CROSS-SECTIONAL STUDY

Are Hypomineralized Primary Molars and Canines Associated with Molar-Incisor Hypomineralization?

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Abstract: ***Purpose:*** *The purpose of this study was to evaluate the prevalence of and relationship between hypomineralized second primary molars (HSPM) and hypomineralized primary canines (HPC) with molar-incisor hypomineralization (MIH) in 1,963 schoolchildren.* ***Methods:*** *The European Academy of Paediatric Dentistry (EAPD) criterion was used for scoring HSPM/HPC and MIH. Only children with four permanent first molars and eight incisors were considered in calculating MIH prevalence (n equals 858); for HSPM/HPC prevalence, only children with four primary second molars (n equals 1,590) and four primary canines (n equals 1,442) were considered. To evaluate the relationship between MIH/HSPM, only children meeting both criteria cited were considered (n equals 534), as was true of MIH/HPC (n equals 408) and HSPM/HPC (n equals 360; chi-square test and logistic regression).* ***Results:*** *The prevalence of MIH was 14.69 percent (126 of 858 children). For HSPM and HPC, the prevalence was 6.48 percent (103 of 1,592) and 2.22 percent (32 of 1,442), respectively. A significant relationship was observed between MIH and both HSPM/HPC (P<0.001). The odds ratio for MIH based on HSPM was 6.31 (95 percent confidence interval [CI] equals 2.59 to 15.13) and for HPC was 6.02 (95 percent CI equals 1.08 to 33.05).* ***Conclusion:*** *The results led to the conclusion that both hypomineralized second primary molars and hypomineralized primary canines are associated with molar-incisor hypomineralization, because children with HSPM/HPC are six times more likely to develop MIH.* *(Pediatr Dent 2017;39(7):445-9) Received May 2, 2017 | Last Revision July 17, 2017 | Accepted July 18, 2017*

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Molar-incisor hypomineralization (**MIH**) is defined as a developmental enamel defect that affects at least one permanent first molar. Affected anterior teeth might also be observed.[1] MIH prevalence varies according to the population studied, ranging from very low values (2.5 percent) in China[2] to a prevalence higher than 40 percent in Australia[3] and Brazil.[4] Such differences cannot be explained only by differences in the population studied; they are also affected by the lack of standardization in the research protocols.[5]

MIH is characterized by demarcated opacities that vary from white to a brownish color and which may progress to a posteruptive enamel breakdown.[6] In the most severely affected individuals, dentin will be exposed. Histologically, the MIH opacity is more porous than sound enamel[7] because of its lower mineral density, and porosity increases from white to brown according to the opacity color.[8] Clinically, this porosity makes MIH opacities more prone to breakdown; also, the treatment is more challenging, because the porous enamel is a barrier to optimal bonding to adhesive materials.[9] To make treatment even more complicated, hypersensitivity is a frequent complaint of patients affected by MIH.[1] A subclinical, but constant, pulp inflammation is present under the opaque area[10]; because of that, pain control using local anesthesia might fail.

Children who are affected by MIH receive more invasive treatments than those who are not affected.[11] Therefore, as soon as MIH is diagnosed, children should be placed under a strict preventive program to avoid cavity development in any posteruptive enamel and the necessity for more complex restorative procedures. Therefore, if the clinical characteristics of the primary dentition could predict the occurrence of MIH in the permanent dentition, the dentist might be able to control recall intervals and advise parents of the importance of seeing the child as soon as the permanent first molar erupts.

The prevalence of hypomineralized second primary molars (**HSPM**) shows a great variation ranging from zero percent[12] to 21.8 percent[13] and an association with MIH.[14,15] However, most studies were conducted in Europe, and there is no information about prevalence of MIH in primary teeth in children from North or South America. Moreover, whether the presence of demarcated opacities in the primary canines is also associated with MIH is unknown, as the studies available report only on primary second molars.

Therefore, the purposes of this study were to: (1) determine the prevalence of hypomineralized second primary molars and hypomineralized primary canines (**HPC**); and (2) investigate whether an association existed between their occurrence and the occurrence of molar-incisor hypomineralization in a group of Brazilian schoolchildren.

Methods

This study was approved by the Research Ethics Committee of the Faculty of Health Science of the University of Brasília, Brasília, Brazil and authorized by the Department of Education of the local government.

A cross-sectional epidemiological study was carried out among six- to 11-year-olds from all six public schools located in a suburban area of Brazil's Federal District (n equals 1,963). Children and their parents were invited to participate, and all those who signed the informed consent were included in

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the survey. Children who did not allow the examination were excluded.

