





Knowledge and Perception of Brazilian Dental Students about Molar-Incisor Hypomineralization

Thalys Gustavo Oliveira Martins¹, Naiara Oliveira Carvalho¹, Cristiane Tomaz Rocha¹, Beatriz Gonçalves Neves¹

¹School of Dentistry, Federal University of Ceará, Sobral, CE, Brazil.

Corresponding author: Beatriz Gonçalves Neves

E-mail: beatrizneves@ufc.br

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ABSTRACT

Objective: To evaluate the knowledge and perception of Brazilian dental students regarding molar incisor hypomineralization (MIH). **Material and Methods:** A cross-sectional study was conducted with dental students from a dental school in the Northeast region. A self-administered questionnaire was applied, containing questions about MIH, including etiology, diagnosis, and treatment. Clinical photographs assessed students' ability to differentiate MIH from other enamel defects. Chi-square or Fisher's exact test was used for associations, and the Kruskal-Wallis test for comparisons, considering the academic year as the independent variable. **Results:** 67 students participated, primarily enrolled in the third and fifth years. The majority (68.7%) reported familiarity with MIH, and 82.1% recognized it as a qualitative defect. MIH awareness was significantly associated with fifth-year students ($p=0.01$). Genetic factors were considered as an etiological factor by 80.6%. None of the students felt "very confident" in diagnosing MIH. No difference was observed in confidence levels across academic years. Enamel hypoplasia (64.2%) was cited as the most challenging differentiating condition from MIH. Students demonstrated uncertainty in diagnosing severe MIH (20.9%), whereas fluorosis was the defect most easily recognized (71.6%). **Conclusion:** Dental students demonstrate knowledge of MIH and recognize some clinical characteristics but lack confidence in diagnosing it. This highlights the need for enhanced dissemination and teaching of MIH in undergraduate dental education.

Keywords: Developmental Defects of Enamel; Molar Hypomineralization; Perception; Students, Dental.

■ Introduction

Molar-incisor hypomineralization (MIH) can be defined as a qualitative developmental defect of enamel (DDE) that affects at least one permanent first molar and may also be associated with permanent incisors [1,2]. This condition is a global health problem [3,4] and can mainly affect children [1,2]. The prevalence of MIH is high worldwide, ranging from 11.8% to 14.5%, [4,5] and in the Americas varies from 2.5% to 40.2% [6]. Differences in diagnostic criteria, sample sizes, and geographic and ethnic factors may explain the variation in prevalence found between studies [4].

The etiology of MIH is still not fully understood; however, this condition is considered complex and multifactorial with the involvement of external factors (systemic and environmental) and genetic factors [7-9]. The current evidence confirms that specific systemic and genetic factors contribute synergistically to induce enamel hypomineralization in cases of MIH. In addition, these factors' duration, intensity, and timing may influence the various clinical features observed in the defect [10]. Prenatal (smoking, illness during pregnancy), perinatal (preterm birth, low birth weight), postnatal exposures (early childhood illness, low birth weight), and also medications may be considered as possible risk factors for MIH [7,11,12].

The clinical presentation of MIH may vary, including the type and number of teeth affected, size or extent of the defect, severity, and hypersensitivity [13]. MIH defects can range from demarcated white to yellow or brownish opacities to enamel breakdown [1]. The hypomineralized enamel of this condition is porous and fragile, discolored, and presents a lack of luster, similar to chalk, and can easily break and expose the dentin during the masticatory function [10,14]. Due to the softness and increased porosity of enamel affected by MIH and biofilm accumulation on occlusal surfaces, an association between this defect and caries has been evidenced [15]. Indeed, MIH has been considered a risk factor for caries development [16].

MIH is considered a silent health condition due to the high number of cases and rapid progression, in addition to the low level of knowledge about this defect among dentists [17-20]. Previous studies have been conducted with dental students in some countries, such as Saudi Arabia [17], China [21], Syria [22], Turkey [23], Egypt [24], Germany [25], Austria [26], Switzerland [27], Spain [28], Italy [29] and New Zealand [30]. The data from these studies indicate that dental students require additional training in diagnosing and treating MIH. However, research on this topic is scarce in Brazil. Therefore, the present study aimed to evaluate the knowledge and perception of Brazilian undergraduate dental students regarding MIH.

