Malocclusion and Facial Morphology Is there a Relationship?

An Epidemiologic Study

Porntip P. Siriwat
Joseph R. Jarabak

A study of 500 randomly selected orthodontic patients finding marked correlations between Angle class of malocclusion and vertical facial dimensions

KEY WORDS: • Cephalometrics • Epidemiology • Growth • Malocclusion •

Relationships between craniofacial morphology and malocclusion have been explored in previous studies with varying results.

Schwarz (1960) concluded from his "cephalometric and gnathometric analyses" that "there is no essential causal connection between malocclusions and skull architecture. Every malocclusion can be combined with the most different natural variations of skull architecture."

Schudy (1964 and 1965), found no correlation between the morphologic pattern and specific types of occlusion in 270 subjects. In 400 malocclusions the only notable finding was that the occlusal/mandibular plane angle and the S-N/mandibular plane angle were excellent indicators of facial type.

The purpose of the present study was to seek possible identifiable associations between the different Angle types of malocclusion and facial morphology as it is identified with hyperdivergent, neutral and hypodivergent facial patterns. These patterns are commonly associated with posterior (hyperdivergent) and anterior (hypodivergent) growth rotations, but growth and growth rotations were not examined directly in this cross-sectional study.

Author Address

Dr. Porntip P. Siriwat
Department of Orthodontics
Washington University
School of Dental Medicine
4559 Scott Avenue
St. Louis, MO 63110

Dr. Siriwat is Assistant Professor of Orthodontics at the Washington University School of Dental Medicine in St. Louis, Missouri. She is a Dental graduate of Mahidol University in Bankok, Thailand and holds an M.S. degree and Certificate in Orthodontics from the University of Chicago.

Dr. Jarabak is Professor Emeritus at Loyola University in Chicago. He is a Dental graduate (D.D.S.) of the University of Michigan, and holds an M.S. degree in Orthodontics and Ph.D. in Physiology from Northwestern University in Chicago.

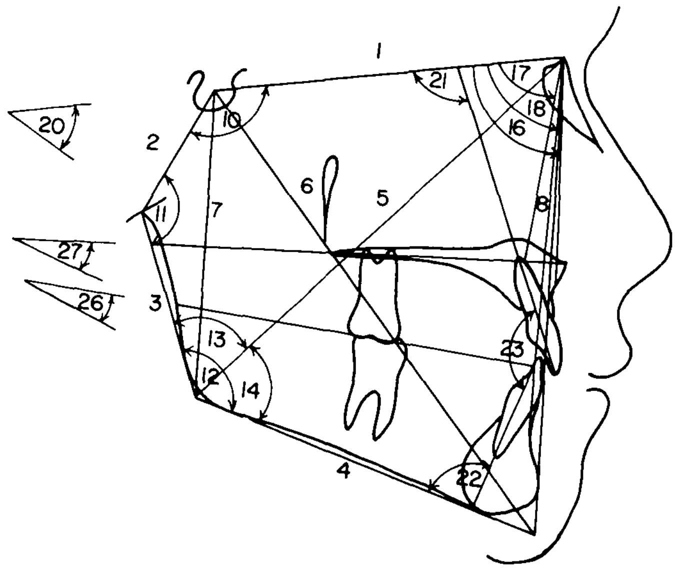

Fig. 1 Measurements in the Jarabak Analysis

Skeletal Parameters

1	S-N (mm)	Anterior Cranial Base
2	S-Ar (mm)	Posterior Cranial Base
3	Ar-Go_C (mm)	Ramus Height
4	Go_C-Me (mm)	Mandibular Corpus
5	N-Go_C (mm)	Facial Depth
6	S-Gn (mm)	Facial Length
7	S-Go_C (mm)	Posterior Facial Height
8	N-Me (mm)	Anterior Facial Height
9	PFH/AFH	Facial Height Ratio (FHR)
10	N-S-Ar	Saddle Angle
11	S-Ar-Go_C	Articular Angle
12	Ar-Go_C-Me	Gonial Angle
13	Ar-Go_C-N	Upper Gonial Angle
14	N-Go_C-Me	Lower Gonial Angle
15	(10)+(11)+(12)	Sum of angles
16	S-N-Pog	Facial Angle
17	S-N-A_S	S-N-Skeletal A
18	S-N-B	S-N-B
19	(17)−(18)	Skeletal A-N-B
20	S-N/Go_C-Me	S-N/Mandibular Plane

