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A clinical and statistical study on enamel hypomineralization of the first permanent molar in the period of mixed dentition

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Abstract

Background: The first permanent molar (FPM) is the first tooth in the permanent dentition that emerges in the oral cavity, at around the age of six and behind the deciduous teeth, thus converting the primary dentition into a mixed dentition. Its early formation represents a risk factor for the onset of hard dental tissues disorders, the most common being the molar incisor hypomineralization (MIH). *Aim*: The aim of the study was to assess the hypomineralization type of developmental defects of enamel at FPM level during the mixed dentition stage, in a group of Romanian children. *Patients, Materials and Methods*: The research was conducted on 87 patients, 44 females and 43 males, divided into the following age groups: 5–6 years, 6–7 years, 7–8 years, 8–9 years, 9–10 years, 10–11 years, 11–12 years and older than 12 years. All children were examined in the dental office by a pediatric dentist. *Results*: Of the subjects, 40.2% presented hypomineralization lesions on the FPM. Among the affected children, 62.9% were girls and 37.1% were boys. Mild forms were the most prevalent, being found in 71.4% of the affected subjects. Moderate forms were present in 22.9% and severe forms in 5.7% of the affected children. MIH prevalence significantly decreased with increasing age. Only two children belonging to the group 8–9 years and 10–11 years, respectively, showed severe MIH lesions. Statistically significant differences were determined in what regards the distribution of MIH children according to the severity of the lesions in relation to age (p=0.007). *Conclusions*: Children 6- to 7-year-old have been the most affected by FPM hypomineralization, which indicates the need for early management of the disease, through a thorough diagnosis, and preventive and interceptive therapeutic approaches.

Keywords: developmental defects of enamel, first permanent molar, prevalence, mixed dentition, pediatric dentistry.

Introduction

The first permanent molar (FPM) is the first tooth in the permanent dentition that emerges in the oral cavity, at around the age of six and behind the deciduous teeth, thus converting the primary dentition into a mixed dentition, characterized by the cohabitation of the primary and permanent teeth in the dental arches. Mixed dentition is considered one of the most dynamic periods in the development of the stomatognathic system [1], the FPM having specific roles in this process. Thus, during this transitional stage, while the deciduous teeth exfoliate, and permanent molars have not erupted, the contacts achieved by the antagonistic FPMs represent the only stable posterior occlusal stops that exist [2]. The FPM compensates for the mandibular rotation pattern through changing its vertical position, in this way establishing the vertical dimension of occlusion [3, 4], which in turn, determines the height of the lower third of the face and contributes to achieving overall facial esthetics [5, 6]. At the same time, the FPM is prone to different pathologies of its dental hard tissues, owing to its early formation and mineralization which take place during difficult periods of human development [2]. Further risk factors related to the specific oral environment of the mixed dentition stage also contribute to the onset and progress of diseases of the dental hard tissues in the FPM; these include the cohabitation with the primary teeth which are mobile at the time of the physiological resorption of their roots, sometimes decayed, thus favoring dental plaque accumulation [2].

Molar incisor hypomineralization (MIH) is considered the most common entity among tooth enamel developmental defects [7]. MIH was first communicated by Swedish dentists in the late 1970s, who noticed an increased prevalence among children of "an extensive and severe hypomineralization of the FPM enamel" [8]. Thirty-one years later, MIH was defined as "a hypomineralization of systemic origin of one to four FPMs frequently associated with affected incisors" [9].

Enamel hypomineralization is caused by a dysfunction in the calcification stage of amelogenesis [10–13]. Therefore, MIH is a qualitative defect, characterized by lower calcium and phosphorus concentrations in the enamel matrix [7] and the presence of high amounts of proteins, which impede the enzymatic activity and the growth of the hydroxyapatite crystals during enamel maturation [14–16]. As amelogenesis is completed at the time of tooth eruption and the ameloblasts (the cells responsible for the amelogenesis) die after the

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end of this process, no enamel regeneration or repair is possible afterwards [17]. Consequently, impairments of the enamel formation emerge as permanent defects in the erupted tooth [12]. Amelogenesis is a sensitive process, which can be disturbed by systemic and environmental factors [10–13, 18]. The amelogenesis of the FPM starts at around the 8th month of intrauterine life and ends at the age of 4; therefore, the risk factors for MIH onset interfere with amelogenesis during this time interval, with the first 10 months of life being critical [7, 19].

