CONTINUING EDUCATION

An estimation of craniofacial growth in the untreated Class III female with anterior crossbite

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The literature has little to say regarding the normal growth and development of untreated individuals with Class III malocclusion or anterior crossbite. In part, this paucity of information is because of the relatively low prevalence of these characteristics in European-American populations and the need, recognized by the lay public and health professionals, for treatment of these conditions. Given the absence of true longitudinal data, this study attempts to estimate the growth of the untreated individual with Class III malocclusion and anterior crossbite by evaluating large samples of untreated subjects at distinct developmental stages. Initially the morphologic characteristics of 2074 Japanese female patients who had anterior crossbite were evaluated cephalometrically before treatment. On the basis of the cephalometric analysis, all subjects who did not have a Class III molar relationship were excluded from further analysis, leaving a sample of 1376. The subjects then were classified into seven groups (120-256 subjects per group) according to Hellman's stages of dental development. Descriptive statistics for 28 measurements were calculated. The results of this study imply that the maxilla in Japanese females maintains a retruded relationship to the cranial base and does not become less retrusive with time. In contrast, the mandible is protrusive even in the late deciduous dentition and becomes more protrusive with time, making the discrepancy between the upper and lower jaws progressively more severe. Dental compensations in both arches become increasingly evident as development progresses, and the underlying skeletal and dentoalveolar imbalances also are reflected in the soft tissue profile. (Am J Orthod Dentofac Orthop 1997;112:425-34.)

Class III malocclusion and anterior crossbite are common clinical problems, especially in patients of Asian ancestry. For example, Lew et al.[1] report that the prevalence of Class III malocclusion is approximately 12% in a Chinese population. Although the prevalence of Angle Class III molar relationship in the Japanese has not been studied in detail, estimates of the frequencies of anterior crossbite and edge-to-edge incisal relationships in Japanese range from 2.3% to 13% and 2.7% to 7.4% respectively.[2-4] If the frequency of occurrence of these two manifestations of Class III malocclusion are combined, a substantial percentage of the Japanese population has characteristics of Class III malocclusion. A relatively high prevalence of Class III malocclusion has been observed in other ethnic groups as well (for example, 9.4% in Saudi Arabian orthodontic patients[5]). In comparison, Class III malocclusion is seen less often in persons of Northern European ancestry, with estimates ranging from 0.8% to 4.2%.[6-16] Slightly higher prevalence in Swedish men (6%) has been noted by Ingervall et al.[17]

The occurrence of anterior crossbite and edge-to-edge incisal relationship also has been evaluated in non-Asian populations. Kelly et al.[18-19] reported that the prevalence of anterior crossbite in samples of European Americans and African Americans was 0.8% and 0.6-1.2% respectively. An earlier study of individuals of predominantly North European ancestry by Mills[10] found slightly higher values. On the basis of an evaluation of incisor relationship regardless of Angle classification, Mills reported that 3.3% of males and 2.9% of females had an anterior crossbite, and an additional 5.0% of males and 3.8% of females were characterized as having an edge-to-edge incisal relationship.

Skeletal Components of Class III Malocclusion

Just as the prevalence of Class III malocclusion and anterior crossbite varies among racial and ethnic groups, so too do the components of these

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malocclusions. Masaki,[20] in a comparative study of native Japanese and of Americans of Northern European ancestry, reported that maxillary skeletal retrusion occurred more often in the Asian face, whereas mandibular prognathism often is observed as a component of Class III malocclusion in individuals of European American ancestry. Masaki reported that posterior cranial base length and facial height were significantly larger in Japanese children, whereas anterior cranial base length and facial depth were significantly larger in American children. The Japanese typically had a more retrusive facial profile and a longer lower anterior facial height than did the Americans. Masaki also noted that a backward rotation of the mandible in the Japanese appeared to be necessary to coordinate occlusion relative to the small maxilla. He postulated further that maxillary skeletal retrusion with or without anterior crossbite may be more frequent in the Japanese, and conversely an orthognathic maxilla in combination with a larger cranial base occurs more often in the European American.

On average, a more retrusive profile and a relatively longer lower anterior facial height is observed even in Japanese with facial profiles and occlusions judged to be near-ideal by clinicians of the same ethnic group as the subjects selected. Miyajima et al.,[21] in a comparative study of Japanese and European American individuals selected on the basis of having well-balanced faces and ideal occlusions, reported that the Japanese sample, in general, was smaller in anteroposterior facial dimensions and proportionately larger in vertical facial dimensions in comparison to the European American sample. The facial axis angle was more vertical in Japanese subjects, indicating a more downward direction of facial development. Thus, it appears that diminished anteroposterior facial dimensions and elongated vertical facial dimensions in comparison to European Americans is a common finding in Japanese subjects regardless of malocclusion type.

Longitudinal Studies of Untreated Class III Malocclusion

There are no major longitudinal studies of untreated Class III subjects. This lack of data is because of at least two factors, the first of which is the low prevalence of this type of malocclusion, particularly in non-Asian populations. All of the well-known "growth studies" of untreated individuals typically contain a preponderance of subjects with Class I and Class II malocclusion as well as normal occlusion.[22-25] Class III subjects are not well represented, even in proportion to their occurrence in the general population.

