Prevalence and severity of Molar–Incisor Hypomineralisation in children in Fujairah, United Arab Emirates



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Abstract

Background: Molar-Incisor Hypomineralization (MIH) prevalence in paediatric patients has been widely studied. However, most of the available studies have utilised criteria that did not offer consistent diagnostic and calibration tools, which resulted in incomparable results.

Aim: This study aims to find the prevalence of MIH in children in the city of Fujairah, United Arab Emirates, utilising the current standardised guidelines for diagnosis and calibration.

Methods: Cross-sectional study. One hundred sixty-two school children aged 7–9 years in the city of Fujairah, UAE have been randomly selected and orally examined for the presence of MIH lesions. This was conducted following Ghanim et al [2015] guidelines and after calibrating examiners following Ghanim et al. [2017] training manual.

Results: MIH prevalence was 38.9% in the sample. No significant differences were found between genders with higher cases among females, but differences were statistically significant between age groups 8 and 9 years old ($p < 0.05$). Most of the lesions were mild (62%). Lower right first permanent molars had the highest occurrences and severity of MIH lesions.

Conclusion: MIH prevalence was high in the city of Fujairah, UAE. More studies utilising the standardised criteria are required for valid comparisons. Further research on the aetiology of MIH is also needed.

KEYWORDS Molar-Incisor Hypomineralisation, Prevalence, Pediatric Dentistry, Developmental Dental Anomalies.

Introduction

Molar-Incisor Hypomineralisation (MIH) was first described by Weerheijm et al. [2001a] as the common name for the phenomenon of dental lesions that "range from white-yellow or yellow-brown demarcated opacities to severely hypomineralized broken enamel" of the permanent first molars (PFM) and permanent incisors. Ever since, researchers have been trying to understand the prevalence, aetiology, and risk factors of MIH because of its negative impact on children. Unfortunately, unlike other well-defined dental lesions, MIH may have been overlooked due to the lack of unified diagnosis and calibration criteria adopted by researchers. Since first described in 2001, researchers have been utilising certain calibration methods and criteria for coding and diagnosis that sometimes were different from other studies. Global standardisation of examinations was not possible due to the lack of standardized coding and calibration guidelines. All of that was reflected by years of research on the topic around the world with considerable diversity and incomparable results. This led to either overestimation or (most likely) underestimation of the prevalence of the defect [Jälevik, 2010]. Studies have mainly been utilising the previous EAPD guidelines for diagnosis of MIH which were introduced in 2003 by Weerheijm et al. However, these guidelines offered written descriptions of MIH lesions but were missing visual illustrations of the lesions for training and calibration of examiners. As a result, researchers worldwide utilised several different methods for training and calibration that led to inconsistent results. In 2015, new standardised guidelines for diagnosis and coding of MIH were introduced by Ghanim et al., based on the European Academy of Paediatric Dentistry (EAPD) guidelines. In 2017, they published a training manual as a calibration protocol [Ghanim et al., 2017], and in 2019 the validity and reliability of this system was tested and verified [Ghanim et al., 2019]. This standardised system for diagnosis, scoring and calibration paved the way for consistent research protocols around the world. Results from different populations from different parts of the world would now be comparable and conclusions could be derivable.

Due to the use of different protocols for diagnosis, scoring, and calibration, studies have shown a very wide range of prevalence of MIH worldwide, ranging between 2.3%–46.6% [Saber et al., 2018, Dourado et al., 2020]. With most prevalence studies clustering in Europe [Ghanim et al., 2017], studies in the middle east were scarce. Few studies investigated the preva-

lence of MIH in the UAE [Haidary, 2014, Hussain et al., 2018, Padmanabhan et al., 2021a, Ahmad et al., 2019, Padmanabhan et al, 2021b]. Haidary et al. [2014] found a prevalence of 7.6% in the city of Dubai. Another study was conducted in Dubai by Hussain et al.[2018] and revealed a prevalence of 27.2%. Padmanabhan et al. [2021], found 21.16% prevalence in Ras Al Khaimah, and 7.57% was found in Dubai by Ahmad et al. [2019]. However, all of these studies utilised the EAPD criteria. There are no studies on the prevalence of MIH in other parts of the UAE.

