

Prevalence of third molars determined by panoramic radiographs in a population-based survey of adult Finns

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ABSTRACT

Objectives: The aim of the study was to examine the prevalence of third molars in panoramic radiographs in a population-based study of adults aged ≥ 30 years.

Methods: Out of a sample of 8028 inhabitants of Finland, selected with two-staged stratified cluster-sampling method for the Health 2000 Survey, 5989 participated in clinical oral examination and panoramic radiography. Mean age was 52.5 years (SD 14.6; range 30–97 years). The following variables were included in the analysis: participant characteristics, clinical number of all teeth, and radiographic prevalence and characteristics of third molars. Statistics included chi-squared, Fisher's exact, and Kruskal-Wallis tests and SAS-SUDAAN calculations.

Results: A total of 5912 third molars in 47.8% of the study population were recorded from panoramic radiographs. At least one impacted third molar was found in 21.9% of the study population. More than half (57.3%) of the remaining third molars were located in the mandible. A preponderance of participants with all third molars missing were observed in the oldest age group, women, those with lower education, and those living in the countryside. Third molars or remnants thereof were observed radiographically in 3.9% of clinically edentulous study population.

Conclusions: The panoramic radiographs disclosed many remaining third molars in adult Finns aged ≥ 30 years. One-third of the third molars located impacted which may cause unexpected need for care.

INTRODUCTION

The prevalence of third molars in the population is not fully clear. There are two major reasons for this; third molars are often ignored in clinical examinations or analyses of clinical data and panoramic radiographs are rarely obtained in population studies. Furthermore, the prevalence of third molars is unique for each country and depends on factors such as ethnicity, health insurance system, access to health care, and resources of health care personnel. For example, according to a US study, Caucasians have fewer visible third molars compared with African Americans¹.

In addition to routine oral health measures, some prevalence information on third molars is reported in population-based studies²⁻⁵. According to these studies, third molars are clinically the most common missing teeth in dentate adults.

There are two detailed studies focused on the prevalence of third molars in the population^{1,6}. From these studies, the US survey is a nationally representative sample of the civilian and non-institutionalized population in the 21st century covering ages from 20 to 80 years and over⁷. The prevalence of clinically visible third molars are reported from a sample of approximately 4000 participants¹. The presence or absence of visible third molars are noted by dental hygienists in non-clinical settings. The mean numbers of third molars per participant range from 1.5 in younger participants to 0.8 in older participants. The US authors correctly conclude that the numbers of third molars may be underreported, as impacted teeth are not visible without a radiograph.

Another study on the prevalence of third molars in the population is a Swedish study from the 1980s including inhabitants of the city of Jönköping⁶. The age of the participants varies from 15 to 80 years. The study is unique as it includes panoramic radiographs. The proportion of participants with absent third molars increases from 6.5% in younger participants to 84.2% in older participants. However, the results are drawn from approximately 700 dentate participants. Therefore, the numbers of third molars may be overrepresented in the sample as edentate participants are excluded from the main analysis.

Third molars in young adults are more compelling and more frequently studied because of the range of variation in eruption, impaction, and extractions. However, it is also

important to have knowledge of third molars in adults and older people: how many third molars survive and may cause need of treatment. The aim of this study is to examine the prevalence of third molars from participants aged from 30 to 100 years representing the population in the country and to include both clinical oral examinations performed in clinical settings and panoramic radiographs.

METHODS

The National Institute for Health and Welfare (THL) in Finland organized the Health 2000 Survey (BRIF8901, Bioresource Research Impact Factor), which began in 2000 and concluded in 2001⁸. The survey was a cross-sectional study that included interviews, questionnaires, general health examination, and also clinical oral examinations and panoramic radiographs⁹. The main sample included 8028 individuals who were selected with a two-staged stratified cluster-sampling method and represented the population aged ≥ 30 years in the country¹⁰. People were motivated to take part in the study in order to receive a free dental examination including an x-ray¹⁰. Clinical oral examinations were performed on 6335 (78.9%) participants and panoramic radiographs were taken from 6115 (76.2%) participants. A total of 110 (1.8%) radiographs were blurred in the third molar area and were excluded from the analysis. An additional 16 participants were also excluded as they participated only in the radiographic examination. The final number of participants included in analyses was 5989 (74.6%).

The following participant characteristics were included: age, gender, level of education (lower, medium, higher), and place of residence (countryside, town, city). Age was categorized as 30–39, 40–49, 50–59, 60–69, and ≥ 70 years.

