

Primary Teeth Stains and Discoloration: A Review

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Abstract

The current review assesses the literature concerning the etiology of primary teeth staining and discoloration. The appearance of the dentition is of concern to many children and their caregivers seeking dental treatment as the color of the teeth is of aesthetic importance. The correct diagnosis of the cause of the discoloration is important as, invariably, it has a profound effect on treatment outcomes. It would seem reasonable, therefore, that dental practitioners understand the etiology of tooth discoloration to make a diagnosis and enable appropriate treatment to be conducted. Knowledge of the etiology of tooth staining is of importance to the dental practitioner to explain the patient the exact nature of the condition. In some instances, the mechanism of staining affects the outcome of the treatment and influences the options the dentist will be able to offer. Many of these contributing factors are preventable if parents are educated, managed by professional interventions, or provide a multidisciplinary approach. In this review, we highlight the importance of children smiles and the difference between primary and permanent teeth. We discuss the different types of primary teeth staining and discoloration and whether it is intrinsic or extrinsic, as well as the different impacts of some conditions on primary teeth compared with permanent teeth.

Keywords

- pediatric dentistry
- oral health
- child
- tooth discoloration

Introduction

Understanding the different etiological factors of staining and discoloration in primary teeth will lead to better management approaches and quality of dental treatments, meeting children's rights and improving their quality of life. Dental treatment can make a positive impact on the psychological and social aspects of a child's life.^{1,2} For pediatric dentists, it is essential to provide parents with information regarding the preventive methods to avoid deciduous teeth discoloration. Increasing population knowledge about tooth discoloration etiology, especially systemic diseases that can cause discoloration, the importance of oral hygiene, pregnancy and infancy care, and preventing injury to deciduous teeth should be a priority.³

received August 22, 2020 accepted after revision November 21, 2020 DOI https://doi.org/ 10.1055/s-0040-1722276. ISSN 2474-5871. Teeth color is influenced by a combination of presence of any extrinsic stains that may form on the tooth surface and their intrinsic color.⁴ Teeth discoloration is defined as the variation from normal color, and this phenomenon can significantly affect the child's personality.⁵ Color variations can be present in an individual tooth from the incisal edge to the darker cervical area around the gingiva.⁶ Among the millions of color varieties, ~100,000 can be found in natural human teeth.⁷ Color is a combination of the psychophysiological response to the physical interaction of light energy with an object and the subjective experience of an individual observer.⁸ In 1981, Munsell described color using the following three terms: chroma, hue, and value.⁹ The value reflects the lightness of the color and the chroma is the brightness reflecting its degree of strength and intensity. The hue enables the

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individual to differentiate between the different families of color.¹⁰ Within the same dentition, tooth color can vary between different types of teeth, where canines are usually darker in color than others.¹¹ For the tooth to appear in its total color, a combination of light will be created and then it will be scattered and reflected by different layers of enamel and the dentin underneath.⁶ The perception of color is influenced by three different factors: the object, the observer, and the light source.¹² Other factors to be considered are the time of day and the angle of the tooth.¹³ As a result, a tooth will exhibit different colors when viewed under different conditions due to the differences in wavelength of the light source.¹⁴ According to Kim and Simmer, A1, A2, and B1 are the most common color shades in primary dentition.¹⁵

Primary teeth develop earlier than permanent teeth. An accurate chronology of primary teeth calcification is clinically significant to dentists.^{16,17} All primary teeth develop throughout the embryonic stage, starting from around 6 weeks and undergoing five stages of the tooth life cycle, including the following: initiation, proliferation, histodifferentiation, morpho-differentiation, apposition, and calcification. It is common to have a defect that includes primary teeth discoloration and staining as a result of a disturbance to any stages.^{16,17} Multiple variations have been found when comparing primary and permanent teeth. These are important to understand, as it is essential to address the difference in response to a condition affecting them and how to deliver an evidence-based treatment. There is a difference in the enamel and dentin thickness between primary and permanent teeth, in addition to a difference toward the enamel rods. A study compared both dentitions' mineral content, the thickness of the enamel, and enamel rods, and concluded the following: the primary enamel structure showed a lower calcium and phosphorus level, less thickness, and higher numerical density of rods.¹⁸

