

**Change in inclination and eruption of mandibular
third molars: a longitudinal radiographic study
among 12 to 21-year-olds**

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SUMMARY

Purpose: The purpose of this study was to examine change in inclination of the mandibular third molar during adolescence and young adulthood, and to analyse the relationship between inclination of the third molar and level of eruption at 21 years.

Sample: The material comprised 59 individuals (106 third molars) selected from the Oslo Craniofacial Growth Archives. Criteria for inclusion were: longitudinal series of orthopantomograms (12, 15, 18, 21 years) and presence of one or two mandibular third molars at each age stage (Table 1).

Methods: The inclination of the third molar was recorded relative to the second molar, and landmarks appear from Figure 1. The eruption level of the third molar was assessed according to three categories (Figure 2). Statistical significance of differences between genders, right and left side, and between the age stages was analysed by t-tests and paired t-tests, respectively.

Main results:

- At 12 years of age, most (94%) of the third molars were inclined mesially relative to the second molar. In more than half of these teeth the angle between the long axis of the third and second molar was more than 30 degrees.
- On average the third molars uprighted 31 degrees between 12 and 21 years.
- At 21 years, 58 of the third molars were in a vertical position and 60% of these teeth had reached the same vertical level as the second molar.

- Third molars (6) which had a vertical position at 12 years were relatively stable during the observation period.
- Of the teeth which were moderately (grade I) or markedly (grade II) mesially inclined at 12 years, about half showed uprighting to a vertical position at 21 years (50% and 55%, respectively), and for almost all these teeth the vertical position was achieved after 15 years of age.
- About one out of 5 of the teeth which were mesially inclined (grade I and II) at 12 years failed to upright to vertical position, but only few showed worsening in inclination. One out of 4 of the initially mesially inclined teeth were distally inclined at 21 years.

INTRODUCTION

Third molars are the teeth that most frequently show eruption problems and become impacted (Ay et al. 2006). Impacted third molars are of great concern in dentistry as unerupted or partially erupted teeth have been associated with various pathologic conditions such as pericoronitis, dental caries, root resorptions, cystic processes, and tumors. In addition, third molars may have an impact on dental arch crowding, and impacted third molars, especially in the mandible, are of concern in management of orthodontic patients (Bishara 1999). The prevalence of third molar impaction is variable and has been reported to range from 9.5% to 39% in different populations (Hattab 1997). A study from Sweden reported that impacted third molars occurred in the mandible in 32% of males aged 20-80 years and in 51% of females in the same age group (Hugoson and Kugelberg 1987).

Radiographic evidence of third molar formation may be observed as early as age 7, and virtually ceases after age 14 (Gravely 1965). At the early stage, the bud is located within the ramus with the occlusal surface facing forward and upward at an angle of approximately 40-45 degrees to the occlusal plane (Silling 1973). It then migrates forward and upward into the body of the mandible, maintaining its rotated position, until it comes into close relationship with the distal aspect of the second molar. At that time the tooth bud rotates into a more upright position. Silling (1973) noted that if this rotational movement fails to occur, impaction is inevitable. It has been reported that uprighting of mandibular third molars occurs more rapidly after 14-15 years (Altonen et al. 1977).

The primary cause of third molar impaction is lack of alveolar arch space distal to the second molar (Güngörmüs 2002). Extraction of molars and premolars may affect

eruption pattern of the third molars (Rindler 1977, Cavanaugh 1985, Richardson 1989, Orton-Gibbs et al. 2001, Årtun et al. 2005, Ay et al. 2006). Årtun et al. (2005) observed that orthodontic treatment with premolar extraction significantly reduced the rate of impaction of maxillary third molars compared to non-extraction treatment. The suggested mechanism is that premolar extraction has a favorable effect on third molar angulation. A similar effect on mandibular third molars was not observed as changes in mandibular third molar angulation were similar in extraction and non-extraction cases. Orthodontic non-extraction treatment, by holding back or distally tipping the lower first and second molars, may increase the chance of third molar impaction. Silling (1973) reported that that 67% of males and 69% of females who had undergone non-extraction therapy eventually developed impacted third molars. However, no control group was included in the study.

A question often to be considered in orthodontic management of adolescent patients relates to the predictability of third molar impaction. Information about change in position, inclination and eruption of the third molars during the active growth period is of relevance in identifying individuals with potential eruption problems, and such data may also serve as a base line for studies about the effect of various orthodontic treatment strategies on third molar eruption.

AIM

The aim of this investigation was to study mandibular third molar eruption and impaction by using a longitudinal study design. The objectives were:

- to examine changes in inclination of the mandibular third molar from 12 to 21 years
- to examine the relationship between inclination of the mandibular third molar and level of eruption of the tooth at 21 years

MATERIAL AND METHODS

Sample

The sample was selected from The University of Oslo Craniofacial Growth Archives. These growth archives consist of participants in a longitudinal growth study at the Department of Orthodontics, University of Oslo. The project was initiated in 1972 and completed in 1992 and included individuals born 1958-1972. All were living in Nittedal, a community of about 16 000 inhabitants near Oslo. Records, including dental study models, lateral cephalograms, panoramic radiographs, and facial photographs, were collected every third year from the age of 6 until 21 years. After 12 years, individuals who received orthodontic treatment were excluded, and in most cases, not further examined. Accordingly, between 9 and 12 years of age, The University of Oslo Growth Archives represents a normal population, and after 12 years of age the material is selected as most individuals have acceptable occlusal conditions.

Criteria for selection of the sample used in the present study

- 1) individuals with longitudinal series of orthopantomograms from 12 until 21 years.
Four age stages were analysed: 12 (T1), 15 (T2), 18 (T3), 21 (T4) years
- 2) presence of one or two mandibular third molars on the orthopantomogram taken at each of the 4 age stages
- 3) development of the third molar at 12 years had reached a stage that allowed the cemento-enamel junction to be identified on the orthopantomogram

The initially selected sample comprised 92 individuals who fulfilled the first criterion. After excluding individuals who did not fulfill the second and third criteria, the final sample consisted of 59 individuals, 21 males and 38 females (106 third molars). All individuals had both first and second mandibular molars present at all stages. The distribution of third molars according to gender and to right and left side is shown in Table 1 (page 19).

