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Causes of Discoloration of Dental Fillings in Adults: A Systematic Review

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Abstract

The purpose of this investigation was to carry out an exhaustive review of the relevant previous research in order to ascertain the underlying causes of the observed discoloration and determine which component, if any, was to blame. A number of phrases taken from previously conducted systematic reviews were used in the search conducted in PubMed. There were a total of 389 teeth treated across eleven different trials that were discovered. Although it was seen more often with the use of the triple antibiotic paste that included minocycline, discoloration was shown to be substantially associated with the utilisation of other components as well. It is strongly suggested that you reevaluate your decision to use minocycline as the intracanal drug in conjunction with the other two antibiotics in the paste. The use of calcium hydroxide or an antibiotic paste containing both metronidazole and ciprofloxacin could be necessary in order to achieve the desired level of discoloration control. The presence of mineral trioxide aggregate was also associated with the discoloration. On the other hand, there is little evidence to suggest that any other material could possibly function as an acceptable coronal barrier. Because discoloration is a result that has a direct impact on patients, further research is required to determine the underlying causes of discoloration.

Keywords: Discoloration, dental filling, MTA, triple antibiotic paste, systematic review.

INTRODUCTION

There are various on-going debates in the field of regenerative endodontics (Smith *et al*., 2017), despite the fact that there are numerous pressing difficulties. Because the treatments and outcomes of regenerative endodontics are so unlike those of conventional endodontic therapy, it has garnered tremendous attention recently. Endodontic treatment remnants in the dental pulp or hemorrhagic materials accumulating in the dentinal tubules following trauma are common causes of tooth discoloration over time (Şişmanoğlu, 2020). In particular, tooth discoloration has been linked to a decline in adolescent, paediatric, and family well-being, making this a serious clinical concern (Magno *et al*., 2019; Comim *et al*., 2021; Reissenberger *et al*., 2022).

Due to the fact that enamel, dentin, and pulp each have their own unique mix of light-reflecting and light-absorbing qualities, tooth looks may vary. The natural tooth colour is darker than the dentin, but the enamel's transparency and thickness enable it to mix in with the dentin more seamlessly (Şişmanoğlu, 2020). Tooth discolouration is classified into three types: those induced by external influences (extrinsic), those driven by internal factors (intrinsic), and those caused by stain internalization (stain internalization) (Mohabatpour *et al*., 2022). Extrinsic stains are those that are caused by chromogens from the outside world depositing themselves into the enamel or pellicle of a tooth. To put it another way: extrinsic stains are simple. Dentin's internal chromogens may produce discoloration on a local or systemic scale, depending on the circumstances. There is a theory that discolorations that begin inside the enamel are caused by faults in the enamel itself, and that these discolorations eventually spread throughout the enamel (Goldstein *et al*., 2018). Dentin is frequently involved in the intrinsic discoloration of nonvital teeth (Feigin *et al*., 2022). However, it has been noted that regenerative endodontic treatment might cause the crown of the tooth to darken (Shokouhinejad *et al*., 2022). Dental filling materials and medicines have both been cited in the past as potential causes of discolouration (Reynolds *et al*.,

2009; Kim *et al*., 2010; Chen *et al*., 2012). Some degree of protection against material-induced tooth discolouration may be achieved by eluding elements with a greater potential of staining. For this reason, it is important to assess the root reasons of discolouration before deciding on a course of action, and to give serious thought to the technical methods involved in whitening non-vital teeth. The goal of this article is to provide a synopsis of the current understanding of what causes tooth discolouration following dental fillings.

MATERIALS AND METHODS

Search Strategy

According to PRISMA criteria, a thorough literature analysis encompassing the last 7 years 2016 to 2022 was carried out. Multiple searches were used to find the articles. The references were obtained via several searches on PubMed, SCOPUS, CINAHL and Cochrane library, using different keyword combinations including 'antibiotic paste', 'calcium hydroxide' 'colour', 'discoloration', 'dressing', 'endodontic', 'eugenol', 'filling', 'medicament', 'MTA' 'obturation', 'obturating materials' 'periodontal filling', 'portland cement', 'root canal', 'sealer', 'staining', 'tooth', 'treatment', and, 'zinc oxide'.

