The Skeletal Patterns Characteristic of Class I and Class II, Division I Malocclusions in Norma Lateralis[1]

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Angle's classification of malocclusion, first announced in 1899, came to be quite generally used soon after its introduction to the profession. But the basis for its acceptance became the subject for much controversy. The validity of accepting the upper first molar as a point from which to reckon (Angle '06) was questioned. So, also, was Angle's contention ('07) that the upper jaw was normal in size and position, and that the lower jaw was underdeveloped or retruded in Class II malocclusions.

Summarizing Angle's concept of Class II, Division 1, Brodie ('31) stated that "the maxillary first molar was never intended to be taken as a fixed and immovable point . . . correct whereever found. It *was* considered the most stable point in the denture, and to occupy a definite relation to cranial anatomy — but it was recognized it would move if the integrity of the arch was broken." He further stated that "the Angle classification is based on the relation of the lower jaw to cranial anatomy, and this relation, at present, can only be determined through a study of tooth relationships."

Simon ('24) attacked the Angle classification, and sought to substitute for it a method of relating the denture to three intersecting cranial and facial planes at right angles to each other. These planes were the Frankfort horizontal plane, the median saggital plane, and the orbital plane. His "orbital-canine law" stated that, in normal cases, the orbital plane passed through the cusps of the upper canine, and through the point "gnathion" of the mandible. The fallacy of this rule was shown by Broadbent ('27), and Connolly ('27) who, upon measuring skull material exhibiting normal occlusions, found no such constant relation of parts to the orbital plane.

Oppenheim ('28) compared anthropometric measurements from a series of skulls having normal occlusion with those exhibiting Class II malocclusions and concluded (in part) "the fact that prosthion and subspinale in the overwhelming majority of Class II cases are situated even further back than in normal cases, precludes the assumption that the anomaly in Class II cases is located in the upper jaw," and "the Class II anomaly consists (with few exceptions) in underdevelopment of the mandible."

Hellman ('22) found that the Class II, Division 1 mandibular angle was more acute than the mandibular angle of skulls exhibiting normal occlusion, and concluded that the "body of the mandible (in Class II, Division 1) therefore assumes a more posterior position in relation to the maxilla than in normal skulls. The teeth of the mandible are therefore in distal occlusion." In 1931 he wrote, "In Class II, Division 1 the upper face may be normal or

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subnormal in its anteroposterior dimension, while the mandible is often subnormal in size, and always posterior to normal in position."

Studies by Adams ('39) on the form of the human mandible showed no significant differences in form between Class I and Class II mandibles. It should be noted that both Division 1 and Division 2 were included in his cross-section of Class II mandibles. Although material for this study was chosen without regard to age or sex factors, he also concluded that absolute mandibular dimensions in the two classes were comparable — a conclusion apparently based on the fact that the mean ages of the two groups were substantially the same. The equating of mean ages derived from samples having wide ranges would only seem justified if yearly growth increments for the individual did not decrease as age advances.

Elman ('40) showed that, in both Class I and Class II mandibles, the distances from the lower first molar to the posterior and inferior borders of the mandible was in the constant ratio of 3 to 2. Again, however, no distinction was made between the two Divisions of the Class II cases used.

Baldridge ('41) measured the position of the maxillary first molar and of the point "gnathion" in relation to the face and cranium. He found that the upper first molar lay in the same relative anteroposterior position to the cranium in Class I and in both divisions of Class II. Gnathion, in Class II, Division 1 cases was shown to lie posterior to the position of gnathion in Class I.

A study of the facial patterns associated with Class I and each of the divisions of Class II was made by Renfroe ('48). His method involved the measurement of only angular relations and he assumed that size and age differences in his material could be ignored or eliminated. It would appear that this method could only yield completely accurate findings if growth occurred by true enlargement in the strictest sense of the word. The study indicated that Class II, Division 1 malocclusions were not characterized by any lack of development of the mandible as compared with Class I cases but only by a more posterior position of the whole mandible.

Drelich ('48), using statistical methods, compared certain characteristics of the facial patterns of two randomly selected groups, namely, an untreated group having excellent occlusion and a comparable group of patients exhibiting Class II, division 1 malocclusion. He found statistically significant differences between the means of certain characteristics of the contrasted groups which suggested the following conclusions:

1. The chin in Class II, division 1 is located relatively more posteriorly than in normal occlusion.
2. The length of the mandible in Class II, division 1 is relatively shorter than in normal occlusion as compared to the S-N distance (anterior cranial base) when the latter are of comparable length.
3. The lower posterior face height is relatively less in Class II, division 1 than in the normal group. This would indicate a relatively steeper mandibular plane angle in the malocclusion group.

