Original Article

Changes in soft tissue nasal widths associated with rapid maxillary expansion in prepubertal and postpubertal subjects

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ABSTRACT

Objective: To evaluate changes in the soft tissue width of the nose induced by rapid maxillary expansion (RME). Data on greater alar cartilage (GAC) and alar base (AB) widths were compared with a normative sample within the same age range.

Materials and Methods: This prospective study consisted of an RME sample of 79 patients treated with an RME protocol. Mean age at the start of RME treatment was 13.5 years; average duration of treatment was 6.7 months. Patients were grouped into prepubertal and postpubertal groups based on their cervical vertebral maturation (CVM) stage. AB and GAC widths were determined at three separate time points. The normative sample consisted of 437 orthodontically untreated whites, aged 10–16 years. A repeated measures analysis of variance (ANOVA) was used to determine group differences. In addition, independent sample *t*-tests were used to compare posttreatment nasal width values vs the untreated normative sample.

Results: Increases in AB and GAC widths of the nose in the RME sample were less than 1.5 mm. No significant differences were noted in width changes between the prepubertal and postpubertal subgroups. Comparisons of T3 values showed that on average nasal width increases were greater in the RME group than in untreated norms by 1.7 mm for the GAC measure (statistically significant), and by less than 1 mm for the AB measure.

Conclusions: RME has no significant clinical effects on the widths of the apical base and the greater alar cartilage of the nose; no differences were observed between the two maturational subgroups. (*Angle Orthod.* 2010;80:995–1001.)

KEY WORDS: Rapid maxillary expansion; Nose; Greater alar cartilage; Alar base; Soft tissue changes

INTRODUCTION

Rapid maxillary expansion (RME) is a common treatment modality, with more than half of practicing orthodontists using some form of expansion.[1,2] RME is indicated in the treatment of orthodontic problems ranging from maxillary transverse deficiency to increasing available arch perimeter in mild to moderate crowding cases.[3–5] The skeletal effects of RME are well documented;[5] however, the number of studies analyzing soft tissue changes associated with RME is limited.

A major concern of some parents whose children undergo RME is the possible negative effect of the expansion procedure on the appearance of the face, with particular emphasis not only on the teeth, but also on the hard and soft tissues of the nose. The only previous study that focused on possible changes in soft tissue morphology of the nose with RME was performed by Berger and colleagues.[6] They photo-

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graphically monitored 20 subjects treated with RME to correct a unilateral or bilateral crossbite. These investigators evaluated 11 soft tissue measurements before RME after placement of the appliance, at completion of expansion, at removal of the appliance, and after 1 year of retention. The study revealed that soft tissue nasal width increased by 2 mm throughout treatment, and that this increase remained stable at 1 year post treatment.

Berger and colleagues[6,7] then correlated the nasal soft tissue changes with changes in skeletal nasal width in 24 patients via posteroanterior cephalograms. Their results showed that the changes in soft tissue and skeletal nasal widths were correlated in a 1:1 ratio. However, the authors[6] did not compare their relatively small treatment group vs an untreated control sample. In addition, they did not account for gender differences or skeletal maturational level within the expander group.

The availability of normative values for craniofacial skeletal measurements is relatively high, yet few data on the soft tissue normative values of the craniofacial region have been gathered. Farkas[8] used 132 anthropometric measurements to analyze the face of a North American white population—data that now make up the North American whites database (NAW). The 132 measurements were surface measurements taken from the head, face, orbits, nose, lips, mouth, and ears. Cranial and facial norms for the white population were established at each year of age from birth to 18 years old, as well as in a young adult population 19–25 years of age.

Of particular interest is the morphologic nasal width, defined as the width between the left ala and the right ala, as well as the anatomical width of the nose, defined as the width between facial insertions of the alar bases where they connect to the skin of the face. The mean morphologic width of the nose ranged from 24.4–34.9 mm; mean anatomical width ranged from 23.2–32.8 mm. The only other study on this subject also was conducted by Farkas and associates,[9] who obtained 14 anthropometric measurements on 780 European whites, separated by gender in roughly equal numbers. The age range of the sample was 18–30 years. This investigation revealed that the morphologic nasal width of European whites was identical to that in the NAW data.

