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The influence of wisdom tooth impaction on root formation

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Summary. The development of wisdom teeth occurs within a definite period of time. The correlation of wisdom tooth development and chronological age has been frequently used for several purposes, e. g. the start of orthodontic treatment, estimates of age or, for legal and anthropological purposes. Wisdom teeth are frequently impacted in the bone. It has been argued that the impaction of wisdom teeth can cause a delay in root development. This thesis could have bearing on age estimations in teenagers and young adults and the timing of dental treatment. The aim of this study was to determine whether the impaction of wisdom teeth influences the velocity of root formation. Material and methods: The dental x-rays (orthopantomograms) of 1053 outpatients were evaluated (age: 14 to 24 years). The condition "impacted" or "not impacted" was registered for each wisdom tooth present. The impaction types were further classified. The data were then calculated using statistical tools. Results: The correlation between the developmental stages of wisdom teeth and the chronological age is high. However, neither any impaction type nor the whole group of retained wisdom teeth showed a statistically significant different course of root development compared to the root development of non-retained wisdom teeth. Discussion: This study provides evidence for the lack of bearing of wisdom teeth topography on the growth stages of the dental roots within definite time intervals, based on the evaluation of orthopantomograms only. Obviously, the variations of root formation in the selected chronological periods are greater than the variations attributable to possible periods of delay in root formation of retained wisdom teeth. These results could have some importance for the fields of dental anthropology and dentistry.

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Key words: Wisdom tooth – Impaction – Retention – Tooth-development – Chronological age – Orthopantomogram – Forensic odontology

Introduction

The development of the human dentition is a lengthy process (Logan and Kronfield 1933; Nolla 1960; Clow 1984). The emergence of the wisdom teeth, usually at the end of the second or beginning of the third decade of life, marks the completion of the normal dental ridge (Demisch and Wartman 1956; Schour and Massler 1940). However, the emergence of teeth can be hampered for a variety of reasons, e. g. inadequate space or the displacement of the tooth germ (Aitasalo et al. 1972; Hattab and Alhaija 1999). In some cases the cause of tooth impaction is not known (Kaban et al. 1976). One frequently found condition associated with non-erupted *third* molars is the disproportion of tooth size and the anterior-posterior length of the alveolar processes (Forsberg 1988) or the vertical growth of the ramus (Richardson 1977). It has been suggested that the impaction of wisdom teeth can cause a delay in root development (Köhler et al. 1994). This thesis has practical implications, e. g. the timing of the tooth extraction could be brought in line with the calculated delay in root formation of retained wisdom teeth (Capelli 1991) or the exclusion of persons with impacted teeth from tasks of forensic-odontologic age estimations (Köhler et al. 1994). Indeed, the forensic-odontologic age-estimations in the teenager and young adult age groups strongly rely on the correlation of developmental stages of third molars and the chronological age (Demirjan et al. 1977; Haavikko et al. 1978; Harris and Nortje 1984; Engström et al. 1983; Ritz and Kaatsch 1996). On the other hand it

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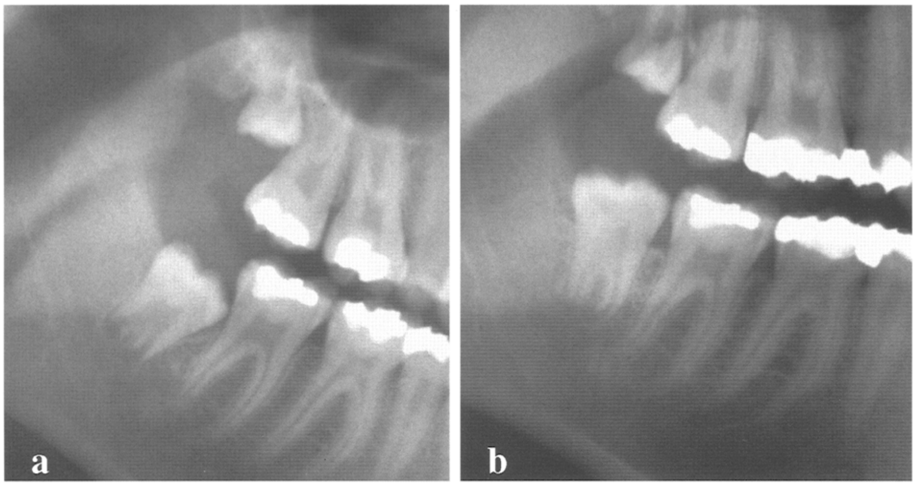


Fig. 1. Different impaction types of the right lower third molar (48) at different growth stages: R 1/2 (Fig. 1 a) and R 3/4 (Fig. 1 b).

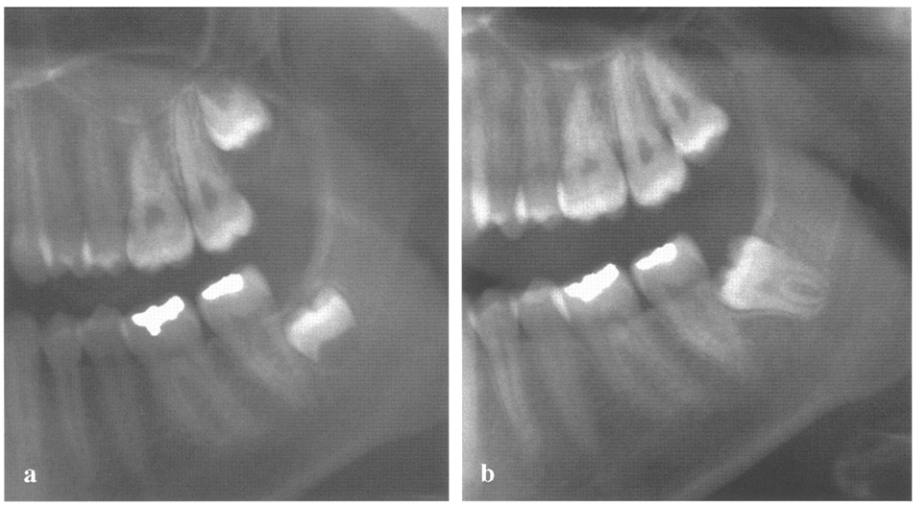


Fig. 2. Different impaction types of the left lower third molar (38) at different growth stages: Ri (Fig. 2 a) and A 1/2 (Fig. 2 b).

is known that the actual topography of a developing wisdom tooth does not always allow the prediction whether the tooth will definitely be retained (Figs. 1, 2), (Venta et al. 2001).

The Figs. 1 a and 1 b show details of 2 orthopantomograms (OPG) of the same patient that were taken within two years. The tooth 48 is in growth stage R 1/2 and the apico-coronal axis is tilted mesio-angularly. The emergence of the wisdom tooth seems impossible due to the close contact to the second molar. The figure 1 b shows the same tooth in growth stage R 3/4. However, 2 years later the tooth is no longer retained, but has gained the occlusal plane.

Figs. 2 a and 2 b show the OPGs of a female taken within 7 years. On figure 2 a the tooth 38 is in growth stage Ri and the orientation of the axis makes the assumption of emerging difficulties unlikely. However, the following Fig. 2 b makes clear that this tooth is completely retained.

