

Severity of MIH findings at tooth surface level among German school children

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Abstract

Aim This study was to investigate the distribution and clinical characteristics of teeth diagnosed with MIH at surface and defect type level in a cohort of German children.

Methods The study cohort included 242 children diagnosed with MIH which had been recorded during the compulsory dental school examinations of 20 German primary schools. The subjects had been enrolled by cluster

sampling. All children attended the second to fourth grade (age 7–10 years, mean 8.1 ± 0.8). The children were examined by five calibrated examiners ($\kappa = 0.9$) after tooth brushing. The recording comprised teeth, surfaces, type and severity of MIH defects and was conducted using a portable light, mirrors and cotton rolls. MIH was registered according to the EAPD criteria. Defects <1 mm were not recorded. Statistical analysis included descriptive statistics and Spearman's correlation.

Results Most affected teeth were first permanent molars (71.4 %) followed by the maxillary central incisors (15.6 %). The most common defects were demarcated opacities (82.2 %), while the remaining 17.8 % of the affected teeth exhibited severe enamel defects. The most frequently affected surface in molars was the occlusal surface (72.4 %); in incisors, it was the buccal surface (73.5 %). There were no atypical restorations in the affected incisors. Different types of MIH defects at various surfaces of the same tooth were common. The number of affected tooth surfaces was positively correlated with the severity of MIH at child ($p < 0.001$).

Conclusions The study demonstrates severe enamel defects involving in almost one-fifth of all MIH teeth. The knowledge of the intra-oral distribution and severity of MIH findings at the enamel surface level is important for assessing the treatment needs.

Keywords MIH · Germany · Tooth surface · Combinations

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Introduction

The enamel defect characterised as “molar incisor hypomineralisation” (MIH) seems to be common among

children in Europe [3.58–21.8 % (Kukleva et al. 2008; Jälevik 2010; Lygidakis et al. 2010; Garcia-Margarit et al. 2014)]. This qualitative defect appears in the first permanent molars and frequently in incisors (Weerheijm et al. 2001; Chawla et al. 2008). The clinical characteristics can differ between the teeth of the same patient (Weerheijm et al. 2003; Lygidakis et al. 2010). Although the clinical findings also differ substantially between patients, most of the MIH studies show no gender-related distribution differences (Jälevik et al. 2001; Leppäniemi et al. 2001; Behrendt et al. 2004; Calderara et al. 2005; Fteita et al. 2006; Muratbegovic et al. 2007; Preusser et al. 2007; Martínez Gómez et al. 2012; Jasulaityte et al. 2007).

According to the EAPD criteria (Weerheijm et al. 2003), MIH teeth present demarcated opacities, post-eruptive breakdown and atypical restorations or may fail to erupt. In some severe cases, MIH molars might also need to be extracted. Although there is a lack of detailed information regarding the distribution of MIH defects between the different surfaces of affected teeth, the occlusal and the buccal surfaces are reported to be the most commonly hypomineralised areas in the first permanent molars and incisors (Muratbegovic et al. 2007; Preusser et al. 2007; da Costa-Silva et al. 2010).

The through mineral content in defective enamel (Chawla et al. 2008) and its breakdown leads to hypersensitivity, e.g. when tooth brushing (Lygidakis et al. 2010). This favours rapid caries development. Thus, some studies have shown statistically significantly higher DMFT values in children with MIH (Behrendt et al. 2004; Preusser et al. 2007), although this has not been the case in other studies (Dietrich et al. 2003; Heitmüller et al. 2013). The necessity of caries prevention in MIH teeth beginning from the early stage of eruption has been strongly reinforced in order to eliminate caries progression and reduce future restorative treatment needs (Lygidakis et al. 2010). Though the knowledge of the intra-oral distribution and severity of MIH findings is helpful for assessing the treatment needs (Oliver et al. 2014), an association with severity has been proven at tooth level, since more severe cases present with more affected teeth (Jasulaityte et al. 2007; Ghanim et al. 2011; Heitmüller et al. 2013).

Thus, the aim of this study was to determine the distribution as well as severity and other clinical characteristics of MIH-affected teeth at surface level in a cohort of children who had been diagnosed with MIH.

