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Developmental enamel defects: A review

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Abstract
Introduction: Defects in tooth enamel development compromise the structural integrity of teeth, making them more susceptible to caries, wear and sensitivity.
Objective: To analyze the literature on dental enamel development defects such as dental fluorosis, molar-incisor hypomineralization (MIH), amelogenesis imperfecta and enamel hypoplasia, as well as their prevalence, etiology and treatment of each one of them.
Methodology: A search was carried out in the databases PubMed, SCOPUS and Google Scholar using the keywords “Dental fluorosis”, “Molar-incisor hypomineralization”, “Hypoplastic enamel” and “Amelogenesis”.
Results: Based on the literature, there is a wide variability in the prevalence of dental defects, with dental fluorosis being the most frequent. Fluorosis is attributed to high fluoride consumption, while MIH has a multifactorial etiology, amelogenesis imperfecta is related to genetic alterations and enamel hypoplasia to environmental and genetic factors. Treatments focus on improving dental esthetics, including whitening, microabrasion and application of infiltrative resins. In the case of MIH, sealants and calcium phosphate substances are additionally used to reduce sensitivity, caries risk and promote remineralization of the tooth.
Conclusion: Dental enamel defects vary in their etiologies and prevalence and have profound impacts on the quality of life of patients. In terms of treatment, there are several options for esthetic purposes, desensitization and minimizing the appearance of carious lesions, such as infiltrative resins, whitening and microabrasion.

Keywords: Dental fluorosis, molar-incisor hypomineralization, hypoplastic enamel, amelogenesis

1. Introduction
The formation of tooth enamel can be affected, which can influence susceptibility to developmental defects and diseases such as dental caries [1]. Developmental defects in enamel are common and may be associated with genetic conditions, as well as environmental factors or systemic diseases occurring during different stages of amelogenesis [2]. Defects may present qualitatively, evidenced by white, yellow or brown opacities, or quantitatively, manifested by cavities, grooves or a more pronounced deficiency, or a combination of both [3]. MIH is a disorder that causes adverse impact on enamel and dentin structure, primarily in the first molars and permanent incisors [4]. Dental fluorosis in more severe situations may be linked to skeletal fluorosis [5]. Research on developmental enamel defects is crucial because of their impact on patients' oral health and quality of life. These conditions can cause tooth sensitivity, pain and increase the risk of caries, affecting masticatory function and dental esthetics, so understanding these alterations is fundamental to improve clinical outcomes. In this paper we analyze the literature on developmental defects of dental enamel, such as dental fluorosis, molar-incisor hypomineralization, amelogenesis imperfecta and enamel hypoplasia, as well as their prevalence, etiology and treatment of each of them.

2. Materials and Methods
An electronic search was carried out through PubMed, Google Scholar and Scopus, using the

terms: “Dental fluorosis”, “Molar-incisor hypomineralization”, “Hypoplastic enamel” and “Amelogenesis”, using Boolean operators "AND" and "OR". The quality of the articles was evaluated using guidelines tool. As inclusion criteria, only articles from high impact journals were collected, including systematic reviews, literature reviews or clinical studies that treated in behavior management techniques. Likewise, the search was delimited in terms of publication date, taking only recent articles, published mainly within the last 5 years. The selection of articles was made according to the relevance of the title and/or abstract to the topic to be analyzed. After the selection of relevant studies, their references were searched for possible additional relevant studies that met the inclusion criteria.

3. Results

3. Developmental enamel defects

3.1 Dental fluorosis

3.1.1 Prevalence

It is estimated that about 65% of people aged 12 to 15 years have this condition, and approximately 30.4% of diagnoses are considered moderate to severe [6]. The incidence is higher in fluoride-endemic areas, where fluoride levels are mild to moderate [7]. mainly due to consumption of groundwater or artesian well water for domestic use [8], which contains fluoride concentrations equal to or greater than 1.5 ppm [9].

3.1.2 Etiology

The likelihood of developing dental fluorosis increases with exposure to higher concentrations of fluoride in water and higher levels of fluoride in the blood [10], as well as indoor burning of charcoal [11] for food preparation [12] and high tea consumption (greater than two cups per day) by the mother during pregnancy and lactation [13].

3.1.3 Treatment

It is possible to successfully treat teeth affected by dental fluorosis using a minimally invasive approach [14] that includes microabrasion, bleaching and especially resin infiltration [15], which has been shown to be the most effective in the long term [16].

The high prevalence of dental fluorosis in young people from areas with fluoride-rich water highlights the importance of effective treatments such as microabrasion, bleaching and resin infiltration, the latter being particularly effective in the long term.