The socioeconomic status of the sample was considered similar, since all participants resided in the same area and lived similar life styles. All children had access to fluoridated water (0.7 ppm).

Three examiners, all dentists, were trained and calibrated on (1) the Caries Assessment Spectrum and Treatment (**CAST**) instrument[16-18] to register carious lesions; and (2) European Academy of Paediatric Dentistry (**EAPD**) criterion[1] to record MIH. The training sessions, conducted by two experts, comprised a theoretical explanation of both criteria (two hours for the CAST instrument and three hours for the EAPD criterion), followed by a discussion of: (1) a series of images containing different stages of carious lesions; and (2) teeth affected by MIH and other developmental enamel defects with different categories of severity. The severity was rated within three categories, according to Leppaniemi et al.[19]: (1) mild (opacities without posteruptive enamel breakdown); (2) moderate (opacities with posteruptive breakdown [**PEB**] limited to enamel); and (3) severe (PEB with dentin involvement, atypical restorations, and tooth extraction due to MIH). PEBs were defined as enamel breakdown that occurred due to the severe porosity of the hypomineralized opaque areas that fracture when subjected to masticatory forces, resulting in unprotected enamel/dentin.[20]

After the visual training, for the CAST instrument, a set of extracted teeth was examined, and the codes were discussed. Afterward, in two separate clinical sessions, 10 children in the same age groups as those in the survey, but who did not participate in the main study, were examined in field conditions. Subsequently, another 10 children were examined, and the inter- and intra-agreements of the examiners were obtained.

The examinations were conducted at the schools using a portable dental chair and artificial light and began by recording the children's visible plaque index[21] and gingival bleeding index.[22] Teeth were then cleaned using a toothbrush and toothpaste, and a caries diagnosis was performed. For the MIH registration, the teeth were wet, and opacities smaller than one mm were not registered. A trained dental assistant aided all examiners. HSPM and HPC were recorded following the same standards used for MIH. The Cohen kappa was approximately 0.61 to 0.69 for all variables (MIH, HSPM, and HPC) during the examination, as presented in Table 1. Children who presented with treatment needs were referred to the clinic of the University Hospital Pediatric Dentistry. Moreover, during the examination session, children received an oral hygiene kit containing fluoridated toothpaste, a toothbrush, and dental floss. The dental team also gave advice on how to use the kit and on healthy diet habits.

Table 1. INTRA- AND INTER-KAPPA VALUES OBTAINED FOR HYPOMINERALIZED SECOND PRIMARY MOLARS (HSPM), HYPOMINERALIZED PRIMARY CANINES (HPC), AND MOLAR-INCISOR HYPOMINERALIZATION (MIH) DURING CLINICAL EXAMINATION

Examiner	1	2	3
1	0.6513 (intra)		
2	0.6476	0.6870 (intra)	
3	0.6977	0.6586	0.6195 (intra)

Data were analyzed using Stata 13.1 software (Stata, College Station, Texas, USA). Different numbers of children were used for calculations as follows: for MIH prevalence, a total of 858 children were included based on the presence of all permanent first molars and eight incisors; for HSPM prevalence and HPC, only children with four primary second molars (n equals 1,590) and four primary canines were considered (n equals 1,442). For the association between MIH/HSPM and MIH/HPC, children had to present both conditions, totaling 534 and 408 included children, respectively. In addition, children were grouped according to MIH/HSPM/HPC severity, as previously described. Statistical analysis was performed using the chi-square test and logistic regression (odds ratio).

Results

Sample descriptive analysis. Of the 858 children with all permanent first molars and eight incisors, 51.57 percent were girls and 48.43 percent were boys, with a mean age of 9.6±1.21 (SD) years. For this group, the prevalence for MIH was 14.69 percent (126 children of 858).

For HSPM, the sex distribution was 53 percent boys and 47 percent girls, with a mean age of 8.11±1.29 (SD) years. The prevalence was 6.48 percent (103 of 1,590). For HPC, the sample was composed of 55 percent boys and 45 percent girls, with a mean age of 7.95±1.19 (SD) years; its prevalence was 2.22 percent (32 of 1,442). In considering the unit tooth, the prevalence was reduced for all variables to 3.99, 2.19, and 0.69 for MIH, HSPM, and HPC, respectively (Table 2).

For all types of hypomineralization, most children presented the condition in one tooth. Moreover, considering the severity of the hypomineralization, at least 70 percent of the affected teeth presented mild to moderate hypomineralization for primary second molars, primary canines, and permanent first molars.