For these reasons we found it necessary to re-investigate the supposed retardation of impacted third molar root development. The aim of this study was to determine the development of dental roots of third molars depending on the topography of the teeth. Teenagers and young adults should preferably be chosen for this aim because radiographic measurements of developing third molars in

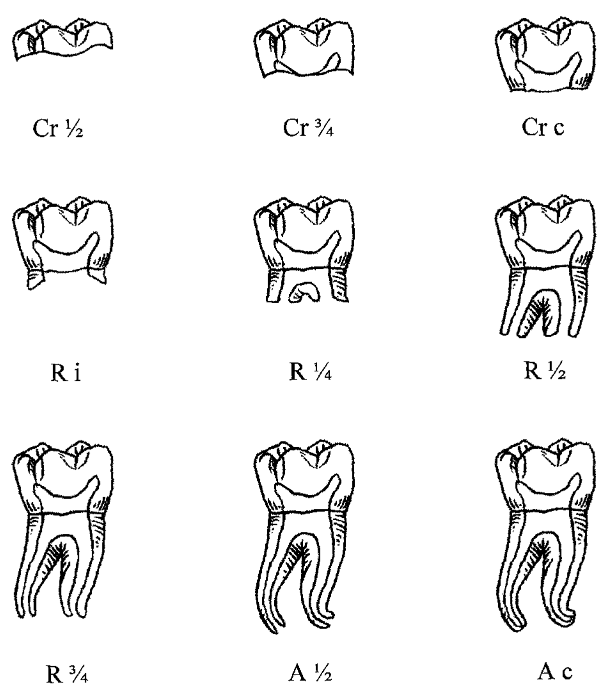


Fig. 3. Growth stages of wisdom teeth modified according to Demirjian et al. (1973).

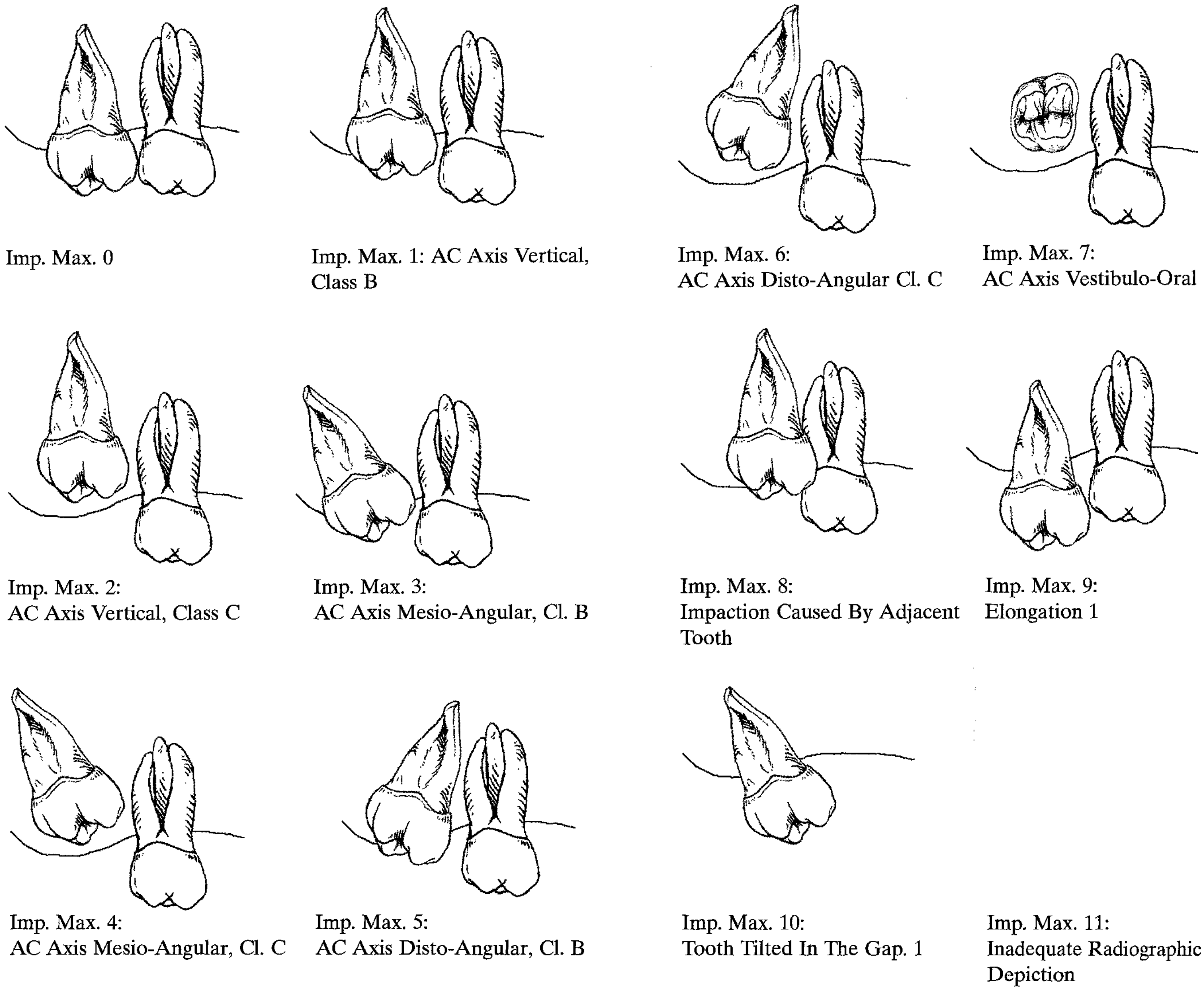


Fig. 4. Impaction types of maxillary wisdom teeth, according to Archer.

children are not predictive of third molar impaction (Richardson 1977; Venta et al. 2001). The evaluation of x-rays was chosen being a non-invasive investigation (Castella et al. 1998).

Material and methods

Patients. The orthopantomograms (OPG) of 1053 patients were evaluated. All radiographs were from different patients who visited the oral and maxillofacial surgery clinic of the Hamburg-Eppendorf University Hospital. Patients suffering from tumors, cleft-lip and palate or who have had accidents in the past were excluded from the evaluation. By using OPG, it was intended to create age-groups (from 14 to 24 years) of nearly the same size. By definition, for example a person is considered fourteen years old from the day of his fourteenth birthday until the last day before his fifteenth birthday. Data concerning gender, age and presence or absence of third molars, third molars being erupted, emerging, or retained, were collected for each patient.

Growth stages. The growth stages of the third molars were determined according to Demirjan (Demirjan et al. 1973), (Fig. 3). In cases where the projection of the dental roots allowed no decisive categorisation, e. g. the apical part of longitudinal axis with angulation directed perpendicular to the radiation source, these roots were excluded from further evaluation.

