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RESEARCH ARTICLE

MOLAR INCISOR HYPOMINERALIZATION IN A GROUP OF FEMALE CHILDREN IN RIYADH: PREVALENCE AND CLINICAL CHARACTERISTICS.

Nouf S. Al-Hammad.

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Abstract

Aims. To evaluate the prevalence of and describe molar- incisor hypo-mineralization (MIH) in a group of female children in Riyadh, Saudi Arabia. *Methods.* The sample consisted of 8-10- year-old (n=682) female student's attending female elementary schools and females of the same age attending pediatric dentistry clinics at the College of Dentistry, King Saud University, Riyadh. Subject's permanent first molars (PFMs) and incisors were examined for demarcated opacities, post-eruptive enamel breakdown, atypical restorations and extraction due to MIH. *Results*. 277 children were affected by hypo-mineralization giving a prevalence rate of 40.6%. The mean affected teeth was 6.5±3.18 (3.8 molars and 2.7 incisors) per child. 46.9% had only molars hypo-mineralization (MH), while 53.1% had molars and incisors affected (MIH). Proportional t-test showed no statistically significant difference between the number of affected upper and lower molars, while upper incisors are affected more than lower incisors. Moderate/severe hypo-mineralization predominated in both MIH and MH with MIH children having more moderate/severely affected teeth. MIH prevalence has no association with the age, but ten- year-old have more moderate/severely affected teeth (P=0.041) than eight and nine-year-old children. *Conclusion*. The observed prevalence of MIH in Riyadh female children was high. Carefully planned short and long-term preventive and therapeutic programs and nationwide larger scale epidemiological studies are needed.

Introduction:-

Molar incisor hypo-mineralization (MIH) is a worldwide, relatively common dental condition among pediatric population. This hypo-mineralization of systemic origin is characterized by the presence of enamel defects that ranged from white-yellow or yellow-brown demarcated opacities to severely hypo-mineralized broken enamel of permanent first molars (PFMs) and incisors (Weerheijm et al., 2001). Enamel loss can occur immediately after eruption and under the masticatory forces leading to increased plaque accumulation, rapid progression of caries, tooth sensitivity, and toothache as well as significant cosmetic problems if the incisors are involved (Weerheijm et al., 2001; Weerheijm et al., 2003). The degree of severity and size of the defects may vary among individuals and within the same affected individual (Jalevik et al., 2001a). Restorative treatments for the affected teeth are challenging for both the patients and the dentist because of hypersensibility and difficulties in getting adequate retention for fillings (Jalevik et al., 2001a; Jalevik and Klingberg, 2002). Also, untimely extraction of severely affected first molars may lead to orthodontic complications (Fayle, 2003).

Corresponding Author:- Nouf S. Al-Hammad.

Before the proposal of the term MIH by Weerheijm and co-workers (2001), various names such as idiopathic enamel hypo-mineralization in PFMs, cheese molars, enamel hypo-mineralization of PFMs, and non-fluoride hypo-mineralization have been used to describe the condition (Koch et al., 1987; Van Amerongen and Kreulen, 1995; Jalevik and Noren, 2000; Leppäniemi et al., 2001).

Although the etiology of MIH is not fully known, it is likely to be complex and multifactorial, with some degree of genetic or epigenetic involvement (Silva et al., 2017).

A variety of possible risk factors have been noted in the literature (Meligy et al., 2014). Children with MIH present with more medical problems than controls during their prenatal, perinatal and postnatal period (Lygidakis et al., 2008a). Prolonged use of antibiotics and childhood illnesses that are occurring during mineralization of the PFMs and permanent incisors such as otitis media, upper respiratory tract infections, pneumonia, asthma, chicken pox, adenoiditis, tonsillitis and high fevers have been implicated (Jalevik et al., 2001b; Chawla et al., 2008; Laisi et al., 2009; Souza et al., 2012; Allazzam et al., 2014; Subramaniam et al., 2016). The majority of these illnesses probably cause hypocalcemia and insufficient oxygen supply affecting the maturation phase of mineralization process leading to enamel hypo-mineralization (Lygidakis et al., 2008a).