Elsasser and Wylie ('48) measured certain cranio-facial dimensions in Class I and Class II, Division 1 male and female subjects. Cases were selected so that for each Class I case of a given age, a Class II, Division 1 case of the same sex and age (to the nearest year) was chosen. The mean age of each of the four groups was 11½ years.

These investigators measured mandibular length by drawing a line tangent to the lower border of the mandible and dropping perpendiculars to this line from the most posterior point on the head of the condyle and from gnathion. The distance between these projected points was designated "overall mandibular length."

In regard to maxillary and "overall mandibular length", they found statistically significant differences between the contrasted groups, as follows:

1. Class II, Division 1 males were larger than Class I males in maxillary length but not in overall mandibular length.
2. Class II, Division 1 females were smaller than Class I females in overall mandibular length but not in maxillary length.

Clinical use of Downs' analysis ('48), (which was based on a study of cases presenting excellent occlusions) corroborates the concept that, when compared with the normal, the chin-point in Class II, Division 1 lies posterior both in its relation to the cranium and to the upper jaw.

Brodie ('41) studied the pattern of growth in a group of normal individuals from three months to eight years of age. He divided the head into its several parts — the brain case, nasal area, upper dental area, and mandible — and considered the growth of each of these areas independently. He demonstrated that growth of these areas is proportional, and so coordinated that any given anatomical point tends to travel on a straight line. He concluded that the pattern of growth for an individual, though not an enlargement in the strict sense of the word, is remarkably constant, and does not deviate from its *basic* form as age progresses.

Most cross-sectional studies dealing with size, form, and position of anatomical parts have, in the past, dealt with the factor of age in one of three ways:

1. Age has been disregarded, and forms compared without regard for size.
2. "Mean ages" have been equated, and size, form and position of parts compared.
3. Material has been divided into groups on the basis of "developmental age of the dentition", and comparisons made of size, form and position of skeletal parts.

The first method would seem open to question inasmuch as the growth process is not one of pure enlargement.

The second method may be equally dangerous, where a "mean age" is derived from a sample having wide variation in age, since a normal growth curve indicates that yearly growth increments decrease with age. Thus a mean reading obtained for two 10 year-olds cannot be compared strictly with a mean derived from a 5 and a 15 year old subject.

The third method has been largely reserved for work on dried skull material in which the age of the subject at death has not been known. Unfortunately, the "dentitional age" groups are, of necessity, large in their range, and, in addition, are subject to the variations encountered in time of eruption.

It would seem desirable to limit, so far as possible, the tendencies for error associated with the age factor. In the present investigation it was therefore decided to select for material only those cases in which records were available within six months of a given age. The age 12 was chosen since this afforded the most material for study.

The study was undertaken to determine what differences existed between the overall composite patterns of two groups of individuals of the same age, one group of which exhibited Class I, the other Class II, Division 1 malocclusion.

Material and Method

The material for this study consisted of cephalometric roentgenograms of seventy cases, selected before the initiation of treatment, and taken from the files of the Department of Orthodontia, University of Illinois. Of the 70 cases, 34 were classified as Class I malocclusions, and this group consisted of 12 males and 22 females; 36 were Class II, Division 1 cases, consisting of 17 males and 19 females. In all cases lateral headplates with teeth in occlusion had been obtained within six months of the patient's twelfth birthday.

The method involved measuring tracings of oriented lateral headplates. The technique for taking and tracing these cephalometric films is well known, having been described by Broadbent ('31), Brodie ('41) and others, and need not be discussed here in detail. As has been pointed out by these writers, bilateral anatomical points and structures are not usually superposed on a well oriented head film. In this study the point midway between the tracing of right and left bilateral structures was measured. This reduced the distortion caused by differences in the distance from the mid-line of the various points used, and in effect allowed the consideration of all structures as mid-line points. This procedure also tended to eliminate errors caused by slightly improper orientation of the patient during exposure of the film.