Dental Parameters

21	U1/S-N	
22	L1/Go_C-Me	L1/Mandibular Plane
23	U1/L1	
24	U1toN-Pog (mm)	U1 to Facial Plane
25	U1toN-Pog (mm)	L1 to Facial Plane
26	OP/MP	Occlusal/Mandibular Plane Angle
27	PP/MP	Palatal/Mandibular Plane Angle

— Materials and Methods —

Pretreatment lateral cephalographs of 500 patients (Table 1) were drawn by random sampling from the private practice files of Dr. Joseph Jarabak. Age range was 8 to 12 years.

Cephalometric analysis was based primarily on measurements used by Jarabak (Fig. 1). Craniofacial landmarks (Fig. 2) were traced and digitized. Bilateral structures were traced by bisecting right and left images.

While several analyses are currently used to assist in diagnosis of growth directions, the Jarabak analysis used in this study employs many of Björk's morphologically descriptive basic skeletal parameters. These are also very adaptable to digitization.

Jarabak has categorized facial morphology on the basis of three distinct patterns defined by the Facial Height Ratio (FHR), or Jarabak quotient. This is the

1 Nasion
2 Sella turcica
3 Articulare
4 Most posterior point on inferior posterior mandibular border
5 Most inferior point on posterior inferior mandibular border
6 Menton
7 Gnathion
8 Pogonion
9 Supramentale (Point B)
10 Mandibular Incisor Apex
11 Mandibular Incisor Edge
12 Cusp tip of Second Bicuspid or Deciduous Molar
13 Mesiobuccal cusp tip of Mandibular First Molar
14 Mesiobuccal cusp tip of Maxillary First Molar
15 Posterior Nasal Spine
16 Anterior Nasal Spine
17 Subnasale (Point A)
18 Point A_S (skeletal A)
19 Maxillary Incisor Apex
20 Maxillary Incisor Edge
21 Orbitale
22 Anatomical Porion

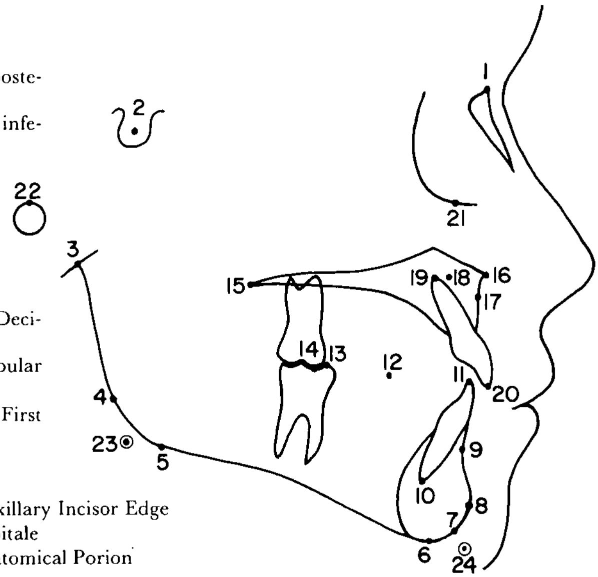

Fig. 2 Digitized points. Points 23 (Go_C) and 24 (Gn_C) are constructed points not digitized from the radiograph.

ratio of posterior facial height ($S\text{-}Go_C$) to anterior facial height (N-Me) —

$$FHR = S\text{-}Go_C/N\text{-}Me$$

These patterns (Figs. 3 and 4) are commonly associated with rotational growth changes that tend to accentuate the pattern characteristics with growth, so even static evaluations are identified in terms of growth, as follows—

1. *Hyperdivergent growth pattern,* with the FHR <59% and the face rotating downward and posteriorly with growth (Fig. 5). Anterior facial height increases more rapidly than posterior height, and Downs's Y-axis and some other angles tend to open.

