

Development of Third Molar in the Czech Population

Rozkovcová E.¹, Marková M.¹, Láník J.², Zvárová J.³

¹Department of Stomatology of the First Faculty of Medicine, Charles University in Prague, and General Teaching Hospital, Czech Republic;

²Private dental practice, Prague 6, Czech Republic;

³Euro MISE Centre UK and AV CR, Prague, Czech Republic

Received September 16, 2004, Accepted December 7, 2004

Abstract: The third molar development was studied on the basis of 1700 panoramic radiographs analysis of randomly selected individuals in the age ranging between 5–21 years inclusive. Each age group consisted of 100 probands – 50 boys and 50 girls. The characteristics of the third molar development were following: time of dental follicle formation – dynamics of development – the most frequent stages of third molar development in individual age groups – intraindividual differences and symmetry of development – incidence of 1–4 third molars agenesis – relation between the third molar development and the dental age – differences in the third molar development between individuals with all four third molars present and individuals with 1–3 third molars agenesis – intersexual differences. On the basis of our analysis of seven stages of development, differences of this process between males and females and the changes in dynamics of development characterizing upper and lower jaw were described. The incidence of the third molar agenesis was statistically significant, being more frequent in boys (24.2%) than in girls (17.6%). The study showed, that when the third molar is not present at the age of thirteen, it could be taken in the Czech population as agenesis. Correlation between developmental stage of third molars and dental age was ascertained. With the exception of the agenesis, no other statistically significant intersexual differences were found.

Key words: Third molar development – Indicators of development – Dental age

The study was worked out on the basis of research Project No.6: Aspects of development of oral health – pathophysiology, diagnostics, therapy and prevention (The First Faculty of Medicine of Charles University). The title of the separate thesis No. 20 61 21 02/11: New findings in physiology and pathology of teeth development and possibilities how to utilize them in practice.

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

Introduction

During ontogenesis the third molar develops in similar relations as other teeth. When looking closely to the time-plan of the developmental process, it becomes obvious that this tooth, it is possible to think in wide relations only. It becomes apparent that the possibility of organism to create variations culminates; sometimes modifying timing of development in such way that it becomes difficult to differentiate the limits where physiology ends and pathology begins. Extreme deviations in the developmental progress, together with frequent agenesis of third molar, establish a complicated complex of questions, from which some remain still open.

The reality, that it is possible to see variability of developmental conditions not only in individuals, but also in the dentition of the same individual, cannot be ignored.

These intraindividual differences of the third molar development reduce its usefulness for evaluation of dental age in youth. Non-predictability of the third molar behaviour is a serious clinical problem, which is projected into all stomatological disciplines. In orthodontics this tooth can turn a scale, which can push to conservative treatment plan once and to extraction therapy the other time.

Literature informs us, that only few papers deal with the third molar development. This problem is discussed mostly only marginally, either in the context with monitoring the dentition development [1–7], or as a part of studies of third molar agenesis [8–14]. From the Czech authors, theoretically discussed this problem Hrdinova [10], who dealt with the development of third molar's crown. Clow's research [8] was focused on the relation between the third molar's crown development and the development of the second permanent molar root. Author did not find correlation between both processes. Conradi [15] followed the progress of the third molar development in white and black race. He described faster mineralisation in black populations.

Because for determination of tooth development authors use different criteria and also because certain ethnic differences has been proved, results of a single work are not transferable [16, 17, 18]. These facts, together with the need for a deeper insight into the process of the third molar development, initiated our study.

The aim of the study was to detect the third molar development in Czech population, to compare results with literature data and to apply the gained information in praxis.

Materials and Methods

For monitoring the third molar development we used 1700 panoramic radiographs of patients from the Pediatric Department of Stomatological Clinic, First Faculty of Medicine of Charles University in Prague, which were randomly chosen. The age of probands was ranging between 5 to 21 years inclusive. In the dependence on age

we have formed 17 groups at 100 individuals each (50 boys and 50 girls) in intervals of one year. These groups included individuals, who passed given age with plus, minus 6 months difference. Males and females were evaluated separately. The third molars were followed in every individual in all dentition quadrants.

We have classified the tooth development from the formation of follicle to the termination of the root development into 7 stages – using the classification according to Kominek and Rozkovcova [19] – see Scheme (Fig. 1).

Beside the record of the developmental stage and of third molar agenesis, dental age of each individual and the relation between third molar development and its agenesis were recorded. Developmental stages and dental age were determined by two of authors after cross-validation.

These characteristics of the third molar development have been registered:

1. Time of dental follicle formation
2. Dynamics of development
3. Intraindividual development differences
4. Symmetry of development
5. Incidence of agenesis
6. Relation between the third molar development and the dental age
7. Third molar development differences in individuals with all four third molars present and in individuals with the 1–3 third molars agenesis
8. Intersexual differences

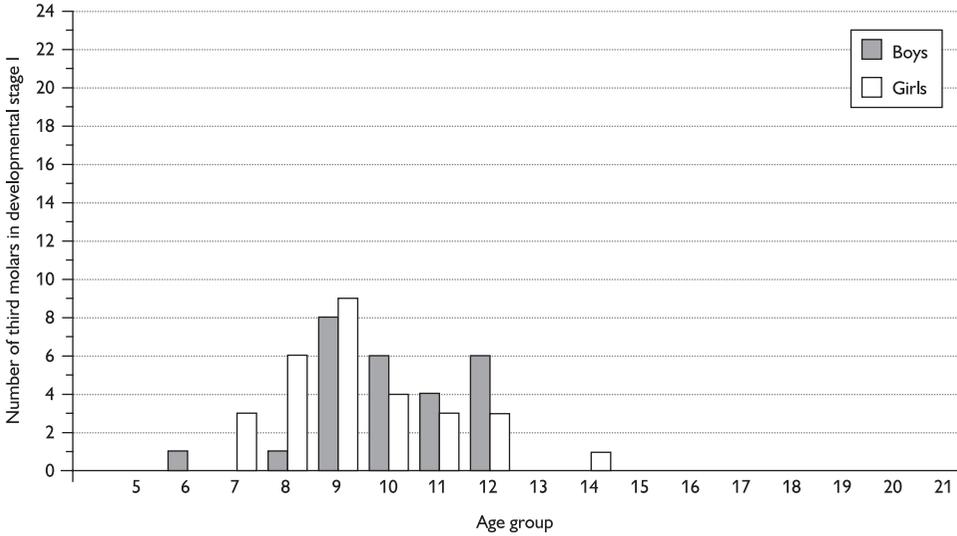
Statistical significance of differences between groups was evaluated by Fisher's exact test on the $p=0.05$ level of significance.

Results

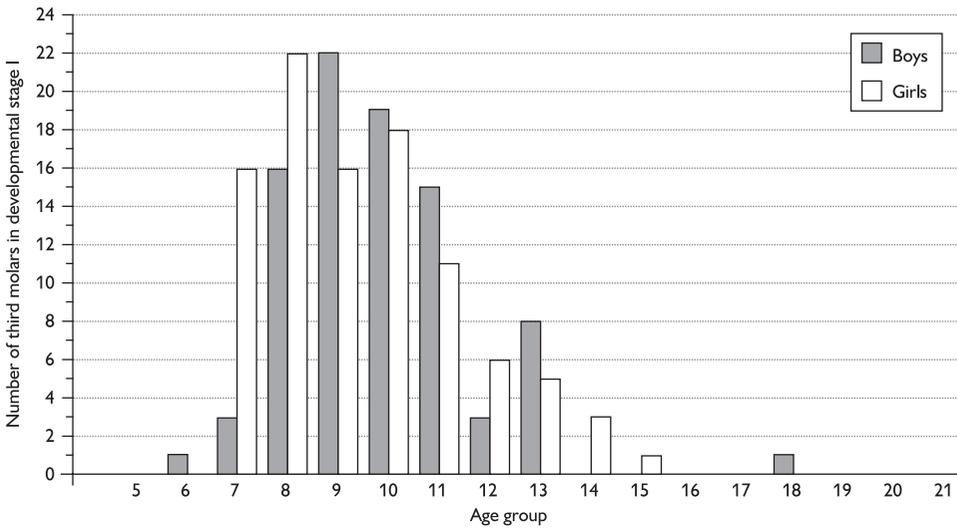
1. Time of dental follicle formation

The radiographic picture of dental follicle is identical with a picture of the first developmental stage. Because in the group of five years old children no germ formation was detected, all documentation was dated from the 6th year of age. Data concerning the time of dental follicle formation in a single quadrants, in upper and lower jaw, in boys and girls can be seen in Tables 1–6 (see I. stage of development).