An increasing interest in this highly variable enamel disorder has been seen during the last two decades. A considerable variation in the prevalence of MIH throughout the world has been reported. In the recent reviews of MIH, rates range from 2.4% to 44% (Jalevik, 2010; Meligy et al., 2014; Elfrink et al., 2015). More studies have been conducted in Northern Europe, while only very few have been done in the region of the Middle East. A noteworthy positive association between MIH and dental caries has been reported (Tadikonda et al., 2015). Knowledge about the prevalence of MIH with its severe clinical manifestations and their complications is needed. To our knowledge, in Saudi Arabia, only one study was conducted in Jeddah and reported a prevalence of 8.6% (Allazzam et al., 2014). The present study aimed to determine the prevalence of and describe molar-incisor hypo-mineralization in a group of 8-10- year-old females in Riyadh, the largest city in Saudi Arabia.

Subjects and Methods:-

The study sample consists of healthy third and fourth-grade female students (8 -10 years) attending female elementary schools of Riyadh city and females of the same age attending pediatric dentistry clinics at the College of Dentistry, King Saud University.

The schools were randomly selected from a list of all elementary schools for girls obtained from the Ministry of Education to represent the five different educational zones of Riyadh city (Central, Northern, Southern, Eastern, and Western).

Ethical clearance was obtained from the ethical committee of the College of Dentistry Research Center and then from the President General for education office in Riyadh to facilitate the visit to the selected schools and implementation of the study protocol.

Information about the nature and purpose of the study were sent to the parents through the selected children seeking their consent for the children to participate in the study.

For the patients from the College of Dentistry, the study was explained directly to the parent/legal guardian, and the consent was obtained during the same visit of the clinical examination.

Dental examination of the subjects was conducted by one trained pediatric dentist (Author) who took part in a pilot study that preceded the study. To assess the reproducibility of the diagnostic criteria application, twenty patients were re-examined after two weeks. Intra-examiner reliability was determined using Cohen's kappa coefficient (0.91).

Inclusion criteria were: 8-10-year-old children, having all PFMs and at least six permanent incisors erupted. Children with dental fluorosis, tetracycline staining, generalized enamel hypoplasia, amelogenesis imperfecta, and children wearing fixed orthodontic appliances were excluded.

The children were examined seated on a chair facing the light source. Permanent first molars and incisors (index teeth) were cleared of debris using cotton roll then examined wet using the criteria for diagnosing MIH established by the European Academy of Pediatric Dentistry, EAPD (Weerheijm et al., 2003) and revised in 2009 (Lygidakis et al., 2010). The presence of demarcated opacities, post-eruptive enamel breakdown (PEB), atypical restorations and extraction due to MIH were assessed and recorded on a form specially designed for the study.

Statistical Analysis:-

The data collected were analyzed using Statistical package for social sciences software for Windows (SPSS Inc., Chicago, IL, USA), version 20.0. Descriptive statistics as frequency, percentage, means, standard deviations and tables, were used to describe the data. Proportional t-test and Chi-square were used to test the difference and the association between categorical variables respectively. The level of significance was set at 0.05.

Table 1:- Distribution of MH & MIH according to age.

Age (Years)	Not Affected	MH Children	MIH Children	Total
8	133	34	50	217 (30.4%)
9	148	37	48	233 (31.7%)
10	124	59	49	232 (37.9%)
Total	405 (59.4%)	130 (46.9%)	147 (53.1%)	682(100%)
		277(40.6%)		

Table 2:- Distribution of affected children according to the number of hypo-mineralized PFMs and incisors.

Hypo-mineralized incisors	Hypo-mineralized molars			Total
	2	3	4	
0	8	6	116	130
1	1	0	6	7
2	3	1	16	20
3	0	0	7	7
4	7	3	34	44
5	2	0	3	5
6	0	0	9	9
7	0	0	4	4
8	0	3	48	51
Total (%)	21 (7.6%)	13 (4.7%)	243 (87.7%)	277 (100%)

Table 3:- Distribution of hypo-mineralized teeth in each arch.

Hypo-mineralized teeth												
Total	#16	#26	#36	#46	#11	#21	#31	#41	#12	#22	#32	#42
	264	262	265	262	131	128	77	75	104	103	72	69
	526		527		259		152		207		141	
	Upper molars		lower molars		upper centrals		Lower centrals		upper laterals		Lower laterals	
	94.9%		95.1%		259/554=46.7%		152/554=27.4%		207/554=37.4%		141/554=25.4%	
					T=6.79		P=0.000*		T=4.31		P=0.000*	

*= significant difference

Table 4:- Distribution of enamel break down and atypical restoration according to tooth number.