Thus, this study aims to find the prevalence and assess severity of MIH lesions in children in the city of Fujairah, United Arab Emirates, utilising the current standardised guidelines for diagnosis and calibration. Data from similar studies will give a better insight of the phenomenon.

Material and methods

A cross-sectional study on children aged 7–9 years old, living and attending schools in the city of Fujairah, United Arab Emirates (UAE), was conducted. Exclusion criteria were children who were not living in the city of Fujairah, and children whose permanent first molars and permanent incisors had not yet erupted.

Ethical approval was obtained from the Ministry of Health and Prevention, UAE (Number: MOHAP/DXB-REC/DJF/No.72020) and was in accordance with the guidelines of the Declaration of Helsinki and constituted according to ICH-GCP requirements. Schools from government and private sectors underwent stratified sampling and 3 schools were selected.

To calculate the sample size, two factors were taken into consideration: diagnosis criteria and ethnic population similarity. Ethnic similarity adds the value of reducing genetic heterogenicity confounders as MIH is considered of a genetic-environmental origin [Jeremias et al., 2016]. In these terms, the study of Hamdan et al. [2020] conducted in Jordan was found to be the most relevant for referencing. Among the very few available studies utilising Ghanim et al. [2015] criteria, the population of their study (Jordan) is genetically considered the closest to the UAE population in the Human Genome Diversity Project (HGDP) map, and in locally conducted studies [Tay et al., 2020; Jones et al., 2017]. Elzein et al. [2020] study also mentioned that they have utilised Ghanim et al. [2015] criteria and that the study

$$CI' = \hat{p} \pm z \times \sqrt{\frac{\hat{p}(1-\hat{p})}{n'} \times \frac{N-n'}{N-1}}$$

FIG. 1 Sample size calculation formula

was conducted in Lebanon. Although Jordan and Lebanon are located in a relatively very close geographical region, the population of Lebanon was found genetically distant from the population of the UAE [Jones et al., 2017]. In regard to the diagnosis criteria, Elzein et al. [2020] looked for defects on first permanent molars only, and they overlooked permanent incisors. Without providing a considerate justification, their inclusion criteria do not strictly follow Ghanim et al. [2015] criteria of index teeth, and hence Hamdan et al (2020) inclusion criteria were more similar to the present study's approach.

Hamdan et al. [2020] found a prevalence of 13.17%. The population of children between 7-9 years old in the city of Fujairah was estimated around 3412 children based on the estimations of Ministry of Education, and Fujairah Statistics Center, UAE [Ministry of Education, 2019b, Ministry of Education, 2019a, Government of Fujairah, 2020]. Accordingly, the formula indicated in Figure 1 was used for sample size calculation.

Dropout rate of 10% was added to the sample size, bringing a total number of 188 children. Response rate was 86.7%. One hundred sixty-three children were randomly recruited from selected schools, and consent forms were obtained from their parents, between the period of February 2020 until March 2020. One child was excluded after sampling as none of his permanent teeth had erupted, bringing the total subjects to 162 children.

Oral examinations were performed after calibration of a single examiner using the MIH Training Manual for Clinical Field Surveys and Practice [Ghanim et al., 2017]. Examinations followed the recent standardized guidelines for diagnosis and recording of MIH introduced by [Ghanim et al. 2015], published in the EAPD journal [Ghanim et al., 2015]. Every child was seated on a standardised armchair with their head supported, and their teeth were examined using disposable dental mirrors under a standardised source of light. Teeth were examined looking for MIH diagnostic criteria: demarcated opacities, post-eruptive enamel breakdown, atypical caries, atypical restorations, and

