Molar Incisor Hypomineralisation: prevalence in Jordanian children and clinical characteristics

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Abstract

AIM: To investigate Molar Incisor Hypomineralisation (MIH) in Jordanian children in terms of prevalence, distribution and severity of defects. **METHODS:** A cross-sectional national study with a representative sample was used. A multistage random sampling system yielded 3,666, 7-9 year-old schoolchildren, from 97 public, private and UNRWA schools from Amman, Irbid and Al-Karak. A questionnaire of six sections was sent to the parents with a consent form to participate in the study. A total of 3,241 children participated resulting in a response rate of 88.4%. A single calibrated investigator examined all children using established criteria for MIH and molar hypomineralisation (MH). Analysis of data was performed with a p value set at 0.05. **RESULTS:** Of the children examined, 570 (17.6%) were diagnosed with MIH with more females affected than males (53% vs. 47%). The 570 subjects were distributed as MIH cases in 196 children (34.4%) and MH cases in 374 children (65.6%) given that at least one incisor was erupted. Mandibular molars and maxillary central incisors were more frequently affected ($p<0.05$). No significant difference was found between right and left sides of the mouth. Most defects were mild in severity (44%) and severity increased with age and was related to the number of teeth affected ($p<0.05$). MIH teeth were more severely affected than MH teeth. **CONCLUSIONS:** MIH was common among 7-9 year-old Jordanian children with a prevalence of 17.6% and was gender related. MH was more common than MIH and can be considered a mild form of an MIH spectrum. Majority of MIH and MH cases were mild in nature but demonstrated an age-related severity.

Introduction

Molar-Incisor-Hypomineralisation (MIH) is defined as hypomineralisation of systemic origin of one to four first permanent molars (FPM) and is frequently associated with affected incisors [Weerheijm et al., 2001a]. The lesions in the FPMs are often seen together with those in the maxillary and, more rarely, the mandibular incisors. These findings indicate a systemic upset during the first years of a child's life, more precisely during the period in which the crowns of FPMs and incisors are mineralized [Koch et al., 1987; Jälevik and Noren, 2000; Weerheijm et al., 2001a].

Paediatric dentists in Europe and Australia are now aware of MIH and a majority considers it to be a clinical problem [Weerheijm and Mejàre, 2003; Arrow, 2008]. Due to the complication and difficulties in management of MIH, children at risk of this condition should be identified prior to FPM eruption, based upon a relevant history of putative aetiological factors in the first 3 years of life and from careful study under magnification of the unerupted molar crowns on any available radiographs [William et al., 2006]. However, only a limited number of studies concerning prevalence data of MIH have been available. Comparable and representative prevalence studies are lacking [Jälevik et al., 2001; Jasulaityte et al., 2007]. The limited prevalence data for MIH reflects several diagnostic classifications [Jälevik et al., 2001].

Prevalence. Based on the criteria of Weerheijm [2003], the prevalence ranges from 4% to 25% [William et al., 2006]. Following the establishment of the diagnostic criteria, the prevalence of MIH seems to vary from 3.6% to 25% in European countries, while there are no epidemiological data on its prevalence from North America [William et al., 2006; Jasulaityte et al., 2007]. In East Asia a single study has reported a prevalence of MIH in Hong Kong to be 2.8% in a sample of 2,635 children with a mean age of 12 years [Cho et al., 2008]. Prevalence studies in the Middle East are still lacking [He and Swain, 2007]. A single study in Greece with a small sample size of 250 children, 7-12 years old, reported prevalence of 14.8% [Lygidakis et al., 2008]. The aim of this study was, therefore, to investigate the prevalence of MIH in Jordanian Arab population, and to define the clinical features, severity and distribution of the defects in the affected individuals.

Methods and materials

Study population. In this cross-sectional national study, a cluster random sample was chosen from the cities of Irbid, Amman and Al-Karak representing the Northern, Middle and Southern parts of Jordan, respectively. A weighted multistage random sampling was adopted to select the children. The first stage comprised a list of all schools teaching 2nd, 3rd and 4th grades (ages 7-9 years) which was obtained from the Ministry of Education in Jordan. A random selection of 5% of the schools [(private, public and The United Nations Relief and Works Agency (UNRWA)), (females, males and mixed)] using random selection tables was performed. The second stage comprised the random selection of 25% of students. The total sample size included 97 schools with 34 in Irbid, 49 in Amman and 14 in AL-Karak, and 3,666 students in total.