2. *Neutral growth pattern,* with FHR 59%-63%, is the most prevalent. Growth direction is downward and forward along Downs's Y-axis, with about the same increments anteriorly and posteriorly and no progressive change in most angular relationships (Fig. 6).

3. *Hypodivergent growth pattern,* with predominantly horizontal growth and FHR >63% (Fig. 7).

The overlap of the circles in Fig. 3 represent what Jarabak calls the gray zones, where it is difficult to predict which direction future growth will carry the face. Generally, males in either of these gray zones tend to become more

Table 1

Sample Distribution

	Female	Male	Total
Class I	134	102	236
Class II^1	113	77	190
Class II^2	26	16	42
ClassIII	19	13	32
Total	292	208	500

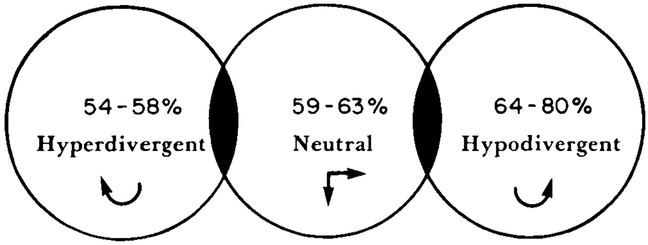

Fig. 3 Jarabak craniofacial growth spheres
Posterior/Anterior Facial Height Ratio (FHR) values

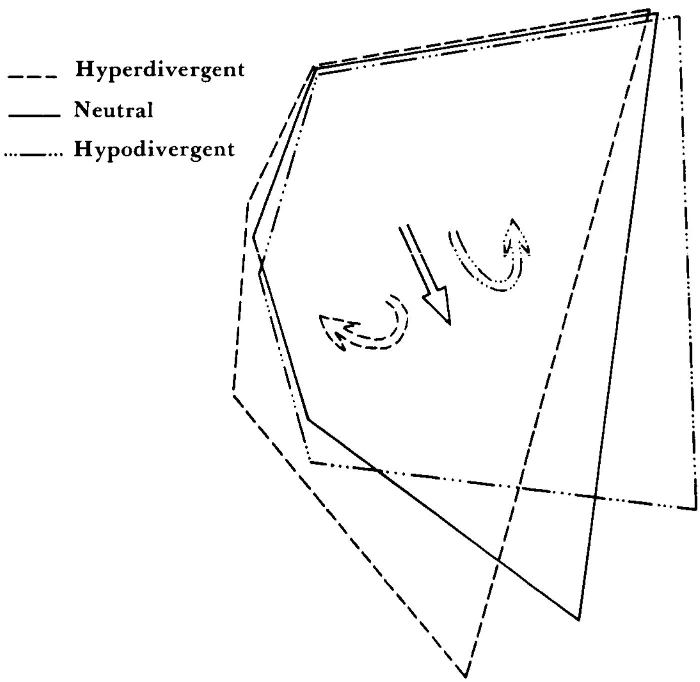

Fig. 4 Facial growth rotations resulting from differential vertical growth

prognathic, while females become more retrognathic or remain the same (Barrett 1976).

Statistical Methods

Means and standard deviations were supplemented by coefficients of correlation (r) between FHR and other cephalometric variables. A value of $r<0.5$ is considered to be a low correlation, $r>0.5$ and <0.7 as moderate, and $r>0.7$ as a high correlation.

— Results —

Facial height values and ratios are shown in Table 2.

Figure 8 and Table 3 show the hyperdivergent pattern group to be the smallest (10%), with the neutral and hypodivergent almost equal at 46% and 44%. Figures 8 - 10 show the distribution of malocclusions among morphological patterns.

Correlations of FHR ratio with other variables are shown in Table 4.

— Discussion —

Class I and Class II[1] dominated among the neutral growers, which also accounted for the largest number of those types of malocclusion.

Similarly, Class II[2] was the dominant malocclusion among the hypodivergent pattern subjects, where the greatest incidence of this type of malocclusion was found.

