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Sexual Dimorphism in the Development, Emergence, and Agenesis of the Mandibular Third Molar

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The development, alveolar emergence, and agenesis of the mandibular third molars, in a homogeneous group of French-Canadian children and young adults ranging in age from seven to 25 yr, were evaluated from 4640 panoramic radiographs using the method of Demirjian et al.[8] *Clinical emergence was recorded from dental casts of children between 15 and 19 yr. The occurrence of bilateral agenesis was about 9%, without significant sexual difference. The left and right third molars had the same pattern of crown and root development and emergence. Girls were ahead of boys up to the second half of crown formation, but this sexual difference disappeared at the first stage of root formation. The root development course was faster in males than in females. At the apex closure, the sexual difference was much more marked for retarded cases (about 2.7 yr) than for median (1.5 yr) or advanced cases (0.4 yr). For alveolar and clinical emergence, males were about six mo ahead of females at the median level.*

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Introduction.

The third molar is characterized by a higher proportion of congenital absence and a later development period than other teeth. Agenesis has been reviewed by Nanda[1] and Thompson *et al.*[2] Nanda noted that there has been a lack of uniformity in securing the data and diverse opinions in interpreting the significance of the findings. Thompson *et al.* summarized the results of previous studies; the proportion of subjects with one to four missing third molars ranged from 9 to 35%. These values must be interpreted with care because they are derived from different sources, for both sexes, for mandibular and maxillary teeth.

The developmental course of the third molar has been investigated by a few authors.[3-6] Banks[3] published a chart of third molar development based on a sample of 1000 American children of both sexes. He noted that crypts appeared between five and 14 yr of age, and that from seven to nine yr are needed for complete development. Calcification of the maxillary third molar was generally earlier than that of the mandibular one, the difference being from one to two yr.

Saito[4,5] reported earlier calcification and emergence on the right side than on the left; he also found Japanese girls to be more advanced than boys until the age of 13 yr.

Demisch and Wartmann[5] presented median chronological and skeletal ages for six stages of crown formation and for the first stage of root formation. In their cross-sectional sample of 151 American children, from eight to 15 yr of age, no apparent difference was found between the left and right sides of the mandible. Their small sample size at each stage of development did not permit comparison of boys and girls. This is the only study to include a reliability test. The authors reported identical ratings of two evaluators in 78% of cases; no bias was observed in the cases of different ratings.

The most recent and most complete study of the third molar development was done by Garn *et al.*[6] They defined nine stages of calcification and emergence for their longitudinal sample of 140 American children from Ohio, aged up to 20 yr. Ages of attainment of each stage were not significantly different for boys and girls, but there was a tendency for boys to be more advanced than girls for crown completion and root formation. They pooled the data for both sexes and calculated the 15th and 85th percentiles for age of attainment of each stage.

The abovementioned investigations are based on relatively small samples, none of which adequately covered the complete age

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range of the third molar development. Furthermore, the questions concerning differences between left and right sides of the mandible and the differences between the sexes for calcification and emergence have not been answered completely. The main purpose of our study is to clearly establish the sexual dimorphism in the calcification and emergence of the mandibular third molar with a large sample of subjects from an ethnically homogeneous population, covering the entire age range of this molar's development. We also present results on the bilateral agenesis of this tooth, and a comparison of its development and emergence for the two sides of the mandible. This study complements a previous one for the same population[7] on the sexual difference in dental development and emergence of the remaining seven mandibular teeth.

Materials and methods.

The material for the present study consisted of 4640 panoramic radiographs: 2362 of females and 2278 of males. All are from a homogeneous population of French-Canadian descent for three generations, and, in majority, of middle socio-economic class.

The sample was a composite one. The main source of material came from the mixed longitudinal growth study of the Human Growth Research Centre of the Université de Montréal. Children were followed longitudinally from 1967 to 1976. This provided 2201 X-rays of subjects between the ages of seven and 19 yr; it should be remembered that they represent 438 children with an average of five radiographs per child. Another group of 588 X-rays, also of a longitudinal nature, were from 146 siblings of these children. The cross-sectional material came from the dental clinic of the Université de Montréal. These 1851 X-rays were from children and young adults between seven and 25 yr of age. All of the material was screened in order to exclude subjects with illnesses which possibly might affect dental development. The number of X-rays for males and females of each age is given in Table 1; the minimum number of X-rays for each group is 17. They are grouped into six-month intervals, represented by their mid-points; for example, 16.0 represents all cases between 15¾ yr and 16¼ yr of age.

