

TECHNICAL NOTE

ODONTOLOGY

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The Third Molar as an Age Marker in Adolescents: New Approach to Age Evaluation*

ABSTRACT: Adolescence is a relatively short period between childhood and adulthood. It is very difficult to determine adulthood based on biological indicators. The third molar may be considered a potential age marker for the period between the ages of 16–21. Our study evaluated a set of 1700 panoramic radiographs of individuals aged between 5 and 21 years. Results confirmed the statistically significant difference in the course of third molars development. The mean deviation for individuals with one third molar agenesis is -0.98 years, for individuals with two third molars agenesis -1.89 years, and with three molars agenesis -3.28 years. Thus, the extent of the deviation is directly proportional to the number of unformed third molars. The calculation of age according to the mean of stages of all third molars could lead to the underestimation of age. No intergender differences were found. Age determination using third molars could be used for forensic purposes.

KEYWORDS: forensic science, dentistry, third molar development, dental age indicator

Adolescence is a relatively short period between childhood and adulthood. It is one of the key life periods as it is a time of somatic, mental, and sexual maturation. It could be said that determining the age of adolescents based on biological indicators is very difficult.

Demirjian et al. (1) carried out a study of somatic, mental, and sexual indicators of maturity on a representative sample of the French–Canadian population at the Montreal Human Growth Research Center. They came to the conclusion that the development of permanent dentition appeared to be the most stable process with regard to chronological age determination.

The third molar could be considered a potential age marker for the period between the ages of 16 and 21 years, as development takes place during adolescence and ends in adulthood (2–8).

The theoretical possibilities of using the third molar for age determination are limited by the duration of its development, which is longer than 10 years. In practice, the 15th year is taken as the lower evaluation limit. Up to this time, estimation by dental age is more rewarding and accurate (9,10). The upper limit for the use of the third molar corresponds to the end of its development and is beyond the adolescent stage. This limit could not be determined precisely due to the fact that, at the age of 21, the

upper limit of the study, no third molars have reached the terminal stage of development. In our setup, the most frequent age of termination of third molar development was 20 years (11).

Exploring third molars for age assessment is not a new idea. Many studies, based on varying criteria, have been devoted to this topic. The results of these studies suggest that the third molar is not, because of the highly variable timing of its development, so suitable for age determination (12).

In our previous contributions (11,13), we focused on the study of third molar development as well as on the incidence of its agenesis in the Czech population. The analysis of the developmental course of the third molar seemed to corroborate the original view of the unsuitability of using this tooth for age determination in adolescents. As is apparent from Fig. 1, most age groups include 3–5 stages of third molar development. However, when studying third molar agenesis, we made some observations that led us to a new strategy of age computation on the basis of the development of the third molar (11,14).

This study explains some basic principles of this method. It concentrates on the otherwise difficult assessment of the adolescent age group and is targeted mainly at anthropologists, forensic medical examiners, and criminologists.

Materials and Methods

The study evaluated a set of 1700 panoramic radiographs of Czech individuals aged between 5 and 21 years (from Charles University, 1st Medical Faculty, Pediatric Dental Department). Indications for X-ray examination were diagnostics and the monitoring of treatment of pathological status in the orofacial area. The children in the study sample were generally healthy, with no striking differences in the social backgrounds of individuals.

All observations were accomplished in accordance with the Helsinki Declaration. Ethical approval for the study was obtained

