Association Between Frequency and Severity of Dental Fluorosis and Molar Incisor Hypomineralization

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Objective: To assess the association between the frequency and severity of dental fluorosis (DF) and molar incisor hypomineralization (MIH) in a fluoridated salt region. Study design: In this retrospective cross-sectional study, we evaluated the buccal, occlusal/incisal, and palatal/lingual surfaces of first permanent molars and permanent incisors of 453 patients aged 13–16 years through intraoral standardized photographs. Two standardized examiners evaluated DF and MIH independently, utilizing the Thylstrup-Fejerskov (TF) index and the MIH index. The statistical analysis was performed using a generalized linear model and logistic regression adjusted for age, sex, and dental caries experience. Results: The MIH frequency at the surface level was lower in the presence of DF (PR= 0.03; P= 0.00, 95% CI: 0.01–0.08). At the surface level, MIH severity was lower among those presenting mild DF (aOR= 0.02; 95% IC: 0.01–0.07). Regarding severe DF, we found no significant difference in MIH severity (P= 0.174). Conclusion: MIH frequency and severity tend to be lower in the presence of DF.

Keywords: MIH, Fluorosis, Hypomineralization, Pediatric dentistry.

INTRODUCTION

While we have seen a decrease in the dental caries experience, developmental defects of enamel (DDE) are increasingly evident in clinical practice. Dental development is a slow, complex, multidimensional, and multilevel genetically-controlled process. DDE are caused by interactions of local, systemic, genetic, and environmental factors, which can affect the functional ameloblast. Hence, the type of defect will depend on when the damage occurred during amelogenesis. If the damage occurs during the secretory phase, when the matrix is deposited, a hypoplasia type DDE can occur. In contrast, if the damage occurs during the maturation phase when the matrix is removed and the mineral content incorporated, a hypomineralization type DDE can occur, which can be diffused or demarcated.

It is widely accepted that fluoride effectively controls dental caries. However, it has been suggested that fluoride excess can stress the ameloblast affecting the synthesis of proteins responsible for the organic matrix removal, clinically resulting in a diffuse hypomineralization named dental fluorosis (DF). This type of DDE varies from thin, white, and fuzzy lines to a completely white surface. The most severe cases may display pigmentation and loss of structure. DF affects symmetrically groups of teeth, especially the permanent maxillary premolars, second molars, and incisors.

Molar incisor hypomineralization (MIH) is a type of DDE of multifactorial origin with a possible genetic component that
asymmetrically affects the first permanent molars and permanent incisors. Clinically, well-demarcated white, yellow, or brown opacities can be seen, which may be associated with post-eruption fractures, atypical dental caries lesions, and atypical restorations. The MIH affected enamel presents significant structural and componental alterations, which may result in hypersensitivity and dental caries.

The studies that have evaluated the association between DF and MIH in fluoridated water regions have found lower MIH frequencies. However, data from fluoridated salt regions are lacking. Also, the available studies have used the modified DDE index (mDDE), which according to Elfrink et al presents disadvantages since it does not consider classic MIH characteristics such as post-eruption fractures, atypical dental caries lesions, atypical restorations, and dental extraction. Thus, for the first time in a fluoridated salt region and using specific and validated indexes, we aimed to evaluate the association between the frequency and severity of DF and MIH.

**MATERIALS AND METHOD**

This study is described according to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement.

**Study design, setting, and participants**

This retrospective cross-sectional study was approved by the Institutional Committee of Research Ethics of CES University (project code Ae-401; act 141; 2019) and followed the Council for International Organizations of Medical Sciences (CIOMS) guidelines related to the use of clinical records for research. Informed consent was obtained from all participants.

We examined intraoral photographic records of adolescents aged 13–16 years, born and residing in Medellin, Colombia, who attended the dental clinic of CES University’s School of Dentistry. Since 1989 and as public health policy, the Colombian population has access to fluoridated salt (180–220 mg F/kg). According to the National Study of Oral Health (ENSAB IV, 2014), the prevalence of DF in 15-year-old Colombian adolescents is 56%.

The data was collected between February and April 2020. The intraoral photographic records of patients with craniofacial syndromes, and those wearing fixed appliances or dental prostheses were excluded.

The inclusion criteria were as follows: patients with permanent dentition and complete digital (JPG format), high-resolution (1280x853 pixels per inch) photographic records, consisting of 5 photographs, i.e., upper arch, lower arch, right lateral, left lateral, and occlusal.

**Variables**

The presence of MIH was defined as the primary outcome. DF was considered an explanatory variable, and age, sex, and dental caries experience were considered confounding variables.

**Measurements and bias**

DF was classified according to the Thylstrup-Fejerskov (TF) index. This index allows to record DF based on histopathological characteristics and includes the mildest to the most severe stages (ordinal scale from 0 to 9). Based on the loss of structure, teeth with TF 1–4 were classified as mild DF, and those with TF ≥ 5 were classified as severe DF. An independent and standardized (Kappa= 0.89) examiner made the DF classification.

MIH was classified according to the MIH index. This index classifies the defect’s clinical state (demarcated opacity, post-eruption enamel fracture, atypical restoration, atypical dental caries lesion, or absent tooth due to MIH) and extension by thirds in the buccal, occlusal/incisal, and palatal/lingual surfaces. The surfaces showing opacities only were classified as mild, and the surfaces showing loss of structure, atypical restorations, atypical dental caries lesions, and extracted teeth were classified as severe. MIH evaluation was performed by another standardized examiner (Kappa= 0.87), who also evaluated the dental caries experience using the decayed, missing, and filled teeth (DMFT) and decayed, missing, and filled surfaces (DMFS) indices proposed by the World Health Organization (WHO) (Kappa= 0.91).