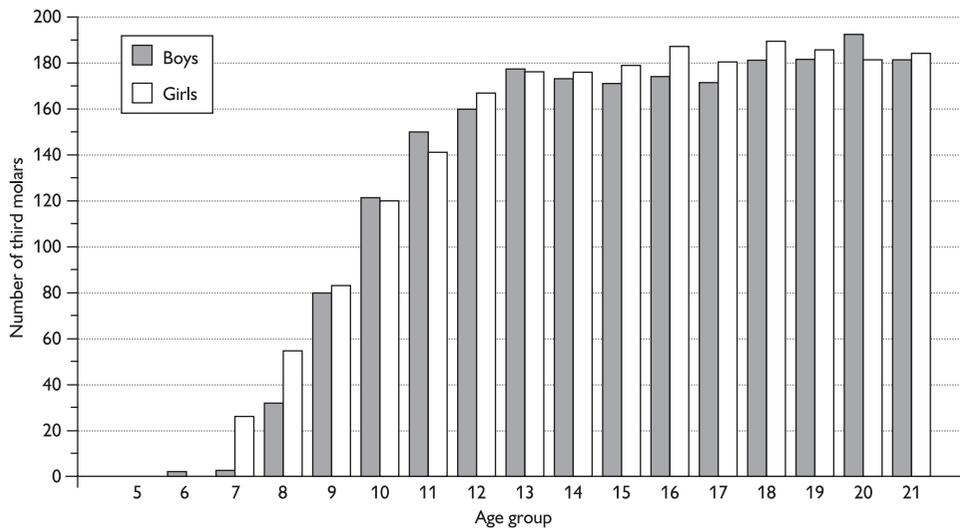
In the Table 7 we can find the basic data concerning the first, most frequent and last occurrence of I. developmental stage of the third molar development. Time range of dental follicle formation in upper and lower jaw is shown in Graphs 1 and 2. The age is on X-axis, the number of third molars founded in given year is on Y-axis. Because a constant number 50 gives the number of probands in each age group, the number of third molars founded in one jaw is identical with its percentage expression. If we don't consider isolated presence of I. developmental stage in 18-year-old boy, the wide range in timing of third molar foundation is going on from 6 to 15 years.



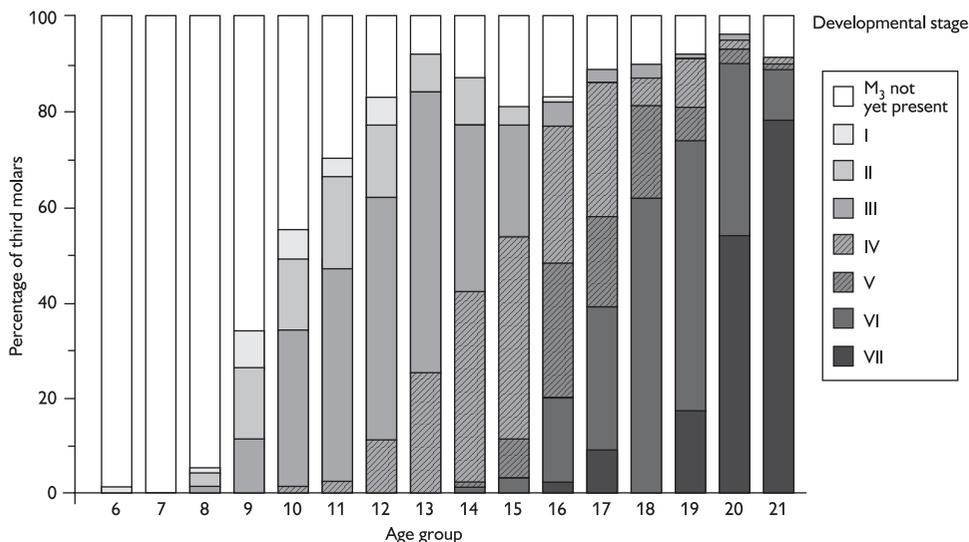
Graph 1 – Number of third molars in stage I of development in single age groups in 1700 individuals. Upper jaw.



Graph 2 – Number of third molars in stage I of development in single age groups in 1700 individuals. Lower jaw.

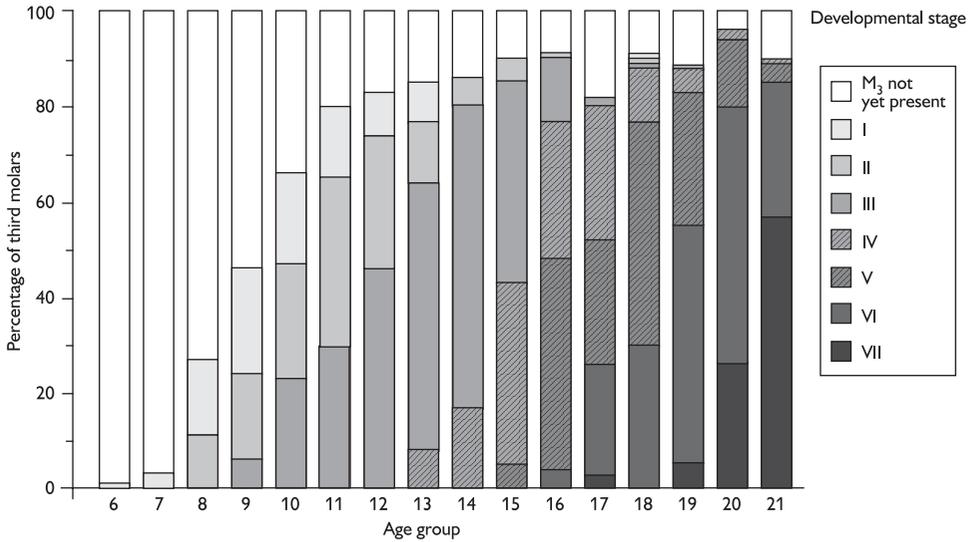


Graph 3 – Number of third molars in upper and lower jaw in single age groups in 850 boys and 850 girls.

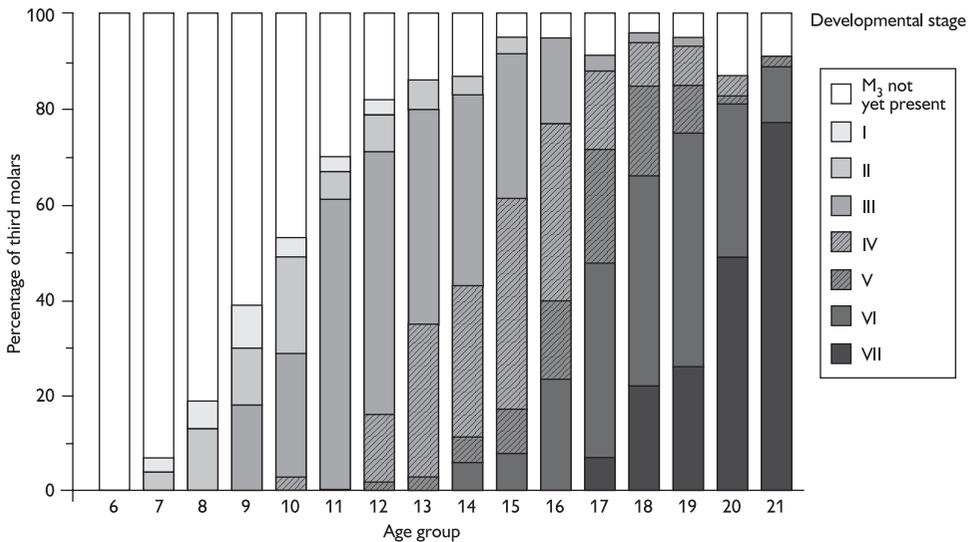


Graph 4 – Developmental stages occurrence of third molars in single age groups. Upper jaw – boys.

Development of Third Molars



Graph 5 – Developmental stages occurrence of third molars in single age groups. Lower jaw – boys.



Graph 6 – Developmental stages occurrence of third molars in single age groups. Upper jaw – girls.

The most frequent time of dental follicle formation in boys is 9th year. In girls the most frequent incidence belongs to 8th–9th year.

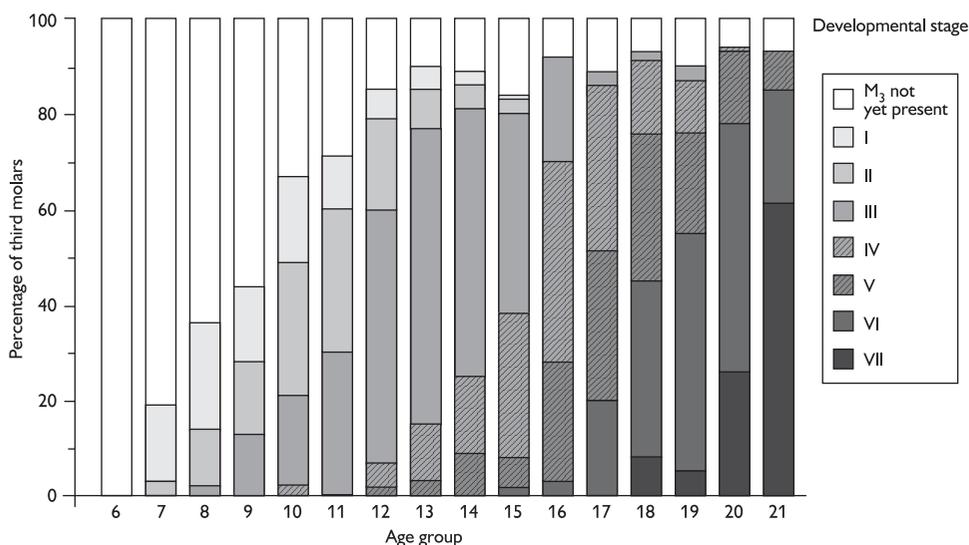
Clinically important upper age limit for dental follicle formation can be seen in Table 7. Synthetic look on stage of this tooth development is shown in Graphs 3, 4, 5, 6, 7.

