Association between facial height development and mandibular growth rotation in low and high MP-SN angle faces: A longitudinal study

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When the mandible rotates during growth, it affects the vertical relationships of the face. How growth brings the mandible to rotate is not fully understood. Among factors closely connected with mandibular growth rotation is development of posterior facial height. According to Björk,[1] forward mandibular rotation occurs when posterior facial height overdevelops relative to anterior facial height; when posterior facial height underdevelops, the mandible rotates backward, with overdevelopment of anterior facial height as a result.

In a previous study,[2] attempts were made to reveal craniofacial growth differences between two groups of males with low and high MP-SN angles. Dimensional group differences were explained by different matrix rotations of the mandible, which was the case in the 6- to 12-year period, but not in the following period up to age 15. The purpose of the present study was to thoroughly examine the associations between dimensional growth changes and mandibular growth rotation in a sample comprising low and high MP-SN angle cases of both genders. The focus of attention was skeletal growth in a vertical direction.

Materials and methods

The children who participated in this present study were selected from the Oslo Growth Material, University of Oslo Department of Orthodontics. This group includes six age classes (n=2167) from the county of Nittedal near Oslo, Norway. In collecting the Oslo Growth Material,

Abstract

Two groups of children with low (n=29) and high (n=29) MP-SN angles were followed longitudinally from 6 to 15 years of age. The purpose was to thoroughly examine associations between vertical craniofacial growth and mandibular growth rotation. Correlations between dimensional and rotational variables occurred in different variable pairs in the two groups and changed with age. Increase in posterior lower facial height distinguished itself by being consistently positively correlated with forward matrix rotation irrespective of mandibular plane angle or age. The same applied to increase in ramus height. Increase in lower anterior facial height was, surprisingly, weakly correlated with mandibular rotation, but strongly and positively correlated with increase in corpus length. Overdevelopment of lower anterior facial height in high angle cases occurred because the steep mandibular plane directed corpus growth more downward than normal, not because the mandible rotated backward.

Key Words

Facial height • Mandibular rotation • MP-SN angle • Longitudinal • Cephalometrics.

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Table 1
Definition of some reference points and lines

Reference points	
Condylion (cd)	Point on the contour of the condyle obtained by bisecting the angle formed by tangents to the upper and posterior borders of the condyle, the tangents being parallels to the sagittal and vertical axes of the face, respectively
Gnathion (gn)	The lowest point of the symphysis, measured in relation to the vertical axis SNP'
Gonion (go)	Point on the contour of the mandible obtained by bisecting the angle between the mandibular plane (MP) and the ramus line (RL)
Pogonion marked (pg')	The most prominent point of the symphysis, measured in relation to the mandibular plane (MP)
Reference lines	
Mandibular plane (MP)	The tangent to the lower border of the mandible through gnathion (gn)
Tangential mandibular line (ML_1)	The tangent to the lower border of the mandible
Ramus line (RL)	The tangent to the posterior border of the mandible

Table 2
Definition of variables

Distances measured along the vertical axis SNP' (Figure 1)	
1. s-go	Posterior facial height
2. s-pm	Upper posterior facial height
3. pm-go	Lower posterior facial height
4. n-gn	Anterior facial height
5. n-sp	Upper anterior facial height
6. sp-gn	Lower anterior facial height
7. ii-is vert	Overbite
Distances measured along the sagittal axis SN' (Figure 1)	
8. go-s	Growth direction of gonion. If gonion had a more forward position than sella, the distance was given a negative value
9. ii-is sag	Overjet
Other linear variables (Figure 2)	
10. pm-MP	Vertical distance between pterygomaxillare and the mandibular plane. A measurement of posterior lower facial height
11. s-cd	Length of the lateral cranial base, posterior portion
12. cd-go	Height of the mandibular ramus
13. go-pg'	Length of the mandibular corpus
Angular variables	
14. MP-SN	Mandibular plane angle
15. cd-s-n	Flexure of the lateral cranial base
16. RL-SN	Inclination of the mandibular ramus

lateral cephalograms were taken every third year from 6 years to 21 years of age. Up to age 12, all accessible individuals were included. After age 12, individuals who needed orthodontic treatment were excluded. So, between 6 and 12 years of age, the Oslo Growth Material represents a normal population; after 12 years, the sample has been selected. Cases with lateral cephalograms available after 12 years of age generally had acceptable occlusal conditions, and none of the cases in the sample received orthodontic treatment.