A second reason behind the lack of information about the growth of untreated Class III individuals is the well-recognized need for early intervention in such patients, especially now that a number of early treatment protocols have been shown effective, including the chin cup,[26-29] the function regulator (FR-3) appliance of Fränkel,[30-31] the orthopedic facial mask,[32-35] and the protraction chin cup.[36] Further, an anterior crossbite and even an edge-to-edge incisal relationship typically are perceived as abnormal by the lay public and by health practitioners. For example, fully a third of the orthodontic patients receiving orthodontic therapy in Japan have correction of Class III-type problems as a primary treatment goal, a far greater percentage than occurs in the Japanese population.

The longitudinal data on untreated patients with Class III malocclusion[6,37-40] that exist are very limited with regard to sample size and duration of longitudinal records, with most studies featuring few patients and short observation intervals. Thus, little is known about growth and development of the untreated person with Class III malocclusion.

Several investigators have attempted to estimate normal craniofacial growth in the untreated Class III individual through the use of cross-sectional records, typically comparing these samples with individuals with normal occlusion. For example, Guyer et al.[41] and Battagel[42] analyzed the pretreatment cephalometric records of 144 and 285 Class III patients, respectively, on the basis of four groups defined by chronological age. Dietrich[43] analyzed the lateral head films of 172 Class III patients on the basis of three stages of dental development (deciduous, mixed, permanent dentitions). Tollaro et al.[44] evaluated the craniofacial patterns of 69 Class III patients in the deciduous dentition, and Chang et al.[45] evaluated the deciduous dentition in 40 subjects according to one stage of dental development as defined by Hellman.[46,47] Sanborn,[48] Ellis and McNamara,[49] and Lew and Foong[50] limited their investigations to adult patients only.

Purpose

To compensate, in part, for the paucity of data on the normal growth of the untreated individual with Class III malocclusion and anterior crossbite, this cross-sectional study was undertaken to identify the cephalometric characteristics of such patients at specific stages of dental development. By analyzing the records of a substantial number of subjects (N =

Table I. Stages of dental development as defined by Hellman (1926, 1932)*

Stage	Definition	N	Years of age		
			Mean	SD	Range
IIA	Eruption of second deciduous molars	185	4.8	0.8	2.7–6.5
IIC	Eruption of permanent incisors	196	6.5	0.7	5.0–8.3
IIIA	Eruption of permanent first molars	120	8.0	0.8	5.7–10.6
IIIB	Eruption of canines and premolars	162	9.8	1.1	7.2–14.1
IIIC	Beginning of second molar eruption	229	11.7	1.1	8.8–14.3
IVA	Eruption of second molars completed	228	13.8	1.2	10.5–15.9
VA (Adult)	Eruption of third molars completed	256	20.6	4.1	16.0–43.8

*The descriptive statistics concerning age for the final sample that was divided into the seven groups also are provided.

1376) at seven defined developmental stages and by limiting the sample to a single gender, new information can be gained concerning the untreated female with Class III malocclusion.

SUBJECTS AND METHOD

The data initially considered for this investigation were lateral cephalometric head films of 2074 Japanese who ranged from 2.7 years to 47.9 years of age (Table I). These films were obtained at the initial visit to the orthodontic clinic at Aichi-Gakuin University and at other associated clinics in Nagoya, Japan. Each patient had anterior crossbite (reverse overbite) and sought treatment for this condition. Each cephalogram was taken in centric occlusion. Subjects with an edge-to-edge incisor relationship were not included. For the purpose of this study, data collection was limited to females only. Comparable data on males will be presented elsewhere.

Cephalometric Analysis

The lateral headfilm of each subject was traced by one investigator and checked for accuracy by another. The selected landmarks were digitized by use of a special computer program that was written in BASIC, and the landmarks were converted to an X-Y coordinate system. Measures of craniofacial form were calculated by computer and tabulated into skeletal, dental, and soft tissue relationships. The 28 angular and linear measurements chosen were derived, in part, from the analysis of Downs,[51] Steiner,[52] Ricketts,[53] Jacobson,[54] and McNamara.[55-58,34] The error of the method has been reported elsewhere.[57]

Identification of Final Sample

After the cephalograms had been traced and digitized, an exclusionary criterion was applied to further define the sample. As mentioned earlier, a patient initially was included in the study if she had an anterior crossbite at the time of the clinical examination. Following the cephalometric evaluation, the parent sample of 2074 females was stratified on the basis of molar relationship (Fig. 1). The distribution of the distance between the distal contact points of the upper and lower first molars ranged from +2 mm to –17 mm, with a negative number indicating that the lower molar is located mesially to the upper molar. Subjects with an anteroposterior molar relationship greater than –4 mm were excluded from the subsample to eliminate patients with an anterior crossbite but a Class I posterior occlusion. This selection criterion was similar to that used by Nezu et al.[59] in determining the borderline between Class I and Class III malocclusion in their attempt to establish Japanese clinical norms for the Ricketts analysis. On the basis of molar relationship, the final sample was reduced to 1376 subjects.

