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Studies on the chronology of third molar mineralization in First Nations people of Canada

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Abstract Forensic age estimation of living subjects has become increasingly important in recent years. One main criterion for dental age estimation in the relevant age group is the evaluation of third molar mineralization. In the present study, we determined the stages of third molar mineralization in 347 female and 258 male First Nations people of Canada aged 11 to 29 years based on radiological evidence from 605 conventional orthopantomograms. The results presented here provide useful data on the mineralization stages of third molars that can be used for forensic estimation of the minimum and most probable ages including the range of scatter of investigated persons.

Keywords Dental age · Tooth mineralization · Third molar · First Nations people of Canada

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Introduction

Forensic age diagnostics in living adolescents and young adults is an established research sector in the field of forensic science [6, 10, 16, 20, 21]. The reason for the increasing importance of forensic age estimation of living individuals today is cross-border migration which led to an increasing rate of foreigners in numerous countries giving doubtful details about their age. The individuals to whom forensic examination is to be applied are foreigners without valid identity documents who are suspected of making false statements about their age and whose genuine age needs to be ascertained in the course of criminal, civil, or asylum proceedings [17]. In most countries, the age thresholds of legal importance lie between 14 and 21 years.

In accordance with the updated recommendations for age estimation in criminal proceedings of the Study Group on Forensic Age Diagnostics, for age estimation, a physical examination, an X-ray examination of the hand as well as a dental examination should be performed. If the skeletal development of the hand is completed, an additional X-ray examination or CT scan of the clavicles should be carried out [19].

One main criterion for dental age estimation in the relevant age group is the evaluation of third molar mineralization. On the basis of published data, it can be assumed that the time course of third molar mineralization is affected by the ethnic affiliation of the investigated population. Hence, it is required to generate population-specific data for forensic age diagnostics in living humans. This paper presents statistical measures on the time course of third molar mineralization in First Nations people of Canada.

Materials and methods

A total of 605 conventional orthopantomograms of 347 female and 258 male First Nations people of Canada of known age (11 to 29 years) were analyzed retrospectively. The First Nations people who were investigated belonged to the Ojibwa tribe. Today, the Ojibwa live in local reservations north of the Lake Superior and the Lake Huron as well as in parts of Minnesota, North Dakota, Wisconsin, Manitoba, and Sasketchewan. The Ojibwa have lower to middle class income level. They eat a combination of traditional (game and fish) and westernized food. The orthopantomograms were taken during the years 1987–2007 because of tooth extractions, temporomandibular joint diagnostics, or oral lesions. Patient identification number, sex, date of birth, date of X-ray, and mineralization stages of the third molars were recorded for each individual subject. The age of each subject was calculated as the date of X-ray minus the date of birth. The age and sex distribution of the study population is shown in Table 1.

The mineralization status of the third molars was assessed using the classification of stages by Demirjian et al. [1] (Fig. 1):

Stage A: Cusp tips are mineralized but have not yet coalesced.
Stage B: Mineralized cusps are united so the mature coronal morphology is well-defined.

Stage C: The crown is about half formed; the pulp chamber is evident and dentinal deposition is occuring.
Stage D: Crown formation is complete to the dentoenamel junction. The pulp chamber has a trapezoidal form.
Stage E: Formation of the inter-radicular bifurcation has begun. Root length is less than the crown length.
Stage F: Root length is at least as great as crown length. Roots have funnel-shaped endings.
Stage G: Root walls are parallel, but apices remain open.
Stage H: Apical ends of the roots are completely closed, and the periodontal membrane has a uniform width around the root.

Statistical analyses were performed using SPSS software. In case of stage H, 50% probability values have been calculated using logistic regression.

Results

Tables 2 and 3 show the number of cases, minimum, maximum, and mean values with standard deviation as well as median values with lower and upper quartiles for the age of mineralization of teeth 18, 28, 38, and 48 according to mineralization stages C to H for males and females, respectively. Stages C and D were not observed for tooth 48 in males. Table 4 shows the 50% probability values for stage H.
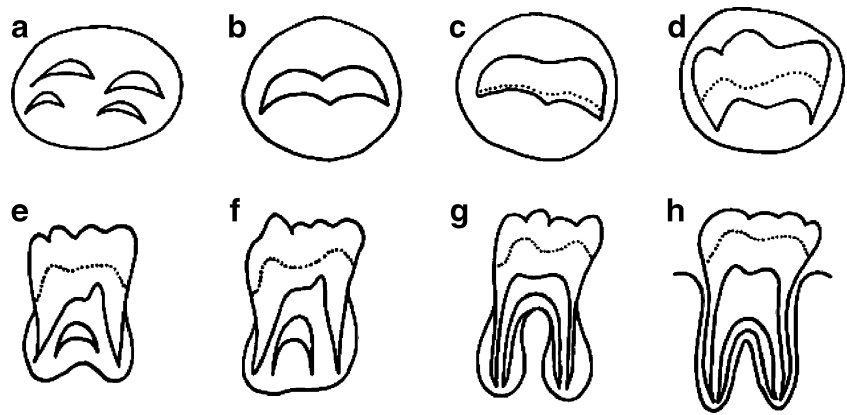
Discussion

