Clinical Oral Investigations (2020) 24:2727–2733
https://doi.org/10.1007/s00784-019-03134-1

ORIGINAL ARTICLE

How many third molars remain unnoticed in a population survey without panoramic radiographs?

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Received: 6 May 2019 / Accepted: 22 October 2019 / Published online: 21 November 2019

Abstract

Objective The aim of the study was to compare the findings of clinical examination and panoramic radiograph regarding the occurrence of third molars in a population survey to find out how many third molars remain clinically unnoticed.

Materials and methods A two-staged stratified cluster-sampling method was used to select 8028 participants representing the adult population aged 30 years and older. Clinical oral examinations and panoramic radiographs were carried out for 5989 subjects (46% men, 54% women; mean age 52.5, SD 14.6; range 30–97 years). Clinical recordings of the presence of third molars were compared with the radiographs. Statistics included chi-squared, Fisher's, Wilcoxon's, and Kruskal-Wallis tests.

Results In the 5989 subjects, 3742 third molars were recorded in the clinical examination, and 5912 were observed in the panoramic images, a difference of 2170 teeth. Furthermore, related to 3668 (61%) of the third molars, both clinical and radiographic recordings were attributed to the same third molar, while 2244 third molars were observed only in the panoramic image, and 74 only in the clinical examination. In every age group, the mean number of third molars per subject was larger radiographically compared with the clinical recordings (means for all 0.99 vs. 0.62; $P < 0.001$).

Conclusion Numbers of third molars, recorded in clinical examination alone, are underreported by approximately one-third compared with radiographic findings.

Clinical relevance The numbers of third molars in a population survey without a panoramic radiograph do not reflect the total number of third molars in a population.

Keywords Adult · Dental health surveys · Epidemiology · Molar · Third · Radiography · panoramic

Introduction

Nationwide surveys on oral health have not usually included panoramic radiographs, except in two studies [1, 2]. In the clinical part of the surveys, numbers of visible teeth and other oral health measures are recorded. It is clear that radiographic images reveal more teeth than are found in clinical examination alone. This is especially true for third molars; however, it remains unknown how large the difference actually is. Therefore, the prevalence numbers of third molars presented in national population studies are not the true numbers of all third molars.

In population surveys, any information on third molars is frequently omitted [3–5]. When they are included, third molars are recorded according to presence or absence of any part of the tooth that is visible through the gum [2, 6, 7], or if the tooth is erupted so that half of the crown is visible [8]. Dental probe is occasionally used to detect hidden third molars [2], and earlier extractions may be inquired from the subjects with questionnaires [6]. In addition to the frequent withdrawal of third molars, another confounding factor is that nationwide surveys are mainly focused on common dental diseases, such as dental caries and periodontal diseases. Therefore, only

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clinically dentate subjects are included [6] or analyzed [2], and less attention is paid to the occurrence of third molars.

Why is it important to know the number of third molars in a population? This information is useful to clinicians, researchers, academic centers, hospital systems, policymakers, pharmaceutical companies, and third-party insurance carriers [7]. At present, the literature does not offer any study on the discrepancy that exists between the number of clinically visible third molars and the number of third molars verified from the panoramic radiograph. This information would be valuable when policymakers, among others, use the results of population-based oral health surveys when radiographic examination is not included. Clinically, it does not matter if a filling is made to a second molar although the tooth actually is a mesially drifted third molar, but endodontic treatment of a third molar is not a common procedure and may not be successful. However, the most common treatment for third molars is extraction, and information on the presence and state of third molars, including also those that are impacted, is essential to estimate the potential need for treatment caused by these teeth both for the individual patient and also at a national level.

The aim of the present study is to compare the findings of clinical examinations and panoramic radiographs in the occurrence of third molars in a population survey representing the whole adult population aged 30 to 100 years. We try to find out how many third molars remain clinically unnoticed in a census study.

Materials and methods

Study design and subjects

Our study was part of the Health 2000 Survey (BRIF8901, Bioresource Research Impact Factor) [9] organized in 2000 and 2001 by the National Institute for Health and Welfare (THL) in Finland. The survey was a cross-sectional, population-based, and nationally representative study on general and oral health [10]. A two-staged stratified cluster sampling method was used to select the 8028 participants representing the Finnish population aged 30 to 100 years [11].

