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Prevalence and Predictors of Molar-Incisor Hypomineralization in 6-12-year-old Iranian Residing in Ilam City

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A B S T R A C T

Introduction: Molar incisor hypo mineralization (MIH) is defined as extensive progressive enamel defects with a developmental origin. This study aimed to assess the prevalence and predictors of molar incisor hypo mineralization (MIH) in 6-12-year-old Iranian children 2022.

Materials and Methods: This cross-sectional study was conducted on all 6-12-year-old Iranian children residing in Ilam City, Iran, in 2022. For clinical oral examination, the surface of maxillary and mandibular permanent first molars and incisors was cleaned with a gauze and inspected and examined under adequate lighting and by using a dental explorer in wet conditions for the presence of opaque spots, surface degradation, and caries. The Chi-square and multiple logistic model were applied. Data were analyzed in SPSS V.24 at the level of 0.05 significance.

Results: Totally 1,016 children between 6-12 years participated in the study's first phase, 112 had MIH, yielding a prevalence rate of 11% for this condition. MIH was found in 53.2% of maxillary molars, 37.1% of mandibular molars, 9.7% of both maxillary and mandibular molars, 66% of maxillary incisors, 32% of mandibular incisors, and 2% of both maxillary and mandibular incisors. History of cesarean section (P<0.001), gestational diabetes (P=0.001), Chickenpox (P=0.041), Newborn jaundice (P<0.001), Otitis (P=0.036), Urinary tract infection (P=0.020), Antibiotic therapy (P<0.001) and Respiratory problems (P=0.047) had a positive association with MIH.

Conclusion: The prevalence of MIH was 11% in the study population, and cesarean section, gestational diabetes, medication intake during pregnancy, genetics, newborn jaundice, respiratory problems, otitis, urinary tract infection, antibiotic therapy, and chickenpox were significantly correlated with its occurrence.

Keywords: Molar Hypo Mineralization, Prevalence, Etiology, Child

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Introduction

Molar incisor hypomineralization (MIH) is when large, progressive enamel defects start during development and show up at tooth eruption or soon after. MIH may affect one to four permanent first molars with variable degrees of severity. Also, well-defined opaque spots may be seen on the surface of maxillary and even mandibular incisors in MIH. The enamel of the affected teeth has a lower-than-normal density and is porous, with white to brownish discoloration. Involvement of other teeth, such as permanent canines and primary second molars, has also been reported (1-4). The prevalence of MIH varies in different communities, ranging from 2.4% to 40.2% (5). Hypomineralized teeth have certain opacities in their incisal or occlusal third and easily undergo enamel fracture. Such opacities are defects that affect enamel translucency without any reduction in its thickness and cause discoloration (6). Molars with MIH usually have 20% less mineral density than normal teeth (7).

MIH is not a novel phenomenon. However, it may remain undetected in populations with high rates of caries. However, MIH emerges as a novel condition in populations with a decreased risk of caries. Clinically, MIH can bring about numerous problems for children and dental clinicians. It can cause esthetic problems in the anterior teeth. In the posterior teeth, hypo-mineralized areas may undergo fracture under masticatory forces (8). The rate of caries progression is slower in the anterior teeth with MIH, and the behavior of the lesion is less predictable. MIH may necessitate extensive restorations, root canal therapy, prosthetic crown placement, or tooth extraction (in molar teeth). Children with MIH at 9 years of age often have 10 times higher need for dental treatments than their peers (7), and kids affected by MIH can have increased treatment needs, with severely affected first permanent molars requiring 4.2 times more treatment by the age of 18 years compared to children unaffected by MIH (9). They have higher dental fear and anxiety and experience pain and hypersensitivity during tooth brushing. Additionally, the inflamed pulp, caused by enamel porosities extending to the pulp chamber, makes it challenging to reach an adequate depth of anesthesia in such teeth (10).