Retention of a wisdom tooth

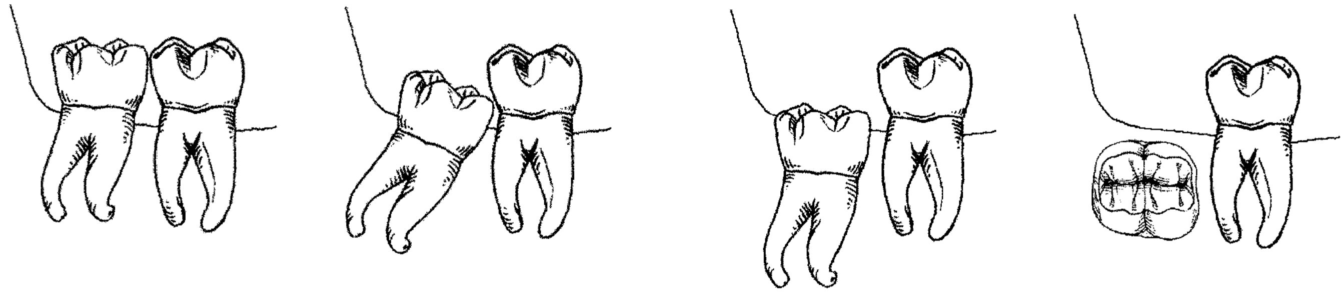
Maxilla. The growth stages of upper third molars were determined according to Archer (Archer 1955). Following the criteria of this classification we described the retention types (Imp. = Impaction, Max. = Maxilla), (Fig. 4):

Imp. Max. 0: No tooth impaction

Imp. Max. 1: Apico-coronal axis vertically oriented, the lowest part of the crown of the retained third molar lies between the occlusional plane and the cervical line of the second molar (class B)

Imp. Max. 2: Apico-coronal axis vertically oriented, the lowest part of the crown of the retained third molar lies in the level of the cervical line of the second molar or higher (class C)

Imp. Max. 3: Apico-coronal axis mesioangularly oriented, class B

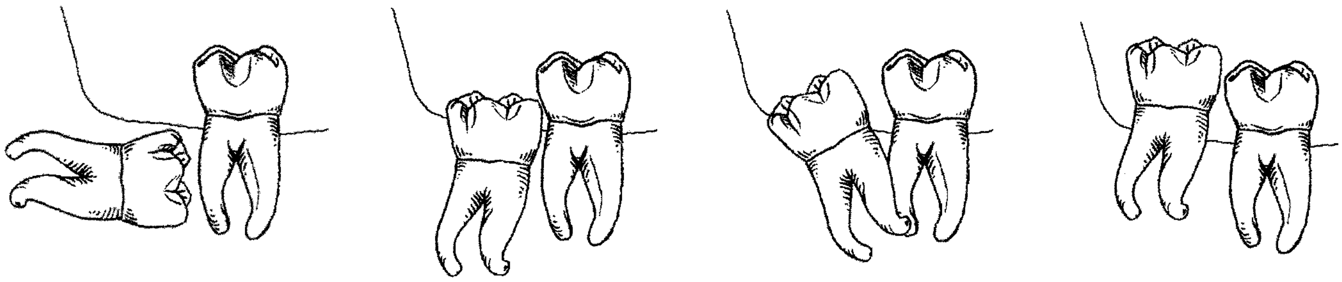


Imp. Man. 0:
No Impaction 1

Imp. Man. 1:
AC Axis Mesio-Angular 1

Imp. Man. 6:
No Apparant Cause for Impaction

Imp. Man. 7:
AC Axis Vestibulo-Oral

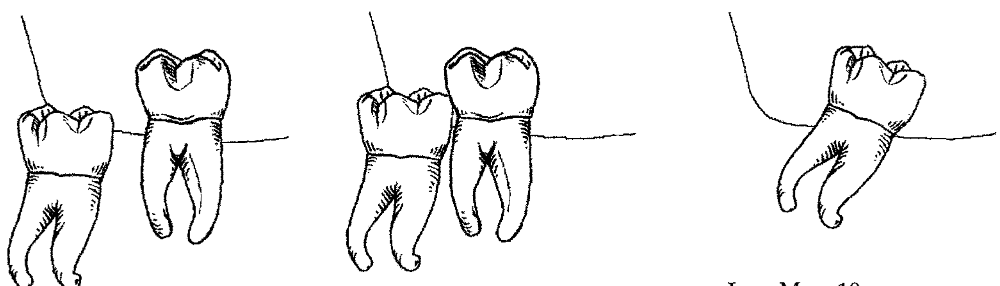


Imp. Man. 2:
AC Axis Horizontal

Imp. Man. 3:
AC Axis Vertical

Imp. Man. 8:
AC Axis Disto-Angular

Imp. Man. 9:
Elongation



Imp. Man. 4:
Mandibular Ramus

Imp. Man. 5:
Mandibular Ramus and Tooth

Imp. Man. 10:
Tooth Tilted In The Gap. 1

Imp. Man. 11:
Inadequate Radiographic Depiction

Fig. 5. Impaction types of mandibular wisdom teeth (modified according to Wolf and Haunfelder), exemplified with tooth 48.

Imp. Max. 4:	Apico-coronal axis mesioangularly oriented, class C
Imp. Max. 5:	Apico-coronal axis distoangularly oriented, class B
Imp. Max. 6:	Apico-coronal axis distoangularly oriented, class C
Imp. Max. 7:	Tooth tilted in vestibulo-oral direction
Imp. Max. 8:	Apico-coronal axis vertical orientated, retention due to generalized crowding in the maxilla
Imp. Max. 9:	Tooth is elongated
Imp. Max. 10:	Tooth tilted in the gap
Imp. Max. 11:	Tooth growth stage not determinable (inaccuracy of radiograph)

Mandible. The retention types of the lower third molars were judged according to the classification proposed by Wolf and Haunfelder (1950 und 1965) (Fig. 5).

Imp. Man. 0:	No tooth retention
Imp. Man. 1:	Apico-coronal axis mesio-angular orientated, the emergence is hindered due to the close topography to the second molar
Imp. Man. 2:	Apico-coronal axis horizontally oriented, the axis of the wisdom tooth butts in the rectangular emergence direction on the axis of the second molar
Imp. Man. 3:	Apico-coronal axis vertically oriented, the curvature of the second molar crown hinders the emergence of the crown of the wisdom tooth
Imp. Man. 4:	Apico-coronal axis vertically oriented, mandibular ramus causes tooth retention
Imp. Man. 5:	Apico-coronal axis is vertically oriented, mandibular ramus and the curvature of the second molar crown cause tooth retention
Imp. Man. 6:	Tooth retention without detectable cause
Imp. Man. 7:	Tooth tilted in the vestibulo-oral direction
Imp. Man. 8:	Apico-coronal axis disto-angular oriented
Imp. Man. 9:	Tooth elongated
Imp. Man. 10:	Tooth tilted in the gap
Imp. Man. 11:	Tooth growth stage not determinable

Terminology. For the purpose of this study the two digit system of the Fedèration Dentaire Internationale (FDI) was used to indicate the tooth number.

Interpretation. The OPG were analysed using a Siemens x-ray viewer, however, in cases or regions showing overlap of structures, a magnifying glass (3.5×) was used.