Initially, hypomineralization lesions can be visualized in the newly erupted tooth as enamel opacities, creamy-white, yellow, or brown colored; a distinct delimitation between the affected and the sound enamel is a characteristic of them, hence the name "demarcated opacities" [8]. The hypomineralized enamel is porous and fragile and collapses under the masticatory forces within a short period of time [20]. Caries rapidly develop and progress on the hypomineralized tooth [20]. In direct relation to specific enamel breakdown and associated dental caries, sensitivity is a common complaint from MIH affected children [20, 21]. MIH is a progressive disease; if untreated, it can rapidly lead to massive loss of hard dental tissues [22]. According to their severity, MIH lesions fall into three categories: mild, moderate, and severe, described by Mathu-Muju & Wright (Table 1) [23, 24].

Table 1 – *The severity scale of MIH (after Wright [24])*

Category	Features
Mild	Isolated, demarcated enamel opacities located on non-stress bearing surfaces of the FPM. No caries and tooth sensitivity present.
Moderate	Demarcated enamel opacities on the occlusal third of the FPM, without initial enamel breakdown. Posteruptive enamel breakdown and caries limited to one or two surfaces without cuspal involvement. FPM in need for atypical restorations, or intact atypical restorations already present. Normal tooth sensitivity.
Severe	Posteruptive enamel breakdown on erupting tooth, with rapid evolution. Large cavities associated with the hypomineralized enamel. History of tooth sensitivity. Esthetic concerns when incisors hypomineralization is associated.

FPM: First permanent molar; MIH: Molar incisor hypomineralization.

A common occurrence in relation to MIH is the variability of the lesions in the same subject, meaning that one tooth may present a mild form, while another can be severely affected [24].

Hypomineralization should not be confused with the other developmental defects of enamel: *amelogenesis imperfecta*, enamel hypoplasia and dental fluorosis. *Amelogenesis imperfecta* is a quantitative structural disturbance of the enamel, without dentin involvement [7]. Unlike MIH lesions, which are located only in FPMs and incisors, *amelogenesis imperfecta* affects all teeth in the permanent dentition [7]. Enamel hypoplasia is a quantitative disorder of the enamel caused by an impairment during the secretory phase of the amelogenesis [7]. It is expressed as an external defect involving the enamel surface [8] and a localized reduction in the enamel thickness [7]. After enamel breakdown has occurred, MIH lesions could resemble hypoplasia ones [7], but the margins of broken hypomineralized enamel are sharp and irregular, while the margins of hypoplastic enamel are rounded and smooth [8]. Dental fluorosis occurs as the result of excessive fluoride absorption during the mineralization stage of amelogenesis and is characterized by diffuse white opacities which affect homologous teeth [7, 8]. Therefore, symmetry is a characteristic of the fluorotic enamel defects [7]. Unlike hypomineralized teeth, the hard dental tissues are caries-resistant in fluorosis [7].

MIH screening is an important component of a child's dental examination. Considering the "dynamic" nature of MIH defects [25], treatment should be focused on intercepting the disease, to improve the long-term prognosis of MIH teeth [20, 26]. Preventive measures envisage fluoride varnish application for initiating enamel remineralization and dental sealants placement [19, 20]. Once the enamel breakdown has occurred, severe restorative problems arise [20]. Restoration failure is a common occurrence in such cases, being the result of the altered prismatic morphology of the hypomineralized enamel which hampers material adhesion [21, 27] and also the result of the difficult determination of the demarcation between hypomineralized and sound enamel [20]. The particular challenges of managing the child's behavior and the difficulties in achieving anesthesia of MIH affected teeth add to the complexity of the treatment [20, 21, 28]. Both the need for repeated restorations and the ongoing enamel breakdown negatively impact the long-term prognosis of the tooth [20, 21, 28]. Therefore, extraction of the severely hypomineralized FPMs should be considered the treatment of choice [20, 28]. Managing the optimal moment for extraction, following-up on tooth eruption and occlusion development, and early orthodontic assessment are indicated [20, 28].

Due to its high prevalence, MIH represents an "emerging disease" [29]. Given its impact on dental treatment needs and the fact that it generates the highest social costs among all enamel defects, MIH is considered a public health concern, yet silent [29, 30].

Aim

The aim of this study was to evaluate the hypomineralization type of developmental defects of enamel at FPM level during the mixed dentition stage, in a group of Romanian children.