■ Material and Methods

Ethical Aspects

This study protocol was submitted and approved by the local Ethics Committee following Resolution no. 466/12 of the National Health Council (Opinion No. 4.831.280). All participants enrolled in this study signed electronically the informed consent form. The photographs used in this study were taken with the parents' consent and patients' assent.

Study Participants

This cross-sectional study was conducted in Sobral, CE, Brazil, with a convenience sample of dental students from the Federal University of Ceará (UFC). Participants were recruited remotely through WhatsApp

groups. Inclusion criteria were students enrolled in their third, fourth, or fifth year with internet access. Students who were physically and/or mentally unable to complete the questionnaires were excluded.

Data Collection

The data collection instrument was developed as a self-administered questionnaire based on questionnaires from previously published articles with modifications [17,18,25]. A pilot study was carried out with seven volunteer dental students to check the comprehension of the questions, the coherent sequence, and the estimated time for answering. Participants in the pre-test phase were not included in the final study. The questionnaire was then analyzed and revised by the researchers for approval.

The questionnaire was divided into seven sections with a total of 20 questions. The first section consisted of general participant information: date of birth, gender, and current course period. The second section contained questions about the participant's general knowledge of MIH. The third section contained questions about etiology. The fourth section sought information about knowledge and the ability to diagnose MIH. The final sections of the questionnaire included questions about the epidemiology, consequences, and treatment of MIH. The survey instrument also included clinical diagnostic questions with photographs of clinical cases of MIH and other DDEs, such as enamel hypoplasia, dental fluorosis, amelogenesis imperfecta, and dental caries. Photographs were taken by a single researcher using the same camera parameters and illumination conditions. Four professors with expertise in the area selected five pictures for the questionnaire. Any discrepancies were resolved through consensus to ensure consistent diagnosis of the conditions. Photographs with uncertain diagnoses were excluded from the study.

The questionnaire was made available to the participants through a link from Google Forms (Google Inc., Mountain View, CA, USA), with an application time between 10 and 15 minutes.

Data Analysis

The data collected was extracted from Google Forms® and converted into an Excel® spreadsheet (Microsoft Corp., Redmond, WA, USA). Statistical analyses were performed using Jamovi software (Jamovi Project 2021, version 2.3.13, Sydney, Australia). Descriptive statistics included absolute and relative frequencies for categorical variables. The dependent variables were students' knowledge (nominal variable) and perception measured by a Likert scale (ordinal variable). The independent variable was the academic year (nominal variable). Chi-square or, whenever appropriate, Fisher's exact test was used to assess the association between students' knowledge (MIH awareness, etiological factors, clinical features) and their academic year. In addition, the Kruskal-Wallis test was applied to compare dental students' confidence levels between graduation years. Statistical significance was set at $p < 0.05$.

■ Results

Out of the potential 140 participants invited to the survey, 67 agreed to participate, resulting in a response rate of 47.9%. Most students were enrolled in the fifth (44.8%) and third-year undergraduate dental curriculum (34.3%). Regarding the gender and age of the participants, the majority were female (67.2%). The average age of the participants was 23.97 ± 2.54 years (Table 1).

Most dental students (68.7%) reported knowing about MIH. Regarding different enrollment periods (third, fourth, and fifth-year- students), a significant association was found between the frequency of positive

answers for MIH awareness and being enrolled in the fifth year (Fisher's Exact test, $p = 0.01$). Among those who were aware, exposure to the topic primarily occurred through lectures (60.9%), followed by social media (41.3%), courses or congresses (34.8%), scientific articles (28.3%), clinical practice (26.1%), online sources such as websites, blogs, and YouTube (21.7%), books (19.6%), and discussions with other students (13.0%).

Table 1. Absolute and percentage distribution of the sample by period, gender, and age.