If we follow the increase of number of formed third molars in the age dependence, we get at certain age to value, which can be considered final. In next years, only small deviations can be seen, which are just fluctuations around the reached final number. As can be seen in Graphs 3, 4, 5, 6, 7 the final age of third molar formation in our population for both sexes is 13 years. Starting from this age, when third molar is missing it is possible to speak about agenesis.

2. Dynamics of third molar development

We have followed third molar development on the basis of progress of single developmental stages and in the relation to sex, as can be seen in Tables 1, 2, 3, 4, 5, 6, 7.

1. stage of development is identical with radiographic picture of dental follicle. When comparing the number of third molars in the upper and lower jaw, remarkable low number of germs was detected in upper jaw in comparison with lower jaw during the whole period. In upper jaw only 26 third molars were registered in boys and 29 in girls, while in lower jaw it was 88 in boys



Graph 7 – Developmental stages occurrence of third molars in single age groups. Lower jaw – girls.

and 98 in girls. It seems, that in upper jaw the I. stage of development is shorter than in lower jaw and lasts only a few months. This noticeable disproportion in the number of third molars germs between both jaws was registered by a number of authors [8, 16, 18, 21, 22]. It is not possible to add it just to worse legibility of I. stage of development in skeletal structures of upper jaw, as Clow [8] states.

- II. stage of development can be recognized similarly as the previous stage: both genders had lower overall number of third molars in the upper jaw, but in comparison with the lower jaw the difference was less noticeable. In the group of boys, presence of the third molars was possible to register most frequently in the upper jaw in 11 years, while in the group of girls this peak came in the 10th year of age. In the lower jaw was the third molar development principally uniform in both sexes with maximum of presence in the 11th year of age (Tables 5, 6, 7). II. stage lasts approximately 1 year.
- III. stage of development is characterized by beginning of matching of the registered number of third molars in both jaws. In the upper jaw the peak of incidence was 13 years of age in boys, in girls already in 11 years of age. In lower jaw the peak of incidence was in boys 14 years, in girls it was 13 years of age (Tables 5, 6, 7). These changes signal that the growth potential of third molars in the upper jaw is getting to the peak. High percentage of teeth in III. stage of development indicates, that this stage last considerably long, approximately 3 to 4 years. If we add II. stage / starting mineralization of the crown/, which does not exceed one year, it is possible to conclude, that the mineralization of the third molar's crown lasts 4–5 years.
- IV. stage is distinguished with inhibition of third molar development in lower jaw. The peak of this stage was reached in upper jaw in boys and girls in 15 years of age. In the lower jaw the corresponding age was 15, respectively 16 years (Tables 5, 6, 7). The duration of this stage is approximately the same in both jaws, it probably lasts 1 to 2 years.
- V. stage of development culminates in relatively wide time range between the 16th to 18th year of age with only a little difference between both jaws and between boys and girls. It is possible to estimate this period to last 2 years.
- VI. stage has the peak in the upper jaw in boys around the 18th year of age, in girls in the 19th year of age. In the lower jaw the corresponding age in both sexes was 20 years. This stage lasts 2 to 3 years.
- VII. stage of development starts in both sexes earlier in the upper jaw- approximately 1 year earlier than in lower jaw. In the group of boys the earliest age was 16 years in the upper jaw, 17 years in the lower jaw, the corresponding values for girls were 17 and 18 years. At the age of 21 years,

when the study ended, considerable percentage of third molars with unfinished development still remained. In the lower jaw in both sexes it was more than one third of teeth.

Concerning the differences in the third molar development in the upper and lower jaw we have found out: There is no statistically significant difference between upper and lower molars at the lowest age groups. Starting with the 10th year of age in boys and with the 11th year in girls, there is a visible advance of upper molars prior to lower. It can be concluded, that in age groups older than 10 years the development of upper third molar is statistically significantly ahead versus the lower third molar.

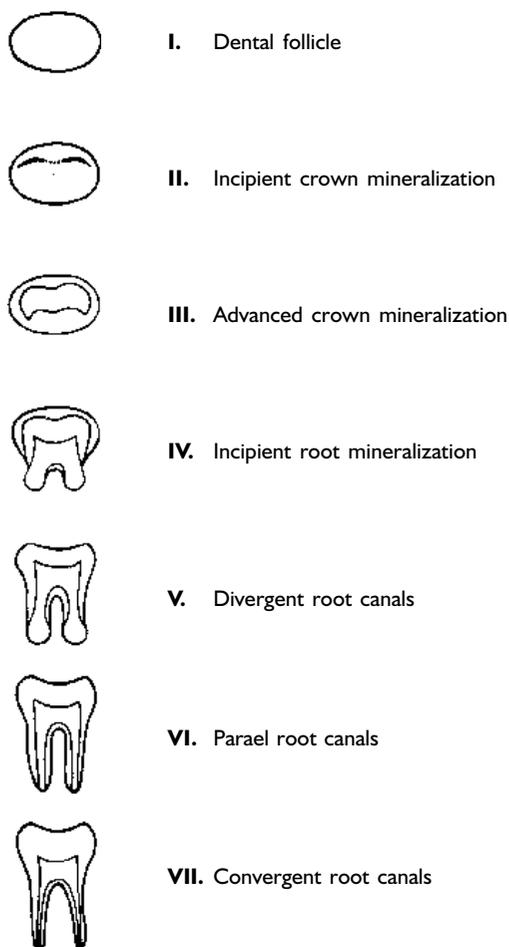


Figure 1 – Scheme of developmental tooth stages.

The representation of individual stages of the third molars development in age groups of 6 to 21 years inclusive in the upper and lower jaw, in boys and girls is given in Graphs 4, 5, 6, 7. Confrontation of the lowest, the highest and the most frequent age with single developmental stages of the third molar is given in Table 7. The most frequent stages of development in individual age groups is shown Table 8 and 9.

3. *Intraindividual differences in the development*

Differences in the third molar development can occur not only between different individuals, but also in the same individual. That means that the process of third molar development can occur in a different stage even in each quadrant of dentition (Fig. 1). These intraindividual differences together with the third molar agenesis make clinical picture rich in combinations. The difference in the single molar development can represent up to three stages. Intraindividual differences can be present during the whole period of third molar development. Even in the last monitored group of 21 years old individuals the difference of 1 to 2 developmental stages was found in 17 boys (42.5%) and in 16 girls (38.1%). Intraindividual differences are given in Table 10.

4. *Symmetry of development*

The third molar development from the symmetry point of view in the upper and lower jaws, in both sexes, from 9 to 21 years of age is given in Tables 11 and 12.

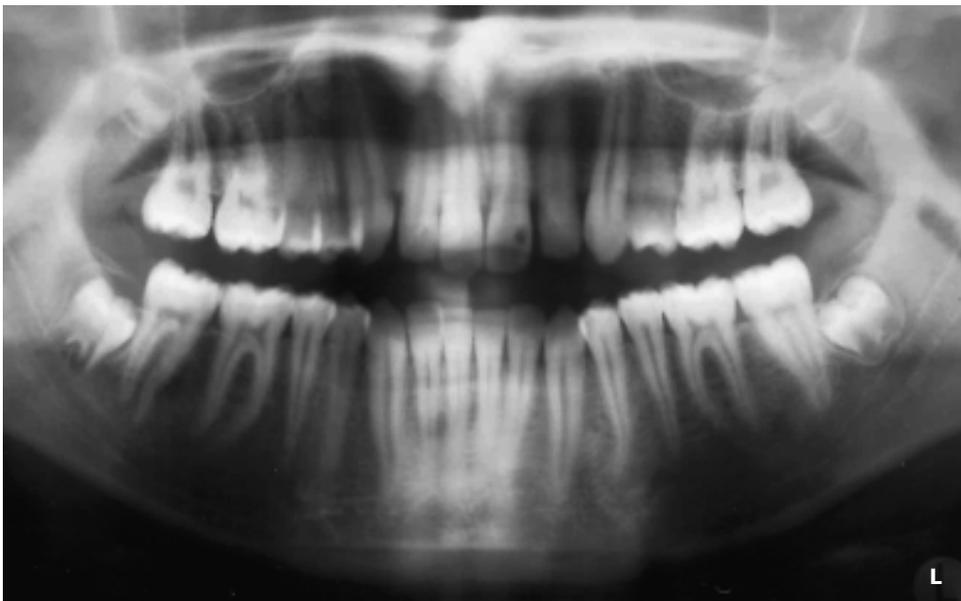


Figure 2 – Interindividual differences in third molar development. Panoramic radiograph of boy 16 year old.

While Table 11 contains all individuals – that means also the ones in which the third molar was unilaterally not founded, in Table 12 are given only those individuals of the same age with both third molars present.

5. Incidence of the third molar agenesis

Our study presents following results: agenesis of 1 to 4 third molars in individuals in age groups 13 to 21 years old inclusive was present in 109 boys, that is in 24.2%, and in 79 girls, that is in 17.6% from 450 probands either sex. This difference is statistically significant. An average presence of one to four third molars agenesis in both sexes was 20.9% (Tab. 13).