Clinical oral examinations were performed in a portable dental chair by five dentists with assisting nurses in 80 localities around the country. All teeth including third molars were recorded if they were clinically visible or could be reached by a probe. If more than half of all vertical surfaces of the crown were damaged, the tooth was recorded as a residual root. The total number of all clinically visible teeth including roots was defined separately for the participants to identify clinically edentulous participants that were included in the analysis.

Immediately after the clinical examination, the nurse obtained a panoramic radiograph with Planmeca 2002 CC Proline (Planmeca, Helsinki, Finland) equipment using the 58 to 68 kV and 4 to 10 mA settings. In addition to the signed informed consent, the participants were asked verbally after the clinical oral examination whether they wanted to take part in the radiographic examination, which was voluntary. Pregnant participants and participants with a postural anomaly in the cervical or thoracic spine were excluded¹⁰.

The first author examined the panoramic radiographs in relation to third molars using Romexis software version 3.6.0.R (Planmeca, Helsinki, Finland). The first 47.1% (2879) of images were examined twice. At the end of image examinations, a randomly selected 10.2% (610) of images were re-examined to obtain measures for intra-examiner reproducibility. The agreement was 93.1% for the recognition of third molars and the corresponding κ -value was 0.882.

A third molar was recorded if a tooth or a tooth remnant was visible on the radiograph. The inclination of a third molar was assessed visually as the angle between the occlusal surface of the third molar and the occlusal plane determined by the highest points of the first premolar and the second molar. The following categories were used: vertical 0-10°, mesioangular 11-70°, distoangular <0°, and mesiohorizontal >70 degrees¹¹. Inclination was not assessed for residual roots.

The state of impaction of third molars was classified as follows: erupted (cemento-enamel junction of the crown mesially and distally above the bone surface), impacted in soft tissue (less than two-thirds of the crown covered by bone), and impacted in bone (two-thirds or more of the crown covered by bone)¹². A third molar without a crown was not classified according to the state of impaction but was recorded as a residual root.

The results were reported both for participants and for third molars. Differences between subgroups were analyzed using the chi-squared and Fisher's exact test for frequencies and Kruskal-Wallis test for means of independent groups. Statistics were computed with SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA). The SAS Callable SUDAAN software version 11.0.1. was used to account for the complex

sampling method and to obtain weighted distributions of third molars representative of all Finns aged ≥ 30 years.

Ethical approvals were obtained from the ethics committee of the organizing institution and from the Ethical Committee for Research in Epidemiology and Public Health at the Hospital District of Helsinki and Uusimaa. A safety license for radiography was granted by the Radiation and Nuclear Safety Authority of Finland. At baseline, all participants signed a written informed consent before the clinical and radiographic examinations. The THL granted permission to use the material for the present study.

RESULTS

Among the 5989 participants, 45.9% were men and 54.1% women and mean age was 52.5 years (SD 14.6; range 30–97 years) (Table 1). Those who participated in the radiography were younger, had higher education, and lived more often in rural than urban areas than those who did not participate.

At least a third molar or a remnant thereof was found in 47.8% of the population aged ≥ 30 years; 18.2% had one, 13.9% had two, 7.5% had three, and 8.2% had all four third molars (Table 2). In the population aged ≥ 30 years, the weighted mean number of third molars or remnants thereof per participant was 1.01 (SE 0.02; 95% CI 0.97–1.05).

At least one impacted third molar was found in 21.9% of the population aged ≥ 30 years and more often in the younger persons than in older ones (Table 3).

When analyzing the prevalence of missing third molars, we observed that all third molars were missing more often in the oldest age group than in the youngest group (81.5% vs. 38.3%; $\chi^2=833.57$, $df=16$, $p<0.001$), in women (60.4% vs. 44.7%; $\chi^2=197.96$, $df=4$, $p<0.001$), those with lower education than higher education (66.7% vs. 42.7%; $\chi^2=324.22$, $df=8$, $p<0.001$), and in those living in the countryside than in the city (57.4% vs. 51.2%; $\chi^2=21.90$, $df=8$, $p=0.005$).

In clinical examinations, 824 (13.8%) participants had no clinically visible teeth (294 men and 530 women) (Table 4). Among these edentulous participants, a total of 38 third molars or remnants thereof were observed in the panoramic radiographs of 34

participants, representing 3.9% of the edentulous population aged ≥ 30 years. Out of the 38 third molars, the majority (25 teeth) were found in the oldest age group, of which 17 (68.0%) were residual roots. The number of third molars in the edentulous participants did not differ by gender (Fisher's exact test 3.52, $df=2$, $p=0.142$).