3.2 Molar-incisor hypomineralization (MIH)

3.2.1 Prevalence

MIH is widely prevalent globally [17], with the Americas having one of the highest rates of involvement and Asia showing the lowest prevalence [18]. The most common lesions affect a single tooth surface, usually the buccal, covering less than one-third of the tooth surface area [19].

3.2.2 Etiology

The cause of this condition is multifactorial [20]. It has been observed that perinatal factors such as hypoxia at birth, prematurity and other problems associated with hypoxia, such as cesarean section, may increase the likelihood of developing MIH [21]. In addition, postnatal factors such as high fever during early infancy, antibiotic use [22], measles, urinary tract infections, kidney disease, pneumonia, asthma and jaundice may also be related to this condition [23].

3.2.3 Treatment

Various therapeutic strategies are employed with the purpose of reducing sensitivity, promoting remineralization and reducing the risk of carious lesions [24]. These strategies include the application of infiltrating resin, fissure sealants, minimally invasive restorative treatment, resin composite restorations, stainless steel crowns and silver-fluoride sealants [25]. In addition, the use of calcium phosphates, calcium glycerophosphate and hydroxyapatite are also options to restore mineralization in MIH-affected teeth and help alleviate tooth sensitivity [26].

MIH is a global dental disorder with significant variations in prevalence, being especially high in the Americas. This condition is mainly characterized by lesions affecting a single tooth surface, its etiology is clearly multifactorial, ranging from perinatal to postnatal factors that complicate its prevention and treatment which focuses on reducing sensitivity, remineralization of enamel and minimizing the risk of carious lesions.

3.3 Amelogenesis imperfecta

3.3.1 Prevalence

Its frequency varied between 1 in 700 and 1 in 14,000 cases [27] of which 73% is non-syndromic amelogenesis imperfecta and 27% as syndromic amelogenesis imperfect [28].

3.3.2 Etiology

Autophagy plays an essential role in the process of ameloblast differentiation and its dysfunction has been linked to the occurrence of amelogenesis imperfect [29], as well as mutations of different genes such as LAMA3 [30], AMELX and ENAM [31].

3.3.3 Treatment

It is crucial to initiate treatment early to maintain the integrity of the dental structures by means of ceramic restorations [32]. For the primary dentition, temporary or direct treatments that address functional problems are proposed [33], while for permanent teeth, definitive solutions using indirect and restorative techniques can be contemplated to restore both function and esthetics [34].

Amelogenesis imperfecta has a variable prevalence and is classified into syndromic and nonsyndromic forms, reflecting its genetic and etiologic complexity. The underlying mechanisms include dysfunctions in autophagy and genetic mutations, so an early approach to treatment is essential, adapting interventions to the functional and esthetic needs of the primary and permanent dentition to preserve dental health and improve the patient's quality of life.

3.4 Enamel hypoplasia

3.4.1 Prevalence

Enamel hypoplasia has a prevalence of 12.8%, with no correlation between sex [35], the most affected teeth are the upper incisors followed by the first primary molars and canines [36]. In addition, patients with MIH show a higher incidence of enamel hypoplasia, suggesting a possible common cause between these problems.

3.4.2 Etiology

It is caused by environmental and/or genetic influences that affect normal tooth development [37], such as vitamin D deficiency [38], trauma to primary teeth affecting the tooth germ [39], diseases suffered during childhood, especially infections, metabolic disorders, premature birth or

malnutrition [40] and lack of adequate levels of retinol in the maternal blood during the 12th to 14th weeks of pregnancy [36].

3.4.3 Treatment

As a treatment, the application of infiltrating resin hides the hypoplasia in the enamel, achieving a homogeneous and shiny surface [41]. Prior to the application of infiltrating resin, microabrasion can be carried out using phosphoric acid and pumice stone [42], as well as composite resin with a silicone palatal guide can also be used [43].

Enamel hypoplasia, with a prevalence of 12.8% and no gender differences, mainly affects upper incisors, primary molars and canines. Its origin is due to environmental and genetic factors, including nutritional deficiencies and childhood diseases, and its effective treatment involves microabrasion followed by the application of infiltrating resin.

4. Conclusions

The high prevalence of fluorosis, MIH and enamel hypoplasia in young people is evidence of the need for a multidisciplinary approach to oral health. The complex etiology of these disorders, combined with their impact on quality of life, demands personalized and early treatment. Microabrasion and resin infiltration are presented as promising therapeutic options, especially for fluorosis and hypoplasia. However, further research is required to develop effective prevention strategies and to address the particularities of each condition, considering genetic, environmental and nutritional factors.

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