6. Relations between the third molar development and dental age

One thousand probands in the age between 7 to 16 years inclusive were examined during the research project. There are many base points in the dentition at this age to estimate dental age. Lately, it is not possible to use the developmental process of dentition as an indicator of dental age, if the third molar is not considered.

Comparison of dental age with the third molar developmental stage of the same individual demonstrated significant relationship between both indicators (Graphs 8, 9, 10, 11). That means that the third molar development is integrated into the development of dentition as its integral part. For clinical practice it is possible to conclude, that the third molar can be considered as an age indicator, mainly in older age groups, when the classical dental age is not valid (over 15 years).

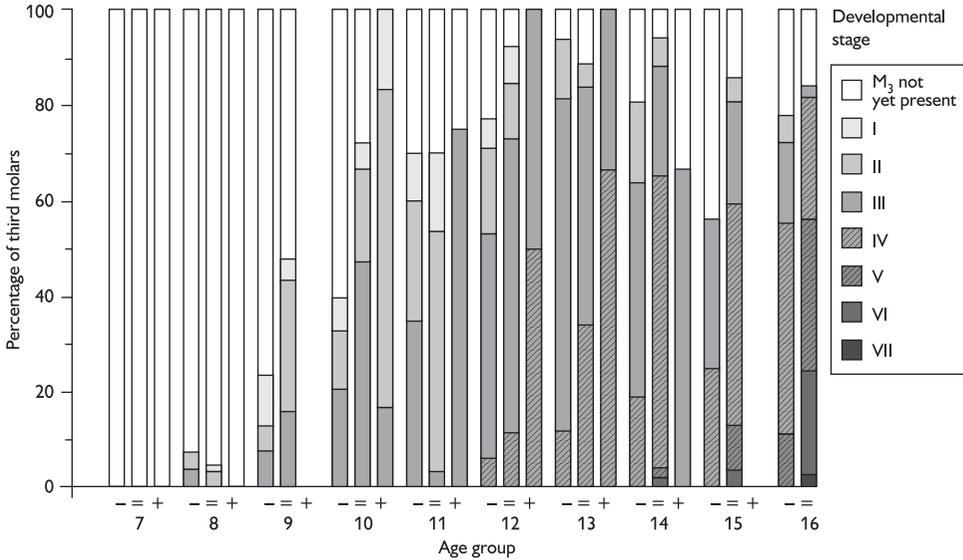
7. Third molar development differences in individuals with all four third molars present and in individuals with 1–3 third molars agenesis

Comparing the groups mentioned above, we have found out that in individuals with one to three third molars agenesis, the development of the given third molars is delayed. In age groups 13 to 20 years inclusive is this delay statistically significant. In the group of 21 years old individuals this significance was not found (Tab. 4, Graph 12).

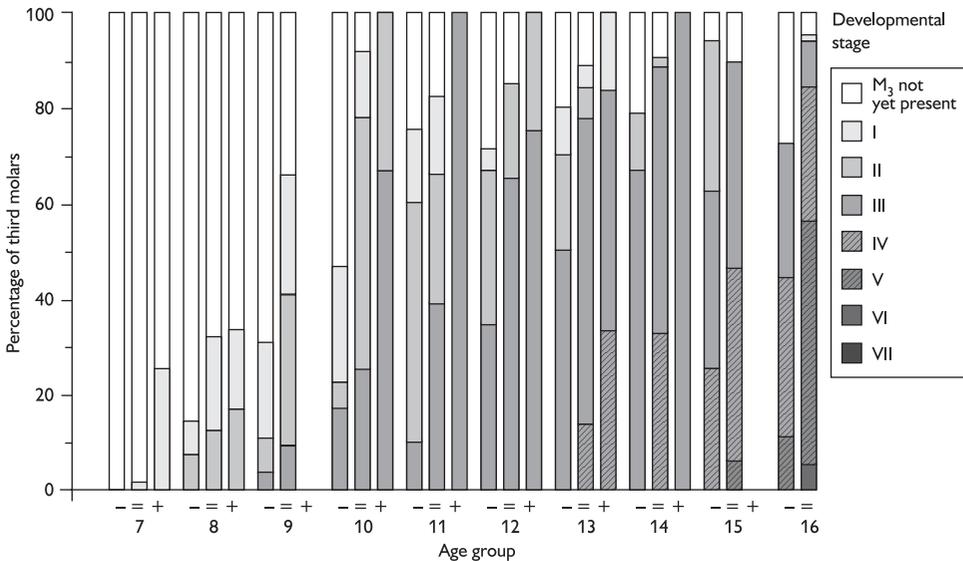
8. Intersexual differences

Statistical evaluation of the third molar development did not show any statistically significant difference between both sexes. However, certain time variations in the dynamics of the third molar development did not miss our attention. They deserve attention, because they have been described also by other authors and are characteristic obviously only for third molar.

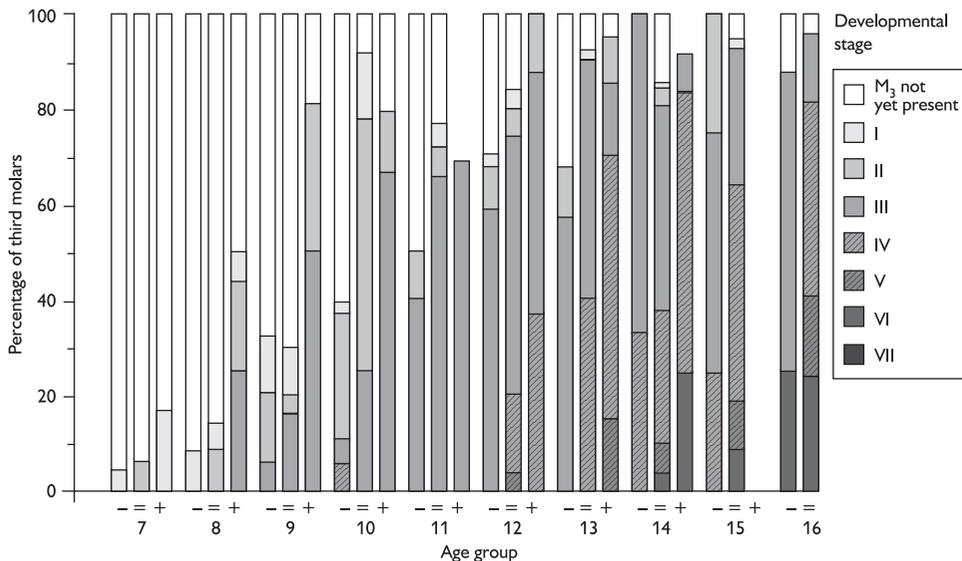
We described in our study, that there is no relevant difference in time of the third molar formation (I. stage of development) between sexes. Until the third stage of development inclusive the third molar development in both sexes runs



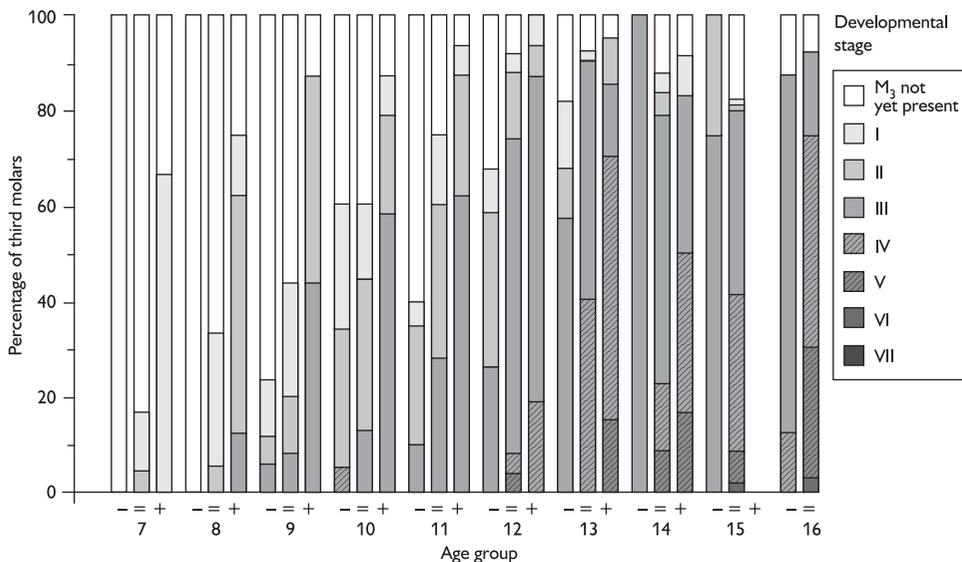
Graph 8 – Developmental stages of third molars in dependence on chronological and dental age, boys, upper jaw. In subgroup marked “-” are individuals, whose dental age is lower than chronological; in subgroup “+” individuals, whose dental age is in reverse higher than chronological and in subgroup “=” dental age is equal to chronological. If there is no individual in subgroup “+”, the relevant column in graph is missing.