Reference lines and measurements

The inclination of the mandibular third molar was measured on orthopantomograms relative to the second molar (Figure 1).

Definition of reference lines

- Long axis of the lower third molar (M3L): a line drawn perpendicular to the line connecting the mesial and distal cemento-enamel junctions (CEJ).
- Long axis of the lower second molar (M2L): definitions same as for the third molar.



Figure 1. Reference lines and the angular measurement used in the present study.

Inclination of the third molar was defined as the angle between the long axis of the third molar and second molar (M3L/M2L).

Category of inclination

The data obtained from the orthopantomograms was classified as follows:

- Distal: $<-10^{\circ}$
- Vertical: $\geq-10^{\circ}, \leq 10^{\circ}$
- Mesial grade I: $>10^{\circ}, \leq 30^{\circ}$
- Mesial grade II: $>30^{\circ}$.

Vertical position of the third molar (eruption level):

The eruption level of the third molar was categorized according to their depth in relation to the cervical line and the occlusion line of the adjacent second molar (Figure 2). In level A, the highest part of the third molar was in the same level or above the occlusal plane of second molar. In level B, the highest part of the third molar was below the occlusal plane but above the cervical line of the second molar. In level C, the highest part of the third molar was beneath the cervical line of the second molar (Hattab 1997).

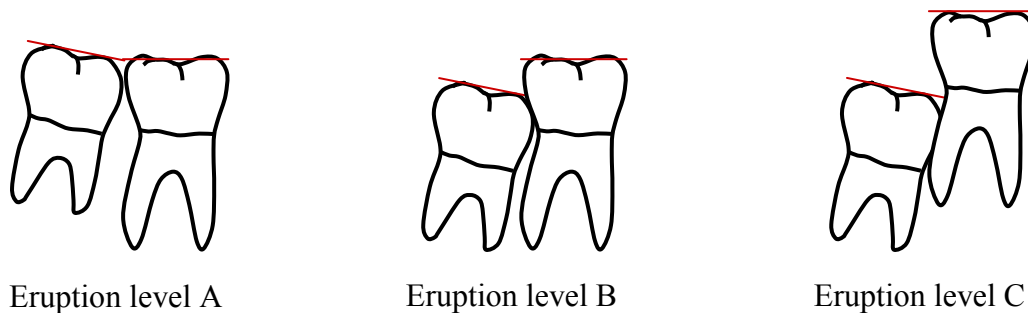


Figure 2. Eruption level of the third molar, categories.

Method study

For training and calibration 10 subjects with complete series of orthopantomograms at 12-21 year were selected (40 radiographs) from The University of Oslo Craniofacial Growth Archives. Each observer traced each of the radiographs manually to be confident with landmark identification, tracing, and measuring procedures. Subsequently, the landmarks were digitized using a customized regimen of Facad, a software program used for cephalometric analysis (Facad, Ilexix AB, Linköping, Sweden). For analyses of method error, landmark identification and measurements were made twice on the same radiographs (10 subjects, 40 radiographs) two weeks apart by one of the examiners. All radiographs in the main sample were recorded by one investigator, and the values were statistically analyzed by another.

Statistical analyses

Statistical analyses were performed by SPSS for Windows (SPSS, Chicago, Ill.). The intra-examiner reliability of the method was analyzed statistically using Dahlberg's calculation and Houston's coefficient of reliability (Houston 1983). Systematic error was analyzed by paired t-test. Statistical significance of differences between genders was analyzed by t-tests. Paired t-tests were used to analyze differences between the various age stages.

RESULTS AND DISCUSSION

Error of the method

Results from the method analyses are presented in Table 2 (page 19). The values indicate that the reliability of the method was acceptable. Differences between duplicate measurements did not reach a 10% significance level.

Inclination and eruption level of the third molar

At 12 years, the mean angle between the long axis of the third and second molar (M3L/M2L) was 33.1 degrees (Table 3, page 20). During the observation period the third molars on average became upright, and at 21 years the mean angle was 1.9 degrees. The individual variation was large, and at 21 years the angle M3L/M2L varied between -26.2 degrees (indicating distally inclined) and 63.2 degrees (mesially inclined).

Comparison between genders showed statistically significant difference only at 12 years as males had more mesially inclined teeth ($p = 0.015$) (Table 4, page 21). Comparison between right and left side showed no significant differences at any of the age stages (Table 5, page 22).

Table 6 (page 23) presents the change in inclination of the third molar during each of the 3-year periods. The mean inclination was reduced about 10 degrees during each of the periods. The overall change in inclination during the total observation period was 31.2 degrees. Among 106 third molars examined, 57 were at the eruption level A at 21 years (Table 7, page 23). That means that about half of the third molars reached the same level as the second molars. The association between the category of inclination and level of eruption at 21 years are presented in Table 8 (page 24). Among the 9 third molars

categorized as mesial grade II, 5 teeth were at level B and 4 teeth at level C. The majority of the third molars which were in a vertical position (60%) or distally inclined (74%) had reached eruption level A at 21 years.

Change in category of inclination during age

The distribution of the 106 third molars according to category of inclination at each of the age stages is presented in Table 9 (page 25). It appears that the number of teeth categorized as vertical and as distally inclined increased with increasing age. The number of teeth in the mesial grade I category increased from 12 to 15 years and reduced thereafter. The number of teeth in the mesial grade II category decreased during the whole observation period.

Longitudinal observations of third molar inclination are illustrated in Figures 3, 4 and 5 (pages 26-28). The 6 third molars with a vertical position at 12 years were relatively stable during the 9-year observation period, and 5 of the 6 teeth were in the vertical category at 21 years (Figure 3, page 26). Of the 42 teeth in the mesial grade I category at 12 years, 21 teeth (50.0%) became upright at 21 years (ended in the vertical category), and 12 (28.6%) were still mesially inclined at 21 years (Figure 4, page 27). Four of the 12 teeth became more mesially inclined and ended in the mesial grade II category. Of the 58 third molars which were in the mesial grade II category at 12 years, 32 (55.2%) became upright to vertical position at 21 years (Figure 5, page 28). Ten (17.2%) of the 58 teeth were still mesially inclined (grade I or II) at 21 years, although half of them showed some uprighting. Almost all teeth which showed uprighting to vertical position at 21 years, achieved this position after 15 years of age.

