Harmonious Anthropometric Relationships

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Because orthodontists are constantly exposed to disharmony within the mouth and face, a study of harmonious relationships is a prerequisite to the understanding of such disharmonies. We have accepted a relationship of teeth which function efficiently and appear evenly arranged as being good occlusion. Notions of facial harmony have been formed and nourished by the media of advertisements, movies and television. There is a tendency to identify variations from these ideal images as being disharmonious.

When good or normal occlusion exists in a mouth over a period of time there must be physiological balance present. If there are statistically significant relationships between basic facial structures and teeth in these good occlusions, it is probable that these relationships are physiologically essential to good occlusion.

A wrong approach has been made in the evaluation of measurements made possible with lateral cephalograms. The establishment of standard deviations from means is important to the understanding of statistics, but misleading in orthodontics. A study of untreated persons with excellent occlusions shows a wide variation of measurements of many factors within the facial complex Separately, each factor can be studied by listing the measurements numerically. Such a listing, however, does not imply that the people represented at each end, the highest and lowest scores, have occlusions any less acceptable or less normal than those in the middle of such a listing. For instance, if but one person in fifty has excellent occlusion and if but one person in ten thousand is seven feet tall, we could expect to find but one excellent occlusion in a seven foot tall person among five hundred thousand people. This concept is more concrete if we use the measurement of a facial factor rather than one of physique. Understanding of harmony must come through knowing how facial factors fit together and how, or if, they affect one another.

This paper presents a study of harmonious relationships as ascertained from the correlation of measurements taken from headfilm tracings of thirty-two good occlusion cases. Mathematical data on correlations and multiple correlations were secured through use of the IBM 650 electronic computer. Properly used, the derived figures provide good occlusion formulae which can be applied to any case. Orthodontists can match harmonies which exist in the dentofacial complex of good occlusion persons to those of their own patients. This may be done prior to the removal of appliances to ascertain whether patients are ready for retention or need further treatment.

The x-ray films studied are in the files of the University of Washington, Seattle, and are the most recent of a series taken at two-year intervals. Most of the patients were fourteen years of age and both male and female Caucasians were included. The following is quoted from a personal communication from Dr. Alton W. Moore, "The cases were selected by Al Baum and Frank Baird, graduate students at the time. They were selected on the basis of their being normal or good occlusions, and they have maintained their occlusal relationships since that time. No attention

Table I

	Minimal	Maximal	Mean	S.D.
Facial Plane Angle	80	93	86.47	3.35
Angle of Convexity	—9	13	1.75	4.55
AB Plane Angle	—10	2	—4.22	2.88
Mandibular Plane Angle	12	40	25.25	5.71
Y Axis	54	70	60.59	3.93
Occlusal Plane Angle	1	17	9.31	3.73
$\underline{1}$ to $\overline{1}$ Angle	115	145	128.97	6.76
$\overline{1}$ to Mandibular Plane	—8	18	5.78	6.41
$\underline{1}$ to FH Angle	101	120	110.47	5.33
$\underline{1}$ to NA Angle	14	35	22.53	4.75
$\underline{1}$ to NA (mm)	3.5	9.5	5.72	1.52
$\overline{1}$ to NB Angle	16	39	26.47	5.42
$\overline{1}$ to NB (mm)	2	10	5.31	1.85
$\overline{1}$ to FH Angle	41	69	58.75	6.11
Pg to NB (mm)	—1	4.5	2.31	1.33
ANB Angle	0	7	2.31	1.79
$\underline{1}$ to Facial Plane (mm)	1.5	13.5	7.16	2.65
Overbite (mm)	1	6	3.53	1.19

was paid to soft tissue profile in selectting any of these cases."

Table I lists the ranges, means, and standard deviations of eighteen measurements from each of the thirty-two good occlusion cases. Most of the measurements are familiar to users of cephalograms. Two have been added; protrusion is measured in millimeters from the facial plane to the most forward point on the crown of the maxillary central incisor; overbite is measured in millimeters from the tips of the maxillary and mandibular central incisors at right angles to the occlusal plane.

Linear measurements as small as one-half millimeter were used to provide a greater variation where small differences exist.

Figure 1 compares tracings of good occlusion cases with the extreme measurements of the facial plane angle. Table II lists all measurements for these two cases. It is apparent that as the facial plane angle decreases there is an increase in both mandibular and occlusal plane angles. If these changes could be shown to exist throughout the whole sample, negative correlations would be demonstrated. Similarly, as the facial plane angle decreases there is decrease in the angles of both maxillary and mandibular central incisors to FH. If these changes could be shown to exist throughout the sample, positive correlations would be demonstrated.

Perfect correlations from biological material are seldom attained. Among the reasons for these imperfections, insofar as this paper is concerned, are the following:

1. The selection of the good occlusion cases was arbitrary and based upon human judgement.
2. The positioning of the head within a holding device permits some error.