Finn, Nelson, and Ash identified 12 differences between deciduous and permanent teeth; deciduous teeth are smaller than their successors in all dimensions, a thinner layer of enamel and dentin thickness is noted with a wider pulp chamber having the pulp horns (specially the mesial horn) closer to the occlusal surface when compared with permanent molars. In addition, the crown of primary teeth is wider mesiodistally and the roots are longer and narrower.^{19,20} In staining, some conditions commonly affect permanent teeth, such as molar incisor hypomineralization.⁵ In contrast, other conditions affect primary teeth more severely, such as dentinogenesis imperfecta (DGI).²¹

Nondental primary care providers can improve children's oral health. There is a growing international interest in the role of pediatricians in children's oral health,²² especially considering the high caries rate affecting children with primary teeth (\sim 33% of 5 years old). While recent findings demonstrate limited knowledge regarding oral health, pediatric awareness of the risk factors and etiology of dental conditions will lead to a timely referral system and costeffective dental management. A study of dental awareness among pediatric postgraduate physicians in the United Kingdom concluded that collaboration with dentists should

be done to ensure that education programs include information about the oral health of children.^{22,23}

Since the United Nation convention on children's rights in 1987, research has shifted toward increasing involving children in decision making, including in dental treatments.²⁴ Meeting patients' aesthetics demands is proven to motivate patients to adhere to preventive measures and to keep their teeth healthy.³ In addition, the psychological concerns of children and their parents or caregivers have been reported. A study of 1,140 adolescents concluded that multiple dental disorders, including caries, tooth loss, and dental trauma affected their self-esteem.²⁵ Another study asked 40 children affected by amelogenesis imperfecta (AI) about the single most important feature they wanted following their dental treatment; the results show that more than 60% of children hoped for color improvement in their teeth. Furthermore, most children started to notice a difference in their teeth color at around 6 years of age due to a defect.²⁶

The purpose of this study is to review the literature on the etiology of primary teeth staining and discoloration as there has been little mention in literature.²⁷

Classification of Tooth Discoloration

The crown of the tooth is composed of the following three layers: enamel, dentin, and pulp. Any disturbance that occurs within these layers may affect the appearance and color of the tooth, caused by the light transmission and reflection properties of these layers. Teeth discoloration is classified as intrinsic and extrinsic based on the stain location, where each can be further classified into the subcategories shown in **Fig. 1**.¹⁴

Intrinsic Discoloration Factors

Intrinsic discoloration occurs due to a change in the structural composition or thickness of the dental hard tissues, both the enamel and dentin. This means that the chromogenic material becomes incorporated within the dental hard tissue: either during tooth development (pre-eruption), such as dental fluorosis, tetracyclic stain, inherited development defects of enamel and dentin without any systemic features and hematologic disorders, or during the post-eruptive phase of tooth development, such as pulpal necrosis. These stains can be localized on one or several teeth, through trauma, inadequate or improper endodontic treatment, and staining due to restoration (amalgam staining).²⁸

The treatment of intrinsic tooth discoloration staining conditions will depend on the cause, severity of the condition, and age of the child. However, appropriate management should include establishing prevention, pain and sensitivity control, improve the aesthetic, and using different behavior management techniques. Both partial (resin composite and glass ionomers) and full coverage (preformed crown) are used to restore defected primary teeth.²⁹

Dental Fluorosis

Dental fluorosis causes generalized intrinsic staining due to excessive exposure to fluoride in both prenatal and postnatal



Fig. 1 Classification of teeth discoloration.

periods. It is the most common cause of intrinsic stain, especially in areas where drinking water has fluoride concentrations above optimal levels. Furthermore, the high prevalence may be due to the high availability of fluoride in multiple sources other than water.^{30,31}

The severity differs based on the dose, duration of exposure, stage of ameloblastic activity, and variation in personal susceptibility.^{32,33} This excessive or chronic ingestion of fluoride during the enamel formation will cause hypomineralization or the porosity of this layer. In severe cases, the porosity will extend to the amelodentinal junction, which may lead to the breakdown of the enamel after tooth eruption.²⁷ High concentrations of fluoride have an effect on the activity of the ameloblasts, with more clinical effect during the formation of the anterior teeth.³⁴

