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(REVIEW ARTICLE)

Black Chromogenic Stains on Teeth: Microbial Etiology, Pathogenic Mechanisms, Clinical Characteristics, and Current Evidence Based Treatment Strategies: A Narrative Review

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Abstract

Tooth discoloration is one of the most commonly encountered complaints in the dental setting. Extrinsic stains on the tooth surface brought on by a result of bacterial metabolism are known as chromogenic stains. Black chromogenic stains in particular affect both pediatric and adult demographics. A wide range of microbial ecological habitat is responsible for these stains, particularly those belonging to actinomyces groups. Several observational studies have described that the presence of chromogenic stains can translate into anticariogenic effects. While time tested Ultrasonic scaling can get rid of these stains, they are known to recur. Currently probiotics, anti-microbial photodynamic therapy are under evaluation. This paper aims to provide a narrative review of chromogenic stains

Keywords: Chromogenic Stains; Black Stains; Ultrasonic Scaling; Extrinsic Tooth Discoloration

1. Introduction

Dental Stains are the pigmented deposits on the surface of the tooth. It is one of the most common complaints in dental clinical settings, including both pediatric and adult populations. Stains can be characterized as Intrinsic and Extrinsic. Intrinsic stains are often caused by developmental anomalies on tooth, such as amelogenesis or dentinogenesis imperfecta. Fluorosis, drugs like tetracycline or minocycline, can also be a cause for intrinsic discoloration of the tooth. [1]

Extrinsic stains are due to exogenous pigments such as beverages (tea, coffee), medications like iron, iodine, herbal preparations etc, tobacco products that include both smoked and smokeless forms. [2] Smoking tobacco releases combustion products that can cause dark brown tenacious stains deposited on the pre-existing pellicle; whereas smokeless tobacco releases tobacco juices into the tooth abnormalities, causing stains [3]

Micro-organism especially bacteria, can cause multiple coloured extrinsic stains on the tooth known as chromogenic stains. For example, micro-organisms like aspergillus can cause green chromogenic stains, while *Serratia marcescens* and *Flavobacterium lutescens* can cause orange chromogenic stains. [2] These stains can be seen in both the dentitions. RB bussell et al in 2010 reported blue stains in a four-year-old child with West syndrome. *Pseudomonas aeruginosa*, a blue pigment-producing bacteria was identified as the causative agent in the histological examination. [4]

Black chromogenic stains are confluent dotted stains present on the cervical third of the crown. (figure 1, 2 and 3) They are often noted to be resistant to conventional treatment modalities and return back in weeks to months. [5] This paper aims to provide a narrative review on extrinsic black stains or black chromogenic stains.

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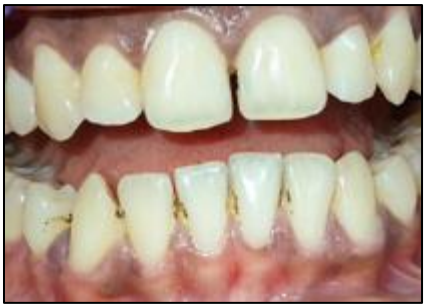

Figure 1 Chromogenic stain noted on the middle third mandibular incisors, canine and premolars tooth

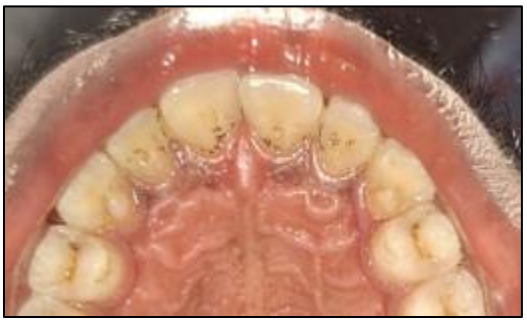

Figure 2 Chromogenic stain on the palatal aspect of maxillary incisors

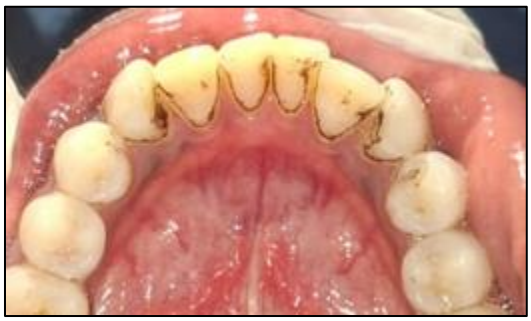

Figure 3 Chromogenic stains on the lingual aspect of mandibular incisors and canine

2. Incidence/Prevalence

Black chromogenic stains have a prevalence rate of 6.1 to 20 % reported among the pediatric age group especially in deciduous dentition but not many studies are done on the permanent dentition. [6] A Swiss study on school children reported a high incidence of up to 19.9% [7] and the lowest incidence was noted in a study among Brazilian school children i,e 2.5% between ages 3-5 [8] Akyuz S et al reported an incidence of 1.5 to 18.5% in mixed dentition age group. There has been no reported gender predilection. [9]

3. Etiology

Dental dyschromia (dental staining) is caused by chromogenic bacteria. They have the unique ability to produce colour. Filamentous bacterial species like *Actinomyces* were initially assumed to be the only causative factors. [10] The current technologies such as next generation sequencing has revealed a vibrant micro-ecological habitat. Hence the stains represent a core microbiome rather a species or two.

