Original Article

Effect of Rapid Maxillary Expansion on Nocturnal Enuresis

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Abstract: One of the effects of rapid maxillary expansion (RME) is a reduction in nighttime bed-wetting. The aim of this prospective study was to investigate the effects of RME on nocturnal enuresis (NE) in children who are liable to psychosocial stress conditions. Eight children (six boys and two girls) who had not responded to different conventional medical treatments were included in the study. The subjects were between eight and 11 years of age with a mean age of nine years five months, and were residents of a government orphanage. All the children wet the bed at least one time every night and previously had been subjected to unsuccessful conventional treatment modalities. Maxillary expansion was performed using a rigid acrylic RME device. Lateral and PA cephalometric films and dental casts were used in the assessment of the dentofacial and nasopharyngeal structures. Data were analyzed using a paired *t*-test. In seven of the eight children, remarkable improvement was observed in NE after three to six mm RME. At the end of eight months observation, the mean rate of improvement in bed-wetting in the seven successful subjects was 74.2% (57.6–87.5%). The findings also indicated significant changes in the nasomaxillary structures and nasopharyngeal airway dimensions with the use of RME. However, none of the subjects became completely dry, and the disorder is probably multicausal including psychological emotions and tensions. This study demonstrated that RME treatment could cause relief for the enuretic children. However, the long-term success rate is still questionable. (*Angle Orthod* 2003;73:532–538.)

Key Words: Nocturnal enuresis; Rapid maxillary expansion; Nasopharyngeal airway

INTRODUCTION

The term nocturnal enuresis (NE) is used for girls and boys over the age of five years who wet their beds more than two nights per month.[1] Fifteen percent of boys and 10% of girls are enuretic at age five years, half of this number remain enuretic at age 10, and by late adolescence, the number falls to 1–3%.[2]

The etiology in the majority of cases of NE remains unclear. Most investigators consider it a multicausal disorder involving genetic, developmental, organic, and psychosocial factors.[3] Upper airway obstruction as a factor in NE has also been discussed and recently several scientific articles mentioned NE as a common symptom among children with breathing problems and sleep apnea.[4–6] Otolaryngologists[7] have demonstrated relief by adenotonsillectomy, but there are surgical difficulties in dealing with anterior nasal constriction. This is where the orthodontist can be involved in the treatment of NE by using rapid maxillary expansion (RME).

The effect of RME on NE has been presented in three articles in the literature. Freeman[8] published the first article in 1970. In this article, cessation of enuresis nocturna was an unexpected benefit when the observer was trying to assess the effect of RME on basal metabolism of mentally retarded 9 to 14 year olds. Freeman[8] related this beneficial effect to improved lymph circulation and an increased antidiuretic function of the pituitary gland due to RME. The second article published in 1990 by Timms[9] was a retrospective study. In the 10 cases examined in this study, NE ceased within a few months of maxillary expansion. Timms[9] related this improvement to the positive effect of RME on the nasal airway resistance. The last article published by Kurol et al[10] in 1998 was a prospective study performed on 10 children who had not responded to conventional medical treatment for bed-wetting. Within one month of RME of 3–5 mm, four children were completely dry and three showed notable improvement. However, the authors were unable to establish any significant associations between improvement in NE and improvement in the nasal airway, age, amount of expansion, or nasopharyngeal dimension.

Therefore, the aims of this prospective study were (1) to investigate the effect of RME in enuretic children from a

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TABLE 1. Results of Interviews With Nurses and Official Records of Orphanage[a]

Patients	CA	AK	IC	MA	RD	TI	ME	HC
Sex	M	M	M	M	M	F	F	M
Age	8	10	10	9	9	9	9	11
Health	OK	Common tonsillitis	OK	OK	Common tonsillitis	OK	Mentally retarded	Mentally retarded
Restless sleep	−	−	−	−	−	−	−	Bruxism
Night sweating	−	−	−	−	−	−	−	−
Snoring	−	−	−	−	−	−	−	−
Sleep apnea	−	−	−	−	−	−	−	−
Tired in the morning	−	−	−	−	−	−	−	−
Poor school performance	+	+	+	+	−	−	+	+
Parents divorced	+	+	+	+	−	+	+	+
Family history of enuresis	−	−	−	+	−	−	−	−
Type of enuresis	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
Prevalence per night	1 or 2	1	1 or 2	1 or 2	1 or 2	1	1 or 2	1 or 2
Treatment								
Rhinogest	+	+	+	+	+	+	+	+
Psychological support	−	+	−	−	+	+	+	−