Study Selection

The complete procedure of literature review and study selection was illustrated in the PRISMA flow chart. Any relevant work available in the English language in peer-reviewed publications and providing important material linked to the goal of this review was evaluated for inclusion. In addition, references to all relevant studies and earlier review articles were manually entered.

The criteria for inclusion employed were the ones that follow:

1. Clinical study relating to the causes of discolouration following dental filling
2. The number of participants was specified.
3. The result was based on both clinical and radiological assessment
4. Appropriate medical indications

Articles were omitted if an English abstract was unavailable, if only single conference reports were included, or if the topic was irrelevant to the theme.

Data Tabulation

Data from the included studies was to be gathered and presented using a consistent, time-tested table for evidence synthesis and study quality grading. Each study that met the criteria provided the following information: the research's lead author, year of publication, study design, sample size, number of patients, number of teeth, tooth type, patient age, follow-up duration, and potential causes of discoloration after periodontal filling. When two studies had overlapping populations, only the bigger of the two groups was included.

RESULTS

Initially 589 publications were obtained by conducting literature search. Total 100 articles were excluded in the start being the duplicate publications. Initial title and abstract screening yielded 24 articles. The 13 articles were removed owing to its invitro nature. Eleven papers were selected based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) requirements (Fig 1). This research included 11 investigations involving 473 individuals and 579 tooth. Table 1 displays the included research, as well as the causes of tooth discoloration for each. Included are 1 cross sectional (Bosenbecker *et al*., 2020) 3 retrospective (Pereira *et al*., 2020; Chrepa *et al*., 2020; Elfrink *et al*., 2021), 2 prospective (Dias *et al*., 2018; Karteva *et al*., 2018), 2 randomized controlled trials (Uesrichai *et al*., 2019; Parinyaprom *et al*., 2018) 1 case series (Antov *et al.*, 2019), and 2 case studies (Rozainah *et al*., 2020; Javed *et al*., 2020). White MTA was utilized in nine of the included studies, whereas Portland cement was used in one case series(Antov *et al*., 2019) and biodentine was used in 1 retrospective study (Chrepa *et al*., 2020) and two RCTs (Uesrichai *et al*., 2019; Parinyaprom *et al*., 2018). These three studies compared the efficacy of white MTA and biodentine. Only one investigation examined resin cuspal coverage (Dias *et al*., 2018). Two case studies examined calcium hydroxide based sealant (Javed et al., 2020; Rozainah *et al*., 2020) one research analyzed fabric and metal plates, one retrospective study and two RCTs compared the efficacy of white MTA and biodentine Three research; two retrospective studies (Chrepa *et al*., 2020; Elfrink *et al*., 2021) and one case study (Rozainah *et al*., 2020) have considered antibiotics to cause discoloration in relation to dental fillings. Most of the research examined premolars and molars, whereas just two examined incisors (Javed *et al*., 2020; Elfrink *et al*., 2021). The lowest follow-up period following treatment was one month (Bosenbecker *et al*., 2020) and the maximum is eight years (Chrepa *et al*., 2020). The studies included were mix of children, adolescent and adults.