A total of 5912 third molars were recorded in the radiographs, consisting of 5644 third molars and 268 residual roots. A distribution of the third molars according to location showed that when the participant had one to three third molars, they were more prevalent in the mandible than in the maxilla (60.8% vs. 39.2%; $\chi^2=47.59$, $df=2$, $p<0.001$) (Table 5).

Among all age groups, maxillary third molars prevailed in the youngest age group and mandibular third molars prevailed in the 40 to 59-year-old group ($\chi^2=19.31$, $df=4$, $p=0.001$) (Table 6). Analysis of the state of impaction revealed that erupted third molars were more prevalent in the upper jaw. Third molars impacted in soft tissue were more prevalent in the lower jaw ($\chi^2=522.61$, $df=2$, $p<0.001$). Regarding inclination, vertical third molars were more prevalent in the upper jaw and inclined third molars in the lower jaw ($\chi^2=350.28$, $df=4$, $p<0.001$).

DISCUSSION

We observed that, at least one third molar or its remnant occurred in 47.8% of the population aged ≥ 30 years and at least one impacted third molar was observed in 21.9%.

A limitation of our study was that our material did not include inhabitants <30 years. However, there are numerous studies in the literature on the prevalence of third molars in young adults from selected samples at dental care units. In addition, age <30 years is the most active period for extractions and many changes occur in the prevalence of third molars¹³. In population-based studies, such as the Adult Dental Health Survey from the United Kingdom, third molars were not clinically visible (50% to 70%) in most participants <34 years^{3,4}. Without radiographic examination it is not possible to assess whether they are missing or already extracted. More comprehensive information on young adults is available from the aforementioned Swedish radiographic study⁶ and from a population-based study in New Zealand¹⁴. In these studies, all four third molars

were found in 72.1% to 77.0% of participants at age 18 and 20 and half of the third molars in the maxilla and two-thirds in the mandible were impacted.

The generalizability of our results may be limited because of those third molars already extracted before the date of examination. In addition, the prevalence of third molars in adults differs among countries depending on factors related to extractions, such as type of insurance, private or public health care system, primary or specialized health care, method of anesthesia, and policy of the country. For example, among insured patients in the US, third molars are most frequently extracted when impacted in adolescents¹⁵, while guidelines in the UK do not recommend extraction of asymptomatic teeth¹⁶, and in the Finnish guideline for third molars, the following selected third molars are recommended to be removed before the age of 25 years: partially erupted, horizontally inclined, and teeth in close vicinity of the mandibular canal¹⁷. In addition, these practices of extraction have changed over time. For example, older patients that were treated before 2000 in the UK may have lower prevalence of third molars, because since 2000 more third molars are remaining^{18,19}.

A very important determinant for the numbers of third molars is the target population or analyzed sample. The authors of a recent meta-analysis emphasized that in the population, the impaction rate for third molars is lower than in selected samples from oral health care units delivering care for third molars²⁰.

Our findings showed an impaction rate of 21.9% for having at least one impacted third molar per inhabitant in the population aged ≥ 30 years. This was similar to the rate reported in a meta-analysis where the average worldwide rate for at least one impacted third molar per participant is 24.4% (19.8% separately for Europe)²⁰. The meta-analysis was based on radiographic data, similar to our study. The slight difference can be explained by the age ranges. The meta-analysis presented data from participants ≥ 17 years; in our study the lower limit of age was 30 years.

We observed a similar prevalence for the presence of all four third molars per participant as found in the US study among 30 to 39 and 50 to 59-year-olds¹. This is surprising as our study was based on radiographs and the US study used clinically visible numbers of third molars. Compared to the Swedish study based on radiographs, our percentages for all four third molars were lower especially in the oldest age group⁶.

These differences may be explained by the fact that our study analyzed both dentate and edentulous participants and the other study only analyzed dentate participants. However, the presence of all four third molars is not a valid measure for third molar prevalence, as all individuals do not have all four third molars congenitally. According to a meta-analysis on the genesis of third molars, 22.6% of individuals worldwide have at least one third molar missing²¹. Conversely, 77.4% have all four congenitally.