The following data was recorded for each OPG: date of birth, date of OPG, gender and age of the patient and the type and the number of missing or present third molars, impaction/no impaction. The impaction type was registered with a numerical code. The registrations were made independently by two experienced dentists. The final evaluation was made by the supervisor of the research work (REF).

Statistics. To describe any correlation between the collected data and the age of the patients, bivariate correlations (Pearson's) were calculated. To compare the frequency of certain findings in different groups of patients (e. g. divided by gender) the Wilcoxon-test for non-related samples was used. Receiver-operating characteristics (ROC) were calculated to predict sensitivity and specificity of age determination (18 years or more) depending on the topography of the third molars ("impaction" or "no impaction"). Registration and statistical analysis of the data was done using special computer software: SPSS®8.0, Excel®2000 and RocWin®V1.3.

Results

Patients

513 of the 1053 investigated patients were males, 518 females. The genders were equally distributed within the chronological ages and no significant differences were found concerning gender in the single age group (Fig. 6). The low number of OPG of 14-year-old patients has to be explained with a low incidence of radiological examination in this age-group.

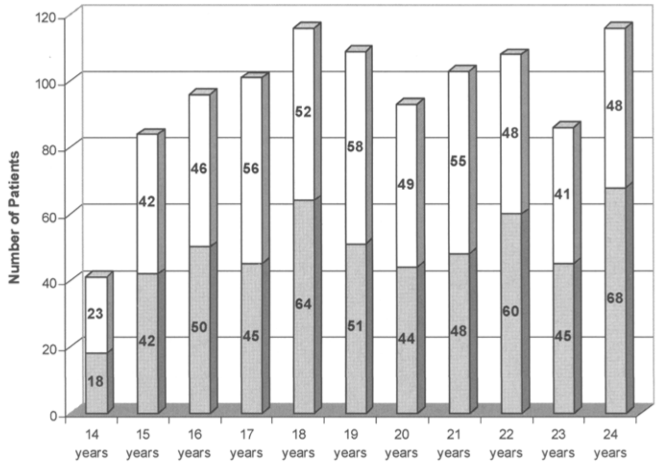


Fig. 6. Numbers of patients per year (chronological age) in the 14 to 24-year-old age groups.
□ female, ▩ male

Missing wisdom teeth

Figure 7 shows that the percentage of missing wisdom teeth is higher in females than in males ($p < 0.001$ for all wisdom teeth, χ-square-test). Another finding is the more frequent absence of lower jaw wisdom teeth compared to those of the upper jaw ($p < 0.001$ for all combinations of wisdom teeth of the upper and lower jaw, χ-square-test).

Frequencies of growth stages

The frequencies of the growth stages are collected in Tables 1 and 2. The first 3 growth stages (Cr 1/2, Cr 3/4 and Cr c) are only rarely present either in the maxilla and the mandible (0.12% up to 2.58%). The growth stage Cr 3/4 is completely missing for the teeth 28 and 48, and also the stage Cr 1/2 for the tooth 48.

Table 1. Growth types of maxillary third molars (p. n. d. = apex completely developed, convergence of the pulp channel at the apex not determinable).

Growth stage (18)	Number	Percent	**Growth stage (28)**	Number	Percent
Cr 1/2	1	0.12	Cr 1/2	2	0.24
Cr 3/4	2	0.24	Cr 3/4	0	0.00
Cr c	5	0.60	Cr c	4	0.48
R i	43	5.20	R i	45	5.36
R 1/4	68	8.22	R 1/4	72	8.57
R 1/2	100	12.09	R 1/2	90	10.71
R 3/4	126	15.24	R 3/4	139	16.55
A 1/2	89	10.76	A 1/2	89	10.60
A c	113	13.66	A c	106	12.62
A c, p. n. d.	213	25.76	A c, p. n. d.	220	26.19
Hypoplastic tooth	15	1.81	Hypoplastic tooth	27	3.21
Not determinable	52	6.29	Not determinable	46	5.48
Sum	827	100	Sum	840	100
Missing tooth 28	226		Missing tooth 28	213	
Total	1053		Total	1053	

Table 2. Frequencies of growth stages of the mandibular wisdom teeth.

Growth stage (38 m)	Number	Percent	Growth stage (38 d)	Number	Percent
Cr 1/2	1	0.13	Cr 1/2	1	0.13
Cr 3/4	3	0.38	Cr 3/4	4	0.50
Cr c	13	1.64	Cr c	20	2.52
R i	40	5.04	R i	47	5.93
R 1/4	89	11.22	R 1/4	91	11.48
R 1/2	107	13.49	R 1/2	105	13.24
R 3/4	142	17.91	R 3/4	140	17.65
A 1/2	112	14.12	A 1/2	109	13.75
A c	149	18.79	A c	135	17.02
A c, p. n. a.	94	11.85	A c, p. n. a.	95	11.98
Hypoplastic tooth	1	0.13	Hypoplastic tooth	1	0.13
Not determinable	42	5.30	Not determinable	45	5.67
Sum	793	100	Sum	793	100
Missing tooth 38	260		Missing tooth 38	260	
Total	1053		Total	1053	

Growth stages (48 m)	Number	Percent	Growth stages (48 d)	Number	Percent
Cr 1/2	0	0	Cr 1/2	0	0
Cr 3/4	0	0	Cr 3/4	0	0
Cr c	18	2.33	Cr c	20	2.58
R i	34	4.39	R i	48	6.20
R 1/4	95	12.27	R 1/4	90	11.63
R 1/2	92	11.89	R 1/2	89	11.50
R 3/4	139	17.96	R 3/4	146	18.86
A 1/2	141	18.22	A 1/2	125	16.15
A c	138	17.83	A c	119	15.37
A c, p. n. d.	84	10.85	A c, p. n. d.	91	11.76
Not determinable	33	4.26	Not determinable	46	5.94
Sum	774	100	Sum	774	100
Missing tooth 48	279		Missing tooth 48	279	
Total	1053		Total	1053	

The number of instances increases up to the stage R 3/4. After the completion of root formation, the configuration of the pulp channel is judged. The assessment of the root configuration is impaired due to lack of contrast and the poor degree sharpness of the OPG.

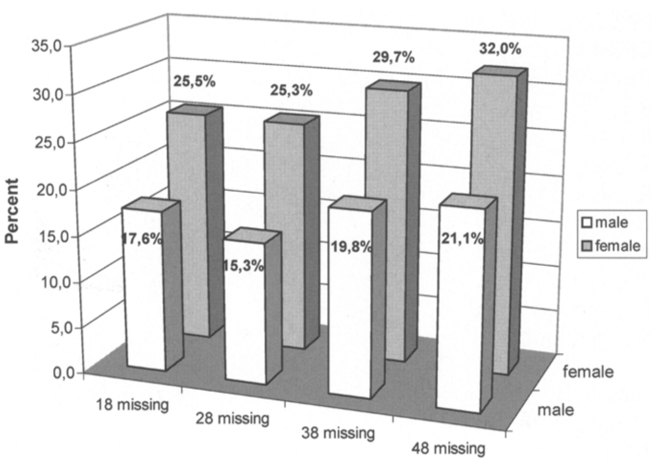


Fig. 7. Missing wisdom teeth (%).