[a] −, No; +, Yes.

government orphanage who are more liable to psychosocial stress conditions, and (2) to analyze the relationship between NE and changes in the nasomaxillary structures and nasopharyngeal airway dimensions by using RME.

MATERIALS AND METHODS

Eight children (mean age 9.4 years), six boys and two girls who were residents of a government orphanage, were included in this study. Table 1 shows the results of interviews and the medical history. Five boys and one girl were judged by the official pediatrician of the orphanage to be healthy, with uncomplicated NE and no bladder or sphincter function pathology or abnormality. The other one boy and one girl were slightly mentally retarded and, thus, were attending a private education institute. All the children had primary enuresis, and they had never achieved consistent dryness. Parents were divorced in seven of the eight children. Of the eight children, six wet the bed once or twice every night and two did once a night. All had tried the conventional treatments including Rhinogest syrup (decongestant) and psychological support (Table 1). An ENT specialist clinically examined all the children to diagnose airway obstruction. The results of the examination are presented in Table 2.

TABLE 2. Results of ENT Examination[a]

Patients	CA	AK	IC	MA	RD	TI	ME	HC
ENT treatment	−	−	−	−	−	−	−	−
Nasal obstruction	+	+	−	−	−	−	−	−
Otitis media	−	−	−	−	−	−	−	−
Hearing loss	−	−	−	−	−	−	−	−
Allergic rhinitis	−	−	−	−	−	−	−	−
Bronchitis	−	−	−	−	−	−	−	−
Asthma	−	−	−	−	−	−	−	−
Septum deviation	+ R	+ R	−	+ R	−	−	−	−
Adenoid hypertrophy	−	−	−	−	−	−	+	−
Tonsillary hypertrophy	−	+	−	−	−	−	−	−

[a] −, No; +, Yes; R, on right side.

FIGURE 1. Bonded RME device.

RME treatment

Maxillary expansion was performed with a rigid acrylic RME device (Figure 1). A hyrax expansion screw was embedded in the acrylic between the first premolars, as close as possible to the palate. The arms of the hyrax screw were bent to achieve contact with the anchor teeth. These arms served as a framework in the acrylic and increased the rigidity of the appliance. Acrylic resin covered the whole dentition over the occlusal and labial surfaces. The resin was trimmed thin enough to preserve freeway space while allowing maximum bilateral occlusal contact. The RME appliance was cemented in the mouth with glass-ionomer cement. The orphanage nurses activated the screw in the

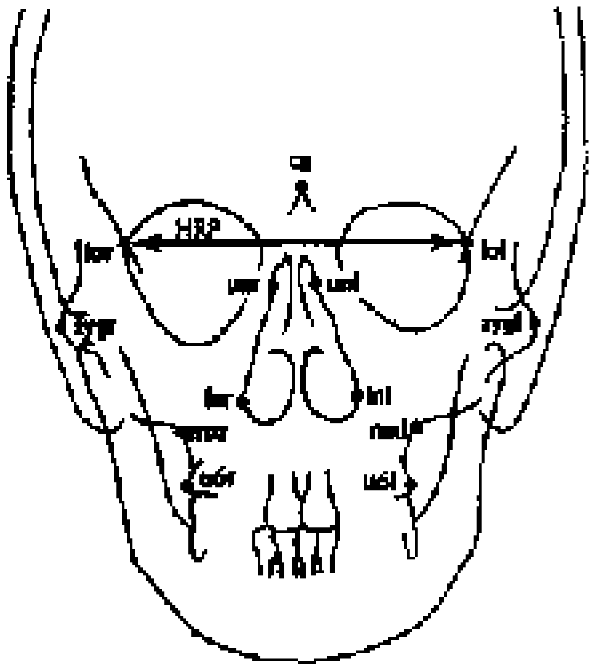

FIGURE 2. Reference points on PA cephalometric films.