Various classifications have been devised for evaluating tooth mineralization [1–5, 8, 9, 11–13]. They differ from each other with regard to the number of stages, the definition of each stage, and the presentation. Since the validity of age estimation depends crucially on the classification method used, practitioners should select the most appropriate one. Olze et al. [15] assessed the validity of five basic types of classification. They chose the methods by Gleiser and Hunt [2], Demirjian et al. [1], Gustafson and Koch [3], Harris and Nortje [5], and Kullman et al. [9]. Out of these methods, the most accurate results were obtained using Demirjian's classification system. Hence, this classification of stages was used for this investigation.

A comparative study of wisdom tooth mineralization [14] was carried out on three population samples: a German sample, a Japanese sample, and a South African sample. To this end, 3,652 conventional orthopantomograms were

Table 1 Age and sex distribution of the sample

Age	Male	Female
11	1	9
12	7	12
13	8	13
14	10	18
15	14	23
16	19	33
17	22	33
18	33	45
19	26	32
20	18	28
21	24	29
22	17	21
23	18	22
24	14	9
25	10	6
26	6	3
27	3	8
28	6	1
29	2	2

Fig. 1 Diagrammatic representation of the formation stages A–H of third molars as described by Demirjian et al. [1]

evaluated on the basis of Demirjian's stages. Statistically significant differences between the samples investigated were established for the age at which stages D–G of third molar mineralization were reached. Significant differences between German and Japanese males were noted for stages D–G of mineralization. Significant differences between Japanese and German females were observed for stages D–F. According to these findings, Japanese males and females were approximately 1–2 years older than their German counterparts when they reached stages D–F. Significant age differences between South African and German males applied to stages D–E. Significant age differences between South African and German females were observed for stages E and G. The South African subjects were approximately 1–2 years younger than the German subjects upon reaching these stages of mineralization. Significant age differences between South African and Japanese samples were ascertained for both sexes at stages D–G. The South African

Table 2 Statistical data on the age of mineralization of teeth 18, 28, 38, and 48, by stage, in females

Tooth	Stage	n	Min	Max	Mean	SD	LQ	Median	UQ
18	C	9	11.0	15.0	12.6	1.4	11.6	12.2	13.7
	D	26	11.4	17.5	14.5	1.5	13.7	14.5	15.7
	E	39	13.0	26.2	15.8	2.4	14.3	15.8	16.9
	F	44	13.7	22.5	18.1	2.0	16.5	18.4	19.7
	G	33	17.2	24.3	20.2	1.9	18.8	19.9	21.1
	H	36	17.8	29.4	23.0	3.2	20.7	23.2	25.1
28	C	8	11.0	15.0	12.3	1.2	11.5	12.2	12.5
	D	25	11.4	17.1	14.1	1.6	12.8	14.1	15.1
	E	46	13.1	26.2	16.1	2.2	14.7	16.0	17.2
	F	39	13.7	23.7	18.1	2.1	16.5	18.4	19.8
	G	40	17.2	25.0	20.2	1.8	18.8	20.4	21.7
	H	37	17.8	29.3	23.3	3.3	20.7	23.6	26.4
38	C	5	11.1	12.2	11.7	0.5	11.3	11.7	12.2
	D	10	11.9	16.1	14.0	1.3	12.8	14.2	15.1
	E	23	13.0	26.2	16.0	2.7	14.4	15.6	17.0
	F	29	13.7	23.7	18.0	2.2	16.3	18.0	19.2
	G	14	17.4	26.1	20.3	2.4	18.6	19.3	22.0
	H	6	17.8	27.4	23.7	3.6	21.5	23.4	27.3
48	C	5	11.1	12.2	11.7	0.5	11.2	11.7	12.2
	D	15	11.4	18.3	14.4	2.0	12.4	14.2	15.4
	E	19	13.0	26.2	15.7	2.9	13.8	15.2	16.5
	F	30	13.7	23.7	18.4	1.8	17.4	18.6	19.4
	G	16	17.4	25.9	20.3	2.4	18.7	19.5	22.3
	H	9	18.2	29.4	23.3	4.2	19.7	21.4	27.3

n number of cases, *Min* minimum age, *Max* maximum age, *SD* standard deviation, *LQ* lower quartile, *UQ* upper quartile