The prevalence of all third molars that were absent in our study ranged from 38.3% in the youngest age group to 81.5% in the oldest group. Except for the youngest age group, these figures are comparable to the Swedish radiographic study⁶. In contrast, the US authors argued that “all third molars were removed at least half the time” based on their finding that all four were not clinically visible in 47% to 61% of participants²².

However, their results interestingly document the difference between clinical examination and panoramic radiograph in the occurrence of third molars. Furthermore, a recent meta-analysis shows that the worldwide rate for all four third molars missing is 3.4% of individuals²¹. The Swedish figure (2.0% at age 20) is thus similar to this value⁶.

Our clinically edentulous population had third molars at a prevalence of 3.9%. This figure is slightly higher when compared with the Swedish study, where edentate participants were analyzed separately from the main group and only a third molar was found in 91 edentulous participants (yielding a prevalence of 1.1%)⁶. This difference may depend on the nature of the samples; our population-based study group of 5989 participants represented inhabitants throughout the country and the Swedish community-based sample consisted of 784 participants living in a single city.

It is worth noting that in the age group ≥ 70 years, 18.4% of our participants had third molars (representing 4.1% of all remaining third molars) and in 4.7% of this age group the teeth were impacted. These figures provide an estimate on the vast amount of extractions during a life-time. According to our recent study, at least one sign of disease in third molars was detected in 99% of the participants >75 years²³. However, medical and technical risks may be associated with extraction of remaining third molars in old and frail patients, and therefore, in case teeth require removal this is best performed earlier in life²⁴.

In the Finnish Current Care Guideline for Third Molars, the following selected third molars are recommended to be removed before the age of 25 years: partially erupted, horizontally inclined, and teeth in close vicinity of the mandibular canal¹⁷. Our findings showed that from the third molars in adults aged ≥ 30 years, 37.1% were impacted and 3.6% were horizontally located (Table 6). Furthermore, our recent study on the same material documented that 39.6% of the mandibular third molars are located close to the mandibular canal²⁵. If these teeth require extraction it would be easier in younger than in older persons.

It is concluded that third molars occurred in almost half of the target population aged ≥ 30 years and one fifth of them had impacted third molars. Therefore, where these teeth require unexpected need for care in terms of infection it may be more difficult and associated with more complications than in younger persons.

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Table 1. Participant characteristics according to study participation.

Character-istics		Participants in radiography (n=6115)		Non- participants (n=1913)	P-value
		Included (n=5989) n (%)	Excluded (n=126) n (%)	n (%)	
Age (years)	mean [SD]	52.5 [14.6]	59.2 [15.5]	59.2 [19.7]	<0.001 ^a
Age group (years)	30-39	1339 (22.4)	16 (12.7)	420 (22.0)	<0.001 ^b
	40-49	1483 (24.8)	21 (16.7)	347 (18.1)	
	50-59	1336 (22.3)	26 (20.6)	266 (13.9)	
	60-69	911 (15.2)	29 (23.0)	178 (9.3)	
	≥70	920 (15.4)	34 (27.0)	702 (36.7)	
Gender	Men	2749 (45.9)	61 (48.4)	827 (43.2)	0.097 ^b
	Women	3240 (54.1)	65 (51.6)	1086 (56.8)	
Education ^c	Higher	1708 (28.6)	21 (16.7)	250 (19.8)	<0.001 ^b
	Medium	1925 (32.3)	32 (25.4)	321 (25.4)	
	Lower	2334 (39.1)	73 (57.9)	694 (54.9)	
Place of residence	City	3650 (60.9)	64 (50.8)	1262 (66.0)	<0.001 ^b
	Town	859 (14.3)	28 (22.2)	252 (13.2)	
	Country- side	1480 (24.7)	34 (27.0)	399 (20.9)	

^aKruskal-Wallis test. ^b χ^2 test. ^cLevel of education was not available for 670 participants.

Table 2. Numbers and weighted percentages (%) of the 5989 participants according to the number of third molars per participant in panoramic radiographs, separately for each age group.

Age (years)	No. of partici- pants	Number of third molars, n (%)				
		None	One	Two	Three	Four
30-39	1339	513 (37.5)	219 (16.3)	236 (17.9)	133 (10.2)	238 (18.1)
40-49	1483	589 (39.3)	326 (22.0)	265 (18.0)	150 (10.2)	153 (10.5)
50-59	1336	698 (52.1)	269 (20.1)	198 (14.9)	102 (7.7)	69 (5.2)
60-69	911	634 (69.4)	155 (17.1)	73 (8.1)	37 (4.1)	12 (1.3)
≥70	920	750 (80.8)	114 (12.6)	40 (4.6)	13 (1.6)	3 (0.4)
Total	5989	3184 (52.2)	1083 (18.2)	812 (13.9)	435 (7.5)	475 (8.2)

Table 3. Numbers and weighted percentages (%) of the 5989 participants according to impacted third molars per participant by age.