Cases, examples

Figures 6-9 (page 29, 31) showed Case one with third molars with initially mesially inclination at 12 years which showed uprighted position at 21 years.

Figures 10-13 (page 31, 32) showed Case two with third molars being mesially inclined at 12 years. The tooth on the right side showed worsening at 21 years, and the tooth on the left side became distally inclined at 21 years.

Discussion

The relationship between the present findings and results of some previous studies appears from the literature review in Table 10 (pages 33-41).

CONCLUSIONS

The results of this radiographic study of 106 mandibular teeth observed at 4 age stages from 12 to 21 years showed:

- At 12 years of age, most (94%) of the third molars were inclined mesially relative to the second molar. In more than half of these teeth the angle between the long axis of the third and second molar was more than 30 degrees.
- At 21 years, 58 (55%) of the third molars were in a vertical position, and 60% of these teeth had reached the same vertical level as the second molar. Only 13% of the mesially inclined teeth had reached that vertical level.
- Only 6% of the third molars had a vertical position at 12 years, and these teeth were relatively stable during the observation period.
- Of the teeth which were moderately (grade I) or markedly (grade II) mesially inclined at 12 years, about half showed uprighting to a vertical position at 21 years. For almost all these teeth, the vertical position was achieved after 15 years of age.
- About one out of 5 of the teeth which were mesially inclined (grade I and II) at 12 years failed to upright to vertical position, but only few showed worsening in inclination. One out of 4 of the initially mesially inclined teeth was distally inclined at 21 years.

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Tables

Table 1. Distribution of third molars according to gender and to right and left side among 59 individuals (106 teeth).

	Number of teeth (female)	Number of teeth (male)	Total
Right side	34	19	53
Left side	35	18	53
Total	69	37	106

Table 2. Error of the method assessed from duplicate tracings of 40 orthopantomograms.

M3/M2 = angle between the long axis of the third and second molar.

Variable	n	Dahlberg's calculation	Houston's coefficient of reliability (%)	Systematic error: paired t-test (p-value)
M3L/M2L at 12 yr	17	0.38	99.8	0.489
M3L/M2L at 15 yr	38	0.54	99.3	0.920
M3L/M2L at 18 yr	40	0.42	99.7	0.105
M3L/M2L at 21 yr	39	0.33	99.9	0.545

Table 3. Angle between the long axis of the third and second molar (M3L/M2L) at 12, 15, 18, and 21 years assessed among 106 third molars (59 individuals). Mean value, 1 standard deviation (SD), and minimum (Min) and maximum (Max) values in degrees.

M3L/M2L	Mean	SD	Min	Max
12 yr	33.1	15.0	6.3	68.8
15 yr	24.0	10.4	1.9	51.4
18 yr	12.9	14.1	-20.9	42.8
21 yr	1.9	17.5	-26.2	63.2

Table 4. Angle between the long axis of the third and second molar (M3L/M2L) at 12, 15, 18, and 21 years assessed among 106 third molars according to gender. Mean value and 1 standard deviation (SD) in degrees.

M3L/M2L	Female (teeth) (n = 69)		Male (teeth) (n = 37)		Difference between genders
	Mean	SD	Mean	SD	p value
12 yr	30.6	14.5	37.9	14.8	0.015
15 yr	22.8	10.7	26.1	9.7	0.129
18 yr	14.1	13.1	10.6	15.6	0.223
21 yr	2.4	16.5	1.1	19.5	0.721

Table 5. Angle between the long axis of the third and second molar (M3L/M2L) at 12, 15, 18, and 21 years assessed among 106 third molars according to right and left side. Mean value and 1 standard deviation (SD) in degrees.

M3L/M2L	Right side (n = 53)		Left side (n = 53)		Difference between sides
	Mean	SD	Mean	SD	p value
12 yr	33.8	14.3	32.4	15.7	0.623
15 yr	24.4	9.3	23.5	11.4	0.645
18 yr	14.3	13.4	11.5	14.6	0.300
21 yr	3.3	17.9	0.6	17.2	0.444

Table 6. Change in the angle between the long axis of the third and second molar (M3L/M2L) between the different age stages assessed among 106 third molars (59 individuals). Mean value, 1 standard deviation (SD), and minimum (Min) and maximum (Max) values in degrees.

M3L/M2L	Mean	SD	Min	Max	Paired t-test p value
12 to 15 yr	-9.2	-12.1	-39.7	21.4	0.000
15 to 18 yr	-11.1	-14.8	-57.2	22.2	0.000
18 to 21 yr	-10.9	-16.0	-45.1	27.6	0.000
12 to 21 yr	-31.2	-24.2	-74.6	34.3	0.000

Table 7. Distribution of 106 third molars according to their level of eruption at 21 years.

For definition of categories, see text page 10.

	N	(%)
Level A	57	53.8
Level B	36	34.0
Level C	13	12.3

Table 8. Association between inclination and level of eruption level of the third molar at 21 years. Number of teeth. For definition of categories, see text pages 9 and 10.

Level of eruption	Inclination of the third molar (M3L/M2L)			
	Distal ($<-10^\circ$)	Vertical ($\geq-10^\circ, \leq 10^\circ$)	Mesial grade I ($>10^\circ, \leq 30^\circ$)	Mesial grade II ($>30^\circ$)
Level A	19	35	3	0
Level B	7	19	5	5
Level C	0	4	5	4
Total	26	58	13	9

Table 9. Distribution of 106 third molars according to category of inclination at the different ages. Number of teeth.

