Longitudinal changes in Class I subjects with moderate mandibular skeletal protrusion

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Are craniofacial characteristics inborn or do they develop with age? In the early days of cephalometrics, Brodie[1] took an interest in this question. Studying growth longitudinally from the third month to the eighth year of life, he concluded that the morphogenetic pattern of the human skull is established very early, and that once attained, it does not change. More recently, Bishara and Jakobsen[2] followed growth longitudinally in three normal facial types and found a strong tendency to maintain the original facial type with age. However, almost one-fourth (23%) of the subjects investigated were typed differently at 5 and 25.5 years.

Some investigators have focused on the appearance of skeletal aberrations connected with Class III malocclusion. Guyer et al.[3] compared a cross-sectional Class III sample with a longitudinal Class I sample. The samples consisted of subjects 5 to 15 years old and were divided into four age groups prior to analysis. Most skeletal characteristics associated with Class III malocclusion in the 13- to 15-year group were already present in the 5- to 7-year-old group. Dietrich[4] compared a cross-sectional sample of individuals who had negative ANB angles with controls who had normal jaw-base relationships. The results indicated that skeletal aberrations associated with a negative ANB angle worsened with time.

In the present study, craniofacial growth was followed longitudinally from early childhood to late adolescence in two groups of females with Class I molar relationships. In one group, the jaw-base relationship was normal when evaluated at 6 years of age, whereas in the other group, the jaw-base relationship was mesial.

The purpose of the study was to analyze and compare craniofacial morphology and incremen-

Abstract

Two groups of Class I females were followed from 6 to 18 years of age. At the initial evaluation, subjects in one group had normal sagittal jaw-base relationships, while those in the other group had moderate mesial relationships between the jaw bases. The purpose of this study was to compare craniofacial morphology and growth in these two groups. Subjects with mesial jaw-base relationships had mandibular skeletal protrusion due to a more forward positioning of the mandible relative to anterior cranial base. Other morphological group differences involved jaw-base relationships (but not jaw size). All the observed group differences were present at age 6; no new differences were observed later. Some differences stayed significant up to age 18, while others became less distinct with time. Incremental growth in the groups was comparable. Similar growth of the jaws apparently helped to maintain initial group differences in jaw-base relationships.

Key Words

Cephalometrics • Longitudinal • Growth • Class I • Mandibular skeletal protrusion

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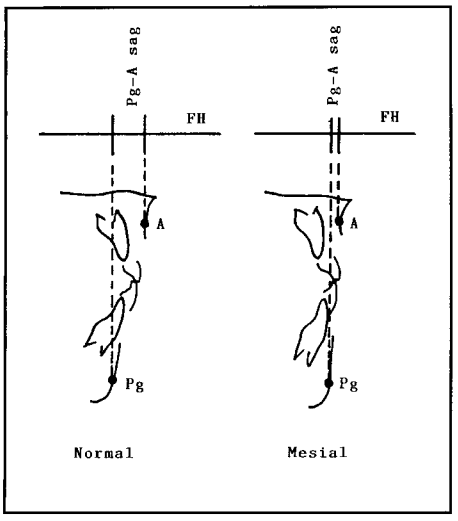

