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Original Article

Nasomaxillary and mandibular bone growth in primary school girls aged 7 to 12 years

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Abstract *Background/purpose:* Facial bone growth manifests in primary school-aged children, especially girls. This study investigated the changes in nasomaxillary and mandibular morphology of primary school girls.
Materials and methods: Cephalograms of 60 primary school girls were divided into 3 groups (group I, aged 7—8 years; group II, aged 9—10 years; and group III, aged 11—12 years). The dimensions of the nasomaxilla (nasal bone length, nasal ridge length, nasal depth, palatal length, and maxillary height) and mandible (condylar length, condylar width, coronoid length, coronoid width, ramus length, body length, symphysis length, and entire mandibular length) were measured. One-way ANOVA and Pearson's correlation coefficient were used for statistical analysis.
Results: Nasal ridge length, nasal depth, and maxillary height were significantly greater in group III than in group I and group II. Condylar width and body length were significantly greater in group III than in group I and group II. Pearson's correlation revealed significant positive correlations between age and nasal ridge length, nasal depth, or maxillary height. There were also significant positive correlations between age and ramus length, body length, or entire length of the mandible.
Conclusion: We found that nasal ridge length, nasal depth, maxillary height, condylar width and body length were significantly greater in group III than in group I or in group II. Moreover,

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there were significant correlations between age and the nasal ridge length, nasal depth, maxillary height, ramus length, body length, or entire length of the mandible.

Introduction

With respect to the timing of human growth, children develop rapidly during their primary school years. As their bodies grow and develop, the versatility of their bodily functions increases continuously. Facial growth also occurs during this period, although facial skeletal growth is different in every child with respect to the direction and amount of growth. There are significant differences in the growth and development of different children at the same age, and girls tend to undergo greater changes in body structure during the primary school years than boys do. The onset of the pubertal growth spurt occurs at around 10 years in girls and 12 years in boys. The period constituting the onset of this growth spurt and the subsequent two years is statistically significantly correlated with the peak period of facial growth. Therefore, the peak facial growth spurt occurs at around 12 years in girls and 14 years in boys.[1–5]

Human facial bones comprise many regional bones connected by sutures, and the growth and development of these bones is closely interrelated. The increase in size and changes in shape of developing children are noticeable during this period, especially in girls. In Taiwan, primary school students are aged 7–12 years. On the basis of body and facial growth, primary-school children can be divided into three groups (group 1 [1st and 2nd grades], group 2 [3rd and 4th grades], and group 3 [5th and 6th grades]), during which their body and face change considerably. The aim of the present study was to investigate the changes in facial skeletal growth patterns in primary school girls by comparing the dimensions of the nasomaxillary bones and mandibles over time.

Material and methods

This study included 60 primary school girls from grade 1 (aged 7 years) to grade 6 (aged 12 years). Cephalograms of the subjects were divided into 3 age groups (group I, 15 girls aged 7–8 years; group II, 27 girls aged 9–10 years; and group III, 18 girls aged 11–12 years) and the characteristics of development and growth were examined. Subjects were excluded if they had: (1) craniofacial symptoms or anomalies; (2) undergone craniofacial surgery; or (3) experienced facial trauma.

The following landmarks (Fig. 1) were identified on each cephalogram: nasion (N); orbitale (Or); porion (Po); rhinion (R), the most anterior and inferior point on the tip of the nasal bone; frontomaxillary nasal suture (MS), the most superior point of the suture where the maxilla articulates with the frontal and nasal bones; pronasale (Prn); anterior nasal spine (ANS); point A; posterior nasal spine (PNS); prosthion (Pr); infradentale (Id); point B; condylion (Cd); coronoid process (CP); antegonial notch (Ag); sigmoid notch (Sm); and menton (Me). The measurements of cephalometric data were performed by SY Hsiao. Twenty cephalograms were randomly investigated by SY Hsiao after a 10-day interval. For evaluation of systematic errors, the paired t-test was applied for landmarks (Prn, ANS, Cd and Me) and no significant differences were observed. The Dahlberg formula was used to investigate the accidental errors and sufficient accuracy of the measurements was confirmed.