Diagnosis of MIH and exclusion criteria. MIH and molar hypomineralisation (MH) were diagnosed clinically based on the diagnostic criteria established by Weerheijm [2003] (Table 1). Children were considered as having MIH when one or more FPM with or without the involvement of the incisors,

when at least one of the incisors is erupted, meeting the diagnostic criteria [Weerheijm et al., 2003]. Children were considered as having MH when one or more FPMs without the involvement of the incisors meet the diagnostic criteria [Chawla et al., 2008b]. All hypomineralised lesions regardless of their size were considered for the diagnosis of the defect. The degree of severity of MIH was determined according to Wetzel and Reckel Scale (Table 1) [Preusser et al., 2007].

Table 1. *Diagnostic criteria and degree of severity of MIH*

Diagnostic criteria:	
1.	Demarcated opacities
2.	Posteruptive enamel break down
3.	Atypical restoration
4.	Extraction of molars due to MIH
5.	Failure of eruption of a molar or an incisor
Other changes in dental enamel such as amelogenesis imperfecta, hypoplasia, diffuse opacities, white spot lesions, tetracycline staining, erosion, flourosis, white cuspal and marginal ridges should be excluded.	
Wetzel and Reckel scale of the degree of severity:	
1.	Isolated white and cream to yellowish-brown discolourations on the chewing surface and upper part of the crown.
2.	Hypomineralised yellowish-brown enamel affecting more or less all the humps on the top of the crown, but with only a slight loss of substance.
Large-scale mineral deficiency with distinct yellowish brown discolourations and defects in crown morphology resulting from extensive loss of enamel.	

Participants with all four FPMs and at least one incisor erupted were included in the study. Partially erupted molars and incisors were included in the examination. FPMs with preformed metal crowns were diagnosed as atypical restorations and were considered cases of MIH. Absence of a FPM due to extraction was related to the condition of other teeth in the dentition. Subjects with all FPMs extracted not due to orthodontic reasons, with MIH signs in any remaining incisors, were diagnosed with MIH.

Changes in dental enamel such as amelogenesis imperfecta, dentinogenesis imperfecta, hypoplasia, diffuse opacities, white spot lesions, tetracycline staining, erosion, fluorosis, white cuspal and marginal ridges were excluded from the study. Opacities noted only on the incisors, or incisors with composite resin restorations with no molar involvement were not diagnosed as MIH.

Examiner reproducibility. The same investigator (MA) who carried out all examinations was extensively trained and calibrated to perform the dental examination and diagnose MIH/MH. Calibration of intra-examiner reproducibility was assessed on a group of 20 children aged 7-9 years old at Jordan University of Science and Technology (JUST), Dental Teaching Centre R=0.95. The examiner was re-calibrated during the study and reproducibility assessed every time one tenth of the sample was examined by re-examination of the first child in that group. In total, 178 children were re-examined during the study and intra-examiner reproducibility was found to be R=0.995 according to Cronbach's Alpha test.

Clinical examination. This was performed by the calibrated investigator in schools where children were examined sitting in an ordinary chair using daylight supplemented with a head light and a portable penlight torch. Examination utilized individually wrapped and sterilized mouth mirrors, probe, gauze and dental gloves. Teeth were dried with gauze and if necessary, cotton rolls were used to remove any residual debris. A full mouth inspection was performed and data was recorded. The examination form contained a section on the demographic data including the name, age, gender, school and residence, and a chart for data entry of the diagnosis and severity of MIH.

Case de-identification and data management. Following data collection, subjects were de-identified and re-coded for anonymity. The analysis of data was carried out using Statistical Package for Social Sciences Computer Software (SPSS 17.0, Inc, and Chicago, USA). A probability value of less than 0.05 was regarded as statistically significant.

Results

After initial screening and recruitment of children, parents of 3,241 children signed and returned the consent form resulting in a response rate of 88.4%. Examinations were performed during the period between March and June 2009.

Biographic and demographic distribution. The total number of children in the sample was 3,241, with slightly more males than females [1702 (52.5%) vs. 1539 (47.5%)]; the mean age was 8.4 ± 0.7 years. The distribution of the sample among the three territories was as follows: 1,298 children from Irbid (North), 1,723 from Amman (Middle) and 220 from AL-Karak (South). According to school type 1,897 children were from government schools, 1,067 from private schools and 277 from UNRWA schools.

