Original Article

Rapid maxillary expansion in therapy-resistant enuretic children: *An orthodontic perspective*

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ABSTRACT

Objective: To evaluate whether rapid maxillary expansion (RME) could reduce the frequency of nocturnal enuresis (NE) in children and whether a placebo effect could be ruled out.

Methods: Thirty-four subjects, 29 boys and five girls with mean age of 10.7 ± 1.8 years suffering from primary NE, were recruited. All subjects were nonresponders to the first-line antienuretic treatment and therefore were classified as "therapy resistant." To rule out a placebo effect of the RME appliance, all children were first treated with a passive appliance for 4 weeks. Rhinomanometry (RM), acoustic rhinometry (AR), polysomnographic registration, and study casts were made at different time points.

Results: One child experienced severe discomfort from the RME appliance and immediately withdrew from the study. Following RME, the long-term cure rate after 1 year was 60%. The RM and AR measurements at baseline and directly after RME showed a significant increase in nasal volume and nasal airflow, and there was a statistically significant correlation between reduction in enuresis and increase in nasal volume. Six months postretention, a 100% relapse of the dental overexpansion could be noted.

Conclusions: RME has a curative effect in some children with NE, which could be connected to the positive influence of RME on the sleep architecture. Normal transverse occlusion does not seem to be a contraindication for moderate maxillary expansion in attempts to cure NE in children. (*Angle Orthod.* 2016;86:481–486.)

KEY WORDS: Rapid maxillary expansion; Nocturnal enuresis

INTRODUCTION

Children over the age of 5 years who wet the bed while asleep are defined as having nocturnal enuresis (NE), or "bedwetting." NE is classified as primary when the child has never achieved nighttime dryness and as secondary when bedwetting occurs after dryness for at least 6 months.[1,2] The previously widely held opinion that NE is mainly a psychiatric/psychological disorder has now been thoroughly discredited. Instead there is common consensus that NE is an often hereditary somatic disorder with a high risk of psychosocial comorbidity. A disorder of sleep arousal, nocturnal detrusor over activity, and nocturnal polyuria are the three factors that interrelate to cause NE.[3] NE is one of the most common pediatric health issues, and its prevalence is comparable to that of asthma in children. It is generally accepted that 15% to 20% of children will have some degree of nighttime wetting at 5 years of age, with a spontaneous resolution rate of approximately 15% per year. NE persists in 0.5% to 2% of otherwise-healthy adults.[4]

NE is a distressing condition that can have a deep impact on a child's emotional wellbeing and social life. It affects quality of life and self-esteem, which improve with successful treatment.[5]

Active treatment is recommended from 6 years of age, particularly if the child and family are motivated to engage in treatment. The enuresis alarm is a first-line treatment for NE and is the most effective long-term

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treatment, as shown in a systematic review of 56 trials in children.[6] The enuresis alarm, although effective, can be onerous for families, and the disruption to sleep can cause stress for the child and family. Contraindications to alarm training include lack of motivation by the child and family, crowded housing, family stress, and intolerance to sleep disturbance. Desmopressin, an analogue of the pituitary hormone vasopressin, reduces urine production and has been used to treat NE for the past 40 years.[5] In a systematic review[7] of 47 trials, desmopressin (standard dose) had some effect during treatment in about 70% of children. Most children experienced a reduction in the amount and frequency (by one to two nights/week) of bedwetting compared with those children who took a placebo. In other words, the efficacy rate of the first-line treatments available is far from satisfactory.

According to several case reports and studies, treatment of upper airway obstruction seems to influence NE. In the early 1990s Timms[8] described 10 enuretic children with upper airway obstruction who became dry when undergoing rapid maxillary expansion (RME). This report inspired other researchers to prospectively test whether RME could be used as an antienuretic therapy, regardless of whether or not there were orthodontic indications for the treatment.[9–11] The studies were mostly rather small case series, but the results indicated that the procedure may indeed be useful.