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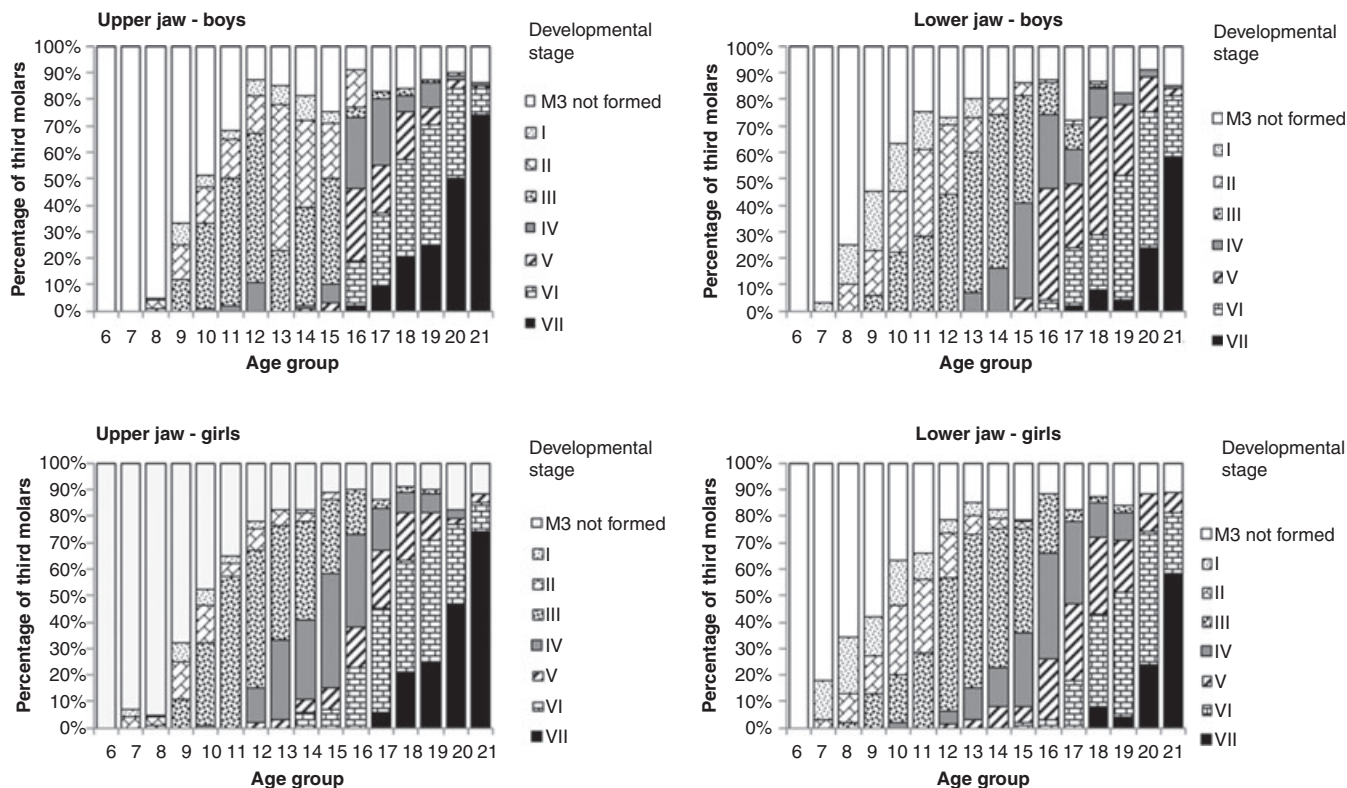


FIG. 1—Representation of third molars developmental stages in age groups.

from the Ethics Committee of the 1st and 2nd Medical Schools of Charles University, Prague.

We prepared 17 groups of 100 patients (50 boys and 50 girls). Groups consisted of individuals who had reached the given age, within a range of ± 6 months. Both sexes were evaluated separately. For each proband, we recorded the developmental stages of third molars in all quadrants of dentition.

The set of 1700 X-ray images was divided into two groups. The first one, consisting of 1100 orthopantomograms (from patients aged 5 to 15) helped to evaluate the stage development of the third molar. The results of 600 adolescents (from adolescents aged 16 to 21) in the second group were used for age calculation based on wisdom teeth eruption. The group of 135 (22.5%) was excluded because of third molar agenesis (15 adolescents—no wisdom teeth had developed in 2.5% of the group).

Out of the wide spectrum of classification systems for the evaluation of the tooth development, the authors of this publication chose the method according to Komínek et al. (15). The development of third molar radices was divided into four stages (tooth crown development was finished). This classification is similar to Demirjian et al. (9). The third molar developmental stages can be easily identified on panoramic radiographs (Fig. 2).

Evaluations of the state of development of the third molar were carried out independently by two authors. Examiners were calibrated using 30 randomly selected panoramic radiographs. Examiners independently recorded the stages of third molar development and the consistency of rating was computed using kappa statistics (16). Interexaminer consistency amounted to $\kappa = 0.86$. Assessments of all radiographs were conducted by two examiners twice within the clear-off time of 2 months, following which the scores were averaged.

The calculation of age according to the developmental condition of third molars was modified. The criteria were the following:

- The relationship between the course of development and the number of third molars formed.
- Interindividual differences in third molar development.

SCHEME OF DEVELOPMENTAL TOOTH STAGES

		I.	Dental follicle
		II.	Incipient crown mineralization
		III.	Advanced crown mineralization
		IV.	Incipient root mineralization
		V.	Divergent root canals
		VI.	Parallel root canals
		VII.	Convergent root canals

FIG. 2—Scheme of developmental tooth stages.