The facultative anaerobic bacillus, Actinomyces, remains identified as the cornerstone of this unique biome. Li Y et al in 2015 published a data by investigating the relationship between black coloured tooth stain and the oral microbiota by using 16s rRNA genetic sequencing in caries free children. This study recognized a total of 30 different species [6]

Another study conducted using Illumina MiSeq sequencing technique identified 13 different phyla, 22 classes, 33 orders, 54 families, 105 genera, and 227 species from a total of 52,646 high-quality sequences. [11]

Several mechanisms have been identified by which these bacterial species induce extrinsic staining. Yu JJ et al. demonstrated that *Actinomyces naeslundii* produces hydrogen sulphide, which reacts with ferric iron in the saliva to form ferric sulphide, that could cause of black extrinsic stains. [12] They are also recognised for their unique ability to generate small but high affinity chelating iron molecules known as siderophores, particularly hydroxamic acid siderophores and catechol siderophore. These could possibly increase the intra oral iron concentration there by causing black stains. [13] Another member of the actinomyces species is *Rothia,* which is a gram positive facultative anerobic cocci and is considered to be another important causative organism for black stains. [14]

Humbert M.V reported that out of the 31 neisserial species, *Neisseria meningitides* and *N. gonorrhoeae*, possesses the ability to metabolize cysteine. It is also known that Hydrogen sulphide a potent substance responsible for staining is produced as a by-product of cysteine metabolism. [15] *Prevoella intermedia* and *Prevotella nigrescens* are identified to have the ability to create pigments that can vary in colour from dark brown to black. They break down haemoglobin and utilize the iron for its growth. [16] Prominent bacterial species identified as Periodontal pathogens such as P. *gingivalis* and *Fusobacterium* species have also been identified in the black stain microbiome in some studies. [17]

While there are limited studies correlating black stains with factors such as age, hygiene, or socioeconomic status, Ortiz-López et al. identified a significant link to environmental and physiological chemistry. Their research indicates that patients with a higher salivary pH, or those consuming water with elevated iron content and pH, are more predisposed to chromogenic staining. [18] Chen L reported that smoking, consumption of iron supplements or caffeinated beverages may not be as much of a significant risk factor as we assume. They also suggested that eating vegetables, eggs, soy, and dairy products significantly contributes to improving the oral as well as gut bacteria that can help in reduction of black stains. [11] França-Pinto CC conducted a cohort study and reported that consumption of tap water had higher prevalence towards black stain formation as opposed to mineral water. [19] S. Prathap et al, 2022 reported that patients with higher haemoglobin levels had higher chromogenic stains though this result did not achieve any statistical significant value. They were also able to note that patients with better oral hygiene index had higher chromogenic stains. [20]

4. Clinical presentation

Clinically, the black stain appears more on the cervical one thirds of the tooth. Often seen as blackish dotted line following the gingival margin curvature (fig 2). Bibby first described it as pigmented dental plaque. [10]

Shourie developed a classification system: (Shourie KL,1947)

- Class 1 Absence of pigmentation
- Class 2 Incomplete coalescence of pigmented spots
- Class 3 Continuous lines of pigmented spots. [21]

A subsequent additional criterion was further added by Koch in 2001, where he described the presence of linear pigmented spots, parallel to the gingival margin in at least two teeth with no caries. [7]

A new modification to this existing classification was given by Gasparetto A et al. (2003)

- Score 1: Pigmented spots or thin lines parallel to the gingival border that are incompletely coalescing
- Score 2: Pigmented continuous lines that cover only the half of cervical third of the tooth.
- Score 3: Shows pigmentation that cover more than half of the cervical third of the tooth. [22]

4.1. Role in caries resistance

For over a century multiple authors have observed that the presence black stains could have a potential caries protective property. Pickerill suggested that thin black pigmented spots showed a familial pattern of inheritance and also indicated the subjects are potentially free from caries. [23] Over the years' multiple studies have tried to report this correlation between Black stain and carries immunity. Koch in 2001[7], Henrich Weltzein et al in 2009 [24], Bhat in 2000 [25], Boka et al in 2013 [26] and X Chen et al in 2014 [27] showed a positive correlation. Whereas Panagidis and Schulte 2012 [28]; Martin et al 2013 [29]; Franca-pinto et al 2012 [19] reported a negative co relation. Koch added that black stains indicate a lower caries experience in permanent dentition but not in deciduous dentition. [7]

