

ORIGINAL ARTICLE

## Prevalence and distribution of demarcated opacities in permanent 1st molars and incisors in 6 to 8-year-old Danish children

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### Abstract

**Objective.** To estimate the prevalence and describe the distribution of demarcated opacities and possible consequences of this condition in permanent 1st molars and incisors in Danish children. **Material and methods.** Among all 6 to 8-year-old children in two municipalities, 745 (83.6%) were clinically examined for the occurrence of creamy-white or yellowish-brown demarcated opacities, posteruptive breakdown of tooth substance in relation to the opacities, atypical restorations, and extractions, i.e. restorations or extractions as a result of the occurrence of demarcated opacities. **Results.** In 647 children with four fully erupted permanent 1st molars, the prevalence of demarcated opacities and of lesions with loss of tooth substance due to demarcated opacities in any 1st molar was 37.3% (95% confidence interval (95% CI) 33.6–41.0%) and 6.3% (95% CI 4.7–8.5%), respectively. Permanent incisors were 2.5 times more frequently affected among children with one or more affected permanent 1st molar than among children with no such teeth. Demarcated creamy-white opacities were the type of lesion found most frequently, and the most frequently affected tooth types were the upper central incisors followed by 1st molars. **Conclusions.** Nearly half of the examined 6 to 8-year-old children had permanent 1st molars or incisors with demarcated opacities. More than 6% of the children had macroscopic loss of tooth substance due to demarcated opacities.

**Key Words:** *Developmental enamel defects, epidemiology, hypomineralization, posteruptive enamel breakdown*

### Introduction

Demarcated opacity is a qualitative dental enamel defect, clinically characterized during the early posteruptive period by a creamy-white and/or yellowish-brown discolored demarcated area of variable size [1,2]. The lesions present with altered translucency resulting from hypomineralization of areas below the enamel surface [3], areas that may gradually break down as a result of the masticatory forces, thereby changing the nature of the lesion. This turns the lesion into a quantitative defect characterized by sharp boundaries between areas with surface breakdown and intact enamel surface [1–3]. Histologically, the hypomineralized areas in the enamel manifest with varying degrees of porosity and disorganization of the enamel prisms [1,2].

The clinical consequences of demarcated opacities are dependent on the size and severity of the enamel defects [1]. Severe and extensive demarcated

opacities, which are often complicated by posteruptive loss of tooth substance, may require extensive treatment that is often complicated by hypersensitivity of the affected teeth. Furthermore, restoration of teeth with loss of tooth substance due to demarcated opacities is often hampered by, among other things, difficulty obtaining sufficient pain control, atypical boundaries of the lesions and thus of the restorations, and, eventually, problems of cooperation with the child [1,4]. As loss of tooth substance due to demarcated opacities is a significant clinical problem, knowledge of its occurrence and distribution is important.

In a number of studies using various diagnostic criteria, demarcated opacities in groups of children (range 227–2,252) at various ages have been explored and have been reported to occur in 6–25% [5–10]. The objective of this study was to estimate the prevalence of demarcated opacities in permanent

1st molars and incisors in Danish children and to describe their distribution in the dentition.

## Material and methods

### Study population

The study was conducted in Støvring and Nibe municipalities in North Jutland County, Denmark. The two municipalities have approximately 21,400 inhabitants, 25% of them below 18 years of age. The study group comprised all children in the two municipalities ( $n = 891$ ) who were 6, 7, or 8 years of age during the study period from 1 January 2005 to 31 December 2005.

The population in Støvring and Nibe municipalities is supplied with drinking water from 41 local waterworks, one of which delivers water with a fluoride content of 0.71 ppm and another of 0.73 ppm. The remaining waterworks deliver drinking water with a fluoride content ranging from 0.05 to 0.48 ppm. Caries-preventive measures, such as prescription of fluoride tablets or fluoride rinsing, have not been implemented for any of the children included.

In Denmark, all dental care is free of charge for children between the ages of 0 and 18 years, and the vast majority take advantage of the free public dental health-care system. All children are regularly offered dental examinations and most are routinely examined each year. In the two study municipalities, the dental service was offered by three municipal child dental clinics and data were collected from two of them; recording of demarcated opacities was made part of the regular clinical examination. The study was approved by the Danish Data Protection Agency (file no. 2007-41-0178).