Period	Sample N (%)	Female N (%)	Male N (%)	Age (Years) Mean \pm SD
3rd Year	23 (34.3)	14 (60.9)	9 (39.1)	22.39 \pm 2.19
4th Year	14 (20.9)	12 (85.7)	2 (14.3)	23.79 \pm 1.72
5th Year	30 (44.8)	19 (63.3)	11 (36.7)	25.27 \pm 2.46
Total	67 (100.0)	45 (67.2)	22 (32.8)	23.97 \pm 2.54

Regarding the etiology of MIH, 68.7% of the participants believed that MIH occurs in the amelogenesis phase, followed by dentinogenesis (16.4%). Additionally, 14.9% of the respondents answered, "I don't know." The possible etiological factors of MIH most frequently mentioned were genetic factors (80.6%), nutritional factors (56.7%), chronic diseases of the mother during pregnancy, and antibiotics/drugs taken by the mother during pregnancy (41.8%) (Table 2).

Table 2. Students' responses to possible etiological factors and clinical characteristics of MIH.

Variables	Academic Year			Total N (%)
	3rd Year N (%)	4rd Year N (%)	5rd Year N (%)	
Etiological Factors				
Genetic Factors	21 (37.0)	12 (22.2)	22 (40.7)	54 (80.6)
Nutritional factors	10 (26.3)	8 (21.1)	20 (52.6)	38 (56.7)
Chronic diseases of the mother during pregnancy	8 (28.6)	6 (21.4)	14 (50.0)	28 (41.8)
Antibiotics/drugs taken by the mother	10 (35.8)	9 (32.1)	9 (32.1)	28 (41.8)
Acute diseases of the mother during pregnancy	8 (33.3)	6 (25.0)	10 (41.7)	24 (35.8)
Environmental contamination	9 (45.0)	6 (30.0)	5 (25.0)	20 (29.9)
Infancy Illness	5 (33.3)	3 (20.0)	7 (46.7)	15 (22.4)
Antibiotics/drugs taken by child	2 (15.4)	4 (30.8)	7 (53.8)	13 (19.4)
Exposure to fluoride	3 (60.0)	0 (0.0)	2 (40.0)	5 (7.5)
Clinical Characteristics				
Qualitative defect	21 (38.2)	12 (21.8)	22 (40.0)	55 (82.1)
Higher enamel porosity	11 (28.2)	8 (20.5)	20 (51.3)	39 (58.2)
Quantitative defect	7 (23.3)	7 (23.3)	16 (53.3)	30 (44.8)
Enamel demarcated opacities	8 (26.7)	7 (23.3)	15 (50.0)	30 (44.8)
Asymmetric pattern of involvement	10 (33.3)	5 (16.7)	15 (50.0)	30 (44.8)
It affects one or more permanent molars and may also be associated with permanent incisors	5 (17.9)	7 (25.7)	16 (57.1)*	28 (41.8)
Enamel diffuse opacities	10 (40.0)	5 (20.0)	10 (40.0)	25 (37.3)
Post-eruptive enamel loss	6 (28.6)	6 (28.6)	9 (42.9)	21 (31.3)
Atypical carious lesions	4 (33.3)	4 (33.3)	4 (33.3)	12 (17.9)
Atypical restorations	1 (20.0)	2 (40.0)	2 (40.0)	5 (7.5)
Symmetric pattern of involvement	2 (50.0)	1 (25.0)	1 (25.0)	4 (6.0)

*Significant differences between groups ($p < 0.05$).



Recognition that MIH typically involves one or more permanent molars, with possible involvement of permanent incisors, was significantly associated with being a fifth-year student ($p < 0.05$). According to the participants, the most frequently cited features observed in individuals with MIH were qualitative enamel defect (82.1%), higher enamel porosity (58.2%), quantitative enamel defect (44.8%), demarcated enamel opacities (color: white, creamy, yellow or brown) (44.8%), and asymmetric pattern of involvement (44.8%) (Table 2).

Most students (68.7%) responded that they had not seen a patient with MIH in clinical practice, 10.4% reported having seen patients with MIH that they had, and 20.9% were unsure. None of the participants reported feeling “very confident” in diagnosing MIH; 11.9% were confident, 29.9% were not confident, and 58.2% were slightly confident. No significant differences in confidence levels were observed when comparing dental students from different graduation years (third-, fourth-, and fifth-year) (Kruskall-Wallis test; $p>0.05$).

