Third Molar as an Age Indicator in Young Individuals

Rozkovcová E.[1], Marková M.[1], Mrklas L[2].
[1]Department of Stomatology of the First Faculty of Medicine, Charles University in Prague, and General Teaching Hospital, Czech Republic; [2]Dental Research Institute of the First Faculty of Medicine, Charles University in Prague, and General Teaching Hospital, Czech Republic

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Mailing Address: Prof. Eva Rozkovcová, MD., DSc., Department of Stomatology of the First Faculty of Medicine, Charles University, Karlovo náměstí 32, 121 11 Prague 2, Czech Republic; Phone: +420 224 966 508

Abstract: The authors developed a method of chronological age estimation in young individuals on the basis of third molar developmental stage. The new method is based on the finding that time course of third molar development depends on the number of assessed third molars. That means, in individuals with 1 to 3 third molars agenesis the development of founded third molars is delayed in comparison with individuals having all third molars present. This difference is statistically significant. Retardation of development is directly proportional to the number of congenitally missing third molars. Chronological age corresponding to individual stages of third molar development was calculated separately for individuals with all four third molars present and separately for individuals with 1 to 3 third molars agenesis. With this division it was possible to decrease the error of age estimation to 1.63 years in the group of individuals with all four third molars present and to correct the age underestimation in individuals with agenesis. The elaborated method of chronological age estimation in young individuals shows incomparably much more accuracy in contrary to methods used in adults. In addition this new method is distinguishing by maximum simplicity.

Introduction

From the earliest times of human history the teeth were considered to be an indicator of age. Relation of both terms was so tight that in some languages are semantically the same. For example in Arabic languages means “asnan” both tooth and age [5]. This idea of relation is understandable, because the processes of eruption and involution of teeth are perfectly visible. That is why they were since the beginning of existence of Homo Sapiens sharply followed. Gained knowledge on teeth development and changes of dentition were all-round used in practice. One of crucial way of this practical application is age estimation according to dental age [3, 9, 11, 13, 14, 15, 20, 30, 33].

The methodology of age estimation is essentially different whether we have a young individual with not finished development of the dentition or an adult. In young individual we can use the natural dentition development changes. That means relatively high accuracy with the difference in months. The reliability of results changes with age. The highest reliability is at the time period when the maximal number of developing teeth is present. The use of this methodology is limited to 16th year of age when the development of the second permanent molar is accomplished. Dental age determination is quite simple and is done by comparing the individual dentition developmental stage, preferably on the panoramic radiograph, with the standard values [3, 5, 11, 15, 20, 28, 30].

The age estimation in adults is possible only by means of indirect dentition changes caused by aging and attrition. These changes can be influenced also by some exogenous factors. Therefore the estimation may be sometimes difficult. For example nowadays frequent hypomineralization of dental tissues can cause atypical attrition and so move the age estimation into higher levels. The accuracy and

reliability of age estimation methods in adults is incomparably less accurate than in young individuals and moves in the range ± 5 to± 12 years. These methods are technically demanding, time-consuming and they need special erudition. They are applicable from 21 years of age when the involution main marks of dental tissues and periodontium are detectable [6, 9, 13, 14, 18, 23, 27, 33].

For the time from 16 to 21 years of age there is no reliable method for age estimation available. The third molar, which develops during this period is considered as such unstable structure that is not systematically used [10, 11, 16, 17, 22, 32]. At this age interval the problem of age estimation is relevant, because biological age markers are not enough reliable.

The age estimated according to dental development is called "a dental age". Strictly speaking this term is valid for the developing dentition only, similarly as in the term skeletal age. We can't talk about dental age in adults, because the mentioned changes are caused by interaction of aging changes manifestation and effects of external factors. More suitable seems the term-age markers [5].

Dental age is a phenomenon belonging to biological markers of individual's somatic maturation. Time changes in the sense of dental development retardation or acceleration are patognomic for many of local and systemic disorders. For this reason the dental age estimation belongs to the basic diagnostic task in the paediatric dentistry and paediatrics [3, 11, 15, 20].

In anthropology and forensic medicine, fields where chronological age of an individual or skeletal remains are often unknown, we have to determine the age on the promise that dental and chronological age are equivalent [29]. Here arises a question to which measure and to what accuracy reflects the dental age the chronological age. Many authors were studying this problem with different results. It comes out that the reliability of results depends mostly on the used methods and the urgent concordance between the ethnics from which the "norms" were deduced and from the ethnics followed [5, 11, 15, 30].

High correlation between chronological and dental age was observed by authors, who studied the process of teeth development. However, results of authors, who followed the age of teeth eruption, showed a large dispersion of markers values. As a very important finding we have to consider the fact that when comparing the different biological age markers with chronological age, the dental age comes out as the most reliable parameter [11, 15, 20, 30].

Due to the absence of reliable method for age estimation of young individuals with unknown date of birth, we decided to check, if the chronological age deduced from the till now omitted third molar could fill in the white spot in the age estimation of young adults.

Materials and methods

To estimate the age of young individuals, information on the developmental stage of third molars is highly valuable. The principal aim of this study is the

determination of the corresponding age for each developmental stage of the third molar. The third molar as age indicator comes to the consideration not before the completion of other permanent teeth development. Our interest will be therefore focused mainly on the period between 15 to 21 years of age.

The project of the evolvement of age markers has to be based on the knowledge of the whole process of the third molar development from the formation of the tooth to the completion of the root development [1, 2, 4, 7, 8, 12, 24, 25, 26].

Our study was based on analysis of 1,700 panoramic, randomly selected radiographs of patients from the Paediatric Department of Stomatological Clinic, First Faculty of Medicine of Charles University in Prague. The age of probands was in the range between 5 to 21 years inclusive. Depending on age we have formed 17 groups, each with 100 individuals (50 boys and 50 girls) in intervals of one year. The groups included individuals, who passed given age with plus, minus 6 months difference. In each individual we have monitored the developmental status of third molars in all quadrants of the dentition. In 1,100 probands from 5 to 15 years we have also registered dental age. The development of the third molar was classified according Komínek and Rozkovcová into 7 stages from the formation of the follicle to the completion of the root development (Figure 1).

It was essential to verify if the two basic precautions limiting the perspective of the whole project were fulfilled. At first, it was to ascertain the relationship between chronological and dental age of our population, which has to be as close as possible. We have followed this relation in 1,100 probands at the age 5 to 15 years. Secondly, it was to verify the existence of close relation between the dental age and the third molar developmental status. For this purpose we have used a group of 1,000 probands at the age of 7 to 15 years.

For the chronological age calculation panoramic radiographs of 900 probands at the age of 13 to 21 years inclusive were selected. The group of 13-year-old children was chosen as the starting one, because it represents the lowest age limit, from which the missing third molar is considered as agenesis. The group of probands at the age of 13 to 21 years offers the representative look of third molar agenesis incidence in the Czech population [25]. This anomaly takes important place in the way of chronological age estimation using the third molar.

We have elaborated the documentation according to findings published in our previous studies on the third molar development. It was mainly finding of the crucial importance that in the individuals with 1 to 3 third molars agenesis is the third molars development significantly delayed in comparison with the individuals with all third molars present. Therefore we have divided the group into 2 subgroups: individuals with four third molars present and individuals with of 1 to 3 third molars agenesis. The percentage of the last mentioned anomaly in our population is 20% [25].

