Tooth colour is of aesthetic importance to many individuals, especially if the discolourations are visible. Stains can be located on the outside tooth surface or within the tooth structure. Factors that result in external staining of the tooth surface or acquired pellicle can include the consumption of tobacco, coffee or certain other beverages/foods. If these discolourations are not removed by dental prophylaxis they can over time become incorporated into the tooth structure through developmental or acquired defects. These internalised stains are thus classified as extrinsic discolourations. Another form of internal staining results from trauma or is of systemic or pulpal origin, such as dental fluorosis or tetracycline staining; this causes the discolourations to begin within the tooth structure during tooth development. These stains are classified as intrinsic discolourations. Alternative treatment options are required depending on the location of the stain. Therefore, it is essential to know the origin of the stain in order to be able to establish the most appropriate treatment plan that will minimise or eliminate the discolouration of the affected dentition.

Dental fluorosis is an enamel defect caused by an excessive systemic absorption of and repeated exposure (i.e. low chronic doses) to fluoride during all stages of tooth development. Although fluoride is an effective agent in preventing caries by inhibiting demineralisation and stimulating remineralisation of enamel, a linear relationship exists between the amount and duration of fluoride ingested and the development and severity of dental fluorosis. Long-term exposure and high doses of systemic fluorides can cause the enamel as well as dentin and cementum to become hypomineralised and more porous. Hypomineralised tissue frequently alternates with hypermineralised bands of enamel. Deeper layers of enamel can become severely hypomineralised, making the affected teeth increasingly fragile.

Dean’s Fluorosis Index, developed by H.T. Dean in 1942, is the gold standard in classifying the varying degrees of severity of dental fluorosis. The six scores according to their clinic-

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**Materials and Methods:** For the present case of mild to moderate dental fluorosis, the microinvasive resin infiltration technique was chosen, following suboptimal results of in-office vital tooth bleaching to improve the aesthetic appearance of the affected teeth.

**Results:** Six months after treatment, the white opaque and brown discolourations remain masked.

**Conclusion:** This case report demonstrates that resin infiltration is an agreeable option for this type of tooth discolouration, rather than choosing more invasive, conventional procedures. More studies need to be completed to determine longer-term outcomes of the technique.

**Key words:** dental fluorosis, long-term stability, tooth discolourations, resin infiltration

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Resin Infiltration for Aesthetic Improvement of Mild to Moderate Fluorosis: A Six-month Follow-up Case Report

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al signs are: 5, 15 0 for normal or unaffected teeth that have a smooth, uniform, creamy white surface; 0.5 for teeth that are questionable and have some white flecks or spots; 1 for very mild where less than 25% of the tooth is covered with small white opaque areas; 2 for mild where no more than 50% of the tooth is covered with white opaque areas; 3 for moderate where more than 50% of the entire tooth surface is affected and may have brown staining; and 4 for teeth that are severely corroded or pitted and often have brown staining affecting 100% of the enamel surface. A single source of fluoride or usually a combination of different factors can cause different degrees of severity of dental fluorosis. Two main sources of fluoride that likely lead to the increased occurrence of dental fluorosis are (1) greater than 1 ppm of added or naturally occurring fluoride in drinking water18 and (2) dental products containing fluoride (e.g. toothpastes and mouthrinses if swallowed during tooth development, or fluoride supplements).5 Other sources of fluoride can be found in foods or baby food.1, 5 Findings from the United States National Health and Nutrition Examination Survey 1999–20043 show that a high percentage (40.6%) of individuals between the ages of 12 and 15 have some form of dental fluorosis. The prevalence decreases as age increases. Furthermore, 22.9% of individuals between the ages of 6 and 49 who were surveyed had some form of detectable dental fluorosis (i.e. very mild, mild, moderate or severe according to Dean’s Fluorosis Index).

Several treatment options, ranging from bleaching (less invasive) to full crowns (more invasive), have been used to treat dental fluorosis depending on the extent of enamel destruction.15 Sherwood15 and Alvarez et al7 have documented cases of varying severities of fluorosis and the chosen treatment; for instance, for mild levels of fluorosis, in-office vital bleaching has been partially successful. Micro- and macro- abrasion have also been moderately successful,14, 15 but this has the potential to remove greater amounts of tooth structure than needed or desired. Treatment of moderate levels of fluorosis has been shown to be successful with veneers. More severe levels of fluorosis require more highly invasive procedures such as crowns, especially if there is mottling and loss of occlusal vertical dimension.15 It is important to remember that any treatment option has its advantages and disadvantages (such as being more or less invasive) and also depends on the patient’s needs and the desired outcome.15

The microinvasive resin infiltration procedure is a new technique developed as a preventive treatment to inhibit the progression of incipient white-spot carious lesions.7 Following the three-step process of etching, drying and infiltrating the affected area with a resin, the end result has a positive outcome of improving the appearance of the carious lesion by masking it.13 Therefore, the aim of this case report was to determine if fluorosed areas of teeth can be successfully treated with resin infiltration and if the results are long-lasting.

