ORIGINAL ARTICLE

Dental age diagnostics by means of radiographical evaluation of the growth stages of lower wisdom teeth

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Abstract The main criterion for dental age estimation in living adolescents and young adults is mineralization of third molars. A total of 1,260 orthopantomograms of 669 female and 591 male subjects aged between 15 and 22 years was examined. Of the orthopantomograms, 1,137 were from patients with Swiss citizenship and 123 were from other European countries. The mineralization status of lower third molars was evaluated based on Demirjian's classification of stages. For the statistical assessment of data, logistic regression and mean value testing were used. The findings show that completed growth in wisdom teeth is observable at ages less than 18. Male individuals were approximately 1 year ahead of females at stage H, and South East Europeans were approximately 6 months ahead of Swiss (Central Europe) at stage H. Mean values led to false conclusions regarding the question of the attained age of 18. Therefore, regression analysis should be used for the statistical assessment of data in dental age diagnostics.

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Introduction

Forensic age estimation in living persons is a current area of research in the field of forensic science [2, 10, 20, 21]. At the Institute for Legal Medicine at the University of Zurich (IRMZ), age estimations in living adolescents and young adults in the context of criminal investigations and asylum procedures have been carried out since 1999. In the period from 1999 to the end of 2006, a total of 292 people (92 people in criminal investigations and 200 in asylum procedures) were examined. Of those examined in the context of criminal procedures 78% were Caucasians, the majority from South East Europe. Over 80% of those examined were Africans seeking asylum with the majority from West Africa.

The aim of carrying out age estimations was to answer the question whether the examined person has attained the age of 18. Based on the recommendations of the Study Group on Forensic Age Diagnostics [18, 19], the forensic age estimation of living people included a physical examination, an X-ray of the left hand, and a dental examination. An important criterion in the dental examination is wisdom tooth root growth [1, 4, 8, 13, 15].

The present paper deals with the following questions:

- How reliable is root growth of wisdom teeth in the lower jaw in determining the attained age of 18 years?
- Does gender play a major role?
- What influence does the origin (Switzerland or South East Europe) have?
- Does mean value analysis provide feasible reference data when the question of the attained age of 18 is posed?

Materials and methods

Patients

A total of 1,260 orthopantomograms (OPT) taken by the Centre for Dental Medicine at the University of Zurich from 1991 to 2001 were assessed [17]. The distribution according to gender is as follows:

- 669 (53.1%) female
- 591 (46.9%) male

Of the OPTs were 1,137 (90.2%) from patients with Swiss citizenship (CH), the remaining 123 (9.8%) were from other European countries. Information with regard to geographical origin and age was gathered from clinical registration forms. It is assumed that these patient details are correct. The numbers of OPTs examined for each age group are shown in Table 1.

Based on the standard age of 18.0 years for the examination, we included patients 3 years younger and 5 years older. The numbers for each age group varied between 142 and 198. The somewhat higher case numbers for the 17- and 18-year-old individuals was made deliberately.

Examination

Radiological examination was limited to the lower wisdom teeth, 38 and 48. Only cases were considered if tooth 38 and/or 48 could be clearly classified according to a Demirjian stage (1973; Fig. 1)

The assessment was carried out according to:

1. Gender: male/female
2. Age: 15 to 22 years old
3. Origin: Swiss (CH)/Rest of Europe with subgroup South East Europe (SEU)
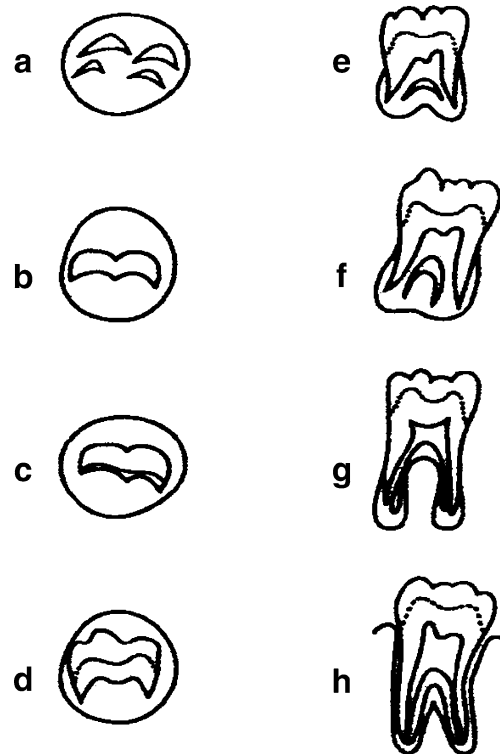4. Stage of tooth development: Classification of stages according to Demirjian

Fig. 1 Stages of tooth mineralization according to Demirjian et al. [3]: *Stage A* top protuberances are mineralized but have not yet fused. *Stage B* The mineralized top protuberances are fused; the definitive coronal morphology is defined. *Stage C* The crown is half formed, the pulp chamber is visible, and the dentine deposit is in process. *Stage D* Coronal formation is complete up to the amelodentinal junction; the pulp has a trapezoidal contour. *Stage E* The formation of the interradicular bifurcation is underway; the root length is less than the coronal length. *Stage F* The root length is at least as long as the coronal length; the roots have funnel-shaped ends. *Stage G* The root walls are parallel; the root apex is still open. *Stage H* The apex of the roots are completely closed

Selecting the wisdom tooth to examine

In each case, only one wisdom tooth was finally considered in the assessment. At different stages left/right (164 cases), the less advanced stage of development was assessed.

