



Developmental Stages of the Third Molar in Israeli Children

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Abstract

Purpose: The purpose of this study was to examine the developmental stages of the third molar in Israeli children, compare its development in boys and girls, in the maxilla and mandible, right to left sides in various age groups, and relate the developmental stage to chronological age.

Methods: Panoramic radiographs of 693 healthy children and adolescents (328 boys and 365 girls) ages 7 to 16 were analyzed using a modified 6-stage method. Since the 16-year-old group was too small for statistical analysis, it was later excluded from the study. Radiographs were obtained from patient files.

Results: There were no significant differences in the development of the third molar between boys and girls and between right and left sides. Slight differences were found between the maxilla and mandible. The first appearance of a radiolucent bud was at age 8.7 in the mandible and 9.3 in the maxilla. Crown completion was observed on average at age 11.7 in the maxilla and 11.8 in the mandible.

Conclusions: There was a high correlation between third molar development and chronological age. Agenesis can be determined conclusively if no radiolucent bud is present beyond age 14. The modified 6-stage method allowed more accurate determination of developmental stages. (*Pediatr Dent.* 2003;25:373-377)

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The third molar or “wisdom tooth” is unique in its development and has the highest rate of agenesis.¹ The timing and sequence of its development are more variable than for all other teeth.²⁻⁶ The relation of third molar development and eruption to dental age, skeletal age, and level of maturity, as well as its effect on malocclusion and the possibility of impaction are of interest.^{5,7-9}

Studies using panoramic, periapical, and lateral oblique radiographs report varying ages of initial calcification and other developmental landmarks.^{2,3,10-14} In a longitudinal study, Garn et al² showed that the total time from beginning of calcification to closure of the apex for the third molar was 12 years, much longer than for any other tooth. Age determination based on third molar development differs between investigators,^{6,15,16} shedding doubt on its accuracy and reliability. In one study,³ the range was between 3 to 5 years. Nortje¹⁷ found a range of 2.4 years with 95% confidence when assessing the dental age of

adolescents. Nevertheless, the need for dental developmental landmarks in young adolescents exists.

Several methods^{2,11,18,19} have been used to determine dental age more accurately using varying stages of development, as well as efforts to increase the accuracy of these evaluations by improving interexaminer reliability.^{20,21} Differences of opinion were found regarding the age of first appearance of the bud and possible differences between boys and girls. Few have compared the upper and lower jaws and the right and left sides, and others used a combination of radiographic methods that could introduce inconsistencies. Those who used panoramic radiographs examined only the mandible.^{10,13,14,17} Several investigators, including Willerhausen et al²² and Kullman et al,²⁰ used only the developmental stages of the root, thus limiting the use of the third molar to late adolescence, whereas less evidence is available for crown development in ages 8 to 12 years. Assessment of third molar development is often the

Table 1. Distribution of Children by Age Group

Age	Number children	Relative percentage	Cumulative of percentage
7	64	9	9
8	131	19	28
9	92	13	41
10	80	12	53
11	71	10	63
12	67	10	73
13	67	10	83
14	62	9	92
15	40	6	97
16	19	3	100
Total	693	100	—

only recourse available for age determination or forensic evaluation.^{6,22,23} The developmental stages of the third molar also can be important for evaluation of physical maturity.

The purpose of this study was to compare the development of third molars of Israeli children between the right and left sides, as well as the upper and lower jaws and relate the stages of third molar development to chronological age.

Methods

Panoramic radiographs were evaluated from files of all 693 children and adolescents, 328 boys (47%) and 365 girls (53%), 7 to 16 years of age attending the Pediatric Dental Clinic at Tel Aviv University during 3 academic years. All participants were normal, healthy children.

All radiographs were taken with a Siemens Orthopantomograph model 30 at 15MA, 55-60 KVP, on AGFA Cassette Film, 15×30 cm with intensifying screens. Radiographs were examined with a magnifying glass on a fluorescent viewer and divided by age groups: half a year above and below were considered one age group (eg, 6.5 to 7.5 were in the 7-year age group). Distribution of children by age is shown in Table 1.

The developmental stage of the third molars was determined from the panoramic radiographs using the 6-stage

method described by Gat et al¹⁸ with 1 modification (Figure 1). Stage 1 was added to allow detection of a radiolucent bud, prior to calcification. The developmental stages were as follows:

- Stage 0=no evidence of bud development
- Stage 1=radiolucent bud, no calcification
- Stage 2=calcification starts to half crown
- Stage 3=calcification of half crown to full crown (no root)
- Stage 4=root formation starts to half root length
- Stage 5=half root length to full length, open apex
- Stage 6=apices closed

Three authors evaluated and separately scored the radiographs after calibration. In cases of disagreement, consensus was reached after discussion.