Further important finding was the high, more than 50% incidence of intraindividual differences in the stage of third molar development [26]. This phenomenon lasts for the whole period of development. Differences are especially considerable in the

group with agenesis, where they can mean up to 3 stages. In these cases a question arises, how to estimate the resulting stage of the third molar development. The fact, that intraindividual differences as a symptom of the hypodoncia syndrome can be accompanied with development retardation of the third molars present, suggests, that the evaluation on the basis of development mean stage, could not be optimal. That is why we have decided to process the results in two ways. In the first way (method 1) we used the data of the developmental status of all third molars present in an individual. The age estimation was calculated as a mean of values of each third molar present. In the second course (method 2) we have estimated the age according to the most developed third molar's stage without considering the developmental stage of the others. As a variant A we have marked the procedure, in which the sexes are

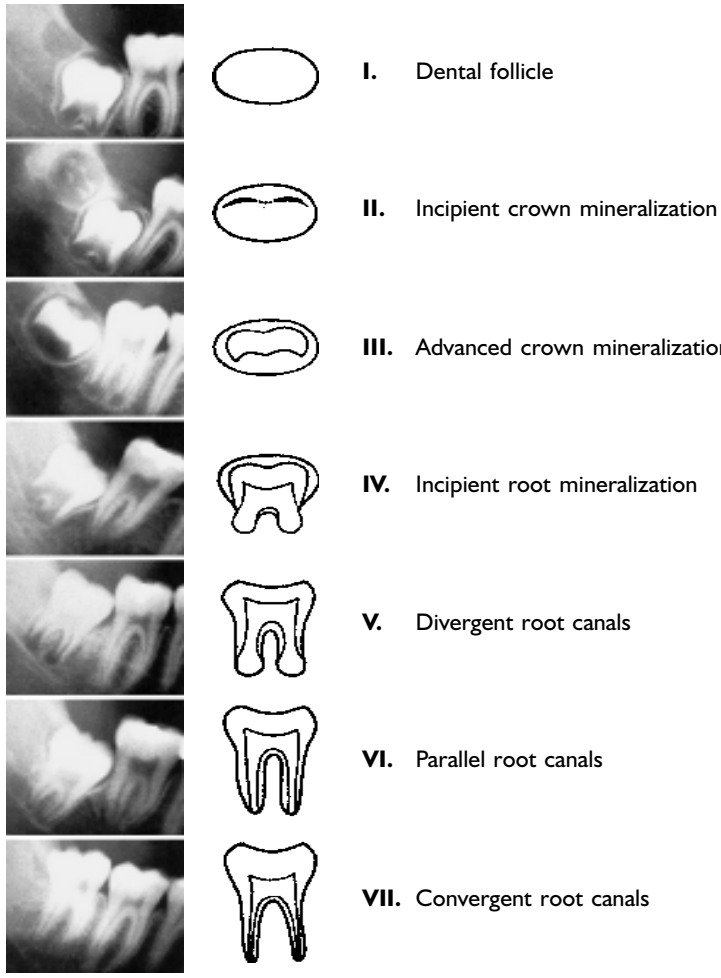


Figure 1 – Scheme of developmental tooth stages.

evaluated separately. As a variant B we have evaluated the results without distinguishing the sexes.

In the group with of 1 to3 third molars agenesis we have, because of low number of probands used variant B only. In this group we have calculated all the data for individuals with one, two and three missing third molars, separately.

Because of established differences in the dynamics of the third molar development in the upper and lower jaw, we have differentiated the results for each jaw separately. For adequate age estimation for individual stages of development we have chosen following steps:

1. Calculation material / 900 probands at the age 13 to 21 years of age.
2. Calculation for the age 15 to 21 years.
3. Check of the results, counting the mean error of estimation. This calculation is also done for age 15 to 21 years.

Adequate age determination for individual developmental stages of third molar in individuals with four third molars present

For each developmental stage, percentage of third molars, which reached in the mentioned stage or which passed through this stage already was taken as a calculation base (Tables I, 2, 3, 4).

From this base the age was calculated, when the half of the third molars number just reached this stage (Tables 5, 6, 7, 8). The duration of the given stage was calculated as a difference of ages for two immediately following stages. For example for stage IV in table 5 it is the difference between values 13.93 and 15.67, that is 1.74. For the last developmental stage it is not possible to estimate the time duration. This time is not possible to estimate also for the developmental stages I to III, because half of third molars reached this stage before the 13^{th} year of individuals age.

For the age estimation for the given stage of development we have chosen half of the time space when the third molar is in the given stage, that means half of the period when the third molar gets into this stage and age when gets into the following stage. For the above mentioned example from the table 5, is the age estimation in the midpoint between ages 13.93 and 15.67, that is 14.80. For the stage I to III, we had to choose the lower age limit of the lowest age group (13 years), for stage VII than the upper age limit for the highest age group (21 years).

For the verification of the estimation accuracy for all the individuals in the age between 15 to 21 years, we have determined the age according to chosen methods (Tables 9, 10, 11, 12). Estimation (non) accuracy we have evaluated as to the mean error of estimation, what is the mean quadratic difference between age estimation and actual individual's age. Table 13 compares the accuracy of age estimation according to different methods. For comparison in the table 14 accuracy of age estimation determined according to dental age for children at the age 5 to 14 years inclusive is registered.

Adequate age determination for individual developmental stages of third molar in individuals with 1 to 3 third molars agenesis

In individuals with agenesis of one to three third molars the development of present third molars is delayed. If the same estimation of age is used for those individuals as for individuals with four third molars present, their age can be underestimated. That is why it is necessary to calculate how large is the deviation between the calculated age and the actual age. According to the average underestimation, we need to correct the age estimation (Tables 15, 16 for methods 1, 2).

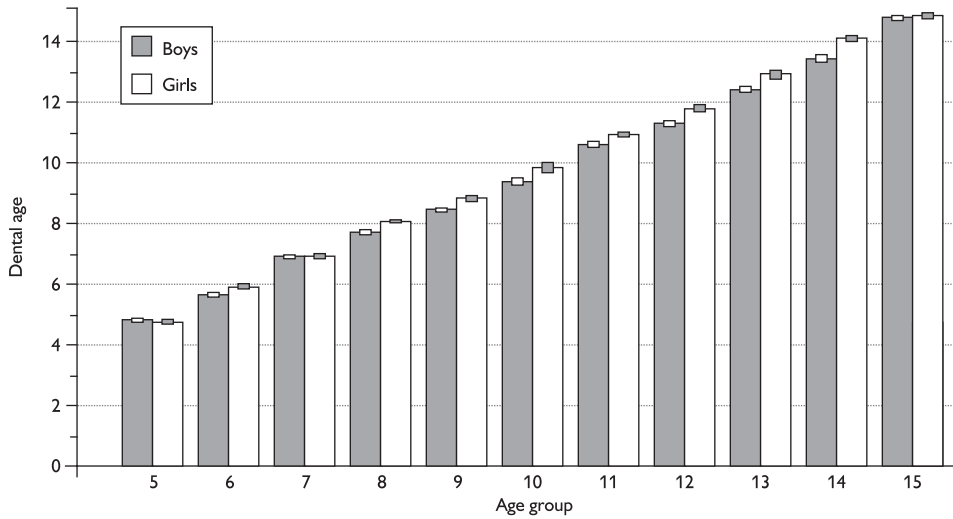
For accuracy verification of individuals with 1–3 third molars agenesis the corrected age estimation was calculated (Tables 17, 18 for methods 1, 2). (Non) accuracy of corrected estimation we have evaluated with the same method as in individuals with four third molars present.

Comparison of the mean errors of age estimation (method 2, variant B) in individuals with four third molars present and in individuals with agenesis of 1–3 third molars shows table 19.

Results

I. Verification of the possibility to use the third molar as chronological age indicator

1. Relation between chronological and dental age.
   This relation in boys and girls is presented in the graph 1. The relation is almost perfectly linear.
2. Relation between dental age and the third molar development status.



Graph 1 – Dependence of chronological age estimation on age group. Rectangels over columns shows the standard error of the mean.

Graphs 2 and 3 show, separately for the third molars in the upper and lower jaw, how third molar development in individual developmental stages depends on dental age.