Since the size of the image on the headplate film is influenced by the distance of the film from the mid-saggital plane of the head during exposure, this factor had also to be taken into account when linear dimensions were measured. In the present study, the mean distance from film to mid-line for the Class I group was 8.5 cm.; for the Class II, Division 1 group 8.6 cm. The resulting difference in enlargement was less than one tenth of one percent.

Tracings of the lateral headplates were made in the prescribed manner and significant anatomical landmarks located. A definition of the anatomical points employed is given in the Glossary of Terms and a typical tracing is illustrated in Fig. 1.

In order to reveal the nature and the magnitude of differences between the facial skeletal patterns of Class I and Class II, Division 1 patients, all tracings were related to a grid system of horizontal and vertical lines by laying each tracing over a sheet of millimeter graph paper on which the centimeter lines were accentuated. The graph paper was divided into four quadrants by two coordinates, one horizontal, and one vertical, which intersect each other one vertical, which intersected each other in the middle of the page.

When a tracing was superposed on this grid, the location of any anatomical point could be recorded as its distances (to the nearest half-millimeter) from each of the vertical and horizontal coordinates. Horizontal readings to the right of the vertical coordinate were indicated by a plus value, those to the left by a minus value. Similarly, vertical readings above the horizontal axis were plus, those below, minus. Thus, the position of each anatomical point was recorded by a vertical and horizontal reading. The readings for any point thus gave its location in relation to all other points.

For each anatomical point used, an arithmetic mean of each of its horizontal and vertical readings was obtained for both the Class I and Class II, Division 1 groups. By plotting these mean readings on the same type of grid and joining the plotted points, the composite pattern for the group was obtained.

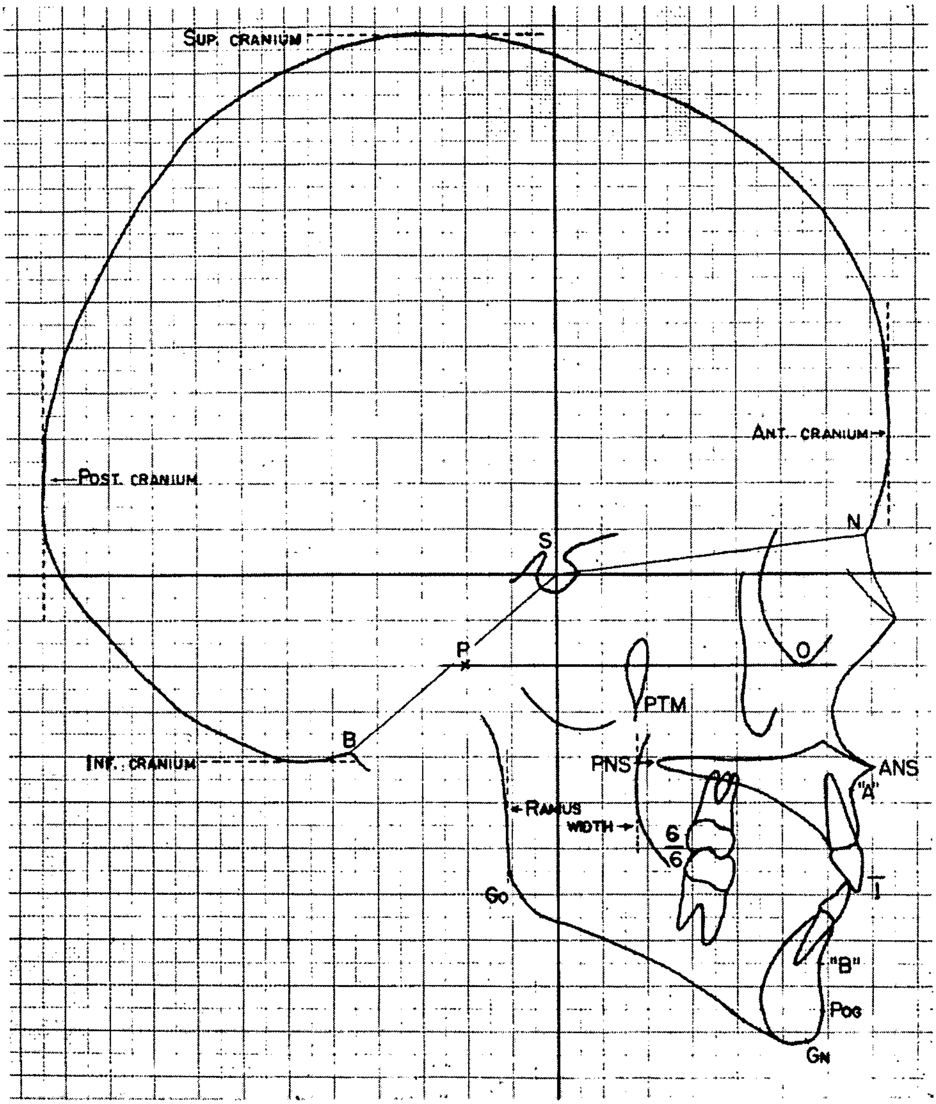

Fig. 1. Typical tracing of cephalometric roentgenogram superposed on grid and showing location of the points and planes of reference used.