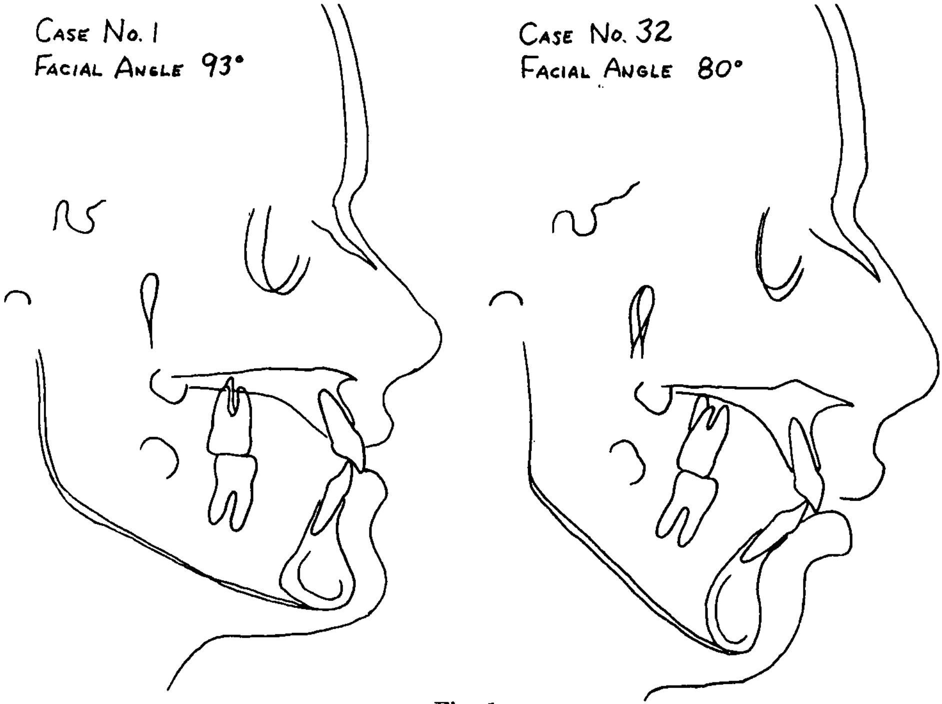


Fig. 1

Table II

CASE NO. 1	AGE 15-5	CASE NO. 32	AGE 13-3
FACIAL ANGLE	93°	FACIAL ANGLE	80°
CONVEXITY	—3°	CONVEXITY	10°
A B PLANE	—3°	A B PLANE	—10°
MANDIBULAR PL	23°	MANDIBULAR PL	40°
Y AXIS	56°	Y AXIS	70°
OCCLUSAL PL	6°	OCCLUSAL PL	16°
$\overline{1}$ TO $\underline{1}$ ANGLE	128°	$\overline{1}$ TO $\underline{1}$ ANGLE	118°
$\overline{1}$ TO MAN. PL.	+3°	$\overline{1}$ TO MAN. PL.	+9°
$\underline{1}$ TO F.H. PL.	116°	$\underline{1}$ TO F.H. PL.	103°
$\underline{1}$ TO NA (°)	24°	$\underline{1}$ TO NA (°)	17°
$\underline{1}$ TO NA (mm)	8 mm	$\underline{1}$ TO NA (mm)	4.5 mm
$\overline{1}$ TO NB (°)	26°	$\overline{1}$ TO NB (°)	38°
$\overline{1}$ TO NB (mm)	5 mm	$\overline{1}$ TO NB (mm)	10 mm
$\overline{1}$ TO FH	64°	$\overline{1}$ TO FH	41°
Pg TO NB	4 mm	Pg TO NB	3 mm
ANB	0°	ANB	6°
$\underline{1}$ TO FAC. PL. (mm)	6 mm	$\underline{1}$ TO FAC. PL. (mm)	12 mm
OVERBITE (mm)	3.5 mm	OVERBITE (mm)	3.5 mm

3. The maturity of the individuals measured was undetermined.
4. Though twelve female and twenty male subjects were measured, they have not been differentiated.
5. Larger millimeter measurements would be anticipated in large persons than in small persons, but no accounting for this effect has been made.
6. The shapes of teeth vary. Steep cusps permit greater closure of the jaws and deeper overbite than flat cusps. This could affect several measurements, but is in no way considered.
7. The tracing and measuring of headfilms are processes subject to error in mechanics and judgement. To limit this error the author performed these operations personally.

Protrusion and retrusion of the teeth affect the profile. Much concern has been expressed over this esthetic effect. Because personal preferences influence treatment results it is important to know if preferences are being substituted for physiologic balance. If correlations exist between facial measurements and dental measurements in this respect, a more subjective approach can be applied.

Figure 2 compares tracings of the good occlusion cases with the extreme measurements for protrusion (1 to facial plane in millimeters). Table III lists all measurements for these two cases.

The most convenient way to observe a correlation is with a scattergram. Two seemingly related measurements are plotted using these measurements from all the cases in a sample. The ranges are designated vertically for one measurement and horizontally for the other. Casual observation of a scattergram gives an indication of correlation. When there is a definite diagonal pattern to the plotted measurements correlation exists, but where the points representing measurements are scattered at random on the graph there is no correlation. Correlations are mathematically measurable. The term r is used for this purpose. If one measurement increases in direct proportion to the other, a perfect correlation of 1.00 is scored. If one measurement decreases in direct proportion to the increase of the other, a perfect negative correlation of -1.00 exists. This is just as valid as a plus score. Where none exists, correlation is measured as 0.00. Technically, this is the mean cross product of standard scores[1].

Figures 3 and 4 demonstrate patterns of both positive and negative correlation. Because some of the angles and distances have greater spread than others, it is necessary to statistically evaluate these graphs. For this purpose the aid of Mr. Charles R. Hebble, professional engineer in hydraulics and member of the American Society of Civil Engineers, was enlisted. In his work Mr. Hebble uses the IBM 650 electronic computer.

The first step taken was to measure the correlation of all 153 possible combinations. Table IV lists these coefficients of correlation.

At this point we are able to select harmonious relationships common to boys and girls fourteen years old, an age at which many are completing orthodontic treatment. By selecting facial factors which are relatively stable and have moderate or high coefficients of correlation, it should be possible to know if any individual presents harmony in these respects. For instance, there is a coefficient of correlation of -.624 between the facial plane angle and the mandibular plane angle.

Figure 5 shows tracings of two cases selected from the practice of the author. Both cases have a facial plane angle of

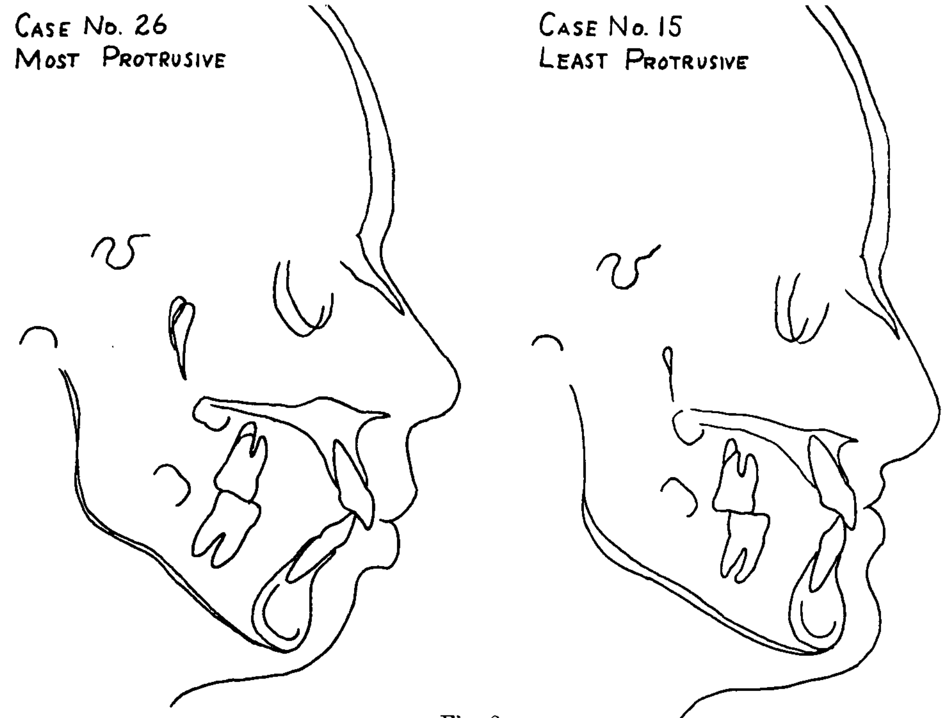


Fig. 2

Table III

CASE NO. 26	AGE 13-4	CASE NO. 15	AGE 15-5
FACIAL ANGLE	83°	FACIAL ANGLE	87°
CONVEXITY	13°	CONVEXITY	—9°
A B PLANE	—10°	A B PLANE	+2°
MANDIBULAR PL	34°	MANDIBULAR PL	24°
Y AXIS	65°	Y AXIS	60°
OCCLUSAL PL	10°	OCCLUSAL PL	5°
$\overline{1}$ TO $\underline{1}$ ANGLE	115°	$\overline{1}$ TO $\underline{1}$ ANGLE	133°
$\overline{1}$ TO MAN. PL.	+9°	$\overline{1}$ TO MAN. PL.	—2°
$\underline{1}$ TO F.H. PL.	112°	$\underline{1}$ TO F.H. PL.	115°
$\underline{1}$ TO NA (°)	23°	$\underline{1}$ TO NA (°)	32°
$\underline{1}$ TO NA (mm)	5 mm	$\underline{1}$ TO NA (mm)	4 mm
$\overline{1}$ TO NB (°)	36°	$\overline{1}$ TO NB (°)	16°
$\overline{1}$ TO NB (mm)	10 mm	$\overline{1}$ TO NB (mm)	2 mm
$\overline{1}$ TO FH	47°	$\overline{1}$ TO FH	69°
Pg TO NB	1 mm	Pg TO NB	3 mm
ANB	7°	ANB	2°
$\underline{1}$ TO FAC. PL. (mm)	13.5 mm	$\underline{1}$ TO FAC. PL. (mm)	1.5 mm
OVERBITE (mm)	4 mm	OVERBITE (mm)	3.5 mm