In the subgroup marked "–" are individuals, whose dental age is lower than corresponding chronological age, in the subgroup "+" individuals whose dental age is higher than corresponding chronological age and in the subgroup "=" are the dental age and chronological age identical. In case no individual was included in the subgroup marked "+", the corresponding column is missing.

These results document the close relation between the dental age and the developmental status of the third molar. Thus third molar can be considered as an integral part of the dentition and can be used a chronological age indicator, with taking into account the variability of its developmental processes.

II. New interpretation of the term "third molar as a chronological age indicator"

The course of third molar development, including the frequency of individual developmental stages in boys and girls is shown in graphs 4, 5, for upper, respectively lower jaw. Excluding the lowest age groups with the small number of third molars, each age group includes mosaic of 4 to 6 developmental stages in different frequencies. From this point of view, the third molar seems to be only partly appropriate for age estimation. But, we need to consider, that the followed group is not homogenous, and consists of two specifically different parts.

- Group of individuals with four third molars present (P). In this group third molars development runs relatively regularly without any conspicuous time deviation
- Group of individuals with 1 to 3 third molars agenesis (A). In this group the third molars development is statistically significantly delayed opposite to the first group (graph 6). The delay depends on the number of missing third molars. The mean deviation from chronological age of individuals is in the range of 0.3 to 4.4 years (Tables 15, 16).

III. Chronological age determination according to the number of present third molars

Group of individuals with 4 third molars present

Data for the calculation of the corresponding age for individual developmental stages are listed in the tables 1, 2, 3, 4.

Estimated age for individual developmental stages is possible to find in tables 5, 6, 7, 8. Tables are arranged in a manner, that the calculation of final information is visible, as described in "Materials and methods".

Developmental stages I to III are presented together, because most of the third molars get to them before the thirteen year of age.

It is not possible to estimate the time period for stage VII, because at 21 years

of age, when the study was finished, the development of all third molars was not complete.

For calculation of (non) accuracy of age estimation we used the calculation of mean quadratic error of estimate, that means mean quadratic difference between age estimate and chronological age. In tables 9, 10, 11, 12 for methods 1 and 2 and variants A and B is listed as well as the average age estimates for the given age group. For both methods of estimation and variants A and B are decisive mean quadratic errors for all age groups and both sexes altogether. These values are for easy survey listed in table 13. For comparison of the rate of estimation accuracy is here the mean quadratic error of chronological age estimation according to dental age calculated (Table 14). The rate of accuracy of age estimation according to dental age and according to developmental stages of third molars is shown in the graph 7.

Group of individuals with 1 to 3 third molars agenesis

Because of a small number of individuals in this group, both sexes were evaluated together; therefore the variant A is missing. For the age estimation according to the stages of third molars development of we used data obtained from individuals with 4 third molars present. Tables 15 and 16 for methods 1 and 2 show for single age groups calculated age estimates. Deviations from chronological age are listed together with them. Their mean values for all age groups altogether show how to correct age underestimation in individuals with 1 to 3 third molars agenesis. The value of these corrections depends on the number of missing third molars; the highest value is in the agenesis of three third molars.

Age estimation after correction according to the number of missing third molars for methods 1 and 2 is demonstrated in tables 17 and 18. Mean error of such corrected estimates does not much exceed the estimation error in individuals with 4 third molars present.

IV. Method of chronological age determination in intraindividual differences of third molars development

When intraindividual differences in third molars development occurred, we had to decide, which method to prefer; method 1, that pays attention to developmental stages of all third molars present and as age estimate uses its average value or method 2, which pays attention only to the developmental stage of the most developed third molar. In the overall assessment no significant differences between both methods were found.

The mean error of estimation for method 2 is just slightly higher than error of method 1. In individuals with 1 to 3 third molars agenesis are mean errors of estimation practically the same. Method 2 is easier and faster than method 1. That is why we consider preferring in chronological age estimation to the method 2, which is the assessment according to the mostly developed third molar.

V. Intersexual differences

Neither in the group with 4 third molars present, nor in the group with 1 to 3 third molars agenesis no significant intersexual differences were found in the third molars development. The only differences was found during the developmental stage IV, which lasts shorter in boys than in girls and during the stage V, which in reverse in boys lasts longer (Tables 5, 6, 7, 8). In consequence of this, developmental stage V in girls is almost one year delayed in comparison to boys, mainly in the lower jaw. This result is in harmony with our previous findings and also with findings of other authors [19, 21, 31].

When we compare the mean errors of age estimation for variants A and B, when the estimation is made in dependence on the sex of the individual (A) or in reverse without paying attention to it (B), the results are practically the same. Because of its simplicity we prefer the variant B, which is not to pay attention to the sex.

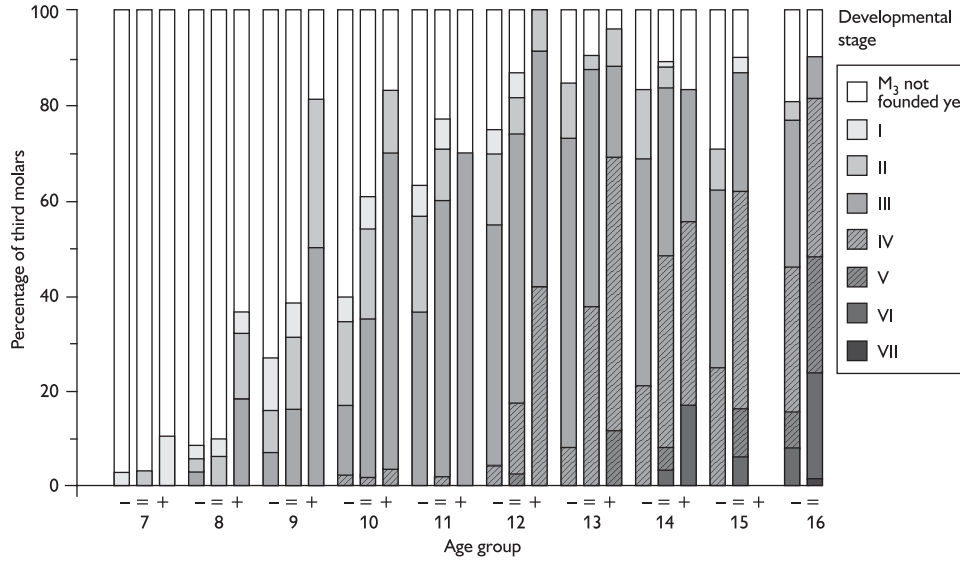
VI. Differences in the third molar development between upper and lower jaw

In both sexes and using the both methods comes into view a visible tendency to delayed development of the third molars in the lower jaw in comparison with third molars in upper jaw. At the age 15 to 21 years the third molars development in the lower jaw is delayed for 1 year in comparison with third molars of the upper jaw. This difference is statistically significant.