The readings derived from any individual tracing were dependent on where the tracing was placed and how it was oriented or rotated on the grid. It should be noted, however, that the size and form of the *group composites* were independent of such placement and orientation. A change in positioning on the grid, of any, or all, of the individual tracings could affect the *composite* pattern only in regard to its *position* on the grid. Consequently, the procedure outlined produced a composite which was true both in size and in form.

As a matter of record, it should be noted that all tracings *were* oriented in the same position — that is, with the center of sella turcica superposed at the intersection of the two coordinates and

GLOSSARY OF TERMS

S *The center of sella turcica.* Located by inspection.

N *Nasion.* The mid-point of the suture between frontal and nasal bones.

B *Bolton point.* The highest point on the concavity of the condyloid fossa.

P *Porion (cephalometric).* The uppermost point on the soft tissues overlying the external auditory meatus.

O *Orbitale.* The lowest point on the inferior margin of the orbit.

PTM *Pterygomaxillary junction.* The point at which the maxillary tuberosity abuts against the pterygoid process of the sphenoid.

PNS *Posterior nasal spine.*

ANS *Anterior nasal spine.*

"A" *Subspinale.* The most posterior mid-line point on the premaxilla between the anterior nasal spine and prosthion.

"B" *Supramentale.* The most posterior mid-line point on the mandible between infradentale and pogonion.
(The above two points have been used by Downs ('48) to indicate the anterior limit of the maxillary and mandibular denture bases.)

POG *Pogonion.* The most anterior point in the mid-line of the mandibular symphysis.

GN *Gnathion.* A point on the chin determined by bisecting the angle formed by the facial and mandibular planes.
(The facial plane passes through nasion and pogonion. The mandibular plane used is a line tangent to the lower border of the mandible posteriorly and the cross-section of the symphysis anteriorly.)

GO *Gonion.* A point on the gonial angle determined by bisecting the angle formed between the mandibular plane and the plane representing the posterior border of the ramus.

U6 *Maxillary first molar.* A point representing the distal contact of the tooth was used to represent its position.

L6 *Mandibular first molar.* A point representing the distal contact of the tooth was used to represent its position.

L1 *Lower central incisor.* A point representing the incisal edge was recorded.

The position of the following points were derived from the oriented tracings and recorded either as horizontal or vertical measurements.

ANT. CRAN. *Most anterior point on the cranium.* Recorded as a horizontal reading only.

POST. CRAN. *Most posterior point on the cranium.* Recorded as a horizontal reading only.

SUP. CRAN. *Most superior point on the cranium.* Recorded as a vertical reading only.

INF. CRAN. *Most inferior point on the cranium.* Recorded as a vertical reading only.

ANT. RAMUS *Most posterior point on anterior border of ramus.* Recorded as a horizontal reading only.

POST. RAMUS *Most anterior point on posterior border of ramus.* Recorded as a horizontal reading only.