Prevalence of Molar Incisor Hypomineralisation. By the end of the study, 570 children with MIH were identified, indicating an overall prevalence of 17.6% in Jordan. Distribution of the affected sample is shown in Table 2. The dentitions diagnosed with enamel hypomineralisation were distributed as follows: MIH cases in 196 children (34.4%), of which almost equal numbers of males and females were affected [99 (17.4%) vs. 97 (17%)]; the remaining 374 cases (65.6%) were MH given that at least one incisor was erupted. Of those children, girls were more affected than boys [205 (36%) vs. 169 (29.6%)] but with no statistical significance (P=0.226). There was no significant relationship between MH and MIH between males and females in the different age groups.

The 196 children diagnosed with MIH were distributed as follows: 95 children (48.5%) with hypomineralised molars and incisors with all incisors erupted, 101 (51.5%) children with hypomineralised molars and incisors and not all incisors erupted. The 374 children with MH were distributed as: 174 children (46.5%) with a single hypomineralised molar only, 96 children (26%) with 2 affected molars, 46 children (12%) with 3 molars and 28 children (7.5%) with all molars affected with MH and 30 children (8%) with affected permanent and primary molars. Not all incisors were erupted in 173 of those diagnosed with MH (46.3%).

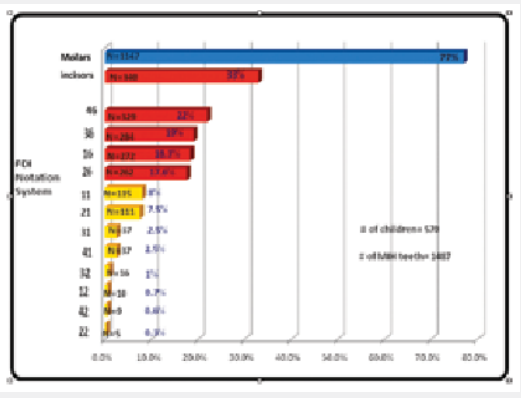
Table 2. *Distribution of MIH in a population of Jordanian children based on biographic and demographic details.*

Population Criteria		Diagnosis		P value
		No MIH n %	MIH n %	
Gender	Male	1,434 (84.3%)	268 (15.7 %)	0.004*
	Female	1,237 (80.4%)	302 (19.6%)	
Age in years	7.0	304 (82.2%)	66 (17.8%)	0.05*
	8.0	995 (85.3%)	172 (14.7%)	
	9.0	1,372 (80.5%)	331 (19.5%)	

* Statistically significant relationship (p<0.05)

Distribution of the affected teeth in the MIH children. Overall there were 1,487 teeth affected in the 570 children; 1,147 molars and 340 incisors as shown in Figure 1. In the molar group, mandibular molars were more frequently affected than maxillary ones (613 (53.4%) vs. 534 (46.6)). Chi-Square analysis of the results indicated a statistically significant relationship with a p value of <0.02. No significant differences existed between hypomineralised maxillary right and left molars (P=0.665) or between hypomineralised mandibular right and left molars (P=0.069).

Figure 1. *Distribution of teeth affected by MIH in a population of Jordanian children.*



In the incisor group, maxillary incisors were more frequently affected than mandibular ones with a statistically significant difference (P=0.00), but no difference was found between maxillary right and left incisors (P=0.562) and mandibular right and left incisors (P=0.482). In the case of central incisors, significantly more maxillary central incisors were involved (p=0.00). A difference was found between maxillary and mandibular incisors (P=0.00) with maxillary central incisors being more affected than their mandibular counterparts, however no significant difference was found between maxillary right and left central incisors (P=0.790) or mandibular right and left central incisors (P=0.577). In contrast, lower lateral incisors were more affected than maxillary lateral incisors but without any significant difference (P=0.206). Overall, the mandibular right molar was the most frequently affected (22%) while maxillary left lateral incisor was the least commonly affected (0.3%).

Distribution of children and teeth affected with all "index" teeth erupted. In order to examine and evaluate further the distribution of all affected teeth in MIH children, a sub-group of children with all their 12 'index' teeth (all FPM, and all maxillary and mandibular central and lateral incisors) erupted was formed; 296 children aged 7-9 years, 123 boys and 173 girls fulfilling these criteria were included. This subgroup of children recorded 731 affected teeth, 555 molars and 176 incisors, the mean number of affected teeth per child being 2.5; 1.9 for molars and 0.6 for incisors.