The clinical appearance of dental fluorosis ranges from mild, gentle accentuation of perikymata pattern, to white opaque spots or streaks on the surface enamel, extending to brown pitting patches, to a more severe case of almost complete loss of the enamel layer. This phenomenon is less aggressive in primary teeth than permanent teeth and this can be attributed to shorter maturation and formation periods of primary teeth or the thinner enamel layer in them.²⁷

Tetracycline Stain

Tetracycline stain was first reported in the mid-1950s. The Food and Drug Administration announced in 1963 the harm of such antibiotics to pregnant women and young children.³⁵ The most critical time for tetracycline staining is during tooth formation (i.e., between the 2nd trimester intrauterine and 8 years of age). Deposition of tetracycline stain in the bone of the fetus will affect bone growth. If large amounts of tetracycline are consumed during the calcification stage, this will result in hypoplasia of dental hard tissues (i.e., enamel or dentin).³⁶

The pattern of deposition occurs on the incremental lines of both dentin and enamel, giving the whole tooth a stained appearance. The mechanism of deposition is explained by the chelation action of the tetracycline molecule with the calcium present in the hydroxyapatite crystals that form a complex named tetracycline-calcium orthophosphate complex.^{36,37} Having a larger surface area of hydroxyapatite crystals, such in dentin, makes it susceptible to absorb a higher load of the tetracycline. After the administration of tetracycline, its chromogen is permanently present in the dental hard tissue; it can even be released throughout the normal bone remodeling. This constant release of tetracycline circulates freely in the bloodstream to reenter and be incorporated into other distant tissues undergoing calcification.³⁸

The extent and severity of the stain depend on the time and duration of the drug's administration and the dosage used, affecting the extent, color, depth, and location of the stain ranging from light yellow to blue or brown in more severe cases.³⁸ Minocycline, a tetracycline analog, may cause serious discoloration in teeth for both children and adults when taken for as short as 1 week.³⁹

Diagnosis of the tetracycline stains is based on history, clinical presentation, and the fluorescence appearance under ultraviolet light (at \sim 360 nm). The labial surface of the anterior teeth is usually the first to get a darker color, whereas the more protected posterior teeth maintain a yellowish color for a longer period.⁴⁰ When comparing the effect on both primary and permanent teeth, permanent teeth are less intense but more diffused compared with the primary teeth.⁴¹

Inherited Development Defects of Enamel and Dentin Without Any Systemic Features

Al is caused by gene mutation or altered expression. The term used when a group of hereditary conditions affects the tooth enamel appearance and structure, frequently associated with changes in other intraoral and/or extraoral tissues. The teeth are sensitive, fragile, and discolored, and are characterized by hypomineralization or hypoplasia. When a child's teeth are affected by AI, the clinical appearance and structure of all or the most of primary and secondary dentitions will be affected. The prevalence of AI differs depending on region or country of origin; however, the average global prevalence is less than 1 in 200.⁴² Aldred et al proposed a classification of AI based on different aspects that includes molecular basis, mode of inheritance, phenotype (appearance), and biochemical outcome.⁴³ Depending on the appearance, the types of AI vary from the relatively mild hypomature "snow-capped" enamel to the more severe hereditary hypoplasia with thin, hard enamel, which has a yellow to yellow-brown appearance¹⁴ as shown in **Fig. 2**.

The etiology of AI is attributed to multiple fetal or maternal conditions. For example, a disturbance in the development of the tooth germ, such as deficiency of maternal vitamin D, infections (i.e., rubella), drug intake during pregnancy, and in pediatric hypocalcemia conditions.⁴⁴ The time at which the interference in development is very important where it characterizes the degree of the systemic uptake.