Patients, Materials and Methods

The study was carried out among consecutive pediatric patients seeking attention in a private dental clinic from February to May 2022. All children were examined by a single doctor, specialized in pediatric dentistry (the first author – SNS).

The inclusion criteria for the subjects' enrollment in the study were: patients in the mixed dentition stage; all four FPMs had to be erupted; prior obtaining informed consent in written form from one of the subjects' parents to use his/her child's dental data in scientific research.

Accordingly, 87 subjects, aged between five to 13 years satisfied the inclusion criteria and were included in the study. The patients were divided into the following age groups: 5–6 years, 6–7 years, 7–8 years, 8–9 years, 9–10 years, 10–11 years, 11–12 years and older than 12 years.

The examinations were carried out at the first visit in the dental office as a routine check-up to assess the current oral health status, or at the second recall appointment, after management of acute tooth pain, in cases when it represented the chief complaint.

The presence of MIH lesions at FPM level, the number of affected molars per patient, the surfaces affected, and the severity of the lesions were analyzed in relation to age group and subjects' gender.

FPM hypomineralization was visually detected, by examination under the artificial light provided by the dental unit, after plaque removal with cotton roles and without drying the teeth. Additionally, tactile exploration of the affected areas with a probe was carried out. The subjects were assigned to one out of five categories in relation to the number of FPMs with hypomineralization per children: one affected molar, both maxillary FPMs affected, both mandibular FPMs affected, all FPMs affected, and no FPM affected. To better characterize the clinical picture, MIH defects were further investigated in relation to their location on the tooth surface.

For the qualitative data, absolute frequencies (number of occurrences) and relative frequencies expressed in percentages were calculated. Qualitative data were compared by *chi*-squared (χ^2) test using STATA/MP13 statistical software. The threshold for statistical significance was $p \leq 0.05$.

Results

From the group of 87 subjects examined, 44 were females and 43 were males. The analyzed subjects' distribution according to age group was balanced, except for the 5–6, 11–12 and >12 years intervals, as presented in Table 2. The gender allotment according to the age group is described in Table 3.

Table 2 – ***Distribution of subjects by age group***

Age group	*N*	%
5–6 years	4	4.6
6–7 years	16	18.4
7–8 years	15	17.2
8–9 years	16	18.4
9–10 years	10	11.5
10–11 years	18	20.7
11–12 years	5	5.8
>12 years	3	3.4
Total	87	100

N: Number of subjects enrolled in the study.

Table 3 – ***Distribution of age groups according to the subjects' gender***

Age group	Female		Male		Total	
	N	%	*N*	%	*N*	%
5–6 years	1	2.3	3	7.0	4	4.6
6–7 years	10	22.7	6	13.9	16	18.4
7–8 years	4	9.1	11	25.6	15	17.2
8–9 years	10	22.7	6	13.9	16	18.4
9–10 years	5	11.4	5	11.6	10	11.5
10–11 years	9	20.4	9	20.9	18	20.7
11–12 years	4	9.1	1	2.3	5	5.8
>12 years	1	2.3	2	4.7	3	3.4
Total	44	50.6	43	49.4	87	100
X^2 test; *p*=0.299						

N: Number of subjects.

All categories of MIH lesions were identified at FPM level in the investigated sample; their clinical characteristics are exemplified in Figures 1–3.

Figure 1 – ***Mild hypomineralization of the tooth 36 in a boy aged eight years and nine months. The demarcated opacity on the distobuccal cusp is noticed.***

Figure 2 – ***Moderate hypomineralization of the tooth 46 in a boy aged nine years and 10 months. The occlusal sealant and loss of enamel at the mesial marginal ridge of the FPM are noticed; demarcated opacities are present on the occlusal, buccal and lingual surfaces and at the borders of the area with enamel loss. FPM: First permanent molar.***

Figure 3 – ***Severe hypomineralization of the tooth 46 in a boy aged eight years and one month. Discolored, chalky and porous enamel on all FPM surfaces and a large occlusal cavity are observed.***

The prevalence by age group of the different categories of MIH lesions at the level of the FPM is detailed in Table 4. Mild forms were the most prevalent, being found in 71.4% of the affected subjects. Moderate forms were present in 22.9% and severe forms in 5.7% of the affected children. Among the patients with mild forms, 48% belonged to the 6–7 years age group, 24% belonged to the 8–9 years age sample and 16% were found in the 7–8 years age sample, while 4% were in each age group 9–10, 10–11 and 11–12 years. Of the children with moderate lesions, each of the 7–8 years and 8–9 years groups represented 37.5%, and each of the 6–7 years and 9–10 years groups represented 12.5%. Only two children belonging to the group 8–9 years and 10–11 years, respectively, showed severe MIH lesions. Statistically significant differences were determined in what regards the distribution of MIH children according to the severity of the lesions in relation to age (*p*=0.007). As shown in Table 4, the overall prevalence of children affected by hypomineralization lesions on the FPM was 40.2%.