The goal of the current study is to analyze the soft tissue nasal width changes associated with RME. Changes were assessed in both prepubertal and postpubertal subjects and were compared with a nontreated normative sample of nasal morphology measurements gathered specifically for this study.

PATIENTS AND METHODS

Rapid Maxillary Expansion Sample

The RME sample consisted of 79 consecutively treated patients from the private practice of one of the authors. Patients underwent expansion with a Hyrax-type expander as part of their overall treatment protocol. The mean age at the beginning of treatment was 13.1 years (range, 10–16 years). Patients were divided into prepubertal (CS1–CS3) and postpubertal (CS4–CS5) groups, according to the cervical vertebral maturation (CVM) method described by Baccetti and colleagues.[10]

Treatment Protocol

All patients received a Hyrax expander with bands on the upper first permanent molars and upper first premolars after the initial T_1 cephalogram was obtained. Patients were instructed to turn the expander one-turn-per-day for an average of 35 days. After the active expansion phase, the expander was tied off using a stainless steel ligature. Patients then wore the expander as a retainer for an additional average period of 5.7 months.

After removal of the expander, the appliance was backturned to determine precisely the amount of expansion that was obtained. Each turn of the expansion screw equaled 0.20 mm, which yielded an average expansion of 7 mm. Upon completion of expansion, fixed appliances were placed; however, this part of the overall treatment was not considered in the current study.

CVM Analysis

CVM stage[10] was determined on the basis of the T_1 cephalogram. Cephalograms were blinded, and the examiners were blinded to the age of the patients. CVM stage was determined by two investigators. Any discrepancies between the two primary evaluators were resolved by a third expert evaluator. The distribution of the RME sample according to CVM stages is reported in Table 1.

Nasal Width Measurements

Nasal width measurements were obtained from the RME sample at three separate time points: T_1, prior to placement of the RME; T_2, after completion of active expansion; and T_3, after removal of the expander. Nasal width measurements were obtained with subjects in a recumbent position with eyes directed at the ceiling and relaxed facial features. All measurements were taken using a digital caliper accurate to 0.01 mm. Alar base (AB) width was obtained by measuring the

Table 1. Distribution According to CVM Stage and Gender for RME Sample

Group	Cervical Vertebral Maturation Stage	Subjects at T_1		CVM Group Total
		Male	Female	
Prepubertal	Cervical stage 1	6	4	31
	Cervical stage 2	3	7	
	Cervical stage 3	3	8	
Postpubertal	Cervical stage 4	7	24	48
	Cervical stage 5	10	7	

distance between the widest points of the insertion of the nose into the soft tissues of the face (Figure 1). Care was taken to not compress the soft tissues during the measuring process. Greater alar cartilage (GAC) width was obtained by measuring the distance between the widest points of the right and left alae (Figure 2).

Similarly to the study by Berger et al.,[6] reliability and intraexaminer reproducibility of the measurements were high (almost 100% according to Cronbach's alpha test), and measurement error was less than 0.5 mm in more than 80% of subjects.

Normative Nasal Width Sample

The original normative study sample included 1043 subjects (579 females, 464 males) from the Department of Orthodontics and Pediatric Dentistry, the University of Michigan School of Dentistry, and from two private orthodontic practices. The sample included subjects with ages ranging from 3 to 79 years. Subjects were excluded from the study if they possessed a history of nasal trauma, surgery, or rhinoplasty, had been treated previously with RME, or possessed a diagnosed craniofacial anomaly (including but not limited to cleft lip and/or cleft palate). Verbal consent was obtained from the subjects, as was child assent if the subject was younger than age 18. After application of exclusionary criteria, and to match the ages of patients considered in the current study, the final normative sample for comparisons consisted of 437 orthodontically untreated whites aged 10–16 years. GAC and AB width measurements were taken on all subjects with the same procedure as in the treated sample.