A significant relationship was observed between MIH and HSPM ($P< 0.001$) and between MIH and HPC (P 0.05). The

Table 2. DISTRIBUTION OF HYPOMINERALIZED SECOND PRIMARY MOLARS (HSPM), HYPOMINERALIZED PRIMARY CANINES (HPC), AND MOLAR-INCISOR HYPOMINERALIZATION (MIH) AT CHILD LEVEL AND TOOTH LEVEL

Distribution	HSPM n (%)	HPC n (%)	MIH n (%)
Children	103/1,590 (6.48)	32/1,442 (2.22)	126/858 (14.69)
Teeth	139/6,360 (2.19)	40/5,768 (0.69)	274/6,872 (3.99)
No. of affected teeth			
1	78 (75.73)	24 (75)	53 (42.06)
2	16 (15.53)	8 (25)	32 (25.4)
3	5 (4.85)	0	22 (17.46)
4	4 (3.89)	0	11 (8.73)
≥5	-	-	8 (6.35)
Mean no. of affected teeth	1.35	1.25	2.17
Severity of hypomineralization			
Mild	80 (57.55)	36 (90)	192 (70.07)
Moderate	17 (12.23)	3 (7.5)	32 (11.68)
Severe	42 (30.22)	1 (2.5)	50 (18.25)

P-value and odds ratio are presented in Table 3. Considering the 534 children evaluated for MIH and HSPM, 443 (82.97 percent) did not present MIH or HSPM; 65 (12.17 percent) presented only MIH, 13 (2.43 percent) presented only HSPM; and 13 (2.43 percent) presented both MIH and HSPM. For the 408 children evaluated for MIH and HPC, 343 (84.04 percent) did not present MIH or HPC; 57 (14 percent) presented only MIH; four (0.98 percent) presented only HPC; and four (0.98 percent) presented both MIH and HPC.

A logistic regression analysis was performed to evaluate whether the number of affected primary teeth and the severity of the primary tooth hypomineralization were associated with the presence of MIH. No association was observed regarding the number of affected teeth or the severity of the hypomineralization for either HSPM or HPC ($P>0.05$). Table 4 presents the opacities and PEBs frequencies comparing MIH and HSPM/HPC.

When the group of children with all four permanent first molars and permanent incisors (MIH), all four primary second molars (HSPM), and all four canines (HPC) was evaluated (N equals 360), a significant association was observed among all three types of hypomineralization ($P<0.005$). Of the 360 children included in this analysis, seven (1.94 percent) presented HPC, 14 (3.89 percent) presented HSPM, and 52 (14.44 percent) presented MIH. Of the seven children with HPC, four of them presented MIH and three presented HSPM. Of the 14 children with HSPM, 10 presented MIH and three presented HPC.

Discussion

Overall, the results of the present investigation showed that the occurrence of both HSPM and HPC was associated with the presence of MIH in a group of Brazilian schoolchildren. As far as the authors are aware, this is the first time that such an evaluation has been carried out in children from the American continent and also the first time that the association between demarcated opacities in primary canines and MIH was investigated.

Table 3. RESULTS OF LOGISTIC REGRESSION ANALYSES ON PRESENCE OF MOLAR-INCISOR HYPOMINERALIZATION (MIH) REGARDING HYPOMINERALIZED SECOND PRIMARY MOLARS (HSPM) AND HYPOMINERALIZED PRIMARY CANINES (HPC), NUMBER OF AFFECTED TEETH, AND SEVERITY OF HYPOMINERALIZATION

MIH	Odds ratio	95% confidence interval	*P*-value
HSPM	6.82	3.03-15.35	<0.0001
HPC	6.02	1.46-24.75	<0.05
No. affected teeth	1.7	0.65- 4.53	0.281
Severity	1.3	0.56- 3.09	0.538

Table 4. OPACITIES AND POSTERUPTIVE BREAKDOWNS (PEBS) FREQUENCIES COMPARING MOLAR-INCISOR HYPOMINERALIZATION (MIH) AND HYPOMINERALIZED SECOND PRIMARY MOLARS (HSPM) AND HYPOMINERALIZED PRIMARY CANINES (HPC)

	HSPM			HPC		
MIH	Not affected	Opacities	Breakdown	Not affected	Opacities	Breakdown
Not affected	443	6	7	343	3	1
Opacities	39	8	2	35	3	0
PEBs	26	3	0	22	1	0

The rationale for including canines in the evaluation was based on the development, including crown mineralization, of the primary second molars and primary canines at around the same time.[23] Moreover, studies that aimed to determine the prevalence of developmental defects of enamel in the primary dentition showed that demarcated opacities are more frequently seen in these two groups of teeth.[24,25] Thus, taking into account that previous studies have shown an association between HSPM and MIH,[14,15] whether this also occurs for HPC was investigated.