Figure 1

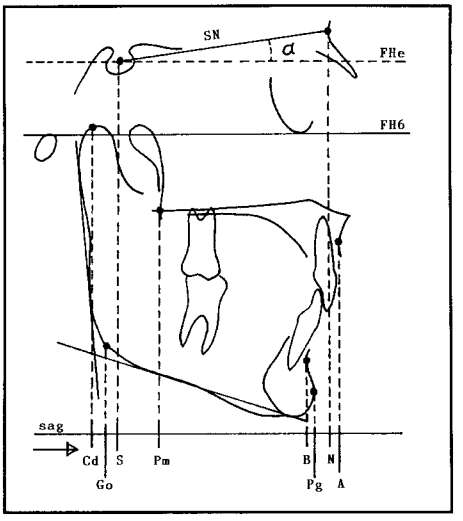

Figure 2

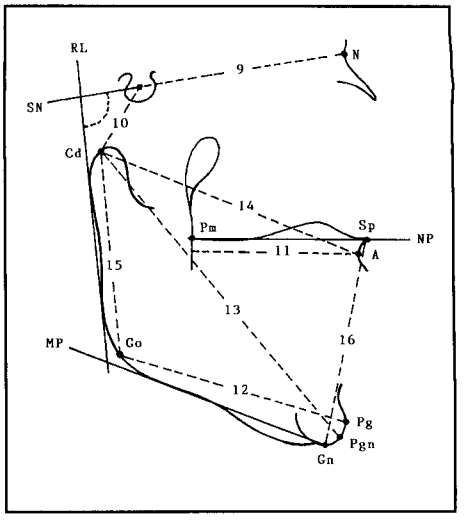

Figure 3

Figure 1
Perpendicular lines were drawn from pogonion and A-point onto Frankfort horizontal plane. Pg-A sag was required to be 7 to 9 mm in the normal group and ≤3 mm in the mesial jaw-base group. Figure illustrates group mean values of Pg-A sag.

Figure 2
On the cephalogram taken at age 6, the angle FH-SN was measured and designated angle alpha (α). A line was constructed through sella at an angle to SN equal to α. This line, designated FH estimated (FHe), was used as a sagittal reference line instead of FH. Points and lines in the cranial base and jaws were projected on a line parallel to FHe. Sagittal dimensions were read left to right and marked "sag" (Table 3, variables 1-8).

Figure 3
Linear variables in cranial base and jaws. Variables numbered according to Table 3 (v. 9 to v. 16). Distance Pm-A (v. 11) was measured along the nasal plane (NP). Angle RL-SN is marked. Points and lines used in measurement of angular variables are also shown.

tal growth in the two groups. Would morphological group differences present at age 6 alter with time? Would new morphological differences arise after age 6? Did faces grow differently in the two groups? Group differences, if any, in the change in sagittal molar relationship were also studied.

Materials and methods

The material consisted of lateral cephalograms selected from the Oslo Growth Material, University of Oslo Department of Orthodontics. This material (n=2167) is based on six age classes from the county of Nittedal, near Oslo, Norway. In collecting the Oslo Growth Material, lateral cephalograms were taken at regular intervals from early childhood to adulthood. The cephalograms were taken with the teeth in occlusion. Subjects in need of orthodontic treatment when examined at 12 years of age were excluded from further registration. Thus, subjects with cephalograms available after 12 years generally had acceptable occlusal conditions, and none received orthodontic treatment.

In the present study, craniofacial growth was followed to 18 years of age. In the files, cephalograms of males older than 15 years were sparse, so only females were included in this study. The subjects selected were divided into two groups based on the sagittal jaw-base relationship at age 6. One group consisted of individuals with normal sagittal relationships and the other group was composed of individuals with a mesial relationship between the jaw bases. The sagittal jaw-base relationship was defined as the distance from pogonion to A-point, measured along the Frankfort horizontal plane (FH). The distance, designated Pg-A sag, had to be 7 to 9 mm in the normal group and 3 mm or less in the mesial jaw-base group (Figure 1). The distance Pg-A sag was a modification of distance AF-BF (distance between A-point and B-point, measured along FH), presented by Chang.[5] Pogonion was included instead of B-point in order to align with Björk's definition of the sagittal jaw-base relationship (angle A-N-Pg).[6]

To be selected, a subject had to have a full set of cephalograms taken at 6, 9, 12, 15, and 18 years of age. The disadvantage of this criterion was that it limited the number of cases available in the files and shrank the number of subjects in each of the two groups to 12.

Judging from the cephalograms, subjects in both groups had Class I molar relationships when selected at 6 years of age. Females with Class III malocclusion who had the required set of cephalograms available were not present in the files.

Craniofacial morphology and growth

Each cephalogram was traced and measured once. All the cephalograms belonging to an individual were traced at the same sitting. Linear and angular dimensions were measured to the nearest 0.5 mm or 0.5°. The following reference points and lines were identified: sella (S), nasion (N), condylion (Cd), porion (Po), orbitale (Or), pterygomaxillare (Pm), spinal point (Sp), gonion (Go), A-point (A), B-point (B), pogonion (Pg), prognathion (Pgn), gnathion (Gn), SN line (SN), Frankfort horizontal plane (FH), nasal plane (NP), mandibular plane (MP), ramus line (RL). The definition of these points and lines has been published earlier.[6]

It was desirable to measure growth change in sagittal skeletal relationship along Frankfort horizontal. Evaluation of subtle growth change in dimensions that are projected on a reference line calls for precise reproduction of the reference line on the serial cephalograms. With FH,