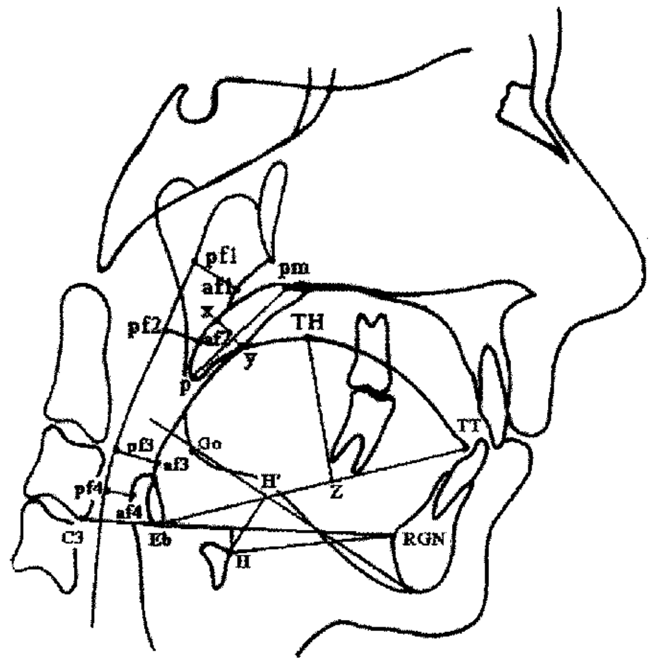

FIGURE 3. Reference points and measurements on lateral cephalometric films.

morning and evening, achieving a total amount of 0.5 mm expansion per day. The palatal arch was expanded until the lingual cusp tips of the upper posterior teeth contacted the buccal cusp tips of the lower posterior teeth. When the expansion was completed, the appliance was replaced with a transpalatal arch that contacted all the posterior teeth. The palatal bar was retained for six months.

Records and measurements

A first set of records (PA and lateral cephalometric, hand-and-wrist and occlusal films and dental casts) was obtained before the initiation of treatment. The second set was gathered when the RME appliance was removed and the third set at the end of eight months follow-up period.

PA and lateral cephalometric films were used in the assessment of the dentofacial and nasopharyngeal structures. The reference points and reference planes used in this study are shown in Figures 2 and 3. The PA cephalometric measurements were as follows (Figure 2):

- Interzygomatic width (IZygW) (mm)—the horizontal distance between left and right most lateral borders of the zygomatic bone.
- Upper nasal width (UNasW) (mm)—the horizontal distance between left and right most lateral aspect of the upper portion of the priform aperture.
- Lower nasal width (LNasW) (mm)—the horizontal distance between left and right most lateral aspect of the priform aperture.
- Basal maxillary width (BMaxW) (mm)—the horizontal distance between left and right intersection of the lateral contour of the maxillary alveolar process and the lower contour of the maxillozygomatic process of the maxilla.
- Upper molar width (U1MolW) (mm)—the horizontal distance between left and right most prominent lateral point on the buccal surfaces of the first permanent maxillary molars.
- Basal maxillary angle (BMax Angle) (°)—the angle formed between left and right intersection of the lateral contour of the maxillary alveolar process and the lower contour of the maxillozygomatic process with tip of crista galli at the apex.
- Lower nasal angle (LNas Angle) (°)—the angle formed between left and right most lateral aspects of the piriform aperture with tip of crista galli at the apex.

The following measurements were carried out on lateral cephalometric films (Figure 3):

- Nasopharynx (af1-pf1) (mm)—the narrowest width of the nasopharynx.
- Velopharynx (af2-pf2) (mm)—the narrowest width of the velopharynx.
- Oropharynx (af3-pf3) (mm)—the narrowest width of the oropharynx.
- Hypopharynx (af4-pf4) (mm)—the narrowest width of the hypopharynx.
- Tongue height (TH-Z) (mm)—the distance between the highest point of tongue (TH) and Z point, where a perpendicular from TH intersects TT (the tip of the tongue)—Eb (base of the epiglottis) line.
- Tongue length (TT-Eb) (mm)—the distance measured between the tip of the tongue and the base of the epiglottis.