The left mandibular third molar of all panorex films and the right one of about 1000 older children and young adults from the cross-sectional sample were rated according to the technique described by Demirjian *et al.*[8] The development of the tooth was divided into eight defined stages and identified by the letters A to H; the rater allo-

TABLE 1
NUMBER OF X-RAYS PER AGE GROUPS OF FRENCH-CANADIAN CHILDREN AND YOUNG ADULTS FOR LONGITUDINAL AND CROSS-SECTIONAL MATERIAL

Females		Age Group (Age ± 3 Mo)	Males	
Long.	Cross-sect.		Long.	Cross-sect.
33	22	7.0	31	18
8	19	7.5	5	34
87	35	8.0	87	35
13	43	8.5	13	35
120	62	9.0	113	42
14	59	9.5	12	57
130	62	10.0	126	73
14	64	10.5	9	43
146	36	11.0	142	39
18	38	11.5	10	28
182	28	12.0	186	32
11	23	12.5	9	13
164	6	13.0	163	3
20	5	13.5	–	–
144	–	14.0	155	1
12	5	14.5	–	–
116	5	15.0	142	3
10	20	15.5	9	14
54	21	16.0	62	20
10	19	16.5	5	14
37	18	17.0	52	24
7	22	17.5	4	15
21	22	18.0	41	14
–	–	18.5	3	16
11	21	19.0	27	13
–	24	19.5	–	20
–	45	20.0	1	24
–	30	20.5	–	19
–	31	21.0	–	25
–	27	21.5	–	26
–	21	22.0	–	28
–	27	22.5	–	25
–	40	23.0	–	30
–	27	23.5	–	23
–	25	24.0	–	22
–	28	24.5	–	25
–	–	25.0	–	18
1382	980	Totals	1407	871
2362			2278	

cated it to its appropriate stage of development. The ratings were performed by three persons: one for the longitudinal material, one for the younger children (from seven to 14 yr of age) of the cross-sectional material, and the last one for older children and young adults of the cross-sectional material. These three evaluators were trained by one of the authors (A.D.); all evaluations were cross-sectional. A reliability study[9] showed close agreement between cross-sectional evaluations performed by five evaluators, including the three raters of the present study.

Alveolar emergence (the piercing of the alveolar bone by the dental cusps) was recorded from all X-rays. Clinical emergence (the appearance of the tip of the cusp in the oral cavity) was observed in 339 dental casts of older children (age 15-19 yr) of the longitudinal sample. Agenesis or congenital absence was investigated in the longitudinal sample; all children or young adults without trace of a calcified cusp at the age of 13 or more were excluded from the sample presented in Table 1.

Results.

Preliminary comparisons. – Since our sample was a composite one, we first compared its longitudinal and cross-sectional components. Contingency tables were compiled for each age group with a sufficient number of X-rays in each component (longitudinal and cross-sectional). We detected no significant difference, for calcification stages and alveolar emergence, between longitudinal and cross-sectional data for the third molar of girls (Table 2); similar results were obtained for boys. Consequently, no further distinction between these two components of our sample is needed.

Left- and right-side mandibular third molars were also compared on 1000 X-rays of the cross-sectional sample. A first analysis indicated no sexual difference in the results of this comparison; therefore, we pooled results for both sexes. In dental development, the same stage was encountered in both sides of the mandible in 87.2% of the cases. The remaining cases were evenly distributed between positive and negative differences of one stage (12.4% of the cases) or two stages (0.4% of the cases). For alveolar emergence, 93.3% of the cases were identical on both sides, 3.6% were of left-side emergence only, and 3.1% were of right-side emergence only. When developmental stages and emergence were not identical on both sides, the side advanced for calcification was never retarded for alveolar emergence. As the development and the emergence of both third molars were chronologically synchronized, all remaining evaluations were performed on the left side only;