Table 1
Definition of the variables

Linear variables measured along FHe (Figure 2)	
1. A-N sag	Maxillary prognathism. If A-point was anterior to nasion, the distance was given a negative value
2. Pg-N sag	Mandibular prognathism. If pogonion was anterior to nasion, the distance was given a negative value
3. B-N sag	Another measurement of mandibular prognathism. If B-point was anterior to nasion, the distance was given a negative value
4. Pg-A sag	Sagittal jaw-base relationship. If pogonion was anterior to A-point, the distance was given a negative value
5. B-A sag	Another measurement of sagittal jaw-base relationship. If B-point was anterior to A-point, the distance was given a negative value
6. S-Pm sag	Sagittal position of the posterior border of maxilla (Pm) relative to sella
7. Cd-S sag	Sagittal position of the mandibular condyles (Cd) relative to sella
8. Go-S sag	Sagittal position of the angular area (Go) relative to sella. If gonion was anterior to sella, the distance was given a negative value
Other linear variables (Figure 3)	
9. S-N	Length of the anterior cranial base
10. Cd-S	Length of the lateral cranial base, posterior portion
11. Pm-A	Length of the maxillary corpus.
12. Go-Pg	Length of the mandibular corpus
13. Cd-Pgn	Effective mandibular length
14. Cd-A	Effective midfacial length
15. Cd-Go	Height of the mandibular ramus
16. Sp-Gn	Anterior lower facial height
Angles (Figure 3)	
17. Cd-S-N	Lateral cranial base angle (saddle angle)
18. MP-SN	Mandibular plane angle
19. MP-RL	Gonial angle
20. RL-SN	Inclination of the mandibular ramus
Incisor relationships	
21. Overjet	
22. Overbite	

this turned out to be somewhat awkward in some cases. Longitudinal studies by Bhatia and Leighton[7] have shown that the angle between FH and the SN line changes very little with age. In the light of this finding, the following procedure was established: On the cephalogram taken at age 6, FH and SN were drawn and the angle FH-SN measured and designated angle alpha (α). Then a line was constructed through sella at an angle to SN equal to α. On subsequent cephalograms, this line, designated FH estimated (FHe), was easily reproducible and its course was probably very near the real FH.

Figure 2 illustrates how FHe was constructed and how points in the cranial base and jaws were projected on a line parallel to FHe. Distances were read along the FHe parallel from left to right and marked "sag." Other linear variables are illustrated in Figure 3, as are points and lines used in the measurement of angular variables. Table 1 gives definitions of linear and angular variables.

Table 2
Means, standard deviations for distance Pg-A sag at age 6 in groups with normal (n=12) and mesial (n=12) jaw-base relationship

	Pg-A sag (mm)
Normal	7.8 ± 0.6
Mesial	1.6 ± 1.5

Statistical analysis

Absolute and incremental group differences were tested with Student's *t*-test for independent samples. Differences in absolute values were tested at ages 6, 9, 12, 15, and 18 years. Incremental differences were tested for the 6- to 9-year, 9- to 12-year, 12- to 15-year, 15- to 18-year, and 6- to 18-year periods. The level of significance was set at $p \leq 0.01$.

In order to determine whether the initial group-

Table 3
Morphological differences between the two groups tested using Student's *t*-test. Standardized enlargement 5.6%