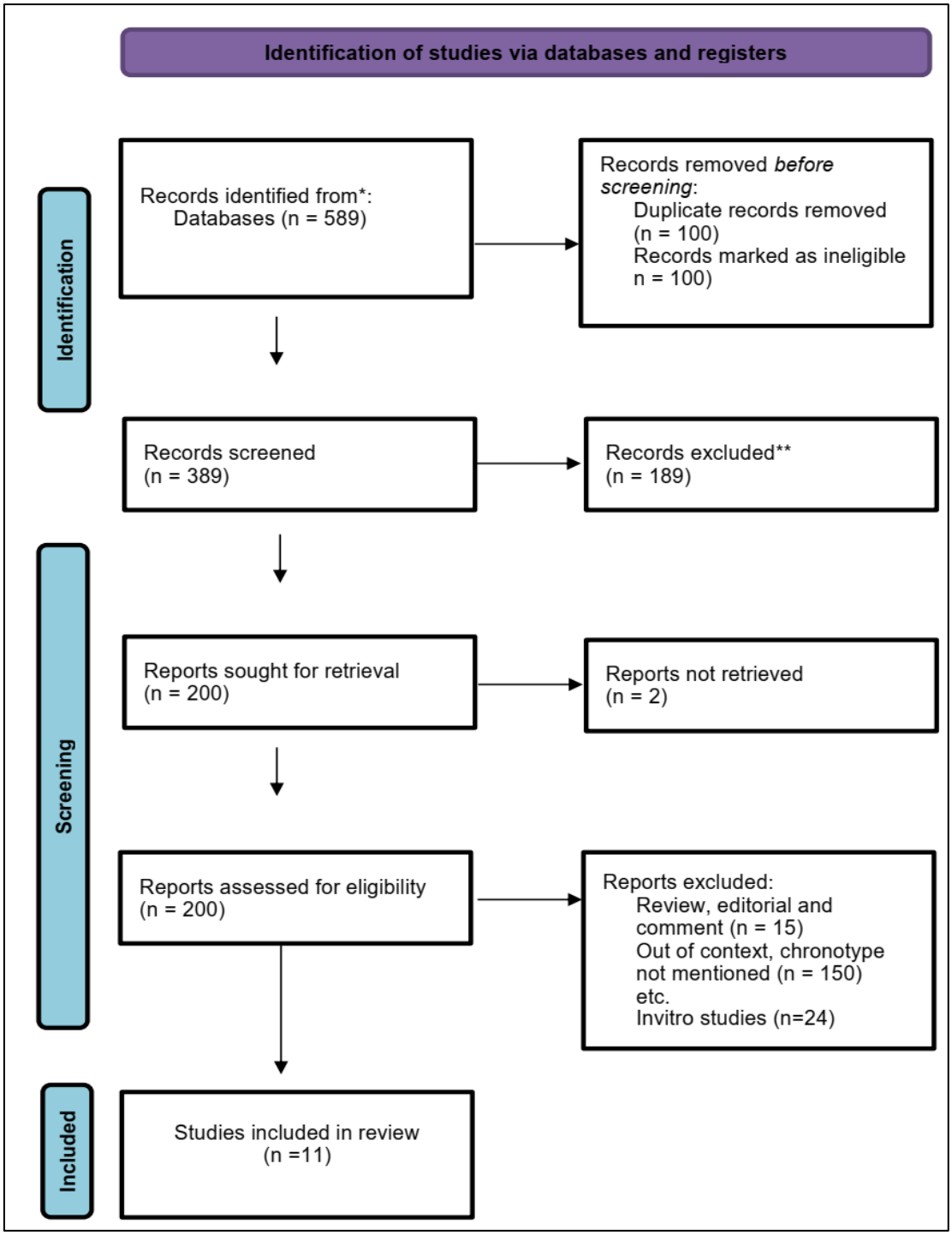

Fig 1: PRISMA flow chart depicting study selection procedure

Table Study characteristics of included studies

Study	Study design	Sample (number of teeth)	No. of Patients Patient	's age range (y)	Teeth type	Follow-up duration	Causes	Findings
Bosenbecker *et al*., 2020	Cross sectional	83	70	greater than 18 y	Premolar teeth up	to 5 years	resinous sealer: ZOE-based sealer MTA-based sealer:	The sealers based on ZOE and MTA showed the most discoloration.
Pereira *et al*., 2020	retrospective study	16	15	7-18 y, 9–		36 mo	white MTA + CaOH	Only 5 crowns showed signs of deterioration.

