Etiology of tooth discoloration- a review

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Abstract

Discoloration of the tooth can erode the sparkle from a smile. In the management of patients with discolored tooth, knowledge of the mechanisms behind tooth discoloration is of relevance as it can influence the treatment plan. In certain instances it may even have an effect on the outcome of the treatment. A grasp of the pathological process involved in tooth staining will also allow the dental practitioner to explain to the patient the exact nature of the condition. An overview of the etiology and the clinical appearance of tooth discoloration are discussed in this review.

Key words: Etiology, extrinsic discoloration, intrinsic discoloration

Introduction

Discoloration of the tooth is one of the most frequent reasons why a patient seeks dental care. Tooth discoloration is usually esthetically displeasing and psychologically traumatizing. An understanding of the etiology of tooth discoloration is important to a dentist in order to make the correct diagnosis. The knowledge of the cause of discoloration will also help the dental practitioner to explain the exact nature of the condition to the patient. In some instances, the mechanism of staining may have an effect on the outcome of treatment and influence the treatment options offered by the dentist to the patients[1].

Classification

The causes for tooth discoloration can be classified according to the location of the stains, either as extrinsic or intrinsic[2, 3, 4]. Extrinsic discoloration lies on the tooth surface or in the acquired pellicle. The intrinsic discoloration occurs when the chromogens are deposited within the bulk of the tooth, which maybe of local or systemic origin[5].

Extrinsic discoloration

Extrinsic discoloration is defined as discoloration located on the outer surface of the tooth structure and is caused by topical or extrinsic agents[6]. This can be divided into two groups; direct and indirect. Direct staining is caused by compounds incorporated into the pellicle layer and the stain is a result of the basic color of the chromogen. Direct staining has multi-factorial etiology with the chromogens derived either from the diet or substances habitually placed in the mouth. Indirect staining on the other hand is caused by a chemical interaction at the tooth s urface. I t is usually associated with cationic antiseptics and metal salts. These agents are without color or a different color from the stain produced on the tooth surface[7]. Traditionally, extrinsic tooth discoloration can also been classified according to its origin, as metallic or non-metallic [8].

Factors responsible for extrinsic discoloration **(Table 1)**

Diet: Brown stains on the surface of the teeth could be due to the deposition of tannins found in tea, coffee and other beverages[2].

Oral hygiene: Accumulations of dental plaque, calculus and food particles cause brown or black stains **(Figure 1)**. Chromogenic bacteria have also been suggested as an etiological factor in the production of stains typically at the gingival margin of the tooth[9].

Habits: Tobacco from cigarettes, cigars, pipes, and chewing tobacco causes tenacious dark brown and black stains that cover the cervical one third to midway on the tooth[10]. Chewing of pan results in the production of blood red saliva that results in a red-black stain on the teeth, gingiva and oral mucosal surfaces[11,12] **(Figure 2)**.

Medication factors: Cationic antiseptics such as chlorhexidine, cetylpyridinium chloride and other mouth washes can cause staining after prolonged use[3, 13]. Chlorhexidine, for example, produces brown to black discoloration. Most evidence indicates that the likely cause of staining is the precipitation of anionic dietary chromogens onto the adsorbed cations[14,15].

Some systemic medications (e.g. minocycline [16-18], doxycycline[19, 20], co-amoxiclav[21], linezolid[22]) are also shown to cause extrinsic staining. Metallic compounds are also implicated in dental discoloration (e.g. Iron containing oral solutions[23, 24], mouth rinses containing metal salts[25, 26]).

Occupation and environmental factors: Industrial exposure to iron, manganese, and silver may stain the teeth black. Mercury and lead dust can cause a blue-green stain; copper and nickel, green-to-blue-green stain and chromic acid fumes may cause deep orange stain[4] . There is a positive correlation between dental extrinsic stains and the concentration of trace elements, especially iron in the water sources[27] **(Figure 3)**.

Intrinsic Discoloration:

There are several causes of intrinsic tooth discoloration which have either an endogenous or exogenous origin. These changes may occur during or after odontogenesis.