TABLE 2
COMPARISON BETWEEN LONGITUDINAL AND CROSS-SECTIONAL DATA FOR THE THIRD MOLAR OF GIRLS

Age Group	Stage of Calcification Encounter	N	χ^2	d.f.	P
		Stage of Calcification			
8.0	O to B	122	1.91	1	.17
9.0	O to C	182	4.67	2	.10
10.0	O to C	192	4.95	3	.18
11.0	O to D	182	2.63	3	.45
12.0	O to E	210	6.67	3	.08
16.0	B to G	75	1.01	2	.60
18.0	D to H	43	1.70	2	.43
		Alveolar Emergence			
16.0	--	75	0.86	1	.35
18.0	--	43	0.04	1	.84

Notes: d.f. = degree of freedom.
P = probability.
Yate's correction is applied when d.f. = 1.

in cases where the left tooth was missing, it was replaced by the one on the right side.[8]

Bilateral agenesis. – The mandibular third molar agenesis was evaluated in the longitudinal data only. When the beginning of calcification was not detected at 13 yr, no subsequent calcification was observed at older ages; this was true of all boys and girls. Bilateral agenesis seemed less frequent in females than in males, the proportions being 7.1% and 11.1%, respectively; however, these values are not statistically different ($\chi^2 = 1.39$; d.f. = 1; $P > .20$).

Development and emergence. – The proportion of subjects of each sex who had reached each stage, in each six-month age group, was calculated. These proportions were plotted, and resulting curves were smoothed by hand (Fig.). The cumulative curves of alveolar and clinical emergence for both sexes are also presented on the same figure. The clinical emergence curves were traced from the longitudinal sample until the 19th yr only, because dental casts were not available for young adults of the cross-sectional sample.

The age of attainment of each stage and the difference between males and females for advanced (10th percentile), median, and retarded cases (90th percentile) are given in Table 3. We have accepted 0.3 yr as a significant difference; the positive difference shows males to be ahead of females. In the same table, the ages of alveolar and clinical emergence are also given for both sexes.

There is no difference between sexes in the age of attainment of the first two stages "A" and "B" which represent, respectively, the beginning of the calcification of the cusps and their fusion (Fig., Table 3). Girls had a tendency to be ahead of boys for stages "C" and "D," except at the lower and upper ends of the curves (Fig.). At the beginning of root formation (stage "E"), the sexual difference had disappeared. In terms of time needed for the passage from one stage to the next, at the median level, boys take longer than girls do to get from stage "B" to "C" (1.3 yr and 0.9 yr, respectively), but it is the opposite for the passage from stages "D" to "E" (1.1 yr for boys and 1.5 yr for girls), where there is an acceleration in boys.

The median age of attainment of stage "F" of root development is 16.3 yr in both sexes. This apparent absence of sexual difference is the result of a crossing over of the developmental curves for stage "F" (Fig.). In fact, girls were more advanced than boys by 0.5 yr at the 10th percentile, but were later than boys by 1.1 yr at the 90th percentile (Table 3).

For the last two stages of root development ("G" and "H"), the lead of males over females is much smaller for the advanced cases (0.3 and 0.4 years, respectively) than for the retarded cases (1.5 yr for stage "G" and about 2.7 yr for stage "H"). For the median ages of attainment, these differences are intermediate, being 0.7 and 1.5 yr, respectively (Table 3). The sexual difference in development is particularly obvious at

TABLE 3
AGES OF ATTAINMENT OF EACH DEVELOPMENTAL STAGE AND EMERGENCE FOR FEMALES AND MALES

		A (1)	B (2)	C (3)	D (4)	E (5)	F (6)	G (7)	H (8)	Alveolar Emergence	Clinical Emergence
10th Percentile	Females	8.0	8.8	9.9	11.2	12.6	14.0	16.1	17.8	14.5	16.2
	Diff.	*0.1*	*0.1*	*−0.1*	*−0.3*	*−0.1*	*−0.5*	*0.3*	*0.4*	*−0.7*	*−0.2*
	Males	7.9	8.7	10.0	11.5	12.7	14.5	15.8	17.4	15.2	16.4
Median	Females	9.8	10.9	11.8	13.0	14.5	16.3	18.3	20.7	17.7	(19.0)
	Diff.	*0.1*	*0.1*	*−0.3*	*−0.4*	*0.0*	*0.0*	*0.7*	*1.5*	*0.5*	*(0.5)*
	Males	9.7	10.8	12.1	13.4	14.5	16.3	17.6	19.2	17.2	(18.5)
90th Percentile	Females	11.8	12.6	13.7	15.2	16.8	19.8	21.9	(24.7)	22.2	–
	Diff.	*0.2*	*−0.2*	*−0.1*	*−0.3*	*0.0*	*1.1*	*1.5*	*(2.7)*	*1.3*	–
	Males	11.6	12.8	13.8	15.5	16.8	18.7	20.4	22.0	20.9	–