To assess reliability, 50 randomly selected radiographs were re-examined 2 months after the first examination. Results were compared using the paired *t* test with no significant differences ($P=.32$).

Data were collected and analyzed using the following tests:²⁴

1. standard *t* test for comparing boys and girls;
2. paired *t* test for comparing sides (maxillary right to maxillary left third molar and mandibular right to mandibular left third molar);
3. paired *t* test for comparing upper and lower jaws (maxillary right to mandibular right third molar and maxillary left to mandibular left third molar);
4. linear regression to show how tooth development and chronological age were related.

Results

Since only 19 children were in the 16-year-old group and the statistical evaluation showed that this group was not of sufficient power to detect slight differences, this group was excluded from the study, and only 674 children and adolescents in the remaining age groups were included in the study and evaluated.

There were very few significant differences in the development of the third molar between boys and girls in all age groups. At age 13, the left mandibular third molar was more advanced in girls ($P=.02$), and the right mandibular third molar was more advanced in boys ($P=.05$). At age 15, the left mandibular third molar was more advanced in boys ($P=.05$).

The paired *t* test showed very few significant differences in the development of the third molar between the right and left sides and the upper and lower jaws. In boys aged 8 (right $P=.01$, left $P=.04$) and 10 (right $P=.05$, left $P=.02$), both the mandibular molars were slightly advanced compared to the maxillary

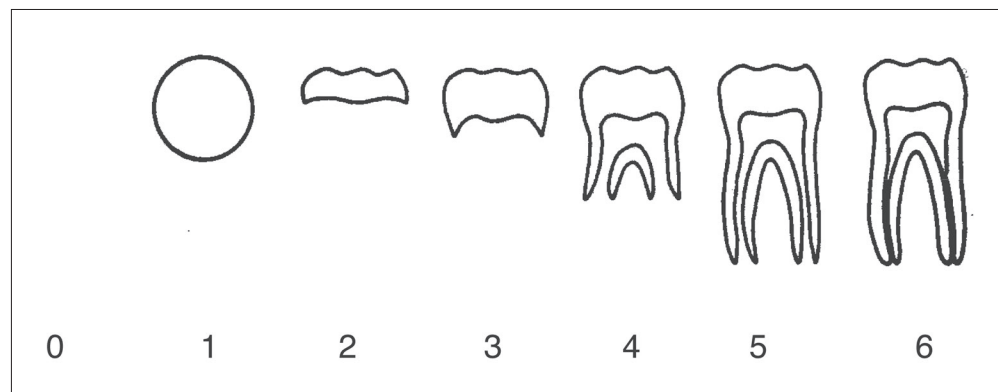


Figure 1. Stages of tooth formation used to assess development of the third molar. Each figure signifies the end of the stage.

molars. In girls, aged 7 (right $P=0.01$, left $P=0.01$) and 8 (right $P=0.01$, left $P=0.02$), the mandibular molars were also slightly advanced compared to the maxillary molars. At age 8, only the right mandibular molars were advanced ($P=0.02$) in boys and girls. At age 12, the maxillary right molars were slightly advanced in girls, but the differences between genders were slight.

Figure 2 shows the relation of stage of development to chronological age. Stage 0 included teeth that had not yet reached bud development, as well as agenesis.

In stage 1, first evidence of bud formation occurred on the average at age 8.62 to 8.88 in the mandible and at age 9.28 to 9.35 in the maxilla. In stage 2, the beginning of calcification up to one half of the crown occurred at age 9.77 to 9.97 in the maxilla and at age 10.02 to 10.07 in the mandible. The maxilla was more advanced at this stage by 1.2 to 3 months. In stage 3, the completed crown was seen at age 11.70 to 11.76 in the maxilla and at age 11.86 to 11.89 in the mandible. In stage 4, root formation to half-length was seen at age 13.60 to 13.76 in the maxilla and at age 13.78 in the mandible. In stage 5, the full length of root and open apices was seen at age 14.8 to 15 in the maxilla and at age 15.08 to 15.15 in the mandible. At stage 6, closed apices were seen at age 15.5 to 16, but were excluded from discussion since only 6 children reached this stage.

Except for the first appearance of the bud in the mandible, the maxillary molars developed slightly earlier, but the differences were not significant.