The criteria used in this study to record demarcated opacities in primary teeth were those proposed by the EAPD[26] for registering hypomineralization in permanent teeth. However, the defects were additionally classified, according to their severity, as mild, moderate, and severe.[27] This was necessary, because canines are different from molars in that opacities may occur on smooth and/or occlusal surfaces in molars, while the opacities were located only at the buccal surface in canines. Therefore, more moderate and severe defects were expected in molars than in canines; this was confirmed by our results that showed 90 percent of the opacities recorded in canines did not progress to PEB, although the time in the mouth was approximately the same for both molars and canines. Regarding primary and permanent molars, the severe condition was three times more likely to occur in the primary second molars than in the permanent first molars. This was most probably because they were in the mouth for a longer period and exposed to more masticatory forces, which is a trigging factor for PEB.[8] As a result, they will more frequently require atypical restorations and extractions.

In terms of prevalence, MIH was observed in 14.69 percent of the children—results that are similar to those obtained in surveys that used the EAPD criteria in Germany[28,29] and Brazil,[30,31] regardless of the differences in the children's age and research protocol. As to HSPM, the prevalence detected was 6.48 percent, almost the same value (6.6 percent) observed in a survey carried out with Iraqi children who were assessed in schools,[14] as in the present investigation. However, a much higher prevalence has already been described (21.8 percent) for Dutch children, most probably due to the small sample size and methodology used to judge the defects (photographs).[13] Still, with respect to prevalence, no other study applying a similar methodology was found, which made the comparison of the prevalence of HPC found in the present study (2.22 percent) impossible. However, in a survey conducted in Spain, a prevalence of 1.7 percent of demarcated opacities was observed for primary teeth, with the canines, second molars, and incisors being the most affected teeth.[25]

The most relevant results of the present study refer to the significant associations found between both HSPM and HPC with MIH. MIH was six times more likely to occur in children with either HSPM or HPC. Such an outcome has already been described for HSPM, where demarcated opacities in second molars are considered a predisposing factor for MIH[15] or a predictor of MIH.[32] Nevertheless, MIH was observed in children who did not present with HSPM or HPC, indicating that the absence of the opacities in primary dentition does not exclude the appearance of MIH.[32] Moreover, an association between HSPM and HPC

was detected. All these associations might be explained by the temporal relationship among the mineralization of primary canines, primary second molars, and permanent first molars.[24,25] It has been shown that the crown formation, growth in length, and closure of the root apex of both primary second molars and canine primary teeth take place at the same time and that the process of crown formation of the permanent first molar also coincides with this period.[23]

Finally, a discussion about the importance of knowing that HSPM and HPC increase the chances of a child presenting with MIH is needed. Currently, the etiology of MIH is not fully understood nor is a treatment available that can effectively prevent PEB. Therefore, exploring factors that can assist the clinician in selecting children who are more prone to MIH is of great relevance. Parents should be alerted to the problem, and children should be followed-up preventively.[9] In addition, early detection of demarcated opacities in primary teeth and, subsequently, adoption of preventive measures (especially in primary second molars) is important for tooth preservation; this is because the mineral content and crystal arrangement of sound enamel in primary teeth is associated with lower mechanical properties than in permanent teeth,[33] a condition that might worsen in areas of hypomineralization.

This study had some limitations. Although it is representative of the children from Paranoá, it did not allow a comparison between different socioeconomic groups. The sample included in the present study was considered vulnerable because of the low income and low level of education of that community, according to a national database.[34] Also, cross-sectional studies do not allow causality inference. Notwithstanding these limitations, the present study shows the importance of clinically examining the primary dentition; this includes recording opacities and hypomineralization in the canines and molars, as they are significantly associated with MIH. Moreover, it is advisable to closely monitor permanent first molars for MIH if children present with HSPM/HPC.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Both hypomineralized second primary molars and hypomineralized primary canines are associated with molar-incisor hypomineralization, as children with HSPM/HPC are six times more likely to develop MIH.
2. No association was observed between the number of affected primary teeth and the severity of hypomineralized primary teeth with the development of MIH.

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