Developmental Position of Lower Third Molar in Relation to Gonial Angle and Lower Second Molar

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In relation to the development and eruption of the other teeth, the development of the lower third molars occurs during a very long period. On the basis of the estimations made from radiographs, the bud stage occurs approximately at the age of 8-9 years ranging from 5 to 14 years.[1,5,6,15,16,22]

Eruption of M_3 also is variable starting at 16 years; averages of 20.5,[9,17] 17.8[5] and 24 ± 1.2 years[8] have been reported.

The third molars are more often impacted than other teeth. In unselected materials the impaction occurred in 20 to 25% of Scandinavian inhabitants.[2,15]

Considered as causes of impaction are: retardation of the facial growth,[3,9] lack of space in the M_3 region,[2,4,12,18] vertical direction of condylar growth associated with low resorption of the anterior surface of the ramus, the distal direction of eruption of the other teeth, shortness of the mandible, and reduced alveolar prognathy.[2,17]

In craniometric and gnathometric analyses, angular measurements have generally been used. This has been based on the assumption that the angulations are affected minimally by growth. Walker and Kowalski[21] consider these assumptions untenable and conclude that the accuracy of cephalometric analyses may be increased, if the sexual dimorphism and the existing regression of these measurements are taken into account. McBride and Huggins[14] stated that trends in angulation of the third molars were of more interest and clinical value than linear measurement. In the present investigation, by using orthopantomograms, the interrelationships of the location of the lower third molar in relation to the shape and occlusal position of the mandible as well as to other teeth were studied.

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MATERIAL AND METHODS

The present material consists of children from Helsinki schools as well as college students, totalling 649 subjects whose ages ranged from 5 to 19 years. Their distribution by age and sex is shown in Table I. Orthopantomograms and lateral skull radiograms were taken for all. The subjects were invited to the examination by classes and therefore the present material is an unselected normal group.

The entire sample was investigated by determining the size of the gonial angle (α); to determine this angle a tangent was drawn through the most dorsal point of the posterior surface of the ramus and caput mandible as well as another tangent through the lowest points in the angle and body of the mandible (Fig. 1). Those halves of the jaw in which the entire caput mandible was not exposed in the film were excluded.

To determine the inclination angle between the lower third and second molars as well as between the second molar and the mandibular base line, the longitudinal axes of these teeth were drawn through the midpoint of the occlusal surface and bifurcation or the

TABLE I
Distribution of material by age and sex

Age	Boys	Girls	Total
5-6.9	37	39	76
7-9.9	64	68	132
10-12.9	82	50	132
13-14.9	80	54	134
15-16.9	29	28	57
17-18.9	40	60	100
19	10	8	18
Total	342	307	649

midpoint of the osseous concentration forming this bifurcation. The longitudinal axes were drawn so that they intersected or, if they were almost parallel, one parallel drawn on the other longitudinal axis intersected the other parallel. The angle between the longitudinal axes gave either a mesial or distal tilting of M_3 in relation to M_2 (β). The longitudinal axis of M_2 was continued downward until it intersected the tangent touching the lower edge of the mandible. The anterior angle between these (δ) gave the angle of M_2 in relation to the mandibular base line (Fig. 1). Furthermore, the distance between M_3 and M_2 was measured from the distal surface with a 0.5 mm accuracy.

To eliminate sources of error, the tracings were made by one person, the measurements by another, and a third performed the determinations of the formation stage of M_3 as well as the position of M_3 in relation to the contact point of M_2.

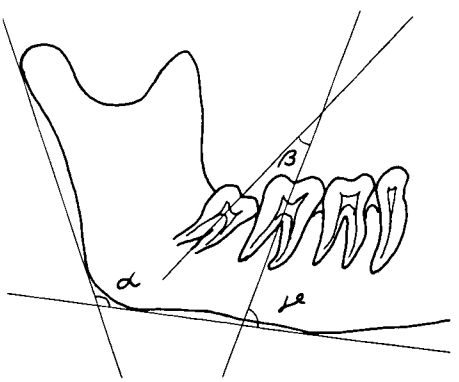

Fig. 1 The lines and angles used in this study.