Table 2

Posterior Facial Height, Anterior Facial Height and Facial Height Ratio

(Mean ± Standard Deviation)

	Female	Male	Total Sample
Class I Malocclusion			
PFH	69.9±4.5	72.2±4.6	70.9±4.7
AFH	110.8±6.4	114.0±6.1	112.2±6.5
FHR	63.2±3.8	63.4±4.5	63.3±4.1
Class II, division 1 Malocclusion			
PFH	70.2±5.0	73.2±4.2	71.4±4.9
AFH	110.6±5.8	113.4±5.4	111.7±5.8
FHR	63.5±4.0	64.6±3.6	63.9±3.9
Class II, division 2 Malocclusion			
PFH	70.1±4.4	74.4±5.4	71.7±5.2
AFH	108.2±5.3	110.7±5.0	109.2±5.3
FHR	64.8±4.5	67.2±2.9	65.7±4.1
Class III Malocclusion			
PFH	71.9±4.9	73.1±4.7	72.4±4.8
AFH	114.3±7.8	113.7±4.6	114.0±6.6
FHR	63.0±4.3	64.4±4.2	63.6±4.2

Table 3

Distribution of Malocclusions Among Growth Patterns

	Class I	Class II[1]	Class II[2]	Class III	Total
All Subjects					
Hyperdivergent	31 (13.1%)	12 (6.3%)	1 (2.4%)	(18.8%)	50 (10.0%)
Neutral	114 (48.3%)	91 (47.9%)	15 (35.7%)	10 (31.2%)	230 (46.0%)
Hypodivergent	91 (38.6%)	87 (45.8%)	26 (61.9%)	16 (50.0%)	220 (44.0%)
Female Subjects					
Hyperdivergent	16 (11.9%)	10 (8.8%)	1 (3.8%)	3 (15.8%)	30 (10.3%)
Neutral	68 (50.8%)	55 (48.7%)	12 (46.2%)	10 (52.6%)	145 (49.7%)
Hypodivergent	50 (37.3%)	48 (42.5%)	13 (50.0%)	6 (31.6%)	117 (40.0%)
Male Subjects					
Hyperdivergent	15 (14.7%)	2 (2.6%)	-0-	3 (23.1%)	20 (9.6%)
Neutral	46 (45.1%)	36 (46.8%)	3 (18.8%)	-0-	85 (40.9%)
Hypodivergent	41 (40.2%)	39 (50.6%)	13 (81.2%)	10 (76.9%)	103 (49.5%)

Table 4

Correlation Coefficients of FHR with Selected Varables

	Female				Male				Total Sample			
	I	II[1]	II[2]	III	I	II[1]	II[2]	III	I	II[1]	II[2]	III
Ramus Height	+.57	+.68	+.76	+.40	+.67	+.58	+.63	+.77	+.61	+.65	+.72	+.56
Gonial Angle	−.40	−.52	−.58	−.46	−.66	−.52	−.58	−.68	−.53	−.53	−.62	−.50
Lower Gon A	−.66	−.69	−.73	−.76	−.76	−.65	−.74	−.72	−.71	−.68	−.75	−.75
Sad+Ar+Gon A	−.93	−.92	−.95	−.96	−.95	−.92	−.97	−.95	−.94	−.92	−.95	−.95
S-N/MP	−.93	−.92	−.95	−.96	−.95	−.92	−.97	−.95	−.94	−.92	−.95	−.95
OP/MP	−.49	−.60	−.55	−.60	−.57	−.55	−.60	−.56	−.53	−.59	−.56	−.58
PP/MP	−.69	−.73	−.72	−.77	−.78	−.67	−.27	−.82	−.74	−.71	−.66	−.77
FH/MP	−.74	−.57	−.84	−.89	−.81	−.47	−.51	−.59	−.80	−.54	−.84	−.80
Y Axis	−.67	−.61	−.81	−.78	−.73	−.69	−.27	−.69	−.69	−.63	−.73	−.73
S-N-B	+.61	+.51	+.57	+.53	+.57	+.59	+.51	+.52	+.59	+.52	+.59	+.50
Post Cran Base	+.33	+.47	+.37	+.41	+.26	+.29	+.71	+.32	+.29	+.42	+.52	+.39