Evidence suggests that systemic factors play a role in different stages of tooth development, despite the lack of a clear etiology. Enamel formation of permanent first molars starts in the 28th week of pregnancy and continues to 10 days after birth. Some of the most sensitive cells in the body are ameloblasts. Even small changes in their environment can hurt them temporarily or permanently, which can cause enamel hypoplasia (problems with making the enamel matrix) or enamel hypomineralization (problems with hardening or maturing) (1). Several factors have been proposed as the etiology of MIH, which may be classified into medical problems (before, during, and after birth), environmental factors, and genetics. Prenatal problems include maternal fever, gestational diabetes, nausea and vomiting, and long-term use of spasmolytic medications. Problems during birth include the cesarean section, preterm birth, and twin pregnancy. Post-natal problems include respiratory diseases, recurrent high fevers, seizures, and intake of some medications (11). Researchers have also proposed a multi-factorial etiology for MIH (12). It also appears that systemic and environmental conditions in the first three years of life may play a role in the development of MIH (13).

Because early detection of MIH and prompt treatment are so important, it is important to find out how common it is in different parts of the world. Thus, this study aimed to assess the prevalence and predictors of MIH in 6- to 12-year-old Iranian children residing in Ilam City.

Materials and Methods

Setting

This cross-sectional study was conducted on Iranian children between 6-12 years residing in Ilam city, Iran, in 2022 who were selected by census sampling. The inclusion criteria were age between 6-12 years, the eruption of permanent first molars, optimal cooperation of children for examination, willingness to participate in the study, and informed consent from the parents to enroll their children. All teeth with enamel or dentin defects, chronological hypoplasia, a history of trauma or infection in the front teeth, amelogenesis imperfecta, tetracycline discoloration, fluorosis, or orthodontic treatment were not eligible.

Sample size

The sample size was determined based on the Ahmadi et al. study (14). The prevalence rate for MIH is 5.2%. The primary outcome of interest, a precision level of 3% and a confidence interval (CI) of 95%, determined the initial sample size to be 683. After applying a design effect of 1.5, the final sample size was calculated to be 1024, rounded to 1024 participants. This final number was deemed as the minimum sample size for the study.

$n = \frac{z^2\,pq}{d^2} = \frac{1.96^2 \times 20\% \times 80\%}{3\%^2} = 6823$ ➔ 683 * design effect (1.5) = 1024

This study was conducted in two phases. An operator, a final-year dental student, performed all examinations. Sampling was done in the first stage using the two-stage cluster method, so that 40 schools (clusters) from two education regions, 1 and 2, were selected through random numbers, including public and non-governmental schools for boys and girls. One class was selected from each school to determine the number of clusters in the second stage (the classes) (15 students per class on average). In the first phase, 1024 students between 6-12 years residing in Ilam City, Iran, were examined for MIH. For this purpose, the examiner received sufficient training to detect clinical manifestations of MIH and other enamel defects, and Cohen's kappa was calculated for the examiner to ensure optimal intra-examiner reliability. For the purpose of clinical examination, the surface of the target tooth is examined. (permanent maxillary and mandibular first molars and incisors) were cleaned with a gauze and inspected and examined under adequate lighting by using a dental explorer in wet conditions for the presence of opaque spots, surface degradation, and caries.

Measurements & Validity and Reliability

Demographic tool

This form was designed to ask for information related to pregnancy and delivery, such as type of delivery, difficult delivery, presence of gestational diabetes, prolonged nausea lasting for the entire pregnancy period, medication intake during pregnancy, information related to lactation and nutrition of the child, such as breastfeeding/bottle feeding, duration of breastfeeding, use of pacifiers, and medication intake during breastfeeding, and information related to the first three years of the children's life, such as premature birth, newborn jaundice, recurrent diarrhea and vomiting, urinary tract infection, recurrent cold and fever, respiratory problems, skin allergy, otitis media, antibiotic therapy, complete vaccination, metabolic diseases, chickenpox, and cardiac problems, similar tooth defects in the family, and exposure to toxins and pesticides. Moreover, the parents were requested to years in children with MIH, and 9.02±1.8 years in those without MIH.

report any other issue that they think might be important.