The distribution of FPM hypomineralization lesions in relation to the subjects' gender is presented in Table 5. Of the total children with mild forms, 68% were girls, and 32% were boys. Moderate and severe forms showed equal distribution in relation to gender. Of the total subjects without FPM hypomineralization lesions, 57.7% were boys and 42.3% were girls. No statistically significant differences were determined in what regards the distribution of MIH lesions according to severity in relation to gender (*p*=0.216).

Table 4 – *Categories of FPM hypomineralization by age group*

Age group	Mild form		Moderate form		Severe form		No modifications		Total	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%
5–6 years	0	0	0	0	0	0	4	7.7	4	4.6
6–7 years	12	48	1	12.5	0	0	3	5.8	16	18.4
7–8 years	4	16	3	37.5	0	0	8	15.4	15	17.2
8–9 years	6	24	3	37.5	1	50	6	11.5	16	18.4
9–10 years	1	4	1	12.5	0	0	8	15.9	10	11.5
10–11 years	1	4	0	0	1	50	16	30.8	18	20.7
11–12 years	1	4	0	0	0	0	4	7.7	5	5.8
>12 years	0	0	0	0	0	0	3	5.8	3	3.4
Total	25	28.7	8	9.2	2	2.3	52	59.8	87	100
X^2 test; ***p*=0.007**										

FPM: First permanent molar; *N*: Number of subjects.

Table 5 – *Categories of FPM hypomineralization in relation to gender*

Gender	Mild form		Moderate form		Severe form		No modifications		Total	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%
Girls	17	68	4	50	1	50	22	42.3	44	50.6
Boys	8	32	4	50	1	50	30	57.7	43	49.4
Total	25	28.7	8	9.2	2	2.3	52	59.8	87	100
X^2 test; *p*=0.216										

FPM: First permanent molar; *N*: Number of subjects.

Obvious differences can be observed in what concerns the number of hypomineralized FPMs per patient in relation to gender, but they are not statistically significant (*p*=0.129), as it is presented in Table 6. Among the children showing all FPMs affected, 69.2% were girls and 30.8% were boys. Male subjects presented a higher rate of both maxillary FPMs affected by hypomineralization compared to female subjects (60% *vs* 40% of such cases), while the clinical picture of both mandibular FPMs affected by hypomineralization was more frequently found in girls than in boys (70% *vs* 30% of such cases).

In what concerns the number of FPMs affected per child in relation to age (Table 7), one patient in the group 8–9 years and one patient in the group 10–11 years presented one FPM with hypomineralization defect, and in both subjects, the left mandibular molar (tooth number 36) was affected. Among the children with both maxillary FPMs affected, 40% were 7- to 8-year-old, 30% were 8- to 9-year-old, 20% were found in the sample 6–7 years, and 10% belonged to the group 11–12 years. Of the children with both mandibular FPMs affected, 80% fell within the age category 6–7 years, and 10% were found in each age groups 7–8 years and 8–9 years. Subjects with all FPMs affected were distributed as follows: 38.5% within the interval 8–9 years, 23.1% within the interval 6–7 years, 15.4% in each age group 7–8 years and 9–10 years, and 7.7% within the age category 10–11 years. There are statistically significant differences in what concerns the number of FPMs with hypomineralization lesions per subject in relation to age (*p*=0.002), as presented in Table 7.

In what concerns the location of hypomineralization lesions on the tooth surface, five situations were found: occlusal surface affected; occlusal and buccal surfaces affected; occlusal, buccal, and oral location; all surfaces involved and no affected surface.