Children in the present study had lateral cephalograms taken at 6, 12, and 15 years of age. The intention was to study craniofacial growth in a juvenile period up to age 12 and, further, during puberty. The goal was to make up two groups of about 30 children each, with fairly even gender distribution and the greatest possible difference in the angle MP-SN. Ideally, selection criteria should be attached to MP-SN measured at 6 years of age. However, among 6-year-olds a limited number of cases with considerable variation in MP-SN was found. Among 12-year-olds the variation was greater. At the selection, therefore, only MP-SN measured at 12 years of age was taken into consideration. In order to achieve the desired group size, MP-SN had to be set at 26° or less in the low angle group and 35° or more in the high angle group. Each group contained 15 boys and 14 girls. Together they represented the outer limits of the archive concerning the size of the angle MP-SN at 12 years of age.

Analysis of dimensional growth changes

Dimensional increase was, in some cases, measured along a sagittal or a vertical axis. The sagittal axis was constructed through sella at an angle of 8° to the SN line and given the designation SN marked (SN′). The vertical axis was the perpendicular to SN′ through nasion, in the following referred to as SNP marked (SNP′). The reason for choosing this coordinate system is given elsewhere.[3] Distances denoting facial height were measured primarily along the vertical axis and so was vertical overbite. Distances measured along the sagittal axis were overjet and the growth direction of gonion.

Figure 1 shows variables that were projected on parallels to the axes SN′ and SNP′. Other linear variables are illustrated in Figure 2, along with points and lines that form part of angular variables. Table 1 gives the definitions of some reference points and lines. Linear and angular variables are explained in Table 2.

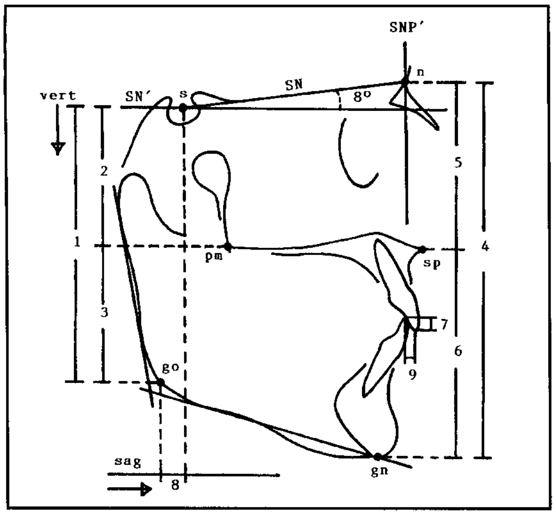

Figure 1

Figure 1
Linear variables projected on parallels to the sagittal axis SN' or the vertical axis SNP'. Sagittal distances were read from left to right, vertical distances from top to bottom (Table 2, v. 1-9). Overbite and overjet (v. 7 and 9) are marked separately.

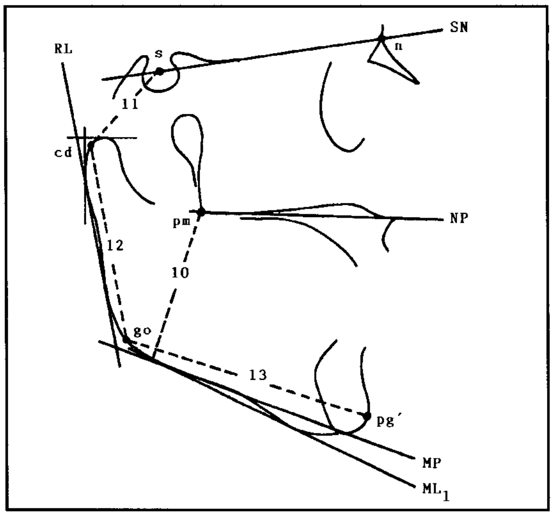

Figure 2

Figure 2
Linear variables within the cranial base and jaws (Table 2, v. 10-13). The figure also illustrates reference points and lines used when measuring angular variables (Table 2, v. 14-16).