The figures in italics represent the differences between the sexes (females minus males). The values lying between parentheses are estimates obtained near the end-point of a curve.

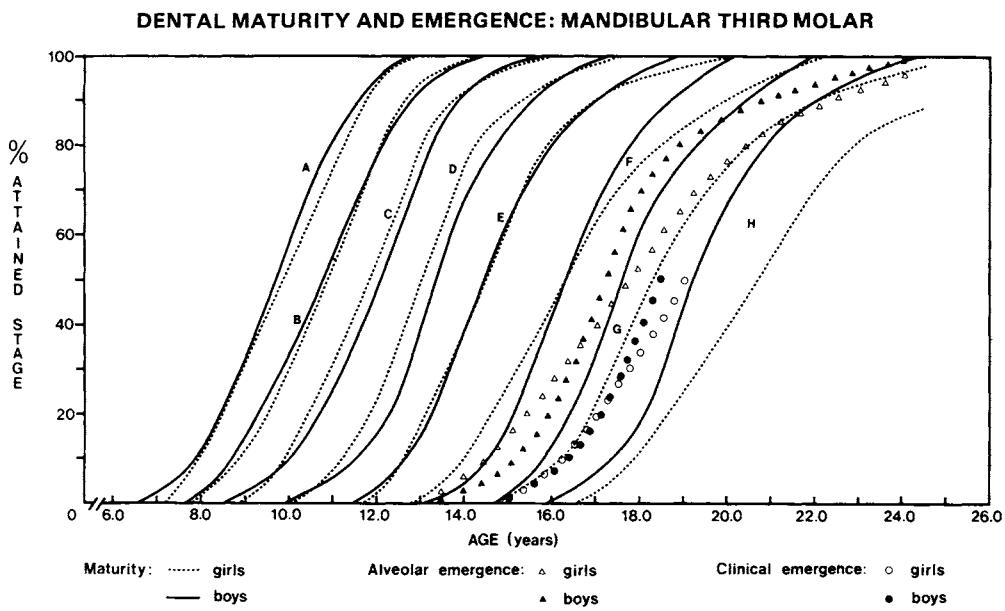

Fig. – Dental maturity and emergence: mandibular third molar.

age 21 yr, where nearly 50% of females and only 20% of males had not reached the last stage of root development (stage "H"); at the same age, 20% of females and 5% of males still had not reached stage "G," and 5% of females had not even attained stage "F" (Fig.).

The pattern of sexual difference for alveolar emergence is similar to that observed at stage "F" of development, except that males already lead females by 0.5 yr at the median level (Fig., Table 3). Alveolar emergence occurred at all stages of root development ("E" to "H"), but mostly in stages "F" and "G." In advanced cases, the third molars had a tendency to emerge from the alveolar bone at an earlier developmental stage (stage "E" or "F") than those of retarded cases (stage "G" or "H").

The curves of clinical emergence for boys and girls coincide from 15 to 17.5 yr of age (Fig.). However, the lead of boys over girls at the median age of clinical emergence, about 0.5 yr, is identical with the sexual difference obtained for alveolar emergence (Table 3). Clinical emergence occurred about 1.3 yr after alveolar emergence in both sexes at the median level; at the 10th percentile, this interval is greater for girls (1.7 yr) than that for boys (1.2 yr).

The completion of root formation in all males occurred about 24 yr of age. The corresponding value for females, obtained by extrapolation, seemed to be between 27 and 28 yr of age (Fig.).

Discussion.