The photographs were taken by a single operator with the same photographic equipment (Nikon D3400 24 mp with a 90mm macro lens and a Dine Mini Ring and Point Flash) and processed with Adobe Photoshop Lightroom (version 2017 for Mac). The photographs were evaluated on a desktop computer with an integrated 21.5-inch screen (1920x1080 pixels per inch) and an Intel HD Graphics 6000 1536 MB graphic card, using Preview (version 11, Apple Inc., CA, USA) in full-screen mode.

**Sample size and statistical analysis**

This study presents a secondary analysis of an existing sample consisting of 453 photographic records (Farias et al unpublished) in which the association of MIH with other permanent teeth was analyzed with an 80% statistical power and a prevalence ratio (PR) ≥ 1.9.

DF and MIH were calculated as an affectation percentage at patient, tooth, and surface level. A generalized linear model with a binomial family and logarithmic link function was used to analyze the association between DF and MIH at the surface level. The results are presented as PR with P-values and 95% confidence intervals (CI). Ordinal logistic regression was used to analyze the association between the DF’s and MIH’s severity. The results are presented as ordinal odds ratios (OR) with P-values and 95% CI. In both cases, the adolescents-teeth-surfaces conglomerate was considered through a robust estimation of the variances. The results are presented as crude estimations adjusted for age, sex, and dental caries experience. Also, statistical power post hoc estimates were made for the OR. The data were analyzed using STATA® (version 16.1; College Station, TX, USA).

**RESULTS**

The final sample consisted of 453 patients, of whom 228 (50.33%) were females. The mean age was 14.49 ± 1.19 years. Figure 1 shows the frequency of DF’s and MIH’s involvement per tooth.

The percentage of patients with DF was 28.70% (n= 130); 23.07% presented at least one tooth with severe DF. The premolar was the most frequently affected tooth (18.15%), with the maxillary (20.84%) being more commonly affected than the mandibular (15.45%). The first permanent maxillary molars (4.09%) were the less affected teeth. The permanent maxillary incisors (7.88%) and canines (9.07%) were more frequently affected by DF than the mandibular (3.37% and 5.03%, respectively). The most commonly...
affected surface was the occlusal (13.03%), followed by the buccal (12.71%) and palatal/lingual (8.10%). Considering all the evaluated permanent teeth surfaces \( (n = 32441) \), the most frequently encountered score was TF2 (3.74%). No teeth/surfaces presented with TF \( \geq 7 \).

The percentage of patients with MIH was 31.06% \( (n = 141) \); 38.3% presented at least one tooth (first permanent molar or permanent incisor) with severe MIH. 32.62% of the patients presented MIH in one tooth, 36.17% in two teeth, 18.44% in three teeth, 6.38% in four teeth, and 2.84% in six teeth. The first permanent right maxillary molar was the most frequently affected tooth (7.73%), followed by the first permanent left maxillary molar (7.21%), the first permanent left mandibular molar (5.15%), and the first permanent right mandibular molar (4.19). Among the permanent incisors, the maxillary were the most frequently affected. The buccal was the most commonly affected surface (3.73%), and the palatal was the least commonly affected (0.51%).

Table 1 shows the distribution of DF and MIH in first permanent molars and permanent incisors at surface level. TF2 was DF’s most frequent score, and white or cream demarcated opacities were the most frequent MIH defect.

Table 2 shows the presence of MIH, according to the presence of DF at surface level. The frequency of MIH frequency at surface level was higher in the absence of DF \( (PR= 0.03; 95\% CI: 0.01–0.08) \) and presence of dental caries \( (PR= 3.80; 95\% CI: 2.39–6.03) \). Age, sex, and dental caries experience did not influence the association between MIH’s and DF’s presence \( (aPR= 0.03; 95\% CI: 0.01–0.08) \). However, we observed heterogeneity in the association’s strength between DF and MIH, being higher in the absence of dental caries.
As the examination was based on photographic records, this study’s limitation is that the history of fluoride exposure could not be identified. However, to control this information bias, we established that all participants should have born and resided in the same city (as obtained from the medical record) as one of the inclusion criteria. The use of photographs could represent a methodological limitation due to the risk of under- or overestimating the frequency and severity of enamel defects. As for MIH and dental caries, the use of standardized photographs for the diagnosis of DF is a reliable and reproducible method compared to clinical diagnosis.

DF’s pathologic mechanism has been widely discussed in the scientific literature. Chronic fluoride intake during amelogenesis affects the dental enamel’s structure and composition. In this study, the permanent premolars and second permanent premolars were the most frequently affected teeth by DF (Figure 1). The frequency and severity of DF tend to be higher in permanent teeth with delayed eruption because fluoride exposure increases with age. According to Bårdesen’s meta-analysis, fluoride exposure duration seems to be more critical than specific risk periods during amelogenesis. In contrast, the first permanent molar was the least affected tooth by DF. This is interesting since the first permanent molar is the most frequently affected tooth in MIH.

Similar to other studies conducted in fluoridated water regions, we found that the frequency and severity of MIH was lower in the presence of DF (Table 2). Balmer et al. (2012) suggest that fluoride could be a MIH protective factor, while Koch (2003) affirms that MIH cannot be related to fluoride intake. Based on our findings, we hypothesize that DF and MIH “compete” with each other; thus, studies are needed that evaluate the temporality of these defects. We also believe that the difference in fluoride exposure between regions/populations could explain the variability in the prevalence and severity of MIH.

CONCLUSION

Our findings showed that in a fluoridated salt region, the MIH frequency and severity tends to be lower in the presence of DF.
REFERENCES