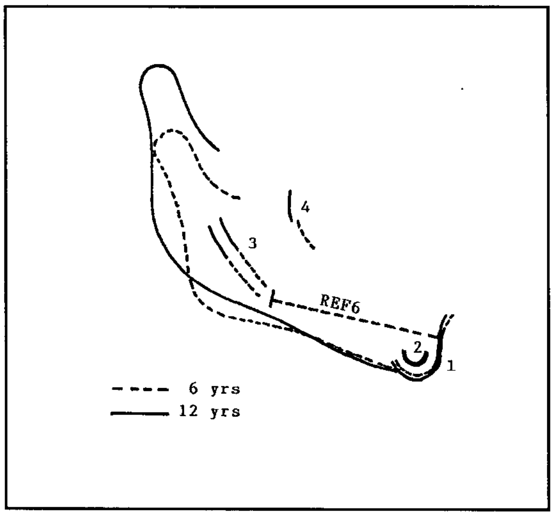

Figure 3A

Figure 3A
Mandibular tracings at two ages superimposed on stable natural structures in the mandibular corpus. At this stage, the reference line (REF 6) can be transferred from the first tracing to the second. Anteriorly, cephalograms are superimposed on the anterior contour of the symphysis (1) and the inner contour of the cortical plate at the lower border of the symphysis (2). Posteriorly, cephalograms are oriented by the contour of the mandibular canal (3). The anterior contour of the ramus is also taken into consideration. Its position on subsequent cephalograms is more posterior, not anterior (4).

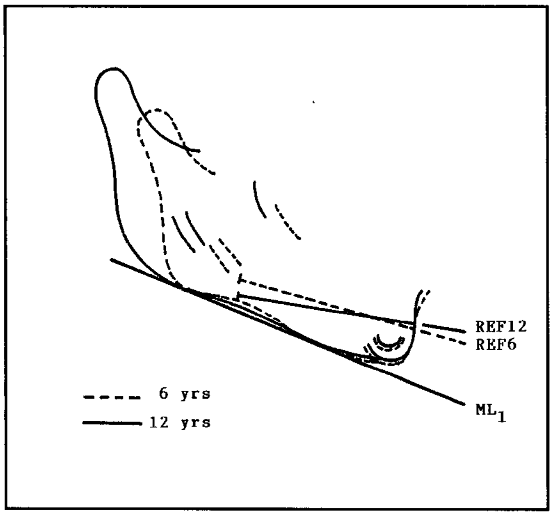

Figure 3B

Figure 3B
Mandibular tracings in Figure 3A superimposed on the ML1-line, showing that the reference line (REF 12) has rotated forward.

Analysis of mandibular growth rotation

Mandibular growth rotation was analyzed by the structural method proposed by Björk and Skieller.[4] Accordingly, mandibular rotation was divided into its two components: matrix rotation and intramatrix rotation. The former is rotation of the soft-tissue covering of the mandibular corpus, which the bony corpus follows. Matrix rotation was defined as the change in inclination of the tangential mandibular line ML_I (Figure 2) relative to the SN line. When ML_I rotated forward, matrix rotation was given a negative sign.

Intramatrix rotation is rotation of the bony corpus inside its soft-tissue covering. This type of rotation is masked by remodeling at the lower border of the mandible. In recording intramatrix rotation, a reference line was drawn in the mandibular corpus on the cephalogram taken at age 6. The line was transferred to subsequent cephalograms after superimposition on stable natural structures in the corpus (Figure 3A-B).

Table 3
Mean and standard deviation for the angle MP-SN at age 12 in the low (n=29) and high (n=29) angle groups

MP-SN (°)	
Low angles	22.1 ± 2.5
High angles	38.7 ± 3.6

Intramatrix rotation was defined as the change in inclination of the reference line relative to the tangential mandibular line ML_I. Intramatrix rotation was recorded as negative when the reference line rotated forward. Total mandibular rotation was defined as the sum of matrix and intramatrix rotation.