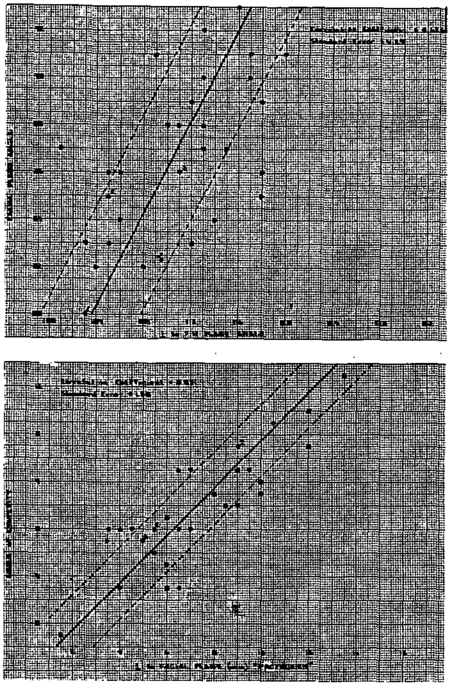


Fig. 3. Positive correlations. Above—Facial plane with 1 to FH. Below—Convexity with 1 to Facial plane.

87 degrees. Where standard error would indicate a variation in mandibular plane angle from 17 degrees to 31 degrees, one of these cases presents a mandibular plane angle of but 10 degrees while the other has a 36 degree angle. This is but one type of facial disharmony.

Another disharmony can exist between the angle of convexity and Pg to NB (mm) or chinbutton. Figure 6 compares tracings of two patients selected from the practice of the author who present different aspects of this disharmony. The standard error indicates, in a case with 4 millimeters of chinbutton, an angle of convexity of from 3 degrees to -5 degrees, but this case presents a 12 degree angle of convexity. The other case presents a chinbutton measurement of -1 millimeter. The standard error indicates a variation in the angle of convexity of from 3 de-

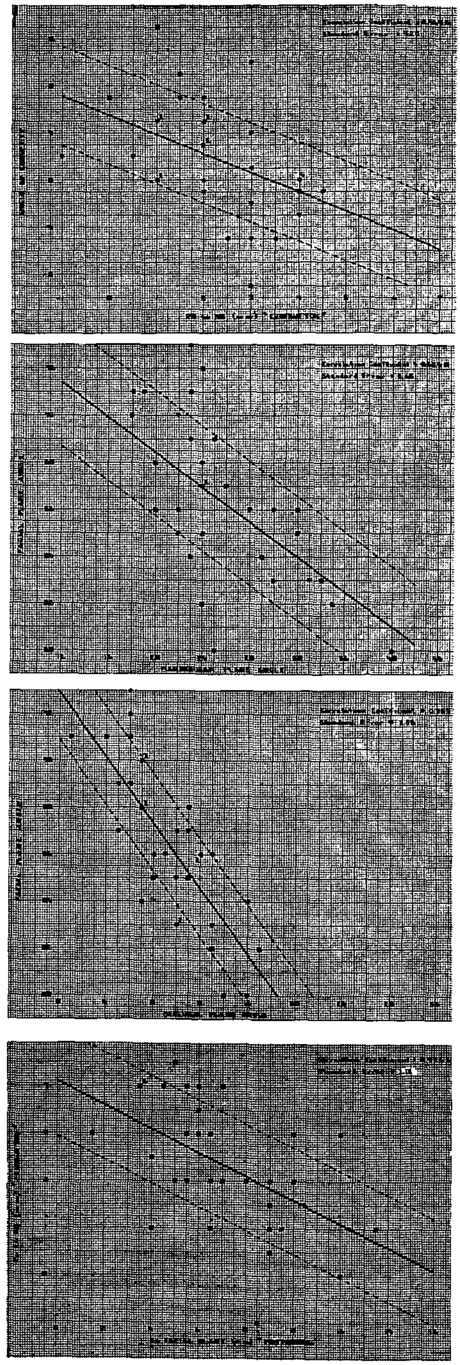


Fig. 4. Negative correlations. Top to bottom—convexity with Pg to NB; facial plane with mandibular plane; facial plane with occlusal plane and Pg to NB with 1 to facial plane.

Table IV

	FAC. PL. (o)	CONVEXITY (o)	AB PL. (o)	MAND. PL. (o)	Y AXIS	OCCLUSAL PL. (o)	$\underline{1}$ TO $\overline{1}$ (o)	$\overline{1}$ TO MAND. PL. (o)	$\underline{1}$ TO FH (o)	$\underline{1}$ TO NA (o)	$\underline{1}$ TO NA (mm)	$\overline{1}$ TO NB (o)	$\overline{1}$ TO NB (mm)	$\overline{1}$ TO FH (o)	Pg TO NB (mm)	ANB (o)	$\underline{1}$ TO FAC. PL. (mm)	OVERBITE (mm)
FAC. PL. (o)																		
CONVEXITY (o)	.269-																	
AB PL. (o)	.116	.825-																
MAND. PL. (o)	.624-	.374	.083-															
Y AXIS	.854-	.353	.086-	.723														
OCCLUSAL PL. (o)	.789-	.347	.103-	.702	.790													
$\underline{1}$ TO $\overline{1}$ (o)	.016	.341-	.281	.046	.029-	.178												
$\overline{1}$ TO MAND. PL. (o)	.014-	.264	.457-	.487-	.097	.218-	.602-											
$\underline{1}$ TO FH (o)	.626	.192-	.178	.441-	.478-	.624-	.476-	.125										
$\underline{1}$ TO NA (o)	.167	.608	.556	.292-	.303-	.420-	.359	.048	.633									
$\underline{1}$ TO NA (mm)	.092	.347-	.442	.134-	.093-	.284-	.376-	.146	.370	.491								
$\overline{1}$ TO NB (o)	.091-	.655	.560-	.182	.179	.069	.818-	.628	.096	.189-	.146							
$\overline{1}$ TO NB (mm)	.401-	.757	.501-	.538-	.511	.308	.620-	.261	.061-	.275	.173	.762						
$\overline{1}$ TO FH (o)	.597	.617-	.546	.446-	.575-	.430	.669	.562-	.278	.220	.049	.821-	.773-					
Pg TO NB (mm)	.137	.463-	.065-	.408-	.350-	.326-	.074	.271	.034	.192	.015	.201	.425-	.095				
ANB	.289-	.832	.810-	.343	.298	.182	.316-	.232	.156-	.478-	.430-	.528	.667	.552-	.172-			
1 TO FAC. PL. (mm)	.298-	.851	.579-	.400	.399	.235-	.567-	.296	.016	.355-	.139	.750	.928	.687	.526-	.690		
OVERBITE (mm)	.068-	.214	.507-	.349-	.200	.162-	.031-	.484	.082-	.201	.131-	.091	.027-	.164-	.412	.338	.140	

