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ORIGINAL ARTICLE

Hypodontia and retention of third molars in Norwegian medieval skeletons: dental radiography in osteoarchaeology

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ABSTRACT

Objectives: The objective of the present study is to compare the prevalence of third molar hypodontia in matched medieval and modern Norwegian sample with the aim to examine whether there are secular changes in dental anomalies. A second objective is to determine the level of primary retention of third molar in the medieval sample.

Material and methods: The medieval material consisted of 130 adult skulls, hypodontia of third molars was determined using radiography and compared to findings with panoramic film images of 400 15-year-old individuals from a contemporary Norwegian epidemiological study.

Results: Among 130 medieval skulls, hypodontia of third molar was found in 36 skulls (27.7%), and in the contemporary sample, hypodontia of third molar was found in 69 individuals (17.2%). Female predominance, although not statistically significant, was observed both in the medieval and in the contemporary group. The third molars showed absence in the mandible (21.5%) more often than the maxilla in the medieval sample, and in both jaws (11.2%) in the contemporary material. In the medieval sample, only 7.7% of the individuals had at least one retained third molar.

Conclusion: No increase in the frequency of third molar hypodontia was found from the medieval period until today. The frequency of retained third molars seems to have increased from the medieval period to modern times. The use of radiographic examination in addition to macroscopic inspection can give us a better understanding of the aetiology on a number of conditions in human skeletal remains.

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Introduction

Osteoarchaeology

Teeth and jaws in human skeletal and dental remains provide many opportunities to investigate craniofacial developmental and pathological changes in human history [1,2]. Macroscopic inspection has been the main method to evaluate the dentition and the jaws in human skeletal remains [3,4]. However, aspects such as tooth retention, hypodontia, diseases of the periodontal structures, caries lesions and some types of jaw lesions are not always observable by visual macroscopic inspection, but rather require radiographic examination in order to be identified [5–7]. A consequence of having no access to radiographs in these early studies might be an underestimation of the true frequency of these conditions. It is of interest to compare tooth retention and hypodontia of a group of Norwegians from various times in order to contribute to the understanding of the changes in environment, nutrition, healthcare, activity and lifestyle over the time period [8,9]. When investigating the frequencies of retained third molars, it is also important that the individuals to be studied are old enough to show calcification of the third molars to minimize the possibility that still uncalcified third molars are recorded as congenitally missing, leading to an overestimation of the true frequency [10]. Garn et al. [11] stated that the chances are less than 1% that calcification of a third molar will start after the age of 14 years.

Hypodontia

Hypodontia, a collective term for congenitally absent teeth, is the most common craniofacial developmental anomaly in humans [12–15]. In modern Scandinavian populations, third molar hypodontia is about 23–25% [16,17]. It is generally accepted that hypodontia is a multifactorial condition. Various genetic and environmental factors that vary in different populations over time, possibly due to differences in ethnic background and gender, have been implicated in the aetiology of hypodontia [13,14,18,19]. Genetic studies in mice suggest that hypodontia represents a complex multifactorial trait influenced by gene function, environmental interaction and developmental timing [14,20].

Primary retention

Primary retention has been used to describe the cessation of eruption of a normally placed and developed tooth germ before emergence for which no physical barrier can be

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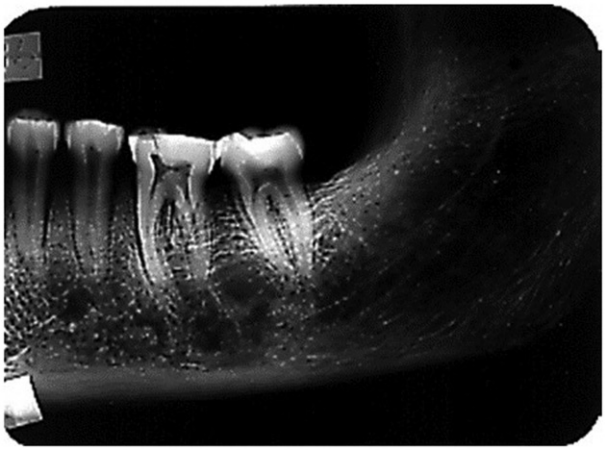

Figure 1. Periapical radiograph from the medieval skull material revealing hypodontia of the lower third molar, left side [35].

identified [6,21]. Root development has been used to distinguish between retained and non-retained teeth. In 1962, Gron showed that the majority of all teeth studied had attained approximately ¾ of their final root length at the time of clinical emergence, and considered a tooth to be 'retained' when it does not erupt at the normal eruption time [22]. The third molar is by far the most common tooth to be either congenitally absent or retained.