The aims of the present prospective study were to evaluate whether RME could reduce the frequency of NE in children with resistance to first-line therapy, whether a placebo effect could be ruled out, and if any adverse effects could be observed in the dentition 1 year posttreatment.

MATERIALS AND METHODS

The regional ethical review board in Uppsala, Sweden, which follows the guidelines of the Declaration of Helsinki, approved the study protocol.

Thirty-four subjects, 29 boys and 5 girls aged 8–15 years (mean, 10.7 ± 1.8 years) with primary NE, were recruited from four different children's hospitals in central Sweden. The recruitment was carried out between June 2008 and December 2011. All subjects were nonresponders to the first-line medical treatment and therefore were classified as "therapy resistant." The exclusion criteria were daytime incontinence and concurrent urological, renal, or neuropsychiatric disorders.

After acquiring informed consent, all patients underwent a baseline registration with polysomnography (PSG), rhinomanometry (RM), and acoustic rhinometry (AR) at the University Hospital Örebro (Örebro, Sweden), and lateral radiographic cephalograms and study casts were obtained at the Postgraduate Dental Education Center (Örebro, Sweden).

A polysomnographic registration was performed during one night with the child and one parent sleeping at the hospital, at baseline, and 6 months postretention. Indices for apneas (central, obstructive, and mixed), hypopneas, desaturation episodes, and arousals (including respiratory arousals) were extracted from the respiratory data. All polysomnographic data were extracted by one technician and assessed by one expert.

To assess nasal airway patency in a noninvasive way, rhinomanometry and acoustic rhinometry were performed before and after nasal decongestion, the details of which were published in an earlier study.[12] Many studies present mean nasal resistance (*R*-values) and volume values (AR) of one nasal cavity at a time; however, we present total values, which are about twice the values of a single nasal cavity.

Two of the 34 subjects had bilateral crossbite; all other subjects had a normal transverse relationship. Twenty-six subjects (76%) had an Angle Class I occlusion, which included the two crossbite cases; seven (21%) had an Angle Class II malocclusion (mean overjet = 5.6 mm; range 4–7 mm); and one subject (3%) had an Angle Class III malocclusion with edge-to-edge incisor relationship.

The orthodontic treatments were carried out at the Department of Orthodontics, Postgraduate Dental Education Center, Örebro, Sweden, or at the Department of Orthodontics, Public Dental Service, Uppsala, Sweden. The treatment consisted of the transverse expansion of the maxilla using an RME appliance with a Hyrax screw soldered to orthodontic bands on the permanent first molars. The appliance was left in a passive state with no activation for 4 weeks to allow monitoring of the patients for any placebo effect. After this month the parents were asked to activate the Hyrax screw twice daily, which gave an expansion rate of ca. 0.5 mm per day. The expansion went on for 10–14 days. The endpoint was defined as the occlusal surface of the maxillary palatal cusp of the permanent first molar coming into contact with the occlusal surface of the mandibular facial cusp of the permanent first molar.

The RME appliance (Figure 1) was then replaced by a transpalatal arch as a retention appliance for 6 months to allow new bone formation at the maxillary median suture. After this time period, the retention appliance was removed, and all children were monitored for another 6 months (Figure 2). Study casts were taken at baseline (T0), directly after expansion (T1), and 6 months postretention (T2). The transverse distances between the maxillary first molars were

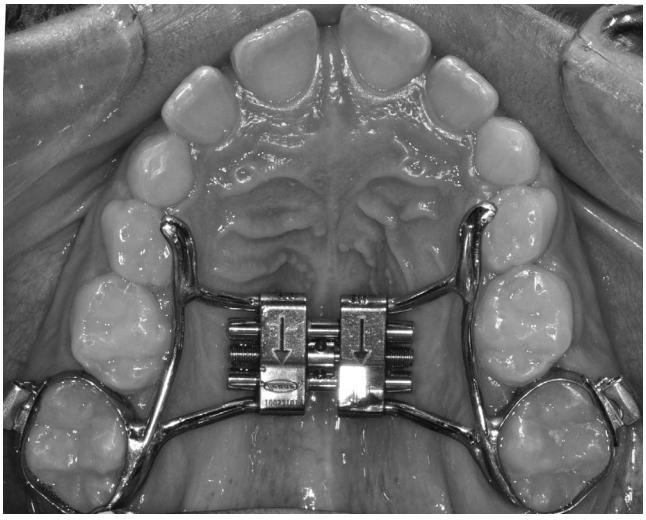

Figure 1. Rapid maxillary expansion (RME) appliance.