Variables	6 yrs Mean	6 yrs SD	9 yrs Mean	9 yrs SD	12 yrs Mean	12 yrs SD	15 yrs Mean	15 yrs SD	18 yrs Mean	18 yrs SD
1. A-N sag (mm)										
Normal	0.9	2.0	0.6	2.5	0.2	2.6	0.0	2.5	-0.3	2.6
Mesial	0.7	2.4	0.4	2.8	0.1	3.3	0.3	3.7	-0.4	3.6
p-value	0.82		0.82		0.95		0.82		0.92	
2. Pg-N sag (mm)										
Normal	8.8	2.7	6.6	3.8	5.0	4.2	3.2	4.1	2.0	4.5
Mesial	2.2	3.2	0.0	4.1	-2.0	5.3	-4.2	5.5	-4.8	5.7
p-value	0.0000^{xx}		0.0006^{xx}		0.0017^{x}		0.0013^{x}		0.0039^{x}	
3. B-N sag (mm)										
Normal	8.1	2.7	6.8	3.7	5.8	4.2	4.6	4.0	3.5	4.4
Mesial	2.9	2.9	1.6	4.0	0.0	5.1	-0.7	5.4	-1.2	5.4
p-value	0.0002^{xx}		0.0039^{x}		0.0095^{x}		0.013		0.029	
4. Pg-A sag (mm)										
Normal	7.8	0.6	5.8	1.6	4.8	1.8	3.0	2.4	2.2	2.9
Mesial	1.4	1.5	0.2	2.3	-1.3	3.2	-4.0	2.7	-4.5	3.1
p-value	0.0000^{xx}		0.0000^{xx}		0.0000^{xx}		0.0000^{xx}		0.0000^{xx}	
5. B-A sag (mm)										
Normal	7.1	0.8	6.1	1.5	5.5	1.7	4.5	2.1	3.8	2.4
Mesial	2.0	1.1	1.2	2.0	0.5	2.5	-0.5	2.5	-0.8	2.7
p-value	0.0000^{xx}		0.0000^{xx}		0.0000^{xx}		0.0000^{xx}		0.0002^{xx}	
6. S-Pm sag (mm)										
Normal	19.0	2.3	19.8	2.5	19.9	2.9	19.8	3.0	19.7	3.2
Mesial	20.8	1.6	21.6	2.2	21.8	2.8	22.3	2.8	22.0	3.1
p-value	0.04		0.068		0.11		0.048		0.083	
7. Cd-S sag (mm)										
Normal	11.6	2.3	12.3	2.4	13.5	3.1	14.3	2.9	14.5	2.9
Mesial	10.0	1.6	10.8	1.4	11.7	1.2	12.1	1.2	12.5	1.3
p-value	0.065		0.083		0.074		0.03		0.045	
8. Go-S sag (mm)										
Normal	3.4	2.7	4.7	3.1	5.3	3.9	5.4	4.3	5.0	4.4
Mesial	-1.9	3.6	-1.0	4.6	-0.9	4.5	-0.9	4.6	-0.6	5.5
p-value	0.0006^{xx}		0.0019^{x}		0.0017^{x}		0.0024^{x}		0.012	
9. S-N (mm)										
Normal	63.2	2.4	65.3	2.6	68.0	2.5	69.0	2.6	69.3	2.4
Mesial	64.5	1.8	67.3	2.0	69.7	2.1	70.9	2.6	71.0	2.8
p-value	0.13		0.058		0.078		0.084		0.11	
10. Cd-S (mm)										
Normal	19.8	2.2	22.0	2.4	24.5	2.7	25.5	2.4	25.7	2.3
Mesial	20.2	1.4	21.8	2.0	23.7	2.0	24.4	1.9	25.0	1.7
p-value	0.62		0.82		0.43		0.23		0.46	
11. Pm-A (mm)										
Normal	43.0	1.5	44.3	1.9	47.0	1.6	48.9	2.2	49.3	2.0
Mesial	42.3	1.8	44.2	1.6	46.6	2.5	48.0	2.4	48.6	2.1
p-value	0.36		0.91		0.64		0.36		0.40	

ing variable Pg-A sag would prevail as a group identifier, it was tested alone at ages 6, 9, 12, 15, and 18 in discriminant analyses. In a stepwise discriminant analysis, variables closely attached to the selection criterion were excluded (variables 4 and 5). The purpose was to determine whether features other than the sagittal jaw-base relationship were characteristic of group differences at 6 years and later.

Discriminant analyses were done with the program 7M in the statistics package BMDP.[8] The 7M program prints out two different classification matrices, an ordinary and a so-called Jackknifed matrix. In the former, a classification formula is calculated from the data of all observed cases, and in the latter from data of all cases except the one that is undergoing the process of classification. The Jackknifed matrix provides a more correct portrait of the classification formula's ability to classify new cases.

Results

Table 2 shows means and standard deviations (mm) for the distance Pg-A sag at age 6 in both groups.