Graph 9 — Developmental stages of third molars in dependence on chronological and dental age, boys, lower jaw. In subgroup marked “-” are individuals, whose dental age is lower than chronological; in subgroup “+” individuals, whose dental age is in reverse higher than chronological and in subgroup “=” dental age is equal to chronological. If there is no individual in subgroup “+”, the relevant column in graph is missing.



Graph 10 – Developmental stages of third molars in dependence on chronological and dental age, girls, upper jaw. In subgroup marked “-” are individuals, whose dental age is lower than chronological; in subgroup “+” individuals, whose dental age is in reverse higher than chronological and in subgroup “=” dental age is equal to chronological. If there is no individual in subgroup “+”, the relevant column in graph is missing.



Graph 11 – Developmental stages of third molars in dependence on chronological and dental age, girls, lower jaw. In subgroup marked “-” are individuals, whose dental age is lower than chronological; in subgroup “+” individuals, whose dental age is in reverse higher than chronological and in subgroup “=” dental age is equal to chronological. If there is no individual in subgroup “+”, the relevant column in graph is missing.

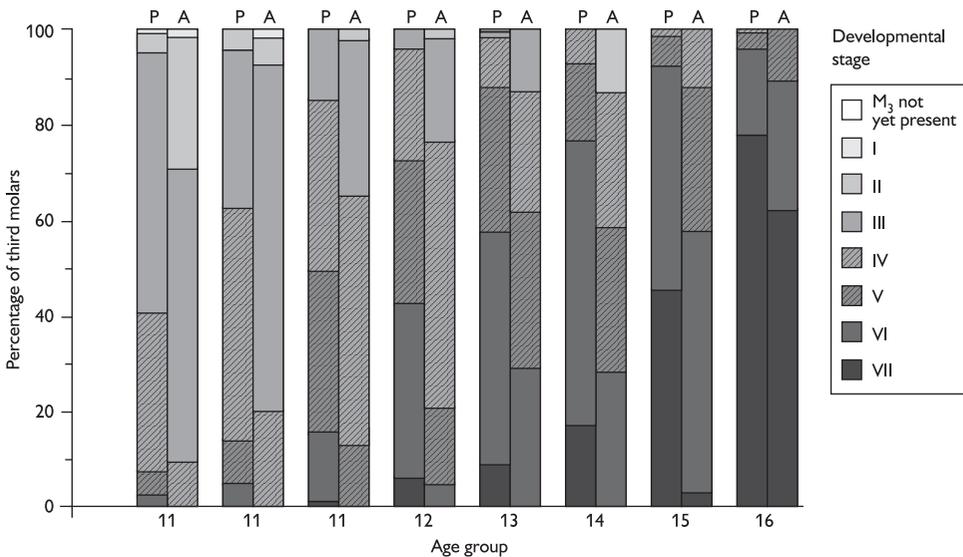
quite parallel. Statistically significant difference between boys and girls were found only in one age group: at the age of 16 – in the lower third molars. In boys, higher developmental stages (V. and VI.) were more frequent present then it is in girls.

Discussion

Frequently used term for third molar – the wisdom tooth – indicates the uniqueness of this tooth, which stands out of permanent dentition development rules and emerges right at the beginning of adulthood. Late formation and wide range of developmental terms timing together with frequent agenesis give to this tooth the sign of lability and certain risks [16, 23, 24, 25]. First sign of development variability is the time of the third molar formation. As it was proved, this period lasts almost one decade. This wide time range, in which it is possible to expect the third molar formation, affects orthodontic treatment planning [26, 27, 28].

If we talk about the time of third molar formation, we cannot overlook the significant difference in informative value, which gives us the terms of first and last formation data. The third molar is a concrete reality, which has to be respected in orthodontic treatment plan.

Data concerning the last time of formation differ according to individual authors up to four years. For example Tanner [29], Tröndle [30], Krekeler et al. [31],



Graph 12 – Developmental stages occurrence of third molars in individuals with four third molars present (P) and in individuals with one to three third molars agenesis (A).

Bredy et al. [32], Hübenthal [33] give this limit to 12th year of age inclusive. Banks [34], Saito [35], Speckin [12], Clow [8], Sonnabend [11], Hugoson a Kugelberg [36], Garn et al. [37, 38] accept the 14th year as an age after which is the third molar formation not likely. According to Richardson [22] the safe limit is the 16th year. Reasons for differences in estimation of upper age limit of third molar formation are not only ethnic differences, but also how the term is defined [18, 39].

As concerns our results, at the beginning we have taken as the upper limit for third molar formation the 12th year /40/. We have based on Hübenthal [33]. Comparing the incidence of the third molar agenesis the author did not find difference between age groups 12–16 and 16–20 years. However our latest findings have shown that the upper limit of the third molar formation must be laid in the 13th year of age. If we estimate the 12th year as the upper limit we get this results: Agenesis of 1–4 third molars occurred in boys in 25.6% in girls in 19.4%, in boys and girls in 22.5%. In the third molar agenesis incidence evaluation one year later, this reality projects into results in this way: boys 24.2%, girls 17.6%, boys and girls 20.9%. In global results that means the decrease of 1.6%. But this difference is not statistically significant.

For the comprehension of the dynamics of the third molar development and for its possible differences between upper and lower jaw and between sexes, the period of dental follicle formation to root apex closing was classified into seven developmental stages. Here, it must be mentioned, that there are many opinions about number of developmental stages according to individual authors. From the oldest division in 3 stages, as was suggested by Logan and Kronfeld [41], and 4 stages according to Schour and Massler [42], other authors came to much higher values.

The best-known classification was suggested by Demirjian et al. [43], who divides the dental development in 8 stages. Gleiser and Hunt (in: Weise and Bruntsch [44, 45]) recognize as much as 15 stages of the dental development. It can be said that almost every author, who was concerned with the dentition development has developed his own classification. This fact makes any comparison of results impossible.

In our study we have used classification suggested by Kominek and Rozkovcova [19]. These authors have followed the process of dental development on X-rays and identified 7 stages.

Generally little attention is paid to intraindividual differences in third molar development and the developmental symmetry. References about these differences can be found only in Elomaa and Elomaa [46] and Weise and Bruntsch [44, 45]. These authors have not followed the whole process of the third molar development, but only the symmetry of development connected with the third molar agenesis. According to our opinion the third molar agenesis belongs by a part of its problems to the group of intraindividual differences. Besides its clinical

Table 1 – Developmental stages of tooth 18 in 800 boys and 800 girls at the age 6 to 21 years (number of teeth)

Age group	Developmental stages							
	0*	I	II	III	IV	V	VI	VII
Boys								
6	49	1						
7	50							
8	48		2					
9	33	2	10	5				
10	24	2	8	16				
11	15	3	10	21	1			
12	9	3	8	24	6			
13	3		5	29	13			
14	6		5	18	20			
15	9		3	11	22	3	2	
16	7			3	16	13	10	1
17	5			2	14	10	15	4
18	7			1	2	11	29	
19	5			1	5	2	28	9
20	3			1	1	1	17	27
21	5				1		6	38
Girls								
6	50							
7	46	2	2					
8	40	4	4	2				
9	31	4	6	9				
10	24	2	9	13				
11	16	1	3	30				
12	9	1	4	27	8	1		
13	8		2	23	15	2		
14	5	1	2	20	16	3	3	
15	3		2	16	21	4	4	
16	2			11	17	8	12	
17	4			1	9	12	21	3
18	3			1	3	10	23	10
19	2			2	4	5	24	13
20	7				2	1	15	25
21	4					1	5	40

* Age group 6 to 13 years inclusive – M₃ is not visible on radiograph* Age group 14 to 21 years inclusive – M₃ agenesis

Table 2 – Developmental stages of tooth 28 in 800 boys and 800 girls at the age 6 to 21 years (number of teeth)

Age group	Developmental stages							
	0*	I	II	III	IV	V	VI	VII
Boys								
6	50							
7	50							
8	47	1	1	1				
9	33	6	5	6				
10	21	4	7	17	1			
11	15	1	9	24	1			
12	8	3	7	27	5			
13	5		3	30	12			
14	7		5	17	20	1		
15	10		1	12	21	5	1	
16	10		1	2	13	15	8	1
17	6			1	14	9	15	5
18	3			2	4	8	33	
19	3			1	4	5	29	8
20	1				1	2	19	27
21	4					1	5	40
Girls								
6	50							
7	47	1	2					
8	41	2	5	2				
9	30	5	6	9				
10	23	2	11	13	1			
11	14	2	3	31				
12	9	2	4	28	6	1		
13	6		4	22	17	1		
14	8		1	20	16	2	3	
15	2		2	14	23	5	4	
16	3			7	20	8	12	
17	5			2	8	11	20	4
18	1			1	6	9	21	12
19	3				4	5	25	13
20	6				2	1	17	24
21	5					1	7	37

* Age group 6 to 13 years inclusive – M₃ is not visible on radiograph* Age group 14 to 21 years inclusive – M₃ agenesis

Table 3 – Developmental stages of tooth 38 in 800 boys and 800 girls at the age 6 to 21 years (number of teeth)