Statistical evaluation

Statistical evaluations were carried out by the Seminar of Statistics of the Federal Institute of Technology, Zurich (ETHZ). Calculations were made using the statistics software R [22].

Where target sizes are not continuous but binary (e.g., "attained age of 18 = yes or no" at stage H), logistic regression is the statistical method of choice. Logistic regression is then capable of predicting the probability for stage H for each combination of the explanatory variables (age, gender, origin).

Table 1 OPT distribution according to age and gender

Age (years)	Number of OPTs
15	144 (M, 71/F, 73)
16	142 (57/85)
17	177 (82/95)
18	198 (86/112)
19	149 (74/75)
20	154 (72/82)
21	145 (70/75)
22	151 (79/72)

Moreover, 10%, 50% and 90% probability values have been calculated for stage H.

The variable nationality is subdivided into two classes, Switzerland (CH) and South East Europe (SEU), as, apart from Switzerland, every other nationality is only seldom represented. Considered in the latter class are the nations Albania, Bosnia, Greece, Yugoslavia, Macedonia, Romania, and Turkey. It is important to know whether the results found for the Swiss also apply to the extended area of the Balkans as age estimations are carried out regularly in Zurich on people from South East Europe. Another 44 individuals, neither Swiss nor South East European (for instance German, Spanish etc.), were not included in the statistical analyses. The overall statistical analysis is therefore based on 1,216 people.

The mean values of the Demirjian stages D–H and the first standard deviation (SD) were determined by an additional analysis for the age groups 15–22 as mean value testing is frequently used in age diagnostics [6–9, 11, 14, 23, 25]. In two further assessments, in a first step, the 21–22 age groups and then the two low-ranking age groups of 15 and 16 were eliminated in order to estimate the influence of age grouping on mean values.

Results

Mineralization stage and age

Demirjian stages A and B were not observed in the 15- to 22-year-old age group. Stage C was rare in the 17- to 19-year-old age groups, showing one case only per age group. Stage C was not observed in the groups over 19 years. Upon attained age of 22, root growth was radiologically complete (Demirjian stage H) in 91% of those examined. In nine of the 1,260 wisdom teeth examined, root growth was complete on both sides (stage H) before attaining the age of 18. These nine cases were all found to be older than age 17 and correspond to 5% of this age group.

Mineralization stages right vs. left

A total of 1,097 individuals (87%) had wisdom teeth on both sides in the lower jaw, and 164 of these (15%) displayed a different stage between right and left. In 156 of these cases, the tooth stages differed by one and in seven cases two, and in one case, three stage differences were detectable.

Stage H: gender and ethnicity

Table 2 shows the mean age for the combination of gender and origin, where the probability for tooth stage H is 10%, 50%, or 90%. This means that at the age of 17.5 years old,

Table 2 Mean age by gender and origin and probability for tooth stage (H 10%, 50%, and 90%)

Gender	Origin	10%	50%	90%	
M	CH	17.53	19.03	21.38	Years
	SEU	17.13	18.39	20.38	Years
F	CH	18.14	19.98	22.88	Years
	SEU	17.64	19.20	21.64	Years

10% of Swiss males showed completed root growth in their wisdom teeth.

For Swiss females, this percentage was reached only at the age of 18.1 years.

If we concentrate on the 50% column, the following statements can be made:

1. Males reach point H 1 year before females.
2. South East Europeans are approximately 0.7 years ahead of Swiss at the same point.

There is a limitation in that the values for South East Europeans are not significant (p value is 0.022, likelihood ratio test), as the sample comprises only 83 South East Europeans.

The minimum age for stage H for Swiss females was found to be 17.08 years and 17.25 for Swiss males. The minimal age for stage H for both males and females from South East Europe was 17.42 years.

Significance of mean values

Table 3 shows the mean values of the Demirjian stages D–H with their first SD for the age groups of 15 to 22. For stage H (completed root growth), a mean value of 20.8 years for teeth 38 and 48 was obtained (SD 1.5 years), a value about 2 years lower than the mean value published by Kahl and Schwarze [7] and Olze et al. [14] for the same stage H and the same teeth.

In a further evaluation, the uppermost age groups 21 and 22 years were deliberately omitted. The effect of this manipulation led to a reduction of the mean value for stage H from 20.8 to 19.6 years (see Table 3, stage H).