Molars	Enamel break down		Atypical restoration	
	Yes (%)	No (%)	Yes (%)	No (%)
#16	202 (72.9)	75 (27.1)	79 (28.5%)	198 (71.5%)
#26	209 (75.5)	68 (24.5)	71 (25.6)	206 (74.4)
#36	228 (82.3)	49 (17.7)	95 (34.3)	182 (65.7)
#46	223 (80.5)	54 (19.5)	92 (33.2)	185 (66.8)
U/L	P=0.054		P=0.004*	
Total	862	246	337	771

U/L= difference between upper & lower *=significant difference

Table 5:- Distribution of Hypo-mineralization severity according to age.

Age	All Children (%)	Affected Children	Severity	
			Mild (%)	Moderate/Severe (%)
8	217 (31.8%)	84	10 (11.9)	74 (88.1)
9	233 (34.2%)	85	13 (15.3)	72 (84.7)
10	232 (34.0%)	108	5 (4.6)	103 (95.4)
Total	682 (100%)	277 (40.6%)	28 (10.1%)	249 (89.9%)
			277(100%)	

Results:-

A total number of 682 female children participated in the study with a mean age of 9.05 years (SD= ±0.78) and an age range of 8-10 years**.** Of the children examined**,** 277 were affected by hypo-mineralization giving a prevalence rate of 40.6%**.** The number of index teeth affected/child ranged from 2 teeth (8 children) to 12 teeth (48 children). In the 277 affected children, 1812 teeth (1053 PFMs and 759 permanent incisors) were hypo-mineralized with a mean of 6.5±3.18 (3.8 for molars and 2.7 for incisors) per child.

Of the 277 children affected, 130 (46.9%) had only molars affected (Molar Hypo-mineralization MH), while 147 (53.1%) had molars and incisors affected (Molar-Incisor Hypo-mineralization MIH). Children were divided into three groups according to their age (8, 9, &10). Pearson Chi-Square showed no association (P=0.112) between the age and the prevalence of hypo-mineralization (Table1). Most of the affected children (87.7%) have all the four PFMs involved (116 with MH and 127 with MIH), and 48 had all the index teeth involved. The most frequently observed association for MIH was the four PFMs-eight incisors combination followed by four PFMs-four incisors. For MH, four molars was the most frequent, and there were no cases of only one molar affected. Incisor involvement increases as the involvement of molars increased (Table 2). One upper right (#16), one lower left (#36) and four lower right first molars (#46) were extracted due to hypo-mineralization. Proportional t-test showed no statistically significant difference between the number of affected upper and lower molars, while upper incisors are affected more than lower incisors. Upper central incisors are affected more than lowers and upper laterals more than lower laterals (Table3). Hypo-mineralization was divided into mild (enamel opacity only) and moderate/severe (presence of enamel break down and/or atypical restoration). Of the 1108 molars in the affected children, 1053 were hypo-mineralized, 862 (81.9%) of them had enamel breakdown, while 191 (18.1%) had demarcated opacities only. Out of the 862 molars with post-eruptive enamel breakdown, only 337 (39%) were restored (a typical restoration). Lower molars have more (p=0.004) atypical restorations than upper molars (Table 4). All incisors were mildly affected. Moderate/severe hypo-mineralization predominated in both MIH (139/147=94.5%) and MH (110/130=84.6%), with MIH children having more moderate/severely affected teeth.

An association between hypo-mineralization severity and age was found. Ten-year-old children have more moderate/severely affected teeth (P=0.041) than eight and nine-year-old children (Table 5). No association was found between hypo-mineralization and area or educational zone (P=0.330).

Discussion:-

The present study assessed the prevalence, severity, clinical features and distribution of MIH in a group of 8-10-year-old female children.

The observed high prevalence of MIH in the present study (40.6%) is much higher than the prevalence (8.6%) reported in Jeddah, Saudi Arabia (Allazzam et al., 2014), and other Arabian countries such as Libya (Fteita et al., 2006), Jordan (Zawaideh et al., 2011), and Iraq (Ghanim et al., 2011). However, such high prevalence was reported previously by other authors in Australia 44%, United Kingdom 40% (Balmer et al., 2005), Denmark 37.3% (Wogelius et al., 2008) and Brazil 40.2% (Soviero et al., 2009).