TABLE 3. Results of Clinical Examination and Cephalometric Analysis[a]

Patients	CA	AK	IC	MA	RD	TI	ME	HC
Mouth breathing	−	Mixed	Mixed	Mixed	−	+	−	Mixed
Angle classification	II	I	I	I	II	I	II	I
Anterior crossbite	−	−	−	Edge of edge	−	+	−	−
Skeletal classification	Class I	Class II	Class I	Class I	Class I	Class I	Class I	Class I
ANB angle	1°	5°	4°	1.5°	2.5°	0°	2°	2°
Face types	−	Long face tendency	Long face tendency	Long face tendency	−	Long face	−	−

[a] −, No; +, Yes.

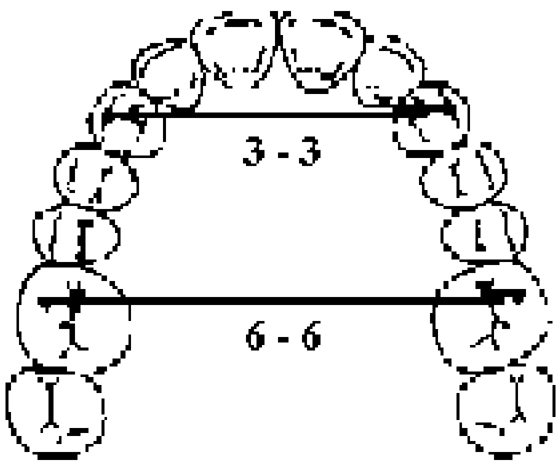

FIGURE 4. Dental cast measurements.

- Soft palate length (p-pm) (mm)—the distance between the tip of the palatine velum (P) to the pterygomaxillary point (pm).
- Soft palate thickness (x-y) (mm)—the thickest part of the palatine velum measured vertical to the line between the points P and pm.
- The vertical airway length (Eb-pm) (mm)—the distance between the posterior nasal spine and the base of the epiglottis.
- H′-H (mm)—the vertical distance of the hyoid bone to the mandibular plane.
- H-C3RGN (mm)—the vertical distance of the hyoid bone to the line between points C3 (third cervical vertebrae) and rethrognathion.
- H-RGN (mm)—the horizontal distance of the hyoid bone to rethrognathion.

Dental casts were used to classify the dental occlusion according to the Angle classification. The results of the clinical examination as well as the dental and skeletal classification are presented in Table 3. Dental casts were also used to perform intercanine and intermolar width measurements. The cusp tips of the maxillary canines and the mesiobuccal cusp tips of the maxillary first molars were used as the reference points (Figure 4). Dental cast measurements were carried out directly on the dental casts using a gauge caliper. The children were followed up for eight months at regular monthly intervals after the completion of RME treatment. The orphanage officers recorded the number of wet nights.

A paired *t*-test was used to compare the mean number of wet nights between pretreatment and follow-up (months 1 to 8, Table 4). A Kolmogorov-Smirnov *Z* test was used to compare the mean rate of wet and dry nights (Table 4). The cephalometric and dental cast measurements were analyzed using a paired *t*-test (Table 5). The reliability of the measurements on the records of all eight subjects were examined by repeating the point marking and measurement procedures and ranged between 0.93 and 0.99.

RESULTS

None of the children had a posterior crossbite at the initiation of RME treatment. Three of the children had a long face tendency and one child was a skeletal open-bite case with a long face. Clinically, four children were judged to be mixed–mouth breathers and one child (open-bite case) was judged to be full–mouth breather. The ENT examination showed no abnormal conditions. Most of the children were wetting their beds at least once a night. Some children wet the bed twice every night.