Table 1: Extrinsic causes of tooth discoloration

Classification		Factors responsible	Examples	Color
Non-Metallic stains	Direct stains	Diet	Tea, coffee & other foods	Brown to black
		Oral hygiene	Dental plaque, calculus & Food particles	Yellow/brown
			Chromogenic bacteria	Brown/black/green Orange
		Habits	Tobacco smoking/chewing	Dark brown/black
			Pan chewing	Red-black
		Medications	Cationic antiseptics e.g.: chorhexidine	Yellow brown
			Essential oils/phenolic mouthrinse	Yellow
			Sysgtemic antibiotics e.g Minocycline	Green-gray
Metallic stains	Indirect stains	Medications	Iron containing oral solutions	Black
			Copper salt in mouth rinse	Green
			Potassium permanganate in mouth rinse	Violet to black
			Stannous fluoride	Golden brown
			Silver nitrate	Gray
		Occupation and environment	Exposure to iron, manganese, silver	Black
			Exposure to mercury and lead dust	Blue green
			Copper & nickel	Green
			Chromic acid fumes	Deep orange

During odontogenesis, teeth may become discolored from the changes in the quality or quantity of enamel or dentin, or from the incorporation of discoloring agent into the hard tissues. Post-eruption discoloration occur when the discoloring agent enters the hard tissues. They may originate from the pulp or the tooth surface[28] **(Tables 2 and 3)**.

Pre-eruptive causes for intrinsic discoloration **(Table 2)**

Metabolic: The diseases that have the potential to cause neonatal hyperbilirubinemia may cause the incorporation of bilirubin into developing teeth, producing jaundice like yellow-green tint within the dental hard tissue known as chlorodontia[29-31]. Congenital erythropoietin porphyria (Günther's disease) is a rare, autosomal recessive disorder of porphyrin metabolism, resulting in an increase in the formation and excretion of porphyrins. The porphyrin pigments have an affinity for calcium phosphate and are incorporated into teeth during dental formation and these cause a characteristic reddish-brown discoloration of the teeth, called erythrodontia. The affected tooth shows a red fluorescence under ultra-violet light[28, 32, 33]. Alkaptonuria, also known as phenylketonuria or ochronosis is an inborn error of metabolism of tyrosin and phenylalanine causing a build-up of homogenistic acid. This results in a brown discoloration of the permanent dentition[34].

Disturbance during development of a tooth: Enamel hypoplasia may result due to the disturbance of the developing tooth germ following trauma, infection or nutritional deficiency giving rise to localized or

generalized enamel defects[35, 36]. Periapical odontogenic infections of the primary teeth can disrupt normal amelogenesis of the underlying permanent successors and can cause localized enamel hypoplasia. Trauma to developing, yet unerupted, teeth can also disturb amelogenesis and may result in enamel hypoplasia, which is visualized as a localized opacity on the erupted tooth. Such hypoplastic lesions are referred to as Turner's hypoplasia[37].

Crown formation begins in utero; therefore, the potential for extensive intrinsic discoloration of the primary dentition may be present throughout pregnancy. Although rare, maternal rubella or cytomegalovirus infection, maternal vitamin D deficiency, drug intake during pregnancy and toxemia of pregnancy can lead to tooth discoloration, which generally manifests as a focal opaque band of enamel hypoplasia. Systemic postnatal infections (e.g., measles, chicken pox, streptococcal infections, scarlet fever) can also cause enamel hypoplasia. The band like discoloration on the tooth are visualized where the enamel layer has variable thickness and becomes extrinsically stained after tooth eruption. Vitamins C and D, calcium, and phosphate are required for healthy tooth formation. Deficiencies can result in exposure-related or dose-related enamel hypoplasia[38].

Molar-incisor hypomineralization is an idiopathic condition characterized by severe hypomineralized enamel affecting incisors and permanent first molars. The enamel defects can vary from white to yellow to brownish areas and they always show a sharp demarcation between sound and affected enamel. The possible etiologies for this condition include environmental changes, infections during the early childhood, dioxin in breast milk and genetic factors[39, 40].