Elfrink et al., (2015) in an updated overview of the available literature (n=55) on the prevalence of MIH reported a variation in the reported prevalence values, the sample sizes and the selection criteria of the recruited subjects. A great majority of the studies they included in their overview (n = 47) examined 8-10- year-old age groups. In most of these studies (n=31) the prevalence of MIH globally varied between 10 and 20 %. They considered the high

prevalence (>40%) as outliers, and they referred that to the small sample size examined by Balmer and coworkers (2005), and to the specific groups of patients included in Balmer and coworkers 2005; Wogelius et al., 2008 and Soviero et al., 2009 studies. In the present study, a high prevalence was found although the sample was relatively large (682) and randomly selected. This increased prevalence might be due to the inclusion of children having all the PFMs and minimum of six incisors erupted as compared to Allazzam et al., (2014) study, who included children with at least one permanent molar present. The more available PFMs for examination, the higher the chance of detecting affected children. The age of 8-10 years in the present study is considered proper, as all PFMs and most of the incisors are usually erupted, and the PFMs are yet not subjected to excessive post-eruptive breakdown.

The high variation in MIH prevalence within the same country, as between the present study and Allazzam et al., (2014), has also been reported within other different countries such as United Kingdom (Zagdwon et al., 2002; Balmer et al., 2005), China (Cho et al., 2008; Li & Li 2012) and Brazil (Soviero et al., 2009; da Costa-Silva et al., 2010; Jeremias et al., 2013). Tadikonda and coworkers, (2015) referred the high prevalence (27%) they found in Udupi district as compared to other Indian regions to the clustering effect of risk factors which they could not evaluate in their cross-sectional study design. One should be cautious when making a cross comparison between different studies. The high variation in the prevalence of MIH could be due to differences in methods, sample sizes, criteria used to diagnose MIH, different age cohorts, or real differences between regions and countries (Jalevik, 2010; Tadikonda et al., 2015). A significantly higher prevalence of MIH in children from the rural area than those from the urban area was reported (da Costa-Silva et al., 2010; Souza et al., 2012).

Similar to the findings of the present study, Allazzam et al., 2014 and Oyedele et al., 2015 reported that the prevalence of MIH has no association with age. Other researchers found the prevalence of MIH to be increasing as the age increases (Bhaskar and Hegde 2014; Gurrusquieta et al., 2017). This could be due to the wider age range (8-13 and 6-12 respectively) they included in their studies as the lesions become more obvious or easily recognized as the age increased.

A higher prevalence of MIH (53.1%) over MH (46.9%) was observed which was in accordance with some previous studies (Lygidakis et al., 2008b; Chawla et al., 2008; Parikh et al., 2012; Mittal et al., 2014). Contradictory results were reported by other researchers (Jasulaityte et al., 2007; Zawaideh et al., 2011; Bhaskar and Hegde, 2014 Subramaniam et al., 2016). Previous reports showed no agreement on the MIH more susceptible gender. Some researchers reported a higher prevalence in boys (Soviero et al., 2009; da Costa-Silva et al., 2010; Ghanim et al., 2011; Bhaskar and Hegde, 2014), while others reported either a contradictory results (Chawla et al., 2008; Zawaideh et al., 2011; Ghanim et al., 2014) or no gender predilection (Jasulaityte et al., 2007; Allazzam et al., 2014; Oyedele et al., 2015; Kirthiga et al., 2015).

Dental age may be more advanced in females than males between 5 to 16 years of age, early eruption and exposure of affected PFMs to masticatory forces will cause post-eruptive enamel breakdown earlier than in males (Chawla et al., 2008).

In the present study, only girls were included as girls have separate schools in Saudi Arabia. More local studies are required to evaluate gender predilection regarding MIH through combined studies in girls and boys schools.

Also, there is no clear evidence about whether maxillary or mandibular PFMs are more susceptible to MIH. In the present study, PFMs hypo-mineralization was similarly distributed between quadrants and arches which was consistent with some previous studies (Weerheijm et al., 2001; Chawla et al., 2008; Allazzam et al., 2014; Oyedele et al., 2015). Different researchers have reported that maxillary molars are more affected than mandibular molars (Ghanim et al., 2011; Lygidakis et al., 2008b; Soviero et al., 2009; Kirthiga et al., 2015), while others have shown contradictory findings (Jasulaityte et al., 2007; Zawaideh et al., 2011; Parikh et al., 2012; Bhaskar and Hegde, 2014; Tadikonda et al., 2015; Mittal et al., 2016; Subramaniam et al., 2016). Some of those researchers attributed the high prevalence in mandibular molars to the fact that differences in examination conditions may make it hard to view maxillary molars as clearly as mandibular molars (Mittal et al., 2016), and the early eruption with early post-eruptive enamel breakdown or caries makes the mandibular more prone than maxillary molars (Zawaideh et al., 2011). On the other hand, Chawla et al., (2008) explained the higher prevalence of hypo-mineralization in the maxillary PFMs by the same reasons analyzed differently. They stated that mandibular molars are more likely to be wetted by saliva or partially obscured by tongue movements, making mild hypo-mineralization harder to detect than

in maxillary molars and early erupting, hypo-mineralized mandibular molars may already be carious by the time of examination and not be counted among affected molars.