The occlusal location was the most frequently found (in 48.6% of the affected subjects), followed by the location on three surfaces – occlusal, buccal, and oral (in 20% of the affected subjects), the location on occlusal and buccal surfaces in 17.1% and on all tooth surfaces in 14.3% of the affected patients (Table 8). Among the children having only occlusal MIH lesions, the 6–7 years age group represented 64.7%, each of the groups 7–8 and 8–9 years represented 11.8% and the sample 9–10 years, 5.9%. Of all children with MIH defects on three surfaces, the 8–9 years age group constituted 57.1%, the 7- to 8-year-old patients represented 28.6%, and the 10- to 11-year-olds accounted for 14.3%. The cases with two surfaces affected (occlusal and buccal) were equally distributed among the age groups 6–7, 7–8 and 8–9 years (33.3%). Statistically significant differences were determined in what concerns the number of affected surfaces in relation to age (*p*=0.002), as it is presented in Table 8.

Table 6 – *The number of FPMs affected by hypomineralization per subject in relation to gender*

Gender	One FPM affected		Both maxillary FPMs affected		Both mandibular FPMs affected		All FPMs affected		No FPM affected		Total	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Girls	2	100	4	40	7	70	9	69.2	22	42.3	44	50.6
Boys	0	0	6	60	3	30	4	30.8	30	57.7	43	49.4
Total	2	2.3	10	11.5	10	11.5	13	14.9	52	59.8	87	100
X^2 test; *p*=0.129												

FPM: First permanent molar; *N*: Number of subjects.

Table 7 – ***The number of FPMs with hypomineralization lesions per subject in relation to age group***

Age group	One FPM affected (tooth 36)		Both maxillary FPMs affected		Both mandibular FPMs affected		All FPMs affected		No FPM affected		Total	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
5–6 years	0	0	0	0	0	0	0	0	4	7.7	4	4.6
6–7 years	0	0	2	20	8	80	3	23.1	3	5.8	16	18.4
7–8 years	0	0	4	40	1	10	2	15.4	8	15.4	15	17.2
8–9 years	1	50	3	30	1	10	5	38.5	6	11.5	16	18.4
9–10 years	0	0	0	0	0	0	2	15.4	8	15.4	10	11.5
10–11 years	1	50	0	0	0	0	1	7.7	16	30.8	18	20.7
11–12 years	0	0	1	10	0	0	0	0	4	7.7	5	5.8
>12 years	0	0	0	0	0	0	0	0	3	5.8	3	3.4
Total	2	2.3	10	11.5	10	11.5	13	14.9	52	59.8	87	100
X^2 test; ***p*=0.002**												

FPM: First permanent molar; *N*: Number of subjects.

Table 8 – ***Surfaces of the FPM with MIH lesions in relation to age***

Age group	Occlusal		Occlusal and buccal		Occlusal, oral and buccal		All surfaces		No surfaces		Total	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
5–6 years	0	0	0	0	0	0	0	0	4	7.7	4	4.6
6–7 years	11	64.7	2	33.3	0	0	0	0	3	5.8	16	18.4
7–8 years	2	11.8	2	33.3	2	28.6	1	20	8	15.4	15	17.2
8–9 years	2	11.8	2	33.3	4	57.1	2	40	6	11.6	16	18.4
9–10 years	1	5.9	0	0	0	0	1	20	8	15.4	10	11.5
10–11 years	0	0	0	0	1	14.3	1	20	16	30.8	18	20.7
11–12 years	1	5.9	0	0	0	0	0	0	4	7.7	5	5.8
>12 years	0	0	0	0	0	0	0	0	3	5.8	3	3.4
Total	17	19.5	6	6.9	7	8.0	5	5.7	52	59.9	87	100
X^2 test; **p=0.002**												

FPM: First permanent molar; MIH: Molar incisor hypomineralization; *N*: Number of subjects.

The occlusal location, the three surfaces (occlusal, buccal, and oral) location and the situation of all surfaces being affected were more prevalent in females compared to males (70.6% *vs* 29.4%, 57.1% *vs* 42.9% and 60% *vs* 40%, respectively), while the location on two surfaces (occlusal and buccal) was equally distributed between boys and girls (50% *vs* 50%). No statistically significant differences were determined in what concerns the number of affected surfaces in relation to gender (*p*=0.349), as can be seen in Table 9.