For instance, about half of all left upper third molars (no. 28) with complete longitudinal growth were not assessable for their apical configuration (220 cases compared to 195 cases of the stages A 1/2 and A c). Fifteen of 827 maxillary third molars of the right side were hypoplastic (1.81%), and in 6.3% the root developmental stage was not assessable due to the inaccuracy of the projection. The distribution of the growth stages of the third molars of the first and second quadrants did not differ significantly.

In the mandible, growth stages earlier than Ri are small in number. The comparison to the maxilla reveals less frequent hypoplastic wisdom teeth in the mandible. The configuration of the wisdom-teeth root channel is easier to determine in the mandible than in the maxilla. Indiscernable root channels were present in the maxilla twice as often as in the mandible. That means, the difference between the growth stages $A^1/_2$ and Ac with parallel running root channel borders is more difficult to perform in the maxilla than in the mandible.

Position of the wisdom teeth in the jaw

The frequencies of the retention types are shown in Tables 3 and 4.

The number of teeth with an retention type unclassifiable is approximately equal in both jaws (tooth 18: 18.14% and tooth 28: 18.93%; tooth 38: 20.68% and tooth 48: 20.67%). The number of retained third molars is about 10% higher in the mandible.

The mesial tilt of the wisdom teeth in the case of a missing ipsilateral second molar was very rare ["tooth tilted in the gap": 1.89% (tooth 38), 1.94% (tooth 48), 0.73% (tooth 18), and 0.83% (tooth 28)]. Elongation of third molars is more frequently seen in the maxilla (mean: 4.3%) than in the mandible (mean: 2.04%).

The most frequent retention type of third molars in the *maxilla* is the narrowing of the third to the second molar *with* physical contact of both crowns and the crown of the second molar acting as a barrier for third molar emergence, without any angulation of these dental axes (13.42% first quadrant, 14.4% second quadrant). The teeth with this impaction type can be grouped together with the retained and vertically oriented wisdom teeth *without* direct contact to the adjacent second molar. This group constitutes 21.5% of all present wisdom teeth and are the numerically largest group of those that are retained. Mesially angulated wisdom teeth (mean: 11.5%) and the distally angulated wisdom teeth (mean: 1.9%) were rare.

Table 3. Impaction types of maxillary wisdom teeth (18 = right upper third molar; 28 = left upper third molar; AC = Apico-Coronal).

Impaction type (18)	Number	Percent	**Impaction type (28)**	Number	Percent
No Impaction	329	39.78	No Impaction	342	40.71
AC Axis Vertical, Class C	21	2.54	AC Axis Vertical, Class C	28	3.33
AC Axis Vertical, Class B	44	5.32	AC Axis Vertical, Class B	34	4.05
AC Axis Mesio-Angular, Class C	95	11.49	AC Axis Mesio-Angular, Class C	72	8.57
AC Axis Mesio-Angular, Class B	9	1.09	AC Axis Mesio-Angular, Class B	13	1.55
AC Axis Disto-Angular, Class C	10	1.21	AC Axis Disto-Angular, Class C	8	0.95
AC Axis Disto-Angular, Class B	7	0.85	AC Axis Disto-Angular, Class B	6	0.71
AC Axis Vestibulo-Orally Tilted	12	1.45	AC Axis Vestibulo-Orally Tilted	11	1.31
AC Axis Vertical, Crowding	111	13.42	AC Axis Vertical, Crowding	121	14.4
Elongation	33	3.99	Elongation	39	4.64
AC Axis Tilted in the Gap (Second Molar Missing)	6	0.73	AC Axis Tilted in the Gap (Second Molar Missing)	7	0.83
Not determinable	150	18.14	Not determinable	159	18.93
Sum	827	100	Sum	840	100
Missing tooth 18	226		Missing tooth 28	213	
Total	1053		Total	1053	

Table 4. Impaction types of mandibular third molars (AC = Apico-Coronal).

Impaction type (38)	Number	Percent	**Impaction type (48)**	Number	Percent
No Impaction	246	31.02	No Impaction	242	31.27
AC Axis Mesio-Angular	107	13.49	AC Axis Mesio-Angular	113	14.6
AC Axis Horizontal	30	3.78	AC Axis Horizontal	30	3.88
AC Axis Parallel	25	3.15	AC Axis Parallel	34	4.39
Mandibular Ramus	61	7.69	Mandibular Ramus	59	7.62
Mandibular Ramus and Adjacent Molar	72	9.08	Mandibular Ramus and Adjacent Molar	61	7.88
No Apparent Cause Detectable	10	1.26	No Apparent Cause Detectable	6	0.78
AC Axis Vestibulo-Orally Tilted	39	4.92	AC Axis Vestibulo-Orally Tilted	31	4.01
AC Axis Disto-Angular Tilted	7	0.88	AC Axis Disto-Angular Tilted	8	1.03
Elongation	17	2.14	Elongation	15	1.94
AC Axis Tilted in the Gap (Second Molar Missing)	15	1.89	AC Axis Tilted in the Gap (Second Molar Missing)	15	1.94
Not determinable	164	20.68	Not determinable	160	20.67
Sum	793	100	Sum	774	100
Missing tooth 38	260		Missing tooth 48	279	
Total	1053		Total	1053	

Table 5. Regression equation. Dependent variable: age.

	B	Significance
Constant	11.085	0.000
Longest root	1.309	0.000
Gender	0.214	0.134

Wisdom teeth with the apico-coronal axis oriented in the vestibulo-oral direction were also rare and less frequently found in the maxilla (1.4%) than in the mandible (4.5%).

The distribution pattern of the impaction types in the *mandible* is similar to that described for the maxilla: the mesio-angular inclined third molars constitute the largest group (mean: 14.1%), and the disto-angular inclined third molars the smallest group (mean: 1%). However, the number of impacted third molars forced by the mandibular ramus alone or in combination with a narrow second inferior molar is considerably higher (mean: 7.7% and 8.5%, respectivily).

Differences between the mesial and distal root development of mandibular wisdom teeth

The growth of the mesial and distal roots of lower jaw wisdom teeth showed some differences from side to side: obviously there were no differences in the growth speed of the roots of the right inferior wisdom tooth ($p = 0.758$). On the other hand, the roots of tooth 38 showed some tendency to an increased growth speed of the mesial root ($p = 0.011$), that is at least statistically conspicuous. This result; i. e. the differences in growth speed between distal and mesial root development, was respected for further calculations: the most advanced developed root of each single case was assigned to the developmental stages.