Methods

Ethical approval

The data had been recorded during an epidemiological MIH study from February 2011 till March 2012 (Petrou et al.

2014) following an approval by the Greifswald University's ethic commission council (BB 66/10). The school principals were also informed and approved all the necessary procedures as school oral examinations in Germany are compulsory with teachers coordinating these surveys.

Materials and methods

During the compulsory dental examinations of 20 German primary schools in four cities of Germany (West: Düsseldorf, East: Greifswald, North: Hamburg, South: Heidelberg), 242 children (10.1 %), out of 2395 examined, attending the second to fourth grade (128 boys, 114 girls), aged 7–10 years (mean 8.1 ± 0.8), were diagnosed with MIH according to the EAPD criteria (Weerheijm et al. 2003; Lygidakis et al. 2010). After tooth brushing, the teeth were examined using a portable light source, mirrors and cotton rolls.

All MIH defects >1 mm in diameter were registered. According to the recent EAPD criteria, defect types and severity (mild, severe) were recorded (Lygidakis et al. 2010). In addition to the clinical examination, standardised questions were asked of each child regarding any history of tooth hypersensitivity in order to evaluate the severity of the alteration at child level (Lygidakis et al. 2010). The questions referred to any experience of hypersensitivity/pain during daily activities (e.g. tooth brushing/eating).

Prior to the dental examinations, the five examiners had been trained and calibrated by using a group of pictures demonstrating different kinds of enamel defects. Repetitive diagnostics with these clinical pictures resulted in excellent intra- and interexaminer reliability ($\kappa = 0.9$). Additionally, the senior investigator (MP) was present during the first examinations performed by each examiner in all the selected cities.

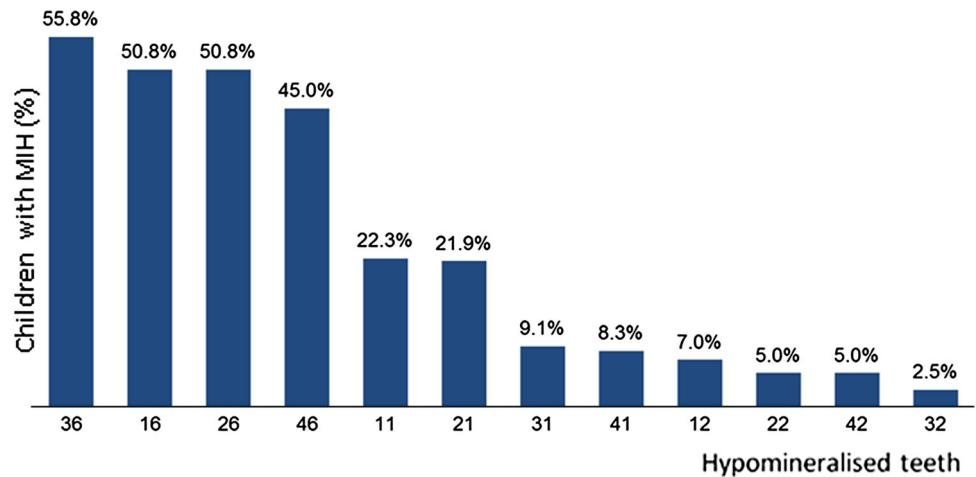
Data were recorded in Excel tables, coded and statistically analysed using the program SPSS[®] for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). The statistical MIH characteristic evaluation was performed with descriptive statistics. Any possible associations of the number of affected teeth and surfaces with the severity of the defects were statistically analysed with χ^2 test and Spearman's correlation.

Results

Defect distribution in the index teeth

The frequency of MIH teeth differed between the four quadrants in the mouth (Fig. 1). The differences between the mean number of affected teeth in the maxilla (1.56 ± 1.21) and mandible (1.25 ± 0.99) were

Fig. 1 Distribution of hypomineralised teeth (first permanent molars and maxillary incisors) in children ($n = 242$) with MIH (%)



statistically significant ($p < 0.001$) and determined by the affected incisors. As shown in Fig. 1, the most frequently affected teeth were the mandibular first permanent molars ($n = 244$) followed by the maxillary molars ($n = 232$) and to lesser extent the maxillary permanent central incisors ($n = 107$). All MIH-affected children had at least one hypomineralised molar, the mean number being 2.0 ± 1.1 , while 39.2 % of the children presented with one affected molar, 33.5 % with two, 12.0 % with three and 15.3 % with four affected molars. The mean number of affected incisors was 0.8 ± 1.2 ; however, 57.8 % of the children with hypomineralised molars had no signs of MIH in their incisors and 19.1 % presented only one affected incisor. The mean number of affected teeth per child was 2.8 ± 1.7 .