CORRELATION COEFFICIENTS
IBM 650 Data

Table IV

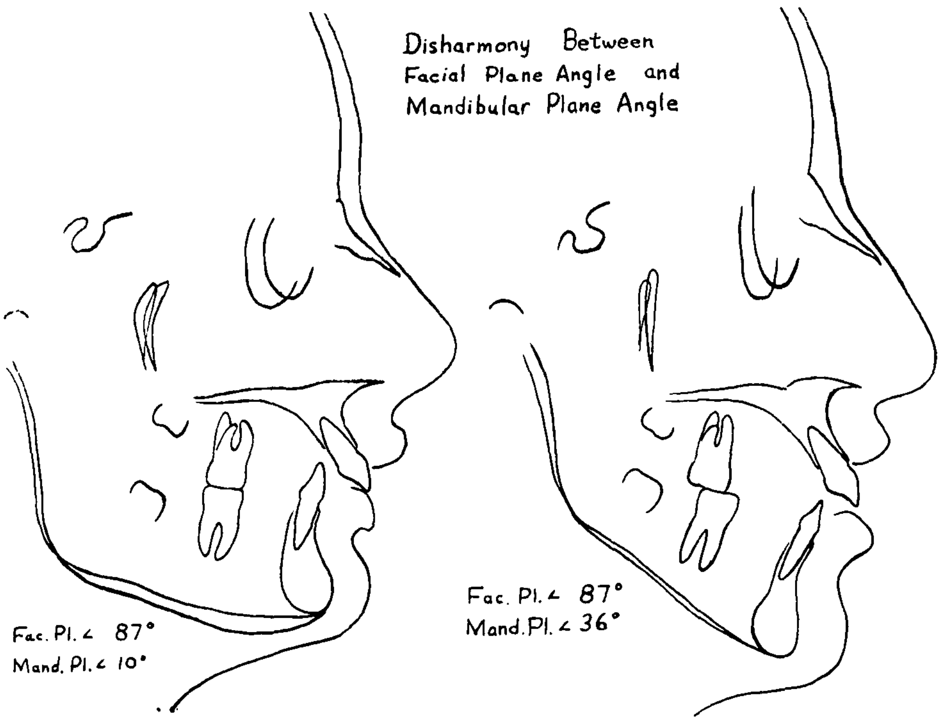


Fig. 5

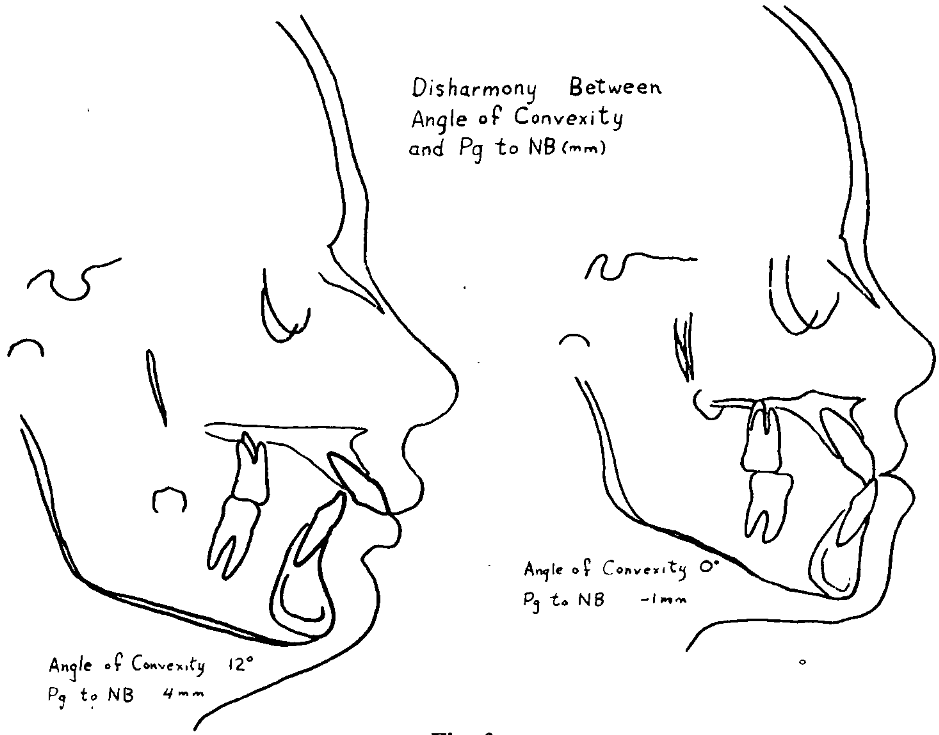


Fig. 6

grees to 11 degrees. Instead the angle of convexity reading is but zero degree.

Figures 5 and 6 each represent a type of disharmony. Both might be found in any patient, along with numerous others unexplained here. Table IV lists fifty-six coefficients of correlation with moderate scores (±.40 to ±.79) and eight with high scores (±.80 to ±1.00). Some of these represent different ways of measuring the same thing. Others, however, measure harmonious relationships which should represent goals in orthodontic treatment evaluation. Using basic anatomical landmarks these harmonies might also be adapted to the practice of prosthodontics.

First Method of Evaluation

One method of orthodontic diagnosis and treatment evaluation devised here uses scattergrams on which the line of regression, along with the lines representing standard errors, is present. This line of regression is drawn to the slope of the line of best fit. It is mathematically determined. Mr. Hebble calculated the slope of these lines as well as the standard errors.