Gender differences (sexual dimorphism)

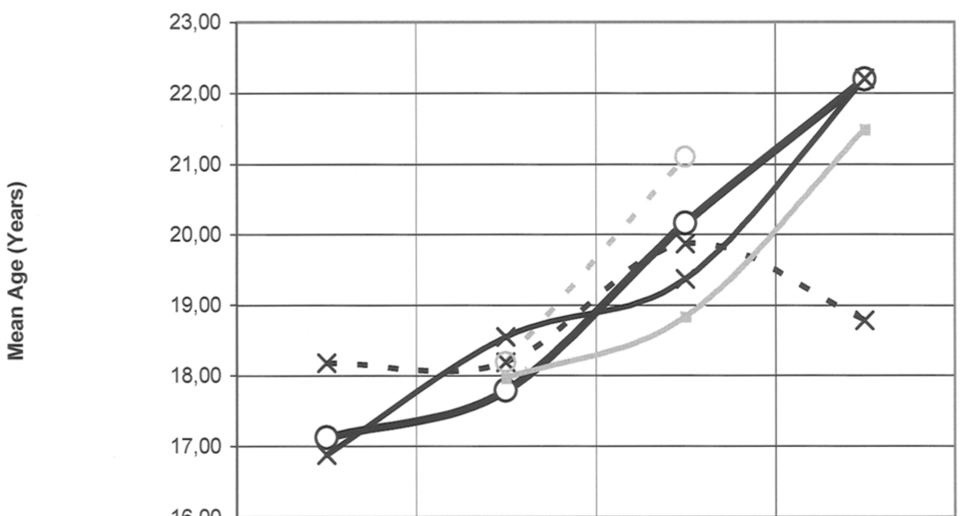
In order to determine sexually related differences linear regression equations were applied. The correlation coefficient $r = 0.697$ shows a strong correlation between the variables "most advanced developed root" and gender on one side and "age" on the other. The type of correlation can be seen in the regression coefficient (B) of the equations (Table 5).

The regression coefficient shows the mean alteration (in years) depending on the increase of the influencing variable by one unit (root length/developmental stage) with all other findings remaining unaltered.

The correlation between age and root length is highly significant ($p < 0.001$), but not the correlation between gender and age ($p = 0.134$). Therefore, the graphical descriptions of the root formation (Figs. 8 to 11) do not include a differentiation for gender.

Maxillo-mandibular comparison

The differences of the growth curves of maxillary and mandibular wisdom teeth were determined with the Wilcoxon-Tests. The comparison was based on the most advanced developed root. The development of the maxillary wisdom teeth is in advance of those developing in the mandible ($p < 0.001$). However, the gradients of the two curves do not differ markedly. Therefore, the root development of wisdom teeth of both jaws is apparently of the same velocity, but with significant differences in regard to



	R 1/2	R 3/4	A 1/2	A c
no impaction	17,12	17,79	20,15	22,20
vertical, adj. T.	18,18	18,18	19,87	18,78
vertical, C		18,19	21,10	
vertical, B		17,96	18,84	21,49
mesioang, C	16,88	18,55	19,37	22,20

Growth Stage

Fig. 8. Growth curves of different types of the impacted right upper wisdom tooth (18), (median). [adj. T. = adjacent tooth; mesioang = mesio-angular].

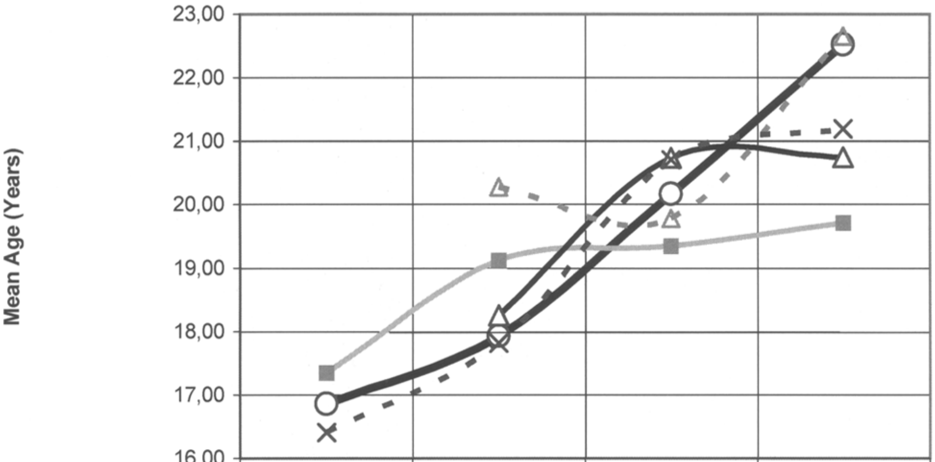
the starting point. The upper wisdom teeth complete their root growth approximately half a year earlier than their antagonists.

Differences between the jaw sides

The comparison of the wisdom root development of the left and the right side excludes any statistically significant impact of laterality on growth (maxilla: $p = 0.547$; mandible: $p = 0.445$; Wilcoxon-Test).

The completion of wisdom root formation

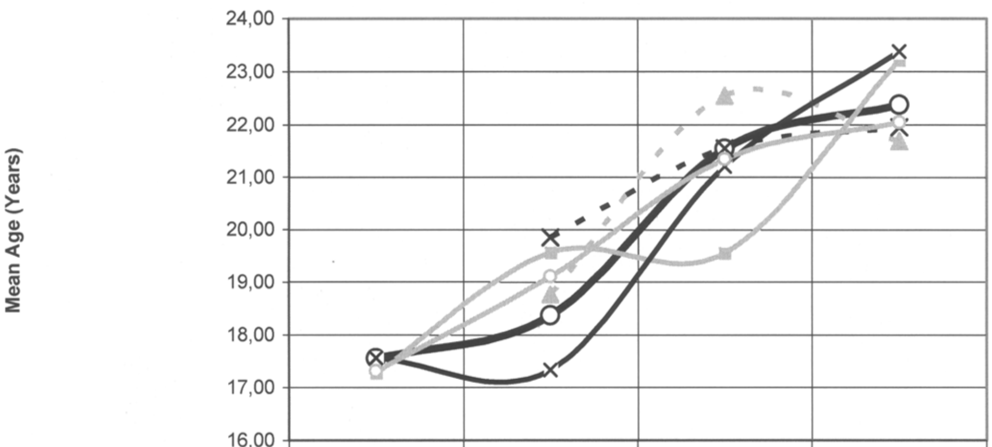
The completion of root formation is achieved with the closure of the apical foramen. This corresponds to the radiological stage "Ac". However, the time point of apical closure cannot be directly observed. Therefore, the determination of Ac on radiographs has to be done with reservation that this stage covers an interval of time. The approximate determination of the time point of apical closure can be assessed when the two last stages are determined A 1/2 und Ac (Table 7 and 8).