As in the present study, there seems to be agreement in the literature that maxillary incisors are more affected than mandibular incisors (Jasulaityte et al., 2007; Lygidakis et al., 2008b; Cho et al., 2008; Soviero et al., 2009; Ghanim et al., 2011; Parikh et al., 2012; Bhaskar & Hegde, 2014; Allazzam et al., 2014; Tadikonda et al., 2015), and laterals are the least affected (Lygidakis et al., 2008b; Parikh et al., 2012).

Opacities only on the incisors were not included in the present study as they may represent different origin of the defect and should not be referred to as MIH (Weerheijm et al., 2003).

Post-eruptive enamel break down and atypical restorations are signs of moderate/severe hypo-mineralization. In this study molars with one or both of these signs were considered moderately/severely hypo-mineralized, while molars with demarcated opacities only were recorded as mildly affected. Out of the 1053 hypo-mineralized molars in affected children, 862 (81.9%) showed post-eruptive enamel breakdown out of which only 337 (39.1%) with atypical restorations indicating a high treatment needs. This predomination of moderate/severe hypo-mineralization in the whole group of affected children and within the MIH and MH groups is similarly reported by Chawla et al., (2008). Of the 277 affected children, 249 (89.9%) had at least one molar moderate/severely affected which requires clinical attention. Ten-year-old children have more moderate/severely affected teeth than eight and nine-year-old children. Similarly, previous studies showed that as the age increased the clinical severity of the affected teeth become more prevalent (Lygidakis et al., 2008b; Zawaideh et al., 2011; Parikh et al., 2012; Bhaskar and Hegde, 2014). This age-dependent severity might be related to the amount of masticatory forces on the affected surfaces which make the incisors mildly affected as compared to PFMs in the present study and other studies (Lygidakis et al., 2008b; Parikh et al., 2012; Bhaskar and Hegde, 2014). Several studies have shown that as the involvement of molars increased the chance of post-eruptive breakdown and incisor involvement increase (Jasulaityte et al., 2007; Zawaideh et al., 2011; Ghanim et al., 2011; Bhaskar and Hegde, 2014). Similarly, in the present study, the involvement of incisors increased as the involved molars increases (Table2).

Hypo-mineralized molars are more vulnerable to the early and rapid propagation of caries (Weerheijm et al. 2001; Bhaskar and Hegde, 2014). Distinguishing a carious lesion associated with MIH from a carious lesion due to traditional risk factors is essential to determine caries risk and prompt appropriate treatment planning and patient counseling (Silva et al., 2017).

In Saudi Arabia, the prevalence of caries in children is very high. Recently a study on a large sample (17,891) of Riyadh 7-9-year-old female students revealed a high (88.8%) caries prevalence (Alshiha et al., 2017). Presence of hypo-mineralization and caries in the same tooth might affect the proper diagnosis of enamel breakdown whether it is actually due to caries or hypo-mineralization or a combination of both. Similar to other studies (Cho et al., 2008; Kirthiga et al., 2015), in the present study, PFM with caries, post-eruption enamel breakdown or restoration was recorded as MIH if demarcated enamel opacities remained at the borders or on the other surfaces. This might explain the large number of PFMs with post-eruptive enamel break down observed in the present study.

Also in this study and previous studies, post-eruptive enamel breakdown was recorded regardless of its size. It would be better in future studies to categorize the enamel breakdown according to the size of disintegrated enamel to assess the degree of severity properly. Elfrink et al., (2015), in their overview of the available literature on the prevalence of MIH, concluded that there is a need to develop standardized scoring criteria and score sheets for diagnosing MIH in order to have worldwide comparable results. Consequently, Ghanim and coworkers (2015) proposed a scoring method that enables the total spectra of MIH to be determined by including the clinical presentation of enamel lesions, the size of the tooth surface area affected by the lesion, and the tooth eruption status. They recommended field-testing of the proposed method in different age groups and different countries after validation of the method and determining its reliability.