Defect types in the index teeth

The majority of the affected teeth presented with demarcated opacities (82.8 %, molars 77.7 %, $n = 380$; incisors 95.9 % $n = 188$), whereas 10.3 % (molars 12.7 %, $n = 62$; incisors 4.1 %, $n = 8$) had post-eruptive breakdown and 6.9 % (only molars 9.6 %, $n = 47$) had atypical restorations. One first permanent molar was missing in a nine-year-old child. The reason remains unknown, but the child was diagnosed with MIH affecting other teeth and had no caries experience or restorations in the permanent dentition, and the other index teeth were completely erupted.

Combinations of defect types in the index teeth

Ninety-two of the total 490 hypomineralised first permanent molars (18.8 %) exhibited various combinations of MIH defects. Among them, 55.4 % ($n = 51$) molars demonstrated demarcated opacities and post-eruptive breakdown, 14.2 % ($n = 13$) demarcated opacities and atypical restorations, 8.7 % ($n = 8$) demarcated opacities, post-eruptive breakdown and atypical restoration, whereas

21.7 % ($n = 20$) had post-eruptive breakdown and atypical restoration. Only 1.5 % ($n = 3$) of the hypomineralised incisors showed demarcated opacities with post-eruptive breakdown affecting different surfaces.

Defect distribution at surface level

The mean number of affected surfaces per child was 4.5 ± 3.8 . The most common defects were demarcated opacities, while the most affected surface in molars was the occlusal (72.4 %, $n = 353$) and in the incisors the buccal (73.5 %, $n = 144$) surface. Buccal surfaces were the second most commonly affected surfaces on MIH molars (57.7 %, $n = 283$) followed by the lingual/palatal surfaces (32.6 %, $n = 160$). The surfaces affected the least were the mesial in both the molars and the incisors (Table 1).

Sensitivity and severity of the enamel defects

Seventy-four out of the 242 (31 %) MIH-affected children presented with hypersensitivity of at least one of their hypomineralised teeth during daily activities (e.g. tooth brushing/eating). In addition 17.8 % ($n = 117$) of the MIH teeth presented with clinically detected surface breakdown and/or atypical restorations.

Correlation of the MIH severity and number of affected surfaces

There was a statistically significant correlation between the number of affected molar surfaces per child and the occurrence of severe forms of MIH (χ^2 test $p < 0.001$; Spearman's correlation $r = 0.366$; $p < 0.001$; Fig. 2). A further statistically significant correlation was revealed between the number of all affected surfaces (including incisors) and the occurrence of severe forms of MIH (Spearman's correlation, $r = 0.321$, $p < 0.001$).

Table 1 Distribution of MIH defects among surfaces of MIH teeth (490 molars and 196 incisors) in a population of German children

	Surfaces of first permanent molars % (n)				Surfaces of incisors % (n)		
	Atypical restoration	Post-eruptive breakdown	Demarcated opacity	All	Demarcated opacity	Post-eruptive breakdown	All
Mesial	1.2 (6)	0.0 (0)	15.9 (78)	17.1 (84)	3.1 (6)	0.0 (0)	3.1 (6)
Occlusal/incisal	9.2 (45)	9.2 (45)	54.1 (265)	72.4 (355)	2.0 (4)	1.5 (3)	3.6 (7)
Distal	1.2 (6)	1.6 (8)	14.9 (73)	17.7 (87)	3.1 (6)	0.5 (1)	3.6 (7)
Buccal	4.5 (22)	2.0 (10)	51.2 (251)	57.7 (283)	72.4 (142)	1.0 (2)	73.5 (144)
Lingual/palatinal	1.8 (9)	1.4 (7)	29.4 (144)	32.6 (160)	24.0 (47)	0.0 (0)	24.0 (47)