Developmental Stages

Each subject was placed in one of seven groups according to her stage of dental development by Hellman's classification system[46,47] (Table I). The stage of tooth eruption, instead of chronological age of the subject, was used to stratify the final sample. The developmental stages ranged from the late mixed dentition to adulthood, at which time the third molars had erupted. The number of individuals in each developmental group ranged from 120 to 256.

To make profilograms of each dental stage, 96 points including soft tissues and cervical vertebrae were selected, a modification of the protocol developed by Hikage.[60] The X and Y coordinates of each landmark of the subjects at each Hellman stage were averaged to produce a typical tracing of the hard and soft tissue outlines of the face for each stage of dental development.

Statistical Analysis

Standard descriptive statistics (means and standard deviations) of age and cephalometric measurements were calculated for each dental stage. Analysis of variance (ANOVA) was used to test for significant differences among the individual groups at Hellman's seven stages of dental development (IIA, IIC, IIIA, IIIB, IIIC, IVA, and VA (adult) stages; Tables I and II). When ANOVA was significant, Scheffè's method of multiple comparisons was applied to test for between- and among-group differences at a significance level of $p < 0.05$ (Table III).

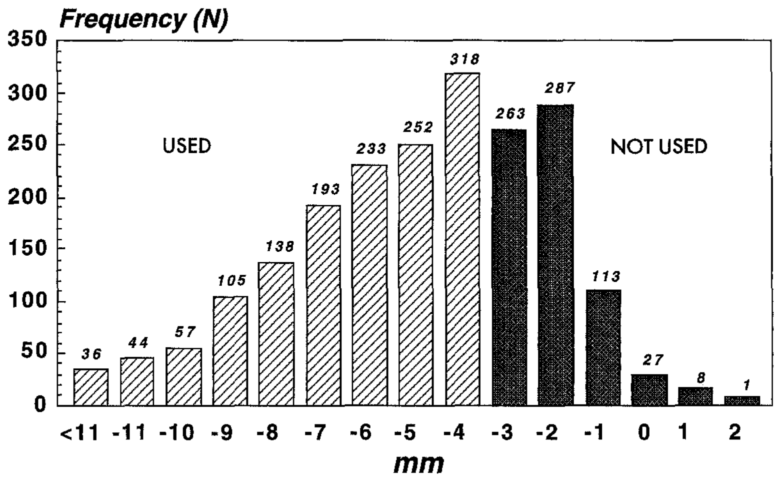

Fig. 1. Distribution of the molar relationship of the parent sample population of 2074 Japanese females. The distance measured on the lateral cephalogram was the sagittal relationship of the mesial contact points of the upper and lower first molars relative to the occlusal plane. Positive values are toward Class I occlusion, negative values toward Class III occlusion. All subjects with an anteroposterior relationship greater than −4 mm were excluded from further consideration.

Table II. Analysis of variance

Variable		*F-value*	*Sig.*
Age	(y)	1554.1	—
Maxilla to Cranial Base			
Nasion Perp. to Point A	(mm)	7.6	**
SNA Angle	(°)	4.7	**
Convexity	(mm)	46.9	**
Mandible to Maxilla			
ANB Angle	(°)	26.7	**
Condylion to Gnathion	(mm)	1033.7	**
Condylion to Point A	(mm)	251.4	**
ANS-Menton	(mm)	373.8	**
Facial Axis	(°)	2.0	
Facial Depth	(°)	60.0	**
Mandibular Plane Angle	(°)	5.8	**
Lower Facial Height	(°)	78.0	**
Mandibular Arc	(°)	21.9	**
Total Facial Height	(°)	71.1	**
Wits appraisal	(mm)	103.4	**
Mandible to Cranial Base			
Pogonion to Nasion Perp.	(mm)	71.2	**
SNB Angle	(°)	23.9	**
Dentition			
Overjet	(mm)	3.2	**
Overbite	(mm)	36.8	**
U1 to SN	(°)	322.0	**
L1 to Mp.	(°)	19.8	**
U1 to Point A Vertical	(mm)	390.5	**
L1 to APo	(mm)	185.2	**
L1 to APo	(°)	110.4	**
Occ to SN	(°)	12.2	**
Soft Tissue			
Upper lip - Esthetic plane	(mm)	89.1	**
Lower lip - Esthetic plane	(mm)	24.4	**
Cant of Upper Lip	(°)	1.7	
Nasolabial Angle	(°)	5.1	**

*$P < 0.05$, **$p < 0.01$.

RESULTS

The results of ANOVA are shown in Table II. The descriptive statistics for each of the seven groups are shown in Table III as is the number of subjects in each group. The significance between measurements at each consecutive stage by Scheffè's method also are shown in Table III. The changes in 13 key measurements at each stage are plotted in Figs. 2 through 8, and a profilogram of six of the seven stages appears as Fig. 9.