	No visible enamel defect	White/creamy or yellow/ brown demarcated opacities	Post- eruptive Enamel Breakdown (PEB)	Atypical restoration	Atypical caries	Other non-MIH-related defects
Upper Right 1st Molar	68.5	11.1	1.9		5.6	12.9
Upper Right Lateral Incisor	83.3	11.1				5.6
Upper Right Central Incisor	83.3	13.0				3.7
Upper Left Central Incisor	77.8	20.4				1.8
Upper Left Lateral Incisor	83.3	13.0				3.7
Upper Left 1st Molar	66.7	7.4	1.9		3.7	25.9
Lower Left 1st Molar	55.6	11.1		1.9	3.7	33.3
Lower Left Lateral Incisor	90.7	7.4				1.9
Lower Left Central Incisor	88.9	9.3				1.8
Lower Right Central Incisor	94.4	3.7				1.9
Lower Right Lateral Incisor	96.3	1.9				1.8
Lower Right 1st Molar	55.6	13.0		5.6	3.7	31.4

TABLE 1 Percentage of permanent incisors and permanent first molars with MIH

	City	Criteria	Age range	Prevalence
Haidary et al (2014)	Dubai	EAPD	6-10	7.4%
Hussain et al (2018)	Dubai	EAPD	8-12	27.2%
Padmanabhan et al (2021)	Ras AL Khaimah	EAPD	8-12	21.6%
Ahmad et al (2019)	Dubai	EAPD	7-9	7.57%

TABLE 2 Available studies in the UAE with their main differences in design

atypical extractions of the first permanent molars and permanent incisors.

Data were entered into SPSS 20.0 software (SPSS Inc., Chicago, Ill., USA) and statistical analysis was performed using Chi-Square test, with 95% level of confidence.

Results

Prevalence of MIH among the sample was 38.9%. Despite the higher prevalence in females (43.3%) compared to males (33.3%), no significant differences were found between genders ($p = 0.454$). The effect of child's age on the prevalence of MIH was investigated and significant differences were found between the groups of 8 and 9 years olds (33.3% at the age of 7 years, 22% at the age of 8 years, and 45.5% at the age of 9 years) ($p = 0.023$).

The severity of MIH in each lesion was graded with a value of either 1 or 2. Grade 1 represents mild lesions with demarcated opacities, while grade 2 represents severe lesions that have undergone post-eruptive enamel breakdown, atypical caries, atypical restoration, and atypical extraction. Thirty eight percent of the children with MIH had at least one tooth with grade 2 severity, and 62% of the children with MIH had mild lesions only (grade 1).

Lower right first molar was the tooth with the highest frequency and severity of MIH. Upper incisors had more MIH occurrences than lower incisors (Table 1).

Discussion

Evidence around MIH prevalence and aetiology is considered weak. Despite the considerable number of studies on MIH prevalence in literature, the lack of standardised diagnosis, calibration and recording of the various manifestations of the lesions led to incomparable results. Some studies found a prevalence of as few as 2.3% [Saber et al., 2018], others resulted in as many as 46.6% , while this study found a prevalence of 38.9 %. However, the comparison is not valid. Most of the available studies in literature utilized the previous EAPD criteria [Weerheijm et al., 2003] for diagnosis and recording of MIH, while the rest used other different protocols. The previous EAPD criteria did not offer a standardised method for calibration of examiners. Each study that utilised EAPD criteria devised its own calibration method. At the same time, the EAPD criteria is based on written descriptions of each manifestation of the lesion. The wide range of different severities of MIH vary in color, texture, shape, and appearance, which require a series of visual examples for explanation. Reliance on written descriptions might be misleading and can cause faulty diagnosis of the lesions.