measured with digital caliper (Digital 6, Mauser, Winterhur, Switzerland). The direct measurements on the study casts were made to the nearest 0.1 mm. The reference points on the first molars were defined as the most cervical point of the palatal fissure.

The families were asked to document wet and dry nights for four consecutive weeks on four occasions: at baseline, with the RME appliance in situ but not expanded (the placebo month), directly after RME expansion, and, finally, 6 months postretention.

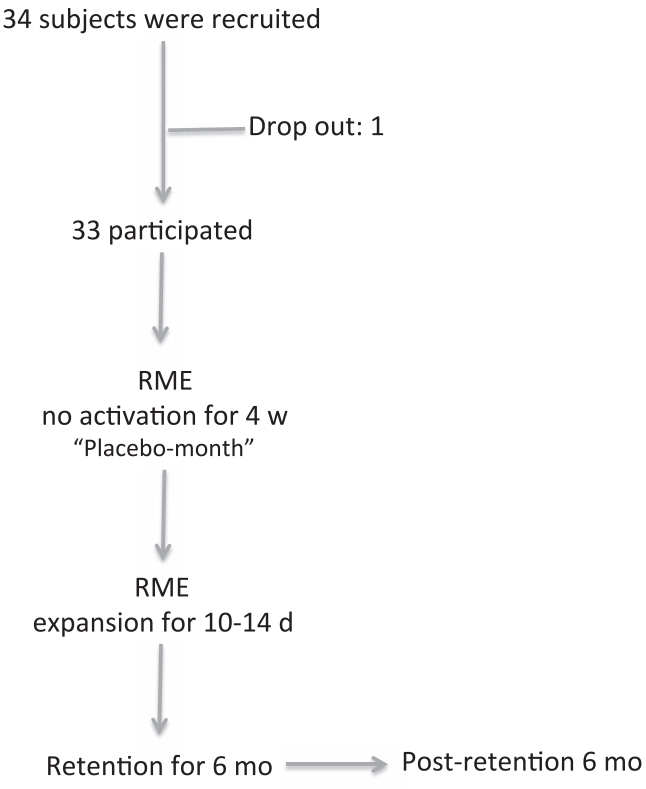

Figure 2. Flow chart.

Sample Size Calculation

The sample size was calculated based on confidence interval (CI) for a so-called one-sample proportion. The assumption was that 45% of the children participating in the study would remain enuretic after the RME treatment, based on data from Schütz-Fransson and Kurol,[11] and a statistical contingency was calculated as 95% CI around this proportion of 45% with an uncertainty of ±20% units. In other words, if the population's proportion was assumed to be 45%, then the CI would be between 25% and 65%. The calculation indicated that a sample of 24 patients would be required. We estimated the dropout rate as 15%, which required that we include at least 28 patients in the study.

Statistical Analysis

Linear regression analysis was used to evaluate the correlation between nasal volume and nasal airflow with reduction in enuresis frequency.

A paired *t*-test was used to compare the difference of mean values between baseline and directly after RME regarding RM and AR data. A *t*-test was also used to compare the difference of mean values between the amount of transverse maxillary expansion directly after expansion (T0–T1) and 6 months postretention (T1–T2). *P*-values of less than 0.05 were regarded as statistically significant.

SPSS Statistics (IBM® SPSS Statistics, Chicago, Ill) was used for the statistical analysis.

RESULTS

One child, who experienced severe discomfort from the RME device and could not tolerate the appliance, withdrew immediately from the study and is not included in the calculations below, which are thus based on 33 children. Three other children, two nonresponders and one intermediate responder to therapy, did not come to the postretention follow-up visit after 1 year.