In contrast to what might be expected from the presence of all erupted 'index' teeth, the percentage of children that had both molars and incisors affected was lower in this group, 32.1% compared with 36.9% in the group of MIH where all index teeth were not erupted and to 34% in the group of all MIH children but without significant difference (p= 0.213). The remaining 67.9% had only molars affected. However, the type of teeth most commonly affected in the 'index' group was exactly the same as in the previous 'all MIH children' group, indicating the reliability of our previous findings. Table 3 illustrates the distribution of children by combination of affected teeth in MIH cases with all 'index' teeth affected.

Overall in descending order the associations most frequently found were: two molars/one incisor (16%), one molar/one incisor (15%), three molars/one incisor (14%), two molars/two incisors (10%) and one molar/two incisors (9%). The remaining associations were much less frequently found.

Prevalence of the severity of MIH. From the total of 1,147 molars affected with MIH according to Wetzel and Reckel Scale, 508 molars (44%) presented with mild lesions, 163 molars (14%) were considered to be moderate and 476 molars (42%) with severe lesions. From the total of 340 incisors affected with MIH, only four incisors presented with severe hypomineralisation while the majority of cases were considered mild in nature (301 incisors, 89%). Moderate cases accounted for only 1% of incisors.

As age increased the clinical severity of affected teeth became more prevalent. Regarding molars, there was an age related statistically significant reduction of mild cases and an

increase of severe cases (P=0.000). By 7 and 8 years of age, the most common degree of severity was the mild form affecting 67 (51.1%) and 161 (47.8) respectively of the molars affected in that age group. While at 9 years of age, 312 (46%) of molars affected were had the severe form (Table 3). For incisors, the most common degree of severity was the mild form regardless of age of the child (Table 4).

Table 3. *The distribution of affected teeth in a group of Jordanian children with MIH with all 'index' teeth erupted.*

Teeth affected					
Molars with:	**One molar n (%)**	**Two molars n (%)**	**Three molars n (%)**	**Four molars n (%)**	**Total n (%)**
Alone	95 (32.1%)	55 (18.6%)	34 (11.5%)	17 (5.7%)	201 (68%)
+1 incisor	15 (5.1%)	16 (5.4%)	14 (4.7%)	5 (1.7%)	50 (17%)
+2 incisors	9 (3%)	10 (3.4%)	5 (1.7%)	5 (1.7%)	29 (10%)
+3 incisors	3 (1%)	1 (0.3%)	4 (1.4%)	2 (0.7%)	10 (3%)
+4 incisors	0 (0%)	1 (0.3%)	3 (1%)	1 (0.3%)	5 (1.7%)
+5 incisors	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
+6 incisors	0 (0%)	0 (0%)	0 (0%)	1 (0.3%)	1 (0.3%)
+7 incisors	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
+8 incisors	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	122 (41%)	83 (28%)	60 (20%)	31 (11%)	296 (100%)

Table 4. *Distribution of 1,147 affected MIH molars in a population of Jordanian children according to degree of severity and age.*

Age of child	Degree of severity of affected molars	Total number	P value
7 years old	Mild	67 (51.1%)	0.000*
	Moderate	22 (16.8%)	
	Severe	42 (32.1%)	
	Total	131 (100%)	
8 years old	Mild	161 (47.8%)	
	Moderate	54 (16%)	
	Severe	122 (36.2%)	
	Total	337 (100%)	
9 years old	Mild	280 (41.2%)	
	Moderate	87 (12.8%)	
	Severe	312 (46%)	
	Total	679 (100%)	

* Pearson correlation, statistically significant relationship (p<0.05)

Table 5. *Distribution of 340 MIH affected incisors in a population of Jordanian children according to degree of severity and age.*

Age	Degree of severity of affected incisors	Total number	P value
7 years old	Mild	30 (86%)	0.000*
	Moderate	5 (14%)	
	Severe	0 (0%)	
	Total	35 (100%)	
8 years old	Mild	100 (90%)	
	Moderate	9 (8%)	
	Severe	2 (2%)	
	Total	111 (100%)	
9 years old	Mild	171 (88%)	
	Moderate	21 (11%)	
	Severe	2 (1%)	
	Total	194 (100%)	

* Pearson correlation, statistically significant relationship (P<0.05)

A statistically significant relationship (P=0.000) was found between the number of affected molars in each case and the severity of defect suggesting a trend that as the number of affected molars increased the severity of the defect increased.