Six scattergrams representing combinations of seven facial and dental measurements were selected (Figures 3 and 4). This group of seven measurements was intended to represent some which are but slightly affected by orthodontic treatment (facial plane angle and mandibular plane angle), some which moderately change with orthodontic treatment (angle of convexity, Pg to NB (mm) and occlusal plane angle), and some which change considerably with orthodontic treatment ($\underline{1}$ to FH

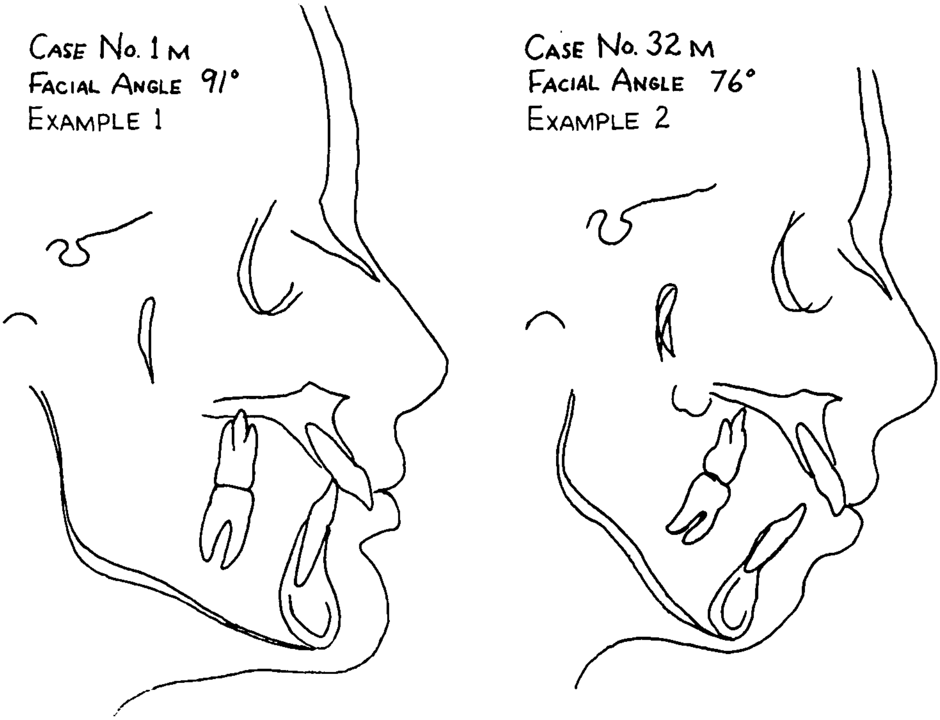

CASE No. 1 M
FACIAL ANGLE 91°
EXAMPLE 1
CASE No. 32 M
FACIAL ANGLE 76°
EXAMPLE 2

Fig. 7

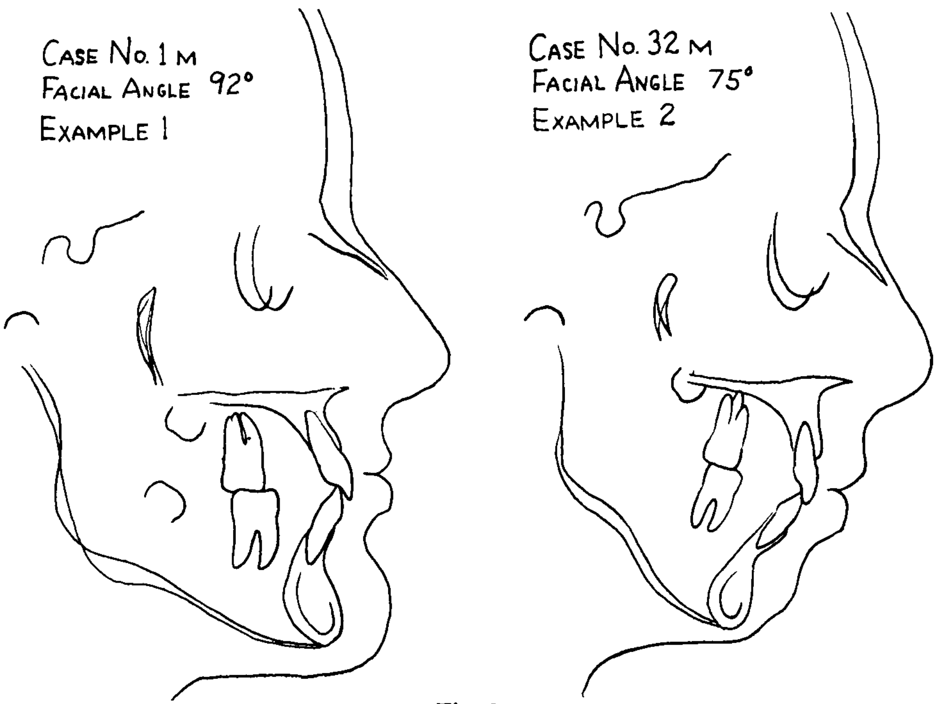

CASE No. 1 M
FACIAL ANGLE 92°
EXAMPLE 1
CASE No. 32 M
FACIAL ANGLE 75°
EXAMPLE 2

Fig. 8

Table V

CASE NO. 1M			
Example 1	AGE 12-4	13-5	14-8
FACIAL ANGLE	91	91	92
CONVEXITY	3	—2	—3
A B PLANE	—9	—2	—4
MANDIBULAR PL	21	22	20
Y AXIS	57	58	57
OCCLUSAL PL	4	—1	1
$\overline{1}$ TO $\underline{1}$ ANGLE	123	137	132
$\overline{1}$ TO MAN. PL.	0	—3	3
$\underline{1}$ TO F.H. PL.	126	115	115
$\underline{1}$ TO NA (°)	32	25	25
$\underline{1}$ TO NA (mm)	9	9	8
$\overline{1}$ TO NB (°)	20	17	23
$\overline{1}$ TO NB (mm)	4	4.5	6
$\overline{1}$ TO FH	69	71	67
Pg TO NB	4	4.5	5
ANB	4	1	1
$\underline{1}$ TO FAC. PL. (mm)	11.5	7	5.5
OVERBITE (mm)	9	5	4.5

CASE NO. 32M			
Example 2	AGE 16-4	17-3	17-8
FACIAL ANGLE	76	74	75
CONVEXITY	12	12	12
A B PLANE	—9	—9	—8
MANDIBULAR PL	44	46	44
Y AXIS	73	76	74
OCCLUSAL PL	15	9	21
$\overline{1}$ TO $\underline{1}$ ANGLE	110	129	139
$\overline{1}$ TO MAN. PL.	—2	—14	—4
$\underline{1}$ TO F.H. PL.	113	108	91
$\underline{1}$ TO NA (°)	31	27	9
$\underline{1}$ TO NA (mm)	10	8	2
$\overline{1}$ TO NB (°)	26	15	29
$\overline{1}$ TO NB (mm)	9	6	8
$\overline{1}$ TO FH	48	58	50
Pg TO NB	1.5	1	2
ANB	7	7	7
$\underline{1}$ TO FAC. PL. (mm)	18.5	17.5	11
OVERBITE (mm)	1	0	2

angle and $\underline{1}$ to facial plane (mm)).

To demonstrate this method thirty-two consecutively treated cases were taken from the practice of the author for evaluation. The only criterion in the selection of these cases was that each required complete maxillary and mandibular banded appliance therapy. They were treated *before* these coefficients of correlation had been calculated.

From these thirty-two cases the extremes in facial plane angle and protrusion were picked to see how treatment had affected the six relationships mentioned above. Because extreme cases were involved it became necessary to repeat these scattergrams on a larger scale to include the greater spread.

The case with the greatest facial plane angle is labeled example 1 and the case with the least facial plane angle is labeled example 2. Figure 7 shows tracings before treatment and can be compared with Figure 8 which shows tracings of examples 1 and 2 after treatment. Table V compares measurements for examples 1 and 2.