Deciduous molar hypomineralization is another enamel defect leading to yellow-brown staining. The significance of this condition comes from the second primary molars develop in the same period of the first permanent molar. As a result, children with primary molars hypomineralization are at a greater risk of molar incisor hypomineralization; therefore, regular monitoring of these patients is recommended (**Fig. 3**).⁴⁵

Enamel hypoplasia in primary teeth has been widely reported in the literature. An association was found between enamel hypoplasia and premature birth, where it was the most frequently reported outcome.⁴⁶ Opacity and hypoplasia are two outcomes of prematurity, referred to as "developmental enamel defects," where another study established a significant difference between exposed and nonexposed subjects.⁴⁷

Heredity dentin disorder is a genetic group of autosomal dominant conditions including DGI and dentin dysplasia (DD). These conditions affect the dentin structures of primary teeth or both dentitions. DGI is more common than DD, the incidence is 1 in 6,000 to 8,000 and 1 in 100,000, respectively. The defects cause teeth staining, which may vary from normal to amber, gray, or purple to bluish translucent discoloration. In addition to the discolored teeth



Fig. 2 Amelogenesis imperfecta.



Fig. 3 Deciduous molar hypomineralization.

caused by these conditions, the teeth are translucent and often roughened with severe amber discoloration, structural defects such as a radiographically small pulp chamber and bulbous crowns. The defect in the mineralization process increases the potential of the enamel layer shearing that subsequently leads to wear in the dentinal layer.⁴⁸

Shields classified DGI into three types and DD into two subcategories.⁴⁹ DGI type I is the most common and the only type associated with genetic disorders that affect bones known as osteogenesis imperfecta. Radiographically, the roots of the teeth are short, constricted, and associated with dentin hypertrophy. Therefore, teeth experience pulp canal obliteration after or before their eruption. Clinically, it affects both dentitions with significant tooth surface loss. The color is translucent and typical amber. Other types include DGI type II, also called hereditary opalescent dentin, and the Brandywine isolate type III, found most commonly in Brandywine in the United States.⁵⁰

Hematologic Disorders

Hematological disease, such as erythroblastosis fetalis and icterus gravis neonatorum, might produce jaundice in the newborn. This can cause a yellow–green discoloration and enamel hypoplasia in deciduous teeth. The reason for this yellow color is due to the deposition of bilirubin in the dental hard tissue during the developmental stage. Congenital erythropoietic porphyria is another disorder that causes purplish–red or reddish–brown discoloration to both deciduous and successor teeth. The discoloration is caused by the deposition of porphyrin pigments in bone and dentin. Diagnostically, the affected teeth can be detected with ultraviolet light under red fluorescence.²⁷

Trauma

When children start to crawl, walk, and run, they are subject to unintentional falls and collisions that may result in trauma to the primary teeth, most commonly in children between 2 and 6 years of age.⁵¹ Some types of trauma will cause necrosis to the primary teeth. Keeping these teeth untreated will lead to resorption of both primary teeth and the supporting bone, this phenomenon will lead to early loss of primary teeth and early eruption of the successor.⁵²

The color change of traumatized teeth is an early common sign witnessed by parents or guardians.⁵³ Furthermore, discoloration is also considered an early sign of pulpal degeneration.⁵⁴ When the pulp degenerates without hemorrhage, a stain of grayish-brown will appear caused by protein degeneration.⁵⁵ The trauma causes a rupture of the blood vessels present in the pulp chamber, causing a breakdown of the blood and hemolysis of the erythrocytes that produce hemoglobin. Hemoglobin then gradually degrades to iron that shows as a bluish-black stain of the tooth,^{52,56} as shown in **~Fig. 4**.

Although it has been suggested that the gray discoloration of the crown is a sign of pulp necrosis,⁵⁷ studies have shown that traumatized primary teeth might stay discolored (having a discolored gray crown) for several years with no other clinical or radiographic sign of pulpal degeneration or necrosis.⁵⁴ Inadequate or improper endodontic treatment following trauma may lead to dark discoloration, which may occur due to incomplete removal of the pulpal tissue or incomplete removal of root canal filling material from the pulp chamber.²⁷