The formation stage was determined beginning with the one-half crown stage. Earlier formation stages could not be accepted, because the longitudinal axis of M_3 could not be reliably drawn by the method we used. In the determination of the angulation of the teeth the youngest subjects accepted for examination were 12 years old. Neither could this determination be carried out in those few cases in which M_2 was extracted. The Angle classification was determined from a lateral X-ray, because, when orthopantomograms were taken, the teeth were not in normal occlusion.

All information of both halves of the mandible was separately transferred to punch cards for data processing; the sex and age of the subjects were checked according to a conversion table with a one-tenth-year accuracy.

Results

When the material was divided into smaller groups (Table II), it was found that the gonial angle increased between the age groups 5-6 and 7-9. In the following age groups this angle decreased regularly with age until 15-16 and 17-18 when it was found to increase slightly (Table II, Fig. 2). The observations made by sex on the size of the gonial angle were very homogeneous.

When distributed into larger age groups the material, however, demonstrated a clear development with age (Table III). In the youngest age group this angle had a higher mean than in either of the older age groups. On the basis of the "t" test statistically highly significant differences ($P < 0.001$) were found at the different points of the mandible in both boys and girls. The means of the middle and the oldest age groups differ very slightly, and Table II shows that the difference originates from the younger subjects in the age group 11-15. The mean obtained in the

TABLE II

Gonial angle in different age groups, measured from orthopantomograms. N of gonial angles in parentheses.

	Boys		Girls	
Age, years	$\bar{x}$	SD	$\bar{x}$	SD
5.0- 6.9	130.6 (74)	5.3	131.0 (77)	5.9
7.0- 9.9	132.6 (124)	5.6	131.5 (135)	5.7
10.0-12.9	130.9 (161)	5.1	129.9 (99)	6.7
13.0-14.9	128.5 (151)	6.2	126.8 (105)	6.3
15.0-16.9	127.9 (50)	6.9	126.7 (56)	6.2
17.0-18.9	128.2 (72)	7.1	128.4 (113)	79
No persons	327		302	

age group 15-16 suggests that the decreasing trend in this angle slows down before the age of 15 (Table II).

The over-all mean of the gonial angle was slightly larger on the right than the left side, but the difference between these could not be statistically confirmed (Table III). It may have been due to some unilaterally observed cases and smaller occasional observation errors. Because of the insignificance of this difference it was not considered appropriate to investigate its cause.

When grouped according to occlusal anomalies, the gonial angles were found to be almost of the same size in Class I and Class II, Division 1, in Class II, Division 2 about 3 degrees smaller, and in Class III about 3 degrees larger (Table IV).

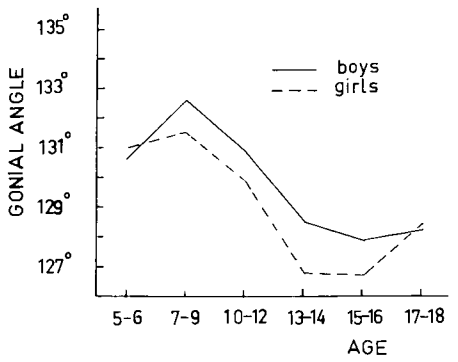

Fig. 2 Gonial angle in different age groups.

TABLE III

The right and left mean gonial angles in various age groups, measured from orthopantomograms.

	right			left		
	$\bar{x}$	SD	N	$\bar{x}$	SD	N
5-10	131.9	5.5	206	131.3	5.7	204
11-15	129.3	6.2	288	129.0	6.2	270
16 >	128.0	7.2	150	127.6	7.1	134
Total	129.8	6.4	644	129.4	6.4	608

The angle (β) between the second and third molars was approximately 19.5 degrees (SD 12.1) in cases in which M_3 was mesially tilted or parallel in relation to M_2, and 8.0 degrees in cases in which M_3's tilting was distal. Third molar teeth, tilted distally in relation to M_2, constituted 5.3%. When the different tilting directions were taken into account, angle β averaged 18 degrees (SD 13.3) in 624 subjects, but did not correlate with the size of the gonial angle (Table V).