The prevalence of third molar retention has been investigated in several studies and varies between 27% and 73% of individuals 19–39 years of age [16,23–25]. Although third molar retention is common in the current population, osteoarchaeology skeletal materials suggest that it may have been less frequent before modern times.

The aetiology of retained teeth has been attributed to various factors, such as lack of space due to crowding of the dental arches, delayed maturation of the third molar, premature bone maturation, the degree of use of the masticatory apparatus, genetic inheritance and methods of registrations [23,26–30]. These factors may affect jaw size, tooth size and facial growth [15,31]. Several animal studies provide evidence that a reduction of masticatory function results in a narrower alveolar process and periodontal ligament with subsequent crowding as a result [1,32,33].

The aim of the present study was to use radiography to describe the occurrence of third molar hypodontia and third molar retention in Norwegian medieval archaeological skeletal material (1100–1600 AD) and to compare the observed frequency of third molar hypodontia with a group of contemporary Norwegian adolescents born between 1958 and 1972. The occurrence of third molar retention in the Norwegian medieval archaeological skeletal material (1100–1600 AD) was compared with reported contemporary Norwegian population.

Materials and methods

Medieval material

The churchyard surrounding the medieval ruins of St Olav's church in Trondheim, Norway was excavated in 1984–85 [34]. The excavated part of the cemetery was estimated to have been in use for about 500 years from *c.* 1100 AD. The excavated remains serve as the medieval material for this study.

In general, archeological skeletons are fragmented and incomplete. In order to be able to compare the archaeological skeletal material with contemporary material, it was necessary to select adult skeletons with intact dentitions and jaws. Individuals with molar areas with extensive ante mortem loss of teeth were excluded because of the uncertainty concerning presence or absence of the third molars. Among the 389 excavated graves, 130 graves contained the remains of individuals with intact jaws and dentitions and whose dental age was determined to be over 15 years of age: 60 males, 49 females and 21 of undetermined sex. All 130 medieval skulls with intact jaws and dentitions were included in this study. Sex determination of the archaeological skeletons had been made in connection with the excavation, using morphologic criteria of the pelvis and skull [34]. This made it possible to compute frequencies of retention and hypodontia of third molars for both sexes on an individual level. The 21 individuals of undetermined sex were excluded when the frequencies were computed for males and females.

The 130 medieval skulls were radiographically examined in 1995 with intraoral paralleling technique using dental films (DF 57) (Eastman Kodak Company, Rochester, NY, USA) [35] (Figure 1). In addition, occlusal films (DF 49) were exposed with bisecting angle technique to localize possibly displaced and impacted third molars. All radiographs were taken by the same examiner [35]. The X-ray source used was a portable X-ray machine, Siemens Heliodent (Sirona, Bensheim, Germany), mounted on a photographic tripod. The exposed films were developed in an automatic processor (Procomat Junior T 380, Elema - Schönander AB, Solna, Sweden).

Contemporary material

Panoramic film images of 400 15-year-old individuals, 200 females and 200 males, were randomly selected from the longitudinal growth material 'Oslo University Growth Archives', Department of Orthodontics. These archives were initiated in 1972 and completed in 1992 and included individuals born in 1958–1972. All were living in Nittedal, a community of about 16,000 inhabitants near Oslo. The individuals included in this study were radiographically examined at the Department of Maxillofacial Radiology in 1981–85.

Assessment of medieval and contemporary material

All radiographs were assessed and data recorded by the first author (CHH). Retained third molars with at least ¾ of its final root length established were registered in the total material of 130 medieval adult skulls according to the method of Gron [22].

Hypodontia of third molars was assessed using panoramic radiographs available for 400 individuals in the contemporary material and periapical radiographs obtained from 130 skulls in the medieval material. Teeth were considered to be

Table 1. Frequency of individuals with third molar hypodontia (TMH) in the medieval and contemporary material.