Clinical oral examinations were carried out for 6335 subjects, of whom 6115 panoramic radiographs were taken [2]. After excluding 110 radiographs due to inaccuracies around the third-molar area, and an additional 16 subjects because they participated only in the radiographic examination but had refused from the clinical oral examination, 5989 subjects remained. Age and gender of the subjects were included. Age was categorized as 30–39, 40–49, 50–59, 60–69, and 70 years or older.

Clinical measurements

Clinical oral examinations took place in a portable dental chair in 80 health centers, schools, etc. around the country by five dentists together with assistant nurses. A third molar was recorded if any part of the tooth was visible or could be reached by probe. In subjects with few remaining teeth, when it was unclear whether a tooth was the second or the third molar, the identification was performed as objectively as possible according to location, shape of the tooth, and information from the subject. However, if the first or second molar was missing and the third molar had drifted mesially so that it was no more than 2 mm apart from the next molar, then, the tooth was recorded as a second molar [11, 12]. A third molar was recorded as a residual root when more than half of all vertical surfaces of the tooth had been damaged [11]. In the clinical examination, supernumerary teeth in the third-molar region were not particularly recorded. The total clinical number of teeth, including roots, was defined separately for the subjects.

Radiographic measurements

Radiographic examination was made immediately after the clinical examination. Digital panoramic radiographs were taken by the nurse with Planmeca 2002 CC Proline (Planmeca, Helsinki, Finland) equipment using 58 to 68 kV and 4 to 10 mA depending on the size of the subject. Radiographic examination was voluntary. Pregnant subjects and subjects with postural anomaly in the cervical or thoracic spine were excluded [11].

The first author examined the images retrospectively for the present study in relation to the third molars using the software of Romexis version 3.6.0.R (Planmeca, Helsinki, Finland). A third molar was recorded if a tooth or a remnant of it was visible on the radiograph. In edentulous or partially edentulous subjects, the identification of the third molar was made according to size and location of the tooth, inclination, curvature of the roots, location of the apex, possible shape of recently extracted tooth socket, and symmetry with the other side of the jaw. Impacted supernumerary teeth in the third-molar region were also recorded.

Third molars were classified according to the state of impaction as follows [13]: (1) erupted (cementoenamel junction of the crown mesially and distally above the bone surface), (2) impacted in soft tissue (less than two-thirds of the crown covered by bone), and (3) impacted in bone (two-thirds or more of the crown covered by bone). A third molar without the crown was not classified according to the state of impaction but was recorded as a residual root.

When examining the radiographs, the first author re-examined 47% (2879) of the images after 6 weeks before proceeding to the rest of radiographs. This was done for training and harmonization of measurements, and especially for

identification of the third molars. When all images had been examined, a randomly selected 10% (610 images) were again re-examined to achieve intra-examiner reproducibility for measurements. This agreement was 93% for the recognition of the third molars and the corresponding kappa value was 0.882.

Statistical analysis

Data were analyzed taking both the third molar and the subject as an observation unit. Third molars were divided into three groups: (1) the same third-molar tooth recorded in both examinations, (2) a third molar recorded only in the clinical examination, or (3) a third molar recorded only in the panoramic image. Subjects were similarly divided into three groups according to the total number of third molars recorded: (1) equal number of third molars recorded both in clinical and in radiographic examinations, (2) more third molars recorded in the clinical examination, or (3) more third molars recorded in the panoramic image. Differences between subgroups were analyzed using the chi-squared test or Fisher's exact test for frequencies, the Wilcoxon signed-rank sum test for means of two related groups, and the Kruskal-Wallis nonparametric test for means of three groups. Statistics were computed with IBM SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA), and the Wilcoxon test was run with SAS 9.4. (SAS Institute Inc., Cary, NC, USA).

Ethical considerations

Ethical approvals for the examinations in 2000 were obtained from the Ethics Committee of the National Public Health Institute and the Ethics Committee of Epidemiology and National Health in the Hospital District of Helsinki and Uusimaa (HUS). A safety license was granted by the Radiation and Nuclear Safety Authority (STUK) of Finland. The subjects had signed a written informed consent before health examinations [11]. The National Institute for Health and Welfare (THL) in Finland provided permission to use the data for the present study.