Table 3 Statistical data on the age of mineralization of teeth 18, 28, 38, and 48, by stage, in males

Tooth	Stage	n	Min	Max	Mean	SD	LQ	Median	UQ
18	C	5	12.0	13.5	12.7	0.6	12.1	12.9	13.3
	D	10	11.7	19.6	15.1	2.7	13.0	14.6	17.8
	E	31	13.4	18.9	15.8	1.5	14.7	15.5	16.8
	F	15	13.6	21.8	17.5	1.8	16.6	17.1	18.7
	G	31	14.5	26.5	19.8	2.3	18.2	19.3	21.2
	H	50	17.4	29.8	23.4	2.7	21.6	23.4	24.9
28	C	6	12.0	13.0	12.4	0.4	12.0	12.2	12.9
	D	11	11.7	17.5	14.5	1.8	13.1	14.2	16.0
	E	33	13.4	19.6	15.8	1.5	14.8	15.5	16.8
	F	17	16.3	19.3	17.8	1.1	16.8	17.9	18.8
	G	26	14.5	23.6	19.4	2.0	18.0	19.0	20.7
	H	52	18.0	29.8	23.7	2.7	21.8	23.7	25.2
38	C	2	12.2	12.9	12.5	0.5	12.2	12.5	12.9
	D	3	12.6	13.5	13.0	0.5	12.6	13.0	13.5
	E	13	13.0	18.2	15.3	1.3	14.7	15.0	15.9
	F	11	13.5	19.5	17.4	1.8	16.6	17.9	18.9
	G	7	18.0	21.2	19.8	1.3	18.4	19.6	21.1
	H	11	19.6	29.3	23.2	2.8	21.3	22.3	25.1
48	E	14	13.5	18.2	15.5	1.4	14.7	15.0	16.6
	F	12	15.7	21.2	18.1	1.6	16.7	18.1	19.5
	G	7	18.0	20.8	19.2	0.9	18.4	19.0	19.6
	H	6	18.9	26.3	21.6	2.6	19.4	21.1	23.6

n number of cases, *Min* minimum age, *Max* maximum age, *SD* standard deviation, *LQ* lower quartile, *UQ* upper quartile

subjects were approximately 1–4 years younger than the Japanese subjects upon reaching these stages. The results of the comparative study [14] show the necessity of generating population-specific data for forensic age diagnostics in living individuals. According to the authors' knowledge, this research paper is the first study of the time course of third molar mineralization in First Nations people of Canada.

In the expert report on dental age estimation, the most probable age of the investigated individuals is to be indicated with the range of scatter [19]. Mean value and median are statistical measures for the most probable chronological age of a subject. When the characteristics are distributed normally, mean value and median are identical. The inter-quartile range is a distribution-independent measure for the range of scatter of age diagnostics. Calculated as the difference between the upper and the lower quartile of a frequency distribution, the inter-quartile range sets the interval in which the inner 50% of the values, which are

classified in ascending order, scatter around their median. In the investigated sample, the inter-quartile ranges of stages C–G in female subjects range from 1.0 to 3.6 years, in male subjects from 0.7 to 4.8 years. Assuming that the chronological age within the groups of subjects is a characteristic which is by approximation statistically normally distributed, the standard deviation can also be used for measuring the range of variation of an estimation result. Sixty-eight percent of the subjects with a certain dental age show a chronological age of mean value±simple standard deviation, 95% of the subjects show a chronological age of mean value±double standard deviation. In our sample, the simple standard deviations for stages C–G in female subjects range from 0.5 to 2.9 years, in male subjects from 0.4 to 2.7 years.

As the mean values and medians in stage H of the third molar mineralization depend on the upper limit of age of the investigated sample, the 50% probability value should be set additionally for this stage [7]. This value refers to the most probable minimum age of a person whose third molars show stage H.

A preferable reduction in ranges of scatter of age diagnostics is only possible when the dental age estimation is combined with methods which collect additional characteristics that are independent from dental development. Therefore, the Study Group on Forensic Age Diagnostics always recommends an additional physical inspection as well

Table 4 50% probability values for stage H

	Tooth 18	Tooth 28	Tooth 38	Tooth 48
Females	22.4	22.6	35.3	25.1
Males	21.2	20.8	20.9	20.8

as a determination of the bone age [19]. This practice allows a reduction in the range of variation of the summarizing age diagnostics to approximately ±12 months [18].

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