Genetic defects and hereditary diseases: Genetic defects in enamel or dentin formation include amelogenesis imperfecta[41] (Figure 4), dentinogenesis imperfecta and dentinal dysplasia[42, 43]. These hereditary diseases can be associated with intrinsic tooth discoloration. Defects in enamel formation may also occur in a number of systemically involved clinical syndromes such as Vitamin D dependent rickets[44], Epidermolysis bullosa[45], Ehlers-

Table 2: Pre-eruptive causes of intrinsic discoloration

Factor responsible	Examples	Color
Merabolic Disorders	Hyperbilirubinemia	Yellow - Green
	Prophyria	Reddish brown
	Alkaptonuria	Brown
Disturbance of tooth Germ	Localized Turner Tooth	White to Yellow to Brownish
	Generalized Infection (maternal or childhood) Nutritional deficiency Molar Incisor Hypomineralization	
Genetic Disorder	Amelogenesis imperfecta	Yellow Brown
	Amelogenesis imperfecta	Blue brown
	dentin dysplasia	Yellow
	Systemic syndrome e.g.: Epidermolysis bullosa	Yellow
Medication	Tetracycline	Yellow, brown, blue or grayish
	Minocycline	Blue - green
	Ciprofloxacin	Greenish
	Fluoride supplements	Chalky white to brown/ black
Environmental	Endemic fluorosis	Chalky white to brown/ black

Table 3: Post-eruptive causes of intrinsic discoloration

Factors responsible	Examples	Colour
Dental conditions	Dental caries	
	- Incipient	Chalky white
	- Active	Yellowish brown
	- Arrested	Dark brown to black
	Tooth wear	Yellowish
Pulpal causes	Ageing	Yellowish
	Pulpal trauma with hemorrhage	Gray-brown
	Calcific metamorphosis	Yellowish to yellowish brown
	Internal resorption	Pinkish
Dental materials	Amalgam	Blue-gray
	Composite/GIC	Yellowish brown
	Intra canal medicaments e.g. Iodoform, Ledermix	Brownish gray
	Obturating materials & sealers	Grayish

Danlos Syndrome[46] and pseudohypoparathyroidism[47].

Medications: Tetracycline, a broad spectrum antibiotic, is known to cause intrinsic discoloration when prescribed during tooth development. Tetracycline staining results from systemic administration of the drug, which chelates with the calcium ions on the surface of the hydroxyl apatite crystals as a stable orthophosphate complex. Teeth affected by tetracycline have a yellowish or brown-gray appearance which is worse on eruption and diminishes with time (Figure 5). The affected teeth also fluoresce under ultraviolet light, giving off a bright yellow color[48, 49].

Minocycline is a semi-synthetic derivative of tetracycline. Its prolonged ingestion can lead to green-gray or blue-gray intrinsic staining of the teeth. Unlike with other tetracyclines, minocycline causes staining during and after the complete formation and eruption of teeth. Four theories have been proposed to explain the possible mechanism of this side effect. The first is the extrinsic theory, where it is thought that minocycline attaches to the glycoprotein in acquired pellicle. It oxidizes on exposure to air or as a result of bacterial activity. This results in the degradation of the aromatic ring forming insoluble black complex. It is possible that the pigment is incorporated into the dentin by a demineralization/remineralization phenomenon. The second is the intrinsic theory, where the minocycline bound to the plasma proteins is deposited in collagen-rich tissues, such as the teeth. This then oxidizes slowly over time with exposure to light. The third possibility is that the drug chelates with iron to form an insoluble complex. The fourth suggestion is that minocycline could be deposited in dentin during secondary dentinogenesis and the process can be accelerated in bruxists[16-18, 50].

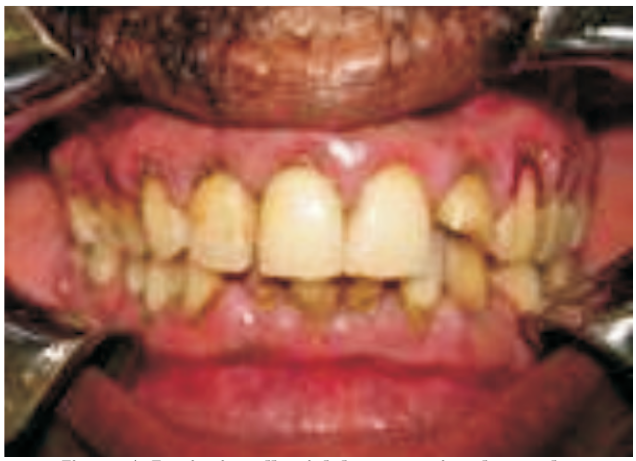

Figure 1: Extrinsic yellowish brown stains due to the accumulation of plaque and calculus