	R 1/2	R 3/4	A 1/2	A c
no impaction	16,86	17,93	20,17	22,52
vertical, adj. T.	17,34	19,12	19,34	19,71
vertical, C		18,25	20,74	20,75
vertical, B		20,28	19,78	22,66
mesioang, C	16,41	17,81	20,71	21,20

Growth Stage

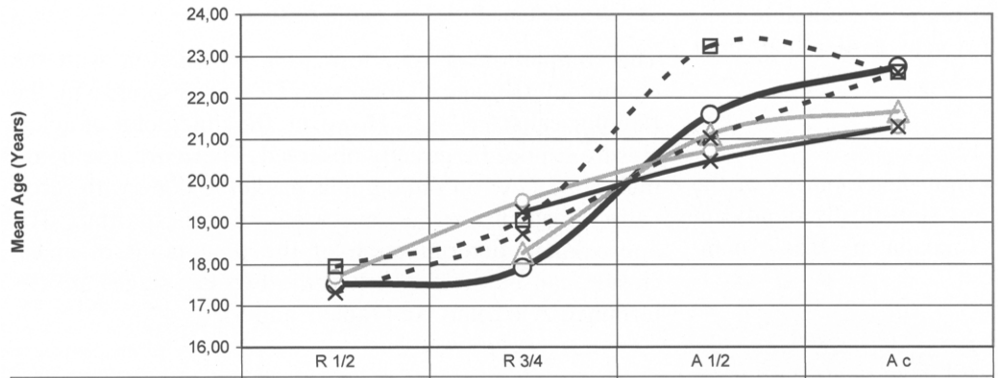
Fig. 9. Growth curves of different types of the impacted left upper wisdom tooth (28), (median).



	R 1/2	R 3/4	A 1/2	A c
no impaction	17,55	18,36	21,54	22,37
mesioang.	17,27	19,57	19,55	23,22
horizontal		18,76	22,55	21,69
vertical	17,56	17,33	21,20	23,38
mand. ramus		19,85	21,54	21,95
mand. ramus & adj. T.	17,31	19,11	21,34	22,04

Growth Stage

Fig. 10. Growth curves of different types of the impacted left lower wisdom tooth (38), (median).



	R 1/2	R 3/4	A 1/2	A c
no impaction	17,50	17,91	21,58	22,74
mesioang.	17,69	19,52	20,71	21,29
horizontal		18,27	21,11	21,65
vertical	17,94	19,06	23,24	22,62
mand. ramus		19,25	20,47	21,30
mand. ramus, adj. T.	17,31	18,73	21,03	22,61

Growth Stage

Fig. 11. Growth curves of different types of the impacted right lower wisdom tooth (48), (median).

Table 6. Influence of the tooth impaction on the growth stages (regression equations for the teeth 18, 28, 38 and 48).

Tooth	B	Significance
Tooth 18		
Constant	11.544	0.000
Growth stage	1.222	0.000
Retention	–0.332	0.118
Tooth 28		
Constant	10.536	0.000
Growth stage	1.364	0.000
Retention	0.345	0.782
Tooth 38		
Constant	9.944	0.000
Growth stage	1.514	0.000
Retention	0.398	0.037
Tooth 48		
Constant	10.181	0.000
Growth stage	1.484	0.000
Retention	0.112	0.562

Table 7. Mean age of the patients at growth stage A 1/2.

Tooth	Mean age (years)	Number n	Standard deviation (years)
18	20.43	89	2.12
28	20.31	89	2.18
38	21.21	103	2.10
48	21.08	132	2.18

Table 8. Mean age of the patients at growth stage A c.

Tooth	Mean age (years)	Number n	Standard deviation (years)
18	21.39	113	2.28
28	21.51	106	2.29
38	21.98	194	2.05
48	21.96	182	2.15

ROC analysis

The ROC-analysis shows the parallel running developmental curves of impacted and not impacted third molars (Fig. 12). The accuracy of the chronological age prediction derived from third molar developmental stages and concerning the threshold value "18 years or more" is not influenced by the topography of the teeth in the jaws.

Discussion

This cross-sectional study shows that the impaction of third molars has no significant influence on the velocity of root formation. The variability of root formation stages within the chronological intervals is high. The possible variability of root formation in impacted third molars does not exceed the variability of the root formation of third molars without any apparent cause for a delay in emergence. The number of retained wisdom teeth of the present investigation is high, 49.8% (tooth 28) and 60.9% (tooth 38). Therefore, the group size of orthopantomograms with retained or non-retained third molars do not differ significantly. Aitasalo et al. (1972) reported on 27% impacted third molars in humans aged 20 to 29 years. The differences can be explained by the different age intervals investigated by Aitasalo et al. (1972) and this study, with young adults investigated by those authors only. In fact, third molars can emerge even decades after completion of root development (Venta et al. 2001).

Sexual dimorphism in dental development is a well known fact for man (Demirjan and Levesque 1980; Levesque et al. 1981; Stroud et al. 1994; Frucht et al. 2000). In this study a difference of third molar root formation depending on the gender was excluded. It is likely that the large variability of root formation over time covers the short temporal differences of tooth development and emergence encountered for females and males.

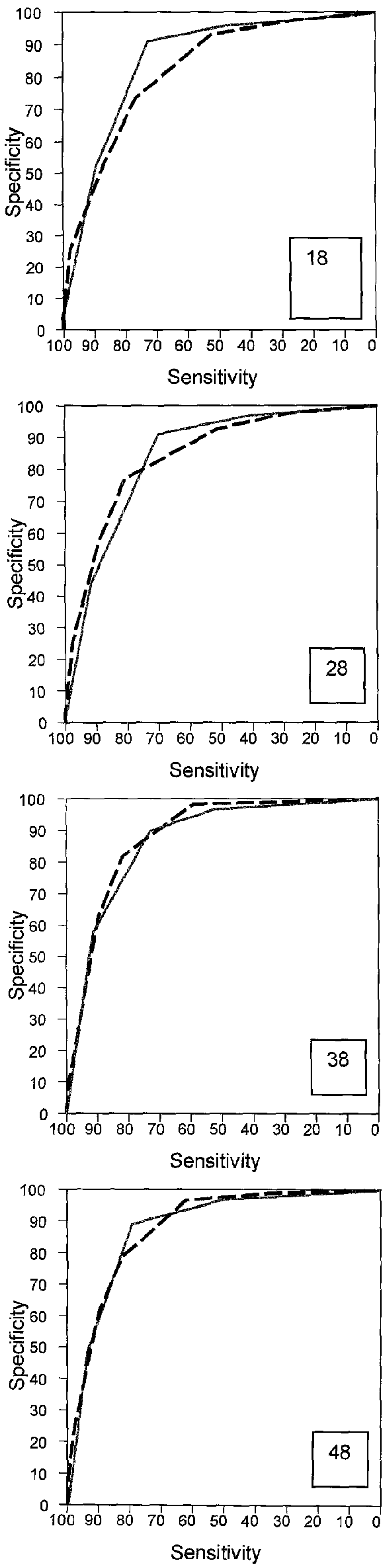


Fig. 12. ROC-curves for the accuracy of predicting the chronological age (18 years or more) calculated from the development of third molars (18, 28, 38, 48) and differentiated for impacted or not impacted teeth. – not impacted, - - impacted

The impaction of wisdom teeth is an anomaly of the human dentition. Several authors investigated the impact of retention on wisdom root development and found contradictory results.