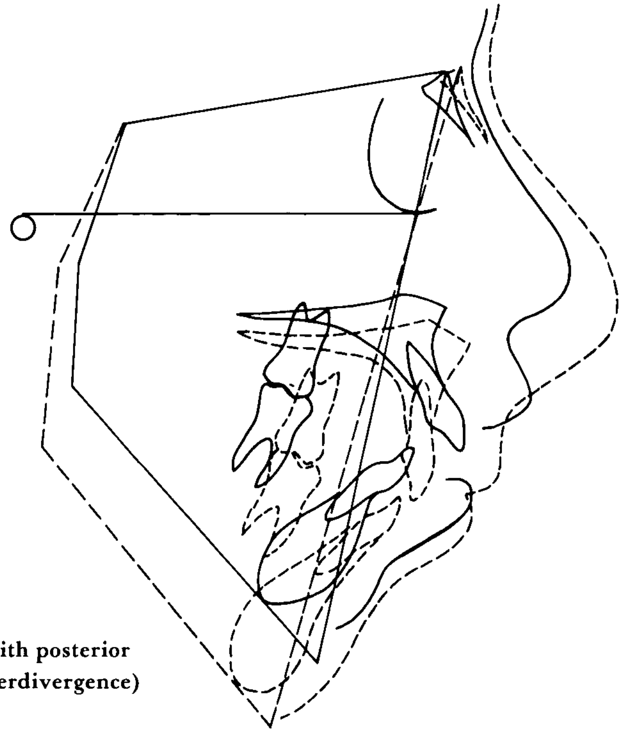

Fig. 5 **Facial morphology with posterior growth rotation (hyperdivergence)**

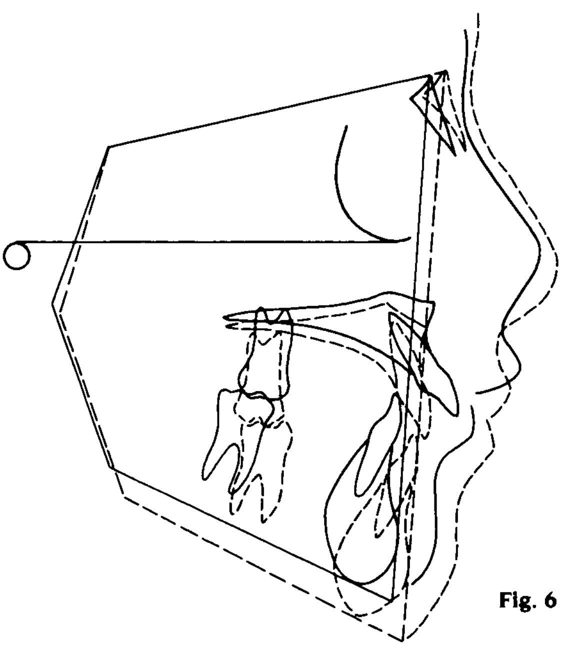

Fig. 6 **Facial morphology with neutral growth pattern**

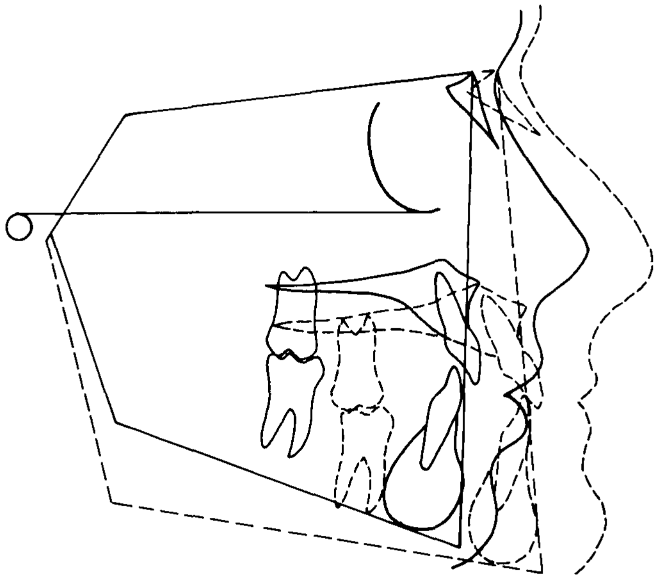

Fig. 7 Facial morphology with anterior growth rotation (hypodivergence)