We then took the following measurements. The nasal dimensions were measured as the nasal bone length (N to R), nasal ridge length (N to Prn), and nasal depth (Prn vertical to MS–Pr line). The maxillary dimensions were measured as the palatal length (ANS to PNS) and the maxillary height (MS to Pr). The dimensions of the mandible were measured as the condylar length (longest distance from Cd to a line parallel to the Or–Po line through Sm), coronoid length (longest distance from CP to a line parallel to the Or–Po line through Sm), ramus length (Sm–Ag), body length (Ag–Me), symphysis length (Me–Id), and entire length (Cd–Me).

The measurement data were analyzed using the statistical software SPSS v. 20 (IBM, Armonk, NY, USA). One-way analysis of variance (ANOVA) was used for intergroup comparisons. Tukey's honest significant difference test was used for post-hoc validation. Pearson's correlation coefficient was calculated to assess the strengths of the correlations between variables. A P-value of <0.05 was considered statistically significant. This study was approved by the Human Investigation Review Committee (KMUHIRB-E(II)-20180200).

Results

The ANB angle did not change significantly with age, and nor did the nasal bone or palatal lengths (Table 1). The nasal ridge length, nasal depth, and maxillary height, however, were significantly greater in group III than group I and group II. Moreover, nasomaxillary dimensions presented no difference between group I and group II. With respect to the comparison of condylar and coronoid portions among the age groups, there was no difference between group I and group II. The condylar length in group III was significantly greater than group I and group II (Table 2). Ramus, mandibular body and entire mandibular lengths in group III were significantly greater than group I. Mandibular body and entire mandibular lengths were not different between group I and group II. Condylar length, coronoid length and width, and symphysis length increased with age, but these differences were not significant among three groups (Table 2).