Discussion

The present study is among the first ones providing detailed information about the distribution of MIH at surface level, as well as reporting findings of MIH characteristics in the same tooth. Although Koch et al. (1987) in their early epidemiological study classified the characteristics of hypomineralised first permanent molars and incisors with respect to surface units, the prevalence of defective surfaces has rarely been examined in the past. In contrast to the criteria used in that study (Koch et al. 1987), the present examination included the fissure systems as part of the molars' occlusal surfaces. Additionally the molars' smooth surfaces were divided into mesial, distal, buccal and lingual surfaces in order to simplify the examination procedure. Although the diagnosis of MIH defects, exhibited on the distal, mesial or occlusal surfaces under preventive fissure sealants could be a challenging task, the inspection around the contact surface with the primary molar and margins of any fissure sealants could be revealed. The most frequently affected surfaces, the occlusal ones in the molars and the buccal ones in the incisors, in addition to the most common

type of defects (demarcated opacities) were observed in the present study. This finding was in agreement with previous studies (Lygidakis et al. 2008; Wogelius et al. 2008; Ghanim et al. 2011; Mittal et al. 2014). Furthermore, similar mean numbers of affected surfaces (4.5 ± 3.8) have been reported in a recent study from India (4.99 ± 2.9 ; Mittal et al. 2014).

The results of the present study regarding the defect characteristics and severity highlight the need for further research on this subject, since the increase in affected surface numbers is apparently related to the severity of MIH. Similar findings were reported in the study of Mittal et al. (2014). Additionally, Oliver et al. (2014) judged the treatment needs of hypomineralised teeth based on the defects' clinical appearance. Those authors suggested that the location of the most severe MIH defects combined with other clinical characteristics (e.g. prior restoration, sensitivity, etc.) and could be the basis for a new MIH severity index. However, as the molar characteristics are related to other tooth surfaces than in the present study (cuspal, occlusal and smooth), a direct comparison with our results would not be reliable. The heterogeneity of the tooth surfaces as examined for MIH emphasizes the need for clear MIH guidelines.

Regarding the distribution of MIH defects at the tooth level, the results of the present study are in agreement with the other German (Dietrich et al. 2003; Heitmüller et al. 2013) and international studies (Jälevik et al. 2001; Jasulaityte et al. 2007; Lygidakis et al. 2008; Ghanim et al. 2011). Demarcated opacities comprised by far the commonest of MIH defects (82.2 %; Jasulaityte et al. 2007; Ghanim et al. 2011; Heitmüller et al. 2013), as well as the upper central incisors, are more frequently affected (22.3–21.9 %) than the lateral (7.0–5.0 %) and mandibular incisors (9.1–2.5 %) (Lygidakis et al. 2008). The mean number of affected molars per child was also consistent with the previous reports (Jälevik et al. 2001; Dietrich et al. 2003). Severe defects with post-eruptive breakdown or atypical restorations have been less common among the affected teeth (Ghanim et al. 2011; Heitmüller et al. 2013), whereas Lygidakis et al. (2008) reported higher

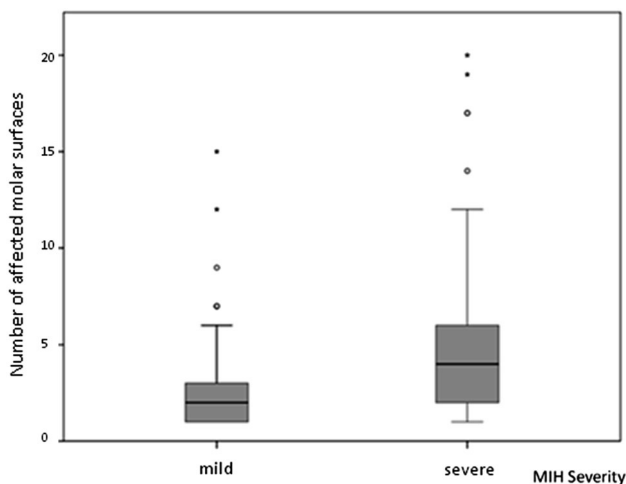


Fig. 2 Number of affected molar surfaces in a group of German children with mild or severe forms of MIH

prevalences of these defect types among children with MIH. However, our findings that nearly one-fifth of all MIH teeth exhibit more severe characteristics and the frequent prevalence of teeth with combinations of different MIH defect types support recommendations of previous investigations for early diagnosis of MIH, in order to prevent more severe defects, more complicated treatments and higher treatment costs (Jasulaityte et al. 2008; Lygidakis et al. 2010; Oliver et al. 2014). This recommendation has an additional implications as multiple treatment sessions reduce patients' collaboration even in adolescence and adulthood (Jälevik and Klingberg 2012). Eighteen-year-old MIH patients tend to show the same dental fear and anxiety during dental treatment as in their childhood (Jälevik and Klingberg 2002, 2012).