### Methods

Immediately before examination, the teeth were brushed manually with a toothbrush and rinsed with water. The teeth were not dried in air, but with cotton-rolls placed in the buccal sulcus before examination. The following conditions were recorded [11]:

1. Eruption stage of the teeth: the teeth were recorded as fully erupted if more than half of the crown was visible; otherwise as unerupted.
2. Demarcated opacities: the color of the opacities was recorded as creamy-white or yellowish-brown.
3. Posteruptive enamel breakdown characterized by irregular and sharp edges [11].
4. Atypical restorations (the extension of restorations in teeth with demarcated opacities is usually atypical and not like that in teeth with caries [11]; the examiner confirmed the diag-

nosis of demarcated opacities as the underlying reason for making the fillings by checking notes in the dental records).

5. Extraction due to demarcated opacities as confirmed from notes in the children's dental records.

The examiners were instructed not to score diffuse opacities, as examination of the condition in this study was restricted to demarcated opacities and their consequences. The examiners were also instructed to use the lower detection limit, i.e. the demarcated opacities should be clearly visible by the eye upon examination. In addition, to avoid over-registration, the examiners were instructed to score the least serious condition in case of doubt, e.g. if in doubt between "no opacity" and "creamy-white opacity", "no opacity" should be scored, and if in doubt between "creamy-white opacity" and "yellowish-brown opacity", "creamy-white opacity" should be scored.

Since there is no national recording system for examination of demarcated opacities, we translated the diagnostic criteria developed by Weerheijm et al. [11] from English into Danish and developed illustrative material with clinical color photographs of the different clinical manifestations of the condition: demarcated opacities, posteruptive breakdown, and atypical restorations. Furthermore, we developed a standard printed form on which clinical recordings could be noted. Examinations were limited to the permanent 1st molars and incisors.

Before initiation of the study, all examiners ( $n = 7$ ) were calibrated during registration of clinical photographs of various patients presenting with different clinical manifestations of the condition. Additionally, seven patients were examined three times each; once by one of the authors (PW) and twice by two different examiners; thus, each examiner had two examinations compared twice. The overall proportion of identical diagnoses between the examiners and PW was 90.2% for eruption status, 75.6% for demarcated creamy-white or yellowish-brown opacities, 93.9% for posteruptive breakdown, 97.5% for atypical restorations, and 97.6% for extractions.

### Statistics

All registrations were transferred to EpiData and analyzed using STATA. Prevalence rates with 95% confidence intervals (95% CIs) were calculated [12] for two groups of children. In the first group, comprising children with all permanent 1st molars fully erupted, the prevalence was calculated as the number of children with one or more affected permanent 1st molar divided by the total number of children in this group. In the second group, comprising children with all permanent incisors

and 1st molars fully erupted, the prevalence was calculated as the number of children with one or more affected permanent incisors or 1st molars divided by the total number of children in this group.

## Results

Among the 891 children in the study group, 745 (83.6%) were examined. The remaining 146 were not examined for the following reasons: 4 were withdrawn from the municipal clinic, 28 moved outside the municipality, 13 missed the appointment, 3 were not invited because the individual interval between 2 routine examinations was longer than 1 year, and the remaining 98 children were not examined owing to various circumstances related to scheduling routines, unforeseen emergency visits, or lack of attention from the dental staff.

Among the children examined, 647 (86.8%) had all permanent 1st molars fully erupted and 268 (36.0%) had all permanent incisors and 1st molars fully erupted. The corresponding numbers were 90.9% and 42.2% in girls, and 83.2% and 30.4% in boys.

Prevalence in accordance with type of lesion and gender is presented in Table I. The prevalence was lower among children with all permanent 1st molars erupted than among those with eruption of all permanent 1st molars and incisors. The prevalence of lesions with tooth substance loss, i.e. posteruptive breakdown and atypical restorations, tended to be higher among girls (7.4% in girls versus 4.2% in boys), whereas no gender differences appeared for other types of lesion (Table I).

Among children with eruption of all permanent 1st molars, the prevalence of posteruptive breakdown or atypical restorations rose by increasing age from 4.7% (95% CI: 2.4–8.9%) among 6-year-olds, 5.7% (95% CI: 3.4–9.5%) among 7-year-olds, to 8.2% (95% CI: 5.4–12.4%) among 8-year-olds.

Among children with eruption of all permanent 1st molars, of which one or more were affected, the overall mean number of affected molars was 2.4 (SD: 1.2). The overall mean number of affected teeth among children with all permanent 1st molars and incisors fully erupted was 1.7 (SD: 2.6). In this group, approximately half of the children with affected teeth had one or two affected teeth, while the remaining part had three or more such teeth (Table II). Among children with affected teeth, the mean number of affected teeth, irrespective of any of the tooth types recorded, was 3.6 (SD: 2.8); the mean number of affected molars was 1.5 (SD: 1.5).