The case with the most protrusion is labeled example 3 and the case with the least protrusion is labeled example 4. Figure 9 shows tracings before treatment and can be compared with Figure 10 which shows tracings of examples 3 and 4 after treatment. Table VI compares measurements for examples 3 and 4.

Figure 11 is the first extended scattergram on which the effects of treatment for these four example cases have been plotted. Because the facial plane angle and the mandibular plane angle change but little, the most to be gain-

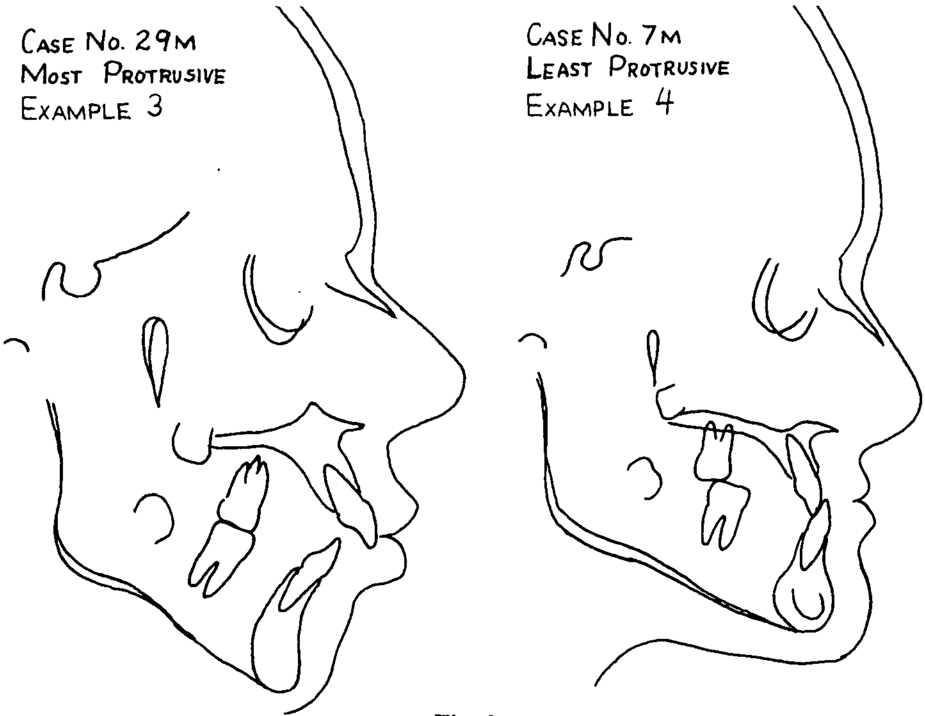

CASE No. 29M
MOST PROTRUSIVE
EXAMPLE 3
CASE No. 7M
LEAST PROTRUSIVE
EXAMPLE 4

Fig. 9

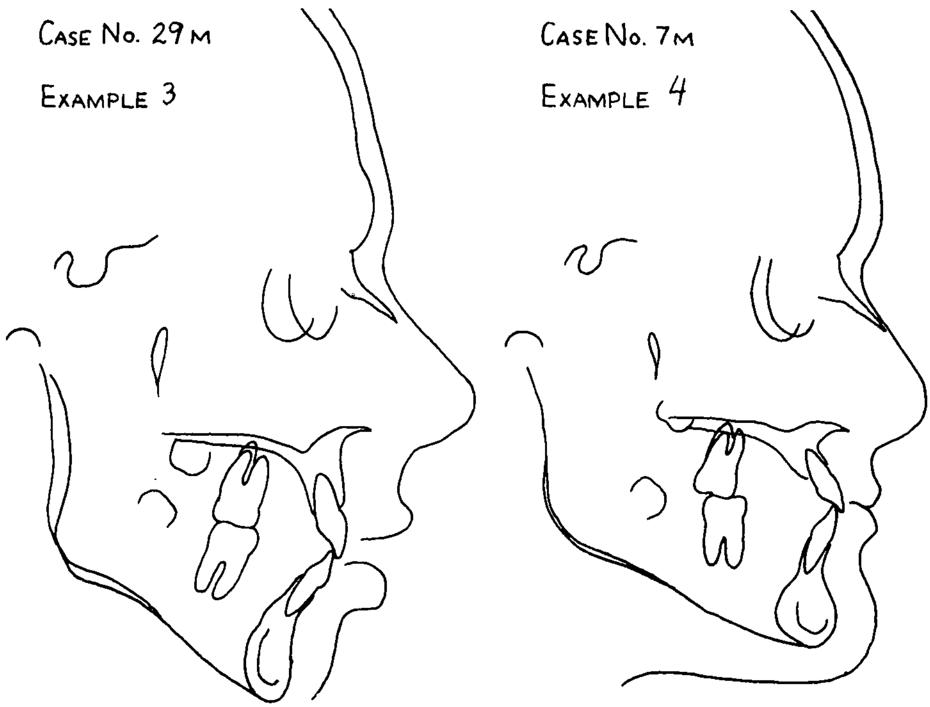

CASE No. 29M
EXAMPLE 3
CASE No. 7M
EXAMPLE 4

Fig. 10

Table VI

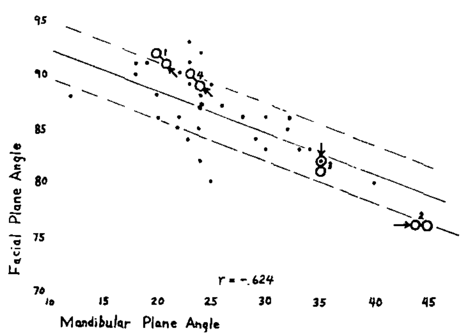
CASE NO. 29M			
Example 3 AGE	15-3	16-6	17-6
FACIAL ANGLE	82	82	82
CONVEXITY	9	8	10
A B PLANE	—6	—6	—7
MANDIBULAR PL	35	34	34
Y AXIS	64	65	66
OCCLUSAL PL	8	10	16
$\bar{1}$ TO $\underline{1}$ ANGLE	109	123	132
$\bar{1}$ TO MAN. PL.	8	—1	+1
$\underline{1}$ TO F.H. PL.	118	115	102
$\underline{1}$ TO NA (°)	31	27	15
$\underline{1}$ TO NA (mm)	12	12	2.5
$\bar{1}$ TO NB (°)	33	24	27
$\bar{1}$ TO NB (mm)	9	7	8.5
$\bar{1}$ TO FH	48	57	55
Pg TO NB	2	1	1
ANB	5	5	6
$\underline{1}$ TO FAC. PL. (mm)	19	19	10
OVERBITE (mm)	1	2	1.5

CASE NO. 7M			
Example 4 AGE	12-2	13-5	13-8
FACIAL ANGLE	89	90	90
CONVEXITY	—16	—17	—12
A B PLANE	+6	+5	+2
MANDIBULAR PL	24	24	23
Y AXIS	58	58	57
OCCLUSAL PL	15	5	4
$\bar{1}$ TO $\underline{1}$ ANGLE	141	120	127
$\bar{1}$ TO MAN. PL.	—5	—5	—1
$\underline{1}$ TO F.H. PL.	109	137	121
$\underline{1}$ TO NA (°)	28	50	33
$\underline{1}$ TO NA (mm)	6	11.5	9
$\bar{1}$ TO NB (°)	17	15	20
$\bar{1}$ TO NB (mm)	1	2	3
$\bar{1}$ TO FH	70	72	68
Pg TO NB	3	5	5
ANB	—5	—6	—3
$\underline{1}$ TO FAC. PL. (mm)	—3	1	1.5
OVERBITE (mm)	6	2.5	1

ed from this graph is the observation that all four examples lie close to, or within, one standard error of the line of regression which represents a basic facial harmony.