Results

Among the 5989 subjects, 46% were men and 54% women. Their mean age was 52.5 years (SD 14.6 years; median 51 years; range 30–97 years). In the clinical examination, at least one third molar was recorded in 31% (1834) of the subjects; and in the radiographic examination in 47% (2805) of the subjects (Fig. 1).

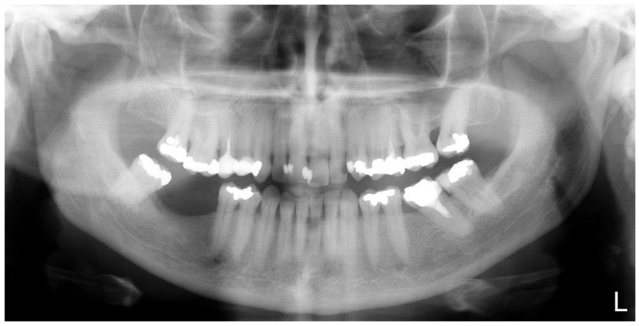

Fig. 1 Panoramic radiograph as an example of the difference between clinical recordings and panoramic radiograph in the occurrence of third molars in a 59-year-old woman. No third molars were recorded in the clinical examination. The radiographic image revealed three third molars: upper left, lower right, and left

Third molar–based findings

The total number of teeth recorded as third molars in the clinical examination was 3742 teeth, and in the panoramic radiographs 5912 teeth, a difference of 2170 teeth. Recorded third molars were not always the same: related to 3668 (61%) third molars, both clinical and radiographic recordings were attributed to the same third molar (Table 1).

When the same third molar was recorded both in clinical examination and in radiographs, such teeth belonged to younger subjects (Kruskal-Wallis $H = 244.723$; df = 2; $P < 0.001$), were mostly male teeth ($\chi^2 = 55.963$; df = 2; $P < 0.001$), and were located more often in the mandible ($\chi^2 = 21.958$; df = 2; $P < 0.001$), and the majority of them were erupted ($\chi^2 = 2271.480$; df = 2; $P < 0.001$) compared with recordings in either or examination alone (Table 1).

Subject-related findings

The mean number of third molars per subject was larger in the radiographic examination compared with that in clinical recordings in every age group (Table 2; Wilcoxon's signed-rank sum test for all $S = 568948.5$; $P < 0.001$).

An equal number of third molars per subject was recorded for 74% (4440) of the subjects, and in the rest, more third molars were recorded either in the radiographic (25%) or in the clinical examination (1%). An equal number was recorded more often in women than in men (76% vs. 72%; $\chi^2 = 17.181$; df = 1; $P < 0.001$). Among the 49 subjects with more third molars recorded in clinical examination, 33 subjects showed no third molars in radiographs.

Related to the total number of clinically visible teeth per subject, recordings between clinical and radiographic examinations of the third molars agreed best when the subject had either full dentition or few remaining teeth and disagreed most when the subject had just 11 teeth in the mouth (Fig. 2).

In the panoramic radiographs, supernumerary teeth impacted in the third-molar region were found in 14 subjects (0.2%

Table 1 Comparison of the characteristics (%) of the 5986 third molars according to the method of recording

	Same third molar recorded in both examinations (n = 3668 teeth)	Recorded only radiographically (n = 2244 teeth)	Recorded only clinically (n = 74 teeth)	P value
Age				
Mean age [SD] years	43.9 [10.3]	48.8 [12.5]	52.1 [12.7]	< 0.001[a]
Gender				
Men	61	52	43	< 0.001[b]
Women	39	48	57	
Jaw				
Maxilla	45	39	50	< 0.001[b]
Mandible	55	61	50	
Radiographic impaction	n = 3620*	n = 2024*		
Erupted	76	40	n.a.	< 0.001[b]
Soft tissue impacted	22	4	n.a.	
In bone impacted	2	56	n.a.	
Third molar				
Whole tooth	99	90	96	< 0.001[c]
Residual root	1	10	4	

[a] The Kruskal-Wallis nonparametric test; [b] χ^2 test; [c] Fisher's exact test; *n.a.* not applicable. *The state of impaction was not assessed for the 268 residual roots

of all subjects), in 10 men and 4 women; the age range was 30–61 years. Four of the subjects had two supernumerary teeth, one subject had four of them, and the rest had one. A total of 21 supernumerary teeth were recorded: 18 in the upper jaw and 3 in the lower jaw. All of these subjects also had one or more third molar.