Discussion

Study sample. This cross-sectional large-scale epidemiological national survey with a representative sample used a random multi-staged sample to ensure representation of three geographic areas in Jordan and three different types of schools. The final sample size of 3,241 schoolchildren was almost equally distributed between males and females.

The age range chosen in the study (7-9 years) was considered most appropriate for the proper assessment of MIH. As at this age, in most children, all 4 FPMs would have erupted, and the majority of incisors. In addition, the risks that enamel hypomineralisation would be masked by caries and/or restorations were minimal. In order to assure consistency in sample examination, a single investigator was used after calibration prior to the commencement of the study and whose reliability was tested prior to and during the study.

Aspects of diagnostic criteria. To define a 'true' prevalence of MIH in Jordan, the diagnostic criteria recommended by the European Academy of Paediatric Dentistry [Weerheijm, 2003] were used. Thus any visible defect, regardless of size, was included in contrast to other studies where defects equal to or larger than 2 mm were considered [Alaluusua et al., 1996a; Jälevik et al., 2001; Leppaniemi et al., 2001; Calderara et al., 2005]. Children with only one affected molar were included and subjects with all FPMs extracted, not due to orthodontic reasons, with MIH signs in one other index tooth, were diagnosed as MIH.

Prevalence of MIH. The overall prevalence of MIH was 17.6% among 7-9 year-old school children in Jordan. Although comparing epidemiological studies from different countries is not applicable because of variations in criteria, sample selection, lesions included and aetiological and environmental factors exist, this study showed that MIH in Jordan was moderately prevalent by comparison with data for other countries.

The prevalence of MIH in Jordan appears to be close to that reported in Sweden (18.4%) among 7-8 year-olds, Finland (17%) among 7-8 year olds and (19.3%) among 7-13 year -olds [Alaluusua et al., 1996a; Jälevik et al., 2001; Leppaniemi et al., 2001]. The high percentages of MIH recorded in some of the previous studies may be attributed to smaller sample sizes, examination of special groups, such as those with prolonged breast feeding or pre-term birth histories, or as a result of using different indices and diagnostic criteria not differentiating between demarcated and diffuse opacities [Alaluusua et al., 1996b; Aine et al., 2000, Leppaniemi et al., 2001; Arrow, 2008].

Comparing the results herein to the only study of the prevalence of MIH in East Asia by Cho et al. [2008] in Hong Kong, it was much higher in Jordan (17.6% vs. 2.8%) despite the fact that both studies utilized the same diagnostic criteria. The difference may be because the mean age of children examined in Hong Kong was 12.0 years. When older children are studied, high caries activity, wear and restorations could have superimposed the developmental defects that might be obscured by restorative treatment.

Only two studies were part of large-scale epidemiological national surveys [Koch et al., 1987; Kosem et al., 2004]. In the study by Koch et al. [1987] six age groups of children (born in 1966, 1969, 1970, 1971, 1972, and 1974) were examined when they were 8–13 year olds. Children born in 1970 (examined at 9 years of age) had a prevalence of 15.4%, which is close to the prevalence of our study in spite of differences in the diagnostic criteria utilized. Kosem et al. [2004] reported the prevalence of MIH in 2,339 Slovenian adolescents, 12-18 year old children to be 14%.

Gender predilection was evident in this study with girls more affected than boys (53% vs. 47%). It is speculated that as girls are more advanced than boys in dental development, affected FPMs may be more advanced in their eruption. This would expose hypomineralised molars to masticatory forces and leading to post eruptive breakdown compared with boys of the same age [Chawla et al., 2008a].

The results of the current study demonstrated a significant relationship between the occurrence of MIH and age. A higher prevalence was reported in 9 year olds compared with 7 and 8 year olds (58.2% vs. 11.6% and 30.2% respectively). That increased prevalence may also be related to a specific environmental factor in the year of birth of the group examined.

Clinical characteristics of MIH. Upon assessing the clinical characteristics of MIH in the population studied, a wide spectrum of the defect was noted. The MH cases were twice as common than MIH (65.6% vs. 34.4%). In the sub-group of children with all their molars and incisors 'index' teeth erupted, similar percentages were also found (67.9% vs. 32.1%). This supports the description of the clinical characteristics mentioned and emphasises the higher prevalence of MH over MIH in Jordanian children.