In an update on the recent literature and discussion of the contemporary management of MIH, Silva and coworkers (2017), recommended conservative treatment for young patients, with more complex options becoming suitable as the child and dentition matures. They listed different management options including remineralization, fissure sealants, direct and indirect restorations or timely extraction of severely affected teeth for PFMs. Etch-bleach-seal

technique, direct and indirect composite veneers and ceramic veneers, which should be delayed till the complete eruption of the teeth, are the options for affected incisors.

Nowadays, enamel disturbances such as MIH contribute to the extraction of the 'keystone' molars which were previously extracted mainly due to high caries prevalence (Weerheijm, 2015).

Knowledge about the etiology, prevalence, importance of early diagnosis and proper treatment is essential for combating this dental problem which causes severe complications and has a negative impact on the child's well-being.

Examining second primary molars before the eruption of the PFMs may help in the early diagnosis of MIH. Some researchers have reported that hypo-mineralized second primary molars could act as a predictor or a risk factor for MIH (Ghanim et al., 2013; Mittal et al., 2016). Dentists should be encouraged to increase their awareness toward early identification of MIH children which will allow monitoring of their PFMs and implementation of remineralization, preventive and restorative measures as soon as the affected teeth erupt.

Conclusion:-

The observed prevalence of MIH in Riyadh female children was very high. Permanent first molars hypo-mineralization was similarly distributed between arches while upper incisors are affected more than lower incisors. There is a need for: increasing awareness of dentists and public health authorities about this alarming dental problem, carefully planned short and long-term preventive and therapeutic programs and nationwide larger scale epidemiological studies.

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References:-

1. Allazzam, SM., Alaki, SM. and El Meligy, OA. (2014): Molar Incisor Hypo-mineralization, Prevalence, and Etiology. Int J Dent., 1-8.
2. Alshiha, S.A., Alwayli, H.M., Hattan, M.A., Alfraih, Y.K., Alamri, A.A. and Aldossary, M.S. (2017): Prevalence of Dental Caries among Elementary School Girls in Riyadh, Kingdom of Saudi Arabia: A Cross-sectional Survey. J Oral Health Comm Dent., 11(2):29-33.
3. Balmer, R.C., Laskey, D., Mahoney, E. and Toumba, K.J. (2005): Prevalence of enamel defects and MIH in non-fluoridated and fluoridated communities. Eur J Paediatr Dent., 6(4):209-212.
4. Bhaskar, S.A. and Hegde, S. (2014): Molar-incisor hypomineralisation: Prevalence, severity and clinical characteristics in 8-to 13-year-old children of Udaipur, India. J Indian Soc Pedod Prev Dent., 32: 332–9.
5. Chawla, N., Messer, L.B. and Silva, M. (2008): Clinical studies on molar incisor hypo-mineralisation. Part 1: distribution and putative associations. Eur Arch Paediatr Dent., 9(4):180-190.
6. Cho, S.Y., Ki, Y. and Chu, V. (2008): Molar incisor hypo-mineralization in Hong Kong Chinese children. Int J Paediatr Dent., 18 (5): 348-352.
7. da Costa-Silva, C.M., Jeremias, F., de Souza, J.F., Cordeiro Rde, C., Santos-Pinto, L. and Zuanon, AC.(2010): Molar incisor hypo-mineralization: prevalence, severity and clinical consequences in Brazilian children. Int J Paediatr Dent., 20(6):426-34.
8. Elfrink, M.E.C., Ghanim, A., Manton, D.J. and Weerheijm, K.L. (2015): Standardised studies on molar incisor hypo-mineralisation (MIH) and hypo-mineralised second primary molars (HSPM): a need. Eur Arch Paediatr Dent., 16:247–255.
9. Fayle, S.A. (2003): Molar incisor hypo-mineralisation: Restorative management. Eur J Paediatr Dent., 4(3):121-126.
10. Fteita, D., Ali, A. and Alaluusua, S. (2006): Molar-incisor hypomineralization (MIH) in a group of school-aged children in Benghazi, Libya. Eur Arch Paediatr Dent., 7(2):92-5.
11. Ghanim, A., Morgan, M., Mariño, R., Bailey, D. and Manton, D. (2011): Molar incisor hypomineralisation: prevalence and defect characteristics in Iraqi children. Int J Paediatr Dent., 21(6): 413-421.