Discussion

The main result of our study was that, in a population study, a panoramic radiograph revealed more third molars than was found in clinical examination alone. Related to only 61% of third molars, both clinical and radiographic recordings were attributed to the same third molar. Furthermore, when clinical recordings and radiographic examinations in this population survey were compared, an equal number of third molars per subject were recorded in 74% of the subjects by both methods. These results mean that at the tooth's level, 39% of the third molars remained unrecorded, and at the subject's level, in 26% of subjects, all existing third molars were not recognized in clinical examination. This finding is significant, and therefore, the numbers of third molars in a population survey without a panoramic radiograph are highly underreported. Perhaps this is the background for the usual manner in population surveys that third molars are often omitted, because without a radiograph, the numbers would be misleading [3–5].

The difference of findings between the clinical and radiographic examinations can be explained by two facts. First, it is clear that a radiograph revealed more third molars including also the impacted ones. Table 1 shows that from the third molars recorded only in the radiographic examination, 60% were impacted. The radiographic image also revealed more residual roots than were identified in the clinical examination. Second, although the third molar was erupted, the identification of it was clinically difficult in subjects that were partially or totally edentulous. In Table 1, it was shown that 40% of the third molars recorded only in the radiographic examination were erupted teeth. Thus, these teeth were visible also in the clinical examination although not recorded like that.

Identification of the tooth in our clinical oral examination was more detailed than is presented in the basic methods for oral health surveys by the World Health Organization [14]. According to the WHO, a tooth should be considered present in the mouth when any part of it is visible. Our identification of the tooth took into account also the role of the tooth in the occlusion. The third molar may take the place of the second molar after extraction of one of the more anteriorly locating molars. Therefore, this may be one of the explanations in our study for the differences between clinical and radiographic numbers of third molars. Our clinical method of recording the third molars was similar to that used in an earlier population study, Mini-Finland Survey [12].

A surprising finding in our study was that in 49 subjects, a total of 74 third molars were recorded clinically but not in radiographs. This group of subjects was older than the rest of the subjects. This result also reveals the difficulty to distinguish the third molar from other molars without a radiograph. However, these teeth were recorded in clinical examination, which means that they were clinically visible, and therefore,

Table 2 Mean number of third molars recorded per subject in radiographic and clinical examinations, by age group ($N = 5989$ subjects). Differences between means were statistically significant at $P < 0.001$ for all age groups

		Radiologically recorded	Clinically recorded	P value[a]
Age group (years)	Number of subjects	Mean (SD)	Mean (SD)	
30–39	1339	1.53 (1.51)	1.09 (1.43)	< 0.001
40–49	1483	1.29 (1.35)	0.87 (1.23)	< 0.001
50–59	1336	0.93 (1.20)	0.52 (0.96)	< 0.001
60–69	911	0.50 (0.90)	0.23 (0.63)	< 0.001
≥ 70	920	0.27 (0.64)	0.11 (0.43)	< 0.001
All	5989	0.99 (1.29)	0.62 (1.12)	< 0.001

[a] Wilcoxon's signed-rank sum test

clinical treatment decisions would probably not be different whether the tooth is considered a third molar instead of a second molar.

Mean numbers of clinically visible third molars are presented for the US population according to age groups [7]. When the US results from the period from 2001 to 2002 and our clinically recorded mean numbers of third molars are compared, it can be seen that our mean values are lower than the US means in every age group from 30 to 70 years. This difference may be due to ethnicity, as our population consists mostly of Caucasians, and thus, our mean values were closest to the Caucasians in the US study. However, our mean values from the radiographic examination were higher than the US results for Caucasians in every age group except for subjects older than 70 years. Thus, the US authors supposed correctly that the number of third molars may be underreported in their study, because unerupted third molars are not recorded without radiographs. The same authors continued their study and compared their numbers of clinically visible third molars with those presented in a Swedish radiographic study [1], and noticed that especially in the youngest age cohorts, the differences were most prominent [15].