Reliability

Cephalograms were taken with the teeth in occlusion. Each cephalogram was traced and mea-

Table 4
Dimensional growth changes in the low (n=29) and high (n=29) angle groups

Growth changes

Variable	6-12 yrs Mean	6-12 yrs SD	12-15 yrs Mean	12-15 yrs SD
1. s-go (mm)				
Low angles	11.6	2.0	6.6	2.8
High angles	9.5	2.2	7.0	2.5
P value	0.0004xx		0.60	
2. s-pm (mm)				
Low angles	6.0	1.3	2.4	1.2
High angles	6.4	1.3	2.5	0.9
P value	0.31		0.62	
3. pm-go (mm)				
Low angles	5.7	2.0	4.2	2.0
High angles	3.1	1.8	4.4	2.2
P value	0.0000xx		0.77	
4. n-gn (mm)				
Low angles	11.2	2.3	5.9	2.9
High angles	14.2	2.4	7.5	2.8
P value	0.0000xx		0.028	
5. n-sp (mm)				
Low angles	6.3	1.4	2.5	1.6
High angles	6.2	1.6	2.8	1.3
P value	0.84		0.49	
6. sp-gn (mm)				
Low angles	5.0	1.6	3.3	1.8
High angles	8.0	1.7	4.7	2.1
P value	0.0000xx		0.0077x	
7. ii-is vert (mm)				
Low angles	2.0	1.4	-0.2	0.6
High angles	2.4	1.7	-0.5	0.9
P value	0.35		0.11	
8. go-s (mm)				
Low angles	1.0	2.5	-0.2	2.1
High angles	1.6	2.0	0.1	1.8
P value	0.31		0.51	
9. ii-is sag (mm)				
Low angles	0.1	1.1	-0.2	0.3
High angles	0.9	1.3	-0.1	0.6
P value	0.029		0.21	
10. pm-MP (mm)				
Low angles	6.1	2.0	4.4	1.9
High angles	4.2	1.5	4.3	2.5
P value	0.0001xx		0.86	
11. s-cd (mm)				
Low angles	4.1	1.1	1.7	1.3
High angles	3.0	1.0	1.9	0.7
P value	0.0003xx		0.40	
12. cd-go (mm)				
Low angles	8.3	2.3	5.3	2.6
High angles	6.9	2.2	5.5	2.5
P value	0.021		0.84	
13. go-pg' (mm)				
Low angles	10.5	1.5	4.7	2.4
High angles	9.6	1.7	4.4	1.8
P value	0.027		0.59	
14. MP-SN (°)				
Low angles	-4.8	1.7	-2.2	1.5
High angles	-1.6	2.1	-2.1	1.5
P value	0.000xx		0.67	
15. cd-s-n (°)				
Low angles	0.5	2.2	0.5	1.0
High angles	0.1	1.6	0.1	0.9
P value	0.36		0.19	
16. RL-SN (°)				
Low angles	1.7	3.0	0.9	1.5
High angles	2.0	2.1	0.6	1.7
P value	0.57		0.41	

xx $P \leq 0.001$, x $P \leq 0.01$.

sured twice. Tolerance limits of 1 mm and 1° were set for differences between the first and second observations of linear and angular measurements. If the limits were exceeded, a new tracing and a new measurement were made. In this way three observations were available, the most extreme being excluded.[5]

Statistical analysis

Group differences in dimensional change and mandibular growth rotation were tested for the 6- to 12-year and 12- to 15-year periods with Student's *t*-test for independent samples. Correlation analyses were performed between dimensional and rotational variables and, further, among some dimensional variables. Each group was analyzed separately. Level of significance was set at $P \leq 0.01$. Finally, a linear discriminant analysis was performed for the 6- to 12-year and 12- to 15-year periods by using total mandibular rotation as group predictor. Statistical analyses were done with programs in the statistics package BMDP.[6]

Results

Table 3 shows means and standard deviations for the angle MP-SN in the low and high angle groups at 12 years of age.

