Static and Dynamic Analyses of Gonial Angle Size

G. W. Thompson, D.D.S., Ph.D.

F. Popovich, D.D.S., M.Sc.D

Many orthodontic analyses[1] emphasize the size and shape of the mandible. The mandibular length and/or size of the gonial angle are often directly or indirectly incorporated in an orthodontic case analysis. However, the associations and cause-and-effect relationships of gonial angle changes have not been investigated on a large sample. The objective of the present study was to evaluate the longitudinal changes and determine the relationships of the gonial angle to other craniofacial dimensions.

Björk[2] described an increasing curvature of the mandibular base and noted that this increase was accompanied by a reduction in the size of the gonial angle. This reduction, in turn, was accompanied by vertical condylar growth while the gonial angle and sagittal growth both increased.

Odegaard[3] showed that the direction of condylar growth, with respect to the mandibular line, correlated strongly with the gonial angle size. He also found that if the gonial angle is acute, mandibular growth is more vertical and directed more anteriorly. Ricketts,[4] however, stated that vertical growth of the mandible is associated with an oblique rather than an acute gonial angle and that, with an acute gonial angle, mandibular body length increases sometimes more than 1.5 mm per year.

Odegaard[5] also suggested that direction of the condylar growth and the angle between the condylar growth line and the mandibular line can be predicted on the basis of the gonial angle.

Ricketts[6] formulated a mandibular growth arc as a guide for estimating mandibular growth. He maintained that the gonial angle position moves posteriorly on this growth arc a distance that equalled almost one half the total increase in mandibular growth.

Dorier and Ciamasoni[7] concluded that the gonial angle size is fairly constant at all ages and that severe dental abrasion or the total loss of teeth had no effects on the angle.

Keen[8] noted an increase in size of the gonial angle with age. This increase, which occurred between the ages of 50-76 years, was accompanied by the loss of the alveolar bone when teeth are lost. In a 6 to 21-year old group, the mean gonial angle was 128.3 degrees, and in a 24 to 45-year old group, the mean gonial angle was 125.4 degrees. Therefore, there was a significant decrease between these two age groups. Keen[8] also noted that an increase in gonial angle is accompanied by an increase in mandibular length.

Maj, Luzi and Lucchese[9] demonstrated a significant association between gonial angle measurements at 9 years of age and relative growth increments of mandibular length between 9 to 13 years. They felt that this association might have some value in estimating mandibular positions.

Material and Methods

This study was based on serial cephalograms of 111 females from the

From the Burlington Growth Centre, Faculty of Dentistry, University of Toronto.

Burlington Growth Centre, Faculty of Dentistry, University of Toronto. The Burlington data collection consists of several serial and cross-sectional groups of children and young adults between the ages of 3 and 21 years. In 1953 these individuals were representative of the three-year old children in Burlington, Ontario. In the present study tracings were made of the lateral cephalograms of each of the 111 females in the serial experimental sample, at each age from 4 to 14, and 16 to 18 years. The tracings were done by two operators, but all of the records for any one individual were made by one investigator.

The Cartesian coordinates were derived for the craniofacial landmarks on the Growth Centre's Gradicon 100 digitizer. The gonial angle was measured through the posterior border of the condyle, gonion, and menton. The size was recorded for each age from 4 to 14, and 16 to 18 years. Sella-pogonion, mandibular length, mandibular body length, S-Na-A, A-Na-B, and Na-A-Pg were measured at ages 4, 8, 12 and 16 years. Mandibular length was measured from the condyle (midpoint between most posterior and most superior points on the condyle relative to the sella-nasion plane) to gnathion. Mandibular body length was measured from gonion to gnathion.

The following measurements were made at ages 4 and 14 years: angles S-Na-A, A-Na-B, Na-A-Pg, Na-S-Gn and orbitale-Bolton point-gnathion, and three distances incorporating sella and gnathion. Besides the sella-gnathion distance, the horizontal and vertical components of that distance relative to the sella-nasion plane were used. That is, the distance sella-gnathion parallel to sella-nasion was the horizontal component, while sella-gnathion perpendicular to sella-nasion plane was the vertical component of the sella-gnathion distance. Since records were missing at some ages, the sample size was not always 111. Only 104 cases had complete records at both ages 4 and 14 years.