Table 2. Developmental Stage of Third Molar at the Various Age Groups

Age	Maxillary		Mandibular		No.
	Right	Left	Right	Left	
7	0.06±0.04	0.07±0.25	0.23±0.53	0.22±0.52	64
8	0.36±0.81	0.37±0.83	0.58±0.88	0.54±0.83	131
9	0.71±1.10	0.68±1.06	0.95±1.02	0.88±1.03	92
10	1.58±1.39	1.57±1.42	1.72±1.17	1.7±1.17	80
11	2.58±0.97	2.63±0.92	2.39±1.05	2.41±1.05	71
12	2.88±0.98	2.81±1.01	2.7±1.01	2.72±1.01	67
13	3.03±1.22	3.18±1.04	3.15±0.97	3.13±0.92	67
14	3.15±1.25	3.11±1.36	3.06±1.22	2.95±1.40	62
15	3.9±1.01	3.89±1.17	3.7±0.92	3.66±0.92	40
Total					674

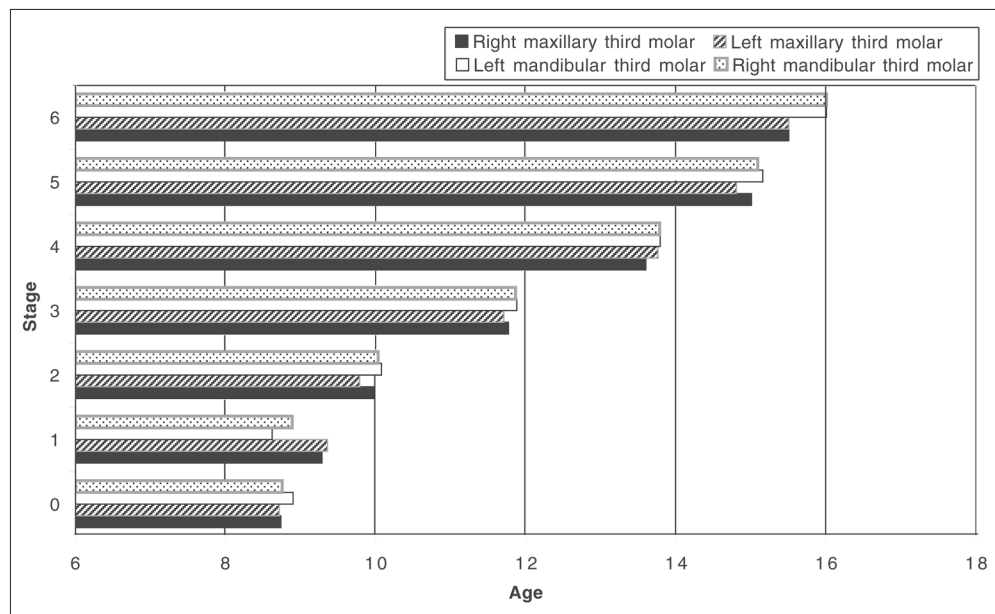


Figure 2. Stage of development of third molars related to age.

To relate the stage of tooth development to chronological age, the findings of the 674 boys and girls were combined (Table 2). At ages 7, 8, and 9, teeth were on the average at stage 1. At age 10, they were mainly between stage 1 and 2, and at ages 11 and 12, between stages 2 and 3. At ages 13 to 16, the teeth were on the average between stages 3 and 4.

The percentage of children in each age group and its relation to the developmental stage is shown in Table 3 as percentage per age group and percentage by stage of development. A total of 2,696 teeth were evaluated. At age 7, 90% of the sites showed no sign of radiolucent bud development. Root formation started after 10 years of age.

Additional observations were:

1. Stage 0 could be seen for all age groups but remained with little change after age 11.
2. Stage 1 (radiolucent bud) could not be seen beyond age 14. No new buds developed after that age.
3. Stage 5 (half-root length to full length, open apex) could hardly be seen before age 13 and showed a sudden appearance at that point.
4. Stage 6 (closure of apices) could not be seen before age 15.

A linear regression test was used with the combined population to assess the correlation of third molar development and chronological age, with a good linear correlation between age and molar development (R values of 0.71 to 0.76).

Discussion

Dental age evaluation is an important tool in the hands of a pediatric dentist. It allows better treatment planning and prediction of occlusal development. Furthermore, dental age is an indicator of the biological maturity of growing children and is relevant to growth disturbances.^{25,26} The third molar is the last tooth to appear and has an effect on the whole dentition.²⁷ Predicting the presence or absence

of the third molar will improve pedodontic as well as orthodontic evaluation and treatment.