Amalgam Staining

The demand for high aesthetics dental filling and the significant increase of minimal intervention of restorative approaches, considering the amalgam as a material of choice for primary teeth, has been reduced.⁵⁸ The use of amalgam has been controversial due to concerns related to its mercury release. An in vivo study that included 20 primary molars indicated that amalgam causes bluish discoloration because of copper release. The grayish–black stain could be a result of an amalgam filling, which may occur due to the corrosion of amalgam, leading to the formation of silver sulfide.^{58,59}

Root Resorption

The physiological pattern of root resorption of primary teeth occurs on the root surface, either within the pulp or from the



Fig. 4 Trauma for upper left primary central incisor.

periodontal ligament (i.e., in the form of internal or external root resorption). The exact location of resorption is hard to detect until the lesion reaches a certain size. Clinically, it is asymptomatic, but occasionally it may appear as pink discoloration of the amelocemental junction.^{14,60}

Dental Caries

Dental caries involves microorganisms excreting acid resulting in changes in dental tissue hardness and color. Dental caries is diagnosed by the change in color and may indicate the stage of the disease and lesion activity. The initial change in color due to caries is an opaque white spot as a result of increased enamel layer porosity due to acid production by the microbial metabolism of sugar.⁶¹ When caries develop further, a brown discolored dentin layer will be present, but the cause of discoloration remains controversial in the literature.⁶² However, particularly for primary teeth, the color and hardness of carious lesions are two clinical criteria used for the diagnosis of the progression degree of the disease. An active caries tends to be light yellow/beige, whereas slowly progressing or arrested caries lesions are usually darker.⁶³

Erosion

Tooth erosion is defined as the loss of dental hard tissue by nonbacterial chemical mechanical processes, resulting in loss of superficial enamel and visible by yellow tooth coloration. Recent lifestyle changes and the increased consumption of acidic foods and beverages have led to an increase in the prevalence of dental erosion worldwide. High prevalence of tooth erosion in 5-year-old children (from 30 to 98%) has been reported.⁶⁴ Due to lower mineralization levels and thinner primary teeth enamel compared with permanent teeth, the process of erosion is expected to be faster in children. A comparative study evaluated 60 primary and permanent teeth focusing on the erosive potential due to different type of beverages consumed and showed that surface microhardness was lower for primary teeth than for permanent teeth.⁶⁵ Darker color can occur due to prolonged exposure of the underlying dentin as the enamel thins.14

Extrinsic Discoloration

Extrinsic discoloration is outside the tooth substance and lies on the tooth surface or in the acquired pellicle.⁶⁶

Stains

Black stains affect 2.4 to 16% of primary teeth.⁶⁷ It starts as early as age 2 and can significantly affect the parents and have an influence on the child's personality as well as the child's self-confidence. It is a form of dental plaque characterized by high calcium and phosphate levels in addition to insoluble iron salts.⁶⁸ The black stain is ferric sulfide from the interaction of hydrogen sulfide arises with gingival fluids or saliva. Another etiological factor reported is the association with some bacterial strains like *Lactobacillus* and *Actinomyces*.⁶⁹ The strength of the adhesion is still under investigation; however, attractive forces, including hydrophobic

interaction, electrostatic, and hydrogen bonds, have been reported.⁶⁸ Different criteria have been proposed to establish a diagnosis. Koch et al considered the presence of dark dots, linear discoloration, and changes to the smooth surfaces of two or more different teeth.⁷⁰ On the other hand, Koch et al relied on the presence or absence of the dental plaque as follows: (1) no line, (2) incomplete coalescence of pigmented dots, or (3) continuous line formed by pigmented spots.⁷⁰

It is essential to state that there is a relationship between the prevalence of dental caries and the presence of black stain. A recent meta-analysis that included 13 studies concluded that individuals experiencing black stain had lower caries experience in comparison to those without the condition.⁷¹

Iron deficiency affects more than two billion people in the world and is one of the most common nutritional deficiencies. Iron can be found in dental hard tissue, including enamel and dentin.⁷² The most common cause of iron deficiency is the insufficient intake of iron in the diet. This is mostly treated by food and syrup supplements that contain iron salts.⁷³ Black stain is a type of complication that results from oral iron supplements to help children fight anemia.⁷⁴