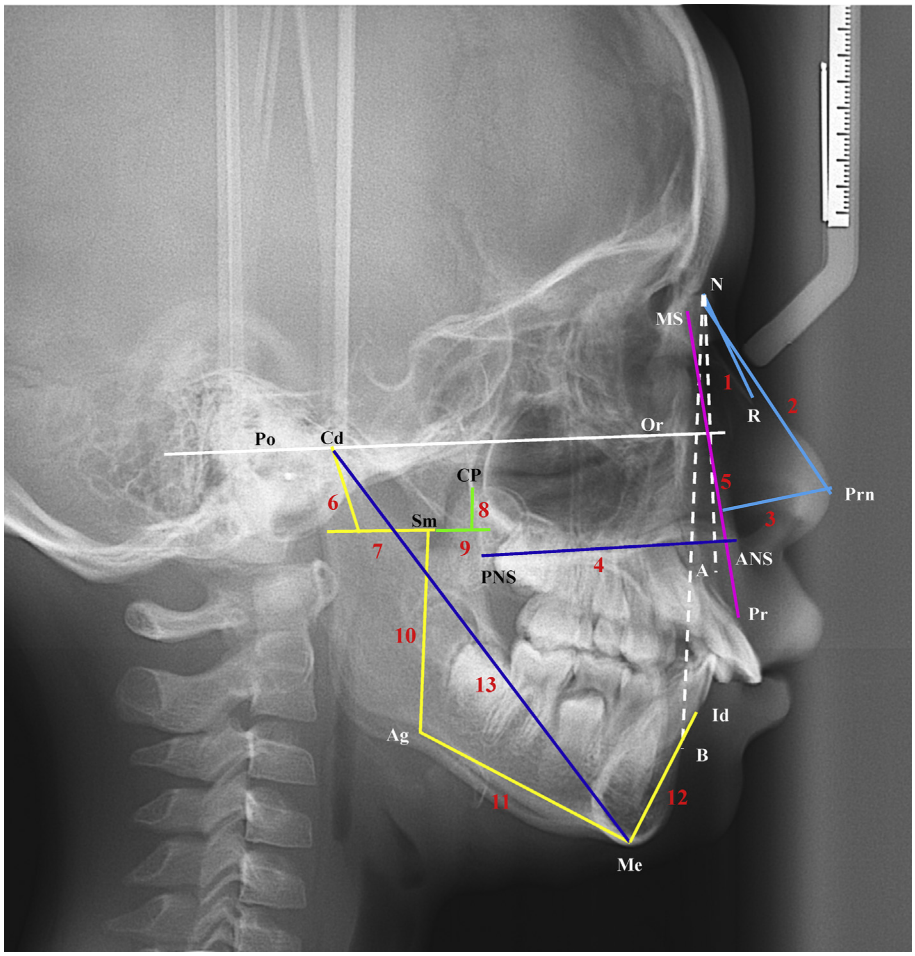

Figure 1 Cephalometric landmarks and linear measurements. N: nasion, Or: orbitale, Po: porion, R: rhinion, MS: frontomaxillary nasal suture, Prn: pronasale, ANS: anterior nasal spine, point A, PNS: posterior nasal spine, Pr: prosthion, Id: infradentale, point B, Cd: condylion, CP: coronoid process, Ag: antegonial notch, Sm: sigmoid notch, Me: menton. Linear distances: 1: nasal bone length, 2: nasal bridge length, 3: nasal depth, 4: palatal length, 5: maxillary height, 6: condylar length, 7: condylar width, 8: coronoid length, 9: coronoid width, 10: ramus length 11: body length, 12: symphysis length, 13: entire mandibular length.

Table 1 Nasomaxillary growth in primary school girls aged 7–12 years (one-way ANOVA).

Variables	Group I		Group II		Group III		*P* value	Intergroup comparison	
	Mean	SD	Mean	SD	Mean	SD		Significant	
ANB	3.6	3.33	4.4	2.67	4.6	3.68	0.635	–	
Nasomaxillary									
Nasal bone length	22.9	3.24	24.4	3.04	25.1	2.42	0.100	–	
Nasal ridge length	47.7	3.73	49.3	3.57	52.7	2.95	<0.001	*	Group III > Group II; Group III > Group I
Nasal depth	21.6	2.88	22.7	2.71	25.4	1.99	<0.001	*	Group III > Group II; Group III > Group I
Palatal length	45.7	3.50	46.0	3.29	48.3	3.49	0.054	–	
Maxillary height	57.0	4.24	58.8	4.03	63.5	3.91	<0.001	*	Group III > Group II; Group III > Group I

Group I: aged 7 and 8 years; Group II: aged 9 and 10 years; Group III: aged 11 and 12 years.
*: Intergroup comparison: statistically significant, $P < 0.05$.
–: Not significant.

Pearson's correlation coefficient (R) revealed a positive significant correlation ($P < 0.05$) between age and nasal bone length, nasal ridge length, nasal depth, maxillary height, condylar width, ramus length, body length, symphysis length and entire length of the mandible (Table 3). There were negative significant correlations ($P < 0.05$) between the ANB angle and some parameters of the nasomaxillary bones and mandible. With respect to the nasomaxillary proportions, maxillary height was significantly positively correlated ($P < 0.05$) with nasal bone length ($R = 0.562$), nasal ridge length ($R = 0.728$), and nasal depth ($R = 0.434$). There were also significant positive

Table 2 Mandibular bone growth in primary school girls aged 7–12 years (one-way ANOVA).

Variables	Group I		Group II		Group III		*P* value	Intergroup comparison	
	Mean	SD	Mean	SD	Mean	SD		Significant	
Mandible									
Condylar length	19.5	2.28	19.0	2.80	20.0	2.73	0.448	–	
Condylar width	18.3	1.78	18.5	1.74	20.1	1.23	0.002	*	Group III > Group II; Group III > Group I
Coronoid length	10.2	3.89	9.4	2.88	9.1	2.91	0.574	–	
Coronoid width	14.9	1.86	16.0	2.15	15.6	2.03	0.247	–	
Ramus length	39.2	4.65	43.0	4.57	43.8	3.36	0.007	*	Group III > Group I; Group II > Group I
Body length	52.9	4.21	54.4	3.58	57.8	3.51	0.001	*	Group III > Group II; Group III > Group I
Symphysis length	29.1	4.69	29.3	2.47	31.3	2.32	0.062	–	
Entire length	103.4	5.67	106.2	6.45	110.6	6.31	0.006	*	Group III > Group I

Group I: age 7 and 8; Group II: age 9 and 10; Group III: age 11 and 12.
*: Intergroup comparison: statistically significant, $P < 0.05$.
–: Not significant.

Table 3 Pearson's correlation coefficient (*R*) test in the nasomaxillary dimensions.