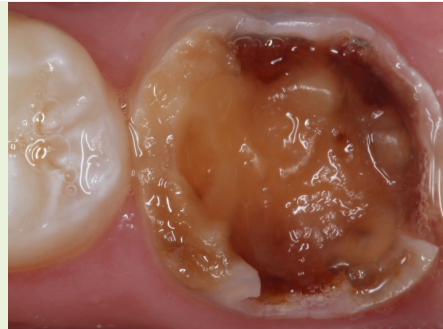
When asked which clinical conditions would be considered most challenging to differentiate from MIH, a significant proportion of participants mentioned enamel hypoplasia (64.2%), followed by amelogenesis imperfecta (55.2%), dental fluorosis (47.8%), hypomineralization due to dental trauma (28.4%), dentinogenesis imperfecta (23.9%) and dental caries (11.9%).

A differential diagnosis assessment was conducted using clinical photographs consisting of five multiple-choice questions. The available options for each question included amelogenesis imperfecta, dental fluorosis, dental caries lesion, molar-incisor hypomineralization, enamel hypoplasia, and an option indicating uncertainty (“I don't know”) (Table 3).

Table 3. Diagnosis of the presented clinical cases by dental students.

Clinical Cases	Answers	N (%)
Clinical case #1 - “What is the probable diagnosis of the buccal surface of tooth 21, knowing that the permanent molars are affected with the same condition?” 	Amelogenesis imperfecta	5 (7.5)
	Dental fluorosis	0 (0.0)
	Dental caries lesion	3 (4.5)
	Molar-incisor hypomineralization	40 (59.7)
	Enamel hypoplasia	15 (22.4)
	I don't know	4 (6.0)
Clinical case #2 - “What is the probable diagnosis of the buccal surface of the upper incisors (teeth 11 and 21), knowing that the permanent molars are also affected by the same condition?” 	Amelogenesis imperfecta	2 (3.0)
	Dental fluorosis	49 (71.6)
	Dental caries lesion	1 (1.5)
	Molar-incisor hypomineralization	4 (6.0)
	Enamel hypoplasia	6 (9.0)
	I don't know	6 (9.0)

Clinical case #3 – “What is the probable diagnosis of the occlusal surface of tooth 16, knowing that the other permanent molars have opacities demarcated with a brownish color?”



Amelogenesis imperfecta	2 (3.0)
Dental fluorosis	1 (1.5)
Dental caries lesion	46 (68.7)
Molar-incisor hypomineralization	14 (20.9)
Enamel hypoplasia	1 (1.5)
I don't know	3 (4.5)

Clinical case #4 – “What is the probable diagnosis of the vestibular face of the maxillary central incisors, knowing that the permanent molars are affected by the same condition?”



Amelogenesis imperfecta	8 (11.9)
Dental fluorosis	6 (9.0)
Dental caries lesion	5 (7.5)
Molar-incisor hypomineralization	31 (46.3)
Enamel hypoplasia	13 (19.4)
I don't know	4 (6.0)

Clinical case #5 – “What is the probable diagnosis of the buccal surface of tooth 21, knowing that the permanent molars are NOT affected by this condition?”



Amelogenesis imperfecta	16 (23.9)
Dental fluorosis	0 (0.0)
Dental caries lesion	20 (29.9)
Molar-incisor hypomineralization	14 (20.9)
Enamel hypoplasia	12 (17.9)
I don't know	5 (7.5)

Most students (58.2%) believed that the presence of hypomineralization in primary teeth may predispose to the occurrence of MIH. Additionally, a significant percentage of the sample population (70.1%) agreed that MIH is not a novel condition.

Almost all participants (94%) agreed that MIH can affect an individual's quality of life. The most commonly reported consequences of MIH were esthetic changes (91%), tooth sensitivity (86.6%), increased biofilm accumulation (86.6%), and postoperative enamel breakdown (74.6%). The least mentioned consequences were difficulty with anesthesia (9%), patient socialization (1.5%), and patient eating (1.5%).

Students considered several factors when making treatment decisions for MIH. Location, extent, and severity (95.5%), aesthetics (85.1%), patient age and behavior (77.6%), associated symptoms (73.1%), and expectations and socioeconomic level (62.7%) were the most frequently cited factors.

When asked about the need for further information regarding MIH in the dental curriculum, including the options of "etiology," "diagnosis," "treatment," and "all," most participants (77.6%) expressed agreement that comprehensive coverage of "all" aspects was necessary.