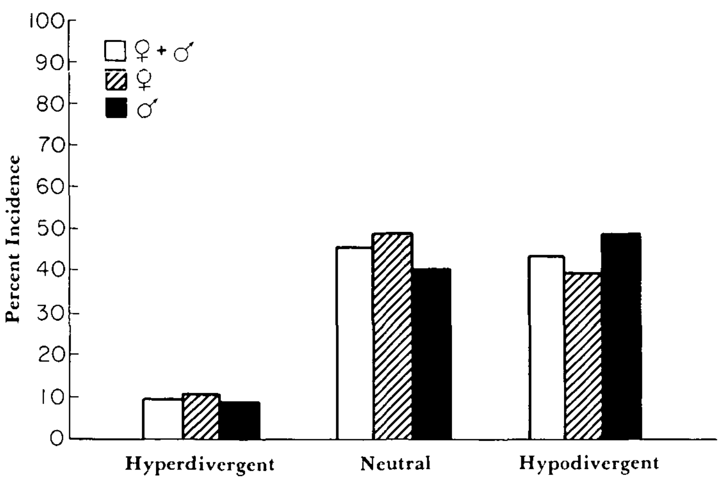

Fig. 8 Distribution of growth patterns among orthodontic patients

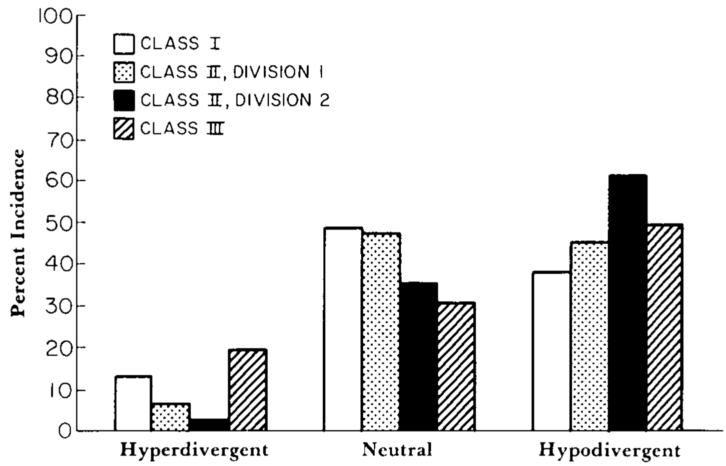

Fig. 9 Distribution of malocclusion classes among patterns in the total sample

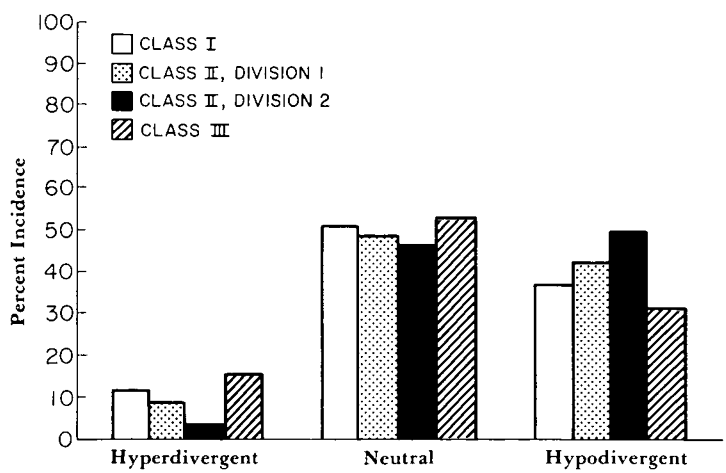

Fig. 10 Distribution of malocclusion classes among growth in female orthodontic patients

