

Tooth discolouration due to endodontic materials and Procedures

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Abstract: *The appearance of the dentition is of great importance to a large number of people. There is an increase in interest in treatment of tooth staining and discolouration in recent times. Correct diagnosis of the cause of tooth discolouration is important in determining the treatment outcome. In order to make a correct diagnosis and to prevent iatrogenic causes of tooth discolouration, it is imperative that we possess an adequate knowledge of the various sources of tooth discolouration, including those that occur due to the use of certain restorative and endodontic materials. This review article summarises the causes and mechanisms of tooth discolouration and staining caused by various endodontic materials.*

Keywords: *discolouration, endodontic, material, staining, tooth.*

I. Introduction:

Tooth discolouration has become a primary cause of concern for many dental patients in recent times. A discolouration is any change in the colour of a tooth, either externally or internally, that presents a major aesthetic problem, especially if it involves the anterior teeth. Tooth discolouration can be categorized based on various factors. Most commonly, based on the incorporation of the staining agent, it is categorized as intrinsic and extrinsic staining. Intrinsic staining includes all stains that were incorporated into the tooth structure during the process of odontogenesis. This type of staining cannot be removed by surface treatments like vital bleaching, microabrasion, etc. Extrinsic staining includes all stains that lie on the tooth surface, which accumulate over time due to factors such as diet, oral hygiene, and medication (For example, Cationic antiseptics like Chlorhexidine and Cetylpyridinium chloride). A further category of internalized discolouration has been included which is due to the incorporation of stain into the tooth structure after development of the tooth is complete. This discolouration caused by the use of various dental restorative materials and endodontic materials used during root canal treatment [1]. An understanding of the various materials which have a potential to cause unaesthetic tooth discolouration is useful in selection of alternative materials and methods for use in the root canals. Discussed below are some of the commonly used endodontic materials used and the mechanisms in which they cause tooth discolouration.

The various endodontic materials that have the potential to induce tooth discolouration can be grouped as follows.

- Irrigants
- Intracanal medicaments
- Medicated pastes
- Sealers and Cements
- Obturating materials and posts

II. Irrigants:

a. Chlorhexidine and its interaction with other irrigant

Zehnder proposed an irrigation regimen where NaOCl can be used during instrumentation followed by EDTA and CHX as a final irrigant. This combination promised an enhanced anti-microbial effect but the possible adverse effects due to chemical reactions between these materials are also important [2]. Studies have shown that mixing NaOCl with CHX produces a brown precipitate. This dark brown precipitate can adhere to the dentine, walls of the cavity, stain the dentine and prevent penetration and action of other intracanal medicaments[VG]. Akisue et al showed the formation of a flocculate precipitate when NaOCl was used prior to use of CHX which formed a smear layer thus reducing dentin permeability. Use of EDTA with CHX creates a pink coloured precipitate [3].

A study was done to evaluate the colour change of enamel and dentine by the use of CHX alone and in combination with EDTA and NaOCl in endodontic therapy. According to this study, the use of CHX gel + NaOCl and CHX gel + NaOCl + EDTA produced a significant colour change in enamel and dentine. Use of CHX solution + NaOCl and CHX solution + EDTA showed a colour change in dentine but not in enamel, whereas, use of NaOCl, CHX gel, NaOCl + EDTA, CHX gel + EDTA, NaOCl + CHX gel + EDTA produced no colour change. The formation of the precipitate as described by Souza et al may be due to an acid-base reaction

that occurs when NaOCl and CHX are used together by a proton exchange process. This study recommends that CHX and NaOCl combination must be avoided in general, but if necessary, the use of NaOCl must precede use of CHX, provided the canals are completely cleared of NaOCl before the introduction of CHX [2].

The usage of CHX in the presence of residual NaOCl lead to the formation of an orange-brown precipitate[4]. This precipitate was found to occlude the dentinal tubules[5]. This orange-brown precipitate is formed when CHX gets hydrolysed into small fragments due to breaking of the bonds between carbon and nitrogen, leading to the formation of a byproduct, ParachloroAniline (PCA) [6]. This PCA is toxic and causes formation of methaemoglobin and occludes dentinal tubules[5].