■ Discussion

The present study shows a lack of consistency in the knowledge of MIH among the dental students evaluated. To the best of the authors' knowledge, this is the first study to assess the knowledge and perception of Brazilian undergraduate dental students in the Northeast region. Assessing dental students' knowledge is important due to their pivotal role in the early diagnosis and management of this defect, which directly affects patient outcomes through early intervention to prevent further dental complications and promote oral health. In addition, the findings of this study could contribute to educational interventions for developing more effective dental curricula and teaching methods.

The findings of this cross-sectional study indicate that many participants had been exposed to this topic in different ways, such as social media and theoretical classes, corroborating that MIH, a globally recognized public health problem, has received greater attention in the literature [10]. A study in Austria found that 98% of dental students were familiar with MIH, and 86% were aware of its clinical presentation [26]. Similar results have been reported regarding dental students' knowledge of the definition/recognition of MIH [23-25,27,31]. In this study, most participants reported understanding the concept of MIH and recognized some of the clinical features associated with the condition. However, the vast majority of the participants lacked confidence in diagnosing MIH. These results are consistent with previous studies [21-23,25-27].

Fifth-year students generally have more clinical experience and enhanced training in diagnosing dental conditions compared to third- and fourth-year students. This increased exposure likely explains the higher awareness of MIH among fifth-year students observed in this study. In addition, the findings indicate that fifth-year students were more capable of recognizing the clinical feature of MIH, which affects one or more permanent molars and may also involve permanent incisors.

Regarding the multifactorial etiology of MIH [10], most students pointed out various etiological factors, such as genetics, nutrition, chronic maternal diseases, and the use of medications during pregnancy. Genetic factors were the most frequently mentioned etiological factor by most students, which aligns with previous studies [17,21,24-27,31]. The literature suggests that the complex etiology of MIH may be due to gene-environment interactions [9,32].

Only 10.4% of the participants reported having treated a patient with MIH, approximately similar to the study that found 3% [21]. These data are consistent with the worldwide prevalence of this enamel defect, as reported in studies [4,5]. In Brazil, Fernandes et al. [33] found a prevalence of 13.4% of MIH in schoolchildren, while Reis et al. [34] reported a prevalence of 28.4%. It is important to note that the study participants may

underreport MIH. Additionally, the limited exposure of participants to patients with MIH in clinical practice highlights the need for greater emphasis on this condition in dental education.

Applying clinical photographs for training allows students to develop their diagnostic skills and distinguish MIH from other DDEs and dental caries lesions [35]. Proper clinical training has been suggested to provide greater assurance of the theoretical knowledge acquired by students [36]. This study observed a divergence of responses regarding diagnosis in the different clinical cases evaluated, reflecting the students' diagnosis uncertainty. The challenges dental students encounter in diagnosing severe MIH, as illustrated in clinical case #3, highlight the need for ongoing education and adequate training. The study indicates that dental students may struggle to identify MIH in clinical practice correctly and may not be fully aware of the diagnostic criteria for MIH, as noted by Fernández-Bonet [36].

The participants frequently cited enamel hypoplasia as the clinical entity most challenging to differentiate from MIH, followed by amelogenesis imperfecta and dental fluorosis. These findings are consistent with those reported by other authors [23,24,28]. In addition, students had considerable difficulty distinguishing between enamel hypoplasia and MIH in the clinical cases evaluated. This can be explained by the fact that enamel hypoplasia, a quantitative enamel defect, may be misdiagnosed, especially when MIH-affected teeth have post-eruptive enamel breakdown surfaces.

Interestingly, our results indicate that dental fluorosis was the most easily recognizable condition in the clinical photographs evaluated, achieving the highest success rate among participants. This finding suggests that dental students are more familiar with dental fluorosis than other DDEs, possibly due to its prevalence and distinct clinical presentation [30], as well as the coverage of the topic in classes in the undergraduate dental curriculum. It is noteworthy to highlight a contrasting result reported in a previous study involving Italian dental students: only 34.59% of respondents accurately identified dental fluorosis in the clinical images assessed [29].