The rapid maxillary expansion was performed in 15 to 20 days, and amounted to three to six mm with a mean expansion of 3.9 mm. In seven of the eight children, bedwetting improved significantly with the initiation of expansion; however, none of the children became completely dry. Some of the children remained dry for some weeks during the observation period and at other times they wet their beds much less often. The mean weekly bed-wetting was 1.8 and ranged between 0.9 and 3.0 times per week during the eight months of follow-up period ($P < .01$) (Table 4). The mean overall percentage of dry nights per week was 74.2% (57.6% to 87.5%) during the same period and the difference between percentage of wet and dry nights was statistically significant ($P < .01$). One subject of the study group (CA) was almost unaffected by the treatment. This case was excluded from the final sample and his values were not taken into consideration for the calculation of the means and percentages. This subject showed an improvement of only 21.9% during the observation period.

Findings of this study indicated changes in the transversal

TABLE 4. Means of Wet Nights Per Week for 32 Week Follow-up Period

Patients	CA[a]	AK	IC	MA	RD	TI	ME	HC	Monthly Average	Test
Mean of wet nights per week										
Before RME	+7[b]	7	+7	+7	+7	7	+7	+7	+7.0	
First month	5.5	2.0	1.8	2.8	1.0	2.0	1.0	1.3	1.7	***
Second month	5.3	1.0	0.0	3.8	1.5	3.0	1.3	3.3	2.0	***
Third month	6.0	1.5	0.5	2.8	0.5	3.0	4.0	3.5	2.3	***
Fourth month	4.3	2.5	2.5	1.8	0.5	1.8	1.8	2.3	1.9	***
Fifth month	5.3	1.3	0.8	0.8	0.5	1.3	1.0	0.8	0.9	***
Sixth month	5.8	1.3	1.0	3.5	1.8	1.0	1.3	1.5	1.6	***
Seventh month	5.8	1.8	2.5	4.3	0.8	1.0	0.8	1.8	1.8	***
Eighth month	6.0	2.0	3.3	4.0	1.0	1.2	1.5	4.0	2.4	***
Average	5.5	1.7	1.4	3.0	0.9	1.8	1.5	2.3	1.8	
Percentage of wet nights	78.1	24.6	20.1	42.4	12.5	26.3	21.9	32.6	25.8	**
Percentage of dry nights	21.9	75.4	79.9	57.6	87.5	73.7	78.1	67.4	74.2	

[a] Excluded from the final sample.
[b] +, one or two times per night.
** $P < .01$ (Kolmogorov-Smirnov *Z* test).
*** $P < .001$ (comparison of means of wet nights between pretreatment and each month by using paired *t*-test).

dimensions of the nasomaxillary complex and nasopharyngeal airway dimensions by RME. Statistically significant increases were present in the measurements of lower nasal width (LNasW), lower nasal angle (LNas angle), basal maxillary width (BMaxW), upper molar width (U1MolW), tongue length (TT-Eb), and hyoid-to-retroganthion (H-RGN). The decrease of tongue height (TT-Z) was also statistically significant. The canine-to-canine and molar-to-molar cast measurements also showed statistically significant increases. However, only upper molar width (U1MolW), tongue length (TT-Eb), hyoid-to-retrognathion (H-RGN), canine-to-canine, and molar-to-molar measurements remained significant at the end of the follow-up period (Table 5).

DISCUSSION

The purpose of this study was to evaluate the effect of RME on NE in children who were faced with psychosocial stress conditions more than other children in their daily life.

Two of previous three studies reported were retrospective[8,9] and the latest study[10] was prospective.

Our study was also a prospective one. The sample included in this study was relatively small, and thus, one should be cautious about the meaning of the findings because it involves a limited number of subjects. On the other hand, the sample of the present study is homogenous regarding the psychosocial conditions and thus differed from the samples of the previously published studies.[9,10] Children treated in this study were residents of a government orphanage. All of them were living in a community of children away from a family atmosphere. They were either orphans or children of divorced couples rejected by the parents. In fact, these factors make them much more liable to psychological stress conditions which may be an important factor in the etiology of bed-wetting.[3]

Another important point by which this sample differs from the previous ones is the prevalence of nighttime bedwetting. These children wet their beds once or twice every night, which makes the treatment even more complicated and necessary. Two of the children were slightly mentally retarded and were taking a special education; however, their compliance to the treatment was good enough to complete the RME treatment.