TABLE I

Age-Specific Gonial Angle Size

AGE	N	*Mean*	*S.D.*
4	109	132.5	4.5
5	109	132.1	4.6
6	111	131.8	4.7
7	111	131.5	4.8
8	111	131.1	4.8
9	109	130.7	5.0
10	111	130.5	5.1
11	111	130.2	5.0
12	111	129.9	5.1
13	107	129.3	5.3
14	106	128.7	5.5
16	100	127.7	5.7
17	46	127.6	6.1
18	74	127.5	5.6

The size of gonial angle at two different ages was investigated in the total serial experimental female sample. The correlation analysis was intracorrelation because it related the same measurement at two different points in time in the same individuals. A static analysis of the relationship of the gonial angle to other craniofacial measurements was done at ages 4, 8, 12 and 16 years. The dynamics of gonial angle and craniofacial growth were demonstrated by the relationship of the former at age 4 to the size at age 14 and the changes from 4 to 14 of some craniofacial measurements.

Results

There was no significant difference between measurements made by the two operators.

The size of the gonial angle decreased from age 4 to 18 years (Table I). The actual measurements tended to be normally distributed, while the increments from age 4 to 14 years were slightly negatively skewed. There were

AGE-SPECIFIC GONIAL ANGLE INTRA-CORRELATIONS OF THE BURLINGTON FEMALE EXPERIMENTAL SAMPLE

AGE (Yrs.)	AGE (YEARS) 4 (n=109)	6 (n=111)	8 (n=111)	10 (n=111)	12 (n=111)	14 (n=106)	16 (n=100)	18 (n=74)
5 (n=109)	.94	.95	.93	.87	.85	.83	.83	.79
7 (n=111)	.89	.95	.96	.93	.92	.91	.91	.87
9 (n=109)	.85	.91	.95	.97	.94	.93	.93	.92
11 (n=111)	.83	.90	.95	.97	.97	.96	.95	.94
13 (n=107)	.82	.88	.92	.95	.97	.98	.97	.96
17 (n=46)	.77	.86	.90	.91	.95	.97	.98	.99

TABLE II

significant correlations between gonial angle at different ages (Table II) even at large age intervals. However, the degree of correlation was inversely proportional to the age change.

Gonial angle size tended to be inversely related and significantly correlated with mandibular body length and the size of angles S-Na-A and A-Na-B (Table III) at ages 4, 8, 12 and 16 years.

The correlations between gonial angle at age 4 and measurements at 14 years and the increments from age 4 to 14 years were higher for the measurements than the increments (Table IV). The age 14 distance between sella and gnathion parallel to the sella-nasion plane was the only measurement that was significantly related to gonial angle size in both analyses. A further qualitative analysis demonstrated more clearly how the size of gonial angle at age 4 was associated with the sella-gnathion distance parallel to sella-nasion plane at age 14 (Table V) and its increment from age 4 to 14 years (Table VI).

Discussion

The principles of orthodontic case analyses are based on the ability to project later craniofacial dimensions from present measurements. The practical significance of gonial angle in the determination of future growth tends to be very limited.

In our sample, gonial angle size decreased from age 4 to 14 years. As indicated by the increase in the standard deviation, the degree of variability of gonial angle size increased with age. At age 4, the average gonial angle measurement was 132.5 degrees. There was a steady decrease in the gonial angle size to 128.7 degrees at age 14 and 127.7 degrees at age 16. However, in individual cases incremental changes

AGE-SPECIFIC CORRELATIONS OF GONIAL ANGLE TO SEVERAL LATERAL CRANIOFACIAL MEASUREMENTS IN THE BURLINGTON SERIAL EXPERIMENTAL FEMALE SAMPLE

MEASUREMENT	AGE 4 (n=109)	AGE 8 (n=111)	AGE 12 (n=111)	AGE 16 (n=100)
S-Pg	-.03	-.04	-.00	.09
Mandibular Length	-.06	-.04	-.05	.05
Mandibular Body Length	-.36**	-.33**	-.38**	-.34**
Angle S-Na-A	-.20*	-.28**	-.30**	-.28**
Angle A-Na-B	-.26**	-.38**	-.39**	-.39**
Angle Na-A-Pg	-.13	-.11	-.03	-.01

* significant at 0.05 level
** significant at 0.01 level

TABLE III

CORRELATION OF GONIAL ANGLE AT AGE 4 WITH SEVERAL CRANIOFACIAL MEASUREMENTS AT AGE 14 AND INCREMENTS FROM AGE 4 TO 14 YEARS