Age group	Developmental stages							
	0*	I	II	III	IV	V	VI	VII
Boys								
6	49	1						
7	48	2						
8	36	8	6					
9	26	11	10	3				
10	19	8	12	11				
11	10	7	18	15				
12	9	2	15	24				
13	7	2	9	28	4			
14	7		3	31	9			
15	5		3	21	19	2		
16	5			7	15	21	2	
17	11			4	9	13	12	1
18	5	1			5	24	15	
19	5				3	12	28	2
20	3				1	6	28	12
21	4				1	2	14	29
Girls								
6	50							
7	41	7	2					
8	33	11	5	1				
9	30	7	6	7				
10	15	10	15	9	1			
11	15	4	17	14				
12	7	5	8	26	3	1		
13	4	2	5	31	7	1		
14	4	2	2	30	7	5		
15	7	1	2	20	16	3	1	
16	4			10	23	12	1	
17	6			2	17	14	11	
18	4				7	16	18	5
19	4			2	6	12	23	3
20	3				1	6	27	13
21	4					4	13	29

* Age group 6 to 13 years inclusive – M₃ is not visible on radiograph* Age group 14 to 21 years inclusive – M₃ agenesis

Table 4 – Developmental stages of tooth 48 in 800 boys and 800 girls at the age 6 to 21 years (number of teeth)

Age group	Developmental stages							
	0*	I	II	III	IV	V	VI	VII
Boys								
6	50							
7	49	1						
8	37	8	5					
9	28	11	8	3				
10	15	11	12	12				
11	10	8	17	15				
12	14	1	13	22				
13	8	6	4	28				
14	7		3	32	8			
15	5		2	21	19	3		
16	4		1	6	14	23	2	
17	7		2	6	9	13	12	1
18	4		1	1	6	23	15	
19	6			1	2	16	22	3
20	1				1	8	26	14
21	6					2	14	28
Girls								
6	50							
7	40	9	1					
8	31	11	7					
9	26	9	9	6				
10	18	8	13	10	1			
11	14	7	13	16				
12	8	1	11	27	2	1		
13	6	3	3	31	5	2		
14	7	1	3	26	9	4		
15	9		1	22	14	3	1	
16	4			12	19	13	2	
17	5			3	16	17	9	
18	3			2	8	15	19	3
19	6			1	5	9	27	2
20	3					9	25	13
21	3					4	11	32

* Age group 6 to 13 years inclusive – M₃ is not visible on radiograph* Age group 14 to 21 years inclusive – M₃ agenesis

Table 5 – Number of third molars in single developmental stages in upper and lower jaw in 800 boys at the age 6 to 21 years

Age group	0*	Developmental stages						
		I	II	III	IV	V	VI	VII
Upper jaw								
6	99	1						
7	100							
8	95	1	3	1				
9	66	8	15	11				
10	45	6	15	33				
11	30	4	19	45	2			
12	17	6	15	51	11			
13	8		8	59	25			
14	13		10	35	40	1	1	
15	19		4	23	43	8	3	
16	17		1	5	29	28	18	2
17	11			3	28	19	30	9
18	10			3	6	19	62	
19	8			1	10	7	57	17
20	4			1	2	3	36	54
21	9				1	1	11	78
Lower jaw								
6	99	1						
7	97	3						
8	73	16	11					
9	54	22	18	6				
10	34	19	24	23				
11	20	15	35	30				
12	23	3	28	46				
13	15	8	13	56	8			
14	14		6	63	17			
15	10		5	42	38	5		
16	9		1	13	29	44	4	
17	18		2	10	18	26	24	2
18	9	1	1	1	11	47	30	
19	11			1	5	28	50	5
20	4				2	14	54	26
21	10				1	4	28	57

* Age group 6 to 13 years inclusive – M₃ is not visible on radiograph* Age group 14 to 21 years inclusive – M₃ agenesis

Table 6 – Number of third molars in single developmental stages in upper and lower jaw in 800 girls at the age 6 to 21 years

Age group	Developmental stages							
	0*	I	II	III	IV	V	VI	VII
Upper jaw								
6	100							
7	93	3	4					
8	81	6	9	4				
9	61	9	12	18				
10	47	4	20	26	3			
11	30	3	6	61				
12	18	3	8	55	14	2		
13	14		6	45	32	3		
14	13	1	3	40	32	5	6	
15	5		4	30	44	9	8	
16	5			18	37	16	24	
17	9			3	17	23	41	7
18	4			2	9	19	44	22
19	5			2	8	10	49	26
20	13				4	2	32	49
21	9					2	12	77
Lower jaw								
6	100							
7	81	16	3					
8	64	22	12	2				
9	56	16	15	13				
10	33	18	28	19	2			
11	29	11	30	30				
12	15	6	19	53	5	2		
13	10	5	8	62	12	3		
14	11	3	5	56	16	9		
15	16	1	3	42	30	6	2	
16	8			22	42	25	3	
17	11			5	33	31	20	
18	7			2	15	31	37	8
19	10			3	11	21	50	5
20	6				1	15	52	26
21	7					8	24	61

* Age group 6 to 13 years inclusive – M_3 is not visible on radiograph* Age group 14 to 21 years inclusive – M_3 agenesis

Table 7 – The lowest, the highest and the most frequent age in single developmental stages of third molars in 800 boys and 800 girls

Stage	Number of teeth in stage	Lowest age	Highest age	Most frequent age		
				Age	Number of teeth	Per cent
Boys, upper jaw						
I	26	6	12	9	8	30.8
II	90	8	16	11	19	21.1
III	271	8	20	13	59	21.8
IV	198	10	21	15	43	21.7
V	86	14	21	16	28	32.6
VI	218	14	21	18	62	28.4
VII	160	16	21	21	78	48.8
Boys, lower jaw						
I	88	6	18	9	22	25.0
II	144	8	18	11	35	24.3
III	291	9	19	14	63	21.6
IV	129	13	21	15	38	29.5
V	168	15	21	18	47	28.0
VI	190	16	21	20	54	28.4
VII	90	17	21	21	57	63.3
Girls, upper jaw						
I	29	7	14	9	9	31.0
II	72	7	15	10	20	27.8
III	304	8	19	11	61	20.1
IV	200	10	20	15	44	22.0
V	91	12	21	17	23	25.3
VI	216	14	21	19	49	22.7
VII	181	17	21	21	77	42.5
Girls, lower jaw						
I	98	7	15	8	22	22.4
II	123	7	15	11	30	24.4
III	309	8	19	13	62	20.1
IV	167	10	20	16	42	25.1
V	151	12	21	17*	31	20.5
				18*	31	20.5
VI	188	15	21	20	52	27.7
VII	100	18	21	21	61	61.0

The highest age is limited by the value of 21 years, which was the age in the highest age group

* V. stage in girls in lower jaw was identical at the age of 17 and 18 years

Table 8 – The most frequent developmental stages of third molars in single age groups in 800 boys

Age group	Upper jaw		Lower jaw	
	Stage	Frequency [%]	Stage	Frequency [%]
6	I*	1	I*	1
7	I/II*	2/2	I*	5
8	II*	4	I*	16
9	II*	15	I*	22
10	III*	33	II*	24
11	III	45	II	35
12	III	51	III	46
13	III	59	III	56
14	IV	40	III	63
15	IV	42	III	41
16	IV	29	V	44
17	VI	30	V	27
18	VI	62	V	47
19	VI	57	VI	50
20	VII	55	VI	55
21	VII	81	VII	58

* At the age 6 to 10 years third molars are most frequently not present yet

Table 9 – The most frequent developmental stages of third molars in single age groups in 800 girls

Age group	Upper jaw		Lower jaw	
	Stage	Frequency [%]	Stage	Frequency [%]
6	–*	0	I*	2
7	II*	4	I*	9
8	II*	9	I*	22
9	II*	18	I*	16
10	III*	26	II*	26
11	III	61	II/III	30/30
12	III	54	III	53
13	III	45	III	62
14	III	39	III	56
15	IV	44	III	42
16	IV	37	IV	42
17	VI	40	IV	33
18	VI	44	VI	37
19	VI	49	VI	49
20	VII	48	VI	54
21	VII	78	VII	61

* At the age 6 to 10 years third molars are most frequently not present yet

Table 10 – Intraindividual differences of third molars development in upper and lower jaw in boys and girls with all third molars present

Age group	Number of individuals	Difference of stages (Percentage of individuals)			
		Without difference	1 stage	2 stages	3 stages
Boys					
7	0				
8	2		100.0		
9	11	36.4	54.5	9.1	
10	20	45.0	55.0		
11	30	56.7	36.7	6.7	
12	31	45.2	54.8		
13	38	47.4	36.8	15.8	
14	37	59.5	37.8	2.7	
15	33	36.4	54.5	9.1	
16	36	41.7	55.6	2.8	
17	35	37.1	54.3	8.6	
18	39	35.9	59.0	5.1	
19	39	41.0	53.8	5.1	
20	44	34.1	65.9		
21	40	57.5	42.5		
Girls					
7	3	66.7	33.3		
8	7	28.6	71.4		
9	12	50.0	33.3	16.7	
10	20	55.0	40.0	5.0	
11	26	50.0	30.8	19.2	
12	34	58.8	38.2	2.9	
13	36	50.0	44.4	5.6	
14	39	48.7	43.6	7.7	
15	40	42.5	50.0	7.5	
16	44	38.6	40.9	18.2	2.3
17	42	33.3	47.6	16.7	2.4
18	46	39.1	50.0	10.9	
19	41	41.5	48.8	9.8	
20	41	53.7	46.3		
21	42	61.9	35.7	2.4	