As shown in Table 3, significant morphological group differences were related to the relationship of the jaws, not jaw size. These differences were already present at age 6. Significant differences arising later were not observed. Some differences stayed highly significant throughout the entire observation period. These involved differences in sagittal jaw-base relationship (variables [v.] 4 and 5) and in the MP-SN angle, the latter

Table 3 (continued)

Variables	6 yrs Mean	6 yrs SD	9 yrs Mean	9 yrs SD	12 yrs Mean	12 yrs SD	15 yrs Mean	15 yrs SD	18 yrs Mean	18 yrs SD
12. Go-Pg (mm)										
Normal	61.3	2.9	66.7	3.2	71.2	3.1	74.0	4.1	74.8	4.0
Mesial	61.9	2.9	67.3	2.9	72.2	3.3	75.3	4.3	76.0	4.6
p-value	0.62		0.63		0.47		0.47		0.50	
13. Cd-Pgn (mm)										
Normal	94.2	4.2	100.7	4.1	107.9	4.5	112.7	4.2	114.3	4.5
Mesial	95.5	3.1	102.0	3.4	108.4	4.0	113.7	4.4	114.9	4.1
p-value	0.47		0.41		0.78		0.56		0.74	
14. Cd-A (mm)										
Normal	77.2	3.6	80.3	3.7	85.0	3.7	87.1	3.4	87.7	3.3
Mesial	75.9	2.6	79.2	2.6	83.4	3.3	85.7	3.2	86.3	3.1
p-value	0.32		0.40		0.29		0.30		0.32	
15. Cd-Go (mm)										
Normal	44.6	1.9	47.5	1.8	51.4	2.3	54.6	3.0	56.4	3.6
Mesial	45.8	2.5	48.8	2.8	53.0	3.6	57.5	2.9	58.9	3.3
p-value	0.19		0.19		0.22		0.021		0.097	
16. Sp-Gn (mm)										
Normal	56.1	3.3	58.6	3.4	62.0	4.0	64.1	4.3	65.0	4.3
Mesial	53.3	1.8	55.5	2.4	58.3	3.0	60.3	3.9	60.8	4.2
p-value	0.02		0.017		0.018		0.033		0.027	
17. Cd-S-N (°)										
Normal	131.9	5.2	131.5	4.5	131.2	5.4	131.6	5.5	131.6	5.4
Mesial	129.5	4.0	128.9	3.4	128.6	3.1	129.2	3.1	129.2	3.3
p-value	0.21		0.13		0.16		0.20		0.21	
18. MP-SN (°)										
Normal	33.3	3.7	32.0	4.1	31.1	3.7	29.8	4.6	28.9	4.8
Mesial	29.4	2.5	27.9	2.5	26.2	3.1	24.2	3.6	23.2	4.0
p-value	0.0063^{x}		0.0086^{x}		0.0019^{x}		0.0035^{x}		0.0048^{x}	
19. MP-RL (°)										
Normal	128.8	4.2	126.0	4.3	125.1	4.6	122.9	5.7	121.9	6.0
Mesial	127.8	4.7	124.5	5.2	122.3	5.2	119.5	6.0	117.8	6.4
p-value	0.57		0.44		0.18		0.17		0.11	
20. RL-SN (°)										
Normal	84.3	3.6	85.6	3.7	85.9	3.2	86.8	3.3	86.6	3.5
Mesial	81.6	3.2	83.1	3.9	83.7	3.9	84.3	4.1	85.2	4.8
p-value	0.067		0.12		0.15		0.12		0.40	
21. Overjet (mm)										
Normal	2.6	1.0	3.4	0.9	3.5	1.2	3.3	1.1	3.3	0.9
Mesial	2.2	0.8	2.5	1.0	2.5	0.8	2.5	0.7	2.4	0.9
p-value	0.23		0.03		0.026		0.027		0.022	
22. Overbite (mm)										
Normal	1.3	1.4	3.0	1.5	3.6	1.3	3.3	1.3	3.2	1.3
Mesial	1.2	1.9	2.6	1.7	3.0	1.4	2.8	1.2	2.6	1.4
p-value	0.86		0.57		0.27		0.30		0.26	

^{xx} $p \leq 0.001$ ^{x} $p \leq 0.01$

being distinctly smallest with mesial jaw-base relationships at all observation stages (v. 18). In contrast, the group difference in mandibular prognathism gradually became less clear with age (v. 2 and 3), as did the difference in the sagittal position of gonion relative to sella, which was clearly more forward with mesial jaw-base relationships up to age 15, but not later (v. 8). Significant group differences in incremental growth were conspicuous by their absence.