	Age	ANB	Nasal bone	Nasal ridge	Nasal depth	Palatal length	Maxillary height
Age	1	0.036	0.282*	0.501*	0.532*	0.232	0.535*
ANB	0.036	1	−0.064	0.071	−0.261*	0.319*	−0.074
Nasomaxillary							
Nasal bone	0.282*	−0.064	1	0.544*	0.235	0.043	0.562*
Nasal ridge	0.501*	0.071	0.544*	1	0.411*	0.327*	0.728*
Nasal depth	0.532*	−0.261*	0.235	0.411*	1	−0.022	0.434*
Palatal length	0.232	0.319*	0.043	0.327*	−0.022	1	0.085
Maxillary height	0.535*	−0.074	0.562*	0.728*	0.434*	0.085	1
Mandible							
Condyle length	0.049	−0.112	0.142	0.132	0.128	0.247	0.065
Condyle width	0.370*	−0.162	0.176	0.205	0.408*	0.267*	0.305*
Coronoid length	−0.099	−0.075	−0.15	0.147	−0.236	0.362*	−0.179
Coronoid width	0.151	−0.07	0.325*	0.291*	−0.158	0.293*	0.22
Ramus length	0.432*	−0.135	0.355*	0.527*	0.188	0.163	0.577*
Body length	0.504*	−0.399*	0.197	0.388*	0.518*	0.177	0.401*
Symphysis length	0.297*	0.247	0.249	0.391*	0.076	0.209	0.399*
Entire length	0.451*	−0.322*	0.263*	0.537*	0.382*	0.243	0.581*

*: Statistically significant, $P < 0.05$.

correlations ($P < 0.05$) between mandibular entire length and condylar length ($R = 0.445$), ramus length ($R = 0.596$), body length ($R = 0.784$), and symphysis length ($R = 0.419$; Table 4).

With respect to the correlations between the nose and mandible, nasal ridge length was significantly positively correlated ($P < 0.05$) with ramus length ($R = 0.527$) and entire length ($R = 0.537$). Nasal depth was significantly positively correlated with condylar width ($R = 0.408$) and body length ($R = 0.518$), and palatal length was weakly but significantly correlated with the nasomaxillary and mandibular bones. Maxillary height was significantly positively correlated with ramus length ($R = 0.577$), body length ($R = 0.401$), and entire length ($R = 0.581$).

Discussion

The nasomaxillary complex is composed of the maxilla and nasal bones. The upper part of the nose is supported by bones and includes the connection between the superior border of the nasal bone and the frontal bone and that between the lateral border of the nasal bone and part of the frontal process of the maxilla. In the middle of the face, the nasal bone is connected to nasal cartilage to form part of the bridge of the nose, and the lower half of the nose is supported by this cartilage.[6] The pattern of facial contours is closely associated with the development of the nose. A study by Heijden et al.[7] showed that the growth rate of the nose is associated with body height, which implies that when a person grows taller, the nose grows longer as well. Heijden et al.[7] indicated that the maximum growth rate of the nose in girls occurs between ages 10 years and 11 years. In our study, there were no significant differences in the nasal bone length between the age groups. In contrast, the growth in the nasal cartilage did result in significant differences between age groups. We also found positive correlations between age and nasal ridge length and between age and nasal depth. In addition, the extent of nose growth was greatest in group III (ages 11 and 12),

Table 4 Pearson's correlation coefficient (R) test in the mandibular dimensions.

	Condyle length	Condyle width	Coronoid length	Coronoid width	Ramus length	Body length	Symphysis length	Entire length
Age	0.049	0.370*	−0.099	0.151	0.432*	0.504*	0.297*	0.451*
ANB	−0.112	−0.162	−0.075	−0.07	−0.135	−0.399*	0.247	−0.322*
Nasomaxillary								
Nasal bone	0.142	0.176	−0.15	0.325*	0.355*	0.197	0.249	0.263*
Nasal ridge	0.132	0.205	0.147	0.291*	0.527*	0.388*	0.391*	0.537*
Nasal depth	0.128	0.408*	−0.236	−0.158	0.188	0.518*	0.076	0.382*
Palatal length	0.247	0.267*	0.362*	0.293*	0.163	0.177	0.209	0.243
Maxillary height	0.065	0.305*	−0.179	0.22	0.577*	0.401*	0.399*	0.581*
Mandible								
Condyle length	1	0.238	0.225	0.165	−0.134	0.300*	0.007	0.445*
Condyle width	0.238	1	−0.16	0.074	0.219	0.357*	0.201	0.394*
Coronoid length	0.225	−0.16	1	0.358*	−0.106	0.15	−0.037	0.122
Coronoid width	0.165	0.074	0.358*	1	0.393*	0.067	0.098	0.221
Ramus length	−0.134	0.219	−0.106	0.393*	1	0.345*	0.413*	0.569*
Body length	0.300*	0.357*	0.15	0.067	0.345*	1	0.314*	0.784*
Symphysis length	0.007	0.201	−0.037	0.098	0.413*	0.314*	1	0.419*
Entire length	0.445*	0.394*	0.122	0.221	0.569*	0.784*	0.419*	1