Dimensional growth changes (Table 4)

Significant group differences in dimensional growth change were almost exclusively confined to the 6- to 12-year period. In the low angle group, posterior facial height (variable 1) increased more and anterior facial height (v. 4) increased less than in the high angle group. The differences only applied to the lower facial heights (v. 3, 10 and 6), not to the upper (v. 2 and 5). In the lateral cranial base, the distance between sella and condylion increased most in the low angle group (v. 11), while ramus height tended to do the same (v. 12). As for the angle MP-SN, it decreased in both groups, but more so in the low angle cases (v. 14). After age 12, dimensional changes were similar in the two groups, the only exception being lower anterior facial height, which increased continuously most in the high angle group (v. 6).

Mandibular growth rotation (Table 5)

Matrix rotation and intramatrix rotation were, in general, directed forward in both groups, and, consequently, so was total rotation. In the 6- to 12-year period, total rotation was clearly more forward in the low angle group than in the high angle group. This was due to a group difference in matrix rotation. After age 12, matrix rotation was about the same in the two groups, but intramatrix rotation was less forward in the high angle group ($P \leq 0.018$).

Correlations (Tables 6 and 7)

Correlations between dimensional and rotational variables were found in quite different variable pairs in the two groups. Further, correlations changed with age. Increases in total posterior facial height and lower posterior facial height, however, were always positively correlated with forward matrix rotation, irrespective of group or age, and so was increase in ramus height (Table 6, v. 1, 3, and 12). Correlations between dimensional increase and forward matrix rotation were mostly positive, while correlations between dimensional increase and forward intramatrix rotation usually had a negative sign. Correlations between dimensional increase and intramatrix rotation primarily appeared with high angle cases in the 12- to 15-year period. Curiously, no correlations were noted between increase in lower anterior facial height and total rotation (Table 6, v. 6), but increase in the former was strongly and positively correlated with increase in corpus length in both groups and at both age intervals (Table 7, v. 6 and 13).

Discriminant analysis

With discriminant analysis, low angle and high angle cases were correctly classified in 82.8% of individuals during the 6- to 12-year period using total rotation alone as the discriminating variable. In the 12- to 15- year period, the same variable correctly classified only 58.6% of the cases.

Discussion

Dimensional group differences were explained by different matrix rotation (Tables 4 and 5), which coincides with previous findings.[2] That group differences in increase of facial heights only involved the lower facial heights, not the upper (Table 4, v. 2, 3, 5, and 6), was also reported earlier.[2]

Posterior facial height

The increase in posterior facial height has two components: (1) lowering of the middle cranial fossae relative to the anterior one, the condylar fossae then being lowered, and (2) increase in ramus height.[1] In both groups of the present study, increase in ramus height was about twice that of distance s-cd in the 6- to 12-year period, and even more dominant later (Table 4, v. 11 and 12). Increase in posterior facial height following increase in distance s-cd and ramus height is influenced by changes in cranial base flexure and ramus inclination. Neither of the two conditions changed differently between the groups, nor did the growth direction of gonion (Table 4, v. 15, 16, and 8).

Table 5
Mandibular rotation (total rotation, matrix rotation, and intramatrix rotation) in the low (n=29) and high (n=29) angle groups

	Total rot. (°) Mean	Total rot. (°) SD	Matrix rot. (°) Mean	Matrix rot. (°) SD	Intramatrix rot. (°) Mean	Intramatrix rot. (°) SD
6-12 yrs						
Low angles	-8.0	2.0	-3.0	2.0	-5.1	2.3
High angles	-4.6	2.2	-0.4	2.2	-4.3	2.2
P value	0.0000[xx]		0.0000[xx]		0.18	
12-15 yrs						
Low angles	-3.2	1.8	-1.3	1.7	-1.9	1.3
High angles	-2.4	1.6	-1.4	1.5	-1.0	1.5
P value	0.091		0.71		0.018	

Negative values denote forward rotation: positive values denote backward rotation.
[xx] $P \leq 0.001$, [x] $P \leq 0.01$.