Of children with all permanent 1st molars and incisors fully erupted, 83 (31.0%) had affected permanent 1st molars. Ninety-six (35.8%) had affected permanent incisors (Table III). Of the children with affected permanent 1st molars, 38.6% had no affected incisors, while 24.3% with affected incisors had no affected permanent 1st molars. Among children with one or more affected permanent 1st molar, affected permanent incisors were 2.5 times more frequent than among children with no affected permanent 1st molar. The mean numbers of affected incisors were 1.1 (SD: 1.5), 1.2 (SD: 1.5), 1.5 (SD: 1.4), and 3.9 (SD: 3.0) among children with 1, 2, 3, and 4 permanent affected 1st molars, respectively.

Among all 745 children examined, the tooth type most frequently affected was the upper central incisor, followed by the 1st molar, the upper lateral incisor, the lower central incisor, and the lower lateral incisor (Table IV). In all teeth, the most frequent lesion was a creamy-white demarcated opacity. Lesions with tooth surface loss were more frequently found in 1st molars and upper lateral incisors than in other teeth. Five teeth had been extracted among two children; both were girls. One girl had one tooth extracted due to demarcated opacity, the other four teeth extracted.

Table I. Prevalence of demarcated opacities or loss of tooth substance due to demarcated opacities (with 95% confidence interval) in permanent first molars among 647 children with all permanent first molars fully erupted, and in permanent first molars and/or incisors among 268 children with all permanent first molars and incisors fully erupted.

Type of lesion	All permanent first molars erupted			All permanent first molars and incisors erupted		
	Girls (N = 321)	Boys (N = 326)	All children (N = 647)	Girls (N = 149)	Boys (N = 119)	All children (N = 268)
Demarcated opacities	35.5 (30.5–40.9)	38.3 (33.2–43.7)	36.9 (33.3–40.7)	47.0 (39.1–55.0)	47.9 39.1–56.8	47.4 41.5–53.4
Creamy-white	32.4 (27.5–37.7)	34.4 (29.4–39.7)	33.4 (29.9–37.1)	46.3 (38.5–54.3)	47.1 (38.3–56.0)	46.6 (40.8–52.6)
Yellowish-brown	7.8 (5.3–11.2)	10.4 (7.6–14.2)	9.1 (7.1–11.6)	8.1 (4.7–13.5)	7.6 (4.0–13.8)	7.8 (5.2–11.7)
Tooth substance loss	8.4 (5.8–12.0)	4.3 (2.6–7.1)	6.3 (4.7–8.5)	7.4 (4.2–12.7)	4.2 (1.8–9.5)	6.0 (3.7–9.5)
Posteruptive breakdown	6.2 (4.1–9.4)	2.8 (1.5–5.2)	4.5 (3.1–6.4)	7.4 (4.2–12.7)	2.5 (0.9–7.2)	5.2 (3.1–8.6)
Atypical restoration	5.6 (3.6–8.7)	2.5 (1.2–4.8)	4.0 (2.8–5.8)	6.7 (3.7–11.9)	3.4 (1.3–8.6)	5.2 (3.1–8.6)
Either demarcated opacities or tooth substance loss due to demarcated opacities	36.1 (31.1–41.5)	38.3 (33.2–43.7)	37.3 (33.6–41.0)	47.7 (39.8–55.6)	47.9 (39.1–56.8)	47.8 (41.9–53.7)

Table II. Distribution of children according to number of teeth with demarcated opacities or loss of tooth substance due to demarcated opacities.

Number of affected teeth	All permanent first molars erupted		All permanent first molars and incisors erupted	
	Number of children	%	Number of children	%
0	406	62.8	140	52.2
1	77	11.9	32	11.9
2	66	10.2	29	10.8
3	33	5.1	16	6.0
4	65	10.1	12	4.5
5	–	–	15	5.6
6	–	–	9	3.4
7	–	–	4	1.5
8	–	–	3	1.1
9	–	–	1	0.4
10	–	–	0	0
11	–	–	1	0.4
12	–	–	6	2.2
Total number of children with one or more affected teeth	241		128	
Total number of children	647	100.1	268	100.0

## Discussion

This population-based study has shown that demarcated opacities or loss of tooth substance due to demarcated opacities in permanent 1st molars and incisors is common in 6 to 8-year-old Danish children.

The study population may not be fully representative of the entire Danish population of children at this age. However, at the 15th IAPD Congress, registrations of hypomineralized 1st permanent molars in 5,277 seven-year-olds from different areas in Denmark were presented showing hypomineralization with loss of tooth substance in 4–5% of the children. These data thus agree closely with ours and indicate a limited geographical variation in the country as to the occurrence of this condition.