**Case report**

A 24-year-old woman attended the dental clinic at Philipps University of Marburg (Germany) for treatment of anterior-tooth discoloration. She presented with white, opaque and several light-brown discoloured areas on the facial aspect of her six maxillary anterior teeth. The affected enamel extended from the incisal edge of each tooth to almost halfway up the crown (Fig 1a to c). After taking the patient’s medical history and completing an intra- and extraoral examination, the white and brown discolorations were diagnosed as being a mild to moderate form of dental fluorosis. This corresponds to scores 2 and 3 of Dean’s Fluorosis Index, as more than 25% and less than 50% of each tooth was affected and some brown staining was evident on the fluorosed portions of the teeth. No pitting of the fluorosed areas was detected.
The initial treatment chosen was the non-invasive method of in-office vital tooth bleaching (Opalescence Boost, 40% H$_2$O$_2$, Ultradent; South Jordan, UT, USA). The goal of bleaching was to match the healthy or non-fluorosed areas of the teeth with the lighter fluorosed portions of the teeth as well as to lighten the shade of teeth (i.e. mandibular anterior teeth 34 to 44) not affected by fluorosis. The pre-treatment tooth colour was determined to be A3 using the Vitashade guide to observe colour changes following bleaching. Bleaching was conducted in several cycles (15 min each) at different appointments to reduce side effects such as tooth hypersensitivity, with a total of eight cycles performed on the maxillary anterior teeth (Fig 2a) and three cycles on the mandibular anterior teeth and first premolars (Fig 2b). The numerous bleaching procedures resulted in an improvement in shade of the treated portions of the teeth, but were unable to match the colour of the fluorosed areas. The patient inquired about alternative treatment options to further improve the aesthetic appearance of the conspicuous white and brown discolorations on the maxillary anterior teeth.

The microinvasive resin infiltration technique (Icon, DMG; Hamburg, Germany) was chosen despite the product being designed for use on cariogenic non-cavitated white spot lesions. Treatment of the fluorosed areas of the teeth using resin infiltration began two months following the last bleaching procedure of the teeth. The first step before beginning the resin infiltration procedure was to remove any external stains and to polish the teeth to be treated with a polishing paste and a soft rotary bristle brush to ensure a clean tooth surface (Fig 3a). Any remaining polishing residue was rinsed away using the water syringe. A liquid dam (LC Dam, Voco; Cuxhaven, Germany) was applied to the gingiva around the teeth to be treated to protect the oral mucosa during certain parts of the procedure (Fig 3b).

The left central incisor was treated first. An etching agent containing 15% to 20% hydrochloric acid was applied to the affected fluorosed area of the tooth. This step ensures that enough of the mineralised surface layer of the tooth is etched away to allow the resin to adequately infiltrate into the porous (hypomineralised) white opacities as well as alternating hypermineralised layers within the affected enamel matrix. A generous amount of etchant is applied and let sit for a period of 2 min (Fig 4e and f), followed by a 30-s rinse with water (Fig 3c). After rinsing with water (Fig 3d) the white opacity of the fluorosed area of the tooth decreased, but increased again following the drying procedure with the air syringe. Prior to each application of the etching agent, the moisture was controlled (Fig 3e).

After the third etching procedure, an air syringe was used to thoroughly dry the surface of the etched left central incisor (Fig 3f) prior to the application of a liquid drying agent (95%–100% ethanol). The drying agent is applied to the affected tooth surface once and let sit for 30 s (Fig 3g), followed by air drying. The ethanol-containing agent confirms that the surface layer of enamel has been stripped away, allowing sufficient penetration of the infiltrant into the etched fluorosed area. When the drying agent is applied, the white colour of affected enamel should decrease or disappear, ensuring that the treatment is effective.