Table 9 – ***Surfaces of the FPMs with MIH lesions in relation to gender***

Gender	Occlusal		Occlusal and buccal		Occlusal, buccal and oral		All surfaces		No surface		Total	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Girls	12	70.6	3	50	4	57.1	3	60	22	42.3	44	50.6
Boys	5	29.4	3	50	3	42.9	2	40	30	57.7	43	49.4
Total	17	19.5	6	6.9	7	8.0	5	5.7	52	59.9	87	100
X^2 test; *p*=0.349												

FPM: First permanent molar; MIH: Molar incisor hypomineralization; *N*: Number of subjects.

Discussions

Initially published research papers on MIH have been from northern European countries, Koch *et al*. (1987) [31], Leppäniemi *et al*. (2001) [32], Weerheijm *et al*. (2001) [9], Weerheijm *et al*. (2001) [33], Jälevik *et al*. (2001) [34], as mentioned in a 2010 systematic review by Jälevik [35]. Therefore, it was thought that the disorder is more common in this geographic region [35]. However, in recent years, MIH prevalence, etiology and characteristics represented the preoccupations of many researchers from almost everywhere in the world.

Compared with other studies, MIH was highly prevalent in the current investigated sample (40.2%). An identical prevalence was reported by Soviero *et al*. (2009), in a group of 249 children, 7- to 13-year-old, from public schools in Rio de Janeiro, among which 100 (40.2%) subjects had at least one MIH affected FPM [36]. However, in a recent research (2021) conducted on 8-year-old children from public schools in Petrópolis, Rio de Janeiro, Brazil, MIH lesions were found in 28.7% of the 450, 8-year-old investigated subjects [37]. A high prevalence, of 35.4%, was also described by Villanueva-Gutiérrez *et al*. (2019), in 686 Mexican children, 7–12 years of age [38]. The research by Elzein *et al*. (2020), reported MIH lesions in 26.7% of the 659 Lebanese children, 7- to 9-year-old, examined [39].

A pilot study conducted in the USA regarding the presence of MIH in children during the mixed dentition period (7–12 years of age), reveals a prevalence of 9.6% (36 cases out of 375 participants) [40]. Severe defects particularly affected the mandibular FPMs (*n*=13, compared to *n*=5 for maxillary FPMs) [40].

Evaluating 4496 children aged 7–9 years from eight regions throughout Japan, Saitoh *et al*. (2018) found that MIH defects affected 19.8% of the subjects [41].

Jasulaityte *et al*. (2007) showed that among 1277 Lithuanian children investigated, 7 to 9 years of age, 124 (9.7%) had at least one affected FPM and were diagnosed as having MIH [42].

Another research conducted on children from Bosnia-Herzegovina revealed a prevalence of MIH lesions of 11.7% [43]. A similar MIH rate, of 12.9%, was determined by Padavala & Sukumaran (2018) in a sample of 170 children, aged between 7 to 12 years, from Chennai, India [19].

As we found in the specialized literature, a low prevalence of enamel hypomineralization was reported by research conducted on German pediatric population. Thus, it was 5.6% in children and adolescents living in Dresden, as determined by Dietrich *et al*. (2003) [44]. In another cross-sectional study conducted on 1022 children aged 6 to 12 years in a middle region of Germany, the prevalence of MIH was 5.9% [45]. A similar result was reported by Ilczuk-Rypuła *et al*. (2022), who found MIH lesions in 6.2% out of 613 investigated Silesian children in Poland [46].

In the recent (2022) *European Academy of Pediatric Dentistry* (EAPD) policy document on "Best clinical practice guidance for clinicians dealing with children presenting with molar-incisor-hypomineralisation (MIH)", it was emphasized on the risk of MIH prevalence being underestimated when investigated by general practitioners which are not as familiar as pediatric dentists with MIH diagnosis [47].

By a 2018 systematic review and meta-analysis on 70 original population-based studies, Zhao *et al*. found geographical variations in MIH prevalence from 0.5% to 40.2%, with a pooled global prevalence of 14.2% [95% confidence interval (CI): 12.6–15.8] [48]. The highest estimated prevalence of MIH was for Spain (21.1%) and South America (18.0%) and the lowest for Africa (10.9%) [48]. Oceania had an estimated prevalence of 16.3%, Europe of 14.3% and Asia of 13.0% [48].

The minimum size of the enamel opacity is an important factor in deciding whether or not the defect represents hypomineralization (the mild category of it) [35]. Only defects of at least 2 mm in diameter were diagnosed as MIH lesions in the present study, according to the recommendations made by Jälevik *et al*. (2001), who pointed out that taking into consideration smaller defects leads to low reproducibility of the studies [34].