Although not proven with certainty, variation in the susceptibility of maxillary and mandibular molars to MIH was emphasised in this study. Mandibular molars were more frequently affected than maxillary ones. This was in agreement with Jasulaityte et al. [2007] and Jälevik et al. [2001] but contradicted other studies that found a similar distribution of hypomineralised molars between arches [Weerheijm et al., 2001b; Cho et al., 2008, Chawla et al., 2008a], and that more maxillary molars were affected than mandibular [Leppaniemi et al., 2001; Preusser et al., 2007; Muratbegovic et al., 2007; Lygidakis et al., 2008].

Several factors may explain the arch difference of MH prevalence as maxillary and mandibular molars may be examined under differing conditions. The sitting position of children during examination, the lighting source may obscure the MH lesions in maxillary molars, and whether teeth were examined wet or dry. The higher prevalence of MH in the mandible could also be due to earlier eruption than maxillary molars [Nanda, 1960]. Erupting earlier, hypomineralised mandibular molars may be examined better, may have already under gone post-eruptive enamel breakdown or may be carious making them more obviously affected than maxillary molars.

As with all other studies, maxillary incisors were more frequently affected than mandibular. In central incisors, similar differences were found between arches and between sides of the mouth. In contrast, mandibular lateral incisors were more affected than maxillary ones but without a significant difference (P=0.827), in agreement with Jasulaityte et al. [2007]. This may be explained as the majority of maxillary lateral incisors not being erupted or assessed due to less than half of a crown being erupted and lesions not noticed, contradicting Preusser et al. [2007] and Lygidakis et al. [2008], who reported maxillary lateral incisors more affected than mandibular ones. The age group of the children in the two studies extended up to 12 year-olds increasing a chance of full eruption of maxillary lateral incisors at the time of examination [Preusser et al., 2007; Lygidakis et al., 2008].

Severity of MIH. In agreement with other reports investigating the same age group, most of the defects noticed and recorded in this study were mild in severity (44%) [Jälevik et al., 2001; Preusser et al., 2007; Jasulaityte et al., 2007]. As hypomineralised teeth erupt, they are very susceptible to dental caries and post-eruptive enamel breakdown because of mastication. As soon as an affected tooth erupts it is

likely that its condition will deteriorate quickly with destruction explaining why fewer teeth are detected with moderate severity which might explain the age-dependant findings as supported in previously published studies [Leppaniemi et al., 2001; Jasulaityte et al., 2007].

A noteworthy finding was the association between teeth affected in the cases of MIH and the degree of severity. This association may be the result of the variation in timing, duration and severity of an insult or combination of insults affecting ameloblasts during the maturation stage of amelogenesis [Jälevik et al., 2001; Leppaniemi et al., 2001; Jasulaityte et al., 2007; Lygidakis et al., 2008]. A higher percentage of children with affected molars and incisors had severe hypomineralisation (44%) than the children with only one type of teeth affected (40%). Involvement of both molars and incisors may be related to more severe insults acting for a longer time on ameloblasts.

Comparing affected dentitions, the mean number of affected FPMs and their severity of hypomineralisation was higher in dentitions with MIH than MH. Chawla et al. [2008a] speculated that MIH and MH form an 'MIH spectrum' of developmental defects of enamel, where MIH is the more severe form of hypomineralisation, affecting both FPMs and permanent incisors, and MH is the milder form, affecting FPMs only. As the precipitating condition or conditions increase in severity and/or duration, more teeth are affected and the effects on mineralisation become more apparent [Chawla et al., 2008a]. The findings in this study support such a suggestion.

Conclusion

Molar-incisor hypomineralisation (MIH) was common among 7-9 year old Jordanian school-children with a prevalence of 17.6% with a predilection for girls and place of residence. Molar Hypomineralisation (MH) was commoner than MIH, even in cases where all 'index' teeth were erupted. Variation in the susceptibility of maxillary and mandibular teeth was noted, with mandibular molars more affected than maxillary ones while in the incisor group maxillary incisors are more commonly affected. The majority of MIH and MH cases in Jordan children were mild in nature but demonstrated an age-related severity and was directly proportionate to the number of teeth affected.

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