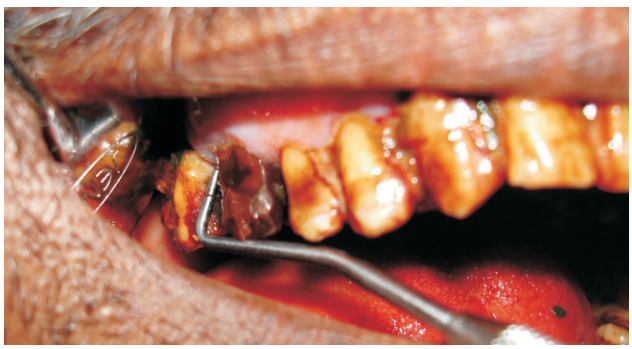

Figure 2: Extrinsic reddish black stains in a patient with the habit of chewing pan

Ciprofloxacin, a quinolone given intravenously to infants at dosages of 10 t o 40 mg/kg/day to treat infections with Klebsiella, has been associated with greenish discoloration of the teeth[13, 51].

Environmental causes: Dental fluorosis is the most common cause of intrinsic tooth discoloration[52]. The most important risk factor for fluorosis is the total a mount of fluoride consumed from all sources during the critical period of teeth development. A daily fluoride intake of more than the optimum of 0.05-0.07 mg fluoride/kg body weight/day is thought to cause dental fluorosis [53]. The sources of fluoride include naturally or artificially fluoridated drinking water, commercially formulated beverages, and oral healthcare products (e.g. toothpastes, mouth rinses, oral fluoride supplements)[54]. Dental fluorosis is characterized by symmetrical patterns of enamel discoloration resulting from sub-surface hypomineralization due to the ingestion of excessive amounts of fluoride during the early maturation stage of enamel formation. The severity depends on when and for how long the overexposure to fluoride occurs and the individual physiologic response. The clinical appearance may vary based on the severity from areas of enamel flecking to diffuse opaque mottling superimposed on chalky white or dark brown/black areas[55] (Figure 6).

Post-eruptive causes for intrinsic discoloration (Table 3)

Dental conditions and caries: Tooth wear is the progressive loss of enamel and dentin due to attrition, abrasion and erosion. As the enamel thins the tooth becomes darker as the color of the dentin becomes more apparent. Once the dentin is exposed the potential for chromogens to enter the body of the tooth increases[3].

The various stages of carious process can be recognized by the change in color as the disease progresses. The pathogenesis of dental caries begins with an incipient lesion confined to the enamel layer. Incipient carious lesions are associated with plaque accumulation and manifest as chalky white areas of discoloration secondary to demineralization. As caries progresses into the dentin, the overlying translucent enamel reveals the color of the underlying caries and appears yellowish brown. Extensive caries that involve destruction of both enamel and dentin produce a color that ranges from light brown, to dark brown or almost black [56] **(Figure 7)**.

The natural darkening and the yellowing of the teeth and the change in their light transmission properties that occur with age can be due to the combination of the factors involving both e namel and dentin. The enamel undergoes both thinning and textural change, while the d eposition of secondary and tertiary dentin and pulp stones all contribute to the darkening process of ageing [57, 58].

Pulpal Pathology

Bacterial, mechanical or chemical irritation to the pulp may result in tissue necrosis and the release of disintegration by-products that might penetrate the tubules and discolor the surrounding dentin. Acute trauma to an erupted tooth can cause intrapulpal hemorrhage giving it a reddish tinge. This discoloration can change to gray-brown in a matter of days as the pulp becomes necrotic (Figure 8). Hemolysis of the red blood cells would follow and release the heme group to combine with the putrefying pulp tissue to form black iron sulfide[59].

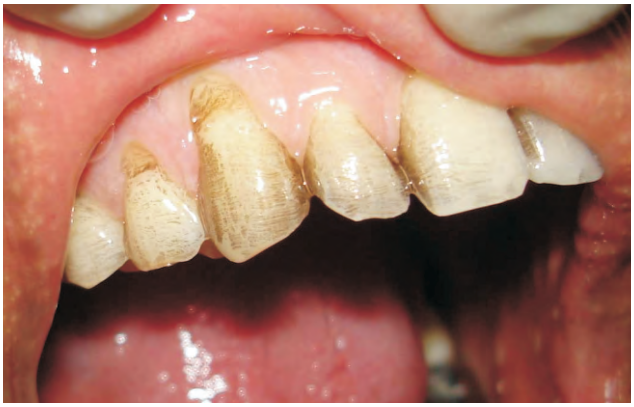

Figure 3: Extrinsic black stains due to high concentration of iron in the water source