Judging from the cephalograms, sagittal molar relationships changed minimally with age. Most 18-year-olds in both groups had full Class I molar relationships, the only exceptions being two subjects in the normal group whose first permanent molars occluded distally by half the width of a premolar tooth and one subject with a mesial jaw-base relationship who had developed a Class III tendency.

Group discrimination

Table 4 gives the percentage of subjects correctly classified with discriminant analysis using the distance Pg-A sag alone as a group predictor at 6, 9, 12, 15, and 18 years. After excluding variables denoting the sagittal jaw-base relationship, a stepwise discriminant analysis chose the sagittal position of gonion (v. 8) and the anterior lower facial height (v. 16) as effective group discriminators in 6-year-olds. Using discriminant analysis at ages 6, 9, 12, 15, and 18, the two variables in combination correctly classified subjects of the two groups, as shown in Table 5.

Table 4
Correctly classified subjects (%) with discriminant analysis using distance Pg-A sag alone as group predictor. Jackknifed classification in parentheses

Age	Normal n=12	Mesial n=12	Total n=24
6 yrs	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)
9 yrs	100.0 (100.0)	100.0 (91.7)	100.0 (95.8)
12 yrs	100.0 (100.0)	91.7 (91.7)	95.8 (95.8)
15 yrs	100.0 (100.0)	100.0 (91.7)	100.0 (95.8)
18 yrs	91.7 (91.7)	83.3 (83.3)	87.5 (87.5)

Table 5
Correctly classified subjects (%) with discriminant analysis using Go-S sag (v. 8) and Sp-Gn (v. 16) as group predictors. Jackknifed classification in parentheses

Age	Normal n=12	Mesial n=12	Total n=24
6 yrs	100.0 (83.3)	83.3 (83.3)	91.7 (83.3)
9 yrs	100.0 (100.0)	75.0 (66.7)	87.5 (83.3)
12 yrs	100.0 (100.0)	75.0 (75.0)	87.5 (87.5)
15 yrs	100.0 (100.0)	75.0 (75.0)	87.5 (87.5)
18 yrs	91.7 (83.3)	75.0 (75.0)	83.3 (79.2)

Discussion

Parameters used to assess the sagittal jaw-base relationship (ANB, Wits, AF-BF, and APDI measurements) are influenced by irrelevant environmental factors that may cause false diagnosis.[5,9-13] This could also happen to diagnoses based on the distance Pg-A sag. Perhaps the group differences shown in Table 2 were not quite "true." Some of the subjects selected may have been borderline with regard to sagittal jaw-base relationship.

When stipulating the criterion for inclusion in the normal group, composite normative standards worked out by McNamara[14] were useful guidelines. According to these norms, the distance between A-point and a perpendicular to FH, drawn through nasion, is 0 mm, while pogonion lies 6 to 8 mm posterior to that perpendicular in mixed dentition subjects. The distance between A-point and nasion perpendicular changes minimally with age. In contrast, the distance from pogonion to nasion perpendicular diminishes by 0.5 mm every year from age 6 to 18. In the present study, subjects were selected at age 6, when pogonion probably had a slightly more posterior position relative to A-point than in the forthcoming mixed dentition.

The two groups in the present study consisted of 12 subjects each. Admittedly, this is a rather small sample, yet it compares fairly well with previous studies using purely longitudinal data.[2,15] Such data have great advantages compared with mixed and/or cross-sectional data. Tanner[16] believed that the material of a cross-sectional study had to be at least 20 times larger than that of a longitudinal study to give the same degree of precision when evaluating average growth increments. In mixed longitudinal series, Tanner recommended dropping subjects with incomplete sets of data and using only the longitudinal element when evaluating growth changes. Bishara and Jakobsen[2] asserted that any increase or decrease in the number of subjects in mixed longitudinal data would cause the mean value to fluctuate between consecutive ages. This variation is not an age-related variation of the parameter studied. In order to eliminate such random variation, Bishara and Jakobsen limited the number of subjects in their study to those with complete sets of longitudinal data.

Comparison of morphology (Table 3)

In theory, a mesial jaw-base relationship results from mandibular skeletal protrusion or maxillary skeletal retrusion, or both. In the present study, maxillary prognathism was very much alike in the two groups (v. 1). Mesial jaw-base relationships were caused by mandibular skeletal protrusion (v. 2 and 3).