Ethical consideration

The research followed ethical guidelines, which included receiving ethical approval from the Ilam University of Medical Sciences (IR.MEDILAM.REC.1402.039), collecting informed consent from participants, ensuring data confidentiality, and adhering to the principles outlined in the Declaration of Helsinki.

Statistical and Data Analysis

The prevalence of MIH was calculated, and its correlation with different variables was analyzed by the Chi-square test. To develop a prediction model, the logistic regression model was used, and for that, two steps were applied. In the first step, the association between MIH and several predictors (delivery type, gestational diabetes, chickenpox, newborn jaundice, otitis, urinary tract infection, antibiotic therapy, respiratory problems, preterm birth, recurrent diarrhea and vomiting, recurrent cold and fever, skin allergy, complete vaccination, metabolic diseases, feeding, and pacifier use) was evaluated by simple logistic regression, and in the second step, multiple logistic regression was used for model building and checking the simultaneous effect of the study variables on the outcomes. It should be noted that the criteria for entering the variables into the multiple logistic regression model was a significance level of less than 0.2. Also, data was analyzed by using SPSS version 24 at a 0.05 significance level.

Results

From 1024 children who was examined, 8 children were excluded due to incomplete data and finally, a total of 1,016 children between 6-12 years participated in the first phase of the study 112 had MIH, yielding a prevalence of 11% for this condition. Each child averagely had 1.44 involved teeth including 0.89 molars and 0.89 incisors. The mean age was 9.5±1.17 Table 1 indicates the medical history of mothers of children with MIH. As shown, the majority of children with MIH had been delivered by cesarean section. Also, the mothers of 94.6% of them had gestational diabetes.

Table 1. Medical history of mothers of children with and without MIH

Variable	Category	Group		P-value (Chi-Square)
		MIH (n=112)	No-MIH (n=904)	
Delivery type	Natural	*51* (*45.5%*)	*592* (*%65.5*)	*0.001*
	Cesarean section	*61* (*54.5%*)	*312* (*34.5%*)	
Gestational Diabetes	Yes	*106* (*94.6%*)	*131* (*14.6%*)	*0.04*
	No	*6* (*5.4%*)	*769* (*85.1*)	

Table 2 presents the medical history of children with MIH in their first three years. As shown, 45.5% had a history of antibiotic therapy, and 44.6% had a history of newborn jaundice.

Of children with MIH, 2.4% had lost their permanent molars, and 0.2% had lost their permanent incisors due to MIH.

Table 2. Medical history of children with MIH in their first three years of life

Medical history of children	Frequency	Percentage
Preterm birth	*13*	*11.6*
Newborn jaundice	*50*	*44.6*
Recurrent diarrhea and vomiting	*5*	*4.5*
Urinary tract infection	*8*	*7.1*
Recurrent cold and fever	*13*	*11.5*
Respiratory problems	*6*	*5.4*
Skin allergy	*1*	*0.9*
Otitis	*10*	*8.9*
Antibiotic therapy	*51*	*45.5*
Complete vaccination	*107*	*95.5*
Chickenpox	*16*	*14.3*

According to Table 3, the prevalence of cesarean section (P=0.001), gestational diabetes (P=0.001), newborn jaundice (P=0.001), urinary tract infection (P=0.003), respiratory problems (P=0.040), otitis media (P=0.009), antibiotic therapy (P=0.001) and chickenpox (P=0.020) was significantly higher in children with MIH than the No-MIH group. The two groups ' differences in other parameters were insignificant (P>0.05).

In the MIH group, 26.8% of children (versus 13.7% in the No-MIH group) had a positive family history of MIH, which was significant (P=0.001). Also, MIH was significantly more common in boys than girls (63.4% versus 36.6%, P<0.001).