Figure 12 is the extended scattergram showing the correlation of the angle of convexity with Pg to NB (mm) or the amount of chinbutton. These measurements have been affected more by treatment than those in Figure 11, particularly examples 1 and 4.

Figure 13 shows the extended scattergram plotting the facial plane angle and the occlusal plane angle. While the facial plane has remained quite constant, the occlusal plane angle has improved in all but example 1 where it maintained good relationship.



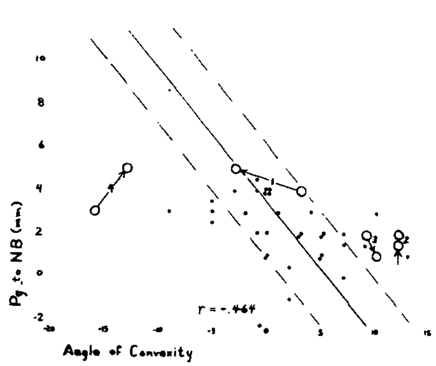
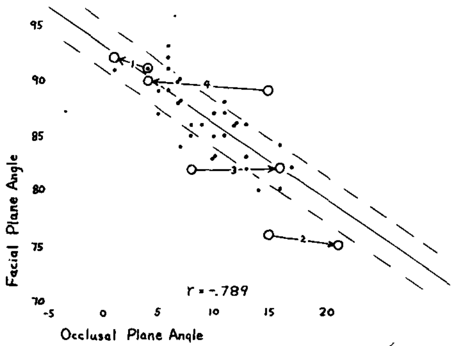


Fig. 11—above
Fig. 12—below



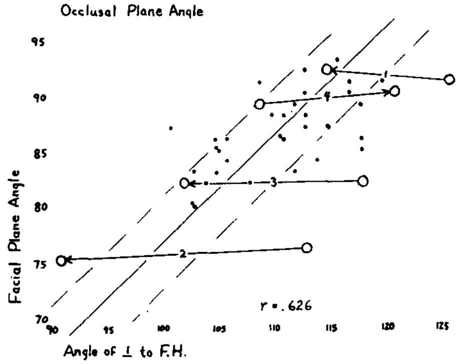


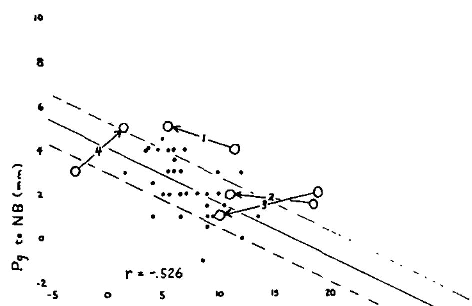
Fig. 13—above
Fig. 14—below

Speculation upon protrusion becomes interesting in the light of these correlated facial factors. Both the angle of convexity and chinbutton change to some degree with the bodily movement of the roots of the anterior teeth. The retraction of these roots affects these measurements in the way that extraction would, but to a lesser degree. At some undetermined points these changes cease and the true junction of alveolar crest with basal bone becomes evident. These points probably represent optimums insofar as Downs' points A and B are concerned.

If one considers the muscle attachments at the base of the nose and upon the symphysis of the mandible, a concept of protrusion emerges. The close attachment of the facial musculature above apparently limits protrusion in the thirty-two good occlusion cases measured, leading to the high coeffi-

Figure 14 is the extended scattergram which shows the correlation of the facial plane angle with the angle of $\underline{1}$ to the FH. Great change in the angle of the maxillary central incisor is evident. Examples 1 and 3 have improved in this relationship, but example 4 worsened and example 2 changed from one extreme to the opposite.

Figures 15 and 16 represent two different ways of comparing the amount of protrusion these four examples presented before and after treatment, and whether or not harmony was achieved in these aspects. Example 1 had an increase in the amount of chinbutton which offset the reduction in protrusion so that no improvement is noted in Figure 15. However, a reduction in the angle of convexity improves the position of example 1 on Figure 16.



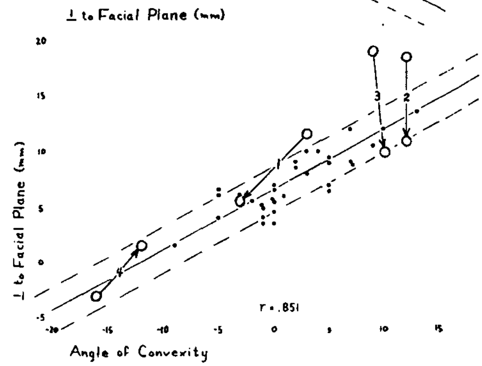


Fig. 15—above
Fig. 16—below

cient of correlation (.851) between the angle of convexity and $\underline{1}$ to facial plane (mm). Similarly, there is a moderate negative coefficient of correlation (—.526) between Pg to NB (mm) and $\underline{1}$ to facial plane (mm), but several factors enter into this relationship. It might be argued that an increase in Pg to NB (mm) moves one end of facial plane forward, but this is refuted by low coefficient of correlation (.157) between Pg to NB and the facial plane angle. Evidently the tilting of the mandible with an increase in the mandibular plane angle negatively affects Pg to NB (mm) as indicated in the moderate negative coefficient of correlation (—.408) between these factors. In our second method of evaluation this effect will be measured and accounted for. It would seem that Pg to NB measures facial muscle pressure, for an increase of Pg to NB of one millimeter corresponds to a decrease in protrusion, $\underline{1}$ to facial plane (mm), of approximately four millimeters.

The above system of evaluating measurements for a case is often all that is necessary to establish concepts of harmonious relationships. By definition, however, only about sixty-eight percent of the cases lie within a standard error of the regression lines in a scattergram. All cases were selected for their good occlusions and therefore must be explained in any valid system of diagnosis using them as criteria. Multiple correlation or multiple regression equations do this.

Where correlations exist between different parts of the face and the teeth, it is reasonable to suspect that the position of the teeth depends upon the facial construction. Some correlations are statistically more significant to tooth position than others. Multiple correlation is a mathematical process which explains variance. Using a stepwise procedure it eliminates irrelevant factors and measures others in proportion to their contribution in a variance. In this case the factors are measurements of facial parts and the variance is of tooth position.