Dietrich[4] drew distinctions between dimensional and positional causes of the skeletal aberrations associated with mesial jaw-base relationships. Studying subjects with a negative ANB angle, she found that maxillary skeletal retrusion was generally caused by a deficiency in the length of the maxilla. Mandibular skeletal protrusion, on the other hand, resulted mainly from a forward positioning of the mandible relative to cranial base. The results of the present study agreed with her results. Mandibular skeletal protrusion in subjects with mesial jaw-base relationships was first caused by gonion having a more forward position than normal relative to sella, the group difference being 5 to 6 mm on average (v. 8). In contrast, the length of the maxilla was about the same in the two groups (v. 11), as was the effective length of the mandible (v. 13).

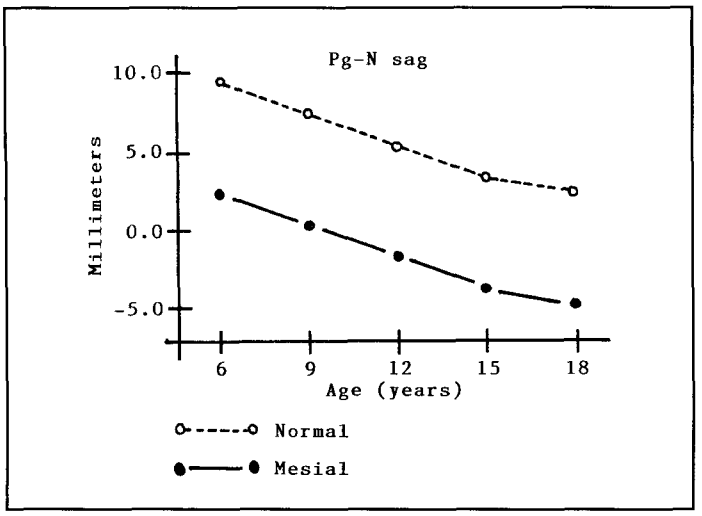

Figure 4

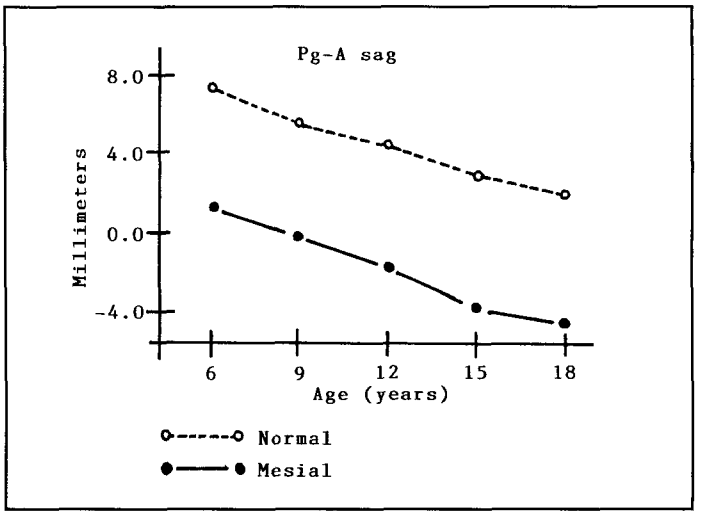

Figure 5

The forward positioning of gonion in subjects with mandibular skeletal protrusion was accompanied by a tendency for a more forward location of the condyles (v. 7). The difference in position of the condyles was, at least in part, caused by the saddle angle being slightly less obtuse in subjects with mandibular skeletal protrusion than in normals (v. 17). Furthermore, subjects with mandibular skeletal protrusion tended to have a more acute angle between ramus and the SN line (v. 20) and a greater ramus height (v. 15). Seemingly, these modest differences in position of the condyles and in inclination and height of the ramus acted synergistically on the group difference for the sagittal position of gonion. The fact that slight changes in more than one variable can have an additive effect that may influence the overall direction of growth has been suggested by previous writers.[2,17] An acute angle between ramus and the SN line giving rise to a forward position of gonion also has been reported earlier.[3]

Conclusively, subjects with mandibular skeletal protrusion had an aberrant mandibular position. Fortunately, they also had a positional aberration in the maxilla, with the posterior maxillary border (Pm) positioned slightly more forward than normal (v. 6). The difference averaged about 2 mm, which was 3 to 4 mm less than the corresponding group difference at gonion (v. 8). Still, the fairly forward position of the rearmost section of the maxillary corpus was a compensatory feature that possibly prevented subjects with mandibular skeletal protrusion from developing a Class III molar relationship and a negative overjet.