Skeletal Measures (Tables II and III)

Changes in the anteroposterior position of the maxilla and mandible were evaluated by use of two cephalometric reference lines, sella-nasion[52] and the nasion perpendicular.[55] The SNA angle (Fig. 2) and the distance from point A to the nasion perpendicular (Fig. 3) were relatively similar across the seven developmental stages, with a slightly more anterior position of the maxilla relative to the cranial base noted in the adolescent and adult. At all developmental stages, the average values for these two cephalometric measures indicated that the maxilla was retrusive relative to normal values.[61] Increases in effective midfacial length (condylion to point A) were relatively consistent at subsequent developmental stages (Fig. 4).

In contrast, increasing mandibular prognathism was noted at each subsequent stage, beginning with

Table III. Japanese female Class III measurements using the method of Scheffè

		Dental stage																			
		IIA (N = 185)			IIC (N = 196)			IIIA (N = 120)			IIIB (N = 162)			IIIC (N = 229)			IVA (N = 228)			Adult (N = 256)	
Variable		Mean	SD	Sig. 1	Mean	SD	Sig. 2	Mean	SD	Sig. 3	Mean	SD	Sig. 4	Mean	SD	Sig. 5	Mean	SD	Sig. 6	Mean	SD
Age	(y)	4.8	0.8	**	6.5	0.7	**	8.0	0.8	**	9.8	1.1	**	11.7	1.0	**	13.8	1.2	**	20.6	4.1
Maxilla to cranial base																					
Point A to N. Perp.	(mm)	0.5	2.4		1.1	2.7		0.6	2.5		1.1	2.8		0.6	3.0		1.4	3.3		2.0	3.6
SNA angle	(°)	77.8	3.4		78.4	3.0		78.3	3.2		78.5	3.0		78.0	3.0		78.6	3.3		79.2	3.6
Convexity	(mm)	0.7	1.9		1.2	2.1	*	0.0	2.4		−0.8	2.4		−1.3	2.6		−2.0	3.3		−2.1	3.4
Mandible to maxilla																					
ANB angle	(°)	−0.7	1.7	*	0.2	1.9		−0.5	2.1		−1.3	2.2		−1.5	2.1		−2.0	2.6		−2.1	2.7
Condylion to gnathion	(mm)	92.2	4.6	**	97.8	4.0	**	101.6	4.4	**	107.0	5.3	**	112.6	5.8	**	119.9	5.8	**	123.7	5.6
Condylion to point A	(mm)	71.1	3.6	**	73.8	3.5		74.3	3.2	**	77.1	3.8	**	79.5	4.0	**	81.9	4.2		82.5	4.4
ANS - menton	(mm)	56.1	3.5	**	58.9	3.5		59.3	4.0	**	61.6	4.2	**	65.1	4.8	**	69.5	5.4	**	72.9	5.5
Facial axis	(°)	87.6	3.2		86.6	3.5		87.5	3.6		87.5	3.6		86.7	3.8		87.0	4.4		86.9	4.4
Facial depth	(°)	89.7	2.6		89.9	2.5		90.7	2.7		91.9	2.8		91.8	3.1	**	93.2	3.2		93.8	3.1
Mandibular plane angle	(°)	25.6	3.8		26.6	4.1		26.0	4.3		25.8	4.3		26.8	4.7		27.4	5.2		27.7	5.5
Lower facial height	(°)	43.1	3.1	**	45.9	3.4		45.7	3.7		46.3	3.6		47.5	4.4		48.8	4.3	**	50.7	4.8
Mandibular arc	(°)	30.6	3.7	**	28.2	3.9		28.1	4.3		27.1	3.9		26.4	4.8		26.1	4.9		26.9	5.5
Total facial height	(°)	57.4	3.8	**	61.5	4.2		62.2	4.2		63.0	4.2		64.4	4.8		65.2	5.4		65.6	5.7
Wits appraisal	(mm)	−5.4	1.5		−4.9	1.9	**	−7.0	2.3		−7.9	2.4		−8.4	2.8	**	−9.8	3.6		−10.4	4.1
Mandible to cranial base																					
Pogonion to nasion perp.	(mm)	−0.5	4.1		−0.2	4.2		1.1	4.8		3.4	5.2		3.4	6.0	**	6.5	6.6		8.0	6.7
SNB angle	(°)	78.5	3.4		78.2	3.0		78.8	3.3		79.9	3.1		79.5	3.2	*	80.6	3.4		81.3	3.7
Dentition																					
Overjet	(mm)	−2.6	1.3		−2.9	1.1		−2.7	1.3		−2.8	1.5		−2.5	1.2		−2.4	1.5		−2.8	2.0
Overbite	(mm)	3.1	1.6		2.5	1.8		2.7	2.1		3.4	2.5		2.5	2.3	**	1.4	2.4		0.7	2.9
U1 to SN	(°)	84.0	7.2	**	88.0	8.6	**	99.9	6.7		102.5	6.6		103.9	6.4		106.2	7.1		106.6	7.1
L1 to mand plane	(°)	78.6	6.3	**	83.7	7.3		85.3	6.7		84.0	6.1		83.1	7.1	*	80.6	7.9		80.2	8.0
U1 to point A vertical	(mm)	−0.4	1.5	*	0.5	1.9	**	2.2	2.0	**	4.0	2.2	**	5.3	2.3	**	6.8	2.5	*	7.5	2.6
L1 to APo	(mm)	3.0	1.5	**	4.1	1.7	**	5.2	1.8	**	6.5	1.8		7.1	2.0		7.5	2.3		8.1	2.3
L1 to APo	(°)	12.9	4.9	**	18.7	6.2	**	22.0	5.0		22.6	4.6		23.1	4.6		23.3	5.2		23.7	5.4
Occ to SN	(°)	21.7	4.3		20.9	4.1		21.5	3.9		20.4	4.0		20.2	4.0		19.5	4.7	*	18.7	5.0
Soft tissue																					
Upper lip - E plane	(mm)	−0.4	1.7		−0.6	1.8		−0.8	2.0		−1.3	1.9		−2.0	2.2	**	−3.1	2.3	**	−3.8	2.0
Lower lip - Esthetic plane	(mm)	3.1	1.9		3.0	2.0		3.1	2.3		3.2	2.4		2.8	2.4	**	1.7	2.5		1.3	2.5
Cant of upper lip	(°)	27.0	8.9		25.5	8.0		26.3	8.4		27.8	8.5		25.7	8.3		26.7	9.5		25.8	7.9
Nasolabial angle	(°)	90.3	10.9		91.9	11.3		89.1	11.2		89.0	12.0		88.5	10.8		88.1	12.4		86.3	10.8