	*n**	0 TMH	1 TMH	2 TMH	3 TMH	4 TMH	Total 1–4 TMH
Medieval	130	94 (72.3 %)	14 (10.8 %)	14 (10.8 %)	6 (4.6 %)	2 (1.5 %)	36 (27.7 %)
Contemporary	400	331 (82.2 %)	27 (6.8 %)	22 (5.5 %)	8 (2.0 %)	12 (3.0 %)	69 (17.2 %)

*n** = number of individuals.

Table 2. Frequency of individuals with third molar hypodontia (TMH) in the medieval and contemporary material, comparing by sex and by jaw.

		Medieval			Contemporary		
		*n**	TMH	*p-value*	*n**	TMH	*p-value*
Gender				*.288*			*.145*
	Male	60	13 (21.7%)		200	29 (14.5%)	
	Female	49	15 (30.6%)		200	40 (20.0%)	
Jaw				*.078*			*>.99*
	Maxilla	130	18 (13.8%)		400	45 (11.2%)	
	Mandible	130	28 (21.5%)		400	45 (11.2%)	

congenitally missing when no mineralization of the crown could be seen on the radiographic examination. When a third molar was absent on the radiographs in the medieval material, the marginal bone was assessed by direct inspection for remains of an alveolus or for grinding facets on the opposing occlusal and adjacent approximal surfaces [36]. When neither could be seen, the absent third molar was registered as congenitally missing.

The dental and panoramic films from the medieval and contemporary materials, respectively, were examined in a darkened room using a light box (REX Messinstrumentebau GmbH, Babenhausen, Germany) with fixed intensity [37].

Statistical analyses

The statistical analyses were performed using SPSS software version 16.0 for Windows (Chicago, IL, USA). McNemar's test was used to compare the frequencies of congenitally missing third molars in the upper and lower jaws. Pearson's Chi-squared test was used to compare the frequencies of congenitally missing third molars and retention between the sexes and to compare the frequencies of congenitally missing third molars in the medieval and contemporary material. The basis of all the analyses was the individual. A statistical significance level of $p < .05$ was used.

Results

Third molar hypodontia

In the medieval material, 27.7% of the individuals were congenitally missing at least one third molar (36 individuals out of 130) compared with 17.2% in the contemporary material (69 individuals out of 400) ($p = .009$) (Table 1). In both the medieval material and the contemporary material, the frequency of individuals with third molar hypodontia was higher for females (30.6% and 20.0%, respectively) than for males (21.7% and 14.5%, respectively), although these sex differences were not statistically significant (Table 2). In the medieval material, the frequency of individuals with third molar hypodontia was higher in the mandible (21.5%) than in the maxilla (13.8%), although not significantly so (Table 2). In the contemporary material, the prevalence of third molar hypodontia was 11.2% in both jaws. None of these frequencies differed significantly by sex or jaw (Table 2).

Third molar primary retention

The frequency of individuals with retained third molars in the medieval material was 7.7% (10 out of 130 individuals). The frequency of individuals with at least one retained third molar was higher for males (8.3%, 5 out of 60 males) than for females (4.1%, 2 out of 49 females), and higher in the maxilla (6.2%, 8 out of 130) than in the mandible (3.8%, 5 out of 130), although none of these differences were statistically significant (Table 1).

Discussion

The present study is one of the first large-scale studies in osteoarchaeology applying radiographic examinations as the main method for determining the frequencies of third molar retention and hypodontia in a medieval material. The introduction of radiography has improved the reliability of the findings with regard to the prevalence of third molar retention and hypodontia, in contrast to other studies that have been limited to macroscopic inspection of the jaws [3,4]. For people living today, third molars often fail to erupt normally and are the most frequently retained teeth. The frequency of retention of the third molar and of malocclusions has generally shown an increase from the Middle Ages to modern times [9,38]. The frequency of retained third molars in our study was only 7.7% in the medieval material, which is radically lower than the range of 27-73% reported in contemporary Norwegian population [16,23–25]. Retention of third molars was not studied in our contemporary material as the material comprised only 15-year-old individuals, an age group too young to be studied with regard to third molar retention.