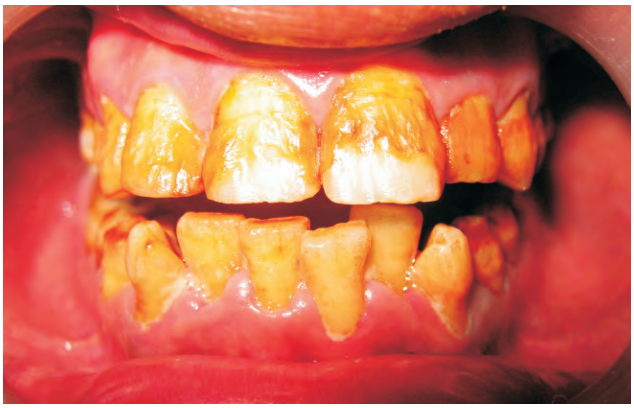

Figure 4: Generalized yellowish discoloration with rough enamel surface in amelogenesis imperfecta

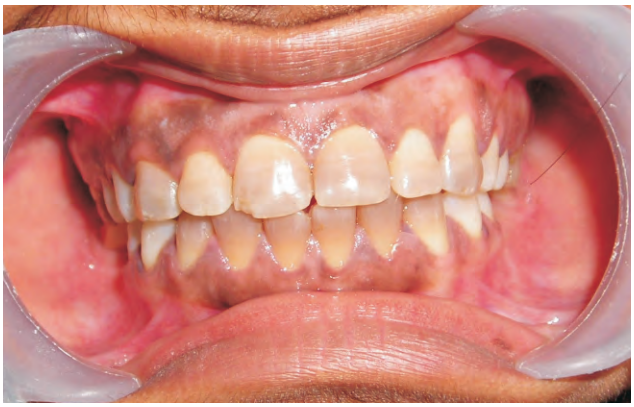

Figure 5: Brown-gray discoloration due to tetracycline.

Excessive formation of irregular dentin in the pulp chamber and along the canal walls may occur following certain traumatic injuries. This is known as calcific metamorphosis. As a result of this, the translucency of the crown gradually decreases, giving rise to yellowish or yellowish brown discoloration[60, 61].

Root resorption following trauma often presents as a pink spot lesion at the cemento-enamel junction in an otherwise