TABLE 1—Chronological age determination on the basis of third molars developmental stage.

Developmental Stage	All Four Third Molars Formed (SD)	Not Formed		
		One Third Molar (SD)	Two Third Molars (SD)	Three Third Molars (SD)
		Corresponding Age		
Upper jaw				
IV	14.7 (2.1)	15.7 (1.2)	16.7 (2.6)	17.7 (2.0)
V	16.3 (3.2)	17.3 (2.3)	18.3 (2.5)	19.3 (1.4)
VI	18.2 (2.4)	19.2 (1.1)	20.1 (0.9)	21.2 (1.2)
Lower jaw				
IV	15.5 (1.9)	16.5 (2.4)	17.5 (2.8)	18.5 (2.4)
V	17.2 (2.3)	18.2 (1.9)	19.2 (1.6)	20.2 (1.1)
VI	19.3 (1.8)	20.3 (1.6)	21.3 (1.6)	22.3 (1.2)

- Intersexual differences in third molar development.
- Differences in the dynamics of third molar development in the upper and lower jaw.

Relationship Between the Course of Development and the Number of Third Molars Formed

The finding that, in individuals with agenesis of 1–3 third molars, the delay in the development of third molars formed is statistically significant when compared to individuals with four formed third molars was of key importance. It means that the set is not homogenous but consists of two specific, different groups (Table 1).

In individuals with agenesis of 1–3 third molars, the development of formed third molars was delayed. If we apply the same method of age evaluation in those individuals as we do to individuals with four third molars formed, we would underestimate the age of the former. It would be then necessary to calculate the deviation based on their real age and then to correct the age estimation according to the mean value of this deviation. The inaccuracy of the corrected estimation was then evaluated using the same method as for individuals with four third molars formed. The calculation was carried out separately for individuals with one, two, and three third molars in agenesis.

Intra-Individual Differences in Third Molar Development

Differences were recorded in more than 50% of cases, with more frequent occurrence in the group with agenesis. These existed for the whole duration of third molar development and had up to three stages (Fig. 3). The differences were in a maximum of three stages. Intra-individual differences in the development of the third molar raise the question of the determination of the individual's age according to development of the third molars. The calculation of age according to the mean of stages of all third molars could lead to the underestimation of age. Therefore, all results



FIG. 3—Intra-individual differences in third molar development. Panoramic radiograph of 16-year-old boy.

were processed in two ways: based on the mean of developmental stages (method 1) and according to the condition of the developmentally most advanced third molar (method 2).

Intersexual Differences in Third Molar Development

Taking into account the possibility of intersexual differences in the course of third molar development, we processed all documents according to variant A (both sexes are evaluated separately) as well as variant B (evaluation regardless of sex).

Differences in the Dynamics of Third Molar Development in the Upper and Lower Jaw

Having found statistically significant differences in the dynamics of third molar development in the upper and lower jaw, we specified all results for the upper and lower jaw separately.

All measurements, together with known chronological ages and calculated dental ages according to the formulae developed for the original technique, were statistically analyzed by means of an SAS UNIVARIATE procedure (SPSS 11.0 package [SPSS Inc., Chicago, IL] for Windows). Differences between chronological and calculated age were analyzed using the Student's *t*-test and the standard error of the estimated age was calculated. All statistical tests were carried out at 5% level of significance.

Results

The Relationship Between the Course of Development and the Number of Third Molars Formed

Results confirmed the statistically significant difference in the course of development of third molars between both groups (individuals with four formed third molars, or with agenesis of 1–3 third molars). In individuals with agenesis, the development of formed third molars is delayed by a statistically significant factor (Fig. 4).

Individuals with Four Third Molars Formed

In this group, development progresses quite evenly over time, without significant disturbances. According to this approach, the average mean quadratic error of estimation is 1.63 years. For the sake of comparison, we give the estimation on the basis of dental age, according to which the average mean quadratic error of estimation is 0.79 years. Methods applied to the estimation of adult age have this value within the range of 5 years. Linear dependence between chronological age, dental age and the age assessed on the basis of third molar development is shown in Fig. 5.