Kim et al studied the use of another biguanide, Alexidine to be used in combination with sodium hypochlorite. This combination neither produced Parachloroaniline nor did it cause a dark precipitate. The precipitate was a colour of light yellow to transparent and was easy to remove from the dentine using irrigants[7].

b. Tetracycline and MTAD

BioPure MTAD, a mixture of tetracycline isomer (doxycycline), an acid (citric acid) and a detergent (Tween 80) was introduced as an irrigant efficient in removing the smear layer and its efficiency in eliminating *E. faecalis* when used in combination with Sodium hypochlorite irrigating solution [8]. Doxycycline, which is a major component of MTAD is strongly adsorbed to the tooth surfaces which makes the tooth retain its antibacterial activity [9]. Tetracycline is a known cause of tooth discolouration. A study has shown tooth discolouration when MTAD was used as an irrigant along with NaOCl. This was due to a photo-oxidation process that was also exaggerated by the NaOCl as an oxidizing agent[10]. The study showed a red-purple staining of light-exposed root dentin when root canals were rinsed with 1.3% NaOCl as an initial irrigant, followed by the use of BioPure MTAD as a final rinse. This product of photo-oxidation had a high affinity for hydroxyapatite. This discolouration that is probably triggered by the NaOCl, can be prevented by use of ascorbic acid as a reducing agent before the application of MTAD [10].

c. Silver diamine fluoride

Silver diamine fluoride is used as irrigant due to antibacterial property. It has also been used as an adjuvant in endodontic preparation using lasers[11]. Hiraishi N et al investigated the use of 3.8% silver diamine fluoride ($\text{Ag}[\text{NH}_3]_2\text{F}$) as an antibacterial agent against *Enterococcus faecalis* biofilms and its ability to penetrate dentinal tubules by the formation of silver salts. *E. faecalis* was completely killed by $\text{Ag}(\text{NH}_3)_2\text{F}$ after exposure to these agents for 60 min[12]. The silver deposits were found to occlude tubular orifices after removal of the smear layer. It has also been used as an adjuvant in endodontic preparation using lasers[24]

III. Intracanal Medicaments And Medicated Pastes:

Intracanal medicaments are materials placed within the root canal system for teeth with extensive periapical radioluscencies, traumatized teeth, teeth requiring apexification and regeneration/revascularization [13]. Some of the intracanal medicaments and polyantibiotic pastes that have been in use and their discolouration potential have been discussed below.

Antibiotic paste

a. Tetracycline and doxycycline

This group of antibiotic is used in endodontics due to its broad spectrum of antibacterial activity. laboratory study was done to compare the discolouration of root dentine by the use of steroid medicaments containing clindamycin (odontopaste), Doxycycline (Doxypaste) and demeclocycline (Ledermix). Photographs taken at 2 and 4 weeks were compared. Ledermix was found to cause the most discolouration of the three. Doxypaste and Odontopaste showed progressive darkening between 2 and 4 weeks. Doxycycline based intracanal medicaments are considered to cause less staining than other tetracyclines.

Clindamycin-based medicaments do not cause much staining. A study was done in 2012 to quantify the discolouration due to various medicaments and sealers. The materials tested were Ledermix, 5% clindamycin in polyethylene glycol (PEG), 2% chlorhexidine acetate in PEG, sealers AH26 and AHPlus. Of these, Ledermix paste caused the most discolouration. So, clindamycin paste has been proposed as an alternative for the tetracycline pastes.

b. Sulfonamides

Sulfonamides are synthetic bactericidal antimicrobial agents used in the past as intracanal medicaments. Sulfanilamide and sulfathiazole were used as root canal medicaments [14]. These drugs tend to cause a yellowish discolouration of the teeth and are no longer used [15].