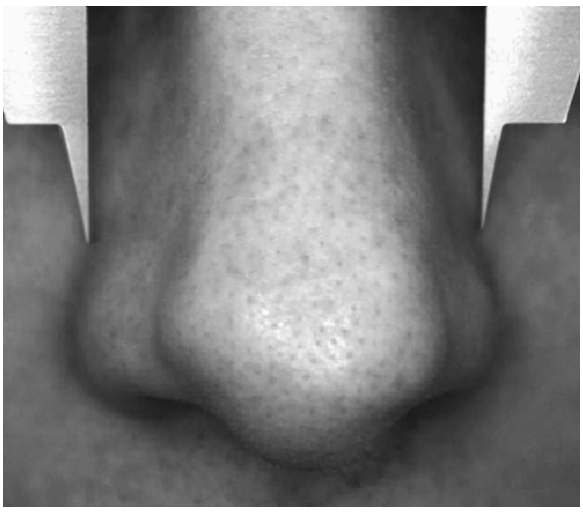

Figure 1. Measurement of AB width.

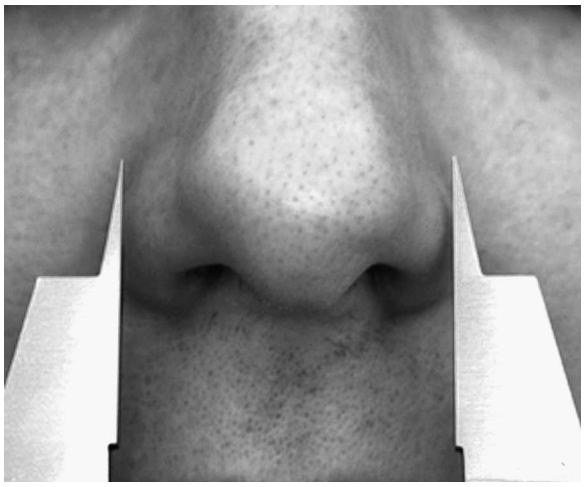

Figure 2. Measurement of GAC width.

Statistical Analysis

Descriptive statistics were calculated for age, sex, prepubertal, and postpubertal groups, as well as for changes between T_1, T_2, and T_3 in the expansion sample. Descriptive statistics, including means and standard deviations, were calculated for age, sex, and age groups also in the nasal width normative sample. Data were analyzed with a Windows-based statistical software package (Statistical Package for the Social Sciences [SPSS], version 17.0, SPSS Inc, Chicago, Ill). Statistical significance was set at $P < .05$. Because of the number of subjects enrolled in the study, the power exceeded 0.90 for both the total samples and the subgroups.

Descriptive statistics were used to evaluate normative nasal width values. Means and standard deviations were calculated for AB and GAC widths, as well as for sex and age groups. Age groups were defined as follows: 10, 11, 12, 13, 14, 15, and 16 years of age.

Nasal width changes in the RME sample group were assessed via two-way repeated measures analysis of variance (ANOVA). The normality of the residuals was assessed for each ANOVA model to confirm normal distribution of the RME sample group. The sample was divided into prepubertal and postpubertal groups and subsequently was separated by gender.

The two-way repeated measures ANOVA with post hoc Bonferroni correction was carried out in the RME

Table 2. Descriptive Statistics for the Normative Sample Groups Ages 10–16 Years

		Female					Male			
		AB		GAC			AB		GAC	
Age Group, y	N	Mean	SD	Mean	SD	n	Mean	SD	Mean	SD
10	17	31.0	1.9	30.2	1.7	13	31.0	2.2	31.1	2.9
11	32	31.8	2.5	32.1	2.1	15	30.9	1.4	31.3	2.1
12	31	32.0	2.4	32.1	2.7	34	32.7	2.5	32.9	2.5
13	44	32.3	2.2	32.9	1.8	33	32.8	2.3	32.9	2.3
14	54	32.9	2.3	33.3	2.2	32	34.2	2.2	35.0	3.0
15	34	32.6	1.9	33.3	2.5	37	34.4	2.9	34.8	2.5
16	24	31.9	2.1	31.9	2.5	37	34.5	2.5	35.7	2.3

sample to compare AB and GAC width means at T_1, T_2, and T_3 by CVM groups. Separate analyses were carried out for males and females. Two-tailed *t*-tests were used to examine differences between T_3 nasal width measurements of the RME group and the untreated sample. Comparisons were analyzed for each year of age from 10 to 16 years; significance was set again at $P < .05$.