*$P < .05$, **$p < .01$. Sig. 1, Significance between stages IIA and IIC; Sig. 2, significance between stages IIC and IIIA; Sig. 3, significance between stages IIIA and IIIB; Sig. 4, significance between stages IIIB and IIIC; Sig. 5, significance between stages IIIC and IVA, and Sig. 6, significance between stages IVA and Adult (more than 16 years old).

stage IIIA (eruption of the first permanent molars completed). The SNB angle increased by three degrees from the early mixed dentition to adulthood (Fig. 2). During the deciduous dentition stage, the chin at pogonion approaches the nasion perpendicular; in the mixed dentition, pogonion is beyond the nasion perpendicular, increasing the amount of mandibular prognathism (Fig. 3). In comparison to the maxilla, mandibular length (condylion-gnathion; Fig. 4) increased at a greater rate at virtually all developmental stages.

The relationship between the maxilla and mandible was evaluated by means of the ANB angle (Fig. 5) and the Wits appraisal[54] (Fig. 6). The ANB angle increased slightly from the late deciduous dentition stage IIA to the early mixed dentition stage IIIA and then decreased during subsequent stages to an increasingly negative angular value (Fig. 5). The Wits appraisal in the late deciduous dentition stage indicated the presence of an average Class III skeletal relationship that increased in magnitude at later developmental stages (Fig. 6).

Lower anterior facial height, as measured from anterior nasal spine to menton (Fig. 4), increased at each developmental period. A trend toward an increasing mandibular plane angle relative to the Frankfort horizontal plane also was noted (Fig. 5).

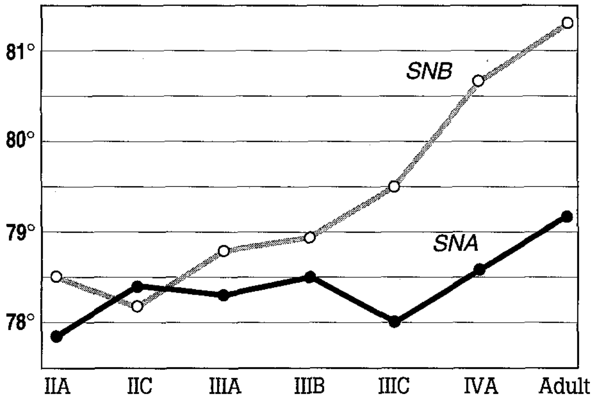

Fig. 2. Changes in the SNA and SNB angles at seven developmental stages of Hellman.[47]

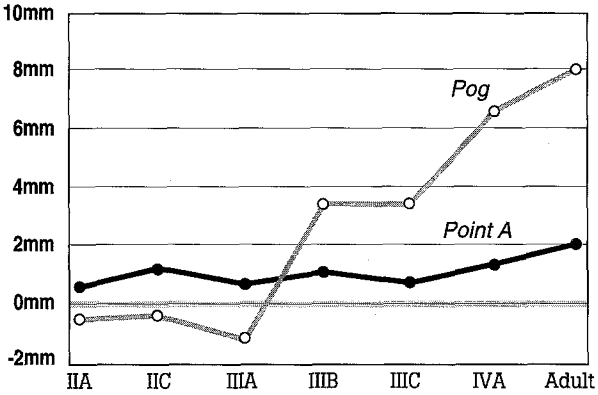

Fig. 3. Changes in the distances from point A and pogonion to the nasion perpendicular at seven developmental stages of Hellman.[47]