Table 3. Differences between the MIH and No-MIH groups in different parameters

Parameters	Group		P-Value
	MIH (n=112)	No-MIH (n=904)	
Preterm birth	*13* (*11.6%*)	*68* (*7.5%*)	*0.090*
Newborn jaundice	*50* (*44.6%*)	*109* (*12.1%*)	*0.001*
Recurrent diarrhea and vomiting	*5* (*4.5%*)	*51* (*5.6%*)	*0.400*
Urinary tract infection	*8* (*7.1%*)	*16* (*1.8%*)	*0.003*
Recurrent cold and fever	*13* (*11.6%*)	*103* (*11.4%*)	*0.520*
Respiratory problems	*6* (*5.4%*)	*19* (*2.1%*)	*0.040*
Skin allergy	*1* (*0.9%*)	*8* (*0.9%*)	*0.650*
Otitis	*10* (*8.9%*)	*30* (*3.3%*)	*0.009*
Antibiotic therapy	*51* (*45.5%*)	*90* (*10%*)	*0.001*
Complete vaccination	*107* (*95.5%*)	*874* (*97.1%*)	*0.554*
Metabolic diseases	*4* (*3.5%*)	*15* (*1.6%*)	*0.162*
Chickenpox	*16* (*14.3%*)	*72* (*8%*)	*0.020*
Cardiac problems	*0*	*2* (*0.2%*)	*0.790*
Breastfeeding	*96* (*85.7%*)	*716* (*79.2%*)	*0.060*
Formula feeding	*16* (*14.3%*)	*188* (*20.8%*)	
Pacifier	*21* (*18.8%*)	*180* (*19.9%*)	*0.440*
Bottle/breastfeeding	*91* (*81.3%*)	*724* (*80.1%*)	

According to the results were shown in the table 4 by simple logistic regression, only the variables of Delivery type, Gestational diabetes, Chickenpox, Newborn jaundice, Otitis, Urinary tract infection, Antibiotic therapy, and Respiratory problems, Preterm birth, and Feeding had criteria to including to multiple model and since the result of multiple model is more reliable, here, only the multiple model was discussed. Accordingly, history of cesarean section (OR: 2.32; p<0.001), gestational diabetes (OR: 11.1; p<0.001), Chickenpox (OR: 1.74; p=0.041), Newborn jaundice (OR: 5.40; p<0.001), Otitis (OR: 2.01; p=0.036), Urinary tract infection (OR: 3.98; p=0.020), Antibiotic therapy (OR: 5.19; p<0.001) and Respiratory problems (OR: 1.89; p=0.047) had a positive association with MIH. Other variables in multiple model including the Preterm birth and Feeding had no association with MIH. The amount of Nagelkerke R Square was 20.1%. in other words, the capability of multiple model of prediction of MIH was 20.1%.

Table 4. The association between MIH with several predictors by using simple and multiple logistic models