c. Corticosteroid + antibiotic

Ledermix paste is a corticosteroid + antibiotic compound that was developed by Schroeder and Triadan in 1960 and released. The aim was to control periapical pain and inflammation in pulpal and periapical diseases by the use of corticosteroids. The addition of antibiotics was to compensate for a possible immune-suppressive effect of the steroid medication.[16]. The steroid reduces resorption in trauma cases. Ledermix is a combination of a tetracycline antibiotic, Demeclocycline HCl (3.2%) and triamcinolone acetonide (1%) in a base of polyethylene glycol [17]. Ledermix caused the most darkening than other medicaments and AH26 caused the more darkening than did the other sealers [18]. To overcome staining with Ledermix, an alternative material containing triamcinolone acetonide or other steroid with 5% clindamycin replacing the tetracycline.

d. Triple antibiotic paste

Triple antibiotic paste containing ciprofloxacin, metronidazole and minocycline is also commonly used. The tetracycline derivatives in these pastes are described to be the source of tooth discolouration as it binds to calcium ions in the dentine and forms a chelate, an insoluble complex which is responsible for the disagreeable colour. A study showed that improper removal of the medicament from the coronal portion of the tooth contributes to staining of the tooth. In addition, if the smear layer was completely removed, the dentinal tubules are more permeable and therefore, more prone to discolouration. Also, the coronal restoration provided after removing the medicament from the coronal portion of the tooth must provide an adequate seal to prevent dissolution of the paste. If there is moisture contamination and seepage into the coronal portion of the tooth which will again cause discolouration [13]. Exposure of teeth with tetracycline medicaments to sunlight has been found to cause a photo-initiated reaction contributing to discolouration[19]. Also, minocycline was found to produce a marked discolouration even without exposure to sunlight.[20]. An alternative to the triple antibiotic paste containing ciprofloxacin, metronidazole and minocycline, a pre-fabricated antibiotic paste containing cefuroxime as a replacement for minocycline is available (TreVitaMix).

e. Formaldehyde-containing paste

Riebler's paste is a paraformaldehyde-containing paste material. Van der Burgt from Holland reported that Riebler's paste caused a severe dark red stain [21]. The entire dentinal depth was found to be stained when Riebler's paste was used. This study also showed that N2 paste containing 14C paraformaldehyde induced a moderate orange-red stain [22].

f. Formocresol and Iodoform-based medicaments

Formocresol and iodoform-based medicaments have also been reported to cause coronal discolouration. Along with its discolouration potential, formocresol is known to cause gingival necrosis and bone sequestration. Iodoform-based pastes were used in a study done in primary incisors. All teeth showed a yellowish discolouration that was highly unesthetic and showed through the translucent composite strip crowns [23]. This discolouration can possibly be reduced by applying an opaquing agent in the facial aspect of the preparation or by using a glass ionomer cement near the orifices of the canals to prevent coronal discolouration due to seepage of the iodoform paste from the root canals [24].

g. Silverdiamine fluoride

Silverdiamine is used as medicament, silver interacts with the sulphhydryl and thiol groups present in the bacterial amino acids and nucleic acids[25], This inhibits cell division, cellular respiration, metabolism, and biofilm formation. SDF has the advantage of formation of fluorapatite in the canal. Mathew VB checked the anti-microbial efficiency of silver diamine fluoride as an endodontic medicament, this study proves the effectiveness of 3.8% SDF as an intra-canal medicament against *E. faecalis*[26]. However silver deposits will occlude tubule thereby remain in the canal and discolor the teeth

IV. Sealers And Cements:

Root canal sealers are materials along with obturating materials to produce a good sealing effect. Sealers are classified based on their composition as eugenol-based and non-eugenol based sealers. Commonly available Sealers which has discoloring potential

- **Eugenol-based sealer (Kerr root canal sealer and procosal)**

Parsons et al studied coronal discolourations due to four sealer materials, SealApex, Roth's 801, AH26 and Kerr pulp canal sealer. All sealers showed coronal discolouration. The most severe was found to be in the case of AH26 and Kerr pulp canal sealer. This was assumed to be due to the presence of silver ions as part of their composition for the material's radioopacity[22].

- **Polyketone-based sealers(Diaket)**

According to the study done by Van der Burgt et al, on examination of hemi-sectioned tested teeth, Tubli-Seal, Diaket and AH26 produced discolouration of the inner one-third of the dentin, One half of the inner dentin was stained on using Grossman's cement, Zinc-oxide eugenol, Endomethasone and N2 paste. Diaket produced the least amount of discolouration which also turned out to be a temporary pink stain, which came back to normal after 6 months. [22].