12. Ghanim, A., Bagheri, R., Golkari, A. and Manton, D. (2014): Molar-incisor hypomineralisation: a prevalence study amongst primary schoolchildren of Shiraz, Iran. Eur Arch Paediatr Dent., 15(2):75-82.
13. Ghanim, A.M., Marino, R., Weerheijm, K., Elfrink, M.E. and Manton, D. (2015): A practical method for use in epidemiologic studies of molar incisor hypomineralisation and hypomineralised second primary molars. Eur Arch Paediatr Dent., 16:235–246.
14. Ghanim, A, Manton, D., Mariño, R., Morgan, M. and Bailey, D. (2013): Prevalence of demarcated hypomineralisation defects in second primary molars in Iraqi children. Int J Paediatr Dent., 23:48–55.
15. Gurrusquieta, B.J., Núñez, V.M. and López, M.L**.** (2017): Prevalence of Molar Incisor Hypomineralization in Mexican Children. J Clin Pediatr Dent., 41(1):18-21.
16. Jälevik, B., Klingberg, G., Barregard, L. and Norén, J.G. (2001a): The prevalence of demarcated opacities in permanent first molars in a group of Swedish children. Acta Odontol Scand., 59(5):255-260.
17. Jalevik, B. and Klingberg, G.A. (2002): Dental treatment, dental fear and behaviour management problems in children with severe enamel hypo-mineralisation of their first permanent molars. Int J Paediatr Dent., 12(1):24-32.
18. Jalevik, B. and Noren, J.G. (2000): Enamel hypomineralization of permanent first molars: A morphological study and survey of possible aetiological factors. Int J Paediatr Dent., 10(4):278-289.
19. Jalevik, B., Noren, J.G., Klingberg, G. and Barregard, L. (2001b): Etiologic factors influencing the prevalence of demarcated opacities in permanent first molars. Arch Oral Biol., 46(3):239-247.
20. Jalevik, B. (2010): Prevalence and diagnosis of Molar-Incisor Hypo-mineralization (MIH): A systematic review. Eur Arch Paediatr Dent., 11:59-64.
21. Jasulaityte, L., Veerkamp, J.S. and Weerheijm, K.L. (2007): Molar incisor hypomineralization: Review and prevalence data from the study of primary school children in Kaunas/Lithuania. Eur Arch Paediatr Dent., 8:87–94.
22. Jeremias, F., de Souza, J.F., Silva, C.M., Cordeiro Rde, C., Zuanon, A.C. and Santos-Pinto, L. (2013): Dental caries experience and Molar-Incisor Hypo-mineralization. Acta Odontol Scand., 71(3-4):870-6.
23. Kirthiga, M., Poornima, P., Praveen, R., Gayathri, P., Manju, M. and Priya, M. (2015): Prevalence and severity of molar incisor hypomineralization in children aged 11-16 years of a city in Karnataka, Davangere. J Indian Soc Pedod Prev Dent., 33:213-7.
24. Koch, G., Hallonsten, A.L., Ludvigsson, N., Hansson, B.O., Holst, A. and Ullbro, C. (1987): Epidemiologic study of idiopathic enamel hypo-mineralization in permanent teeth of Swedish children. Community Dent Oral Epidemiol., 15(5):279-285.
25. Laisi, S., Ess, A., Sahlberg, C., Arvio, P., Lukinmaa, P.L. and Alaluusua, S. (2009): Amoxicillin may cause molar incisor hypo-mineralization. J Dent Res., 88 (2):132-136.
26. Leppäniemi, A., Lukinmaa, P.L. and Alaluusua, S. (2001): Nonfluoride hypomineralizations in the permanent first molars and their impact on the treatment need. Caries Res., 35(1):36-40.
27. Li, L. and Li, J. (2012): Investigation of molar-incisor hypomineralization among children from 6 to 11 years in Lucheng district, Wenzhou city. Shanghai Kou Qiang Yi Xue., 21(5):576-9.
28. Lygidakis, N.A., Dimou, G. and Marinou D. (2008a): Molar incisor hypo-mineralisation (MIH). A retrospective clinical study in Greek children II. Possible medical aetiological factors. Eur Arch Paediatr Dent., 9(4):207-217.
29. Lygidakis, N.A., Dimou, G. and Briseniou, E. (2008b): Molar-incisor- hypomineralisation (MIH). Retrospective clinical study in Greek children. I. Prevalence and defect characteristics. Eur Arch Paediatr Dent., 9:200–6.
30. Lygidakis, N.A., Wong, F., Jälevik, B., Vierrou, A.M., Alaluusua, S. and Espelid, I. (2010): Best clinical practice guidance for clinicians dealing with children presenting with Molar-Incisor Hypo-mineralization (MIH): An EAPD Policy Document. Eur Arch Paediatr Dent., 11:75-81.
31. Meligy, O.A.E.S.E., Alaki, S.M. and Allazzam, S.M. (2014): Molar Incisor Hypomineralization in Children: A Review of Literature. Oral Hyg Health., 2: 139.
32. Mittal, N.P., Goyal, A., Gauba, K. and Kapur, A. (2014): Molar incisor hypomineralisation: Prevalence and clinical presentation in school children of the northern region of India. Eur Arch Paediatr Dent., 15:11–8.
33. Mittal, R., Chandak, S., Chandwani, M., Singh, P. and Pimpale, J. (2016): Assessment of association between molar incisor hypomineralization and hypomineralized second primary molar. J Int Soc Prev Community Dent., 6(1): 34–39.
34. Oyedele, T.A., Folayan, M.O., Adekoya-Sofowora, C.A., Oziegbe, E.O. and Esan, T.A. (2015): Prevalence, pattern and severity of molar incisor hypomineralisation in 8- to 10-year-old school children in Ile-Ife, Nigeria. Eur Arch Paediatr Dent., 16(3):277-82.