Studies in the region of the middle east and north Africa have generally shown lower prevalence rates as compared to this study. For example, some regions in the middle east, such as Syria, Bahrain and Iran had few variations in MIH prevalence (11.77%, 17.6%, 12.7%, respectively) [Naway F, 2015; Ditto et al., 2018; Ahmadi et al., 2012]. In other countries, such as Iraq, Saudi Arabia and Turkey, prevalence was assessed by more than one study. In Saudi Arabia, for example, some studies investigated MIH prevalence [Al-Hammad et al., 2018, Rizk et al., 2018, Allazzam et al., 2014], and they showed prevalence ranging from 8.6% [Allazzam et al., 2014] to 40.7% [Al-Hammad et al., 2018]. In Iraq, in Amir and Salih [2015] study in Al-Najaf governate, prevalence was 22.9% [Ofi and Salih, 2015], while in Ghanim et al [2011] study in Mosul city, MIH prevalence was 18.6%. Another example is Turkey, where Kilinç et al. [2019] reported 11.5% prevalence, whereas the result of Kusku et al. [2008] results showed a prevalence of 14.9%. In general, the prevalence found in this study was higher than the other studies in the rest of the region, but such comparison should take into consideration that the inclusion, examination, and calibration criteria were different

United Arab Emirates lies in the middle east, yet only few studies have investigated the prevalence of MIH and mainly conducted in the city of Dubai [Haidary, 2014, Hussain et al., 2018, Padmanabhan et al., 2021, Ahmad et al., 2019]. Studying the defect in other regions of the UAE, such as Fujairah, would help understand the geographical distribution of the lesion and aid in prevention protocols. Haidary [2014] found a prevalence of 7.6% in the city of Dubai. His study utilised the previous EAPD criteria [Weerheijm et al., 2001b], and sampled children 6–10 years old. The other study conducted in Dubai was by Hussain et al. [Hussain et al., 2018]. Their sample consisted of 342 school children aged 8-12 years old. They utilized two indices for detecting and recording MIH and found that the prevalence was 27.2% of the sample, with higher occurrence in females. The prevalence of this study was higher from the other studies conducted in the UAE. Again, this difference may be attributed to the dissimilarity in inclusion, examination, and calibration criteria. For example, in this study the inclusion criteria were children aged 7–9 years old, as the range of 6–12 years old is considered wide and inappropriate for MIH detection. According to Weerheijm et al. [2003], the best timing for detection of MIH defects is at 8 years old. At this age, all 4 permanent molars would have erupted as well as most permanent incisors, while MIH diagnostic signs will still be present. Any delay in this timing may lead to faulty diagnosis of the case due to enamel breakdown, caries progression or extraction of the tooth. Table 2 compares the available studies in the UAE with their main differences in design.

In literature, few studies were found comparable to this study. Elzein et al. [2020] mentioned that they utilised Ghanim et al criteria and training manual and found a prevalence of 26.7 %. Similarly to the present study, their sample consisted of children aged 7–9 years. However, they found no significant differences among age groups, but similar to the present study, their results revealed lower prevalence among 8 year olds (25% at the age of 7 years, 20.7% at the age of 8 years old, and 29.8% at the age of 9 years old). They have also found higher prevalence in lower molars, and most of the lesions were mild. Despite the similar findings, the prevalence they found was lower than the prevalence of this study. As discussed earlier, this could be due to not including permanent incisors as index teeth. As the factors contributing to MIH occurrence remain unclear, further studies looking at the genetic and environmental etiological factors may explain the differences between populations.

Another study was conducted in Jordan by Hamdan et al. [2020] with a prevalence of 13.17%, and one in Mexico with 12.4% [Sosa-Soto et al., 2021]. However, both prevalence rates found in these studies were lower than those of the present study. Their samples consisted of children aged 8 years. In this study, the age range of the sample was 7-9 years old, and the group of 8-year-old children had the lowest prevalence among the sample (22%). Hamdan et al. [2020] and Sosa-Soto et al. [2021] have utilised the guidelines introduced by Ghanim et al. [2015], but unlike this study, did not calibrate the examiners according to the training manual of Ghanim et al. [2017], which could have led to further inconsistencies in their findings.

In Egypt, one study utilized Ghanim et al. [2015] criteria and found a prevalence of 2.3% [Saber et al., 2018]. However, the lower prevalence in their study could be due to their sample consisting of children aged 8–12 years. At higher ages, teeth affected with MIH would have a higher chance of being treated, covered with crowns, or extracted, which may lead to misdiagnosis.