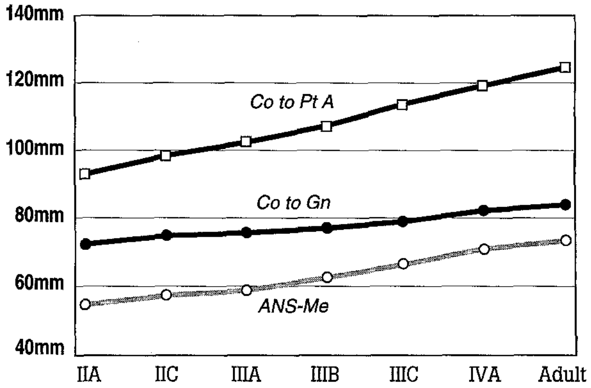

Fig. 4. Changes in the effective midfacial length (condylion - point A), effective mandibular length (condylion - gnathion), and lower anterior facial height (ANS - menton) at seven developmental stages of Hellman.[47]

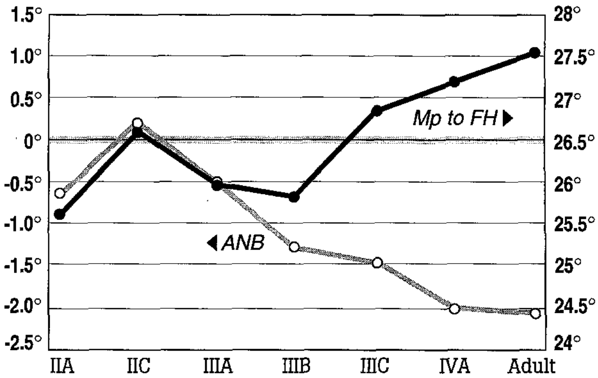

Fig. 5. Changes in the ANB angle and the mandibular plane *(Mp)* angle relative to the Frankfort horizontal *(FH)* at seven developmental stages of Hellman.[47]

Dentoalveolar Measures (Tables II and III)

As anticipated, a negative overjet was observed at each developmental stage (Fig. 7), and the overjet values were relatively similar (–2.5 mm). In contrast, overbite decreased slightly (Fig. 7).

Dental compensations, presumably camouflaging the underlying skeletal discrepancy, were observed in the incisor region. The angle of the upper incisor relative to the S-N line became more obtuse at each developmental stage (Fig. 8), reflecting an increasing flaring of the upper incisor. The lower incisor was lingually inclined at each stage relative to normal values,[61] but became increasingly retroclined beginning in the early mixed dentition (Fig. 8). In spite of the lingual inclination, the labial surface of the lower incisor became more protruded relative to the A-Pogonion line[53] with maturation.

Soft Tissue Measures (Tables II and III)

Patients with an anterior crossbite typically have a protruded contour of the upper lip, as indicated by the cant of the upper lip. The average value of this measure remained constant at approximately 25°, and the nasolabial angle became slightly more acute at later developmental stages (Table III). Both the upper and lower lips, although protrusive, became increasingly posterior to the esthetic ("E") line of Ricketts[53] with development.

DISCUSSION

Very little information exists in the orthodontic or anthropologic literature concerning the longitudinal growth and development of individuals with Class III malocclusion or anterior crossbite or both. Although the data presented in this study are cross-

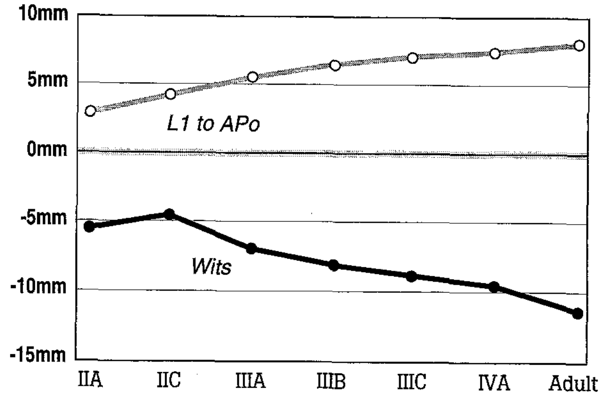

Fig. 6. Changes in the Wits appraisal and the lower incisor *(L1)* to the point A - pogonion *(APo)* line at seven developmental stages of Hellman.[47]

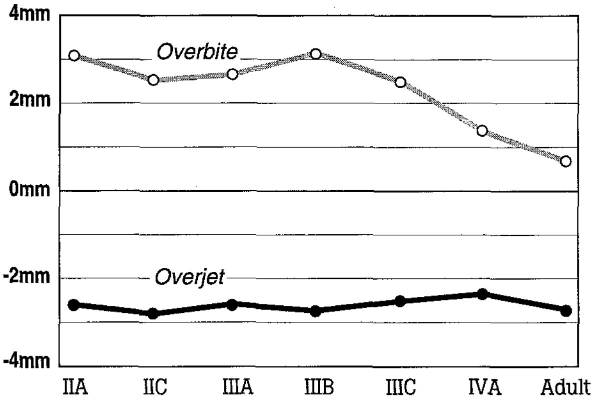

Fig. 7. Changes in overbite and overjet at seven developmental stages of Hellman.[47]

sectional, the sample sizes at each of seven developmental stages are large and the sample is restricted to one gender (female) and one ethnic group (Japanese). In addition, all subjects had an anterior crossbite; subjects with an edge-to-edge incisal relationship, a clinical sign often accompanying mild Class III malocclusion, were not included. The sample was further defined cephalometrically on the basis of Class III molar relationship. Thus, given the sample sizes and the selection criteria, these cross-sectional data are suggestive, at least in general terms, of the growth of the untreated female with Class III malocclusion.