Category of inclination	12 yr	15 yr	18 yr	21 yr
Distal ($< -10^\circ$)	0	0	5	26
Vertical ($\geq -10^\circ, \leq 10^\circ$)	6	8	37	58
Mesial grade I ($> 10^\circ, \leq 30^\circ$)	42	73	52	13
Mesial grade II ($> 30^\circ$)	58	25	12	9

Figures

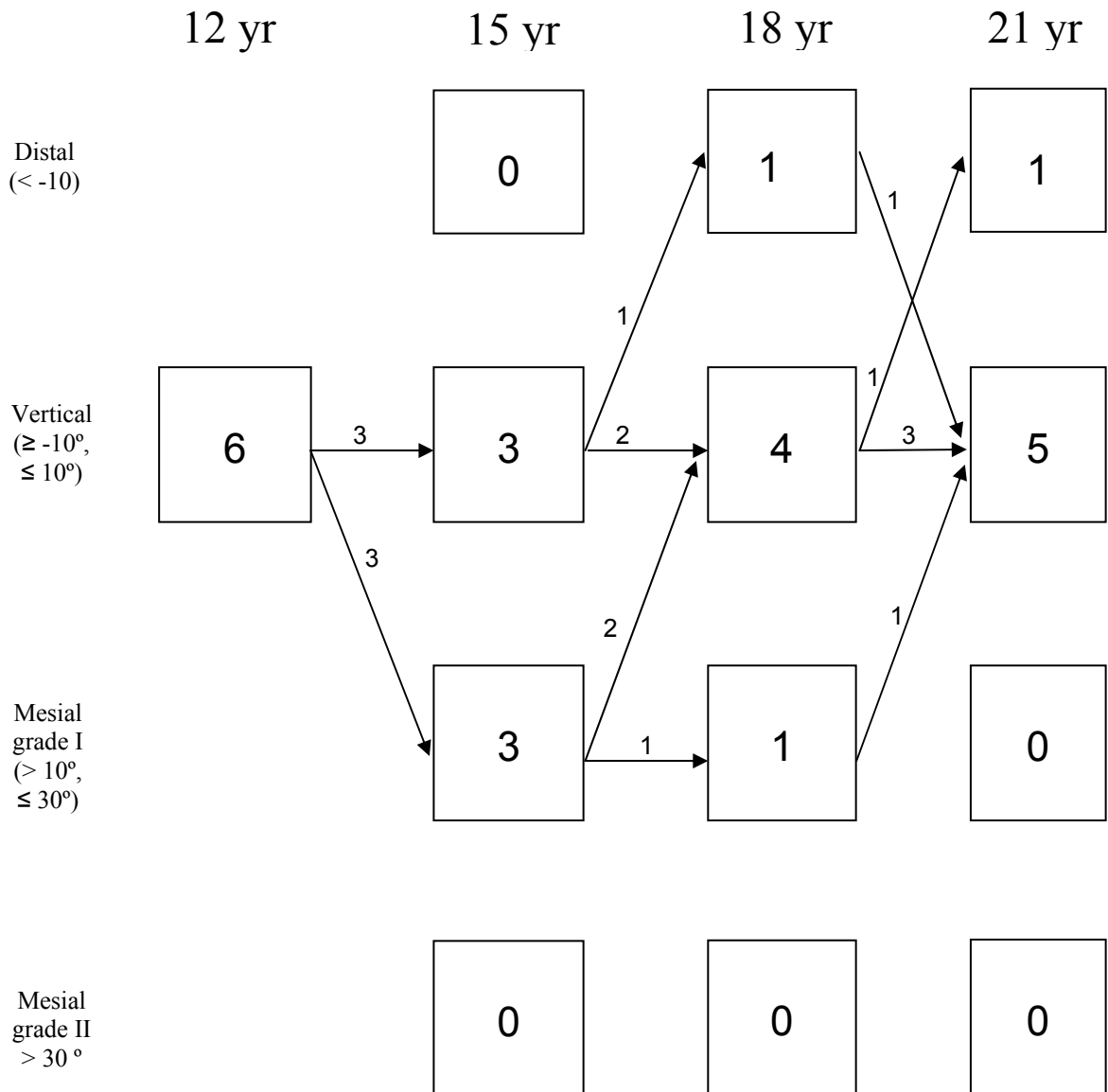


Figure 3. Change in category of inclination during the various age stages among the 6 third molars which were categorized as vertical at 12 years.