RESULTS

Descriptive data for nasal width norms by age group for ages 10–16 years are shown in Table 2.

Alar Base (AB) Width Changes

Significant increments from T_1-T_2-T_3 were found for both males and females for AB width (Figures 1, 3, and 4; Table 3). T_1-T_2 increases in AB width were significant in both sex groups and maturation groups (with the exception of the prepubertal female group). The amount of average increase in AB width was smaller than 1 mm. T_1-T_3 increases in AB width were significant only in postpubertal females and in prepubertal males (0.5 mm and 1.3 mm, respectively).

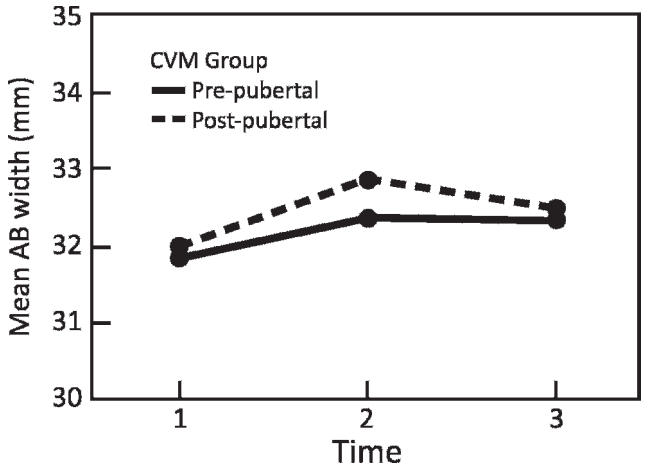

Figure 3. Mean AB width at T_1, T_2, and T_3 for females (RME group).

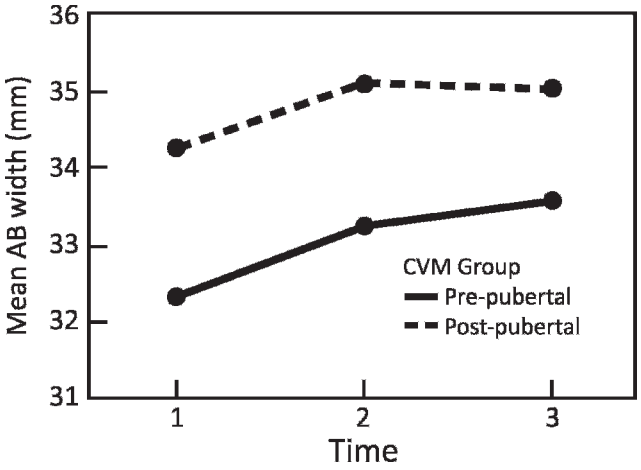

Figure 4. Mean AB width at T_1, T_2, and T_3 for males (RME group).

Post hoc comparisons of the means of the AB widths showed no significant differences between the values of the prepubertal and postpubertal CVM groups at any time point for either males or females (Table 4).

Greater Alar Cartilage (GAC) Width Changes

Significant changes from T_1-T_2-T_3 were found in both males and females for GAC width, indicating that GAC width (Figure 2) increased from T_1-T_3 (Figures 5 and 6; Table 3). T_1-T_2 increases in GAC width were significant only in the postpubertal females and in the prepubertal males (0.4 mm and 1.1 mm, respectively). T_1-T_3 increases in GAC width were significant only in the prepubertal males (1 mm).