Only a few correlations between dimensional and rotational variables conformed to a regular pattern not taking account of MP-SN angle or age interval. This involved increase in total posterior and lower posterior facial heights, which were always positively correlated with forward matrix rotation, as was increase in ramus height (Table 6, v. 1, 3 and 12). This points to the significance of ramus height in the development of posterior facial height, especially total posterior and the lower posterior. Whether increase in ramus height was primary or secondary to matrix rotation depends upon the nature of condylar growth, which is still controversial.[7]

As for distance s-cd, a positive correlation with forward matrix rotation only presented itself with high angle cases in the 6- to 12-year period (Table 6, v. 11). Sutural growth of the lateral cranial base is, presumably, adapted to growth of the brain, not of the face. In that case, increase in distance s-cd may have been a primary factor, contributing to an otherwise modestly marked forward matrix rotation in juvenile high angle cases (Table 5).

Sometimes increase in posterior lower facial height was correlated positively with forward matrix rotation and negatively with forward intramatrix rotation. Then a correlation between dimensional increase and total rotation did not exist. Most likely this had to do with remodeling processes at the lower border of the angular region. Seemingly such remodeling was a growth-associated variable in juvenile low angle

Table 6
Coefficients of correlation between dimensional increase and mandibular growth rotation in the low (n=29) and high (n=29) angle groups. The signs of the correlation coefficients were changed before producing the table, so a positive correlation appears when dimensional increase is associated with forward rotation

	6-12 yrs			12-15 yrs		
Variable	Total	Matrix	Intram.	Total	Matrix	Intram.
Low angles						
1. s-go	0.215	**0.370**	-0.133	**0.586**	**0.529**	0.135
2. s-pm	0.137	**-0.408**	**0.487**	**0.409**	**0.394**	0.063
3. pm-go	0.130	**0.649**	**-0.458**	**0.600**	**0.501**	0.190
4. n-gn	-0.180	-0.267	0.074	0.262	0.248	0.042
5. n-sp	-0.155	**-0.442**	0.252	**0.428**	**0.459**	0.015
6. sp-gn	-0.190	0.016	-0.187	0.068	0.008	0.073
10. pm-MP	-0.081	**0.375**	**-0.406**	**0.522**	**0.543**	0.031
11. s-cd	-0.105	0.112	-0.194	**0.365**	0.288	0.148
12. cd-go	**0.391**	**0.337**	0.056	**0.543**	**0.434**	0.193
13. go-pg'	0.150	0.313	-0.142	**0.568**	**0.653**	-0.044
High angles						
1. s-go	**0.379**	**0.625**	-0.231	-0.051	**0.608**	**-0.633**
2. s-pm	0.266	**0.384**	-0.108	0.154	0.222	0.051
3. pm-go	**0.348**	**0.556**	-0.194	-0.111	**0.595**	**-0.683**
4. n-gn	0.155	0.083	0.078	-0.227	**0.341**	**-0.562**
5. n-sp	0.070	0.203	-0.130	-0.070	0.284	**-0.343**
6. sp-gn	0.128	-0.088	0.219	-0.242	0.314	**-0.552**
10. pm-MP	0.152	0.276	-0.117	-0.170	**0.642**	**-0.790**
11. s-cd	**0.475**	**0.538**	-0.046	0.211	0.288	-0.054
12. cd-go	0.252	**0.339**	-0.078	0.014	**0.622**	**-0.578**
13. go-pg'	**0.599**	0.245	**0.373**	0.053	**0.644**	**-0.559**

1% significance level demands |r| ≥ 0.337. Significant r-values in bold type.

and adolescent high angle cases (Table 6, v. 3).