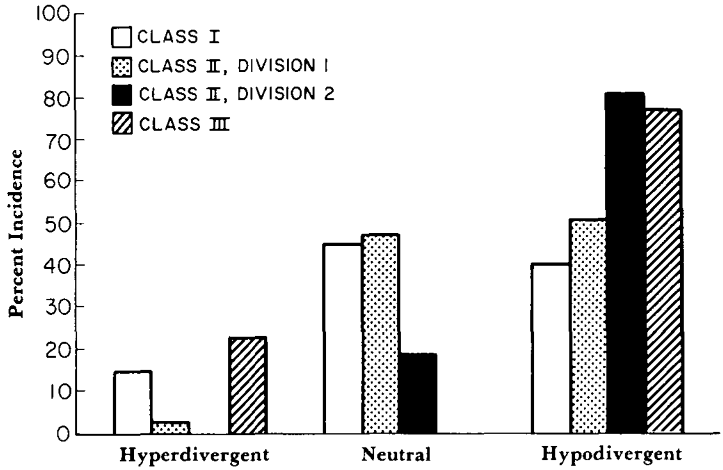

Fig. 11 **Distribution of malocclusion classes among patterns in male orthodontic patients**

On the other hand, even though Class III malocclusion was the dominant type among the hyperdivergent subjects, the highest incidence of Class III was in the hypodivergent pattern group (Fig. 9).

Of the Class I malocclusions, 13.1% demonstrated hyperdivergence, 48.3% neutrality and 38.6% hypodivergence.

For Class II^1 malocclusion, 6.3% were hyperdivergent, 47.9% neutral and 45.8% hypodivergent.

Class II^2 malocclusions demonstrated 2.4% hyperdivergent, 35.7% neutral and 61.9% hypodivergent patterns.

Among the Class III malocclusion subjects, the distribution was 18.8% hyperdivergent, 31.2% neutral and 50% hypodivergent. The hyperdivergent pattern in Class III was probably related to those with openbite, short posterior cranial base length and short ramus height characteristic of a prominent subgroup of Class III subjects, while long ramus and corpus were observed in Class III hypodivergent patterns.

Sexual dimorphism was evident in several categories (Figs. 10 and 11). In the female population, 40% demonstrated a hypodivergent pattern, compared to 49.5% of the males, while those figures were almost reversed for the neutral pattern (49.7% of all females, 40.9% of all males).

Among the malocclusion groups, sexual dimorphism was lowest among Class I malocclusions and progressively greater in Classes II^1, II^2 and III.

The findings in this study differ somewhat from those of Barrett (1976), whose study of 26 nongrowing postretention orthodontic patients included 20 Class I (8 males, 12 females) and 6 Class II^1 (4 males, 2 females). Barrett reported a hypodivergent pattern in almost all males, while the female subjects included both hyperdivergent and hypodivergent patterns.

The correlation matrix (Table 4) shows strong correlations between facial height ratio (FHR) and other variables. Biologic interpretation of these highly complex interrelated morphological parameters suggests the existence of certain patterns in growth direction. These correlations indicate that high FHR values are associated with relatively high values of ramus height and S-N-B, and with relatively low values for gonial angle, lower gonial angle, S-N/MP angle, Y-axis angle and the sum of saddle + articular + gonial angles.

These relationships essentially characterize two distinct basic morphological architectures —

- ***The hyperdivergent face*** is associated with short ramus height and small S-N-B angle, and with large gonial angle, S-N/MP angle, PP/MP angle, OP/MP angle, FH/MP angle, Y-axis angle and sum of saddle + articular + gonial angles.
- ***The hypodivergent face*** is associated with long vertical ramus height and larger S-N-B angle, and with smaller gonial angle, lower gonial angle, SN-MP angle, PP/MP angle, OP/MP angle, FH-MP angle, Y-axis angle, and sum of saddle + articular + gonial angles.

The findings described by Schudy (1965 and 1966) for hyperdivergent and hypodivergent faces are supported by the findings in this study. Schudy reported that the S-N/MP and OP/MP angles were highly correlated with these facial types, and that the Y-axis was not. In this study, the Y-axis was found to be even more highly correlated with FHR than was the OP/MP angle ($r=-0.63$ to -0.73 vs. $r=-0.53$ to -0.59). FHR was strongly correlated with posterior cranial base only in males with Class II² malocclusions.