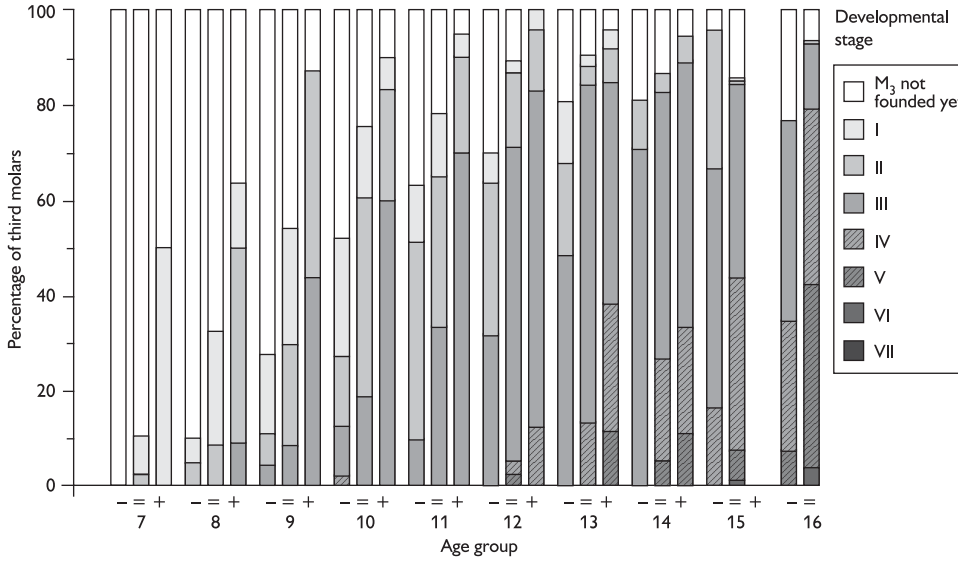
Described method of chronological age estimation is based mostly on developmental stages IV, V and VI, stages I to III almost does not exist after the 14^{th} year of age. If there was an individual with completely developed dentition to second molars inclusive, whose most developed third molar is in developmental stage III (or lower), we need to set his/her age to 16 years. For developmental stage VII the upper age limit cannot be estimated accurately, because at 21 years of age when the study was closed, the development of all third molars was not yet finished. For the group with 4 third molars present we have set the upper limit of the stage VII according to the highest age that is 21.5 years. In the group with agenesis we need to count even with higher age.

At the end we can conclude: Authors have been looking for possible third molar usage in the age estimation in young individuals. In the study they recorded all methods, which were used in this project. Results of the calculation are shown in 20 tables and 7 graphs.

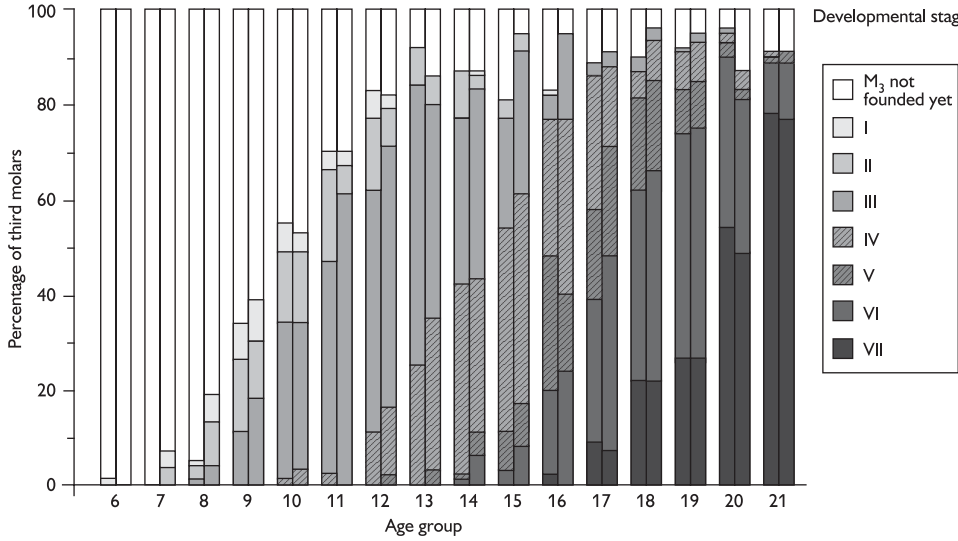
After the statistical evaluation of listed alternatives, authors have ascertained that from the practical point of view, the method 2, variant B seems to be optimal. According to that criterion, a universal table was introduced, which allows to state directly the age corresponding to individual developmental stages of the third molar. In the group of individuals with 1 to 3 third molars agenesis results are already corrected according to agenesis of one, two, and three third molars, to correspond to actual age (Table 20).



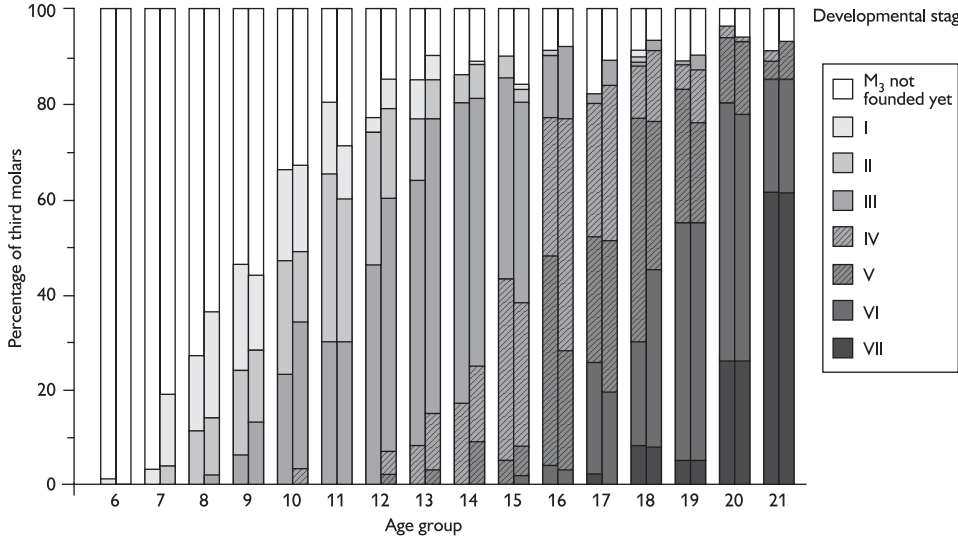
Graph 2 – Frequency of developmental stages of third molars in dependence on chronological and dental age, boys and girls, upper jaw. In the subgroup marked "–" are individuals whose dental age is lower than corresponding chronological age, in the subgroup „+" are individuals whose dental age is higher then chronological and in the subgroup "=" are individuals whose dental age is equal to chronological. If there was no individual in the subgroup "+", the corresponding column in the graph is omitted.



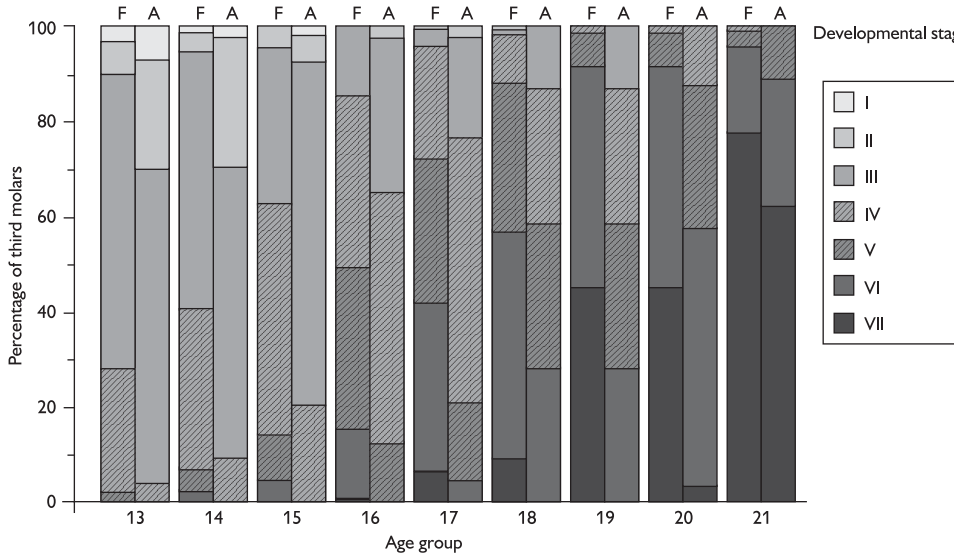
Graph 3 – Frequency of developmental stages of third molars in dependence on chronological and dental age, boys and girls, lower jaw. In the subgroup marked "–" are individuals whose dental age is lower than corresponding chronological age, in the subgroup "+" are individuals whose dental age is higher then chronological and in the subgroup "=" are individuals whose dental age is equal to chronological. If there was no individual in the subgroup "+", the corresponding column in the graph is omitted.