Third molars, being the last teeth to erupt, encounter special difficulties since the space available distally in the dental arch is often inadequate [39]. Lack of space may lead not only to tooth retention, but also to malposition or partial eruption, which again may lead to dental caries, pericoronitis (i.e. inflammation of the soft tissues around the crown of a partially erupted tooth) or resorption of adjacent roots.

During evolution, there has been a gradual reduction in the size of both the jaws and teeth. The reduction, however, has occurred faster in the jaws than in the teeth. The result of this 'lack of coordination' in jaw and tooth size reduction is that the jaws have become too small to accommodate the teeth, i.e. smaller jaws rather than large teeth are responsible for the tooth/arch discrepancy [8,40,41]. Begg [42] stated that the extensive tooth wear from prehistoric times

increased the tooth space in the arch and led to less dental crowding. However, today this is somewhat contradicted by others who emphasize the role of heredity [27]. Other researchers found that early physical maturity in combination with late mineralization of the third molar was an important aetiological factor for the impaction of the third molar [24,26]. Fanning and Moorrees [43] found marked delay in the development of third molars in Caucasoid Australian children compared to Australian Aborigines. In a study of panoramic radiographs, the third molar space was significantly smaller in the group of individuals with retained lower third molars than in the group with erupted third molars [39]. However, eruption, defined as the clinical or gingival emergence of a tooth, is not possible to evaluate in skeletal materials because of the lack of soft tissue.

When the frequency of third molar hypodontia in archaeological skeletal material is to be compared with the frequency in contemporary material, it is important to select a young adult (or adolescent) age group in the latter material since the practice today is to remove impacted and partly impacted third molars in individuals in the older age groups as a consequence of lack of space and/or crowding in the jaw. In order to get the most reliable results with regard to the frequencies of hypodontia, panoramic radiographs of 15-year-olds were chosen because by then the third molar tooth crown is visible radiographically, but has not yet erupted [44].

Analyses of the prevalence of retention or hypodontia of third molars are variously reported in the literature, based either on tooth loci or on individuals. In our study, we chose the individual as our basis for analysis, and since our study deals with frequencies of occurrence in individuals, this has limited our choice of comparative materials. In the present radiographic study, 27.7% of the skulls in the Norwegian medieval material had 1–4 congenitally missing third molars. This confirms the result of Sagne [36], who reported 26.3% in Swedish medieval material. However, in our study, the frequencies in the maxilla (13.8%) and in the mandible (21.5%) were higher than in medieval material from Denmark studied by Lundström et al. [3], who reported a frequency of 8.3% in the maxilla and 15.7% in the mandible. The frequency of third molar hypodontia was the same in both jaws in our contemporary material, but higher in the mandible than in the maxilla in the medieval material, although not statistically significant. Other studies of archaeological skeletal materials have reported a slightly higher frequency of third molar hypodontia in the mandible than in the maxilla [3,4,36], which is also the case in contemporary materials [16,22].

Interestingly, females were found to have a slightly higher frequency of third molar hypodontia in both the contemporary and medieval material in our study, although the differences between males and females were not statistically significant. Similar findings have been previously reported [4,16,36,45].

The present study revealed a significantly higher frequency of third molar absence in the medieval material compared to the contemporary material. One explanation for this difference could be that the medieval material derives from the churchyard of St. Olav's church in Trondheim, Norway, where there is a possibility of close biological relationships between the buried individuals[46]. The contemporary material, on the other hand, consists of radiographic examinations of 15-year-old non-related individuals from Nittedal, Norway.

Conclusion

In the present study, radiographic examinations were conducted to determine the frequencies of third molar retention and hypodontia in a large sample of medieval archaeological skeletal material. Based on the findings from the medieval material and recent literature on contemporary populations, the frequency of retained third molars seems to have increased from the medieval period to modern times. No significant increase in the frequency of third molar hypodontia was found from the medieval period until today. Hypodontia of third molars was found to be more common in the mandible than in the maxilla in the medieval material, and was more common in females than in males in both populations, although none of these differences were statistically significant. Macroscopic inspection has been the main method to evaluate the dentition and the jaws in human skeletal remains, however, the use of radiographic examination in addition can give us a better understanding of the aetiology on a number of conditions.

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Disclosure statement

The authors report no conflicts of interest related to this study.

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