Post hoc comparisons of mean GAC widths in the prepubertal and postpubertal groups showed no significant differences among mean GAC values for females at any time point. For males, the postpubertal CVM group was significantly larger than the prepubertal CVM group at T_1; however, no significant differences in mean GAC widths were noted at T_2 or T_3 between the prepubertal and postpubertal groups (Table 4).

Comparison of Posttreatment Nasal Widths vs Untreated Norms

Posttreatment nasal width values (T_3) were compared with the untreated normative sample using an independent samples Student's *t*-test at ages 10 to 16 years. The statistical test was not allowed because of the limited number of subjects in the RME group at ages 10, 15, and 16 years. No significant differences in average AB width were noted between the RME sample post treatment (T_3) and the untreated normative sample in any of the tested age groups (Table 5). Actual differences between average values for AB width in the two groups never exceeded 1 mm.

Table 3. Comparison of Nasal Width Changes Within Each CVM Group

Measure	Sex	CVM Group	Time Interval	Mean Diff	Standard Error	Value[a,b]	Significance
AB	F	Prepubertal	T1-T2	0.5	0.2	0.115	NS
			T1-T3	0.5	0.2	0.073	NS
			T2-T3	−0.03	0.2	1	NS
		Postpubertal	T1-T2	0.9	0.2	<0.001	***
			T1-T3	0.5	0.2	0.004	**
			T2-T3	−0.4	0.2	0.058	NS
	M	Prepubertal	T1-T2	0.9	0.3	0.006	**
			T1-T3	1.3	0.4	0.018	*
			T2-T3	0.3	0.3	0.861	NS
		Postpubertal	T1-T2	0.8	0.2	0.005	**
			T1-T3	0.8	0.4	0.145	NS
			T2-T3	−0.06	0.3	1	NS
GAC	F	Prepubertal	T1-T2	0.4	0.2	0.33	NS
			T1-T3	0.3	0.2	0.557	NS
			T2-T3	−0.02	0.2	1	NS
		Postpubertal	T1-T2	0.4	0.2	0.032	*
			T1-T3	0.2	0.2	0.682	NS
			T2-T3	−0.2	0.1	0.334	NS
	M	Prepubertal	T1-T2	1.1	0.2	<0.001	***
			T1-T3	1.0	0.3	0.005	**
			T2-T3	−0.04	0.3	1	NS
		Postpubertal	T1-T2	0.3	0.2	0.336	NS
			T1-T3	0.8	0.2	0.015	*
			T2-T3	0.5	0.2	0.16	NS

[a] Independent samples Student's *t*-test.
[b] Bonferroni adjustment for multiple comparisons.
* $P < .05$; ** $P < .01$; *** $P < .001$.

Table 4. Comparison of Prepubertal and Postpubertal Nasal Widths at T_1-T_2-T_3

Measure	Sex	Time	CVM Group	Mean	Standard Error	*P* Value[a]	Significance
AB	F	1	Prepubertal	31.9	0.5	.868	NS
		1	Postpubertal	31.9	0.4		
		2	Prepubertal	32.3	0.5	.430	NS
		2	Postpubertal	32.9	0.4		
		3	Prepubertal	32.3	0.5	.800	NS
		3	Postpubertal	32.5	0.4		
	M	1	Prepubertal	32.3	0.8	.071	NS
		1	Postpubertal	34.3	0.7		
		2	Prepubertal	33.3	0.8	.078	NS
		2	Postpubertal	35.1	0.7		
		3	Prepubertal	33.6	0.8	.193	NS
		3	Postpubertal	35.0	0.7		
GAC	F	1	Prepubertal	33.3	0.5	.794	NS
		1	Postpubertal	33.5	0.4		
		2	Prepubertal	33.6	0.5	.702	NS
		2	Postpubertal	33.9	0.4		
		3	Prepubertal	33.6	0.5	.916	NS
		3	Postpubertal	33.7	0.4		
	M	1	Prepubertal	33.9	0.8	.025	*
		1	Postpubertal	36.5	0.7		
		2	Prepubertal	34.9	0.9	.115	NS
		2	Postpubertal	36.8	0.8		
		3	Prepubertal	34.9	0.9	.051	NS
		3	Postpubertal	37.3	0.8		

[a] Independent samples Student's *t*-test.
* $P < .05$.