In the regression analysis concerning the interaction of angle β, the distance between M_3 and M_2, and age in the entire material, it was found that, with age, parallelism was greater in M_2 and M_3. When the distance was longer the parallelism was less.

Regression equations by sides are:

Right: $Y = 39.7 - 1.48 \cdot X_1 + 2.11 \cdot X_2$

Left: $Y = 35.4 - 1.19 \cdot X_1 + 1.39 \cdot X_2$

In equations: Y = angle β, degrees
X_1 = age, years
X_2 = M_2 and M_3 distance, mm.

TABLE IV

Gonial angle and the anterior angle of the mandibular base line and the longitudinal axis of second mandibular molar according to Angle's Classes I-III.

Angle	Gonial angle			M_2/ base line		
class	$\bar{x}$	SD	N	$\bar{x}$	SD	N
I	130.3	6.4	335	86.5	6.7	394
II_1	129.9	5.6	95	86.4	6.7	107
II_2	126.8	4.5	13	83.9	7.3	11
III	133.5	5.5	12	94.8	9.6	15

TABLE V
Angulation between longitudinal axes M_2 and M_3 (β) compared with gonial angle.

	Angulation					
	Right side		Left Side		Both sides	
Gonial angle	Mesial or parallel	Distal	Mesial or parallel	Distal	Mesial or parallel	Distal
-120	21.3	12.5	17.5	6.0	19.4	9.2
121-130	18.5	7.8	19.4	7.5	18.9	7.6
131-140	21.3	11.0	21.3	6.8	21.3	8.9
141-	22.3	8.0	11.2	11.0	16.7	9.6
Mean	19.8	8.6	19.2	7.3	19.5	8.0
SD	11.6	4.3	12.7	2.6	12.1	3.5
N	301	17	290	16	591	33
Percentages	94.7	5.3	94.8	5.2	94.7	5.3

The regression coefficients of age differed from zero, highly significantly ($P < 0.001$), while of the regression coefficients of the distance of M_3 and M_2 only the right side was statistically significant ($P < 0.01$). The very analogous result on both sides, however, means that the connection between this distance and the size of angle β was highly confirmed.

Moreover, the age dependency of angle β was investigated on the basis of the observations. When the material was divided into three age groups, $\leq$ 13 years, 14-15, and $>$ 16 years, the analysis of variation confirmed statistically the difference between these age groups ($P < 0.001$). This angle decreased more rapidly when moving from the age group 14-15 to the older age group than it did before the former group (Fig. 3).

With age, the distance of M_3 and M_2 decreased regularly up to the age group 11-12. Between this group and that of 13-14 there was an increase in this distance in both boys and girls (Table VI).

A similar change was observed when examining the distance of M_2 and M_3 when the material was classified according to the formation stages of M_3. The increase in the distance occurred between the stages of R 1/4 and R 1/2 (Table VII). The analysis of individual cases showed that the increase in the distance was due to M_2 erupting into occlusion, whereby its broadest part, the crown, moved higher and simultaneously farther from M_3. The anterior angle (δ) between the longitudinal axis of the lower second molar and the mandibular base line did not demonstrate any statistically significant difference between the two sides of the jaw (86.3° and 86.5°). Therefore, it was considered more appropriate to combine both sides.