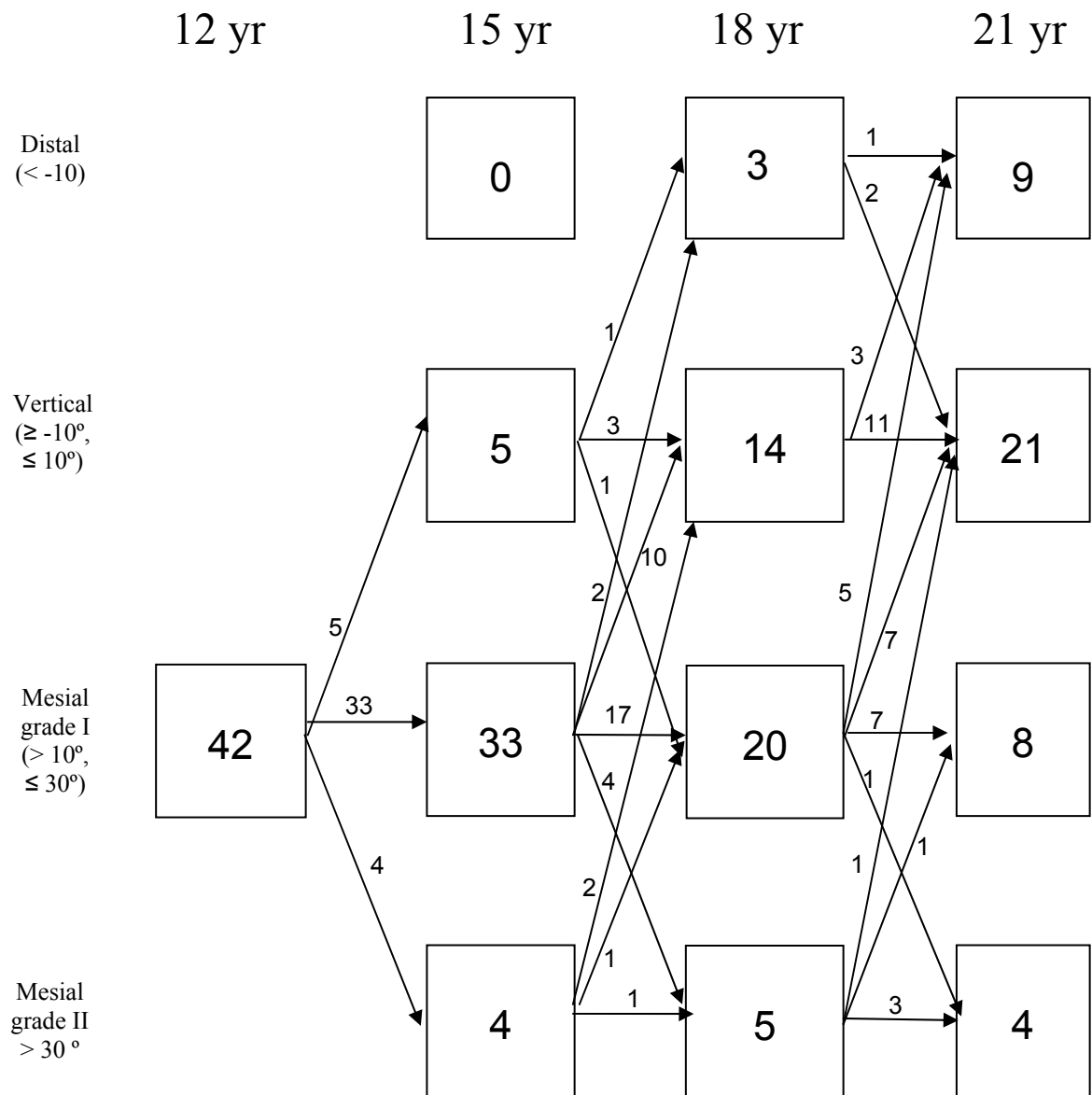


Figure 4. Change in category of inclination during the various age stages among the 42 third molars which were categorized as mesially grade I inclined at 12 years.

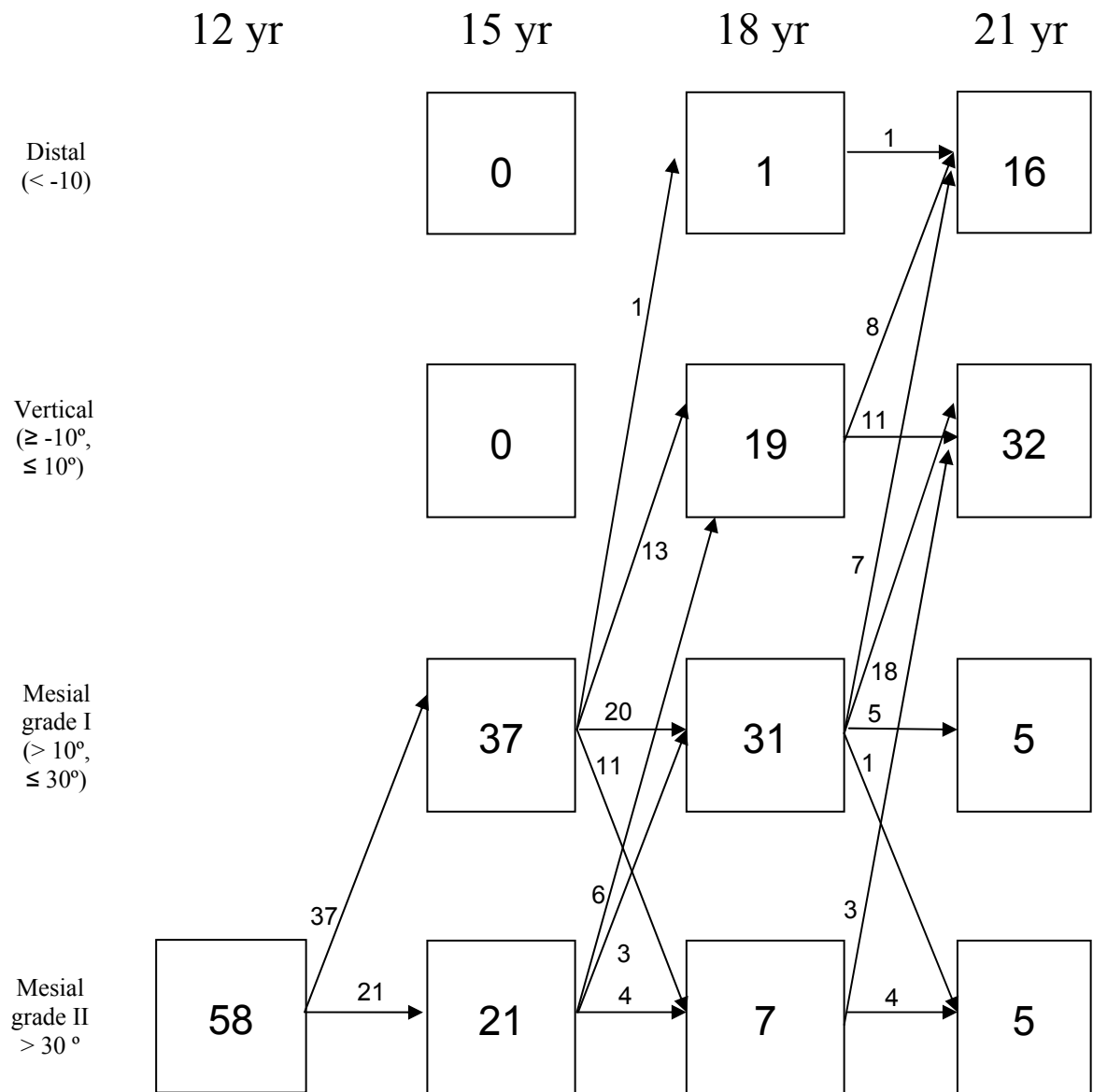


Figure 5. Change in category of inclination during the various age stages among the 58 third molars which were categorized as mesially grade II inclined at 12 years.

Cases, examples



Figure 6. Case one, 12 years: Third molars mesially inclined (38.0 degrees on the right side and 33.2 degrees on the left side).



Figure 7. Case one, 15 years: Third molars mesially inclined (19.4 degrees on the right side and 18.3 on the left side).



Figure 8. Case one, 18 years: Third molars being uprighted (0.5 degrees on the right side and -4.4 on the left side).