The number of wet nights per week was 5.48 ± 1.48 at baseline, 5.12 ± 1.73 with the dental appliance in situ (placebo month), 3.09 ± 2.49 after RME, and 2.63 ± 2.81 after 1 year (Figure 3). The differences were highly statistically significant ($P < .001$). After RME the number of responders and intermediate responders (>50% reduction of enuresis frequency) was 16/33 (48.5%), and the number of nonresponders was 17/33 (51.5%). The long-term cure rate after 1 year was 18/30 (60%), whereas 12/30 (40%) had no long-term response (data published previously).[13]

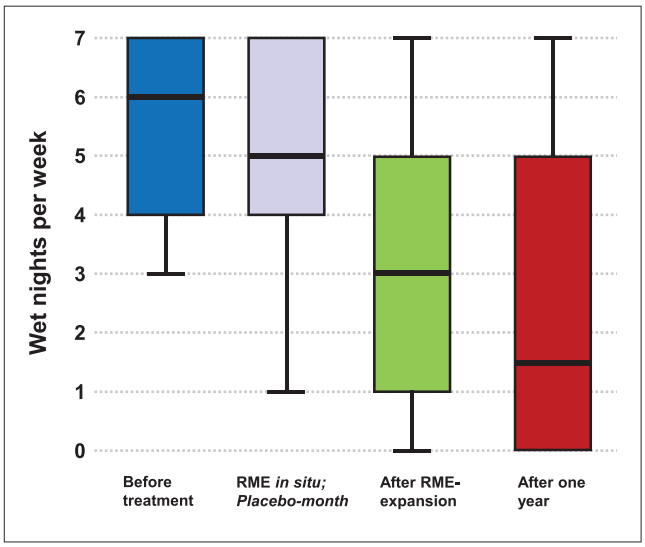

Figure 3. Antienuretic effect. The number of wet nights per week before, after, and 1 year posttreatment.

The transverse maxillary expansion was 4 ± 1 mm (mean ± standard deviation [SD]) (T0–T1), which declined to 2.3 ± 0.85 mm (mean ± SD) 6 months postretention (T0–T2) ($P < .001$). Thus, the mean transverse relapse from T1 to T2 at the first molar region was 1.7 ± 0.95 mm.

The RM and AR measurements at baseline and directly after RME showed a significant increase in nasal airflow ($P = .012$) and nasal volume ($P = .012$), respectively (Table 1). There was also a statistically significant correlation between reduction in enuresis and increase in nasal volume ($P = .034$), but there was no correlation between increased nasal airflow and reduction in enuresis ($P = .46$).

Evaluation of patients' cephalograms did not indicate an abnormal enlargement of the pharyngeal tonsils or an obstruction of the oropharyngeal airway. The type of occlusion did not influence the outcome.

In all 30 subjects who showed up at the postretention follow-up 1 year after expansion, a 100% relapse of the dental overexpansion could be noted. The upper arch was somewhat expanded with good occlusion, and no other side effects on the dentition were evident.

Table 1. Rhinomanometry (RM) and Acoustic Rhinometry (AR) Results; Comparisons Between Before (T0) and After Rapid Maxillary Expansion (RME) (T1)

	T0 (n = 33)	T1 (n = 30)	*P*-Value[a]
Nasal airflow	298 ± 104	350 ± 128	.012
Nasal volume 0–2.2 cm[b]	2.48 ± 0.52	2.75 ± 0.57	.003
Nasal volume 2.2–5.4 cm[b]	9.26 ± 3.02	10.60 ± 3.22	.011
Nasal volume 0–5.4 cm[b]	11.74 ± 3.34	13.21 ± 3.58	.012

[a] *P*-values of <.05 are considered significant.
[b] Volumes refer to distance intervals from the nasal aperture.