The existence of a large proportion (81.2%) of hypodivergent patterns in the class II² male group, and the fact that the posterior cranial base in Class II² males was found to be larger than in other malocclusions of both sexes are both significant findings.

A high FHR is strongly correlated with long posterior cranial base.

It is also interesting to note the sexual dimorphism in correlations between FHR and gonial angle. Correlations were stronger in males (−0.63 vs. −0.48), probably due to the tendency of the male pattern toward hypodivergence while the female tends toward neutral.

— Summary and Conclusions —

The purpose of this study is to examine associations between facial morphology and malocclusion, and to test for sexual dimorphism in such relationships.

The sample of 500 subjects is studied by roentgenographic cephalometry, using the Facial Height Ratio (FHR) of Jarabak as the mensurational approach to describe craniofacial morphology.

Significant findings are:

- Neutral pattern is dominant in Class I and Class II¹ malocclusions.
- Hypodivergent pattern is dominant in Class II² and Class III malocclusions.
- The majority of females demonstrate a neutral pattern, whereas the majority of males demonstrate a hypodivergent pattern.
- Sexual dimorphism in pattern is greatest in Class II¹ and Class III.
- Males show a greater tendency toward prognathism, while females tend toward orthognathism and retrognathism.
- Mean values of all linear measurements in males are larger than in females.
- Relatively strong correlations are found between facial height ratio and ramus height, gonial angle, lower gonial angle, mandibular plane angle, occlusal/mandibular plane angle, palatal/mandibular plane angle, Frankfurt/mandibular plane angle, S-N-B, Y-axis angle, and the sum of the saddle + articular + gonial angles.

References on next page

References

Barrett, J. 1976. *Serial cephalometric study of growth and treatment changes*. Masters Thesis, University of Chicago.

Björk, A.

1947 The face in profile; an anthropological X-ray investigation on Swedish children and conscripts. *Svensk. Tandl. Tidskr.* 40:No.5B, supp. Lund.

1969 Prediction of mandibular growth rotation. *Am. J. Orthod.* 55:585-99.

Coben, S. E.

1955 The integration of facial skeletal variants: a serial cephalometric roentgenographic analysis of craniofacial form and growth. *Am. J. Orthod.* 41:407-34.

1961 Growth concepts. *Angle Orthod.* 31:194-201.

1966 Growth and Class II treatment. *Am. J. Orthod.* 52:5-26.

1971 The biology of Class II treatment. *Am. J. Orthod.* 59:470-87.

Creekmore, T. D. 1967. Inhibition or stimulation of the vertical growth of the facial complex, its significance to treatment. *Angle Orthod.* 37:285-97.

Goldstein, M. 1964. Changes in dimensions and form of the face and head with age. *Am. J. Phys. Anthrop.* 22:37-89.

Hunter, W. S. 1968. Elementary principles of cephalometrics. In *The human face*, ed. D. H. Enlow. New York:Harper and Row.

Jarabak, J. R., and Fizzell, J. A. 1972. *Technique and treatment with light wire Edgewise appliances.* 2d. ed. St. Louis:C.V. Mosby Co.

Lande, M. J. 1952. Growth behavior of the human bony facial profile as revealed by serial cephalometric roentgenology. *Angle Orthod.*. 22:78-90.

Riolo, M. L.; Moyers, R.E.; McNamara, J.A. Jr.; and Hunter, W.S. 1974. *An atlas of craniofacial growth.* The Center for Human Growth and Development, the University of Michigan.

Schudy, F. F.

1964 Vertical growth versus anteroposterior growth as related to function and treatment. *Angle Orthod.* 34:75-93.

1965 The rotation of the mandible resulting from growth: its implications in orthodontic treatment. *Angle Orthod.* 35:36-50.

1966 The association of anatomical entities as applied to clinical orthodontics. *Angle Orthod.* 36:190-203.

1968 The control of vertical overbite in clinical orthodontics. *Angle Orthod.* 38:19-39.

Schwarz, A. M. 1960. *Roentgenostatics.* New York:Leo L. Bruder.