Table 11 – Percentage of individuals with symmetric or asymmetric third molars development in 650 boys and 650 girls at the age 9 to 21 years

Age group	Upper jaw		Lower jaw	
	Symmetric development	Asymmetric development	Symmetric development	Asymmetric development
Boys				
9	86.0	14.0	88.0	12.0
10	78.0	22.0	86.0	14.0
11	82.0	18.0	94.0	6.0
12	86.0	14.0	80.0	20.0
13	90.0	10.0	80.0	20.0
14	84.0	16.0	88.0	12.0
15	66.0	34.0	80.0	20.0
16	84.0	16.0	88.0	12.0
17	84.0	16.0	76.0	24.0
18	84.0	16.0	72.0	28.0
19	84.0	16.0	76.0	24.0
20	72.0	28.0	76.0	24.0
21	82.0	18.0	82.0	18.0
9 to 21	81.7	18.3	81.8	18.2
Girls				
9	90.0	10.0	78.0	22.0
10	88.0	12.0	78.0	22.0
11	92.0	8.0	76.0	24.0
12	78.0	22.0	80.0	20.0
13	66.0	34.0	84.0	16.0
14	82.0	18.0	86.0	14.0
15	82.0	18.0	86.0	14.0
16	82.0	18.0	86.0	14.0
17	86.0	14.0	84.0	16.0
18	88.0	12.0	84.0	16.0
19	92.0	8.0	80.0	20.0
20	86.0	14.0	90.0	10.0
21	86.0	14.0	82.0	18.0
9 to 21	84.5	15.5	82.6	17.4

Note: Counted were also individuals with third molars not yet present

Table 12 – Frequency of symmetric third molars development in upper and lower jaw only in individuals with both molars present

Age group	Upper jaw			Lower jaw		
	Number of individuals in total	Symmetric development Number of individuals	Per cent	Number of individuals in total	Symmetric development Number of individuals	Per cent
Boys						
7	0	0		1	1	100.0
8	2	1	50.0	13	12	92.3
9	15	12	80.0	21	19	90.5
10	24	20	83.3	31	28	90.3
11	33	29	87.9	40	37	92.5
12	39	37	94.9	34	33	97.1
13	45	42	93.3	41	33	80.5
14	42	37	88.1	41	39	95.1
15	37	27	73.0	43	36	83.7
16	39	37	94.9	44	41	93.2
17	43	38	88.4	37	32	86.5
18	43	39	90.7	43	34	79.1
19	45	39	86.7	43	34	79.1
20	46	35	76.1	47	36	76.6
21	44	40	90.9	44	36	81.8
Girls						
7	3	3	100.0	9	8	88.9
8	8	7	87.5	16	14	87.5
9	17	17	100.0	19	14	73.7
10	25	22	88.0	31	25	80.6
11	33	33	100.0	33	26	78.8
12	37	35	94.6	40	35	87.5
13	38	31	81.6	44	38	86.4
14	42	35	83.3	41	37	90.2
15	46	40	87.0	40	37	92.5
16	47	39	83.0	45	40	88.9
17	45	40	88.9	43	37	86.0
18	47	43	91.5	46	39	84.8
19	46	44	95.7	43	38	88.4
20	42	39	92.9	47	44	93.6
21	44	41	93.2	45	39	86.7

Table 13 – Agenesis of 1 – 4 third molars in 450 boys and 450 girls at the age 13 to 21 years

Age group	Sex	Individuals with 1–4 third molars agenesis		Number of non founded third molars
		Number of individuals	Percent	
13	Boys	12	24.0	23
	Girls	14	28.0	24
	Boys and girls	26	26.0	47
14	Boys	13	26.0	27
	Girls	11	22.0	24
	Boys and girls	24	24.0	51
15	Boys	17	34.0	29
	Girls	10	20.0	21
	Boys and girls	27	27.0	50
16	Boys	14	28.0	26
	Girls	6	12.0	13
	Boys and girls	20	20.0	39
17	Boys	15	30.0	29
	Girls	8	16.0	20
	Boys and girls	23	23.0	49
18	Boys	11	22.0	19
	Girls	4	8.0	11
	Boys and girls	15	15.0	30
19	Boys	11	22.0	19
	Girls	9	18.0	16
	Boys and girls	20	20.0	35
20	Boys	6	12.0	8
	Girls	9	18.0	19
	Boys and girls	15	15.0	27
21	Boys	10	20.0	19
	Girls	8	16.0	16
	Boys and girls	18	18.0	35
13 to 21	Boys	109	24.2	199
	Girls	79	17.6	163
	Boys and girls	188	20.9	362

Table 14 – Percentage of third molars in single developmental stages in individuals with four third molars and in individuals with agenesis of one to three third molars in age groups 13 to 21 years inclusive

Age group	Number of teeth	Developmental stages						
		I	II	III	IV	V	VI	VII
Percentage of teeth								
Individuals with four third molars								
13	296	3.0	7.4	62.2	25.3	2.0		
14	304	1.0	3.9	54.9	32.9	4.9	2.3	
15	292		4.5	32.5	49.0	9.6	4.5	
16	320			14.1	36.3	33.8	15.3	0.6
17	308		0.3	3.9	23.4	39.9	36.7	5.8
18	340	0.3	0.3	1.2	9.7	31.2	48.5	8.8
19	320				6.9	16.3	60.3	16.6
20	340				1.5	6.8	46.5	45.3
21	328				0.6	3.4	19.2	76.8
Individuals with one to three third molars agenesis								
13	57	7.0	22.8	66.7	3.5			
14	45	2.2	26.7	60.0	11.1			
15	58	1.7	5.2	72.4	20.7			
16	41		4.9	31.7	51.2	12.2		
17	43		2.3	20.9	55.8	16.3	4.7	
18	30			13.3	26.7	33.3	26.7	
19	46			15.2	26.1	30.4	28.3	
20	33			3.0	12.1	33.3	48.5	3.0
21	37					10.8	32.4	56.8

importance, these differences have also another aspect, because they belong to symptoms of hypodontia syndrome.

High variability in developmental terms leads some authors to speculation, that the third molar development is autonomous, on the dentition non-dependent action. Our comparison of dental age of a given individual with the stage of his third molar development has shown that third molar development is integrated into the dentition development as its inseparable component.

We can find only a few works in the literature, which concern sexual dimorphism in the third molar development. While Clow [8], Gravely [47], Elomaa and Elomaa [46], Legovick et al. [48] found no differences in the dynamics of development in boys and girls, other authors mention certain differences. For example Weise and Bruntsch [44, 45] remark: "There is only a little advantage in timing of the third molar development in girls, but it lately disappears and changes to very opposite". Delay in the third molar development in girls in comparison with boys found out also Levesque et al. [49], Kullman et al. [50] and Mincer et al. [51]. Thompson (in Kullman et al. [50]) mentioned that "mineralization of the permanent dentition is delayed in boys in comparison with girls except the third molars". From the stage IV of the third molar development we have found analogous signs of retardation in girls in comparison with boys. This retardation was statistically significant only in stages V and VI of the third molar development in the lower jaw.

Conclusion

Analyzing panoramic radiographs of 1700 individuals in the age of 5 to 21 years we have gained a complete picture of the third molar development. This picture can be taken as specific for the Czech population. Gained results are standard markers for individual assessments.

Time range of the dental follicle formation of the third molar includes 8 years. The first formation was noticed in the age of 6 years. The most frequent age of formation was found to be 10 years. As the last term of formation the 13th year was stated. These results are valid for the population, not loaded with hypodontia syndrome.

For the clinical use the most frequent stage of third molar development for every age group was specified.

As a new contribution the estimation of time of single development stages can be taken. By adding these values we got to 10 years as an average time of the third molar development.

Following the development dynamics we have found differences in this process in the upper and lower jaw. That suggests that each jaw is guided by its own mechanism as other authors indicate [50, 51].

Intraindividual differences, including the asymmetry of the third molar development, were found in our study in about 50% and it lasted for the whole

period of development. This rarely followed phenomenon has high clinical significance as a microsymptom of hypodontia syndrome.

As inseparable part of the third molar developmental problem, the agenesis incidence of the third molar can be considered. Not only for a given individual, but also for the whole group it is characteristic, if the third molar is or not. Agenesis of 1–4 third molars was found in 24.2% in boys and in 17.6% in girls. This difference is statistically significant.

The correlation between the third molar developmental stage and the dental age has been found. To important findings belongs also the fact, that the agenesis of 1–3 third molars is accompanied by statistically significant developmental delay of the third molar.

We have evaluated all results separately for boys and girls. Except agenesis there were no statistically significant intersexual differences found in any of the indicators.

Gained results can specify characteristics of the dental development in the young Czech population. Precise timing of important events in the third molar development can bring more reliability into the planning of orthodontical treatment and it will be an important indicator for the third molar extraction. Our results may also help to estimate the age of young individuals, if there is no other biological method on disposal.