*: Statistically significant, $P < 0.05$.

and this was significantly greater than that of group I and group II (ages 7–10 years). Based on our findings, development of the nose in girls is consistent with the peak period of facial skeletal growth.

Several growth centers in bone sutures are located on both sides of the maxillary complex, namely the zygomaticomaxillary, frontomaxillary, zygomaticotemporal, and pterygopalatine sutures. Bone appositions occurring in these sutures have the effect of enlarging the maxillary complex. Therefore, sutural growth shifts the maxillary complex downward and anteriorly. Nahhas et al.[8] reported that the age of onset, peak, and cessation of maxillary development and growth was significantly earlier in women than in men, with peaks at ages 10.8 years and 13.4 years, respectively. A study by Nanda et al.[9] showed that the change in the sella–nasion–point A (SNA) angle during the development of the maxilla is less than 1° at age 12 years and above, which implies that there is little maxillary growth after age 12 years. The present study found no significant difference in palatal bone length between age groups, which implies that the palate grew at a constant rate from age 7–12 years in these girls. However, maxillary height exhibited a positive significant correlation with age and increased most strongly in group II, being significantly greater than in group I and group II.

The mandibular growth centers include the body, angle, condyle, coronoid process, alveolar process, and periosteum of the mandible. The growth of the condylar cartilage contributes incrementally to mandibular ramus height, total length of the mandible, and intercondylar distance. The development of dentition and alveolar bone increases mandibular height. In addition, muscular attachments and movements also facilitate mandibular growth, which results in functional remodeling and strengthening.[10,11] A study by Baumrind et al.[12] on 31 subjects, most of whom were girls, showed that condylar growth was relatively stable between 8.5 years and 15.5 years of age. The present study found no significant correlations between age and the condylar and coronoid lengths, which implies that condylar development in these girls was stable at ages 7–12 years. Thus, the condylar and coronoid bones did not exhibit an obvious growth spurt, which is consistent with the findings of Baumrind et al.[12]

The pterygomasseteric sling comprises the masseter and medial pterygoid muscles, which are powerful elevators of the jaw. The antegonial notch is the attachment point that joins both muscles to the lower border of the mandible. Singer et al.[13] and Lambrechts et al.[14] reported that the depth of the antegonial notches could be used as a predictor of the potential and direction of mandibular growth. We therefore used these points as the boundary between the mandibular ramus and body, which was appropriate according to the physiological processes of mandibular growth and development. We found a positive significant correlation between age and ramus length, body length, and entire length of the mandible. Entire mandibular length increased most strongly in group III, becoming significantly greater than in group I. Thus mandibular development in these girls was consistent with the peak period of facial skeleton growth. Ricketts[15] proposed that symphysis morphology could be used as a predictor of the direction of mandibular growth. Aki et al.[16] found that symphysis height and depth increased with age and exhibited an accelerated growth rate during puberty. Although we found a positive significant correlation between age and symphysis length in this study, there were no significant differences in symphysis length between the age groups.

With respect to the skeletal relationship (ANB angle) between the maxilla and the mandible, we found a positive significant correlation between the ANB angle and palatal length. We also found a negative significant correlation between the ANB angle and nasal depth. With respect to the growth of each portion of the nasomaxillary bones, there was a positive significant correlation (R = 0.728) between maxillary height and nasal ridge length. In addition, with respect to maxillary height, there was a positive significant correlation between nasal bone length and depth. Our findings thus revealed that nasal growth was significantly correlated with maxillary growth in girls aged 7–12 years. Notably, there was no correlation between palatal length and maxillary height, which implies that the growth patterns of these two features were different.