Comparison of growth changes

Mandibular prognathism increased at very similar rates in the two groups. Between ages 6 and 18, pogonion moved forward relative to nasion an average of 6.8 mm in normals and 7.0 mm in subjects with mesial jaw-base relationships. Annual increases in mandibular prognathism thus averaged 0.57 mm in normals and 0.58 mm in those with mesial jaw-base relationships, which approximates the norm of 0.5 mm given by McNamara[7] (v. 2 and Figure 4).

In both groups, A-point had a rather stationary sagittal position relative to anterior cranial base, moving forward an average of only approximately 1.0 mm from 6 to 18 years (v. 1), whereas gonion moved slightly distally, about 1.5 to 2.0 mm (v. 8). Consequently, when the mandibular corpus lengthened about equally in the two groups, the initial group difference in sagittal jaw-base relationship underwent small changes (v. 4 and Figure 5).

Accordingly, growth progressed more or less alike in the two groups, while initial morphological group differences persisted. Studying longitudinal changes in three normal facial types, Bishara and Jakobsen[2] suggested that "the outcome of facial growth is influenced, at least in part, by the original size and relationship of the different parts of the face." In the present study, the jaws were originally about the same size in both groups. Variables with original group differences were related to the jaw-base relationship (Table 3, v. 2, 3, 4, 5, 8, 18), and similar growth of equal jaws apparently helped to maintain original differences.

The 6-year-olds with mesial jaw-base relationships deviated only moderately from normal. The initial group difference in distance Pg-A sag therefore was relatively small. Even so, nearly all subjects observed (87.5%) were categorized identically at 6 and 18 years of age when using Pg-A sag as the group predictor (Table 4). When evalu-

Figure 4
Change in group mean distance Pg-N sag (v. 2) in groups with normal and mesial jaw-base relationships. The distance gradually diminished, indicating that mandibular prognathism increased with age; parallel curves are a sign that the increase in mandibular prognathism occurred at similar rates in the two groups.

Figure 5
Change in group mean distance Pg-A sag (v. 4) in groups with normal and mesial jaw-base relationship. Falling and parallel curves indicate that the distance diminished with age equally in both groups.

ated at 18, only one subject from the normal group and two from the mesial jaw-base group were misclassified, indicating a growth pattern that brought them out of their original group characteristics.

After excluding variables attached to the selection criterion, stepwise discriminant analyses chose the sagittal position of gonion (v. 8) and anterior lower facial height (v. 16) as the best group predictors, not only at age 6, but also later. In the normal group, the two variables in combination classified nearly 100% correctly up to age 15. After that, two subjects from the normal group gained facial features characteristic of the mesial jaw-base relationship group. In the mesial jaw-base group, on the other hand, some 75% to 80% of subjects were correctly classified throughout the 6- to 18-year period, with no change in the classification score occurring between ages 15 and 18 (Table 5).

Clinical considerations

The findings of this study could be of some value to those who wish to predict mandibular growth in juvenile Class I females with moderate mandibular skeletal protrusion. Aggravation of the sagittal aberration should generally not be expected. More likely, the sagittal distance between pogonion and A-point will decrease at a normal rate, thereby allowing the Class I molar relationship and positive overjet to endure with time. A mandible that is of normal size in a juvenile is, apparently, a good sign for future mandibular growth.

Conclusions

1. Morphological group differences existed at 6 years of age. New differences did not arise later. Variables that were good group predictors at 6 years continued to show high predictive ability up to late adolescence. The findings thus supported the assumption that the craniofacial pattern is usually determined at an early age and rarely changes with time.

2. Morphological group differences mainly involved jaw-base relationships, not jaw size. Incremental growth progressed very much alike in the two groups. Similar increases in equal jaws seemingly helped to maintain the initial group differences in jaw-base relationships.

3. Mesial jaw-base relationships were the result of mandibular skeletal protrusion caused by the gonial area in particular having a more forward position than normal relative to the anterior cranial base.

4. Mesial jaw-base relationships and mandibular skeletal protrusion did not worsen with growth. Initial group differences in the sagittal jaw-base relationship (distance Pg-A sag) and in mandibular prognathism (Pg-N sag) thus stayed relatively unchanged from 6 to 18 years of age.

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