Study	Study design	Sample (number of teeth)	No. of Patients Patient	's age range (y)	Teeth type	Follow-up duration	Causes	Findings
Antov *et al*., 2019.	Case series 339			-15 y	11,21,22	2-5y	white MTA Portland cement	Discoloration following dental filling is highly probable. Chrepa
et al., 2020 retrospective 51517				–26 y	Anterior (75%) Premolar (22%) Molar (3%)	1–8 years Pro Pro.	Root MTA, or biodentine, Antibiotic TAP, DAP CaOH	Discoloration is 21 times more common in MTA than in Biodentine.
Rozainah *et al*., 2020	Case study	1	1	26 year old man	tooth 22	5 years	AH plus sealer+CaOH	The upper lateral incisor teeth were stained and infected.
Dias *et al*., 2018	Prospective	150	150		Premolar (n = 66) Molar (n =84) 2–	5 years	Resin Cuspal Coverage	30 with discolouration described as border pigmentation.
Karteva *et al*., 2018	Prospective	35	22 patients	18	premolars	12 months	Fibre and metal groups	Inconclusive results across the board
Javed *et al*., 2020	Case study	1	1	23 year old female right	central incisor	2 YEARS		clinical crown of maxillary right central incisor
Elfrink *et al*., 2021		Children's						Teeth showed discoloration at the outset of therapy, and this color did not improve during the course of treatment.
Uesrichai *et al*., 2019	RCT	67	67	6-to-18-year	N/M	-	MTA and biodentine	Discoloration occurred in Biodentine at a much lower rate than it did in ProRoot MTA.
Parinyaprom *et al*., 2018	RCT	55	55	6-to 18-year	N/M	-	MTA (31.4% 11/35)	The use of biodentine did not result in any graying of the teeth in this investigation.

DISCUSSION

Tooth discolorations after regenerative endodontic therapies are regarded as a negative consequence. The problem of discoloration caused by endodontic treatment is well described in the dental literature, with many published reviews of discoloration caused by root canal treatment (Kahler *et al*., 2016; Athanassiadis *et al*., 2022) A previously published review analyzed case reports of reasons of discoloration following endodontic therapy (Kahler *et al*., 2016). Nonetheless, the data is out of date, and this is, to the best of our knowledge, the first comprehensive research of the reasons of tooth discoloration following dental fillings. Our review covered wide range of clinical studies including case studies, case series cross-sectional studies, prospective and retrospective studies, and randomized control trials were included in this research. Tooth discoloration was caused by materials used for dental fillings and Antiobotic paste.

Materials used in dental fillings

A number of different cements and MTA formulations were used in the research on tooth discoloration. These cements and formulations included WMTA, calcium, propylene glycol, and Portland cement, amongst others. Mineral Trioxide Aggregate (MTA) is the calcium-silicate based cement and the most popular material for the coronal barrier because of its beneficial properties, such as its high sealing efficiency, low cytotoxicity, antibacterial activity,

biocompatibility, and the potential to stimulate stem cell growth from the apical papilla. Besides, it is the most cited cause of tooth discoloration in dental fillings. In in vitro studies, tooth discoloration has been linked to both gray and white MTA, abbreviated as GMTA and WMTA, respectively. Studies indicate that Retro MTA, MM-MTA, and MTA Ledermix have the lowest potential for staining. However, reports also indicate that gray MTA, white MTA Angelus, and white ProRoot MTA have a high potential for staining. Dental fillings performed with MTA in primary molars have also been connected to tooth discoloration as a potential side effect. The results, which were gathered over a period of six months, revealed that Portland cement discolored the most, whereas MTA and MTA-PG discolored the least. Although an intracanal medication containing calcium hydroxide was administered, staining still occurred (Pereira *et al*., 2020). The usage of white MTA is probably the prime reason for the discoloration.

Bismuth oxide, the radiopacifying ingredient in the cement MTA, may be destabilized when it comes into contact with strong oxidizing agents such as sodium hypochlorite or the amino acids contained in dentin collagen, leading to tooth discoloration. To discolor teeth, bismuth either (a) undergoes oxidation when brought into contact with a powerful oxidizing agent (specifically sodium hypochlorite and amino acids from dentin matrix collagen) and produces bismuth carbonate, which results in a black precipitate when exposed to light; or (b) undergoes reduction from its oxide form to metal by reduction, resulting in a black compound and subsequent tooth staining. This discoloration of teeth may be seen when this cement is used for various treatment methods, such as vital pulp therapy, sealing root canal perforations, and root resorptions. Vallés *et al*., suggest that bismuth oxide is sensitive to oxygen and light, which are both elements present in its natural habitat (Vallés *et al*., 2015).

