

Black Chromogenic Stains- Why, How and What now?

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KEYWORDS	ABSTRACT
Black Stain, Chromogenic compounds, Dental Caries, Periodontal Disease, Bleaching, Lactoferrin, Carbamide Peroxide	The prevalence of black chromogenic stains has become a common finding in the recent days, unsure if it has been present all these years and the diagnosis was missed due to its similarity with other extrinsic stains. The main concern has been the unesthetic appearance and the obstinate recurrence of the black stain. Often found on the cervical third of the tooth along the gingival margin in both paediatric and adult patients. The etiology of the black stains has been poorly understood and this knowledge is important for clinicians to be able to diagnose so as to give the appropriate treatment plan. The nature of the black pigmentation is dominated by chromogenic bacteria such as the Actinomyces species and is a unique type of plaque with tendency to calcify making its removal tedious. The main constituent of the black stain is ferric sulphide which is a product of the reaction between the ferric ions in the saliva and the hydrogen sulphide released from the chromogenic bacteria. Factors influencing the formation of the black stains are iron supplementation, pH of the saliva, dietary factors, microbial interaction, et cetera. The association between the black stains with dental caries and periodontal disease is a significant factor as it can determine the susceptibility of the individual. Professional hygiene procedures included ultrasonic scaling and polishing using either prophylactic paste or air/water-jet polishing. But professional cleaning was comparatively invasive if performed frequently and was not sufficient to eliminate these stains. Hence, the article was aimed to understand the various causative factors to provide a less invasive treatment..

INTRODUCTION

Black chromogenic tooth stains have been under the radar in the recent times, being an aesthetic concern for most of the children and adults. Clinicians often confuse chromogenic stains with blackish brown extrinsic stains. Black stain is a type of extrinsic discoloration characterized by the presence of a dark line, or an incomplete aggregation of dark spots formed parallel to the gingival margin on the cervical third of the crown. The prevalence of black stains ranges from 2.4 to 16% in primary dentition. Generally, these stains are believed to disappear once the permanent teeth erupt or once the child reaches adulthood.¹ However, occasionally these stains persist into adulthood.

Chromogenic bacteria were proposed as one of the etiological factors in the production of black pigment. Traditional microbiological evaluation of the plaque samples of children with black stains was predominated by Actinomyces Species mainly Actinomyces naeslundii, whereas lactobacillus count was higher in non-discolored plaque samples.²⁻⁴ Thus, the bacterial composition of the microbiota may modulate susceptibility and resistance to dental caries.

Over the years, several attempts have been made to solve the mystery of the occurrence of black stains. Microscopically, black stains are considered as a special form of dental plaque with a relatively stable and homogeneous microbiota, and the presence of calcification markedly differing from the ultrastructural appearance of a normal biofilm. These black stains have the tendency to calcify and are firmly attached to the teeth making it hard to be wiped off by daily tooth brushing. Black stains tend to recur after professional hygiene. For this reason, it can cause an aesthetic problem for the patients affecting their self-esteem.

Children less than 6 years do not develop black stains related to beverages like tea, coffee, soft drinks, smoking, tobacco, long-term use of mouthwashes, or exposure to manganese and silver.⁵ However, there is no reliable evidence on how the presence of black stains on the tooth surface reduces susceptibility to caries, and the etiology is also not fully understood. Hence, the aim of this review was to update the latest knowledge of etiologies of black stains, understand the causative factors and their association with dental caries. Therefore, clinicians will be able to diagnose the black stains and take appropriate care to prevent its recurrence.

FORMATION OF EXTRINSIC STAIN

The buccal and palatal/lingual surfaces of the teeth are stained black; this staining often follows the gingival edge and does not reach the proximal regions. Due to its near proximity to the mandibular salivary glands and its function in the etiology of black staining, studies show that the lingual surfaces of the mandibular teeth have the highest prevalence.⁶

Extrinsic tooth discoloration occurs on the tooth surface or within the acquired pellicle due to chromogenic compounds. Plaque composition is influenced by genetics, saliva, hygiene, and diet. These stains are common in individuals with good oral hygiene and low caries rates.^{7,8}

A study involving black stain scrapings from school students used Inductively Coupled Plasma (ICP) Spectrometry for trace element analysis. Of the five samples, three contained 2.56% ferrous ions, 17.15% calcium ions, and 0.72% magnesium ions, while two samples had 14.86% calcium, 0.82% magnesium, and no ferrous ions.⁹

Black stain forms when iron in saliva reacts with hydrogen sulfide from oral bacteria, creating ferric sulfide precipitates that adhere to teeth along the gingival contour. Linked to iron homeostasis disorders,¹⁰ black stains show higher iron levels than dental plaque,¹¹ with increased risk in individuals consuming iron-rich foods or supplements.