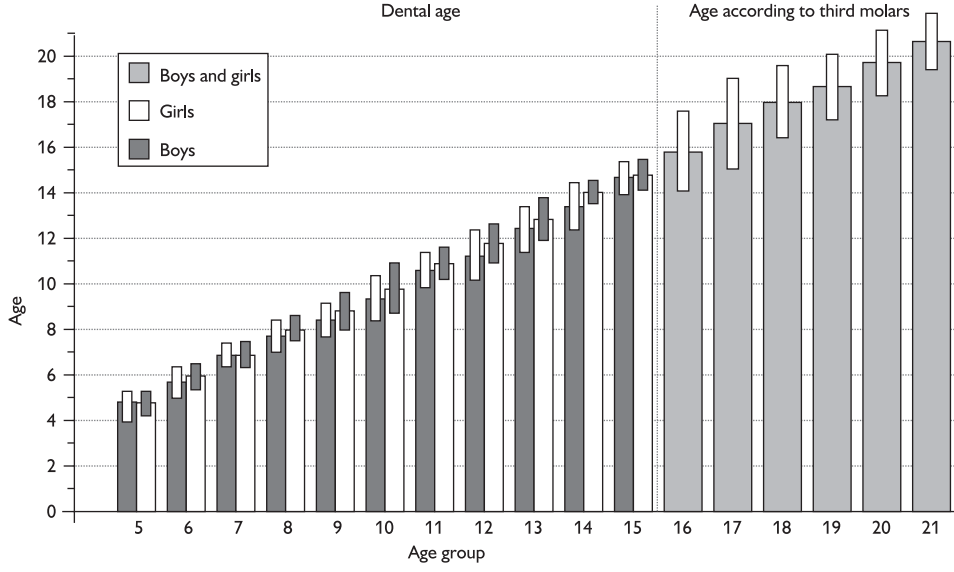
Graph 4 – Frequency of individual developmental stages of third molars in dependence on chronological age, upper jaw. Left column in each pair shows distribution in boys and, right column in girls.



Graph 5 – Frequency of individual developmental stages of third molars in dependence on chronological age, lower jaw. Left column in each pair shows distribution in boys and, right column in girls.



Graph 6 – Frequency of individual developmental stages in dependence on chronological age, boys and girls and both jaws together. In the subgroup marked „P" are boys and girls with four third molars present, in the subgroup marked „A" are boys and girls with one to three third molars agenesis.



Graph 7 – Dependence of chronological age estimation on age group. Rectangels over columns shows the standard error of the mean.

Table 1 – Individuals with all four third molars present
Data for age estimation – method 1, variant A. Percentage of third molars found in the given developmental stage + those which already underwent it

Age group	Number of teeth	Developmental stages I	II	III	IV	V	VI	VII
				Boys, upper jaw				
13	76	**100.0**	**100.0**	**93.4**	30.3			
14	74	100.0	100.0	93.2	**51.4**	2.7	1.4	
15	66	100.0	100.0	95.5	75.8	16.7	4.5	
16	72	100.0	100.0	100.0	94.4	**66.7**	27.8	2.8
17	70	100.0	100.0	100.0	98.6	77.1	**52.9**	12.9
18	78	100.0	100.0	100.0	97.4	91.0	73.1	
19	78	100.0	100.0	100.0	100.0	93.6	89.7	21.8
20	88	100.0	100.0	100.0	100.0	100.0	97.7	**60.2**
21	80	100.0	100.0	100.0	100.0	98.8	97.5	90.0
				Boys, lower jaw				
13	76	**100.0**	**89.5**	**75.0**	10.5			
14	74	100.0	100.0	95.9	23.0			
15	66	100.0	100.0	95.5	**57.6**	7.6		
16	72	100.0	100.0	100.0	88.9	**59.7**	5.6	
17	70	100.0	100.0	98.6	87.1	70.0	37.1	2.9
18	78	100.0	98.7	97.4	97.4	91.0	34.6	
19	78	100.0	100.0	100.0	100.0	94.9	**66.7**	6.4
20	88	100.0	100.0	100.0	100.0	98.9	87.5	29.5
21	80	100.0	100.0	100.0	100.0	98.8	95.0	**65.0**
				Girls, upper jaw				
13	72	**100.0**	**100.0**	**97.2**	48.6	4.2		
14	78	100.0	98.7	97.4	**53.8**	14.1	7.7	
15	80	100.0	100.0	95.0	72.5	21.3	10.0	
16	88	100.0	100.0	100.0	85.2	45.5	27.3	
17	84	100.0	100.0	100.0	100.0	**84.5**	**57.1**	8.3
18	92	100.0	100.0	100.0	98.9	90.2	71.7	23.9
19	82	100.0	100.0	100.0	100.0	95.1	86.6	31.7
20	82	100.0	100.0	100.0	100.0	96.3	95.1	**59.8**
21	84	100.0	100.0	100.0	100.0	100.0	98.8	85.7
				Girls, lower jaw				
13	72	**100.0**	**98.6**	**93.1**	20.8	4.2		
14	78	100.0	97.4	93.6	32.1	11.5		
15	80	100.0	100.0	96.3	47.5	10.0	2.5	
16	88	100.0	100.0	100.0	**77.3**	31.8	3.4	
17	84	100.0	100.0	100.0	96.4	**58.3**	23.8	
18	92	100.0	100.0	100.0	98.9	82.6	48.9	8.7
19	82	100.0	100.0	100.0	100.0	89.0	**64.6**	6.1
20	82	100.0	100.0	100.0	100.0	98.8	86.6	31.7
21	84	100.0	100.0	100.0	100.0	100.0	92.9	**66.7**

Graphically highlighted numbers shows the age group in which half or more of third molars get for the first time into the given stage

Table 2 – Individuals with all four third molars present
Data for age estimation – method 1, variant B. Percentage of third molars found in the given developmental stage + those which already underwent it

Age group	Number of teeth	Developmental stages I	II	III	IV	V	VI	VII
				Boys and girls, upper jaw				
13	148	**100.0**	**100.0**	**95.3**	39.2	2.0		
14	152	100.0	99.3	95.4	**52.6**	8.6	4.6	
15	146	100.0	100.0	95.2	74.0	19.2	7.5	
16	160	100.0	100.0	100.0	89.4	**55.0**	27.5	1.3
17	154	100.0	100.0	100.0	99.4	81.2	**55.2**	10.4
18	170	100.0	100.0	100.0	98.2	90.6	72.4	12.9
19	160	100.0	100.0	100.0	100.0	94.4	88.1	26.9
20	170	100.0	100.0	100.0	100.0	98.2	96.5	**60.0**
21	164	100.0	100.0	100.0	100.0	99.4	98.2	87.8
				Boys and girls, lower jaw				
13	148	**100.0**	**93.9**	**83.8**	15.5	2.0		
14	152	100.0	98.7	94.7	27.6	5.9		
15	146	100.0	100.0	95.9	**52.1**	8.9	1.4	
16	160	100.0	100.0	100.0	82.5	44.4	4.4	
17	154	100.0	100.0	99.4	92.2	**63.6**	29.9	1.3
18	170	100.0	99.4	98.8	98.2	86.5	42.4	4.7
19	160	100.0	100.0	100.0	100.0	91.9	**65.6**	6.3
20	170	100.0	100.0	100.0	100.0	98.8	87.1	30.6
21	164	100.0	100.0	100.0	100.0	99.4	93.9	**65.9**

Graphically highlighted numbers shows the age group in which half or more of third molars get for the first time into the given stage

Table 3 – Individuals with all four third molars present Data for age estimation – method 2, variant A. Percentage of individuals, whose most developed third molar was found in the given developmental stage + those which already underwent it