MEASUREMENT	AGE (YEARS) Age 14	Age 4-14
S-Gn	-.06	-.11
S-Gn // S-Na	-.41**	-.27**
S-Gn ⊥ S-Na	-.16	-.01
S-Na-A pt	-.28**	-.11
A pt-Na-B pt	-.30**	-.05
Na-A pt-Pg	-.05	.07
Na-S-Gn	.45**	.11
Gonial Angle	.80**	-.06
Or-Bolton Pt-Gn	.34**	.08

** significant at 0.01 level

TABLE IV

ASSOCIATION BETWEEN GONIAL ANGLE AT AGE 4 AND SELLA-GNATHION PARALLEL TO SELLA-NASION PLANE AT AGE 14 IN 104 FEMALES OF THE BURLINGTON GROWTH CENTRE EXPERIMENTAL SAMPLE

SELLA TO GNATHION (mm)	GONIAL ANGLE (DEGREES) Small (<129) n	%	Medium (129-136) n	%	Large (>136) n	%	TOTAL
Small (<34)	0	(0.0)	8	(44.4)	10	(55.6)	18
Medium (34-46)	17	(26.2)	36	(55.3)	12	(18.5)	65
Large (>46)	6	(28.5)	13	(61.9)	2	(9.5)	21
TOTAL	23	(22.1)	57	(54.8)	24	(23.1)	104

$X^2 = 15.91$

d.f. = 4

$p < 0.01$

TABLE V

varied considerably from —11.0 degrees to +3.5 degrees over the interval from age 4 to 14 years.

A significant intracorrelation was found for gonial angle size at all ages. When the age difference was small, the intracorrelation of gonial angle improved as age increased; for example, the correlation between age 9 and 14 was larger than the correlation between 4 and 9 years. Therefore, there is less error in estimating gonial angle size at a later age than at an earlier age if the age interval between initial and final measurements is the same.

The degree of correlation decreased as the age interval increased. As is the case in most craniofacial dimensions, it is easier to project gonial angle size over a short time-interval than a longer one. However, unlike many craniofacial dimensions, the gonial angle size can be estimated with a good degree of accuracy over as much as a thirteen-year interval.

The static analyses relating gonial angle to other craniofacial dimensions at ages 4, 8, 12, and 16 years demonstrated that gonial angle was significantly related to the same measurements at all ages. The combined lower anterior face size, as measured by the sella to pogonion distance, was not related to gonial angle. Mandibular length was not at all related to gonial angle size. The mandibular body length was significantly related and inversely proportional to the gonial angle size. That is, individuals with a small gonial angle tended to have a larger

ASSOCIATION BETWEEN GONIAL ANGLE AT AGE 4 AND THE CHANGE IN SELLA-GNATHION PARALLEL TO SELLA-NASION PLANE FROM AGE 4 TO 14 IN 104 FEMALES OF THE BURLINGTON GROWTH CENTRE EXPERIMENTAL SAMPLE

SELLA TO GNATHION (mm)	GONIAL ANGLE (DEGREES) Small (< 129) n	%	Medium (129-136) n	%	Large (> 136) n	%	TOTAL
Small (< 4)	0	(0.0)	11	(57.9)	8	(42.1)	19
Medium (4-13)	18	(27.3)	34	(51.5)	14	(21.2)	66
Large (> 13)	5	(26.3)	12	(63.2)	2	(10.5)	19
TOTAL	23	(22.1)	57	(54.8)	24	(23.1)	104

$X^2 = 9.93$

d.f. = 4

$p < 0.05$

TABLE VI

mandibular body length; the S-Na-A angle and A-Na-B angle were also larger in cases with a smaller gonial angle. However, the angle Na-A-Pg was not related to the gonial angle size. A small gonial angle was therefore associated with a larger mandibular body length, a large S-Na-A angle and a large S-Na-B angle.