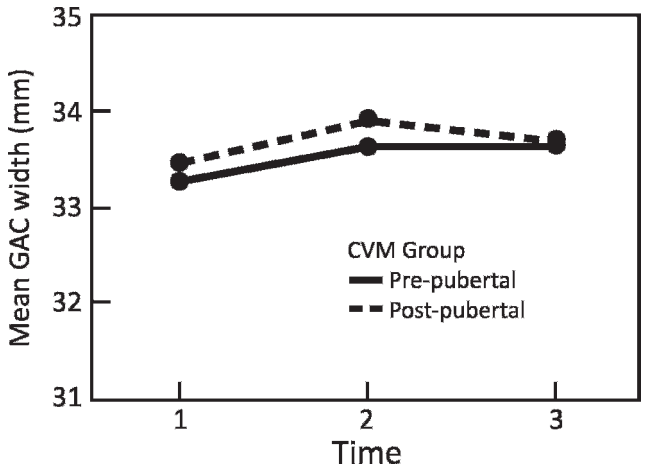

Figure 5. Mean GAC width at T_1, T_2, and T_3 for females (RME group).

Average posttreatment (T_3) GAC width was significantly greater for the RME sample than for the normative sample at ages 11, 12, and 13 years (Table 6). When GAC width increases for all ages were averaged and compared with control data, the mean difference was +1.7 mm.

DISCUSSION

The purpose of this prospective clinical study was to describe the soft tissue changes in nasal width associated with a Hyrax-type rapid maxillary expander. To put the findings of this study into a broader perspective, a large cross-sectional sample of individuals within the same age range who had not undergone RME were measured to determine normal soft tissue nasal width values for adolescents.

The only previous study that analyzed soft tissue changes associated with RME was performed by Berger and co-workers.[6] Photographs of 20 patients were taken at four different time points, and nasal widths measured off the photographs. A unique aspect of the current study was the analysis of changes in width of the alar base (AB). To our knowledge, no study has analyzed this anatomical distance. Our study found no clinically significant increases in the width of the alar base.

Berger et al.[6] reported an increase in GAC of 2 mm in their RME-treated sample. The present study reported that increases in GAC generally were less than 1.5 mm, which shows that the treatment effects of RME on the width of the greater alar cartilages are not clinically significant. In all groups, a small increase in nasal width is apparent during active expansion (within 1 mm for both AB and GAC), followed by a slight decrease or virtually no change during the retention period. The overall effect was an increase in width smaller than 1.5 mm for both measurements. The previous study,[6] however, did not analyze nasal width changes by age, nor did it use an untreated sample as comparative data. Categorization of subjects according to chronological age and skeletal maturation (CVM)

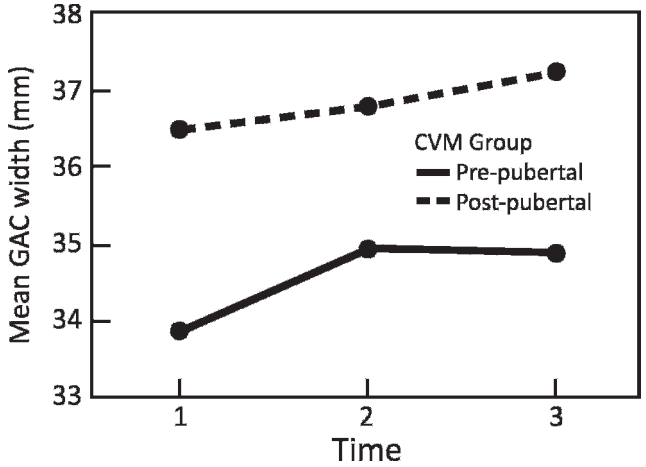

Figure 6. Mean GAC width at T_1, T_2, and T_3 for males (RME group).