Our results on mandibular bilateral agenesis of French-Canadian males agree with those of Thompson *et al.*[2] for Canadians of Anglo-Saxon descent, and those of Björk *et al.*[10] for Scandinavians: All the reported proportions are between 10.1 and 11.5% (Table 4). The proportion of agenesis for French-Canadian females was less than that of males, but the difference, unlike the sample of Thompson,[2] was not significant. The values obtained for Canadian females, however, are higher than results reported by Nanda[1] for young women of Boston (Table 5). The hypothesis of higher frequencies of third molar agenesis in females than in males[11,12] is not corroborated by our findings or by those of Thompson *et al.*

The right and left mandibular third molars have the same pattern of development in both sexes of French-Canadian children. This is a clarification of the results of Demisch and Wartmann,[5] which showed no definite trend in dissymmetry for American subjects. In these two populations, dissimilar stages were encountered for the two sides of the mandible, but no systematic

TABLE 4
MANDIBULAR BILATERAL AGENESIS IN SOME CAUCASIAN POPULATIONS

Population	Type of Data*	Age Range (Yr)	Females		Males		Reference
			Sample Size	Bilateral Agenesis (%)	Sample Size	Bilateral Agenesis (%)	
French-Canadian (Montreal)	L	13-16	182	7.1	187	11.1	This study
Anglo-Canadian (Toronto)†	L,CS	~ 16	237	10.4	284	10.4	(2)
American (Boston)	CS	18-21	200	3.0	–	–	(1)
Swedish	L	12&20	–	–	243	11.5	(10)
Danish	CS	19-30	–	–	237	10.1	(10)

*L = longitudinal, CS = cross-sectional.
†Sexes were not separated.

difference was detected. The synchronized development of the two mandibular third molars observed in North American subjects does not seem a general rule. In Japanese patients, Saito[4,5] reported earlier calcification and emergence on the right side of the mandible than on the left.

The sexual dimorphism observed at stages "C" and "D" of crown formation (0.3-0.4 yr) is identical with corresponding stages for the second molar.[7] Girls were ahead of boys for the last stage of crown formation; this was also noted for other mandibular teeth in the same population. Therefore, the pattern of sexual differentiation at the time of crown completion is the same for all mandibular teeth, including the third molar. This result agrees with those of Saito,[4,5] that, until the age of 13, Japanese girls had a more rapid rate of development for the third molar than did Japanese boys. On the contrary, Garn *et al.*[6] reported a non-significant advance of 0.6 yr for boys over girls at crown completion.

At the beginning of root formation (stage "E"), the girls' lead had disappeared. During the next stages of root formation, a second sexual dimorphism was progressively established – this time in favor of boys. From stage "F" (half-root formation) to stage "H" (apex closure), the developmental curves of males and females were not parallel, the curves of females being more flattened. Consequently, the sexual difference is minimal for advanced cases (0.4 yr at apex closure) and maximal for retarded cases (about 2.7 yr at apex closure). This pattern is peculiar to the third molar. For all other mandibular teeth in the same population, the advance of girls already established at crown completion was maintained until apex closure, and there was no major difference between the slopes of developmental curves of boys and girls.[7] Our findings contrast with the conclusions of Garn *et al.*[6] for American children, where they found a non-significant difference of about six mo in favor of boys, for the first two stages of root formation, and no sexual difference for the apical completion stage.

The cumulative curves of alveolar and clinical emergence showed males to be ahead of females, except for the advanced cases. This sexual difference was about six mo at the median level. The median ages of alveolar emergence, 17.2 yr for males and 17.7 for females, were higher than the median age reported for American children: 17.0 yr in both sexes.[6] However, the median ages of clinical emergence, about 18.5 yr for males and 19.0 yr for females, were lower than the mean values obtained by Hellman[11] for Americans (20.5 yr for males and 20.8 yr for females).

Conclusions.

Bilateral agenesis was encountered in about 9% of the cases, with no significant sexual difference. The right and left mandibular third molars had the same pattern of development and emergence.

The slight advance of girls over boys at the crown-completion stage was similar to previous observations on other mandibular teeth, particularly the second molar. The root development course of the third molar was faster in males than in females; this sexual dimorphism was much greater for retarded cases than for advanced cases. At the apex closure, the difference between median ages of males and females was 1.5 yr. Alveolar emergence tended to occur at a lower developmental stage in advanced cases compared with retarded cases.

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