35. Parikh, D.R., Ganesh, M. and Bhaskar, V. (2012): Prevalence and characteristics of Molar Incisor Hypomineralisation (MIH) in the child population residing in Gandhinagar, Gujarat, India. Eur Arch Paediatr Dent., 13:21–6.
36. Silva, M.J., Kilpatrick, N., Crombie, F., Ghanim, A. and Manton, D. (2017): What's New in Molar Incisor Hypo-mineralization? Dent Update, 44: 100–106.
37. Souza, J.F., Costa-Silva, C.M., Jeremias, F., Santos-Pinto, L., Zuanon, A.C. and Cordeiro, R.C.L. (2012): Molar incisor hypo-mineralisation: possible aetiological factors in children from urban and rural areas. Eur Arch Paediatr Dent., 13: 164-170.
38. Soviero, V., Haubeck, D., Trindae, C., Matta, T.D. and Poulsen, S. (2009): Prevalence and distribution of demarcated opacities and their sequelae in permanent 1st molars and incisors in 7 to 13 years old Brazilian children. Acta Odontol Scand., 67(3):170-175.
39. Subramaniam, P., Gupta, T. and Sharma, A. (2016): Prevalence of molar incisor hypo-mineralization in 7–9-year-old children of Bengaluru City, India. Contemporary Clinical Dentistry.,7(1):11-15.
40. Tadikonda, A.N., Acharya, S. and Pentapati, K.C. (2015): Prevalence of Molar Incisor Hypomineralization and its Relation with Dental Caries in School Children of Udupi District, South India. World J Dent., 6(3):143-146.
41. Van Amerongen, W.E. and Kreulen, C.M. (1995): "Cheese molars: a pilot study of the etiology of hypocalcifications in first permanent molars," ASDC Journal of Dentistry for Children., 62(4): 266–269.
42. Weerheijm, K.L., Jälevik, B. and Alaluusua, S. (2001): Molar-incisor hypomineralisation. Caries Res., 35: 390-391.
43. Weerheijm, K.L., Duggal, M., Mejàre, I., Papagiannoulis, L., Koch, G., Martens, L.C., and Hallonsten, A.L. (2003): Judgment criteria for molar incisor hypo-mineralisation (MIH) in epidemiologic studies: A summary of the European meeting on MIH held in Athens, 2003. Eur J Paediatr Dent., 4:110–113.
44. Weerheijm, K. (2015): The European Academy of Paediatric Dentistry and Molar Incisor Hypomineralisation. Eur Arch Paediatr Dent., 16(3):233-4.
45. Wogelius, P., Haubek, D. and Poulsen, S. (2008): Prevalence and distribution of demarcated opacities in permanent 1st molars and incisors in 6 to 8-years-old. Danish children. Acta Odontol Scand., 66(1):58-64.
46. Zagdwon, A.M., Toumba, K.J. and Curzon, M.E., (2002): The prevalence of developmental enamel defects in permanent molars in a group of English school children. Eur J Paediatr Dent., 3(2):91-6.
47. Zawaideh, F.I., Al-Jundi, S.H. and Al-Jaljoli, M.H. (2011): Molar incisor hypomineralisation: prevalence in Jordanian children and clinical characteristics. Eur Arch Paediatr Dent., 12(1):31-36.