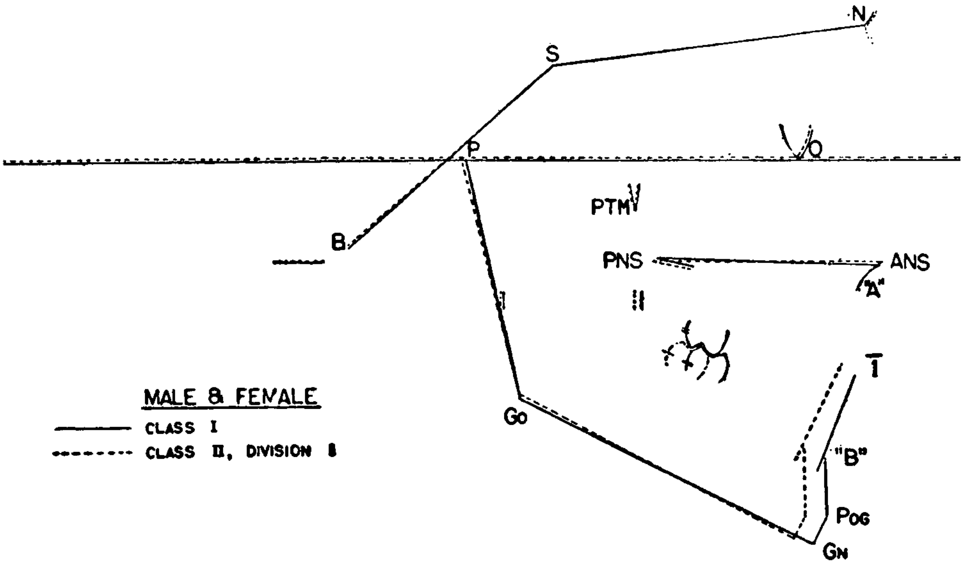

Fig. 2. Superposed composites of male and female Class I and Class I, Division 1 patterns.

with the porion-orbitale line (Frankfort) parallel to the horizontal axis.

In order to subject the material of this study to a statistical appraisal, the absolute length of the following anatomical units were measured and recorded for all tracings of both the Class I and the Class II, Division I groups:

S-N—The anterior cranial base.

S-B—The posterior cranial base.

Ans-Pns—The length of the hard palate.

Go-Gn—The length of the body of the mandible.

S-Go—Posterior facial height.

N-Gn—Anterior facial height.

In addition, the following cranial dimensions, derived from tracings oriented in the Frankfort plane, were recorded:

A-P cran.—Greatest anteroposterior length of cranium.

S-I cran. — Greatest superoinferior height of cranium.

The mean was calculated for each dimension of the two groups. It was then possible to determine if these dimensions showed statistically significant differences between the two groups.

Findings

When the composite patterns of the male and female Class I and Class II, Division I cases were superposed, (Fig. 2) a striking similarity of position of all the selected anatomical points was evident — with the very definite exception of those associated with the body of the mandible.

The anterior and posterior cranial bases, S-N and S-B, were found to be comparable in both their lengths and in the angle formed between them, (N-S-B), and both lay at practically the same angle in relation to the Frankfort plane. The proportions and size of the cranium appeared similar in both Class I and Class II, Division I. The points representing the position and size of the maxillae — Ptm, Pns, Ans, and point "A" — were closely comparable, as was also the point representing the distal contact of the upper first permanent molar.

Only when the mandible was considered were large variations evident between the composite Class I and Class II, Division I patterns. And here, only in the *body* of the mandible and its associated parts, did these

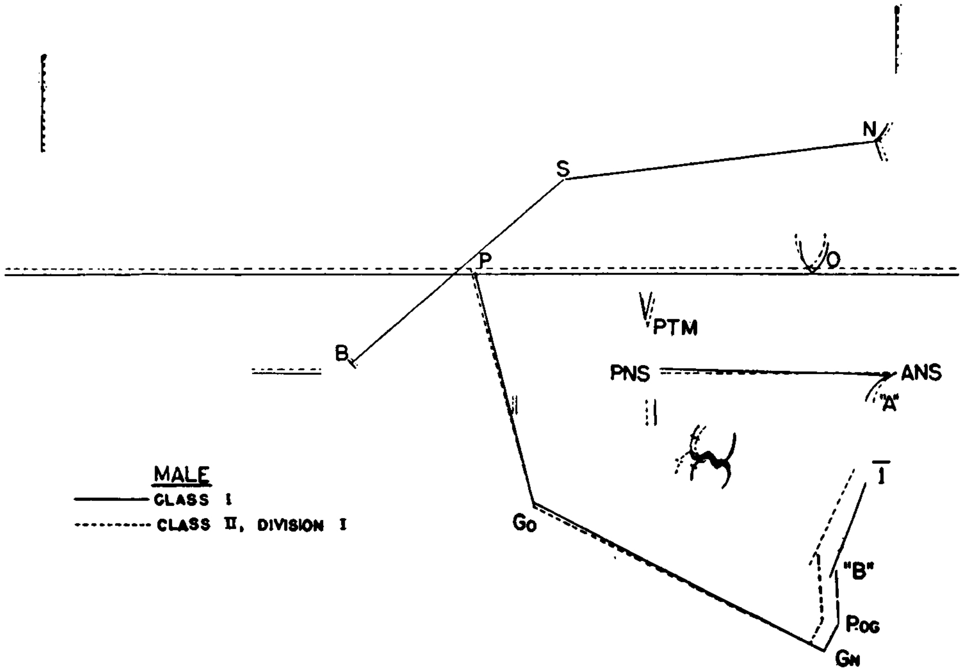

Fig. 3. Superposed composites of male Class I and Class II, Division 1 patterns.

differences appear great enough to be considered significant.