Age group	Number of teeth	Developmental stages I	II	III	IV	V	VI	VII
				Boys, upper jaw				
13	38	**100.0**	**100.0**	**94.7**	31.6			
14	37	100.0	100.0	94.6	**54.1**	2.7	2.7	
15	33	100.0	100.0	97.0	81.8	21.2	6.1	
16	36	100.0	100.0	100.0	94.4	**66.7**	30.6	2.8
17	35	100.0	100.0	100.0	100.0	77.1	**54.3**	14.3
18	39	100.0	100.0	100.0	97.4	92.3	76.9	
19	39	100.0	100.0	100.0	100.0	94.9	92.3	23.1
20	44	100.0	100.0	100.0	100.0	100.0	97.7	**72.7**
21	40	100.0	100.0	100.0	100.0	100.0	97.5	92.5
				Boys, lower jaw				
13	38	**100.0**	**97.4**	**78.9**	10.5			
14	37	100.0	100.0	97.3	24.3			
15	33	100.0	100.0	97.0	**63.6**	9.1		
16	36	100.0	100.0	100.0	88.9	**61.1**	5.6	
17	35	100.0	100.0	100.0	88.6	71.4	40.0	2.9
18	39	100.0	100.0	97.4	97.4	94.9	41.0	
19	39	100.0	100.0	100.0	100.0	97.4	**74.4**	7.7
20	44	100.0	100.0	100.0	100.0	100.0	88.6	38.6
21	40	100.0	100.0	100.0	100.0	100.0	95.0	**72.5**
				Girls, upper jaw				
13	36	**100.0**	**100.0**	**97.2**	**55.6**	5.6		
14	39	100.0	100.0	100.0	56.4	15.4	10.3	
15	40	100.0	100.0	95.0	77.5	22.5	10.0	
16	44	100.0	100.0	100.0	93.2	**50.0**	27.3	
17	42	100.0	100.0	100.0	100.0	85.7	**59.5**	9.5
18	46	100.0	100.0	100.0	100.0	91.3	71.7	26.1
19	41	100.0	100.0	100.0	100.0	95.1	87.8	31.7
20	41	100.0	100.0	100.0	100.0	97.6	95.1	**61.0**
21	42	100.0	100.0	100.0	100.0	100.0	100.0	88.1
				Girls, lower jaw				
13	36	**100.0**	**100.0**	**94.4**	22.2	5.6		
14	39	100.0	97.4	94.9	33.3	12.8		
15	40	100.0	100.0	97.5	**50.0**	10.0	2.5	
16	44	100.0	100.0	100.0	79.5	34.1	4.5	
17	42	100.0	100.0	100.0	97.6	**59.5**	28.6	
18	46	100.0	100.0	100.0	100.0	87.0	**50.0**	10.9
19	41	100.0	100.0	100.0	100.0	90.2	68.3	7.3
20	41	100.0	100.0	100.0	100.0	100.0	87.8	31.7
21	42	100.0	100.0	100.0	100.0	100.0	95.2	**71.4**

Graphically highlighted numbers shows age group, in which for the first time in the half or more individuals the most developed third molar get into the given developmental stage

Table 4 – Individuals with all four third molars present Data for age estimation – method 2, variant B. Percentage of individuals, whose most developed third molar was found in the given developmental stage + those which already underwent it

Age group	Number of individuals	Developmental stages I	II	III	IV	V	VI	VII
				Boys and girls, upper jaw				
13	74	**100.0**	**100.0**	**95.9**	43.2	2.7		
14	76	100.0	100.0	97.4	**55.3**	9.2	6.6	
15	73	100.0	100.0	95.9	79.5	21.9	8.2	
16	80	100.0	100.0	100.0	93.8	**57.5**	28.8	1.3
17	77	100.0	100.0	100.0	100.0	81.8	**57.1**	11.7
18	85	100.0	100.0	100.0	98.8	91.8	74.1	14.1
19	80	100.0	100.0	100.0	100.0	95.0	90.0	27.5
20	85	100.0	100.0	100.0	100.0	98.8	96.5	**67.1**
21	82	100.0	100.0	100.0	100.0	100.0	98.8	90.2
				Boys and girls, lower jaw				
13	74	**100.0**	**98.6**	**86.5**	16.2	2.7		
14	76	100.0	98.7	96.1	28.9	6.6		
15	73	100.0	100.0	97.3	**56.2**	9.6	1.4	
16	80	100.0	100.0	100.0	83.8	46.3	5.0	
17	77	100.0	100.0	100.0	93.5	**64.9**	33.8	1.3
18	85	100.0	100.0	98.8	98.8	90.6	45.9	5.9
19	80	100.0	100.0	100.0	100.0	93.8	**71.3**	7.5
20	85	100.0	100.0	100.0	100.0	100.0	88.2	35.3
21	82	100.0	100.0	100.0	100.0	100.0	95.1	**72.0**

Graphically highlighted numbers shows age group, in which for the first time in the half or more individuals the most developed third molar get into the given developmental stage

Table 5 – Individuals with all four third molars present
Age estimation – method 1, variant A

Developmental stage	Age, in which the third molar gets into this stage	Time period of this stage	Age estimate* according to the stage
	Boys, upper jaw		
I to III	< 13	?	**12.50**
IV	13.93	1.74	**14.80**
V	15.67	1.22	**16.28**
VI	16.89	2.84	**18.31**
VII	19.73	–	**21.50**
	Boys, lower jaw		
I to III	< 13	?	**12.50**
IV	14.79	1.02	**15.30**
V	15.81	2.67	**17.15**
VI	18.48	2.10	**19.53**
VII	20.58	?	**21.50**
	Girls, upper jaw		
I to III	< 13	?	**12.50**
IV	13.27	2.85	**14.69**
V	16.12	0.64	**16.44**
VI	16.76	2.89	**18.20**
VII	19.65	?	**21.50**
	Girls, lower jaw		
I to III	< 13	?	**12.50**
IV	15.08	1.61	**15.88**
V	16.69	1.38	**17.38**
VI	18.07	2.45	**19.29**
VII	20.52	?	**21.50**

* For stages I to III was as age estimate chosen lower bound of the lowest age group, for stage VII the upper bound of the highest age group

? For stages I to III and stage VII was not possible to establish the time period

Table 6 – Individuals with all four third molars present
Age estimation – method 1, variant B

Developmental stage	Age, in which the third molar gets into this stage	Time period of this stage	Age estimate* according to the stage
	Boys and girls, upper jaw		
I to III	< 13	?	**12.50**
IV	13.81	2.05	**14.83**
V	15.86	0.95	**16.34**
VI	16.81	2.89	**18.25**
VII	19.70	?	**21.50**
	Boys and girls, lower jaw		
I to III	< 13	?	**12.50**
IV	14.91	1.38	**15.60**
V	16.29	2.04	**17.31**
VI	18.33	2.22	**19.44**
VII	20.55	?	**21.50**

*For stages I to III was as age estimate chosen lower bound of the lowest age group, for stage VII the upper bound of the highest age group

? For stages I to III and stage VII was not possible to establish the time period

Table 7 – Individuals with all four third molars present
Age estimation – method 2, variant A

Developmental stage	Age, in which the third molar gets into this stage	Time period of this stage	Age estimate* according to the stage
	Boys, upper jaw		
I to III	< 13	?	**12.50**
IV	13.82	1.81	**14.72**
V	15.63	1.19	**16.23**
VI	16.82	2.72	**18.18**
VII	19.54	?	**21.50**
	Boys, lower jaw		
I to III	< 13	?	**12.50**
IV	14.65	1.14	**15.22**
V	15.79	2.48	**17.03**
VI	18.27	2.07	**19.30**
VII	20.34	?	**21.50**
	Girls, upper jaw		
I to III	< 13	?	**12.50**
IV	< 13	?	**12.50**
V	16.00	0.70	**16.35**
VI	16.70	2.92	**18.16**
VII	19.62	?	**21.50**
	Girls, lower jaw		
I to III	< 13	?	**12.50**
IV	15.00	1.63	**15.82**
V	16.63	1.37	**17.31**
VI	18.00	2.46	**19.23**
VII	20.46	?	**21.50**