We used the diagnostic criteria previously proposed for epidemiological studies of permanent 1st molars and incisors with demarcated opacities or loss of tooth substance due to demarcated opacities in a daily clinical setting [11]. The examiners were calibrated and internal reliability was found to be satisfactory. However, this was better for posteruptive enamel breakdown and atypical restorations than for the creamy-white demarcated opacities.

Thus, the data on posteruptive enamel breakdown and atypical restorations are probably more valid than the data for creamy-white demarcated opacities. Misclassification of restoration caused by caries might be a source of bias, especially in permanent 1st molars. However, the examiners were instructed to verify the reasons for performing atypical restorations by checking the dental records of the children, which makes this source of misclassification unlikely. Another source of bias might be misclassification of teeth with dental fluorosis [13].

In contrast to the age of children previously recommended for evaluation of demarcated opacities, the children examined in the present study were 6 to 8 years of age [11]. The analyses, however, were restricted to groups of children with either all permanent 1st molars or all molars and incisors fully erupted. As children grow older, they usually require more dental treatment. Selection of older children as the preferred age group compared with selection of an age group presenting newly erupted molars may increase the risk of being unable to identify the underlying reason for making a restoration in a specific molar with an existing filling. As indicated in the term “atypical restoration” previously suggested [11], in most but not necessarily all cases, an

Table III. Distribution of 268 children with fully erupted permanent first molars and incisors according to presence of demarcated opacities or loss of tooth substance due to demarcated opacities in permanent first molars and incisors.

Demarcated opacities or loss of tooth substance due to demarcated opacities in one or more first molar	Demarcated opacities or loss of tooth substance due to demarcated opacities in one or more incisor		
	Present	Absent	Total
Present	51 (61.5%)	32 (38.6%)	83 (100%)
Absent	45 (24.3%)	140 (75.7%)	185 (100%)
Total	96	172	268

Table IV. Type of demarcated opacities according to tooth type in 745 6-to-8-year-old children. Percentages (%) of defects are calculated with the number of erupted teeth as reference.

	Tooth type												
	16 674	12 302	11 538	21 525	22 306	26 680	36 684	32 459	31 665	41 662	42 460	46 685	
<b>Type of lesion</b>													
Demarcated creamy-white opacity	128 (19.0)	38 (12.6)	131 (24.4)	128 (24.4)	51 (16.7)	130 (19.1)	121 (17.7)	25 (5.5)	40 (6.0)	49 (7.4)	26 (5.7)	122 (17.8)	
Demarcated yellowish-brown opacity	23 (3.4)	1 (0.3)	3 (0.6)	2 (0.4)	0	29 (4.3)	18 (2.6)	1 (0.2)	0	3 (0.5)	3 (0.7)	23 (3.4)	
Posteruptive enamel breakdown	9 (1.3)	1 (0.3)	0	0	2 (0.7)	10 (1.5)	10 (1.5)	0	0	1 (0.1)	1 (0.2)	13 (1.9)	
Atypical restorations	14 (2.1)	0	3 (0.6)	2 (0.4)	2 (0.7)	6 (0.9)	8 (1.2)	1 (0.2)	0	1 (0.1)	1 (0.2)	11 (1.6)	
Extractions	2 (0.3)	0	0	0	0	1 (0.2)	1 (0.2)	0	0	0	0	1 (0.2)	

atypical demarcation may signal that restorations have been placed due to demarcated opacities. If much dental treatment has been performed, the underlying reasons for placing the fillings may be blurred. We therefore chose to examine children aged 6 to 8 years in order to be able to consider primarily children with newly erupted molars, and thereby to reduce the potential risk of misinterpreting the reasons for the child having a restoration.

The finding in this study of an increased prevalence of posteruptive enamel breakdown or atypical restorations among girls has to be interpreted with caution. First, the statistical precision was limited. Second, even though the analyses were restricted to individuals with eruption of all permanent 1st molars or all permanent 1st molars and incisors, it was not possible to determine the exact time of eruption. It has been shown that girls' teeth erupt earlier than boys' [14]. The tendency towards a gradual shift over time from less to more severe defects due to later loss of tooth substance may therefore have influenced the prevalence figures. Longitudinal studies are needed to elucidate this question.