The mandibular fossa and the condyle of the mandible are both obscured during the film exposure by the cephalometer posts supporting the ear-rods. However, the external auditory meatus (the position of which is indicated by porion) lies in close relation of the mandibular fossa, and the latter, in turn, gives some indication of the condylar position. Porion was therefore taken to indicate the *relative* position of the mandibular condyles in the composites.

When this was done, the relative position of the condyles were found to be comparable. The posterior borders of the rami, and the points representing the gonial angle likewise almost superposed.

The points representing the anterior surface of the Class II, Division 1 mandible fell 4 to 5 mm. posterior to corresponding points of the Class I mandibular composite, as did also the mandibular first molar and incisors. The anterior border of the ramus was somewhat more posterior than in the Class I mandible, indicating a narrower ramus (in the Class II), but not narrow enough to compensate for the posterior relation of the molar. The lower molar, therefore, would seem to lie somewhat closer to the ramus in Class II, Division 1.

When the groups were broken down so that males could be compared with males, (Fig. 3) and females with females, (Fig. 4) of the two classifications, the findings were essentially the same, except that certain points did not correspond so closely. This could be partially accounted for by the smaller samples involved, but also seemed to be caused by a slight difference in absolute size in the smaller groups — the Class II males appearing slightly larger than the Class I males, and the Class II females appearing

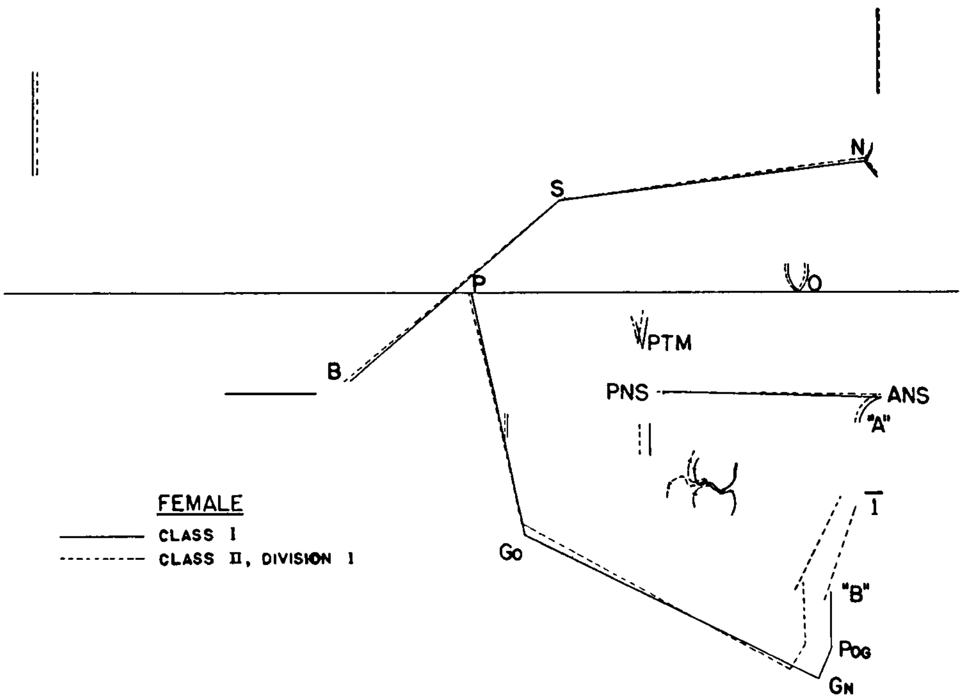

Fig. 4. Superposed composites of female Class I and Class II, Division 1 patterns.

slightly smaller than the Class I females. These differences tended to cancel out in the combined composites.

A comparison of the overall size of the composites, grouped by sex, indicated that 12 year old males have a cranial and facial skeletal pattern somewhat larger than have females of the same age.