Reid and Beeley reported a biochemical estimation of the plaque sample collected from pediatric age group. This study reported higher amount of calcium and phosphate from the plaque samples. This could correlate as to why there is decreased caries incidence in studies. But they also suggested a variation in the results among the plaque sample collected using metal and plastic instrument. [30] To counter this bias, another study was conducted in 1998 by D. Tantbiroj et al, they used extracted teeth with black pigment. They found traces of iron and copper in the sample. The spatial chemistry analysis showed traces of Sulphur in areas with higher pigmentations. [31]

There are very limited studies co-relating the saliva parameters with black stains. A. Surdacka, 1989 conducted two different studies on the Polish population that estimated the inorganic constituents, pH, buffering capacity in the saliva of patients with or without black stains. They reported a significantly higher level of calcium, inorganic phosphates, sodium and copper in patients with black pigmentation compared to controls. The level of iron, zinc as well as magnesium concentration showed difference. Higher pH levels and lower glucose levels were directly proportional to black stains. They reported no significant correlation between salivary flow rate and black stains [32,33]

Another study by Aysun et al. reported conflicting results. Though the salivary buffer capacity and calcium levels were significantly higher. There wasn't much variation between the salivary pH and phosphate levels. These factors can possibly explain the correlation between reduced caries index among patients with recurring black stain. [34]

4.2. Treatment modalities

Black discoloured plaque becomes a major aesthetic concern to both Pediatric and adult demographic. Patients often assume it can indicate a neglect in Oral hygiene. Many patients often report rigorous tooth brushing, using multiple commercially available tooth pastes and mouthwashes as means of self-treatment. Scaling and polishing becomes the first line of treatment in these cases. Pumice polishing with 3% hydrogen peroxide shows better results with more resistant stains. Bicarbonate sprays also show good results. [35]

The recurrence rates for black pigmentation is extremely high. This creates a challenge for the clinician. Recurrent scaling can cause enamel wear, and hyper sensitivity in patients with weakened enamel. Though mouth washes like Chlorohexidine can reduce the recurrence rates of black pigmentation, it can cause alterations in taste sensations, metallic taste, or even allergic reactions in some patients. [36] Whitening treatments with carbmide or peroxide are also recommended but they are known to cause alterations in enamel morphology.

Antibiotic photodynamic therapy is an emerging technique to reduce bacterial count without the risk of antibiotic resistance. Nokhbatolfoghahaei, H., et al conducted an in-vitro study with Methylene blue (660nm wavelength) and Indocyanine green (808nm wavelength) with diode laser. They showed that indocyanine green was able to get rid of chromogenic bacteria with or without laser activation. [37] Catalano LN in 2025 published a case series with photodynamic therapy using red light diode laser at 660 nm, 6 J/point, 60 seconds in 3 sessions. Both Pediatric and geriatric age group was included in this study. They noted a significance reduction in discoloration as well reported reduced sensitivity. But recurrence was noted at follow up after 6 months. [38]

R. Sangermano suggested that lactoferrin (Lf), a glycoprotein has the ability to perform iron dependent antimicrobial action by its ability to chelate two ferric ions per molecule of iron. This unique ability can be utilized to reduce the iron load in the oral cavity thus reducing its availability to bacteria, thereby reducing the black stains. [39]

Latest methodologies also include introducing probiotic microbiota to decrease the chromogenic bacterial load. N Wahba in 2025 conducted an in-vivo and in-vitro study by introducing Streptococcus Salivarius BLIS M18, Lactobacillus reuteri LR08, Lactobacillus paracasei Lpc- 37 probiotic strains to check their effect on *Aggregatibacter actinomycetemcomitans* and *Actinomyces naeslundii*. They reported a positive dose dependent inhibitory effect by completely eliminating *Aggregatibacter actinomycetemcomitans* and marked reduction in *A. naeslundii* count. [40] JJ yu, 2025 had contradicting opinions with a Taiwan based commercially available probiotic containing various *Lactobacillus* species. Their reports indicated *actinobacteriota* decreased slightly, *Firmicutes* increased modestly while *patescibateria* and *proteobacteria* showed minimal changes. [12]

Probiotics can modulate the immune response by inhibiting the inflammatory pathways typically activated by stain-associated pathogens. By competing for adhesion sites and secreting anti-inflammatory signalling molecules, probiotics reduce local inflammation and promote a balanced microbial environment. [41] There isn't much evidence on the long term effects of probiotics on black chromogenic stains though they have been shown effective in some studies.

Despite these advances advancements, not many solutions are achieved till date to completely eliminate the recurrence of black stain.

5. Conclusion

The chromogenic black stain occurs due to microbial dysbiosis, that can be eliminated with scaling and polishing. It possesses a unique challenge to the clinicians due to its high recurrence rates. Despite multiple advancements with photodynamic therapy and whitening, a permanent solution for its total elimination still remains a mystery.

Compliance with ethical standards

Disclosure of conflict of interest

Authors declare no conflict of interest.

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