* For stages I to III was as age estimate chosen lower bound of the lowest age group as well as for stage IV in upper jaw in girls, for stage VII the upper bound of the highest age group

? For stages I to III, stage VII and for stage IV in upper jaw in girls was not possible to establish the time period

Table 8 – Individuals with all four third molars present
Age estimation – method 2, variant B

Developmental stage	Age, in which the third molar gets into this stage	Time period of this stage	Age estimate* according to the stage
	Boys and girls, upper jaw		
I to III	< 13	?	**12.50**
IV	13.56	2.23	**14.68**
V	15.79	0.94	**16.26**
VI	16.75	2.82	**18.16**
VII	19.57	?	**21.50**
	Boys and girls, lower jaw		
I to III	< 13	?	**12.50**
IV	14.77	1.43	**15.49**
V	16.20	1.96	**17.18**
VI	18.16	2.24	**19.28**
VII	20.40	?	**21.50**

* For stages I to III was as age estimate chosen lower bound of the lowest age group as well as for stage IV in upper jaw in girls, for stage VII the upper bound of the highest age group

? For stages I to III, stage VII and for stage IV in upper jaw in girls was not possible to establish the time period

Table 9 – Individuals with all four third molars present
Verification of age estimation – method 1, variant B

Age group	Number of individuals	Age estimation	
		Mean	Mean error of estimation
	Boys		
15	33	**14.42**	**1.41**
16	36	**16.27**	**1.60**
17	35	**17.28**	**2.13**
18	39	**17.65**	**1.30**
19	39	**18.74**	**1.41**
20	44	**19.99**	**1.29**
21	40	**20.89**	**1.11**
15 to 21	266	–	**1.48**
	Girls		
15	40	**14.47**	**1.74**
16	44	**15.65**	**1.66**
17	42	**17.27**	**1.44**
18	46	**18.25**	**1.75**
19	41	**18.75**	**1.50**
20	41	**19.87**	**1.51**
21	42	**20.82**	**1.08**
15 to 21	296	–	**1.54**
	Boys and girls		
15 to 21	562	–	**1.51**

Table 10 – Individuals with all four third molars present
Verification of age estimation – method 1, variant B

Age group	Number of individuals	Age estimation Mean	Mean error of estimation
	Boys and girls		
15	73	**14.48**	**1.59**
16	80	**15.94**	**1.63**
17	77	**17.27**	**1.78**
18	85	**17.99**	**1.58**
19	80	**18.75**	**1.46**
20	85	**19.94**	**1.39**
21	82	**20.86**	**1.08**
15 to 21	562	**—**	**1.51**

Table 11 – Individuals with all four third molars present
Verification of age estimation – method 2, variant A

Age group	Number of individuals	Age estimation Mean	Mean error of estimation
	Boys		
15	33	**14.40**	**1.64**
16	36	**16.15**	**1.65**
17	35	**17.17**	**2.32**
18	39	**17.80**	**1.47**
19	39	**18.84**	**1.34**
20	44	**19.89**	**1.45**
21	40	**20.78**	**1.27**
15 to 21	266	**–**	**1.61**
	Girls		
15	40	**14.36**	**2.06**
16	44	**15.74**	**1.87**
17	42	**17.18**	**1.57**
18	46	**18.32**	**1.65**
19	41	**18.64**	**1.45**
20	41	**19.72**	**1.39**
21	42	**20.76**	**1.25**
15 to 21	296	**–**	**1.63**
	Boys and girls		
15 to 21	562	**–**	**1.62**

Table 12 – Individuals with all four third molars present
Verification of age estimation – method 2, variant B

Age group	Number of individuals	Age estimation	
		Mean	Mean error of estimation
	Boys and girls		
15	73	**14.37**	**1.87**
16	80	**15.89**	**1.79**
17	77	**17.13**	**1.98**
18	85	**18.08**	**1.60**
19	80	**18.74**	**1.43**
20	85	**19.82**	**1.42**
21	82	**20.77**	**1.26**
15 to 21	562	**–**	**1.63**

Table 13 – Individuals with all four third molars present
Comparison of single methods of age estimation

Method	Number of individuals	Mean error of age estimation
1, variant A	562	**1.51**
1, variant B	562	**1.51**
2, variant A	562	**1.62**
2, variant B	562	**1.63**

Table 14 – Age estimation of an individual according to the dental age

Age group	Number of individuals	Age estimation	
		Mean	Mean error of estimation
	Boys		
5	50	**4.82**	**0.51**
6	50	**5.68**	**0.69**
7	50	**6.90**	**0.51**
8	50	**7.72**	**0.72**
9	50	**8.44**	**0.75**
10	50	**9.38**	**0.97**
11	50	**10.60**	**0.75**
12	50	**11.28**	**1.08**
13	50	**12.40**	**1.02**
14	50	**13.42**	**1.07**
5 to 14	500	**–**	**0.83**
	Girls		
5	50	**4.76**	**0.57**
6	50	**5.92**	**0.57**
7	50	**6.90**	**0.58**
8	50	**8.06**	**0.58**
9	50	**8.82**	**0.79**
10	50	**9.82**	**1.10**
11	50	**10.92**	**0.69**
12	50	**11.80**	**0.85**
13	50	**12.90**	**0.95**
14	50	**14.08**	**0.49**
5 to 14	500	**–**	**0.74**
	Boys and girls		
5 to 14	1000	**–**	**0.79**

Table 15 – Individuals with one to three third molars agenesis
Age estimation of an individual – method 1, variant B

Age group	Number of individuals	Age estimation Mean	SD	Mean deviation from chron. age
Boys and girls with three third molars agenesis				
15	3	**13.28**	1.35	**–1.62**
16	2	**12.50**	0.00	**–3.50**
17	4	**12.50**	0.00	**–4.50**
18	1	**14.83**	–	**–3.17**
19	2	**15.97**	0.52	**–3.03**
20	0	–	–	–
21	3	**18.01**	1.56	**–2.99**
15 to 21	15	–	–	**–3.22**
Boys and girls with two third molars agenesis				
15	11	**13.28**	1.34	**–1.72**
16	9	**14.42**	1.94	**–1.58**
17	6	**14.76**	1.01	**–2.24**
18	7	**15.27**	2.14	**–2.73**
19	10	**15.99**	1.84	**–3.01**
20	6	**16.78**	2.33	**–3.22**
21	8	**20.70**	1.25	**–0.30**
15 to 21	57	–	–	**–2.06**
Boys and girls with one third molar agenesis				
15	11	**12.88**	0.56	**–2.12**
16	7	**14.69**	0.91	**–1.31**
17	9	**15.37**	1.27	**–1.63**
18	5	**17.37**	1.07	**–0.63**
19	8	**16.45**	2.35	**–2.55**
20	7	**18.34**	1.02	**–1.66**
21	6	**20.04**	1.13	**–0.97**
15 to 21	53	–	–	**–1.66**

Table 16 – Individuals with one to three third molars agenesis
Age estimation of an individual – method 2, variant B