Certain anatomical units were subjected to statistical appraisal. The problem was to determine whether or not the selected dimensions exhibited differences between their means in the two classes greater than could be accounted for on the basis of chance alone. The probability that the difference between two means is due to chance alone can be determined from the "t" value derived from the difference. Fisher ('36) has stated that it is convenient to take five precent as the standard level of significance. The difference between the means is thus accepted as significant where the probability (P) is less than .05. Table 2 shows the results of the statistical calculations. Of the dimensions chosen for study, only the length of the body of the mandible

TABLE I

MEAN DISTANCE OF ANATOMICAL POINTS FROM HORIZONTAL AND VERTICAL COORDINATES IN MM.

(Location of points inferior to horizontal coordinate and/or posterior to vertical coordinate is indicated by minus reading.)

34 Class I — 12 Males, 22 Females
36 Class II, Division I — 17 Males, 19 Females

Point	Group	Horizontal Reading		Vertical Reading	
S	Male	0.0	0.0	0.0	0.0
	Female	0.0	0.0	0.0	0.0
	M & F	0.0	0.0	0.0	0.0
N	Male	69.3	70.3	8.3	8.6
	Female	67.2	67.2	8.8	9.3
	M & F	67.9	68.7	8.6	8.9
O	Male	54.8	54.4	— 20.5	— 19.3
	Female	52.6	51.9	— 19.6	— 19.5
	M & F	53.4	53.0	— 19.9	— 19.4
P	Male	— 20.0	— 21.1	— 20.5	— 19.3
	Female	— 19.3	— 20.0	— 19.6	— 19.5
	M & F	— 19.5	— 20.5	— 19.9	— 19.4
B	Male	— 48.0	— 47.5	— 40.5	— 40.1
	Female	— 44.5	— 46.2	— 38.5	— 38.7
	M & F	— 45.8	— 46.8	— 39.2	— 39.4
PTM	Male	18.1	18.5	— 30.7	— 32.4
	Female	17.9	17.0	— 31.2	— 30.3
	M & F	18.0	17.7	— 31.0	— 31.3
PNS	Male	21.4	21.6	— 41.4	— 42.6
	Female	22.5	21.1	— 40.8	— 40.9
	M & F	22.1	21.3	— 41.0	— 41.7
ANS	Male	72.0	73.7	— 43.0	— 42.2
	Female	70.6	70.2	— 41.9	— 41.3
	M & F	71.1	71.9	— 42.3	— 41.7
"A"	Male	66.9	68.6	— 48.8	— 48.9
	Female	65.3	64.5	— 47.7	— 47.7
	M & F	65.9	66.4	— 48.1	— 48.2
"B"	Male	59.9	56.2	— 85.6	— 82.2
	Female	58.2	52.4	— 83.4	— 81.4
	M & F	58.8	54.2	— 84.1	— 81.8
Pog	Male	60.5	57.0	— 97.3	— 96.8
	Female	58.3	52.5	— 95.7	— 94.9
	M & F	59.1	54.6	— 96.3	— 95.8
Gn	Male	57.5	54.2	—103.2	—101.8
	Female	55.5	49.4	—101.9	—100.0
	M & F	56.0	51.7	—102.3	—100.9
Go	Male	— 7.2	— 7.1	— 71.2	— 72.1
	Female	— 8.0	— 8.7	— 71.6	— 68.9
	M & F	— 7.7	— 7.9	— 71.5	— 70.4
U6	Male	28.3	29.5	— 56.3	— 57.1
	Female	29.0	27.9	— 57.4	— 55.7
	M & F	28.8	28.7	— 57.0	— 56.4

TABLE I (Cont.)

Point	Group	Horizontal Reading		Vertical Reading	
L6	Male	28.4	25.8	— 63.1	— 62.0
	Female	29.0	23.7	— 63.6	— 60.7
	M & F	28.8	24.7	— 63.4	— 61.3
L1	Male	66.8	64.2	— 66.8	— 63.6
	Female	64.6	61.0	— 65.5	— 63.4
	M & F	65.4	62.5	— 65.9	— 63.5
Ant. ramus	Male	20.2	18.4		
	Female	19.3	17.1		
	M & F	19.6	17.7		
Post. ramus.	Male	— 10.8	— 11.5		
	Female	— 11.5	— 12.2		
	M & F	— 11.2	— 11.9		
Post. cran.	Male	—118.5	—118.0		
	Female	—115.4	—114.3		
	M & F	—116.4	—116.1		
Ant. cran.	Male	74.1	74.4		
	Female	70.5	71.0		
	M & F	71.7	72.6		
Sup. cran.	Male			112.7	111.5
	Female			106.9	106.6
	M & F			108.8	108.9
Inf. cran.	Male			— 43.0	— 42.1
	Female			— 41.3	— 41.3
	M & F			— 41.9	— 41.7

(Go-Gn) shows a statistically significant difference between the means of Class I and Class II, Division 1. This finding bears out the general impression gained from a comparison of the composites.