In cases where MIH is diagnosed later, the condition of the affected teeth might significantly deteriorate as avoidance of brushing the hypersensitive defective teeth may result in rapid caries development (Leppäniemi et al. 2001; Weerheijm 2003, 2004). Hence, information regarding MIH, the importance of tooth brushing and of regular dental examinations as well as early treatment, has to be emphasised to the public and, especially, to parents.

Conclusion

Almost one-fifth of teeth diagnosed with MIH exhibit severe defects. The MIH alterations are concentrated mostly at specific tooth surfaces, and there was a risk of having more severe lesions with an increasing number of affected surfaces per child. Detailed knowledge of the intra-oral distribution of MIH at the tooth surface level would be beneficial in assessing appropriate treatment approaches. Further epidemiological studies concerning MIH should consider the prevalence of MIH as well as the distribution of hypomineralisations at the tooth surface level.

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

References

- Behrendt A, Ansari F, Reckel U, Schleenbecker F, Wetzel WE. Molar–incisor hypomineralisation (MIH): a German study. *Oralprophylaxe&Kinderzahnheilkunde*. 2004;26:112–7.
- Calderara PC, Gerthoux PM, Mocarrelli P, et al. The prevalence of molar incisor hypomineralisation (MIH) in a group of Italian school children. *Eur J Paediatr Dent*. 2005;6:79–83.
- Chawla N, Messer LB, Silva M. Clinical studies on molar–incisor hypomineralisation part 1: distribution and putative associations. *Eur Arch Paediatr Dent*. 2008;9:180–90.
- da Costa-Silva CM, Jeremias F, de Souza JF, et al. Molar incisor hypomineralization: prevalence, severity and clinical consequences in Brazilian children. *Int J Paediatr Dent*. 2010;20:426–34.
- Dietrich G, Sperling S, Hetzer G. Molar incisor hypomineralisation in a group of children and adolescents living in Dresden (Germany). *Eur J Paediatr Dent*. 2003;4:133–7.
- Fteita D, Ali A, Alaluusua S. Molar–incisor hypomineralization (MIH) in a group of school-aged children in Benghazi, Libya. *Eur Arch Paediatr Dent*. 2006;7:92–5.
- Garcia-Margarit M, Catalá-Pizarro M, Montiel-Company JM, Almerich-Silla JM. Epidemiologic study of molar–incisor hypomineralization in 8-year-old Spanish children. *Int J Paediatr Dent*. 2014;24(1):14–22.
- Ghanim A, Morgan M, Mariño R, Bailey D, Manton D. Molar–incisor hypomineralisation: prevalence and defect characteristics in Iraqi children. *Int J Paediatr Dent*. 2011;21:413–21.
- Heitmüller D, Thiering E, Hoffmann U, et al. Is there a positive relationship between molar incisor hypomineralisations and the presence of dental caries? *Int J Paediatr Dent*. 2013;23:116–24.
- Jälevik B. Prevalence and diagnosis of molar–incisor hypomineralisation (MIH): a systematic review. *Eur Arch Paediatr Dent*. 2010;11:59–64.
- Jälevik B, Klingberg GA. Dental treatment, dental fear and behaviour management problems in children with severe enamel hypomineralization of their permanent first molars. *Int J Paediatr Dent*. 2002;12:24–32.
- Jälevik B, Klingberg G. Treatment outcomes and dental anxiety in 18-year-olds with MIH, comparisons with healthy controls: a longitudinal study. *Int J Paediatr Dent*. 2012;22:85–91.
- Jälevik B, Klingberg G, Barregård L, Norén JG. The prevalence of demarcated opacities in permanent first molars in a group of Swedish children. *Acta Odontol Scand*. 2001;59:255–60.
- Jasulaityte L, Veerkamp JS, Weerheijm KL. Molar incisor hypomineralization: review and prevalence data from the study of primary school children in Kaunas/Lithuania. *Eur Arch Paediatr Dent*. 2007;8:87–94.
- Jasulaityte L, Weerheijm KL, Veerkamp JS. Prevalence of molar–incisor-hypomineralisation among children participating in the Dutch National Epidemiological Survey (2003). *Eur Arch Paediatr Dent*. 2008;9:218–23.
- Koch G, Hallonsten A-L, Ludvigsson N, et al. Epidemiology study of idiopathic enamel hypomineralisation in permanent teeth of Swedish children. *Community Dent Oral Epidemiol*. 1987;15:279–85.
- Kukleva MP, Petrova SG, Kondeva VK, Nihtyanova TI. Molar incisor hypomineralisation in 7-to-14-year old children in Plovdiv, Bulgaria: an epidemiologic study. *Folia Med (Plovdiv)*. 2008;50(3):71–5.
- Leppäniemi A, Lukinmaa PL, Alaluusua S. Nonfluoride hypomineralizations in the permanent first molars and their impact on the treatment need. *Caries Res*. 2001;35:36–40.
- Lygidakis NA, Dimou G, Briseniou E. Molar–incisor-hypomineralisation (MIH). Retrospective clinical study in Greek children. I. Prevalence and defect characteristics. *Eur Arch Paediatr Dent*. 2008;9:200–6.
- Lygidakis NA, Wong F, Jälevik B, et al. Best clinical practice guidance for clinicians dealing with children presenting with molar–incisor-hypomineralisation (MIH): an EAPD policy document. *Eur Arch Paediatr Dent*. 2010;11:75–81.
- Martínez Gómez TP, Guinot Jimeno F, Bellet Dalmau LJ, Giner Tarrida L. Prevalence of molar-incisor hypomineralisation