The results of this study are not surprising in most respects. In general, the maxilla maintains a retruded relationship to the cranial base and does not become less retrusive with time, In contrast, the mandible is protrusive even in the late deciduous dentition and becomes more protrusive with time, making the discrepancy between the upper and lower jaws increasingly severe. Dental compensations in both arches become increasingly evident as development progresses, and the underlying skeletal and dentoalveolar imbalances also are reflected in the soft tissue profile. These findings are discussed in detail here.

Maxillary Size and Position

The maxilla in the anterior crossbite sample on average appeared to be retrusive relative to normal Japanese standards of craniofacial morphology.[61] The position of the maxilla relative to the nasion perpendicular (Fig. 3), however, indicates that the maxilla maintains a constant relationship to anterior cranial base structures as the patient matures. In addition, midfacial size, as measured from condylion to point A, was small at each stage when compared with European American norms.[34] These findings are similar to those of Björk,[62] Sanborn,[48] Dietrich,[43] Masaki,[20] and Guyer et al.[41]

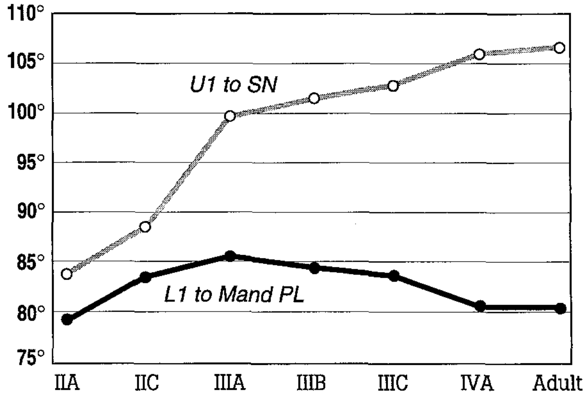

Fig. 8. Changes in the relationship of the upper incisor *(U1)* to the sella - nasion *(SN)* line and the lower incisor *(L1)* to the mandibular plane *(Mand Pl)* at seven developmental stages of Hellman.[47]

Mandibular Size and Position

The effective length of the Japanese mandible, as measured from condylion to anatomical gnathion,[55] was relatively large in comparison to European American standards, although the values observes at each Hellman stage are within one standard deviation of the values derived from the so-called "Bolton Standards."[23] The anteroposterior position of the mandible relative to the cranial base (SNB angle; Fig. 3) became more prognathic during development. Pogonion to nasion perpendicular (Fig. 5)

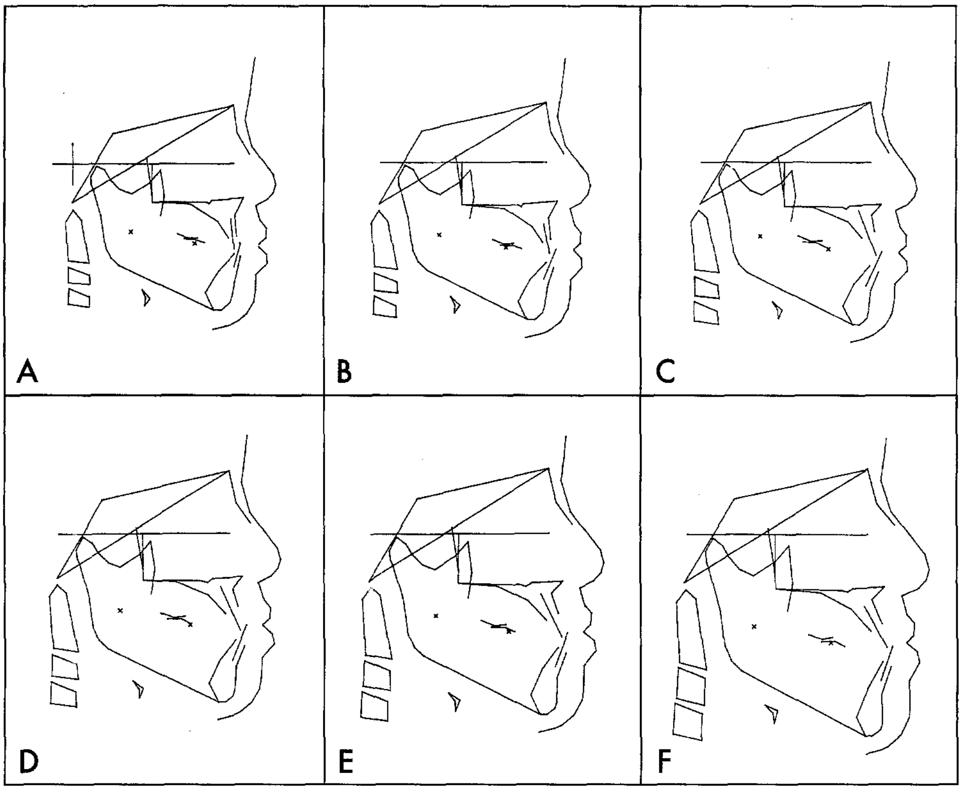

Fig. 9. Profilograms of composite tracings at six developmental stages of Hellman.[47] **A,** Stage IIA; **B,** Stage IIIA; **C,** Stage IIIB; **D,** Stage IIIC; **E,** Stage IVA; F, adult.

increased significantly from stage IIIC (11.7 years) to stage IVA (13.8 years).