ASSOCIATION OF DENTAL CARIES AND BLACK STAINS

VS de Rezende et al, in a systematic review and meta-analysis, concluded that individuals with extrinsic black stains have a lower incidence of dental caries compared to those without.¹² Furthermore, multiple studies suggest that black stains act as a protective factor against caries.^{13,4}

Microbiota:

Black-pigmented anaerobes like *Porphyromonas gingivalis* and *Prevotella* species require iron from hemoglobin for growth.^{13,14} Black plaque samples have shown the presence of *Actinomyces*, *Aggregatibacter actinomycetemcomitans*, and *Lactobacilli*.^{15,16,3} Recent studies also highlight an increase in *Cardiobacterium*, *Haemophilus*, and *Treponema* in children with black stains.¹⁷

Children with black stains have reduced microbial diversity and altered plaque microbiota.¹⁸ *Actinomyces* species, including *Actinomyces naeslundii*, are early colonizers in infants' mouths, with *A. naeslundii* detected by age one.¹⁹ However, *Actinomyces* may not be the sole microorganism responsible for black stain formation. These microorganisms create a competitive environment that hinders cariogenic bacteria's adhesion to tooth surfaces. Studies show that high levels of *A. naeslundii* in biofilms are linked to lower caries incidence and reduced *Streptococcus mutans* adhesion, suggesting the microbiota composition influences caries susceptibility and resistance.²⁰

In a recent study, *Enterobacter ludwigi* of the *Enterobacter* species was also identified to cause black stains. Members of *Enterobacter* are considered opportunistic pathogens and often have been linked to nosocomial outbreaks.

Bacterial growth:

Fermentable carbohydrates and sugars are known to act as bacterial growth substrate. Several studies have confirmed the increase in bacterial growth and biofilm formation in the presence of sugar supporting the direct relation between intake of dietary sugars and dental caries.²¹

Research shows that calcium plays a key role in bacterial growth and adhesion.²² Although no significant impact on bacterial growth was noted with Ca^{2+} , this divalent cation stabilizes bacterial cell walls and facilitates ionic cross-linking between cells, promoting aggregation, adhesion, and biofilm formation.²³

Consumption of vegetables, fruits, dairy products, eggs, legumes, and soy sauce may promote the growth and colonization of bacteria related to black stains, which, in turn, may alter the growth and survival of cariogenic bacteria leading to lower caries status.²⁴

Chen et al concluded that children who were never fed with the nursing bottle during sleep tend to have less growth of cariogenic bacteria and higher pH, thus, creating a favorable environment for the bacteria related to black stains.⁶

In the research conducted by Głabska et al, it was found that individuals who consumed cheese had black stains and there was a decrease in dental caries coefficient.²⁵

Saliva:

Salivary parameters such as pH, buffering capacity, calcium and phosphate ion concentrations are well-known caries-protective factors. Analysis of salivary parameters by Surdacka et al 1989, concluded that significantly higher levels of calcium, inorganic phosphates, copper, sodium, total protein, and lower levels of glucose were found in patients with black stains. Notably, greater buffering capacity and high calcium levels were reported in children with black stains.^{26,17} Salivary calcium indirectly regulates the aggregation of microorganism in saliva to help to maintain the globular structure of salivary micelles and act as a reservoir for remineralization.

Oral iron supplements:

Oral iron supplements fortified with folic acid and/or Vitamin B12 are routinely prescribed to children below 5 years of age.²⁷ Iron salts are also incorporated in infant cereals and multivitamin formulas.²⁸ They get attracted on to the organic portion of the tooth surface and protects from acidic by-products by reducing the acidogenic potential of dental plaque. Thus, the presence of iron in the black stain may contribute lower caries experience in children.²⁴ The regular consumption of foods rich in iron and the use of iron supplements during the pregnancy and the early childhood, could favor the development of the chromogenic microbiota.²⁴

Water content:

According to Claudia et al 2018, three factors were found to be associated with black dental stains-consuming water with high iron content, consuming water with high pH and having a high salivary pH. In another study by Tirth A et al 2009, water consumed by the children with black stains showed the presence of ferric ions of about 1.2 mg/lit which is more than the tolerable dose that is 0.3 mg/lit prescribed by Indian Standard Drinking Water – Specification.⁹ In a study by Franca-Pinto CC et al, children who drank tap water had more black stains than those who consumed mineral water and natural well water.²⁹ Children who drank water from natural wells presented higher caries prevalence than those who consumed mineral water or tap/filtered water. Higher iron content and higher pH in consumable water may alter the normal microbiota leading lesser caries experience in children with black stains.