Green stain is a type of stain of unknown etiology that affects more male children than female. However, it has been reported that it is an action of chromogenic bacteria. The most common teeth affected are the maxillary central incisor, especially on the gingival third labially. Mouth breathing is also considered as a contributing factor.²⁷

The orange stain is less frequent when compared with previously mentioned black and green stains, and can be removed more easily. Types of chromogenic bacteria, including *Serratia marcescens* and *Flavobacterium lutescens*, have been reported as potential etiology in combination with poor oral hygiene. Orange stain is mostly noted on the gingival third of the tooth.⁷⁵

As it is not possible to remove extrinsic stains by daily oral care, professional cleaning is usually required to meet the child aesthetic demands. Brushing with pumice powder following simple scaling is usually enough; however, the stain tends to recur. As a result, the enamel beneath the stain might be affected, resulting in initial demineralization or roughness.^{27,68}

Stannous Fluoride Pigmentation

Research done by Muhler in 1946 reported the efficiency of using stannous fluoride (SnF2) on reducing dental caries. The study compared two groups receiving 2 and 4% of SnF2, respectively, with a control group showed that children received SnF2 had experienced 37% reduction in new caries surface.⁷⁶ Upon applying 8% SnF2 solution, certain areas of the tooth become discolored, ranging from light brown to black depending on the depth and involvement of caries. Furthermore, pigmentations affect caries and precarious enamel following stannous fluoride application.⁷⁷

Silver Diamine Fluoride Stain

Silver diamine fluoride (SDF) is one of the recently recommended materials to prevent and arrest dental caries owing



Fig. 5 Stain following silver diamine fluoride application.

to the low cost of using SDF.⁷⁸ SDF is a colorless alkaline solution containing silver and fluoride, which forms a complex with ammonia. The ammonia ions combine with silver ions to produce a complex called the diamine–silver ion.

Several studies have demonstrated the efficacy use of this type of fluoride in treating carious primary dentition.⁷⁹ Thus, SDF usage could increase the cost-effectiveness of health care and improve oral health, ultimately reducing the need for urgent care.⁸⁰ Since the 1940s, silver components have been developed and used for caries prevention and it has been used in Japan for more than 40 years. Moreover, in Hong Kong and China, a trial compared the effect of 38% SDF and 5% sodium fluoride varnish and found that the SDF is more effective arresting primary teeth caries.⁷⁸ Other studies have reported a caries arrest rate of 81%.⁸¹ SDF application is affected by the concentration used and the number of times applied per year, showing that 38% SDF treatment is more recommended than 12% SDF, especially when applied twice a year.⁸¹

Regarding the mechanism of action, the antimicrobial effect is a result of silver particles acting on proteins. Moreover, the black stain of carious dentin and enamel resulting from SDF silver particles is included in **– Fig. 5**. A recent scoping review stated that "The aesthetic perception of black staining associated with SDF is not directly related to acceptability and satisfaction of patients and parents but related to a lower professional's acceptance."⁸²

Conclusion

It is essential that health care professionals be familiar with the causes of primary teeth staining and pigmentation. A better knowledge will guide the clinician to a proper diagnosis and facilitate the referral to a specialized pediatric dentist that will provide proper dental care. Children's teeth change until physiological exfoliation. The ultimate aim for pediatric dentistry is the proper management of primary dentition until normal exfoliation. Several strategies can be utilized, such as using fluoride varnish for preventing caries and erosion. A restorative approach, including fillings and preformed crowns, might be considered. Bleaching can be applied on traumatized primary incisors. Sometimes, the extraction of primary teeth is the only option to treat the child's signs and symptoms.

Primary dentition is crucial due to its close relation to the developing permanent dentition. Considering healthy permanent dentition is a priority when planning treatment of primary teeth. Stains are multifactorial, but with proper management, the effect on the successor teeth can be limited. Recent aesthetical demands are increasing for both children and parents or caregiver, avoiding factors that contribute to teeth staining is mandatory when possible. Stained and discolored teeth have a great effect on aesthetics, which might lead to lower self-confidence. Educating children and parents on treatment management and good oral health is mandatory to improve the child's well-being for a better smile.

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