Age group	Number of individuals	Age estimation		
		Mean	SD	Mean deviation from chron. age
Boys and girls with three third molars agenesis				
15	3	**13.23**	1.26	**–1.77**
16	2	**12.50**	0.00	**–3.50**
17	4	**12.50**	0.00	**–4.50**
18	1	**14.68**	–	**–3.32**
19	2	**15.88**	0.54	**–3.12**
20	0	**–**	**–**	**–**
21	3	**17.90**	1.53	**–3.10**
15 to 21	15	**–**	**–**	**–3.28**
Boys and girls with two third molars agenesis				
15	11	**13.24**	1.29	**–1.76**
16	9	**14.45**	2.01	**–1.55**
17	6	**15.08**	0.66	**–1.92**
18	7	**15.40**	2.36	**–2.60**
19	10	**16.23**	1.67	**–2.77**
20	6	**17.03**	1.93	**–2.97**
21	8	**21.08**	1.18	**+0.08**
15 to 21	57	**–**	**–**	**–1.89**
Boys and girls with one third molar agenesis				
15	11	**13.37**	1.22	**–1.63**
16	7	**15.38**	0.89	**–0.62**
17	9	**16.26**	1.17	**–0.74**
18	5	**17.81**	1.14	**–0.19**
19	8	**17.06**	2.41	**–1.94**
20	7	**18.98**	1.37	**–1.02**
21	6	**21.13**	0.91	**+0.13**
15 to 21	53	**–**	**–**	**–0.98**

Table 17 – Individuals with one to three third molars agenesis Age estimation of an individual – method 1, variant B – after the correction according to the number of non present third molars

Age group	Number of individuals	Age estimation Mean	Mean error of estimation
	Boys and girls		
15	25	**14.95**	**1.36**
16	18	**16.29**	**1.47**
17	19	**16.85**	**1.02**
18	13	**17.92**	**1.87**
19	20	**18.19**	**2.01**
20	13	**19.48**	**1.68**
21	17	**22.35**	**1.83**
15 to 21	125	**–**	**1.61**

For age estimation using the method 1 was as correction added in individuals with agenesis of three third molars 3.28 years, in individuals with agenesis of two third molars 1.89 years and in individuals with one third molar agenesis 0.98 years

Table 18 – Individuals with one to three third molars agenesis Age estimation of an individual – method 2, variant B – after the correction according to the number of non present third molars

Age group	Number of individuals	Age estimation Mean	Mean error of estimation
	Boys and girls		
15	25	**14.97**	**1.33**
16	18	**16.32**	**1.50**
17	19	**16.83**	**1.10**
18	13	**17.96**	**1.85**
19	20	**18.23**	**1.99**
20	13	**19.54**	**1.65**
21	17	**22.36**	**1.89**
15 to 21	125	**–**	**1.62**

For age estimation according to method 2 was as correction added 1 year for every non present third molar

Table 19 – Comparison of the mean errors of age estimation (method 2) in individuals with four third molars present and in individuals with one to three third molars agenesis (after the correction according to the number of non present third molars)

Method	Number of individuals	Mean error of age estimation
Individuals with four third molars present	562	**1.63**
Individuals with three third molars agenesis	15	**1.22**
Individuals with two third molars agenesis	57	**1.82**
Individuals with one third molar agenesis	53	**1.48**
Individuals with one to three third molars agenesis – total	125	**1.62**

Table 20 – Chronological age determination on the basis of developmental stage of third molars – method 2

Developmental stage	All four third molars present	Non present: One third molar	Non present: Two third molars	Non present: Three third molars
	Corresponding age			
	Upper jaw			
IV	**14.68**	15.68	16.68	17.68
V	**16.26**	17.26	18.26	19.26
VI	**18.16**	19.16	20.16	21.16
	Lower jaw			
IV	**15.49**	16.49	17.49	18.49
V	**17.18**	18.18	19.18	20.18
VI	**19.28**	20.28	21.28	22.28

Discussion

The question of chronological age estimation of young individuals from 15 to 21 years was due to absence of reliable biological markers not solved. The only potential age indicator in this period – third molar – was not used in the praxis, due to the wide range of single markers. Our findings, obtained during detailed studying of third molar development allowed us to eliminate this deficiency and introduce a new method giving more accurate and reliable results. For all this progress of crucial importance, we can in the praxis during the chronological age estimation find some difficulties that deserve attention.

As we have shown, the described method is based on the assumption that between chronological age and age deduced from the third molar is not statistically significant difference. This premise is valid for physiological states, when time difference in the third molar development is moving in the range of average error of estimation. In the praxis we can meet pathological states, which are accompanied with deviations exceeding the borders of standard time limits. Mostly it is severe retardation of third molars and whole dentition development, which can shift the individual into the lower age group. The acceleration of development is much rarer.

Such possibility must be always considered, when the facial and cranial skeleton are affected with morphological anomalies, manifestations of systemic diseases of the skeleton etc. The attention deserves also all syndromes accompanied with severe hypodoncia. In these cases the local finding must be confronted with the skeletal and possibly also soft tissues data. In such cases we estimated the chronological age after the consultation with specialists. Mentioned pathological states are in normal praxis rare, more often they occur in isolates.

In the evaluation of skeletal remains the accuracy of age estimation can be lower, because of incomplete material absence of relevant parts of the dentition. For the approximate orientation we need to have at least one third molar and one permanent second molar. The teeth do not have to be from the same quadrant of the dentition. If we look from the third molar, than is the terminal marker of dental and also chronological age second molar, by which is the development of permanent dentition closed. That means that after the finish of development of second permanent molar comes into account third molar as an age indicator.

Unknown sex does not mean a serious problem. As we have find out, in the Czech population no statistically significant intersexual difference occurs in the time range of third molar development.

A cardinal question remains, whether the absence of the third molars is due to agenesis or if it is due to extraction. On this fact depends the method choice of chronological age calculation. Early extractions of third molars for the orthodontics reasons are nowadays very common. Later, after the 18th year of age comes into account the third molar extractions for eruption complications. It is necessary to

say, that here we are on a fragile field of our hypotheses. Nevertheless certain clues exist, which allow increasing the probability of correct evaluation and making conclusions more reliable.

Missing of all four third molars can be a result of agenesis as well as orthodontic extractions. In such cases the aetiology is not relevant, because there is nothing to evaluate.

Every case needs careful analysis and individual approach. Absence of third molars in some quadrants of the dentition, which development is otherwise finished, together with finding of developmental stage III or IV of present third molars, means almost with certainty agenesis of missing molars.

Although coincidence of hypodontia syndrome or its microsymptoms present – anomalies of shape, size and position of some tooth means that in cases of third molars absence we incline to diagnosis of agenesis.

Third molars extractions may be accompanied by symptoms of crowding in dental arches and by the states after orthodontics extractions. With eruption complications as a cause of third molar extraction at the given age we meets mostly in the lower jaw, where the diagnosis is proofed by lack of space in the third molar region. In these cases we can orientate according to the developmental stage of third molars in the upper jaw. It is always necessary to search for possible changes in the bone structure in the place of healed extraction wound.

Conclusion

Authors have introduced a method of chronological age estimation in young individuals on the basis of third molars developmental state. For that, from biological and forensic point of view important life period, no simple method of age estimation was available until now. Finished development of the dentition does not give at this time supporting points for evaluation, and more than that, regressive changes on the dentition and periodontium, according to which the age can be determined in adults, are not yet evident. At this time only the third molar has not finished its development, but because of the large time range in its developmental terms, it was as an age indicator considered to be unsuitable.

The new method of chronological age determination is based on the finding, that in individuals with agenesis of 1 to 3 third molars the development of present third molars is statistically significant delayed in comparison with individuals with 4 third molars present. The retardation is directly related to the number of missed third molars. Classification of individuals into groups according to the number of present third molars and determining the age for each of these groups separately, we were able to decrease the average error of age estimation in the group with 4 present third molars to 1.63 years and correct the under estimation in the group with 1 to 3 third molars missing.

Comparing the methods used in adults where the range of determined age values is 5 to 10 years, the obtained result seems as optimal. As satisfactory we

can take it even with comparing the assessment of dental age with classical method, in which the average error of estimation is 0.79 years.

Age determination according to the third molars is very easy in praxis. The criterion is the stage of the third molar, which is the most advanced. The optimal visualization of the third molars can give us panoramic radiograph. Age corresponding for a developmental stage can be determined according to the tables presented by authors.

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