The developmental nature of Class III malocclusion has been noted, even in the early part of the twentieth century. Angle[63] stated that if a Class III malocclusion were allowed to develop without intervention, the condition progressed and became more severe. Seipel,[64] Björk,[62] Lande,[65] Tweed,[66] and Graber[67] also suggest that the growth of the mandible exceeds the growth of the maxilla and increased mandibular prognathism results. This observation holds true for the Japanese female sample considered in this study.

Intermaxillary Measurements

Negative ANB angle (Fig. 5) and Wit's appraisal (Fig. 6) indicate that Class III anterior crossbite subjects show a significant underlying skeletal discrepancy, and this discrepancy become greater as dental stages advance after IIIA. This change appears to be caused by forward growth of the mandible instead of by a lack of growth of the maxilla. The mandibular plane angle increases, presumably to compensate for the underlying skeletal discrepancy (Fig. 5).

Dentition

Overbite decreases gradually as the dental stages advance, except during the time of eruption of the permanent incisors, whereas overjet remains relatively stable (Fig. 2). This change in overbite can be associated with an opening of the mandibular plane angle. Battagel[42] reported that the upper incisors showed a consistent proclination and no tendency for overbite to reduce with age. The upper incisors in the present study, however, are tipped labially and lower incisors are tipped lingually during development. This tendency became greater as the dental stages advanced, presumably to compensate for the underlying skeletal discrepancy. Similar findings were observed by Guyer et al.[41]

Soft Tissue

Although the contours of the soft tissue generally camouflage the associated skeletal discrepancy, the present data indicate protrusion of the lower lip.

Interestingly, this characteristic become less noticeable as the stages of dental development advance, whereas the skeletal discrepancy actually increases during late mixed dentition.

The protrusive appearance of the lower lip may be related to the retrusion of the upper lip relative to the esthetic "E"-line of Ricketts,[53] a retrusion that begins to appear at stage III A (6.5 years). Thus, the lower lip seems to follow the retrusion of the upper lip.

The cant of upper lip[57] remains procumbent in Class III subjects, although the nasolabial angle stays constant at approximately 90 degrees. As these data indicate, the nasolabial angle is not as sensitive a measurement of soft tissue esthetics as is the cant of upper lip. The nasolabial angle remains within normal limits because the cant of the upper lip reflects the relative compensatory protrusion of the upper incisor.

SUMMARY AND CONCLUSIONS

This study was undertaken to obtain an indirect estimate of the growth and development of craniofacial structures in the untreated female with Class III malocclusion and an anterior crossbite. The pretreatment lateral head films of a cross-sectional sample of 2074 Japanese females 2.7 years to 47.9 years of age with anterior crossbite were analyzed. Patients who did not have a Class III molar relationship (<−4 mm intermolar measurement) were excluded from this study. Given the large number of subjects at each of seven defined stage of dental development (late deciduous dentition to adulthood), conclusions regarding longitudinal growth of the Class III patient can be inferred.

This study indicates that in the Class III female:

1. The maxilla is retrusive at early developmental stages and remains in a relatively constant relationship to cranial base structures throughout development.
2. The mandible is protrusive early in development and becomes increasingly so as the patient matures.
3. Lower anterior facial height increases at each developmental period. A trend toward an increasing mandibular plane angle is also noted.
4. Overbite decreases slightly during maturation, and a negative overjet (–2.5 mm) is constant. Dental compensations are noted at each developmental stage, presumably as a camouflage of the underlying skeletal discrepancies.
5. The soft tissue also serves to camouflage the hard tissue structures. The cant of the upper lip is angled forward at approximately 25 degrees and the average value for the nasolabial angle remains similar across developmental stages.

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AAO MEETING CALENDAR

1998 — Dallas, Texas, May 16 to 20, Dallas Convention Center
1999 — San Diego, Calif., May 15 to 19, San Diego Convention Center
2000 — Chicago, Ill., April 29 to May 3, McCormick Place Convention Center *(5th IOC* and *2nd Meeting of WFO)*
2001 — Toronto, Ontario, Canada, May 5 to 9, Toronto Convention Center
2002 — Baltimore, Md., April 20 to 24, Baltimore Convention Center
2003 — Hawaiian Islands, May 2 to 9, Hawaii Convention Center
2004 — Orlando, Fla., May 1 to 5, Orlando Convention Center