We found the significant negative correlations between the ANB angle and the mandibular body length or the entire length of the mandible, which implies that the ANB angle was not correlated with the mandibular bone in our study subjects. With respect to the various parts of the mandible, there was a positive significant correlation ($R = 0.784$) between the entire length and the body length of the mandible, which implies that the growth of the mandibular body is the most important factor in mandibular growth. In addition, there were significant correlations between the entire mandibular length and the mandibular condylar, ramus, and symphysis lengths. The growth of various parts of the mandible thus promoted the increase in the entire mandibular length. In conclusion, in the growth of nasomaxillary bones in girls aged 7 to 12 years, there are significant correlations between the age and the nasal ridge length, nasal depth, or maxillary height. However, there is no significant correlation between age and palatal length. In terms of mandibular growth and development, there are moderate significant correlations between age and ramus length, body length, and entire length of the mandible, but no significant correlation between age and condylar or coronoid lengths.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

References

1. Aksglaede L, Olsen LW, Sørensen TI, Juul A. Forty years trends in timing of pubertal growth spurt in 157,000 Danish school children. *PLoS One* 2008;3:e2728.
2. Aksglaede L, Juul A, Olsen LW, Sørensen TI. Age at puberty and the emerging obesity epidemic. *PLoS One* 2009;4:e8450.
3. Tinggaard J, Mieritz MG, Sørensen K, et al. The physiology and timing of male puberty. *Curr Opin Endocrinol Diabetes Obes* 2012;19:197–203.
4. Karpati AM, Rubin CH, Kieszak SM, Marcus M, Troiano RP. Stature and pubertal stage assessment in American boys: the 1988-1994 Third National Health and Nutrition Examination Survey. *J Adolesc Health* 2002;30:205–12.
5. Wheeler MD. Physical changes of puberty. *Endocrinol Metab Clin N Am* 1991;20:1–14.
6. Karadag D, Ozdol NC, Beriat K, Akinci T. CT evaluation of the bony nasal pyramid dimensions in Anatolian people. *Dentomaxillofac Radiol* 2011;40:160–4.
7. van der Heijden P, Korsten-Meijer AG, van der Laan BF, Wit HP, Goorhuis-Brouwer SM. Nasal growth and maturation age in adolescents: a systematic review. *Arch Otolaryngol Head Neck Surg* 2008;134:1288–93.
8. Nahhas RW, Valiathan M, Sherwood RJ. Variation in timing, duration, intensity, and direction of adolescent growth in the mandible, maxilla, and cranial base: The Fels Longitudinal Study. *Anat Rec (Hoboken)* 2014;297:1195–207.
9. Nanda RS. Growth changes in skeletal-facial profile and their significance in orthodontic diagnosis. *Am J Orthod* 1971;59:501–13.
10. Enlow D. *The facial growth process. Handbook of facial growth*. Philadelphia: Saunders, 1990:58–148.
11. Precious DS, Hall BK. *Growth and development of the maxillofacial region. Principle of oral and maxillofacial surgery.* Philadelphia: J.B. Lippincott Co, 1992:1211–36.
12. Baumrind S, Ben-Bassat Y, Korn EL, Bravo LA, Curry S. Mandibular remodeling measured on cephalograms. 1. Osseous changes relative to superimposition on metallic implants. *Am J Orthod Dentofac Orthop* 1992;102:134–42.
13. Singer CP, Mamandras AH, Hunter WS. The depth of the mandibular antegonial notch as an indicator of mandibular growth potential. *Am J Orthod Dentofac Orthop* 1987;91:117–24.
14. Lambrechts AH, Harris AM, Rossouw PE, Stander I. Dimensional differences in the craniofacial morphologies of groups with deep and shallow mandibular antegonial notching. *Angle Orthod* 1996;66:265–72.
15. Ricketts RM. Cephalometric synthesis. *Am J Orthod* 1960;46:647–73.
16. Aki T, Nanda RS, Currier GF, Nanda SK. Assessment of symphysis morphology as a predictor of the direction of mandibular growth. *Am J Orthod Dentofac Orthop* 1994;106:60–9.