Variable	Category	Simple model		Multiple model	
		OR (95% CI)	P-value	OR (95% CI)	P-value
Delivery type	Natural	1	---	1	---
	Cesarean section	2.27 (1.53 to 3.37)	<0.001*	2.32 (1.64 to 3.69)	<0.001*
Gestational diabetes	No	1	---	1	---
	Yes	103.7 (44.63 to 240.96)	<0.001*	11.1 (4.51 to 21.01)	<0.001*
Chickenpox	No	1	---	1	---
	Yes	1.93 (1.08 to 3.44)	0.027*	1.74 (1.02 to 3.03)	0.041*
Newborn jaundice	No	1	---	1	---
	Yes	5.40 (3.54 to 8.25)	<0.001*	5.40 (3.54 to 8.25)	<0.001*
Otitis	No	1	---	1	---
	Yes	2.86 (1.36 to 6.01)	0.006*	2.01 (1.03 to 5.41)	0.036*
Urinary tract infection	No	1	---	1	---
	Yes	4.27 (1.78 to 10.22)	0.001*	3.98 (1.08 to 8.09)	0.020*
Antibiotic therapy	No	1	---	1	---
	Yes	7.56 (4.91 to 11.63)	<0.001*	5.19 (3.01 to 7.99)	<0.001*
Respiratory problems	No	1	---	1	---
	Yes	2.64 (1.03 to 6.75)	0.043*	1.89 (1.01 to 3.70)	0.047*
Preterm birth	No	1	---	1	---
	Yes	1.62 (0.86 to 3.04)	0.133	1.06 (0.66 to 2.96)	0.311
Feeding	Breastfeeding	1	---	1	---
	Formula feeding	1.57 (0.91 to 2.74)	0.107	1.04 (0.48 to 2.74)	0.645
Recurrent cold and fever	No	1	---	Not included	
	Yes	1.02 (0.55 to 1.89)	0.947		
Skin allergy	No	1	---		
	Yes	1.01 (0.12 to 8.14)	0.993		
Complete vaccination	No	1	---		
	Yes	0.74 (0.28 to 1.93)	0.532		
Metabolic diseases	No	1	---		
	Yes	2.20 (0.72 to 6.73)	0.269		
Recurrent diarrhea and vomiting	No	1	---		
	Yes	0.78 (0.30 to 2.01)	0.607		
Pacifier Using	Pacifier	1	---		
	Bottle/breastfeeding	0.93 (0.56 to 1.53)	0.771		

*: Significant at 0.05
CI: Confidence Interval
OR: Odds Ratio

Discussion

This study evaluated the prevalence and predictors of MIH in Iranian children aged 6–12 who live in Ilam City. The results showed that the prevalence of MIH was 11% in the study population, which was close to the value of 11.5% reported by Kilinc et al. (15). This rate was 9.6% in a study by Hartsock et al. (16) in the USA and 40.5% in a study by Alhowaish et al. (17). In the Shiraz Province of Iran, a study found the

prevalence of MIH to be 20.2% (18), 5.14% in Kerman (19), and 12.7% in Zahedan (14). Iraq reported a prevalence rate of 18.6% of MIH. 17.6% in Jordan, 21.8% in Spain, 12.5% in Singapore, 20.2% in Sudan, 7.7% in Turkey, and 18.7% in France (2, 20-25). Different rates of MIH are caused by things in the environment (before, during, and after birth), the socioeconomic status of the populations (which affects nutrition and breastfeeding), the assessment methods (for example, lighting during examination), the type of study (retrospective, prospective, or longitudinal), and the number of cavities in the study populations (21, 23, 24). In the present study, each child with MIH averaged 1.44 affected teeth, including 0.89 molar and 0.89 incisor teeth. The mean number of affected teeth was 5.6 in rural areas, 2.1 in Zahedan, 3.5 in Spain, and 2.2 in Singapore (14, 22, 26).

The mean age was 9.5±1.17 years in children with MIH and 9.02±1.8 years in those without MIH in the present study. The MIH group consisted of 71 boys (63.4%) and 41 girls (36.6%), while the No-MIH group included 300 boys (33.2%) and 604 girls (66.8%). The male-to-female ratio was 1:1.1 in the study by Kirthiga et al. (27). The prevalence of MIH was 20.2% in a study by Jafari et al. (28) in Sari; this rate was 21.1% in boys and 19.4% in girls. The current study found that maxillary molar teeth were more often affected than mandibular molars. Only 9.7% of children had MIH in both jaws, which is different from what Salem et al. (26) found. Other previous studies either found no significant difference or reported a higher frequency of MIH in maxillary molars (29, 30). Since the development of mandibular molars begins later, a higher frequency of MIH in mandibular molars may indicate the presence of causative agents later in life.