- **Resin-based sealers(AH26, Silver-free AH26)**

Most studies that test sealers have concluded that they cause tooth discolouration. AH26 is a sealer containing silver as a radio-opacifier. AHPlus is an epoxy-amine resin based root canal sealer introduced to overcome the problem of discolouration associated with AH26. AHPlus, tested in a study by Lenherr et al, showed satisfactory colour stability because it contains a stable radiopacifier, zirconium dioxide. Comparison of coronal discolouration between AH26 and ZOE sealers showed that AH26 causes greater mean discolouration when compared to Dorifill sealer(ZOE) [27].

In silver-free AH26 which has bismuth trioxide as a radioopacifier, the bismuth trioxide converts to a group of bismuth compounds which are green and progressively turn a black colour [28].

An in vitro spectrophotometric analysis of the coronal discolouration effect of three endodontic sealers was done by El Sayed et al. The sealers compared were AHPlus, Apexit Plus, Sultan sealer, along with amalgam and distilled water as a control. Sultan sealer is a zinc-oxide eugenol based sealer that contains zinc oxide powder without silver. Sultan sealer displayed the greatest amount of discolouration and the cause may be due to the presence of eugenol which forms a bond with zinc oxide. This eugenol chemically oxidizes and darkens with time [29]. AHPlus, despite being free of silver, did cause a grayish coronal discolouration more severe than Apexit plus, which showed a reddish brown discolouration. So, the cause for discolouration due to AH26 cannot be attributed primarily to the presence of silver. Apexit Plus showed the lowest coronal discolouration compared to the others.

- **Calcium Hydroxide-based sealers**

Davis et al studied the coronal distribution and long term discolouration of dentin due to four different sealers. The sealers tested were AH26, Kerr Pulp Canal sealer, Roth 801, and SealApex. All teeth showed marked discolouration at 2 years. The sealers discoloured but did not penetrate dentin [30].

V. Obturating Materials And Posts:

Silver cones

Silver cones which were initially used to obturate root canals are no longer used because of their tendency for corrosion and tooth staining and more importantly , their inability to provide an adequate seal. Post endodontic restorations with metallic materials like amalgam, metallic pins and posts will cause significant coronal discolouration due to the corrosion products and the translucency of the remaining tooth structure or crown. As much as possible, metallic restorations must be avoided in anterior teeth after root canal treatment due to esthetic reasons.

Gutta Percha & Resilon

Gutta Percha has been used as a root canal filling material and has been found to cause a light pink discolouration [31]. Resilon filling material has also been found to react with CHX to form a precipitate. This was explained as due to a chemical interaction with a dye present in Resilon [24].

Mineral Trioxide aggregate

Mineral Trioxide aggregate (Gray MTA), based on Portland cement was introduced by Torabinajed et al of Loma Linda university. Due to its high sealing ability and excellent biocompatibility and handling characteristic, it was recommended for use in vital pulp therapy, pulpotomy, apexification and root-end fillings. One of the main drawbacks is its discolouration potential. It is a gray material that lead to visible colour changes on the tooth surface. White MTA was later introduced to overcome this obstacle, the difference being the lack of iron ions in the white MTA. But, even then, White MTA has also been found to cause some discolouration. Bismuth oxide, which was added as a radioopacifier in Gray and White MTA was believed to be the cause of the discolouration. The effect of application of dentin bonding agent before placement of MTA can reduce tooth discolouration as shown in a study done by AKbari et al [32]. The discolouration due to DBA + Gray MTA and DBA + White MTA was shown to be significantly less than that caused by Gray MTA and White MTA alone. This can be attributed to the sealing ability of dentin bonding agent that seals the dentinal tubules before MTA application.

VI. Conclusion:

Endodontic procedures, in addition to focussing on biological and functional factors, must also take aesthetic concern into consideration. So, selection of endodontic materials used during the procedure plays an important role in prevention of iatrogenic causes of discolouration. With the information gained from results of all the studies done to determine the discolouration potential, we can use alternative materials that comparatively reduce discolouration.

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