Number of impacted third molars*, n (%)							
Age (years)	No. of participants	None	One	Two	Three	Four	At least one
30-39	1339	801 (59.1)	238 (18.1)	213 (16.3)	48 (3.6)	39 (2.9)	538 (40.9)
40-49	1483	1099 (73.9)	217 (14.7)	127 (8.7)	28 (1.9)	12 (0.8)	384 (26.1)
50-59	1336	1124 (84.0)	132 (9.9)	49 (3.7)	26 (2.0)	5 (0.4)	212 (16.0)
60-69	911	812 (89.1)	65 (7.2)	22 (2.4)	9 (1.0)	3 (0.3)	99 (10.9)
≥70	920	877 (94.7)	34 (4.2)	8 (1.0)	1 (0.1)	0 (0.0)	43 (5.3)
Total	5989	4713 (78.1)	686 (11.8)	419 (7.2)	112 (1.9)	59 (1.0)	1276 (21.9)

*The 268 residual roots were not classified according to impaction, and thus, are not included.

Table 4. Numbers and weighted percentages (%) of the 824 clinically edentulous participants according to the number of third molars in panoramic radiographs by age.

Number of third molars, n (%)					
Age (years)	No. of participants	None	One	Two	Mean (SE)*
30-39	1	1 (n.a.)	0	0	0 (0)
40-49	36	35 (97.1)	1 (2.9)	0	0.03 (0.03)
50-59	135	133 (98.6)	2 (1.4)	0	0.01 (0.01)
60-69	199	189 (95.1)	10 (4.9)	0	0.05 (0.02)
≥70	453	432 (95.6)	17 (3.5)	4 (0.9)	0.05 (0.01)
Total	824	790 (96.1)	30 (3.4)	4 (0.5)	0.04 (0.01)

*SE=standard error. n.a.=not applicable.

Table 5. Distribution (%) of the participants (n=2805) with third molars and/or remnants according to number and location of third molars (n=5912).

Location and no. of third molars	Participants by number of third molars			
	One n=1083	Two n=812	Three n=435	Four n=475
Upper right, n=1246	173 (16.0)	305 (18.8)	293 (22.4)	475 (25.0)
Upper left, n=1276	186 (17.2)	302 (18.5)	313 (24.0)	475 (25.0)
Lower left, n=1683	370 (34.1)	503 (31.0)	335 (25.7)	475 (25.0)
Lower right, n=1707	354 (32.7)	514 (31.7)	364 (27.9)	475 (25.0)
Total no. of third molars	1083 (18.3)	1624 (27.5)	1305 (22.1)	1900 (32.1)

Table 6. Characteristics of the 5912 third molars in upper and lower jaw in panoramic radiographs according to gender, age group, impaction, and inclination.

Characteristic		Maxilla n (%)	Mandible n (%)	P value ^a
Gender	Male	1475 (58.5)	1927 (56.8)	0.207
	Female	1047 (41.5)	1463 (43.2)	
Age group (years)	30-39	942 (37.4)	1100 (32.4)	0.001
	40-49	787 (31.2)	1131 (33.4)	
	50-59	491 (19.5)	756 (22.3)	
	60-69	189 (7.5)	271 (8.0)	
	≥70	113 (4.5)	132 (3.9)	
Impaction ^b (n=5644)	Erupted	1820 (75.0)	1728 (53.7)	<0.001
	Soft tissue	78 (3.2)	808 (25.1)	
	In bone	528 (21.8)	682 (21.2)	
Inclination ^b (n=5644)	Vertical	1745 (71.9)	1598 (49.7)	<0.001
	Mesioangular	476 (19.6)	985 (30.6)	
	Distoangular	176 (7.3)	433 (13.5)	
	Horizontal	12 (0.5)	193 (6.0)	
	Other	17 (0.7)	9 (0.3)	
Total		2522 (42.7)	3390 (57.3)	

^a χ^2 test. ^bState of impaction and inclination was not measured for the 268 residual roots.