The present study found that MIH was more common in boys than in girls— a finding that differs from the findings of several previous studies (14, 21, 22, 24, 26, 31, 32) and is similar to the findings of another study (33). Unlike Al-Nerabieah's study (34), differences in the prevalence of MIH in males and females in our study may be attributed to differences in the time of completion of crown formation, tooth eruption, and oral hygiene practice of girls and boys. The cesarean section in the current study was delivered. The majority of the children were diagnosed with MIH. Of their mothers, 20.3% had difficult delivery, 94.6% had gestational diabetes, and 15.2% had prolonged nausea. Also, of MIH children, 45.5% had a history of antibiotic therapy, and 44.6% had a history of newborn jaundice. Moreover, the frequency of permanent molar and incisor loss due to MIH in them was 2.4% and 0.2%, respectively. Kılınç et al. (15) reported a significant difference between the maxilla and mandible regarding the prevalence of MIH. Soares et al. (35) showed that maxillary teeth were more commonly affected than mandibular teeth by MIH. The type of delivery, gestational diabetes, and medication intake during pregnancy significantly correlated with MIH. In the current study, pregnancy did not correlate with difficulties. delivery or prolonged nausea. MIH had no significant correlation with breastfeeding/bottle feeding or using a pacifier. Pavithra Devi et al. (36) reported that pre-, peri-, and postnatal factors and maternal illnesses during pregnancy and early childhood illnesses in children significantly correlated with enamel hypomineralization of primary second molars. Haque Afzal et al. (37) demonstrated that intake of antibiotics during the first year of life was correlated with MIH. No consensus has been reached. on the causes of the development of MIH (38). The lack of specific etiologies suggests a role for genetics in this regard (39). Variations in the prevalence rates can also be due to genetic differences in the study populations (39). In the present study, a significant correlation was found between genetics and MIH, such that 26.8% of children with MIH had a positive family history of MIH. This study found that children with MIH were much more likely to have newborn jaundice, urinary tract infections, respiratory problems, otitis media, antibiotic therapy, and chickenpox than children who did not have MIH. Kılınç et al. (15) showed a significantly higher prevalence of MIH in children with low birth weight, premature delivery, high fever, and asthma/bronitis. Mejía et al. (40) reported that MIH was associated with changes in the third trimester of pregnancy, the type of delivery, respiratory problems, and various factors that play a significant role in the first three years of a child's life after birth. Né YG et al. (41) demonstrated significant correlations between MIH and respiratory disease. Gurrusquieta et al. (42) also reported low birth weight, urinary tract infection, and history of allergies as risk factors for MIH, highlighting the significant higher frequency of medical conditions in the first years of life in children with MIH. Venugopal (43) demonstrated a correlation between MIH and prenatal and postnatal infections, as well as a lower-middle-class socioeconomic status. Allazzam et al. (44) indicated a higher prevalence of MIH in children with a history of disease in their first 4 years of life, such as adenoids, tonsillar edema, asthma, fever, and antibiotic therapy. Ahmadi et al. (14) showed a higher prevalence of prenatal and postnatal medical conditions in children with MIH. One of the weaknesses of our research was its small sample size. The sample size takes into account the population of primary schoolchildren in Ilam City.

Conclusion

The prevalence of MIH was 11% in the present study. population, and type of delivery, gestational diabetes, medication intake during pregnancy, genetics, newborn jaundice, respiratory problems, urinary tract infection, antibiotic therapy, and chickenpox were significantly correlated with its occurrence. Further studies are required on the prevalence of MIH in different parts of Iran. Also, the effect of maternal diet and child's diet on MIH should be investigated in future studies.

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Conflict of interest
The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors' contributions
Conceptualization, Supervision: RSM, AK, Methodology: RSM, SM, Validation, Visualization: RSM, Formal Analysis: AK, MN, Investigation, Resources: MN, Data Curation: AK, Writing– Original Draft Preparation, Writing– Review & Editing: SM, Project Administration: RSM, AK, SM

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