Most of the lesions in this study were mild (62%). This corresponds to what found by Elzein et al. [2020] and Saber et al. [2018], while Sosa-Soto et al. [2021] and Hamdan et al. [2020] obtained opposite results (i.e., mostly severe cases). Sosa-Soto et al. [2021] population was children living in an endemic fluorosis area. This may have led to overlapping diagnosis between MIH and fluorosis, which in turn may have led to underdiagnosed MIH. Water sources in the UAE contain fluoride ions less than the recommended global values for caries prevention (0.04-0.1 mg F/L in the UAE) [Walia et al., 2017]. This probably reduces chances of fluorosis induced by water consumption. Infant formulas in the UAE market were also found very low in fluoride content [Agha et al., 2020]. These factors are likely to decrease fluorosis incidences in the UAE. Very limited data about fluorosis is available in literature in the UAE. In their study, Ahmad et al. [2019] found 10.9% fluorosis prevalence in Dubai, UAE. However, their study was investigating MIH utilising EAPD criteria. With the available evidence of low fluoride concentrations in drinking water and infant formulas, it is likely that such a considerable prevalence of fluorosis of 10.9% may have been overlapped with MIH cases in the lack of standardised diagnosis and calibration criteria, as similar consequent misdiagnosis has been reported [Cook and Lopez, 2022]. Hamdan et al. [2020] study applied their own modifications to the coding criteria, which may have produced misdiagnosis or underdiagnosis of the lesion. Both studies did not utilize the same calibration criteria of the training manual of Ghanim et al. [2017] . Adherence to the current criteria in diagnosis and calibration in a representative sample would improve reliability and validity of the studies.

The severity ratios in this study do not indicate the severity of MIH in the child as an individual. Some children had multiple teeth with grade 1 severity, while others had a lower number of affected teeth but with a grade 2 severity. For now, we do not have a method to determine the severity of MIH for the individual. It would be highly advantageous to have a protocol for assessing the overall severity degree for the child in conjunction with the severity of each tooth. This will facilitate establishing correlations between suspected aetiological factors and MIH severity for children.

Some factors have added to the strength of this study. Conducted in schools of Fujairah, this study better represents the population compared to clinic or hospital-based studies, where usually only patients seeking treatments are admitted. Gender distribution of the sample represented the gender distribution of school children in Fujairah, with 55.6% females (90) girls and 44.4% males (72 boys), which further validates the sample. In addition, oral examinations were conducted by a single examiner. This eliminates the inter-examiner error and provides more consistent data. Examiner calibration was done under the recent guidelines introduced by Ghanim et al. [2017].

This study also faced some limitations. Intra-examiner reliability test was not achievable as Covid-19 pandemic hit amid the sample collection process. The clinical data collection phase was cut short due to the pandemic as it was impossible for the research team to reexamine children for reliability testing purposes, as schools of Fujairah went into complete lock down. The findings of this study should take into consideration the mentioned limitations.

Conclusions

This study revealed a molar-incisor hypomineralisation prevalence of 38.9% in the sample. There were no significant differences in terms of gender between MIH and non-MIH children. Sixty-two percent of the sample had mild lesions. Lower right first molars had the highest occurrences and severity of the lesion. These results can be confidently compared with results from other studies utilising the same criteria in diagnosis and calibration. This study recommends the use of the updated guidelines of diagnosis and calibration of MIH introduced by Ghanim et al. [2017], and an age range from 7–9 years old. A standardised method for MIH severity classification for individuals would be highly beneficial for correlation studies.

Institutional Review Board Statement

Ethical approval was obtained from Ministry of Health and Prevention (MOHAP, UAE) (Number: MOHAP/DXB-REC/DJF/No.72020) and was in accordance with the guidelines of the Declaration of Helsinki and constituted according to ICH-GCP requirements. Written consent was obtained from parents of the participating children.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study

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Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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