Second Method of Evaluation

A mathematical process combining ten separate steps to work as a single solution was devised. Eight of the eighteen measurements from Table I were selected as basic and least affected by tooth movement. These were as follows:

1. Facial plane angle
2. Angle of convexity
3. AB plane angle
4. Mandibular plane angle
5. Y axis
6. Occlusal plane angle
7. Pg to NB (mm)
8. ANB angle

These eight factors were separately analyzed with each of the remaining ten tooth measurements to arrive at equations which best explain their variance and interacting effects.

As a result, good occlusion equations have been established to determine ten separate measurements for tooth positions. The measurements are ideal, representing harmonious anthropometric relationships presented by the sample of thirty-two good occlusion cases. Table VII is a key to the formulae, found in Table VIII, which provides mathematical solutions for harmonious angulation and antero-posterior positioning of the maxillary and mandibular central incisors.

Table VIII groups ten $\underline{y}$ (dental measurement) lists. Each list contains those $\underline{x}$ values which are statistically significant in the determination of the desired $\underline{y}$ measurement, as well as a constant (K) for that $\underline{y}$ measurement.

Table VII

Key to Good Occlusion Equations

X1	Facial Plane Angle	y1	$\overline{1}$ to $\underline{1}$ Angle
X2	Angle of Convexity	y2	$\overline{1}$ to Mandibular Plane Angle
X3	AB Plane Angle	y3	$\underline{1}$ to F.H. Angle
X4	Mandibular Plane Angle	y4	$\underline{1}$ to NA Angle
X5	Y Axis	y5	$\underline{1}$ to N.A. (mm)
X6	Occlusal Plane Angle	y6	$\overline{1}$ to N.B. Angle
X7	Pg to NB (mm)	y7	$\overline{1}$ to NB (mm)
X8	ANB Angle	y8	$\overline{1}$ to F.H. Angle
K	Constant	y9	$\underline{1}$ to Facial Plane (mm)
±	Standard Error	y10	Overbite (mm)

Table VIII

Good Occlusion Equations

y1		y2		y3	
X1	.75	X1	—1.33	X1	.56
X2	—2.72	X2	2.10	X2	1.21
X3	—3.09	X3	1.14	X3	1.87
X6	1.39	X4	—.85	X6	—.71
X7	—3.56	X6	—.77	X7	1.53
K	51.31±6	X7	2.92	K	71.23±4
		X8	—1.44		
		K	147.06±4		

y4		y5		y6	
X1	—1.02	X1	—.29	X2	2.34
X2	.03	X2	.69	X3	1.66
X3	.82	X3	.84	X5	.30
X5	—.39	X6	—.40	X6	—.64
X6	—.86	X7	.86	X7	2.76
X8	—.26	X8	—.70	X8	—1.00
K	145.99±3.5	K	36.61±1	K	13.15±4

y7		y8		y9	
X1	—.13	X1	1.31	X1	—.32
X2	.75	X2	—2.16	X2	1.16
X3	.72	X3	—1.17	X3	.84
X4	.09	X4	—.21	X4	.07
X5	.10	X6	.82	X6	—.46
X6	—.30	X7	—3.06	X7	.67
X7	.77	X8	1.59	X8	—.38
K	10.47±1	K	—54.48±3.5	K	38.18±1

y10	
X1	—.26
X3	—.21
X4	—.09
X5	—.16
X7	.13
K	36.90±1

Use of Good Occlusion Equation y3 to determine the Ideal Angle of 1 to F.H. for Example 2

measurements for			multiplied by			
x1	Facial Plane Angle	75	.56	42.00		
x2	Angle of Convexity	12	1.21	14.52		
x3	AB Plane Angle	-8	1.87		-14.96	
x6	Occlusal Plane Angle	21	-.71		-14.91	
x7	Po to NB (mm)	2	1.53	3.06		
K	Constant 71.23±4		+	59.58	-29.87	= 100.94±4

for Example 4

x1	90	· .56	=	50.40		
x2	-12	· 1.21	=		-14.52	
x3	2	· 1.87	=	3.74		
x6	4	· -.71	=		-2.84	
x7	5	· 1.53	=	7.75		
K	71.23±4		+	61.89	-17.36	= 115.76±4

Fig. 17

To solve an equation for a given case it is necessary to multiply these x values by the corresponding facial measurements found in the key (Table VII). The sum of these products added to the constant in each group represents an ideal dental measurement.

A practical example of combining the above two methods for evaluating treated cases would be as follows:

In Figure 14 it was noted that for examples 2 and 4 the angles of 1 to FH were outside the standard error at completion of treatment. To know if these variations were due to factors which accounted for variance among the good occlusion cases the formula for 1 to FH angle (y3) should be applied. Figure 17 demonstrates these applications.

Good occlusion equation y3 indicates that for example 2 the proper angle is 101±4 degrees rather than the 91 degrees it is. For example 4 the proper angle is 115±4 degrees rather than the 121 degrees at completion of treatment. An examination of the headfilm for example 2 shows that the root of the maxillary central incisor was almost through the palatal plate of bone when treatment ceased. This might be a limitation over which no control exists. In example 4 the high angle of 1 to FH is out of harmony with the dentofacial complex. If protrusion, as measured by 1 to facial plane (mm) is also too large, this might have been an extraction case. The good occlusion equation y9 provides this information, as demonstrated in Figure 18.

This calculation indicates that for this least protrusive example harmony is achieved with a 1 to facial plane (mm) measurement of 1.40±1 millimeters. The treatment result of 1.5 millimeters is correct for this case. The angle of the maxillary central incisor to the FH, in this example, is the re-

Use of Good Occlusion Equation y9 to determine Ideal Protrusion for EXAMPLE 4

x1	90	·	-.32	=		-28.80		
x2	-12	·	1.16	=		-13.92		
x3	2	·	.84	=	1.68			
x4	23	·	.07	=	1.61			
x6	4	·	-.46	=		-1.84		
x7	5	·	.67	=	3.35			
x8	-3	·	-.38	=	1.14			
K	38.18±1			+	7.78	-44.56	=	1.40±1

Fig. 18

sult of an extremely negative angle of convexity which would indicate lack of maxillary forward development.

If the incisor teeth can be positioned within the profile in harmony with surrounding structures, they should be stable and esthetically correct. Esthetics is the science of beauty and taste[2]. It is scientifically more correct to use relationships between measurable landmarks for the positioning of the teeth than to use averages or preconceived notions. For practical purposes, the equations to determine the angle and the anteroposterior position of the maxillary central incisor (y3 and y9) are most useful because they are important esthetically. If these check with treatment results after good occlusal relationships are established and if arch form has not been violated, the same harmonies are present as those found in the group of selected good occlusion cases.

These methods of evaluation may not be based upon the best possible facial or tooth measurements, but as methods they are statistically sound. Different measurements or ways to reduce the reasons for imperfection of correlations listed previously might bring greater significance to these harmonies. Harmonious relationships might vary with age, sex or racial differences but, as biological correlations with statistical significance, they indicate that such variations should be consistent and measurable.

Classification of malocclusion might be made according to deviation from harmonies and might be measurable. Hereditary deviations from harmonious relationships might be shown to exist.

The use of the above scattergrams and good occlusion equations provide new and useful methods for orthodontic complex.

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