Discussion

This investigation seems to indicate that the basic reason for the molar relationship in the Class II, Division 1 malocclusion lies in the fact that the mandibular body is shorter than in Class I. It should not be forgotten, however, that this represents only the mean or average picture. When one studies the individual pattern, one cannot but be impressed by the variations from the mean which usually go to make up the skeletal pattern of the individual. As Brodie ('46) and Wylie ('49) have pointed out, the large and random variation in the positioning and size of the parts making up the whole are, to a large extent, responsible for the infinite variety in the form and size of the facial skeleton. It would appear that it is the combination of these two factors, namely the wide variations in individuals, and the tendency for a difference in mandibular body length between the classes of malocclusion here studied, that is responsible for many of the controversies and difficulties surrounding the assessment of skeletal dysplasia.

A number of investigators in the past have arrived at findings similar to some of those presented here — especially with regard to the posterior position of the chin-point in Class II, Division 1 as compared to Class I. However, there appears to be a need for clarity and greater precision in the manner in which this particular condition is described. Again and again, in the literature, one finds the expression "the man-

TABLE 2

COMPARISON OF MEANS OF ABSOLUTE DIMENSIONS OF SELECTED ANATOMICAL UNITS

Dimension	Class	Range	Mean	Standard Deviation	"t"	Probability
S-N	I	63.0 - 74.5	68.4 ± .53	3.11	1.08	.3
	II-I	63.5 - 76.5	69.2 ± .51	3.05		
S-B	I	54.0 - 68.5	60.3 ± .59	3.42	1.03	.3
	II-I	55.5 - 70.0	61.1 ± .51	3.06		
ANS-PNS	I	43.5 - 56.5	49.1 ± .60	3.47	1.92	.1
	II-I	45.5 - 57.0	50.6 ± .50	2.99		
Go-Gn	I	65.0 - 79.0	70.9 ± .63	3.66	3.88	Less than .01
	II-I	59.0 - 79.0	67.1 ± .75	4.50		
S-Go	I	64.5 - 79.0	72.1 ± .62	3.60	1.06	.3
	II-I	62.0 - 80.0	71.0 ± .84	5.04		
N-Gn	I	101.0 - 123.0	111.9 ± 1.02	5.96	0.38	Greater than 1.0
	II-I	102.5 - 122.0	111.4 ± .81	4.86		
AP cran.	I	175.0 - 207.0	188.2 ± 1.30	7.59	0.29	Greater than 1.0
	II-I	178.5 - 203.5	188.7 ± 1.11	6.67		
SI cran.	I	139.5 - 164.5	151.5 ± 1.22	6.23	0.56	Greater than 1.0
	II-I	142.5 - 159.0	150.5 ± 1.05	5.26		

dible is posterior", when the investigators offer evidence indicating only that the chin-point is posterior — while the ramus and condyle may lie in the same relationship in the contrasted groups. In a similar fashion "the mandible is smaller or underdeveloped" is used to describe findings which may indicate only that the body of the mandible tends to be shorter. The intended meaning is usually evident to anyone reading the full content of the report, but unfortunately, conclusions which do not reveal accurately the author's meaning are too frequently quoted. It would appear that this is an area in which a lessening of confusion and controversy could be obtained at the relatively low cost of more careful description.

Further investigations along the lines employed in the present study would seem to be indicated — especially those aimed at assessing the Class II, Division 2 and Class III patterns.

SUMMARY

The composite facial skeletal patterns of a group of 12 year old patients presenting Class I malocclusions was compared with a Class II, Divi-

sion 1 group of comparable age. Superpositioning indicated the two groups had essentially the same composite pattern — with the exception that the body of the mandible appeared shorter and the lower first molar more posterior in the Class II, Division 1 composite.

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