Blood contamination has been shown to hasten discoloration in materials based on calcium silicate (Lenherr *et al*., 2012; Tripathi *et al*., 2020). Investigations have shown that even bismuth oxide-free Portland cement will change color after being exposed to blood (Lenherr *et al*., 2012). Blood contamination has been shown to hasten discoloration in calcium silicate-based materials (Paulo *et al*., 2021). Due to the prolonged hydration process that is characteristic of MTA, erythrocyte sorption and subsequent hemolysis may take place, which may eventually result in the staining of both the material and the teeth (Shalini Maria, 2020; Palma *et al*., 2020). This has resulted in the formulation of the notion that unset MTA displays surface porosities, which are capable of absorbing blood components, to explain the amplification of CSC discolouration (Antonijevi *et al*., 2021). The oxidation and absorption of the remaining iron component in the set material is one probable explanation for tooth discoloration following MTA insertion (Palma *et al*., 2019). Blood causes the ferrous (Fe2+) ion that is housed within the porphyrin ring to be lost through a natural redox process, giving rise to Fe3+, a dark brown component that is likely to promote material and, as a result, tooth discoloration. When blood comes into contact with the porphyrin ring, the ferrous (Fe2+) ion that is housed there is lost. For instance, Guimares *et al*., (2015) found that a vehicle composed of 80% distilled water and 20% propylene glycol significantly decreased the amount of color change that occurred when blood was exposed to MTA (Guimares *et al*., 2015). There is a possibility that the discoloration originates in the dentinal tubules as a result of the presence of hematin molecules (Marin *et al*., 1997).

It is possible that variations in the thickness of the residual tooth structure, the colorimetric technique of color measurement, and the different application methods contributed to the varying reports of MTA-induced color change and its longevity. In the tooth-colored formula, the metal oxides are present, although at a very low concentration, and may cause tooth discoloration. D-electron elements, including iron, manganese, and copper, are noted for their vivid oxide hues. Excitation of the d-electrons by light in the visible range is straightforward. Bismuth, unlike lighter metals like calcium, silicon, aluminum, magnesium, and sulfur, has a yellow oxide. Previously, it was claimed that the radiopacity-increasing yellow oxide of bismuth present in both forms of MTA is the primary cause of tooth discoloration.

A retrospective investigation found that 62 percent of people had some kind of discoloration. The MTA was used to treat 97% of all discolored teeth, and it caused considerable discoloration in 80% of all MTA-treated teeth, regardless of the intracanal medicament that was employed. Subset assessments of discolored teeth revealed this information. In contrast, every single one of the teeth that had been treated with Biodentine exhibited evidence of discoloration, with the exception of just one. During dental filling, a grayish discoloration was only found in teeth that had been treated with ProRoot MTA (Chrepa *et al*., 2020). This was also observed in randomized controlled studies, and it is likely related to the difference in radiopacifier that the two materials possess (Uesrichai *et al*., 2019; Parinyaprom *et al*., 2018).

RetroMTA has many desirable properties that make it an acceptable replacement for the MTA. Some of these properties include a fast setting time, low tooth discoloration, high tensile strength, increasing adhesion with time, increasing push-out resistance to cracking, dissolution rate, lower toxicity, bioactivity, antimicrobial activities, and applicability for application in restorative techniques in the existence of blood residues (Maru & Dixit, 2021).

This study's (Bosenbecker *et al*., 2020) findings that ZOE-based endodontic materials exhibit coronal discolouration are consistent with those of prior in vitro research (Partovi *et al*., 2006). (Ioannidis *et al*., 2013), (Jang *et al*., 2013). It has been hypothesized that the chromogenic potential of ZOE is related to the comparatively unstable chemical connection between zinc oxide and eugenol. (Ioannidis *et al*., 2013) (Jang *et al*., 2013), (Lee *et al*., 2016). It turns out that eugenol is still being produced after the setting reaction has taken place, leading to gradual darkening due to self-oxidation (Parsons *et al*., 2001).