Anterior facial height

Lower anterior facial height increased most with the high angle cases, not only in the 6- to 12-year period, but also later, when other dimensional group differences ceased to exist (Table 4, v. 6). Increases in lower anterior facial height and total mandibular rotation were not correlated (Table 6, v. 6). Apparently the difference in increase in lower anterior facial height had little to do with total rotation. More likely this difference was connected with the growth direction of gnathion. In high angle cases, MP-SN decreased by, on average, 3.7° from 6 years to 15 years of age (Table 4, v. 14). Still, lower anterior facial height increased 12.7 mm and the lower posterior height increased only 7.5 mm (Table 4, v. 6 and 3). In both groups gonion was lowered only slightly in a distal direction during growth (Table 4, v. 8). Therefore, when corpus lengthened, gnathion was moved forward and downward.

As Table 7 shows, increase in lower anterior facial height and lengthening of the mandibular corpus were strongly correlated, not only in the high angle group, but also in the low (v. 6 and 13). Due to the difference in mandibular plane inclination, corpus growth was directed most downward in the high angle cases.

In the 6- to 12-year period, MP-SN was a fairly good indicator of the direction of total mandibular rotation, but not later (compare results of the discriminant analysis). However, correlations between increase in lower anterior facial height and change in the MP-SN angle were nonexistent at both age intervals (Table 7, v. 6 and 14). This reinforces the impression that lower anterior facial height was influenced to only a small degree by total mandibular rotation.

As mentioned, subjects selected for this study had no need for orthodontic treatment when examined at 12 years of age. This suggests that they had normal incisal relationships, and, consequently, that forward total rotation occurred without the development of a deepbite. The fact that vertical overbite changed modestly and similarly in the two groups supports that assumption (Table 4, v. 7). A stable incisor occlusion prevented underdevelopment of lower anterior facial height.[1] This, in turn, may explain why cases of the present study displayed no negative correlations between increase in lower anterior facial height and forward total rotation. Such a correlation was demonstrated earlier,[2] although in that study, low and high angle groups were considered together in the correlation analysis, not separately as was the case in the present study.

Growth change in puberal high angle cases

In the high angle group, growth changed character in the 12- to 15- year period. Matrix rotation, being only slightly marked in the 6- to 12-year period, turned forward at a rate similar to matrix rotation in the low angle group. In the latter, on the other hand, a fairly clear forward matrix rotation existed, not only after age 12, but also in the preceding period. Therefore, a noticeable change in growth did not take place (Table 5).

According to Björk and Skieller,[4] intramatrix rotation compensates for the difference between total rotation and matrix rotation. When matrix rotation in puberal high angle cases increases relative to total rotation, intramatrix rotation decreases. In the 12- to 15-year period, a clear group difference in mandibular rotation only involved intramatrix rotation in high angle cases being a little less forward than in the low angle cases

(Table 5). Judging from Table 6, intramatrix rotation in puberal high angle cases initiated remodeling processes at the lower border of the mandible, both anteriorly and posteriorly, resulting in a negative correlation between dimensional increase and forward intramatrix rotation. This must have modified dimensional increase connected with forward matrix rotation. Hans, Enlow, and Noachtar,[8] describing remodeling of the ramus, proposed that variations in the pattern of apposition and resorption were related to morphologic requirements placed on mandibular development by morphologic and functional conditions of the surroundings. Intramatrix rotation, causing remodeling and change in form of the mandibular corpus, could be a reply to similar morphologic requirements.

Table 7
Coefficients of correlation between growth changes of lower anterior facial height, corpus length and the angle MP-SN in the low (n=29) and high (n=29) angle groups

	6-12 yrs		12-15 yrs	
	13. go-pg'	14. MP-SN	13. go-pg'	14. MP-SN
Low angle group				
6. sp-gn	**0.585**	-0.077	**0.442**	-0.009
High angle group				
6. sp-gn	**0.579**	-0.049	**0.797**	-0.316

1% significance level demands |r| ≥ 0.337. Significant r-values in bold type.

Backward rotators - a rarity?