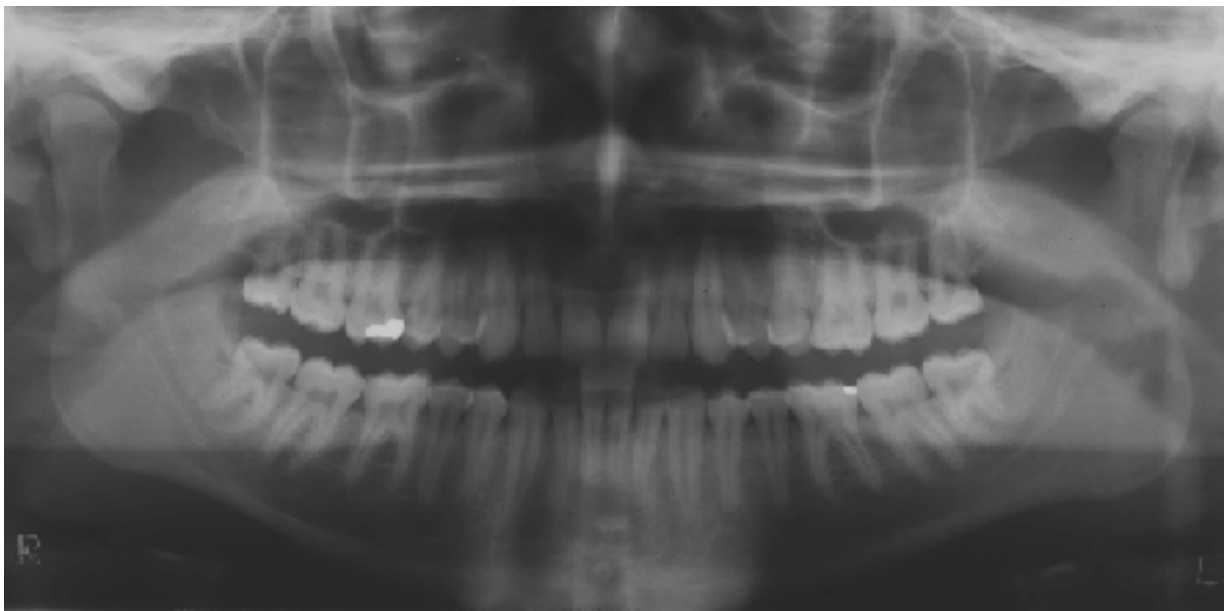


Figure 9. Case one, 21 years: Third molars uprighted and reached eruption level A (-4.9 degrees on the right side and -7.4 on the left side).

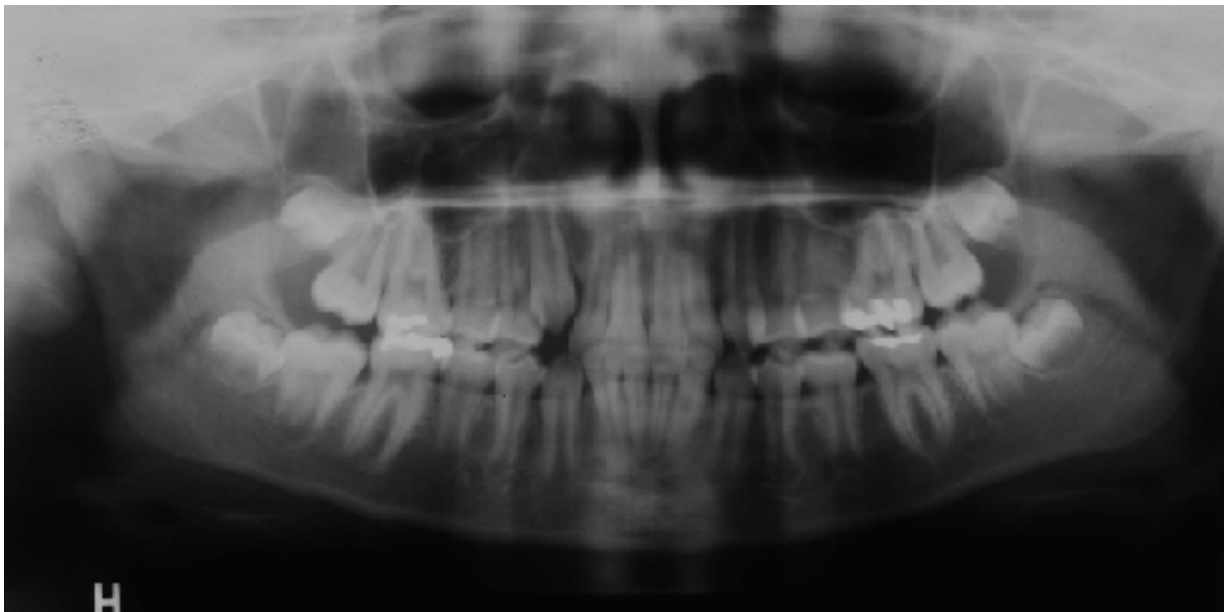


Figure 10. Case two, 12 years: Third molars mesially inclined (26.3 degrees on right side and 31.3 degrees on the left side).



Figure 11. Case two, 15 years: Third molars mesially inclined (20.4 degrees on the right side and 20.4 degrees on the left side).