All the children of the present study had normal transverse occlusal characteristics and the only aim of the expansion therapy was the cessation of NE. The mean amount of maxillary expansion was 3.9 mm and thus was relatively limited compared with that of Timms[9] who was dealing with crossbites. The appliance used was a rigid acrylic RME device, which exerted more directional forces to the maxillary structures.[11,12] Four children were nose and mouth breathers and one child was judged to be a mouth breather by the orthodontist. None of the children had major respiratory problems according to the ENT examination.

Orphanage physician provided the children with almost all treatment modalities including psychological support, decongestant syrups, and placebo. The success rate for the treatment methods were about 50%, which means that previously applied treatment modalities demonstrated limited effectiveness. However, these treatment approaches were completely reversible after the cessation of treatment. By taking the results of the published studies into account and also by considering that all previous treatment effects have failed, the orphanage administrators, the official pediatrician, and our group agreed on performing RME treatments in these particular NE cases. At the same meeting, the parties also agreed on providing any kind of dental and orthodontic treatment at the dental school, without any cost to the children or the orphanage.

TABLE 5. Comparison of Measurements (mm) Before and After RME Treatment

	Before RME (1)		After RME (2)		8 Months follow-up (3)		*t*-test		
Measurement	Mean	SD	Mean	SD	Mean	SD	1–2	2–3	1–3
PA analysis									
IZygW	125.14	6.91	125.43	4.75	126.21	4.72			
UnasW	9.64	2.21	10.07	2.28	9.94	2.26			
LNasW	29.93	4.39	32.36	4.69	31.71	4.10	***		
BMaxW	64.14	2.46	66.86	2.90	65.86	3.45	**		
UlMolW	58.43	1.46	61.79	1.52	60.50	1.50	***	**	**
BMax Angle	57.50	3.30	59.36	1.75	59.79	2.21			
LNas Angle	35.96	6.50	38.21	6.61	36.36	4.19	**		
Pharynx, tongue, and hyoid									
af1-pf1	3.36	2.27	3.29	1.47	3.36	1.11			
af2-pf2	5.93	2.78	6.43	2.71	7.43	2.64			
af3-pf3	10.64	1.95	11.57	2.39	11.57	2.39			
af4-pf4	5.36	1.73	5.71	0.99	6.44	1.72			
TH-Z	31.64	4.57	28.64	4.20	28.44	3.70	*		
TT-Eb	61.00	6.27	66.71	4.62	67.29	3.77	**		*
p-pm	32.79	2.67	33.21	2.48	33.21	1.78			
x-y	9.29	1.68	8.86	1.57	9.14	1.35			
Eb-pm	55.07	5.81	56.57	3.98	55.93	5.20			
H′-H	12.14	3.44	14.14	3.18	13.50	4.79			
H-C3RGN	5.21	6.14	5.57	3.63	5.57	4.12			
H-RGN	31.57	3.40	36.07	5.22	34.86	5.90	**		*
Cast analysis									
Intercanine width	34.93	3.60	39.14	3.59	38.20	3.36	***	**	***
Intermolar width	51.29	2.02	55.21	1.87	54.00	2.00	***	**	**

* $P < .05$, ** $P < .01$, *** $P < .001$.

In the present study, the success rate for RME treatment was 74.2% over a follow-up period of eight months. On the other hand, RME treatment was unsuccessful in one of the cases and none of the study cases was completely dry at the end of the observation period. In Timms'[9] study, the frequency of NE in all cases declined after RME, and within two months on average, the patients were generally dry at night. However, over a longer period of time, half the cases reported an occasional micturition. Besides this, Kurol et al[10] reported that of 10 cases, four children were completely dry and three showed notable improvement after RME. Therefore, it is obvious that the results of the three studies are quite encouraging when compared with the spontaneous recovery rate of 15% per year. However, unsuccessful cases were also reported in all the abovementioned studies, as well as in the present study.