Since third molar development takes longer and is more varied than other teeth in the mouth, it has been suggested that it not be used to determine age.¹⁻⁵ The present study showed that the modified 6 developmental stages of both crown and root allowed evaluation of dental age in Israeli children with a standard deviation of about 1.5 years and a high correlation to chronological age—a smaller range compared to other findings, which showed a range of 2 years,²⁸ 2.4 years,¹⁷ or more.³ Recently, Willerhausen et al²²

found a margin of error of 2 to 4 years. The panoramic radiograph, commonly taken by dentists, can be used for age determination, which in many instances could eliminate the need for a hand-wrist radiograph. Additional radiation is prevented and radiation exposure is minimized. A component of good medical and dental practice is to eliminate the risk of radiation exposure as much as possible.^{29,30}

There were very few significant differences between boys and girls, as was previously shown,^{2,12,13,22,28} although others¹⁴ report significant differences between genders, especially at the stage of root closure. In the present study, this stage could not be compared due to the small number of children at this stage. On the other hand, stages of crown formation were more accurately defined in this study.

No significant differences were found between the right and left sides, as was previously reported.^{2,3,11-14,31} Only a few small, sporadic differences were found when the upper and lower jaws were compared.

The first appearance of a bud in the mandible was 4 to 8 months earlier than in the maxilla. The other stages appeared first in the maxilla with a 2 to 4 months difference, confirming earlier reports.^{11,28} Crown formation was completed at about the same age in the maxilla and mandible.

There was hardly any bud formation noticed after age 11. Failure of the bud to appear until age 11 could be a first sign of agenesis, which can be confirmed, if no radiolucent bud appears until age 14.^{12,27} The findings are not too different from those suggested by others.^{27,32,33} Richardson²⁷ also showed that after age 12, the chance of new tooth bud development was very small. A missing third molar can also be an indication of other missing teeth. Garn and Lewis³³ reported that when a third molar is missing, the chance of other missing teeth increases 13-fold.

Table 3. Number of Teeth and Relative Percentage by Age and Developmental Stage

Age	Stage							Total no. of teeth
	0	1	2	3	4	5	6	
7	229 (89%)*	17 (7%)	10 (4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	256
8	378 (72%)	69 (13%)	62 (12%)	10 (2%)	4 (1%)	0 (0%)	0 (0%)	523
9	219 (60%)	28 (8%)	94 (26%)	27 (7%)	0 (0%)	0 (0%)	0 (0%)	368
10	103 (32%)	31 (10%)	69 (22%)	112 (35%)	4 (1%)	1 (0%)	0 (0%)	320
11	26 (9%)	9 (3%)	64 (22%)	167 (59%)	19 (7%)	0 (0%)	0 (0%)	285
12	21 (8%)	4 (1%)	32 (12%)	168 (63%)	43 (16%)	0 (0%)	0 (0%)	268
13	19 (7%)	3 (1%)	11 (4%)	134 (50%)	95 (35%)	6 (2%)	0 (0%)	268
14	29 (12%)	2 (1%)	19 (8%)	79 (32%)	111 (45%)	8 (3%)	0 (0%)	248
15	10 (6%)	0 (0%)	1 (1%)	24 (15%)	99 (62%)	24 (15%)	2 (1%)	160
Total teeth	1,034	163	362	721	375	39	2	2,696

*Percent of total number of teeth at that age.

The present study differs from previous studies in that a different definition of the stages was used,¹⁸ adding stage 1 to identify the appearance of a radiolucent bud, as well as using only panoramic radiographs. Previous studies also used lateral oblique radiographs, where it is more difficult to view the maxillary molars. In addition, the study population consisted of Israeli children where there is a mixture of ethnic groups. According to Willerhausen et al,²² ethnic differences do not influence the results.

Since there were some promising results of the present study, it could be worthwhile to obtain a suitable sample of 16 to 21 year olds and analyze the relation to age of the final stages of third molar development up to completion of apical closure, and compare it to other studies elsewhere.

Conclusions

1. There were few differences in the development of the third molar between boys and girls, left and right sides, and maxilla and mandible.
2. A high correlation was found between third molar development and chronological age.
3. The first sign of tooth development (radiolucent bud) appeared first in the mandible at age 8.7 years and then in the maxilla at age 9.3 years.
4. Failure of a radiolucent bud to appear at age 11 could be a first sign of agenesis, to be confirmed at age 14.
5. The modified 6-stage method of crown and root development allowed more accurate determination of developmental stages.

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