A Swedish study [1] on the prevalence of third molars in the city of Jönköping is widely cited in the third-molar literature. The study includes 693 subjects that are examined both clinically and radiographically. When our radiographic mean values of third molars in each age group are compared with the Swedish study, it can be found that the Swedish mean values are higher than ours, except for the age groups of 40 and 50 years of age. This difference can be explained by the fact that the Swedish material included only dentate subjects, whereas our material represented the whole adult population with also edentate subjects, approximately 15% [2].

In the clinical examination, supernumerary teeth in the third-molar region were not particularly recorded. In the radiographs, the prevalence of these teeth impacted in the third-molar region was 0.2% for the subjects. This prevalence is a little lower than is reported from a military material, where the prevalence of fourth molars is 2.2% and separately for white patients 0.9% [16]. The difference can be explained by two reasons: in the military material, the subjects were patients for third-molar surgery and they were also younger (aged 18 years and above) than our subjects. Although our number of fourth molars was small, they are usually extracted simultaneously with the third molar and therefore may slightly increase the treatment load at a national level.

Our study was a population-based study in a developed country. It may be asked whether our results present a problem for a patient's health. Is it important to detect hidden third molars? We showed that without a radiograph, it was not possible to recognize all third molars or retained roots thereof. Therefore, impacted teeth and other pathological findings cannot be diagnosed and clinical decisions of the need of treatment for the patient cannot be made without proper radiographic examination. Our finding does not imply that all patients should have a panoramic radiograph. However, it is important for the clinician to recognize the difference between clinical and radiographic findings.

Regarding the third molar, a limitation of our study was that our sample represented adults aged 30 years and older. It would have been interesting to analyze third molars also in younger subjects; however, the Health 2000 Survey was designed to examine general and oral health in adult population alone. Nonetheless, extrapolating from Table 2, the mean numbers of third molars both in clinical and in radiographic recordings may be higher for subjects younger than 30-year-olds. The strengths of our study were as follows: the subjects were examined in clinical settings; the study was not a patient sample from a clinic; the subjects represented the adult population in the country; and the study was the largest population survey ever with panoramic radiographs.

It is concluded that numbers of third molars recorded in clinical examination alone are underreported by approximately one-third and therefore do not reflect the total number of third molars, including also impacted ones, in a population. For future population-based studies, to ensure consistency

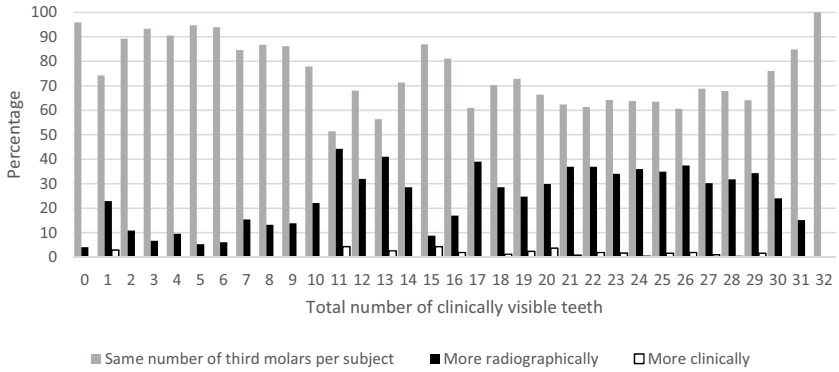

Fig. 2 Histogram (%) of the 5989 subjects according to the agreement in clinical and radiographic examinations in the number of third molars per subject, by subject's total number of clinically visible teeth. Recordings between clinical and radiographic examinations of the third molars agreed best when the subject had either full dentition or few remaining teeth

between clinical and radiographic findings, we recommend that clinical examiners check the radiographs on the same day and confirm the identification of teeth.

Funding information Open access funding provided by University of Helsinki including Helsinki University Central Hospital. Field surveys were organized by the National Institute for Health and Welfare (THL) in Finland and partly funded by the Finnish Dental Society Apollonia and the Finnish Dental Association. Planmeca Oy placed digital panoramic X-ray apparatus and software at our disposal during the survey.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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