Variations in reported prevalence between studies also derive from the methodologies used in recording MIH by different investigators. The published consensus of the specialists in the field of Pediatric Dentistry shows that "An examination for MIH should be performed on wet teeth after cleaning" [49], as we followed in the research herein. According to the 2010 systematic review by Jälevik, some researchers examined wet teeth, others examined dry teeth, and others did not describe how the teeth were examined, dry or wet [35].

Of the affected children, 71.4% presented mild lesions, 22.9% moderate defects and 5.7% the severe type. Similar prevalence rates in relation to severity were reported by Thakur *et al*. (2020): 71.5% for demarcated opacities, 19.6% for post-eruptive enamel breakdown and 8.9% for atypical restorations, in 2000 Indian patients, 8- to 16-year-old, but the overall prevalence was very low as compared to the one in the present study, 2.9% [50]. Comparable results on MIH severity pattern with those in the present research were obtained by Oyedele *et al.* (2015): the mild form was the most prevalent, in 80.8% of the cases, followed by the moderate form, in 14% of the cases, and severe form in 5.2% of the cases [51]. A high percent of mild defects (77.4% of the 261 affected teeth) was found by Silva *et al*. (2020), as well, when studying 407 Brazilian children aged between 7 to 14 years, but of the 59 teeth severely affected, 50 (84.7%) were FPMs [52]. In the research carried out on a Mexican pediatric sample by Villanueva-Gutiérrez *et al*. (2019), the moderate lesions were the most prevalent (67.1%), followed by the mild category (18.5%) and the severe one (14.4%) [38]. The results on MIH prevalence according to severity of a study conducted on children from Bosnia-Herzegovina also differ from the ones in the present study [43]. Thus, of the 23 affected FPMs, seven (30%) showed demarcated opacities, and 16 (70%) presented the severe type of hypomineralization, the latter being equally represented by post-eruptive enamel breakdown and atypical restorations, in eight (35%) FPMs and in eight (35%) FPMs, respectively [43]. A high percent for mild defects (53.5%) was determined by Emmatty *et al.* (2020), researching 5318 Indian children, followed by severe defects (31.2%) and moderate defects (15.3%) [53], results which are different from the results of the current study.

Jälevik (2010) emphasized the importance of reporting MIH frequency in relation to each age group, for better comparison of the results of different studies on MIH prevalence [35]. Age-specific prevalence of MIH affected children was assessed in the present study. The small number of children in the youngest and oldest age groups investigated in the current study is explained through the fact that few children have all FPMs erupted by the age 5–6 years, while most children older than 12 years of age are not any more in the mixed dentition stage, but in the permanent dentition period, hence they do not meet the inclusion criteria. The distribution of children affected by FPM hypomineralization in relation to age was: 81.25% for the 6- to 7-year-old group, 43.3% for the 7- to 8-year-olds, 56.25% in patients aged 8 to 9 years, 20% in the 9- to 10-year-old subjects and 11.11% in 10- to 11-year-olds. Therefore, MIH prevalence in the studied sample significantly decreased with increasing age. This observation is consistent with the results by Saitoh *et al*. (2018), who also determined an inverse correlation between MIH frequency and age studying Japanese pediatric patients, but the prevalence values were lower for each age group, compared to ours [41]. Thus, the prevalence rates obtained by Saitoh *et al*. (2018) were: 22.2% in 7-year-old subjects, 19.9% in 8-year-olds and 17.0% in 9-year-olds [41]. Thakur *et al*. (2020), detailing MIH children according to age, found that amongst 58 MIH affected subjects, 32.8% were 8-year-old, 17.2% belonged to 9-year-old group, 15.5% were 10-year-old, 10.3% were in the age 11 year, 20.7% in the age 12 year and 3.4% were 13-year-old [50]. The older subjects (14- to

16-year-old) did not present MIH lesions, as reported by Thakur *et al*. (2020) [50]. Koruyucu *et al*. (2018) described a significant difference between 8- and 11-year-old subjects diagnosed with MIH from a sample of 1511 children in Istanbul, the former representing 9.9% and the latter representing 18.2% of the total MIH affected individuals [54]. Therefore, MIH prevalence increased with increasing age as reported by Koruyucu *et al*. (2018) [54], which is a different result from the one obtained in the present study. Lygidakis *et al*. (2008), investigating 3518 Greek children, 5.5- to 12-year-old, determined an age-related reduction of mild cases and an age-related increase of moderate and severe cases of FPM hypomineralization, which were statistically significant ($p<0.0001$) [55], a result which also differs from the one found in the present study.