DISCUSSION

Our results confirm the impression from previous studies that RME may indeed help some children with enuresis. By assessing the children's sleep and nasal airways, we have also found some prognostically valuable clues and provided grounds for speculation regarding both enuresis pathogenesis in general and the reason why RME may help.

One of our aims in this study was to evaluate whether or not we could rule out a placebo effect of the appliance. We found a small reduction of enuresis during the "placebo month" in a few patients. The fact that the main reduction of wet nights came after the maxillary expansion and not during the placebo month argues against the placebo hypothesis, as does the observation that the beneficial effects tended to persist after therapy: that is, the children were not just successfully treated, but they were cured. Al-Taai et al.[14] found no placebo effect either in their study, which used a similar study design.

The results of the polysomnographic and otorhinolaryngologic baseline examinations of the children in our study have been published separately.[12] In short, we found that the children had more hypopneas and respiratory arousals than expected, without a history of snoring or sleep apnea, an observation that led us to speculate that persistent arousal stimuli from subclinical obstructed airways may, via paradoxically increased arousal thresholds, be a pathogenetic factor behind enuresis. Furthermore, we found that children who respond to RME have larger nasal airway volume at baseline, which may be taken as further support for this hypothesis.[13] We also concluded that RME does increase the nasal volume and airflow, which coincides with the findings in other studies.[14–19]

Further, our findings concluded a significant correlation between the reduction of NE and increase in nasal volume after RME treatment, which indicates a strong connection between nasal volume and incidence of NE. Although we could not with certainty show a similar correlation between increased nasal airflow and reduction of NE, such a relationship cannot be ruled out. The fact that we could not significantly correlate the increase of airflow with the reduction of NE could be due to the lack of power in this study with regard to the airflow measurements.

A meta-analysis[20] pointed out that there is strong support for reduced upper airway width in children with obstructive sleep apnea; at the same time, NE is reported to be a common symptom among children with breathing problems and sleep apnea[21–23] and also

can be caused by upper airway obstruction.[24] Juszczak[25] stated that the reduction in NE is correlated with improvement in breathing and oxygen saturation of blood, which could offer an explanation for the RME effect on NE in some children. It also has been suggested[14] that improvement in NE may also be a result of an increase in secretion of the antidiuretic hormone, vasopressin, following RME. However, in our study this is unlikely to be true since the participants were all nonresponders to standard antienuretic treatment, including the vasopressin analogue desmopressin. Enuretic children with nocturnal vasopressin deficiency usually respond to desmopressin therapy. Because our study population was found to have the subclinical sign of disordered respiration without a history of snoring or sleep apnea, a more likely explanation for the possible antienuretic effect of RME is that the responders may, at baseline, have suffered from persistent arousal stimuli due to partly obstructed nasal airways, which presumably made the children paradoxically more difficult to awaken from sleep. If sleep is constantly disturbed the arousal thresholds will increase in order to preserve sleep. Thus, when the airway obstruction is alleviated by RME the arousal thresholds can return to normal and the child will notice when the micturition is about to occur. These speculative theories on the mechanisms by which the RME affects NE should be verified by future studies, and, thus, RME cannot yet be recommended as a standard therapy for enuretic children.

All of the patients included in the study relapsed to normal transverse occlusion 6 months postretention. No adverse effects on the dentition could be seen at follow-up. Therefore, normal transverse occlusion does not seem to be a contraindication for moderate maxillary expansion in an attempt to cure NE in children, which is in accordance with earlier findings.[11] However, as mentioned above, the mechanisms by which RME affects NE are not yet known, and clinicians should be careful not to expand all cases in order to improve airway issues.

Further studies with adequate sample size and proper design are needed to explore the effect of RME on sleep architecture as well as the impact of this treatment on quality of life in children with NE.

CONCLUSIONS

- RME significantly increases nasal volume and nasal airflow.
- There was a statistically significant correlation between reduction in NE and increase in nasal volume.
- Following RME the long-term cure rate after 1 year was 60%.
- Normal transverse occlusion does not seem to be a contraindication for moderate maxillary expansion in an attempt to cure NE in children.

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