Table 5. Posttreatment AB Widths (T_3) of RME Sample vs Combined Untreated Norms

	Normative Sample			RME				
Age, y	N	Mean	SD	N	Mean	SD	*P* Value[a]	Significance
10	30	31.0	2.0	2	31.8	1.8	.625	TNA
11	47	31.5	2.0	10	31.8	2.4	.738	NS
12	65	32.4	2.5	14	33.1	2.4	.382	NS
13	77	32.5	2.2	24	33.5	2.3	.065	NS
14	86	33.4	2.4	18	33.4	2.9	.980	NS
15	71	33.5	2.6	5	33.4	2.6	.916	TNA
16	61	33.5	2.7	6	34.9	2.9	.241	TNA

[a] Independent samples Student's *t*-test.
NS indicates not significant; TNA, test not allowed (too limited n of subjects).

Table 6. Posttreatment GAC Width (T_3) of RME Sample vs Combined Untreated Norms

	Normative Sample			RME				
Age, y	N	Mean	SD	N	Mean	SD	*P* Value[a]	Significance
10	30	30.6	2.3	2	32.8	2.5	.205	TNA
11	47	31.8	2.1	10	33.6	2.9	.027	*
12	65	32.5	2.6	14	34.4	2.6	.014	**
13	77	32.9	2.0	24	34.7	2.3	< .001	***
14	86	33.9	2.7	18	34.8	3.3	.246	NS
15	71	34.1	2.6	5	34.9	2.6	.485	NS
16	61	34.2	3.0	6	36.9	3.5	.039	TNA

[a] Independent samples Student's *t*-test.
* $P < .05$; ** $P < .01$; *** $P < .001$.
NS indicates not significant; TNA, test not allowed (too limited n of subjects).

ensured that noted changes were not due to growth. The current study showed significant increases in postretention GAC width, when compared with untreated norms, for those aged 11–13 years. However, when GAC width increases for all ages from 10–16 years were averaged, the mean difference with respect to normative controls was +1.7 mm. This difference was less than 1 mm for the AB width.

When nasal width changes were compared in prepubertal and postpubertal patients, RME had similar effects on the two groups. The lack of any difference between the two groups in relation to puberty was of great interest. Previous studies by Cameron et al.,[11] Landsberger,[12] Krebs,[13] Wertz,[14] Skieller,[15] Baccetti et al.,[16] and Lagravere et al.[17] analyzed the skeletal effects of RME. These investigators found that the greatest amount of skeletal expansion at the level of the maxillary transverse dimensions was obtained if the patient was treated before the pubertal growth spurt. The current study showed no difference in soft tissue changes between prepubertal and postpubertal groups. This finding would suggest that the effects that RME exerts on the soft tissue may not be as dependent on maturational status as are the maxillary skeletal effects. It should be noted that Baccetti et al.[16] described similar changes in skeletal lateral nasal width for prepubertal and postpubertal patients undergoing RME (range, 1.5–2.2 mm), whereas increases in maxillary skeletal width were significant only in the prepubertal group. Finally, in the present investigation, prepubertal male patients before treatment showed GAC width on average 2.5 mm smaller than that of postpubertal patients, thus indicating the role of the pubertal growth spurt in increasing the transverse size of nasal soft tissues in male adolescents.

CONCLUSIONS

- The effects of RME on alar base or greater alar cartilage widths indicated that the actual amount of change was less than 1.5 mm, an increase that is not significant clinically. Prepubertal and postpubertal CVM groups did not react significantly differently to RME, suggesting that maturational status during adolescence plays no role in the effect that RME has on the soft tissue width of the nose.
- Comparison of posttreatment nasal width values vs untreated norms showed no differences in soft tissue nasal widths that can be considered of clinical impact ($<$2 mm).
- The effects that RME exerts on the soft tissue may not be as dependent on maturational status as are the maxillary skeletal effects.

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