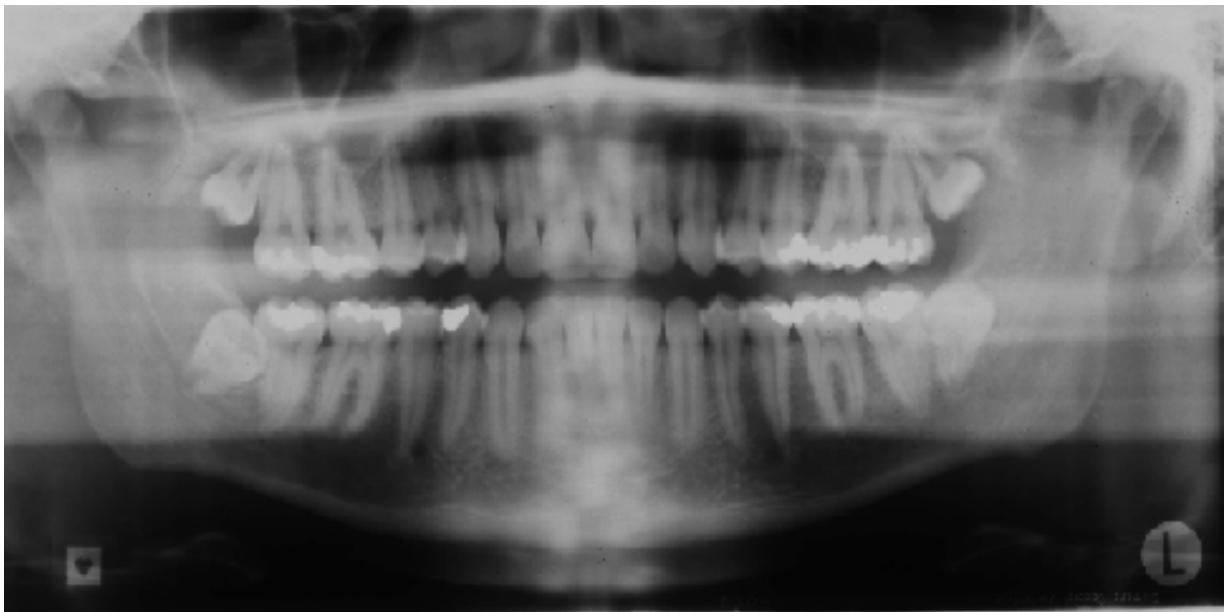


Figure 12. Case 2, 18 years. The third molar on the right side is becoming increasingly mesially inclined (37.5 degrees), and the third molar on the left side is becoming distally inclined (-20.9 degrees)



Figure 13. Case two, 21 years. The third molar on the right side increasingly mesially inclined (60.6 degrees), and the third molar on the left side is distally inclined (-26.2 degrees).

Literature review (Table 10)

Table 10 cont. Literature review: Development and eruption of third molars.

References	Title	Material	Observation time	Radiogrhs	Meassurements method	Results
Cavanaugh JJ 1985 Phoenix, Arizona	“Third molar changes following second molar extractions”	25 individulas ex of all 4 M2. 2 Orthod. treatment	10½-18½ yr	OPG	The angulation of the occlusal surface of each crown was measured to the long axis of the tooth and to the long axis of the root.	- All third molars erupted, no teeth was impacted. - Change in inclination from 0-49°

Table 10. Literature review: Development and eruption of third molars.

References	Title	Material	Observation time	Radiographs	Measurements method	Results
Gooris et al. 1990	Eruption of mandibular third molars after second-molar extractions: A radiographic study	95 ind./140 teeth	T1 :mean age 13.3 yr, SD1.8 (time of M2 extraction) T2: mean age 18.7 yr, SD1.9 (time of final evaluation)	OPG	The occlusal line (OL) was constructed through the cusp tips of the 1. molar and 2. premolar. The mandibular line (ML) was constructed as a tangent to the two lowest points on the anterior and posterior borders of the mandible Inclinations relative to OL and ML: The long axis of each molar crown was drawn through the midpoint of a line connecting the most mesial and distal points of the crown and the midpoint of the bifurcation. For each long axis, the angle was measured relative to OL and ML.	Third molar impaction was found in 4% of the sites in the subsample of 25 consecutively treated patients. Measurements of crown axis inclination revealed that the third molar invariably erupted into a mesially tilted position.

Table 10 cont. Literature review: Development and eruption of third molars.

References	Title	Material	Observation time	Radiographs	Measurements method	Definitions lines	Results
Güngörmüs 2002	“Pathologic status and changes in mandibular third molar position during orthodontic treatment”	76 ind. 42 males, 34 females 30 nonex, 26 ex of premolars, 20 control group	18-23 yr	KEF, OPG	<p>Angulation: - M3 or M2 angulations were measured as the anterior angles formed between long axes of these teeth with mand. line</p> <p>Eruption level: - 1: the highest part of the M3 was on the same level as or above the occlusal plane of the adjacent second molar - 2: highest part of the M3 was below the occlusal plane but above the cervical line of the M2 - 3: highest part of the M3 was on the same level as the cervical line of the M2 - 4: highest part of the M3 was below the cervical line but above the CEJ of the M2</p>	<p>OL: occlusal line, was constructed through the cusp tips of the M1 and the second premolar. ML: mand. line, a tangent to the two lowest points on the anterior and posterior borders of the mand. RL: ramus line, through the two most distal points of the ramus. A and B: the long axis of M3 and M2 were drawn through the occlusal middle point and the bifurcation point of the root.....</p>	<p>-Clinically observed that 18% M3 in non-ex group and 15% in ex group erupted in normal position. - 83% in both groups erupted partially in a mesioangular position. - 43% of the teeth that partially erupted developed pericoronitis and 4% had dental caries.</p>

Table 10 cont. Literature review: Development and eruption of third molars.

References	Title	Material	Observation time	Radiographs	Measurements method	Results
Haavikko et al. 1978	“Predicting angulational development and eruption of the lower third molar”	Longitudinal set of OPG of 110 young people 80 randomly selected, 30 orthodontic patients with two lower premolar extractions	1.OPG: average age 13.5 yr 2.OPG: average age 19.5 yr	OPG	The lines and angles used in this study: α = gonial angle between the mand. plane and the ramus plane. β = angulation of M3 to M2 tooth γ = angulation of M2 to the mand. plane	<ul style="list-style-type: none"> - mean angle (β): 23.3°=13.5yr: 13.9°=19.5yr: normal group=23.6°, ex group=15.1°. - small initial angle favourable for the eruption of M3 - β angle is parallel or less than 10° M3 in most cases will erupt - initial angle 20°-30° the possibility of eruption seems to be 1 in every 3 cases - large initial β angle the prediction of eruption becomes more difficult and the number of impacted cases increases - 71.8% M3 was unerupted in the normal group and in 65% in ex group at the 19.5 yr.

Table 10 cont. Literature review: Development and eruption of third molars.