The influence of age on the size of angle δ was slight. However, the difference of angle δ between the two youngest age groups (87.7° and 85.6°)

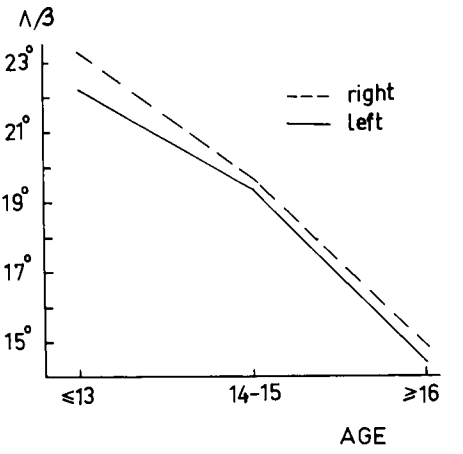

Fig. 3 The mean angle between the second and third molar decreases during the growth period and is more rapid after age of 15 years than before.

TABLE VI

Distance (in mm, $\bar{x}$) between M_2 and M_3 in different age groups.

Age, years	Boys Right	Boys Left	Girls Right	Girls Left	Mean	SD
5- 6	2.3	3.3	3.3	3.8	3.4	2.8
8- 9	1.3	1.0	2.0	1.3	1.4	0.9
11-12	0.8	0.8	0.9	0.7	0.8	0.5
13-14	0.9	0.9	1.0	0.8	1.0	0.5
15-16	0.7	0.9	0.7	0.8	0.7	0.4
Mean	1.2	1.2	1.4	1.1		
SD	0.9	1.2	1.7	1.3		

was statistically almost significant ($t = 2.10$, $F = 159$, $P < 0.05$), but because in the oldest age group the angle remained between the angles of the two youngest age groups (86.0°), the interpretation remained open on this basis.

The regression analyses showed that there was a statistically highly confirmed connection between angles α and δ in all age groups ($P < 0.001$).

In equation

$$\delta = b \cdot \alpha + a$$

The b coefficient varied from 0.48 to 0.65 with values from 24.8° to 3.5° in the different age groups. Because variation in the coefficients in the regression equations by age groups occurred and the means of angle δ varied by age groups slightly, it was appropriate to carry out regression analysis investigating the values of angle δ as dependent on both age and angle α. Equations:

$$\delta = b_1 \cdot \text{age} + b_2 \cdot \alpha + a$$

were separately calculated for each side. In this linear regression pattern the regression coefficients of age remained insignificantly small and were not statistically confirmed. The values of b_2 were by sides 0.51 and 0.53. The values of constant a were also very close to one another. By using the means of both sides for the regression coefficient and standard term of angle α the following over-all result was arrived at:

$$\delta = 0.52 \cdot \alpha + 19.6 \text{ degrees}$$

The changes in angle δ in Class I and Class III were also similar to those of the gonial angle: in Class I and Class II, Division 1 almost of equal size; in Class II, Division 2 smallest; and in Class III largest (Table IV). The trend was similar on both sides of the jaw. Angle δ changed with almost the same number of degrees as angle α.

Discussion

As a tangent for the lower jaw the drawing of the mandibular base line from an orthopantomogram is essential. Gnathion cannot be determined from it as reliably as from a lateral X-ray. The comparison of the gonial angles made from the lateral X-rays and orthopantomograms taken of the same material, however, shows that the gonial angle, measured from the mandibular base line and drawn as a tangent, correlates well with the size of the gonial angle obtained from lateral X-rays and clinical measurements.[13] Orthopantomography enables a comparison of both sides, because it reproduces both sides symmetrically.

The gonial angle has been found to increase from an early embryonal stage in the intrauterine period to the moment of birth and then to decrease continuously to old age[10] when enlarging

TABLE VII

Distance (in mm, x) between M_2 and M_3 at different formation stages of M_3.