Finally, the two lowermost age groups of 15 and 16 years were omitted. For the remaining age groups of 17 to 22, the mean value for stage H did not change in comparison to all age groups (15–22). The mean value for stage D however increased considerably by almost 2 years from 16.4 to 18.2 (see Table 3, stage D).

Discussion

In this study on wisdom teeth only of the lower jaws, 1,260 panoramic radiographs (OPTs) of 15 to 22 year olds were

Table 3 Mean value of the age groups 15–22, 15–20, and 17–22 for 38 and 48 teeth

Tooth	38			48		
Age	15–22	15–20	17–22	15–22	15–20	17–22
Stage D	16.4	16.4	18.2	16.4	16.4	18.2
(SD)	1.3	1.3	1	1.2	1.2	1
Stage E	17.2	17	18.8	17.2	17	18.6
(SD)	1.8	1.5	1.5	1.7	1.4	1.4
Stage F	18	17.8	18.5	17.9	17.8	18.5
(SD)	1.4	1.3	1.2	1.4	1.3	1.1
Stage G	18.8	18.4	19	18.9	18.5	19.1
(SD)	1.5	1.2	1.4	1.6	1.2	1.5
Stage H	20.9	19.6	20.9	20.8	19.6	20.8
(SD)	1.5	0.9	1.5	1.5	0.9	1.5

examined. The classification of stages according to Demirjian et al. [3] was used to estimate the extent of mineralization. Olze et al. [16] examined the various stage classifications. The classification of stages according to Demirjian et al. [3] revealed in total the highest inter- and intraindividual correspondence level between the assessors (intraclass correlation), as well as the highest correspondence between estimated age and chronological age.

Various authors [7, 12, 13, 25] have determined that the root growth in the wisdom teeth in the upper jaw finished earlier than the lower jaw. It can be deduced from this that the wisdom teeth in the upper jaw are of secondary importance for age diagnostics, as opposed to those in the lower jaw. Friedrich et al. [5] showed that in twice as many cases, the root anatomy in the upper jaw could not be assessed in the same way as the lower jaw.

With a few exceptions, mean values and standard deviations are determined in age diagnostics. As shown in Table 3, mean value tests for stage H are not suitable. Papers with mean value tests in age diagnostics should therefore not be included in recommendations or guidelines as reference papers. In order to come to correct conclusions for average age groups, the statistics for all age groups have to be taken into consideration (i.e., from the earliest to the latest occurrence in all groups). These mean values could be misinterpreted.

The statistical assessment of our data was carried out by the help of logistical regression analysis. These regression analyses do not depend on the age group selected. Using logistical regression the age at which stage H can be expected according to Demirjian can be determined, e.g., in 10%, 50%, and 90% of cases (see Table 2). Amongst Swiss women, the age (with a 10% probability of completed root growth of the wisdom tooth) is marginally higher than 18 years. For the Swiss and South East Europeans

examined, the 10% value was clearly below 18 years. Therefore, the wisdom tooth as sole criterion cannot be considered reliable for attained age of 18 years.

Many authors [5, 7–9, 14, 25] did not find significant differences in development between the right and left wisdom teeth. Mincer et al. (26%) and Levesque et al. (12.8%) found asymmetry in the development. Weise and Bruntsch [24] even found a varying growth rate of 40% between right and left third molar. In our study, there was a difference in root development of 14.9%. Recommendations as to whether or not in each case all wisdom teeth have to be assessed differ in literature. In our study, in cases with root growth differences between right and left, the least developed wisdom tooth was considered. Whether this conservative, judicially founded procedure (in dubio pro reo) is correct from a biological point of view has to be verified by further examinations.

Olze et al. [15] were able to show an influence of ethnicity on mineralization of the wisdom teeth for stages D–F for Japanese and D–G for South Africans. For stage H, an ethnic influence could neither be proven nor disproven. Willershausen et al. [25] classified the sample into three defined groups (Turkish, Central, and South East European) and additionally into one undefined group. Growth rate differed within 0.5 years. There was insufficient evidence to support the premise of ethnically conditional differences. In our analysis, South East Europeans were 0.7 years ahead of Swiss. This conclusion, however, is uncertain since the South East European group was relatively small.

To clarify the influence of ethnicity, Gunst et al. [4] recommend prospective examinations on age estimation, where ethnicity and culture are precisely defined.

Conclusions

- Completed root growth in wisdom teeth is observable at ages less than 18 years. As a single criterion for age estimation, wisdom teeth are not suitable, especially regarding the question of attained age of 18 years old.
- Male individuals are approximately 1 year ahead of females at stage H.
- South East Europeans are approximately 6 months ahead of Swiss (Central Europe) at stage H. This statement is statistically uncertain due to the small number of South East Europeans examined.
- In dental age diagnostics, regression analysis is suggested for the statistical assessment of data. Mean values lead to false conclusions regarding the question of the attained age of 18 years and are therefore not suitable.
- How to select the wisdom tooth to be assessed (the furthest or least developed) requires further examination.

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