Salivary lactoferrin

Lactoferrin, an iron-binding glycoprotein in the transferrin family, is found in mammalian exocrine secretions and has a high affinity for iron. Bovine lactoferrin binds iron more weakly and releases it more easily than human lactoferrin.³⁰ It also inhibits the binding of human lactoferrin to its receptors. Human lactoferrin releases iron only at pH levels below 4, making it effective at acidic sites of infection and inflammation. Its strong iron-binding ability keeps free iron levels in body fluids low, preventing metal precipitation, reactive oxygen species (ROS) formation, and inhibiting microbial growth and biofilm formation. Human Lactoferrin and bovine Lactoferrin exert a bacteriostatic activity and can exert a potent bactericidal action by binding to lipopolysaccharide (LPS), porins and other surface molecules.¹⁰

Nordbo et al reported a higher concentration of salivary lactoferrin in the saliva of individuals with black stains and has an antibacterial activity against *Streptococcus mutans* through its binding with bacterial DNA.³¹ Lactoferrin concentrations were found to be lower in children with early childhood caries and higher in caries-free children.³² Hence it confers a cariostatic effect in children with black stains.

Lactoferrin, an iron-binding protein in milk, can bind iron in saliva, especially in individuals with iron deficiency anemia or beta thalassemia minor.³³ It may serve as a marker for iron imbalance, particularly in children and pregnant women. Its quick, non-invasive detection makes it a cost-effective tool for routine check-ups, especially in developing countries.

TREATMENT

Understanding the various factors that can affect the growth and colonization of the chromogenic bacteria will help in treating the black stains.

Main emphasis is on the parent education and awareness regarding the preventive measures of extrinsic stains in deciduous dentition. Parents must emphasize to their children about the Oral hygiene maintenance instructions such as twice daily tooth brushing and flossing. Black stain tends to reform again despite good personal oral care, but quantity may be less when biofilm control procedures are meticulous.

Professional oral prophylaxis:

As it is not possible to remove extrinsic stains by daily tooth brushing, the common treatment is professional hygiene procedures consisting of ultrasonic scaling, rotary polishing with an abrasive prophylactic paste, or air-jet polishing with an abrasive powder. However, all these techniques are not strong enough to permanently eradicate the black stria, because these precipitates disappear only for short periods and tend to reform within 30 days.¹⁵ Frequent ultrasonic cleaning is not recommended as this modality can affect the enamel beneath the stain resulting in initial demineralization or roughness.³⁴ Thus, new therapies are emerging that are targeted to the control of oral microbiota.

Bovine lactoferrin:

In an observational study, participants followed a protocol that included professional hygiene practices and oral administration of 50 mg of bovine lactoferrin tablets twice daily for 90 days. A case report of a 43-year-old woman with recurring black stains during her second pregnancy showed a link to iron deficiency (hemoglobin 10.80 g/dl, ferritin 12.95 ng/ml). After 30 days of treatment with bovine lactoferrin capsules (100 mg twice daily) and orosoluble tablets (50 mg twice daily after oral hygiene), her hemoglobin and ferritin levels increased, and the black stain significantly decreased without professional treatment. This suggests bovine lactoferrin as an effective therapy for reducing black stains by sequestering free iron and inhibiting anaerobic bacterial growth.¹⁰

LASER:

Nosotti et al noted that after the use of laser nd: YAG, after 60 days, the patient at the control has had an important reduction of the black stains.³⁵

Antimicrobial Phototherapy:

Antimicrobial Phototherapy is a non-invasive treatment that uses light to inactivate microorganisms. It has shown positive results in treating periodontitis. In one study, teeth were irradiated for 16 minutes in two 8-minute sessions, improving patient adherence and ease of application. Although black stains recurred, 48.4% of patients showed lighter stains during the restoration phase. Over time, the color returned to pre-treatment levels, supporting the idea that

black stain formation is biologically driven by microbial metabolism. Another study by A. Albelda-Bernardo et al. found that phototherapy reduced black plaque area, color, and bacterial colonization in adults. L. Pessoa et al. reported that phototherapy effectively removed black stains without recurrence over a 7-month follow-up.³⁶⁻³⁸

Probiotic:

A study by Bardellini E et al showed that black stain formation could be prevented by the administration of a probiotic streptococcus salivarius M18 for 3 months which significantly reduced the reformation of black stains in children for that period without affecting its manifestation in the successive quarter.³⁹

Chemical agents:

NaCl is bactericidal in the 4M and 5M concentration. NaCl inhibits the bacterial growth may be by plasmolysis or by disrupting the membrane potential of the bacterial membrane significantly.^{40,41}

3% hydrogen peroxide (H₂O₂) disrupts key bacterial processes, including membrane damage, enzyme inhibition, and oxidation, leading to impaired energy production and protein synthesis, ultimately causing bacterial cell death.⁴²

Nuclear magnetic resonance (NMR) spectra of the Alternanthera sessilis leaf extract showed the presence of the compound, 3- acetoxo-6-benzoyloxyapangamide which is considered majorly responsible for antibacterial activity. Aziz et al have also reported the presence of the compound in the leaf and stem of Achyranthus aspera.⁴³ Mustard oil is rich in allyl isothiocyanate (AIT), a non-phenolic volatile compound, known to inhibit many pathogenic microbes also inhibited the Enterobacter species.⁴⁴ 3% H₂O₂ and plant extract of Alternanthera sessilis and Achyranthus aspera showed a more potential biofilm inhibitory activity.

Bleaching:

Peroxide inhibits microbial growth by disrupting cell membranes and DNA, with its antibacterial effects driven by oxygen release and catalase/peroxidase actions. At appropriate concentrations, it's safe for use in bleaching, with minimal exposure and no systemic toxicity. Its breakdown in the mouth is rapid, aided by saliva and remineralizing agents.

Peroxide temporarily affects tooth surfaces, making them more porous, but this is reversible with remineralization. It can also alter biofilm formation and reduce gingivitis. Common side effects are mild and transient. Studies confirm that tooth whitening, when used properly, is safe and effective. A 10-year follow-up case showed minor black spots after bleaching, but relapse was less intense.⁴⁵

DISCUSSION

Chromogenic black stains are more common in individuals with good oral hygiene, as confirmed by Eriksen et al.⁴⁶ and Xi Chen et al.,⁶ who found a lower visible plaque index in patients with black stains compared to controls. Similarly, Dayan et al.⁴⁷ reported lower plaque scores in individuals with black stains. However, Sarkonen et al. contradicted these findings, noting that black stains were more prevalent in females and associated with poor oral hygiene.⁴⁸

Similarly, predominance of gram-positive rods was seen, which increased with the increase in black stain scores and decreased with severity of periodontal destruction. It was seen that like caries, the severity of periodontal destruction increases with decrease in black stains and a positive correlation is seen with prevalence of gram-positive rods and severity of black stains.

According to Mesonjesi et al., the iron levels in saliva are significantly higher in individuals with iron deficiency anemia or iron overload, which may explain the presence of extrinsic black stains on teeth as a potential indicator of these conditions.⁴⁹

Children who were never fed from a nursing bottle tend to have a higher occurrence of black stains. In 1890, Miller observed black stains in his family members and proposed a possible hereditary link. While not all family members with similar eating habits developed black stains, suggesting a limited environmental influence, the study's findings support a genetic predisposition, with family members showing a high severity of 47.8%.⁵⁰

The presence of black stains in only one monozygotic twin suggests that factors beyond diet, such as genetics, may play a role. Both children share a similar iron-rich diet, but stains appeared in just one. Current antibacterial agents for oral diseases have toxic effects, alter microbiota, and contribute to bacterial resistance, highlighting the need for safer, alternative treatments like herbal remedies. Lactoferrin may be a promising topical treatment for oral conditions due to its anti-inflammatory and bacteriostatic properties. Patients with pigmentation are typically older, smoke, and have lower saliva pH and fewer *Streptococcus mutans*. There was no significant difference in drug intake between those with and without pigmentation. Despite evidence of a unique microbiological composition in black stains, the relationship between microorganisms and stains remains unclear, as both cariogenic and non-cariogenic bacteria are present.

CONCLUSION

Black chromogenic stains are often found in individuals with good oral hygiene, but they tend to recur quickly, often within a month after scaling and polishing. More research is needed to identify their precise cause and develop effective preventive measures. Although primarily an aesthetic concern, these stains are associated with a lower incidence of caries, possibly due to favorable salivary factors. The stains may also spread through shared personal items such as toothbrushes or cutlery. Proper diagnosis is essential for selecting the most suitable treatment, as the underlying cause of the staining can affect treatment outcomes. Dentists should customize treatments and prioritize preventive care based on individual needs.

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