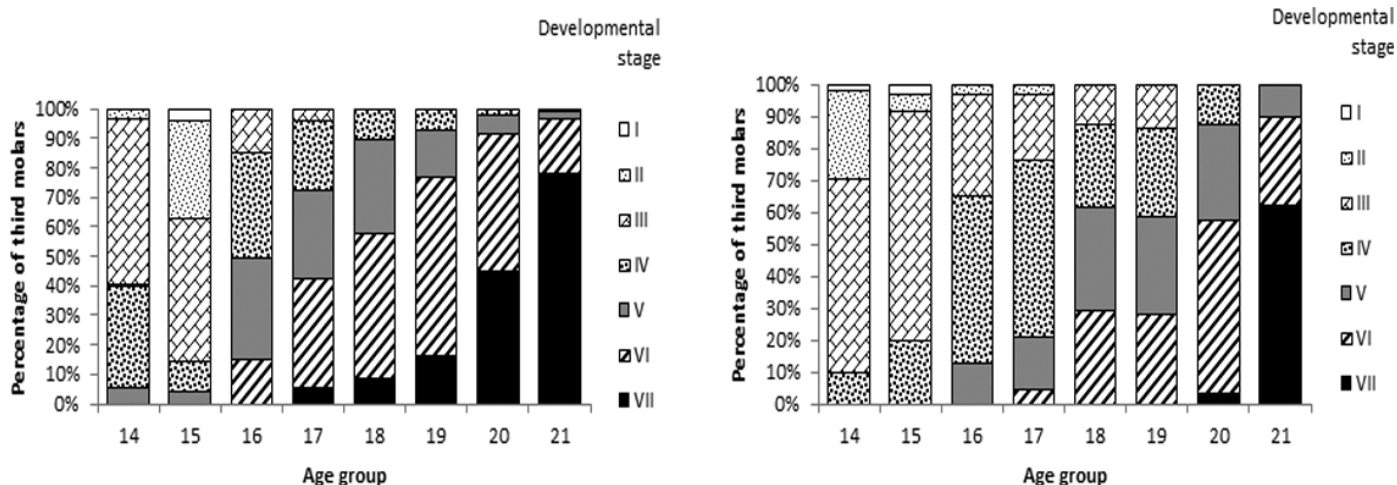


FIG. 4—Representation of third molars developmental stages in individuals with four third molars formed and in individuals with 1–3 third molars agenesis.

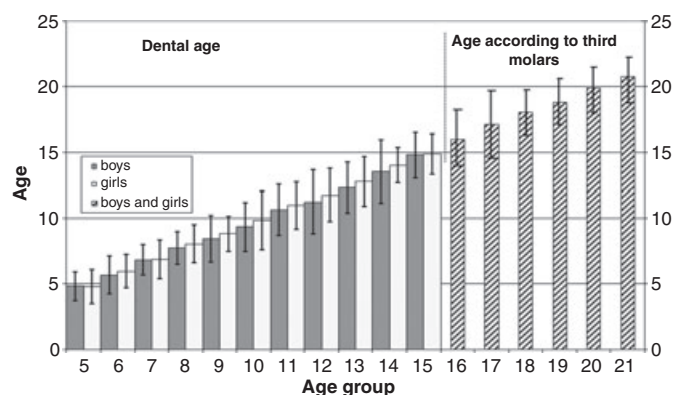


FIG. 5—Dependence of dental age and age determined according to third molars on chronological age in age groups. Error lines over columns show mean quadratic error of estimation.

Individuals with Agenesis of 1–3 Third Molars

To assess the age in this group, we used values obtained from individuals with four formed molars. The age corresponding to particular stages of third molar development, including quadratic deviation and their average for all age groups, was calculated separately for individuals with agenesis of one, two, and three third molars. For individuals with agenesis of one molar, the mean deviation is -0.98 years, with agenesis of two molars -1.89 years and with agenesis of three molars -3.28 years. Thus, the extent of the deviation is directly related to the number of unformed third molars.

The calculated mean values of medium quadratic deviations were then used for the correction of the age of individuals with agenesis of 1–3 third molars. The medium estimation error of the results adjusted in this way is not significantly superior to the estimation error for individuals with four formed third molars.

Intra-Individual Differences in the Development of Third Molars

When calculating age by comparing methods 1 and 2, it became apparent that there difference between the two was not statistically significant. However, method 2 for age evaluation according to the developmentally most advanced third molar appeared to be substantially simpler and faster, and therefore, it was preferred for final calculation.