References	Title	Material	Observtion time	Radiograhs	Meassurements method	Results
Hattab 1997	“Positional changes and eruption of impacted mandibular third molars in young adults”	18-21 yr 36 ind. 67 teeth	4 yr	OPG	<p>Angulation: A line was drawn through the midpoint of the occlusal surface and bifurcation of the M2 and M3. These lines represent the long axis of the teeth. The angle formed between the intersected long axis gave the degree of M3 inclination relative to the M2.</p> <p>The levels of eruption of M3: were grouped accordering to their depth in relation to the cervical line of the adjacent M2. (levels A, B, C)</p>	<p>Intial examination showed that among 59 mesioangular, 49 (83%) had inclation 5 and 30 degrees.</p> <p>The proportion of M3 that became upright was 76% (13/17): 5 to 10 degrees. 61% (11/18): 15 to 20 degrees. 14% (2/14): 25 to 30 degrees.</p> <p>In total, 26 M3 of 59 (44%) became upright during the follow-up periode.</p> <p>Levels of eruption. (59 M3): 13 (22%) were partially erupted. and the rest were unerupted. Of the total sample, 25 (42%) had erupted to full occlusion during the observation period.</p>

Table 10 cont. Literature review: Development and eruption of third molars.

References	Title	Material	Observation time	Radiographs	Measurements method	Results
Hugoson and Kugelberg 1988	“The prevalence of third molars in a Swedish population. An epidemiological study”	A random sample of 693 dentate individuals, (337 males and 356 females)	8 age groups (15, 20, 30, 40, 50, 60, 70 and 80 yr)	OPG and periapical radiographs	<ol style="list-style-type: none"> 1. number and location of third molars 2. angulation and positional relationship to the adjacent second molar (Winter’s classification) <ul style="list-style-type: none"> 0-25°: vertical 26-75°: mesioangular < 0 : distoangular >75 °: horisontal impacted 3. state of eruption 4. developmental stages of M3 in the aged 15, 20 and 30 yr. 	<p>Prevalence: distribution of 56 M3 missing in the mand. was equal between males and females, suggesting that agenesis was slightly more frequent in the mand. than in the max. Absence of mand M3 was equally common in both sexes.</p> <p>- state of eruption: 32% of the mand. M3 in males were partially or completely impacted. Difference in M3 impaction between males and females was statisticcally significant in the mand. - full erupted. in the mand were 37.4%</p> <p>-angulation and positional: relationship to the adjacent M2: most frequent angulation of M3 was vertical 75.5%, Mesioangular 17.2%, distoangular 5.1% and horizontally inclined 2.2%</p>

Table 10 cont. Literature review: Development and eruption of third molars.

References	Title	Material	Observation time	Radiographs	Measurements method	Results
Orton-Gibbs 2001 London	“Eruption of third permanent molars after the extraction of second permanent molars. Part1: assessment of third molar position and size”	63 ind.	3-17 yr (mean 8.5 yr)	OPG start and end of active treatment	<ol style="list-style-type: none"> 1. angulation crown long axis of third molar to occlusal plane 2. angulation whole tooth long axis of third molar to occlusal plane 3. angulation whole tooth long axis of first molar to occlusal plane 4. height of third molar below occlusal plane 5. horizontal distance of third molar to first molar 	<ul style="list-style-type: none"> - there were no impacted M3 - the teeth of the male patients were larger than those of the female patients (Table VI)

Table 10 cont. Literature review: Development and eruption of third molars.

References	Title	Material	Observation time	Radiographs	Measurements method	Definitions lines	Results
Shiller 1979	"Positional changes in mesioangular impacted mandibular third molars during a year"	Recruits, 18-23 yr, 223 individuals, 296 teeth	1 yr	Bite-wing	Inclination of the occlusal surface of the third molar was measured in relation of the occlusal surface of the second molar	Inclination was recorded in increments of 5° to a maximum of 65°. Inclination $\geq 70^\circ$: horizontally impacted	<ul style="list-style-type: none"> - 43% of impacted M3 of 18 yr patients showed decreased inclination where as only 23% of those of 21 yr patients did. - those teeth with lower initial inclination, a greater percentage became more upright than those with the higher initial inclination. - those teeth with high initial inclination became more impacted - 37 (13%) mesioangular teeth became completely upright - 4% of the teeth incline 30° or more became upright

Table 10 cont. Literature review: Development and eruption of third molars.

References	Title	Material	Observation time	Radiographs	Measurements method	Results
Ventä et al. 1991	“Assessing the eruption of lower third molars on the basis of radiographic features”	123 ind, 39 men and 84 women	6 yr T1: 20.3 yr T2: 26.7 yr	OPG before and after	The following variables (five radiographic features) were examined at aged 20: 1. Development of the root of a M3 was classified as complete or incomplete 2. state of impaction 3. angulation of M3 (Shiller 1979): vertical: ± 10 mesio/disto: $\pm 11-70$ horizontal $> \pm 71$ 4. relative depth of M3 (Archer 1975): The highest point of a lower M3 could be at level with the occlusal, cervical or apical portion of the neighbouring M2 5. the relation of the tooth to the ramus of the mandible and the M2	The results were presented in histograms. The results showed that the Lower M3 that did erupt after the age of 20 yr were initially: 1. root formation completed 2. impacted in soft tissue 3. vertical 4. placed at the same occlusal level as the M2 5. showed sufficient space between the ramus and the M2

Table 10 cont. Literature review: Development and eruption of third molars.

References	Title	Material	Observatin time	Radiograhs	Measurements method	Results
Ventä et al. 1999	“Change in clinical status of third molars in adult during 12 years of observation”	32 female 49 males Longitudinal	20-32 yr	Clinical examination, OPG	Clinical state of third molars was recorded as unerupted (not visible), partially erupted (part of the occlusal surface visible), erupted (entire occlusal surface visible or in more advanced state of eruption), or missing (radiographically confirmed).	120 teeth, 60 students Mand. 20 yr: - 18 teeth (15%) missing - 50 teeth (42%) unerupted - 30 teeth (25%) partially erupted. - 22 teeth (18%) erupted. 32 yr: - 66 teeth (55%) missing - 13 teeth (11%) unerupted. - 4 teeth (3%) partially erupted. - 37 teeth (31%) erupted.