		$Cr_{1/2}$	Cr_c	$R_{1/4}$	$R_{1/2}$	$R_{3/4}$	R_c	A_c
Boys	$\bar{x}$	1.4	0.5	0.4	0.6	0.3	0.1	0.1
	SD	2.1	0.8	0.5	0.5	0.5	0.3	0.1
	N	34	142	64	27	23	36	20
Girls	$\bar{x}$	2.4	0.8	0.5	0.8	0.5	0.2	0.0
	SD	4.3	1.0	0.6	0.5	0.5	0.4	0.1
	N	16	81	57	30	47	36	13

reoccurs as a consequence of loss of teeth.[11]

In the present study the gonial angle also decreased with age but not as a rule, as in Thompson and Popovich's[20] longitudinal study from the age of 4 to 18, but in between there were increases. It cannot be concluded from the cross-sectional material what causes the increase of the angle in the years 5-9 and 15-18. Herkelmann's hypothesis[10] that in a fetus the gonial angle straightens out because the base of the skull and the upper part of the face grow faster than the lower jaw, could also harmonize with this observation. This hypothesis is also supported by our observation that simultaneously with the straightening of the gonial angle growth spurts in head length[19] occur.

The gonial angle has been found to be 3-5 degrees larger in women than in men. On the basis of the present study there was no clear difference between boys and girls in this angle. In several age groups the gonial angle was smaller in girls, but in the oldest age group it was slightly larger than in boys.

The clear decrease in the gonial angle demonstrated in Class II, Division 2, compared with the groups in Class I and Class II, Division 1, may be caused by the retarding effect of the teeth of the upper jaw on the length growth of the lower jaw. In Class II, Division 2 the growth of the mandible and the size of the gonial angle may be determined in a way characteristic of this occlusion type. An occlusal disturbance, however, does not appear to have a backward-tilting effect on the teeth of the lower jaw. By contrast the anterior angle (δ), formed by the longitudinal axis of M_2 and the base line of the mandible, decreases in the same proportion as the gonial angle (Table IV) which would appear to support the latter alternative. When the gonial angle increases in Class III, angle δ follows it. In this group, M_2 tilted distally in relation to the mandibular plane. In the entire sample the connection between angles α and δ was statistically highly significant.

Björk et al.[2] found that the space of M_3 decreased when the growth of the condyle was vertical; the gonial angle becomes small, and the direction of eruption of the other teeth is distal. In the light of the present study these conditions do not occur simultaneously, but if the gonial angle is small, M_2 tilts forward. Correspondingly, the space allowed by the large gonial angle for the third molar is decreased by the backward-tilted M_2.

The decrease with age of angle β was statistically highly confirmed ($P < 0.001$). The moving of M_3 into an upright position occurred more rapidly after the ages of 14-15 (Fig. 2). This and the decrease in the distance between M_3 and M_2 at the R_e stage (root development complete) support Broadbent's opinion[3] that, between the ages of 16 and 18, M_3 moves rapidly forward in the bone and terminates this movement, as well as Henry and Morant's (ref. Silling[18]) observation that the rotation of M_3 takes place in a close contact with the second molar. The authors have shown in another study[7] that distal inclinations of M_3 do increase with age, this increase being 0.7% at the age of 13 and 14.6% at the age of 19.

Conclusions

The aspects examined in the present study concerning the location and position of the lower third molar and the interrelationships of this molar, the gonial angle, and the second lower molar in subjects aged 5-19 are based on measurements made from 649 orthopantomograms.

The following conclusions were drawn on the basis of the present study:

1. The gonial angle decreased with age. This decrease was more rapid before the age of puberty than after it.

2. The decrease in the gonial angle was not continuous, but slight enlarging occurred between the age groups 5-6 and 7-9 as well as 15-16 and 17-18.

3. The angulation of the third molar in relation to the second molar did not correlate with the size of the gonial angle, but decreased with age. The angle decreased more rapidly after the age of puberty than before it.

4. The mesial angle between the longitudinal axis of the second molar and the mandibular base line correlated highly significantly with the size of the gonial angle.

5. The above angles were smaller in Class II, Division 2 and larger in Class III than in Class I and Class II, Division 1, in which they were of an almost equal size.

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