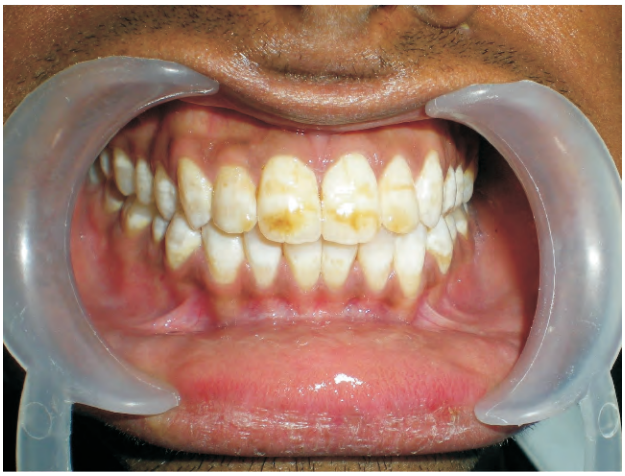

Figure 6: White opaque and brown discoloration as a result of fluorosis

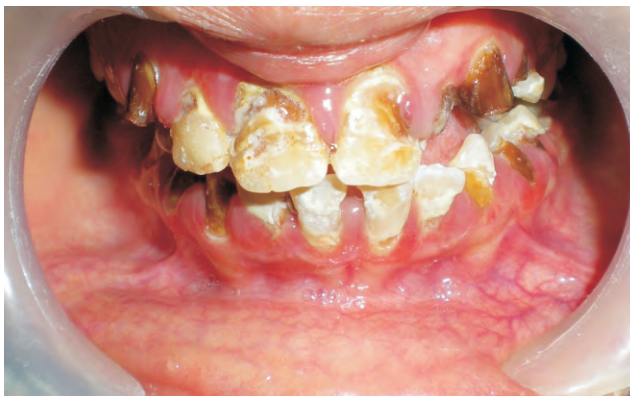

Figure 7: Yellowish brown discoloration in a patient with rampant caries

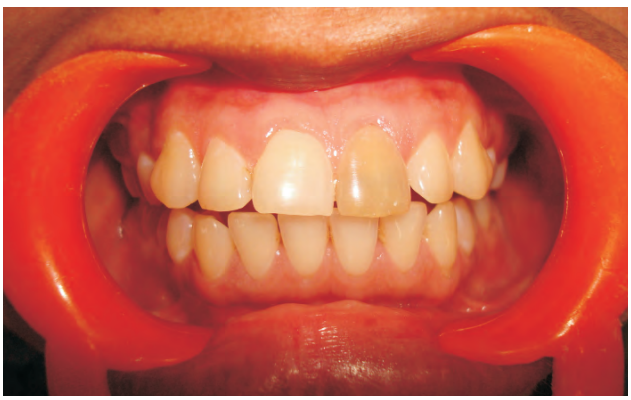

Figure 8: Grayish brown discoloration in the upper left central incisor due to pulpal hemorrhagic products

symptomless tooth, known as the 'Pink tooth of Mummery'. The resorption may be internal, being of pulp origin or external of periodontal origin [62, 63].

Dental materials

Dental restorations most commonly cause intrinsic discoloration[64]. Amalgam restorations can generate corrosion products, leaving a blue-gray color in the tooth, especially in large cavity preparations with undermined enamel known as amalgam blue[65]. Open margins around composite or glass ionomer restoration may allow chemicals to enter between the restoration and the tooth structure and discolor the underlying dentine.

Several intracanal medicaments are liable to cause internal staining of the dentin. Phenols or iodoform based medicaments sealed in the root canal are in direct contact with dentin, allowing penetration and oxidation. Tetracyclines (e.g. Ledermix- triamcinolone acetonide and demethylchlortetracycline) used within the tooth for endodontic therapy may also cause dark gray-brown discoloration[66, 67]. Incomplete removal of obturating material and sealer remnants in the pulp chamber, mainly those containing metallic components, often result in dark discoloration[68, 69].

Diagnosis

History

The patient's history of tooth discoloration provides useful information regarding the etiology [2, 70]. The history should include the following:

- § Dental history (previous dental treatment, oral hygiene practices, use of mouthwashes, amount and scheduling of fluoride intake, history of dental trauma)
- § Medical history (history of maternal or childhood diseases, use of medications)
- § Family history (genetic disorders)
- § Diet history (nutritional deficiencies, diet that can cause staining of the teeth)
- § Social history (occupational exposure to metals, use of tobacco)

Clinical Examination

The scratch test is usually used to distinguish between extrinsic and intrinsic discoloration[70]. Discolored tooth surfaces are scratched with care by using a dental explorer, scaler, or similar sharp instrument to assess surface texture. Light scratching with a dental instrument removes weakly adherent plaque that causes extrinsic discoloration. If the discoloration requires removal with a sharp dental scaler, the discoloration is considered to be tenacious. Intrinsic discoloration cannot be removed by using the scratch test.

Extrinsic staining of a single tooth is unusual. The distribution is usually generalized. The stains are usually found on surfaces with poor tooth brush accessibility. Whereas in case of intrinsic discoloration distribution is either generalized to all teeth or localized to certain teeth or tooth surfaces. An intrinsic etiology usually exists when a single tooth is discolored. Teeth with extrinsic tooth discoloration usually demonstrate no signs of pulp disease, usually associated with intrinsic discoloration.

Management

The treatment of tooth discoloration consists of identifying the etiology and implementing the required therapy[71]. Scaling and polishing of the teeth using prophylactic paste applied with a rotating rubber cup may remove many extrinsic stains. For more stubborn extrinsic and intrinsic stain, various bleaching techniques may be attempted[2]. Bleaching can be performed externally, termed night guard bleaching or vital tooth bleaching , or intracoronally

in root-filled teeth, called non-vital tooth bleaching [52, 72].

Teeth discolored by dental caries or dental materials require the removal of the caries or restorative materials, followed by proper restoration of the tooth. Partial (e.g. laminate veneers) or full-coverage dental restorations may be used to treat generalized intrinsic tooth discoloration in which bleaching is not indicated or in which the esthetic results of bleaching fail to meet the patient's expectations [73-75].

Conclusion

In the management of patients with discolored tooth, an understanding of the mechanism behind the discoloration is of relevance to the dental practitioner as it can be valuable in the decision-making process when considering how to treat the condition. An understanding of the pathological process involved can assist in e xplaining the cause to anxious or concerned patients/ parents.

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