In the present study, transverse changes in the dentofacial structures and nasopharyngeal airway dimensions were analyzed statistically. The improvement of NE is hypothetically linked to improved breathing and thus to better saturation of blood. It is a well-known anatomical fact that there is an increase in the width of the nasal cavity immediately after expansion, particularly at the floor of the nose adjacent to the midpalatal suture,[12–14] and RME positively affects nasal breathing by expanding the maxilla and the nasal cavity. Rhinomanometry and acoustic rhinometry provide the best methods for objective assessment of nasal airflow. However, care should be taken to calibrate the device properly, and the user should be completely familiar with rhinomanometers regarding the mathematical algorithm for resistance used by the accompanying software.[15] Moreover, these two systems do not always reveal correlating results,[16] and other factors, such as esophageal pressure, irrelevant to the nasal area may affect the measurements.[17]

In this study, indirect measurement of nasal airflow was carried out with cephalometric methods and rhinomanometry was not used. This decision was based on reports by Linder-Aronson,[18] Handelman and Osborne,[19] and Behfelt et al,[20] which state that two-dimensional measurements of the nasal resistance were closely correlated with anterior or posterior rhinomanometric measurements. In this study, nasal airflow was assumed to increase parallel to increases in the nasal airway dimensions.

The nasopharyngeal airway dimensions showed increases in the present study, but the changes obtained were not statistically significant, probably because of the limited number of cases. Three of 12 nasopharyngeal measurements showed statistically significant differences compared with the start of RME treatment. Tongue length (TT-Eb) increased significantly, whereas tongue height (TH-Z) measurement showed a significant decrease. Hyoid-to-retrognathion measurements displayed a significant increase. However, only tongue length (TT-Eb) and hyoid-to-retrognathion measurement changes remained significant at the end of the follow-up period.

In the present study, skeletal and dental changes were obtained by RME. Lower nasal width (LNasW), basal maxillary width (BMaxW), upper molar width (U1MolW), intercanine width, and intermolar widths (3-to-3 and 6-to-6 dental cast measurements) showed significant increases at the end of the RME procedure. A transpalatal arch was placed immediately after the removal of the RME device and, at the end of 8 months follow-up period, no statistically significant relapse was observed except in upper molar (U1MolW) width and 3-to-3 and 6-to-6 cast measurements. However, increases in these measurements were still significant compared with the start of treatment.

Even though a recovery rate of 74.2% was reached, none of the children were completely dry at the end of the eight-month follow-up period. Moreover, in our last communication, which was two years after the start of our RME treatment, the officials of the orphanage informed us that one child was almost dry with 1–2 times bed-wetting during a month (AK), two children were still enuretic with no recovery compared with the start of treatment (CA and MA, brothers), two children 1–2 times a week (IC and RD), and one child more than 2–3 times a week (TI). Two children have already left the orphanage (ME and HC), so the officials did not have enough information regarding the long-term prognosis of their treatment. Therefore, it seems that nasopharyngeal airway problem is not the only etiological factor responsible, but the disorder should possibly be multicausal and includes strong psychological emotions and tensions, such as being an orphan in this particular sample. Therefore, improvement in the nasal airway cannot be described as the only treatment modality in the NE cases of the present study.

Another hypothesis for the improvement of this specific sample can be the placebo effect. It is clear that coming to the dental school several times for the treatment and being taken care of might have positively affected the psychology of the children. However, the orthodontist is the final referral, and such a possible placebo effect should have expressed itself earlier, when previous treatment alternatives were introduced. The introduction of an orthodontic appliance in the mouth may also have a placebo effect. However, how long and to what extent the presence of an orthodontic appliance could be successful in the treatment of NE is an open question.

CONCLUSIONS

This study demonstrated that RME treatment might cause relief for the enuretic children, although the long-term success rate is questionable and the underlying responsible mechanisms are still unclear. Therefore, further long-term follow-up research studies taking psychosocial factors into consideration are desirable in larger samples to build up a more reliable chain between responsible etiological factors and NE treatment modalities like RME.

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