It has been said that AH Plus, a silver-free sealer, has a far lower discoloration potential than its predecessor, AH26 (Bosenbecker *et al*., 2020). Results from this research are consistent with those of a prior study showing that AH Plus caused noticeable discolouration after 6 weeks, which diminished after 8 weeks. Results from our study indicated that AH Plus caused clinically detectable coronal discolouration in the first month of assessment, which subsequently faded (Bosenbecker *et al.*, 2020). It's not clear from the published research whether or not AH Plus really causes discoloration. One study found growing poor coronal darkening after 6 months, while another found good color stability after 12 months.

According to the evidence, margin discolorations after composite resin cuspal coverage, also known as margin pigmentation, have been shown to be common after 5 years of treatment (Shafiei *et al.*, 2010). The research carried out by Dias and colleagues revealed that 20% of the margins were discolored. These findings are in line with what has been previously documented (Shafiei *et al*., 2010). It's possible that this is due to the composite's natural coloring developing over time. In several instances, all that was required to bring back the original color was a quick polish of the edge (Dias *et al*., 2018).

One study (Karteva *et al*., 2018) demonstrated that different restoration methods do not show any significant changes. And suggested that the reasons behind slight color change could be due to the dietary habits of the patients (intake of dark-coloured beverages, smoking), as well as the qualities of the composite material used. Previous study has revealed that restorations created from silorane-based composite may be yellow, opaque, or inconsistently translucent. However, this is largely irrelevant given that the material was developed with posterior restorations in mind; therefore this concern is largely unfounded. In prior research, it was discovered that restorations made using silorane or methacrylate did not exhibit any visible change in color or undesired marginal discoloration ((Attia *et al*., 2014; Gönülol *et al*., 2019). These results of this study are consistent with those findings (Karteva *et al*., 2018).

Antibiotic Treatment

When performing normal endodontic treatment, the use of antibiotics is not recommended (Segura-Egea *et al*., 2018). A dental filling, on the other hand, and the use of antibiotics topically, are two very different approaches. According to the findings of Montero-Miralles *et al*., (2018) review, it is safe to use mixes containing three or two antibiotics for topical administration in dental fillings. The researchers based their conclusion on their examination of the literature. The antimicrobial agents are biochemically compliant and do not have a toxic effect on the progenitor cells at the apices of the tooth when used at low concentrations (Lin and Kahler 2017), which results in a nearly optimal outcome (Montero-Miralles *et al*., 2018). In a study by Chrepa *et al*., the impact of minocycline in TAP on tooth discolouration could not be evaluated because no teeth had been treated with TAP and Biodentine. However, when combined with Biodentine, DAP has the potential to lessen the prevalence of tooth discoloration, a major downside of REPs overall, especially in the esthetic zone (Chrepa *et al*., 2020). The antibiotic mixture may cause a yellowish color, as depicted by Elfrink *et al*., 2021.

Conclusion and Future Recommendations

MTA and triple antibiotic paste are the most common causes of discoloration following dental fillings. Patients receiving regenerative endodontic therapy should be advised of the likelihood of discoloration per the most recent AAE standards. The recommendations continue to encourage utilizing minocycline in intracanal medications, albeit permitting a low concentration of TAP. In light of the findings associating minocycline with coronal discoloration, it is proposed that this recommendation be reevaluated. MTA, the material most frequently used as a coronal barrier in these trials, has been related to tooth discoloration, but no alternative material has yet been identified. Biodentin has been demonstrated to have a lower discoloration potential than other alternatives, making it a feasible option. All three dentin bonding agents, syringe delivery of agents into the canal, maintaining TAP below the cementoenamel junction, and employing materials other than MTA as the coronal barrier are all recommended methods for preventing tooth discolouration.

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