The distribution of the study group in relation to gender was beneficial for comparison and statistical analysis. Gender-specific differences in MIH prevalence were registered in our study: among the affected subjects, 62.9% were girls and 37.1% were boys. This is consistent with the results by Lygidakis *et al*. (2008) [55], Mulic *et al*. (2017) [43], Elzein *et al*. (2020) [39], who found a higher MIH prevalence in girls than in boys. In a study by Kemoli (2008), in 6- to 8-year-old children in two rural areas in Kenya, the ratio between affected girls and boys was even 3:1 [56]. On the contrary, MIH lesions were more prevalent in males than in females as shown by Thakur *et al*. (2020) [50], Silva *et al*. (2020) [52], Emmatty *et al*. (2020) [53]. Equal distribution of MIH affected children in relation to gender was found by Preusser *et al*. (2007) [45]. No significant gender-related differences in MIH prevalence were reported by Soviero *et al*. (2009) [36], Saitoh *et al*. (2018) [41], Koruyucu *et al*. (2018) [54], Allazzam *et al*. (2014) [57], Petrou *et al*. (2014) [58].

Few studies have investigated the distribution of MIH lesion according to the number of affected FPM surfaces, as we did. It is the case of the study by Petrou *et al*. (2014), who researching MIH on a sample of 2395 children with a mean age of 8.1±0.8 years, from four geographic regions of Germany, determined an overall prevalence of 10.1% [58]. Of the total of 490 affected FPMs, 95 (18.8%) presented MIH lesions on different surfaces [58]. Oliver *et al*. (2014) even suggested a new MIH severity index, according to the location of enamel hypomineralization defects at tooth surface level [59].

There are authors who analyzed if the presence of MIH defects relates to the patients' socioeconomic background. Surprisingly, Balmer *et al*. (2012) found higher MIH prevalence in 12-year-old children of high socioeconomic status from Northern England [60]. This is explained by the fact that in the UK there is a correlation between the socioeconomic status and the maternal age, the higher maternal age being associated to a higher socioeconomic status but, at the same time, to pre- and perinatal risk factors for amelogenesis disturbances at FPM level [60]. On the contrary, Padavala & Sukumaran (2018) identified a higher distribution of MIH among 7- to 12-year-old Indian children in government schools compared to those in private schools [19], while Oyedele *et al*. (2015) found no association between Nigerian 8- to 10-year-old children's socioeconomic status and MIH [51]. Correlations between MIH patients' socioeconomic gradient and the prevalence of the disease was not the purpose of the present research. However, its results show that enamel hypomineralization lesions in the FPM do not progress with age in children investigated, which could indicate that the little patients in the studied sample utilize dental care services and benefit from MIH interceptive treatment. Furthermore, analyzing the specialized literature, we found that there are differences between Romanian MIH children who utilize private dental health care services (who have a high socioeconomic background) and those who visit public dental care services (who have a lower socioeconomic status). Thus, in the sample researched in the present study, severe MIH lesions were found in 5.7% of the affected children and the mean number of affected FPMs per child was 2.7, while in a group of 100 patients, 6- to 12-year-old, diagnosed with MIH in a Romanian public pediatric dental care service, severe lesions were found in 80% of the cases and the average number of affected FPMs per child was 3.66 [61].

Although cohort cross sectional studies are necessary to better describe MIH prevalence and characteristics in the Romanian pediatric population, the results of the present research show that the mixed dentition is a susceptible period for MIH occurrence, which requires special care by pedodontists for early detection of the disease and implementation of treatment strategies.

Conclusions

The overall MIH prevalence was high in the investigated sample, but it significantly decreased with increasing age. The distribution of MIH lesions according to the severity scale was: 71.4% for mild defects, 22.9% for moderate lesions and 5.7% for the severe type. The prevalence was higher in girls than in boys. Children 6- to 7-year-old have been the most affected by FPM hypomineralization, which indicates the need for early management of the disease, through a thorough diagnosis, and preventive and interceptive therapeutic approaches.

Conflict of interests

The authors declare that they have no conflict of interests.

Compliance with ethical standards

Informed consent in written form was obtained from one of the subjects' parents to use his/her child's dental data in scientific research.

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