeon and inclusion of awareness training[31] in the treatment protocol to involve patients in the treatment of their dysfunction may be necessary.

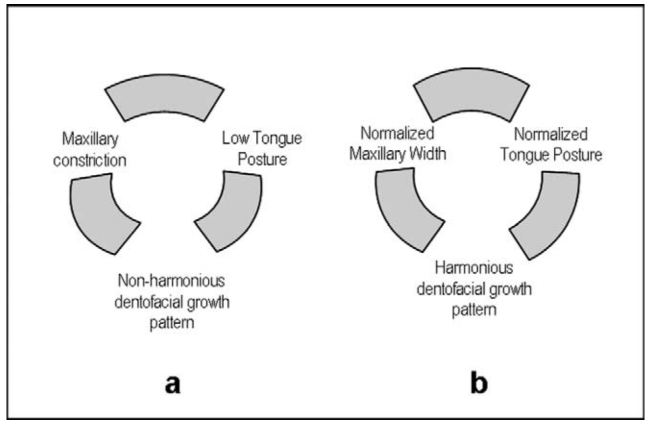

Figure 6. (A) Cycle of low tongue posture showing nonharmonious growth. (B) Cycle of high tongue posture showing harmonious growth.

CONCLUSION

- ME results in a higher tongue posture in children with no signs and symptoms of RD. This spontaneous alteration in tongue posture may be related, at least in part, to the documented stability of ME in selected cases.

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