High angle cases of the present study had total rotation directed forward. No case of backward total rotation was noted, in spite of the fact that there were some extreme cases, with seven of the children having MP-SN values of 40° or more, the highest being 44.5° (measured at age 12). But the rotation rate was somewhat slower than in the low angle group. From 6 to 15 years of age, total rotation was forward with, on average, 11.2° in the low angle group and only 7.0° in the high (Table 5). In comparison, Björk and Skieller[4] found total rotation to be forward an average of 15.4° from 4 years to adulthood in a sample composed mainly of harmonious faces and good occlusions. Miller and Kerr[9] gave a somewhat lower mean value (12.5°) for forward total rotation from 4 to 20 years of age in material encompassing a wide range of malocclusions. Since mandibular rotation decreases markedly after age 15,[9] these two means bear fair concordance with mean rotation of the low angle group. Obviously, most high angle cases of the present study had total rotation directed less forward than normal, especially in the 6- to 12-year period.

Traditionally, high angle cases are believed to be "backward rotators." The present findings suggest that "forward hyporotators" is a more realistic term, provided there are no aberrations in condylar growth caused by disease or trauma. This would be in accordance with Björk and Skieller,[10] who considered backward total rotation in a case of long face syndrome an extreme example of normal variation.

Is backward total rotation a common etiological factor in the development of a skeletally conditioned anterior open bite? The present findings question that assumption by excluding backward total rotation as a common trait of craniofacial growth in healthy individuals. According to earlier writers,[11,12] most people have the same facial type from early childhood to adulthood. In high angle cases of the present study, the inclination of the mandibular plane remained fairly unchanged from 6 years to 15 years of age. Average decrease in the angle MP-SN only amounted to 3.7°, which was less than in the low angle group (Table 4, v. 14). Most likely, a steep mandibular plane and a large lower anterior facial height are inherent characteristics. A steep mandibular plane contributes to anterior open bite by directing corpus growth in a more downward direction than normal, thus maintaining or aggravating overdevelopment of lower anterior facial height.

Clinical considerations

In the present study, no correlation was noted between an increase in lower anterior facial height and total rotation (Table 6, v. 6). From this can be deduced that clinical attempts to stimulate forward mandibular rotation in high angle cases may have questionable compensatory effects on lower anterior facial height and vertical overbite. Vertical overbite changed similarly in the low and high angle groups (Table 4, v. 7). Apparently, elongation of incisor heights had a great potential for compensation of overdevelopment of lower anterior facial height. This would be in accordance with earlier findings.[2] A main treatment objective in high angle cases should therefore be avoidance of forces that interfere with the natural dentoalveolar compensatory mechanisms. Preventive or interceptive therapies are desired in order to eliminate finger sucking, prolonged infantile swallowing, tongue thrust and other abnormal perioral muscle activities. Preferably, the orthodontist should see the child at an early stage, i.e., before a frontal openbite has developed. This would call for collaboration between the orthodontist and general dentist.

Conclusions

1. Increase in lower posterior facial height was consistently and positively correlated with forward matrix rotation irrespective of mandibular plane angle or age. In juvenile low angle cases and puberal high angle cases, increase in lower posterior facial height was correlated positively with forward matrix rotation and negatively with forward intramatrix rotation. In such cases, a correlation between increase in lower posterior facial height and total rotation was cancelled, possibly due to remodeling processes at the lower border of the angular region initiated by intramatrix rotation.

2. Contrary to expectations, an increase in lower anterior facial height was weakly correlated with mandibular rotation, but strongly and positively correlated with increase in corpus length. The role of mandibular rotation as a determinant of lower anterior facial height (distance sp-gn) is probably less than what is generally believed. With reference to this, an exception should be made for individuals with basal deepbite.

3. In healthy individuals, backward total rotation occurs less frequently than what has been previously assumed. A steep mandibular plane is probably an inherent characteristic in most cases, not the result of backward total rotation. In juvenile high angle cases, inadequate forward matrix rotation accompanied by underdevelopment of posterior lower facial height often maintain gonion in a relatively cranial position, thus conserving the steep course of the mandibular plane. Skeletal frontal openbite may occur at a juvenile age or later when a steep mandibular plane directs corpus growth more downward than normal, thereby maintaining or accentuating overdevelopment of lower anterior facial height. The elongation of incisor height has, however, a great potential for compensation of a skeletal anterior openbite pattern of growth.

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