References

1. ANDLAW W. R. Y., ROCK W. P.: A manual of pedodontics. 3rd ed., Churchill Livingstone, London, 1993, p. 233.
2. FASS E. N.: A chronology of growth of the human dentition. *J. Dent. Child.* 36: p. 391–396, 1969.
3. FIELDS H. W., SINCLAIR P. M.: Dentofacial growth and development. *J. Dent. Child.* 57: p. 46–55, 1990.
4. LILIEQUIST B., LUNDBERG M.: Skeletal and tooth development. A metodologic investigation. *Acta Radiol. /Sweden/, fasc. 2:* p.97–112, 1971.
5. MAPPES M. S., HARRIS E. F., BEHRENS R. G.: An example of regional variation in the tempos of tooth mineralization. *Am. J. Orthod. Dentofac. Orthop.* 101: p. 145–151, 1992.
6. NOLLA C. H.: The development of the permanent teeth. *J. Dent. Child.* 27: p. 254–266, 1960.
7. WISE G. E.: The biology of tooth development. *J. dent. Res.* 77: p. 1576–1579, 1998.
8. CLOW I. M.: A radiographic survey of third molar development: A comparison. *Brit. J. Orthodont.* 11: p. 9–15, 1984.
9. HELLMANN M.: Our third molar teeth; their eruption, presence and absence. *Dent. Cosmos* 78: p. 750–762, 1936.
10. HRDINOVÁ V., NOVÁK J., TACHOVSKÁ A.: Rentgenologická studie vývoje korunky dolního třetího moláru. *Čs. Stomat.* 80: p. 355–362, 1980.
11. SONNABEND F.: Zur Unterzahl der Zähne insbesondere der dritten Molaren. *Dtsch. Zahn-Mund-Kieferheilk.* 46: p. 34–43, 1966.
12. SPECKIN J.: Besteht ein Zusammenhang zwischen allgemeiner Hypodontie und der Nichtanlage der dritten Molaren? Med. Diss., Hamburg, 1981.
13. STEINHARDT J., MERTINS J., MERTINS H.: Röntgenologische Befunde zur Keimanlage und zum Durchbruch der dritten Molaren. *Fortschr. Kieferorthop.* 49: p. 152–159, 1988.

14. TANNER P.: Die Zahnunterzahl im bleibenden Gebiss unter besonderer Berücksichtigung der Nichtanlage des Weisheitszahnes. Med. Diss., Zürich, 1946.
15. CONRADI G.: Ricerche sulla frequenza del terzo molare nei criminali et negli alienati. *Stomatologia Modena* 26: p. 1228–1239, 1349–1964, 1928.
16. GORGANI N., SULLIVAN R.E., DU BOIS.: A radiographic investigation of third molar development. *J. Dent. Child.* 57: p. 106–111, 1990.
17. POULSEN S., KOCH G.: Pediatric Dentistry: A clinical approach. Munksgaard, Kopenhagen, 2002, p. 358–427.
18. UZAMIS M., KANSU Ö., TANER T. U., ALPAR R.: Radiographic evaluation of third molar development in a group of Turkish children. *J. Dent. Child.* 67: p. 136–141, 2000.
19. KOMÍNEK J., ROZKOVCOVÁ E., VÁŠKOVÁ J.: Age determination of individuals on the basis of the development of teeth. *Scripta medica* 48: p. 171–177, 1975.
20. ZVÁROVÁ J.: Základy statistiky pro biomedicínské obory. Univerzita Karlova, Karolinum, Praha, 2002, p. 218.
21. RICHARDSON M. E.: Late third molar genesis: Its significance in orthodontic treatment. *Angle Orthod.* 50: p. 121–128, 1980.
22. RICHARDSON M. E.: Development of the lower third molars from 10 to 15 years. *Angle Orthod.* 43: p. 191–193, 1973.
23. DEMISCH A., HARTMANN P.: Calcification of the mandibular third molar and its relation to skeletal and chronological age in children. *Child Development* 27: p. 459–473, 1956.
24. GERNER H. G.: Der Durchbruchsweg des Weisheitszahnes-eine röntgenologische Longitudinalstudie. Med. Diss., Thübingen, 1990.
25. GOAZ P. W., WHITE S. C.: Oral radiology: principles and interpretation. 3rd ed., Mosby, St. Louis, 1994, p. 102–105.
26. PARKIN S. F.: Notes on pediatric dentistry. Wright, London, 1991, p. 225.
27. PINKHAM J. R.: Pediatric Dentistry. 2nd ed., Saunders, London, 1994, p. 647.
28. SCHULHOF R. J.: Third molars and orthodontic diagnoses. *J. clin. Orthod.* 10: p. 248–257, 1976.
29. TANNER J. M., HEALY M. J. P., GOLDSTEIN H., CAMERON M.: Assessment of skeletal maturity. 3rd ed., Saunders and Mosby, London, Edinburgh, New York, Philadelphia, St. Louis, 2001, p. 110–119.
30. TRÖNDLE D.: Röntgenologische Untersuchungen zum Nachweis der Nichtanlage und Dystopie der Weisheitszähne. Med. Diss., Freiburg, 1973.
31. KREKELER B., SCHARF F., TRÖNDLE D.: Röntgenstatistische Untersuchungen über Nichtanlage und Dystopien der Weisheitszähne. *Dtsch. zahnärztl. Z.* 29: p. 591–593, 1974.
32. BREDY E., ERBRING CH., HÜBENTHAL B.: Häufigkeit der Zahnunterzahl bei Anlage und Nichtanlage von Weisheitszähnen. *Dtsch. Zahn-Mund-Kieferheilk.* 79: p. 357–363, 1991.
33. HÜBENTHAL B.: Beitrag zum Zusammenhang zwischen den Anomalien der Zahnzahl und der Weisheitszahnanlage. Med. Diss., Halle-Wittenberg, 1989.
34. BANKS H. V.: Incidence of third molar development. *Angle Orthod.* 4: p. 223–233, 1934.
35. SAITO H.: Radiological studies on the development of the third molar. *Kokubyo Gakkai Zasshi* 10: p. 366–377, 1936.
36. HUGOSON A., KUGELBERG C. F.: The prevalence of third molar in a Swedish population. Epidemiologic study. *Com. Dent. Health* 5: p. 121–138, 1988.
37. GARN S. M., LEWIS A. B., VICINUS J. H.: Third molar agenesis and reduction in the number of other teeth. *J. Dent. Res.* 41: p. 717, 1962.

38. GARN S. M., LEWIS A. B., BONNÉ B.: Third molar formation and its developmental course. *Angle Orthod.* 32: p. 270–279, 1962.
39. DAITO M., TANAKA T., HIEDA T.: Clinical observations on the development of third molars. *J. Osaka Dent. Univ.* 26: p. 91–104, 1992.
40. ROZKOVCOVÁ E., MARKOVÁ M., LÁNÍK J., ZVÁROVÁ J.: Agenesis of third molars in young Czech population. *Prague Med. Rep.* 105: p. 35–52, 2004.
41. LOGAN W. H. G., KRONFELD R.: Development of human jaws and surrounding structures from the birth to the age of fifteen years. *J. Am. Dent. Ass.* 20: p. 379–427, 1933.
42. SCHOUR I., MASSLER M.: Studies in tooth development: The growth pattern of human teeth. Part I. *J. Am. Dent. Ass.* 27: p. 1778–1793, 1940.
Part II. *J. Am. Dent. Ass.* 27: p. 1918–1931, 1940.
43. DEMIRJIAN A., GOLDSTEIN H., TANNER J. M.: A new system of dental stage assessment. *Hum. Biol.* 45: p. 211–227, 1973.
44. WEISE W., BRUNTSCH E.: Röntgenologische Untersuchungen zum Nachweis und zur Entwicklung des Weisheitszahnes. *Zahnärztl. Rdsch.* 74: p. 205–216, 1965.
45. WEISE W., BRUNTSCH E.: Röntgenologische Untersuchungen zum Nachweis und zur Entwicklung des Weisheitszahnes. *Zahnärztl. Rdsch.* 74: p. 245–249, 1965.
46. ELOMAA M., ELOMAA E.: Third molar aplasia and formation in orthodontic patients. *Proc. Finn. Dent. Soc.* 69: p. 141–146, 1973.
47. GRAVELY J. F.: A radiographic survey of third molar development. *Brit. dent. J.* 119: p. 394–401, 1965.
48. LEGOVİK M., MEDI L.: Razvitie tretich moljarov u detej Chorvatii. *Stomatologia* 1993, p. 9–11.
49. LEVESQUE G. J., DEMIRJIAN A., TANGUAY R.: Sexual dimorphism in the development, emergence and agenesis of mandibular third molar. *J. dent. Res.* 60: p. 1735–1741, 1981.
50. KULLMAN L., MARTINSSON T., ZIMMERMAN H., WELANDER U.: Computerized measurements of the lower third molar related to chronological age in young adults. *Acta odontol. Scand.* 53: p. 211–216, 1995.
51. MINCER H. H., HARRIS E. F., BERRYMAN H. E.: The A.B.F.O. Study of third molar development and its use as an estimator of chronological age. *J. forensic Science* 38: p. 379–390, 1993.