Comparisons with earlier prevalence studies are hampered by differences in the diagnostic criteria applied. However, four studies from different countries used the same examination method and judgement criteria as we did [7,9,10,15]. In the studies conducted in Sweden [7], Italy [9], and Libya [10], 7 and 8-year-old children were included, whereas in the study conducted in Finland, the age of the study group was 7 to 13 years [15]. The Swedish population-based study found that 25% of the children had one or more teeth with demarcated opacities or loss of tooth substance due to demarcated opacities, which is a lower proportion than found in the present study [7]. One possible explanation for this disagreement could be that defects less than 2 mm in diameter were excluded in the Swedish study but not in the present study. Furthermore, the children did not receive a special invitation in connection with the present study, but were examined during routine examinations, and a number of the children were not examined for different reasons. Recall of children with demarcated opacities may receive more attention in the administrative system, while children without this condition may be more likely to be missed in the recall routines. This may have biased our results towards overestimation of the prevalence. Finally, data analyses in the present study were restricted to groups of children with either all permanent 1st molars or all molars and incisors fully erupted. This reduced the size of the materials for estimation of prevalence, so the estimates are less precise than those produced on the basis of larger study materials.

Prevalences of macroscopic loss of tooth substance in the Swedish (6.4%) [7] and Italian (7.5%) studies

[9] largely corresponded to the prevalence reported in our study (6.3%). The Finnish study reported macroscopic tooth substance loss in permanent 1st molars among 8.4% of the children, which is slightly higher than our estimates [15]. This may partly be explained by the inclusion of older children in the Finnish study, as some of the yellowish-brown demarcated opacities may break down over time. This explanation is supported by findings in the present study of an increased prevalence of macroscopic loss of tooth substance by increasing age.

Fteita and co-workers examined 369 children from Libya, none of whom had loss of enamel in permanent 1st molars and only 7.1% had demarcated opacities [10]. The authors rejected ethnicity as an explanation for their low prevalence figures, arguing that the findings by Zagdwon and co-workers [16] failed to demonstrate any differences between different ethnic groups. In the present study, no data were available with which to examine the effect of ethnicity, but the study population was mainly of Caucasian origin.

In a German study, only 5.6% of the 10 to 17-year-old children had demarcated opacities or loss of tooth substance due to demarcated opacities [8]. Even though atypical restorations were registered during the examination, the authors pointed out that some atypical restorations and opacities could be “masked” as restorations due to caries. The probability of identifying posteruptive breakdowns or atypical restorations in permanent 1st molars, and hence the reported prevalence of demarcated opacities, may have been hampered by the ‘high’ age of this population.

In agreement with previous findings, the present study has shown that creamy-white demarcated opacities are the most frequent type of lesion [17,18]. Furthermore, the finding that the upper central incisor is the most frequently affected tooth type, followed by the permanent 1st molar, is also in agreement with earlier reports [17,19].

The present study has demonstrated that children with affected permanent 1st molars have a higher number of affected incisors than children without such defects in the molars. Furthermore, most of the children with demarcated opacities have more than one affected tooth. As pointed out by Weerheijm [20], one clinical implication of this is that children with an affected tooth should be offered closer surveillance because they are at increased risk of having more than one affected tooth. The finding of several affected teeth of the same tooth type may support the hypothesis of the systemic origin of demarcated opacities [20], which will most likely affect all teeth developing during the time period where the systemic factor is effective.

A number of different terms have been used for this condition; use of the term “molar incisor hypomineralization” has therefore been suggested

defined as “hypomineralization of systemic origin of 1–4 permanent first molars, frequently associated with affected incisors” [11,21]. In the present study, no exact information as to the origin of the recorded demarcated opacities was obtainable, except that examiners were instructed not to include disturbances due to trauma in the incisor region by checking the children’s dental records. It was not possible, therefore, to ensure that the demarcated opacities recorded were all of systemic origin rather than due to a local, conditional type of affection. We therefore chose not to use the MIH terminology in the present study.

Owing to the simplicity of the suggested clinical recording of demarcated opacities or loss of tooth substance due to demarcated opacities [11], our data collection could be performed in a rational way, which is an important advantage in epidemiological studies. Regular reporting of the condition using these criteria could thus contribute valuable information to the reporting of dental health among Danish children [22].

The demonstrated high prevalence of affected teeth, of which some have a more or less severe tooth substance loss, testifies to the urgent need for appropriate clinical management and calls for the development of new, or the improvement of existing, methods for providing these children with proper dental treatment. In Denmark, linkage of data on demarcated opacities to data from other health registries is possible using the unique Civil Personal Registration number [23]. Such an approach would be conducive to epidemiological studies aimed at improving our understanding of the etiology and prognosis of demarcated opacities.

In conclusion, nearly half of the examined 6 to 8-year-old children had permanent 1st molars or incisors with demarcated opacities. More than 6% of the children had demarcated opacities resulting in macroscopic loss of tooth substance.

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