Köhler et al. (1994) describe a delay of root development of retained wisdom teeth lasting 2 to even 3.5 years. The current investigation could not substantiate this result. We found no significant correlation between age and impaction. According to our own findings the root growth of retained teeth is apparently irregular. Therefore, no continuous delay or acceleration is detectable. These authors also reported on differences of the delayed root growth depending on the type of impaction. According to these authors the combination of the factors "impaction in the mandibular ramus" and "close topography to the adjacent molar" causes a longer lasting delay of root formation than the presence of only one these factors. However, Köhler et al. (1974) conceded that their results were founded on a small sample size. On the other hand the influence of tooth impaction on root development forced Köhler et al. (1994) to exclude persons of unknown age with retained third molars from age determination. We were neither able to substantiate the extreme importance of tooth impaction on the wisdom tooth development nor to identify any variant of tooth topography being significantly associated with chronological alterations of root development.

Björk et al. (1965) registered 17.3% impacted mandibular third molars in a study on 12 to 20-year-old Swedish persons. These authors stated that the process of root formation is delayed in retained wisdom teeth. They found different causes for third molar retention: poor longitudinal mandibular growth, vertical growth of the condyles, and a distal orientation of the emerging tooth. These authors suggested that the growth direction of the condyle had the most important impact on third molar retention. This assumption was also proposed by others (Capelli 1991). However, these authors did not publish quantitative data for their suggestions.

The angulation of the third molar to the occlusal plane was identified as a further factor of impaction (Köhler et al. 1994). The number of angulated third molars is high in this study. However, completely developed third molars were also retained without apparent cause in the young adult age group of this study. The angulation of the third molar to the occlusal plane had no significant effect on the velocity of root formation.

From a practical point of view the influence of topographical variations of third molars (and other dystopic teeth) is also unlikely to play an important role in determining the chronological line of root formation. The autotransplantation of premolars is a therapeutic option for teenagers who have experienced tooth loss. Incomplete root development and the intact dental follicle are two known prerequisites for a successful therapy. In these cases the transplanted tooth has to gain new access to the vasculature to remain vital. It is well known that the root development of the transplanted premolars does not differ significantly from their orthotopic contralaterals (Paulsen et al. 2001). Further, the transplanted tooth will probably receive a new ingrowth of nerve fibers. In recent studies evidence has been provided that the trigeminal nerve branches strongly influence the pattern of tooth emergence in man (Parner et al. 2002).

Conclusion

This study excludes significant differences in growth for the mesial and distal roots of mandibular third molars, in root growth depending on the gender, and between the body sides. Statistically significant differences in third molar root development were found for maxillo-mandibular comparison and for number of missing third molars related to gender. Differences in root development stages of a single tooth should result in the evaluation of the more advanced developed root for the purposes of dental treatment or age determinations.

References

Aitasalo K, Lehtinen R, Oksala M (1972) An orthopantomographic study of prevalence of impacted teeth. Int J Oral Surg 1: 117–120

Archer WH (1955) Die Chirurgie des Mundes und der Zähne. 3. Aufl. Medica Verlag: Stuttgart, pp 150–163

Björk A, Jensen E, Palling M (1956) Mandibular growth and third molar impaction. Acta Odont Scand 18: 3–35

Castella P, Albright RH jr, Straja S, Tuncay OC (1998) Prediction of mandibular third molar impaction in the orthognathic patient from a panoramic radiograph. Clin Orthod Res 1: 37–43

Capelli J jr (1991) Mandibular growth and third molar impaction in extraction cases. Angle Orthod 61: 223–229

Clow IM (1984) A radiographic survey of third molar development: a comparison. Br J Orthod 11: 9–15

Demirjian A, Goldstein H, Tanner JM (1973) A new system of dental age assessment. Hum Biol 45: 211–227

Demirjan A, Levesque GY (1980) Sexual differences in dental development and prediction of emergence. J Dent Res 59: 1110–1122

Demisch A, Wartmann P (1956) Calcification of the mandibular third molar and its relation to skeletal and chronological age in children. Child Develop 27: 459–473

Engström C, Engström H, Sagne S (1983) Lower third molar development in relation to skeletal maturity and chronological age. Angle Orthod 53: 97–106

Forsberg CM (1988) Tooth size, spacing, and crowding in relation to eruption or impaction of third molars. Am J Orthod Dentofacial Orthop 94: 57–62

Frucht S, Schnegelsberg C, Schulte-Möntig J, Rose E, Jonas I (2000) Dental Age in Southwest Germany. J Orofac Orthop 61: 318–329

Haavikko K, Altonen M, Mattila K (1978) Predicting angulational development and eruption of the lower third molar. Angle Orthod 48: 39–48

Harris MJ, Nortje CJ (1984) The mesial root of the third mandibular molar. J For Odonto-Stomatol 2: 39–43

Hattab PN, Alhaija ES (1999) Radiographic evaluation of mandibular third molar eruption space. Oral Surg Oral Med Oral Pathol 88: 285–291

Kaban LB, Neddleman HL, Hertzberg J (1976) Idiopathic failure of eruption of permanent molar teeth. Oral Surg Oral Med Oral Pathol 42: 155–163

Köhler S, Schmelzle R, Loitz C, Puschel K (1994) Die Entwicklung des Weisheitszahnes als Kriterium der Lebensaltersbestimmung. Anat Anz 176: 339–345

Kvaal SI, Kolltveit KM, Thomsen IO, Solheim T (1995) Age estimation of adults from dental radiographs. For Sci Int 74: 175–185

Levesque GY, Demirjian A, Tanguay R (1981) Sexual dimorphism in the development, emergence and agenesis of the mandibular third molar. J Dent Res 60: 1735–1741

Logan WHG, Kronfield R (1933) Development of the human jaws and surrounding structures from birth to the age of fifteen years. J Am Dent Assoc 20: 379

Nolla CM (1960) The development of the permanent teeth. J Dent Child 27: 254–266

Parner ET, Heidmann JM, Kjaer I, Vaeth M, Poulsen S (2002) Biological interpretation of emergence times of permanent teeth. J Dent Res 81: 451–454

Paulsen HU, Shi XQ, Welander U, Huggare J, Scheutz F (2001) Eruption pattern of autotransplanted premolars visualized by radiographic color-coding. Am J Orthod Dentofac Orthop 119: 338–345

Richardson ME (1977) The etiology and prediction of mandibular third molar impaction. Angle Orthod 47: 165–172

Ritz S, Kaatsch HJ (1996) Methoden der Altersbestimmung an lebenden Personen: Möglichkeiten, Grenzen, Zulässigkeit und ethische Vertretbarkeit. Rechtsmedizin 6: 171–176

Schour I, Massler M (1940) Studies in tooth development: the growth pattern of human teeth. J Am Dent Assoc 27: 1918–1931

Stroud JL, Buschang PH, Goaz PW (1994) Sexual dimorphism in mesiodistal dentin and enamel thickness. Dentomaxillofac Radiol 23: 169–171

Venta I, Turtola L, Ylipaavalniemi P (2001) Radiographic follow-up of impacted third molars from age 20 to 32 years. Int J Oral Maxillofac Surg 30: 54–57

Wolf H, Haunfelder D (1960) Zahnärztliche Mundchirurgie für Studierende der Zahnheilkunde. Berlinische Verlagsanstalt, Band 5, pp 59–67

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