- observed using transillumination in a group of children from Barcelona (Spain). *Int J Paediatr Dent*. 2012;22:100–9.
- Mittal NP, Goyal A, Gauba K, Kapur A. Molar incisor hypomineralisation: prevalence and clinical presentation in school children of the northern region of India. *Eur Arch Paediatr Dent*. 2014;15:11–8.
- Muratbegovic A, Markovic N, Ganibegovic Selimovic M. Molar incisor hypomineralisation in Bosnia and Herzegovina: aetiology and clinical consequences in medium caries activity population. *Eur Arch Paediatr Dent*. 2007;8:189–94.
- Oliver K, Messer LB, Manton DJ, et al. Distribution and severity of molar hypomineralisation: trial of a new severity index. *Int J Paediatr Dent*. 2014;24:131–51.
- Petrou MA, Giraki M, Bissar AR, et al. Prevalence of molar–incisor–hypomineralisation among school children in four German cities. *Int J Paediatr Dent*. 2014;24:434–40.
- Preusser SE, Ferring V, Wleklinski C, Wetzel WE. Prevalence and severity of molar incisor hypomineralization in a region of Germany: a brief communication. *J Public Health Dent*. 2007;67:148–50.
- Weerheijm KL, Groen HJ, Beentjes VE, Poorterman JH. Prevalence of cheese molars in eleven-year-old Dutch children. *ASDC J Dent Child*. 2001;68(259–62):229.
- Weerheijm KL, Duggal M, Mejare I, et al. Judgement criteria for molar incisor hypomineralisation (MIH) in epidemiologic studies: a summary of the European meeting on MIH held in Athens, 2003. *Eur J Paediatr Dent*. 2003;4:110–3.
- Weerheijm KL. Molar incisor hypomineralisation (MIH). *Eur J Paediatr Dent*. 2003;4:114–20.
- Weerheijm KL. Molar incisor hypomineralization (MIH): clinical presentation, aetiology and management. *Dent Update*. 2004;31:9–12.
- Wogelius P, Haubek D, Poulsen S. Prevalence and distribution of demarcated opacities in permanent 1st molars and incisors in 6 to 8-year-old Danish children. *Acta Odontol Scand*. 2008;66:58–64.