Gonial angle at age 4 tended to be of limited value in projecting other mandibular relationships at age 14. The degree to which an age 14 measurement could be estimated was indirectly a function of its correlation to gonial angle at age 14. Measurements at age 14 that were significantly correlated to gonial angle at age 14 were also significantly correlated to gonial angle at age 4. With respect to the dynamics of growth, the accuracy with which future craniofacial measurements can be estimated depends on the relationships of gonial angle to these measurements at a specific age. For example, the correlation between the size of gonial angle and angle sella-nasion-A point was -0.20 at age 4 and -0.28 at age 14 years. However, the intracorrelation of gonial angle at ages 4 and 14 was 0.80. The dynamics of estimating the size of angle S-Na-A at age 14 from gonial angle size at age 4 was really brought about indirectly by the high intracorrelation of gonial angle at the different ages. That is, since the sizes of the gonial angle and S-Na-A were related at age 4 and then at age 14, the gonial angle size at age 4 and 14 was correlated, and the gonial angle size at age 4 and S-Na-A size at age 14 were correlated. Even though these relationships were statistically significant, they were of limited practical and no clinical significance.

Gonial angle was not a useful estimator of changes in size of gonial angle or other measurements. The only incremental dimension that was significantly related to gonial angle at age 4 was the distance of sella-gnathion parallel to the sella-nasion plane. However, this dimension was better estimated as its actual size rather than the interval change from age 4 to 14 years.

In the qualitative analysis of these data, there were no cases with a small gonial angle and a small sella-gnathion parallel to sella-nasion plane distance. In addition, only two of the twenty-one children with a large sella-gnathion distance parallel to sella-nasion plane had a large gonial angle. Similar tendencies were demonstrated for the increments of sella-gnathion parallel to sella-nasion plane from age 4 to 14 years relative to gonial angle at age 4.

This study demonstrates that gonial angle is not a particularly good indicator of craniofacial dimensions at a later age, and is of little use as a *quantitative* index of later dimensions. However, the gonial angle size at an early age is useful in *qualitatively* classifying later dimensions. A small gonial angle at an early age indicates a more horizontal growth pattern as noted by Ricketts[4] and a larger mandibular body length. This type of clinical judgment can be made on the size of gonial angle at an early age, while a definitive growth prediction cannot.

Summary and Conclusions

This investigation relates the relationships of gonial angle to other measurements at the same age and later ages in 111 females of the Burlington Growth Centre sample. Gonial angle was measured at each age from 4 to 14 and 16 to 18 years. Six other measurements were related to gonial angle at ages 4, 8, 12 and 16 years. Eight measurements at age 14 and their increments from age 4 to 14 years were compared with the gonial angle at age 4.

The results of this investigation permit the following conclusions:

1. Mandibular length is not related to gonial angle size.
2. Mandibular body length is related to the size of the gonial angle.
3. The size of gonial angle at one age is significantly related to its later size.
4. The initial gonial angle size does not indicate the later gonial angle changes.

124 Edward Street,
Toronto, Ontario.
M5G 1G6
Canada

Acknowledgment

This study was made possible by use of material from the Burlington Growth Centre, Faculty of Dentistry, University of Toronto which was supported by funds provided by Grants (No. 605-7-299 and 605-7-733) of the National Health Grants (Canada) Programme. The authors wish to acknowledge the assistance of Dr. J. Godden and Miss A. Knuut in the preparation of this manuscript.

REFERENCES

1. Krogman, W. M., and Sassouni, V.: A syllabus in roentgenographic cephalometry, *Phil. Cent. Res. Child Growth,* 1957.
2. Björk, A.: Variations in the growth pattern of the human mandible: Longitudinal radiographic study by the implant method, *J. Dent. Res.,* 42:400-411, 1963.
3. Odegaard, J.: Growth of the mandible studied with the aid of metal implants, *Am. J. Orthod.,* 57:145-157, 1970.
4. Ricketts, R. M.: Planning treatment on the basis of the facial pattern and an estimate of its growth, *Angle Orthod.,* 27:14-37, 1957.
5. Odegaard, J.: Mandibular rotation studied with the aid of metal implants, *Am. J. Orthod.,* 58:448-454, 1970.
6. Ricketts, R. M.: The principle of archial growth of the mandible, *Angle Orthod.,* 42:368-386, 1972.
7. Dorier, M. and Ciamasoni, G.: Variations de l'angle goniaque et des diedres condyliens mandibularaires en fonction de l'abrasion dentaire et de la perte des dents, Rev. mens. suisse Odont-Stomatol., 75:201-207, 1965.
8. Keen, J. A.: A study of the angle of the mandible, *J. Dent, Res.,* 24:77-86, 1945.
9. Maj, G., Luzi, G. and Lucchese, P.: Relation between mandibular growth and mandibular features, *Europ. Orthod. Soc. Trans.,* 1963.