The findings of this study showed that nearly all participants perceive MIH as impacting individuals' quality of life. While some studies, such as those by Jälevik et al. [37] and Kisacik et al. [38], suggest a negative effect of MIH on quality of life, Fernandes et al. [33] found no such adverse effect on the quality of life of Brazilian schoolchildren. However, MIH may have socio-psychological implications [10], affecting various aspects of patients' daily lives due to factors such as hypersensitivity, esthetic concerns, dental caries lesions, and post-eruptive enamel fractures [37].

Students considered several aspects of managing MIH-affected teeth, including location, extent, severity of MIH, aesthetics, and patient age and behavior. It is important to emphasize that treating this condition is complex and relies on multiple factors for making appropriate decisions. Among these considerations, the severity of the defect and the patient's age emerge as crucial factors for comprehensive patient care, treatment planning, and implementation of preventive strategies for MIH [10].

This study has several limitations. First, a convenience sampling technique was used to select participants, and the sample size was relatively small, potentially limiting the generalizability of the findings to broader populations. The survey was conducted at only one institution, so the results may not represent Brazilian students. Future studies should include dental students from multiple universities across the country.

Moreover, the presentation of photographs for diagnosis may have posed challenges for dental students, particularly when compared to conducting clinical examinations on actual patients, as patient history and anamnesis were not assessed. While photographs might have restricted students' ability to evaluate tooth surfaces thoroughly, it is worth noting that this approach to assessing students' knowledge of MIH diagnosis

and differentiation from other DDEs has been explored in previous studies [29,30,35]. Further research could benefit from conducting the questionnaire in person, allowing for the projection of images in a controlled, standardized environment, thus minimizing variability in participants' image perception.





MIH was not comprehensively addressed in a specific didactic lecture within our dental curriculum but instead discussed through fragmented traditional lectures in various courses, such as Cariology and Pediatric Dentistry. As a result of this study, a dedicated MIH lecture was introduced for participants. Additionally, it underscored the importance of integrating MIH-specific content into the Pediatric Dentistry course. Then, theoretical and practical training classes were included, incorporating interactive sessions with photographs to distinguish MIH from other developmental defects of enamel. To enhance learning, clinical cases illustrating varying severities of MIH, classified according to the European Academy of Paediatric Dentistry (EAPD) diagnostic criteria [39], will be selected to deepen students' understanding of the essential diagnostic criteria for clinical practice. These curriculum modifications with a different teaching strategy may improve students' confidence in identifying MIH.

Overall, there is a notable lack of diagnostic clinical accuracy among students and a low level of diagnostic confidence in identifying MIH. However, the participants also demonstrated a pronounced interest in improving their understanding of MIH, particularly its etiology, treatment, and diagnosis, as shown in previous studies [21,22,26,27]. Based on these findings, reviewing and improving the dental curriculum and teaching methods about this topic may be necessary to ensure that dental students receive accurate and comprehensive education, as observed by Fernández-Bonet [36]. By improving and updating dental curricula and training strategies to enhance students' diagnostic ability, dental schools will better prepare undergraduate students by integrating conventional theoretical classes and pre-clinical practices focused on developing MIH diagnostic skills [35]. Future research should focus on studies and interventions to improve students' diagnostic skills and clinical confidence in managing MIH and other dental conditions.

■ Conclusion

While students demonstrated awareness of Molar Incisor Hypomineralization (MIH) and could identify clinical characteristics associated with this defect, the majority lacked confidence in making a diagnosis. This highlights a clear need for enhanced dissemination and teaching of MIH-related topics within the undergraduate curriculum.

■ Authors' Contributions

TGOM		https://orcid.org/0000-0001-7054-0676	Formal Analysis, Investigation, Data Curation, and Writing - Original Draft.
NOC		https://orcid.org/0000-0003-1717-1124	Writing - Original Draft and Writing - Review and Editing.
CTR		https://orcid.org/0000-0001-7756-7732	Conceptualization, Formal Analysis, Investigation, Writing - Original Draft and Writing - Review and Editing.
BGN		https://orcid.org/0000-0002-9599-0662	Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review and Editing and Project Administration.

All authors declare that they contributed to a critical review of intellectual content and approval of the final version to be published.

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None.

■ Conflict of Interest

The authors declare no conflicts of interest.

■ Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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