Intersexual Differences in the Development of Third Molars

Statistical evaluation of the third molar development schedule did not show statistically significant differences between both sexes. However, certain time variations in dynamics of third molars development did not go unnoticed. We have found out that until stage IV inclusive, the development of third molars runs in parallel in both sexes. Some differences were found in the third lower jaw molars of boys and girls at the age of 16–17 years. Developmental stages V and VI were slightly more frequent in boys than in girls. Differences were not statistically significant.

If mean errors in the estimation for variants A and B (intersexual differences) are compared, the results were almost the same. For this reason, we processed the documentation without considering sex.

Differences in the Dynamics of the Development of Third Molars in the Upper and Lower Jaw

When both methods (1 and 2) are applied to both sexes, there is a clear tendency toward the delayed development of third molars in the lower jaw compared with the upper jaw. Between the ages of 15 and 21 years, the development of third molars in the lower jaw is delayed by approximately one developmental stage. This represents a statistically significant difference.

The final results for the differentiation of the third molars of both jaws are summarized in Table 1 with which it is possible to determine age depending on the particular stage of third molar development. This can be carried out for individuals with formed four third molars as well as for individuals with agenesis of 1–3 third molars where results have already been adjusted according to the number of third molars congenitally absent so that they correspond to the real age.

Discussion

The determination of the age in young individuals (16–21 years of age) remains an unresolved issue because of the absence of reliable biological markers. A potential age indicator—the third molar—was used only rarely in practice owing to the wide dispersion of age marker values within time limits.

In recent years, there has been a certain renaissance in the use of the third molar as an age indicator and attempts were made for such an application (1,17). Compliance with age indicator and individual evaluation measurements was found. Evident racial (18–20) and also important differences were found between Belgian, French–Canadian, German, and Swedish test subjects (3,8,10,21). The existing classification systems differ in the number of stages (4–25) and the extent of objectivity/subjectivity of their estimation (21,22). The most frequently used as well as recognized is the method by Demirjian et al. (9).

It became apparent that the excessive segmentation of the developmental process into too many stages does not increase the accuracy of the method as it is based on the subjective evaluation of the amount of mineralized dental tissue during development. This approach leads to intra- and interpersonal errors during estimation (17,22).

In most studies, third molars of the lower jaw only are evaluated or only one-half of it. (23). Some authors consider only the development of the mesial root of the third molar of the lower jaw and evaluate it on a radiogram, either visually or according to a graphic computer record (12,24,25).

The method of age evaluation according to third molar development described in this study certainly introduced new options for forensic dentistry.

As already mentioned, the method described is based on the assumption that there is no statistically significant difference between chronological age and the age derived from the third molar. This premise is valid for physiological conditions when time fluctuations in the third molar development are within the limits of mean estimation error. However, in practice, we can encounter pathological conditions that are accompanied by deviations exceeding standard time limits. Mostly, it is a serious retardation in the development of the whole dentition on the basis of which the individual may be put into a lower age group. Acceleration of dentition development is quite rare.

It was confirmed that in the Czech population, there are no statistically significant intersexual differences over the course of third molar development (11,14,26,27).

In recent populations, the main issue is that of the absence of third molars because of agenesis or extraction. Early extractions of third molars for orthodontic reasons are nowadays quite frequent. After the 18th year, even third molar extractions for eruption complications can be considered.

Precise dental documentation, including X-ray images, does exist. Where these materials are not available, there are certain guides that increase the probability of correct evaluation and the reaching of more reliable conclusions. Eruption complications as the cause of the extraction of third molars at any given age are seen mostly in the lower jaw, where the diagnosis is proved by the lack of space in the third molar region. In such cases, we can proceed according to the condition of the development of third molars in the upper jaw.

The absence of all third molars can be caused by agenesis, as well as by orthodontic extractions. In such cases, etiology is irrelevant as there is nothing to evaluate.

Results achieved seem to be optimal in comparison with methods of age determination for adults based on dental tissue examination where the dissociation of age values varies by ± 5 years (28).

The observation of third molars via X-ray is possible not only ante but also postmortem. *In vivo*, the panoramic radiograph offers optimal imaging of the third molar. Special portable digital X-ray devices can be used for those purposes.

In practice, age determination by third molars is simple. The determining criterion is the stage of the third molar which is the most advanced in development. Age corresponding to the developmental stage is determined by means of the table worked out by the authors. Age can be determined by anyone who is able to identify the four stages of third molar development.

When the third molars in an adolescent have not erupted, an orthopantomogram is advisable because of possible wisdom teeth agenesis. This X-ray image could form part of dental documentation or an electronic health record and can also be used in future for forensic purposes.

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