The resin infiltrant containing acrylate resin was applied to the fluorosed tooth (Fig 3h). On an etched tooth surface, the low viscosity resin has the ability to fill and seal the porous surface via capillary action. The first application of the infiltrant to tooth 21 was let sit for 3 min. This was determined to be an adequate amount of time for sufficient penetration into microporosities of enamel (such as non-cavitated carious lesions). The excess resin was removed prior to light curing the area for 40 s (Fig 3i). A second application of the infiltrant was carried out for 1 min to ensure that the resin penetrated into any remaining open microporosities. Excess resin was removed again before the area was...
light cured for another 40 s. Light curing ensures that the infiltrant is retained within the microporosities of the tooth surface (Fig 3j).\textsuperscript{10}

The patient was very pleased with the results of the resin infiltration technique, as there was an aesthetic improvement of the white opacities and brown discolourations of all maxillary anterior teeth directly following treatment (Figs 4a to c). Figures 5a to c demonstrate that the outcome of the treatment was effective and had long-term stability six months after treatment.

**DISCUSSION**

Tooth discolourations such as those from dental fluorosis are an aesthetic concern for many individuals,\textsuperscript{6,14,18} especially if the discolourations are visible, such as the facial surfaces of the anterior teeth. The correct diagnosis is needed to determine the best treatment options;\textsuperscript{18} however, it is difficult to distinguish between dental fluorosis and other types of hypoplastic or hypomineralised enamel (e.g. molar incisive hypomineralisation), both clinically and histologically.\textsuperscript{18,19} Based on the patient’s history, the visible white hypomineralised opacities in the enamel subsurface\textsuperscript{4,5,15} and the description of the Dean’s Fluorosis Index, the individual described here was diagnosed with mild to moderate dental fluorosis.

Several treatment options exist and have been shown to improve the aesthetic appearance of varying degrees of dental fluorosis. In this case, the minimally invasive in-office bleaching technique was first chosen to attempt to lighten the shade of the non-fluorosed apical portions of the maxillary
anterior tooth crowns to more closely match the white-opaque incisal thirds of the fluorosed teeth. The mandibular anterior teeth and first mandibular premolars were also bleached to match the colour of the bleached maxillary anterior teeth. Bleaching has been shown to be an accepted form of treatment for mild to moderate dental fluorosis and teeth generally become lighter in shade with increased exposure to and concentration of the bleaching agent. In the present case, the treated areas of the teeth improved in shade following bleaching therapy. Bleaching was performed over several appointments to prevent tooth hypersensitivity. However, the bleached non-fluorosed portions were unable to match the fluorosed areas of the teeth. In-office bleaching is indicated in this case because a 14-day home-bleaching procedure would have caused both fluorosed and the non-fluorosed areas of the teeth to be exposed to the bleaching agent.

With this suboptimal bleaching outcome, the patient underwent the microinvasive resin infiltration treatment to attempt to improve the aesthetic appearance of the fluorosed incisal thirds of the facial surface of the maxillary anterior teeth. This treatment option was chosen despite the resin infiltration technique being initially developed for white spot caries lesions. However, similar to caries development, dental fluorosis is a hypomineralisation of the enamel that causes the fluorosed portion of the tooth to have increased porosity and appear white and opaque in colour. Therefore, infiltrating the microporosities with a resin should cause the fluorosed areas of the teeth to acquire an appearance similar to the non-fluorosed healthy teeth. This case report demonstrated that the resin infiltration technique had a positive outcome in masking the discolorations of the mild to moderately fluorosed portions of the teeth.

The resin is a clear, unfilled composite material that has very low viscosity, low contact angles to the enamel and high surface tension, enabling the resin to infiltrate into the microporosities of the tooth via capillary forces. The resin fills the air and water microporosities within the enamel, which have lower refractive indices (1.0 and 1.33, respectively) than sound enamel (1.62). The difference in refractive indices between these air- or water-filled microporosities and sound enamel causes light to scatter and reflect more, thus making the affected fluorosed tooth surfaces to appear whiter and opaque in colour. The refractive index of the resin-filled microporosities is 1.46, close to that of normal enamel. Thus, less light is scattered due to the smaller difference between the refractive indices of the resin-infiltrated and sound enamel, thereby allowing the infiltrated enamel to acquire an appearance similar to that of the unaffected enamel.

In the present case, the non-fluorosed portions of the affected teeth were first bleached, while the fluorosed portions of the teeth were subsequently...
infiltrated with resin. The question must be posed whether the resin-infiltrated areas of the tooth adopt the same shade as the previously bleached non-fluorotic areas of the teeth if the entire facial surface of each maxillary anterior tooth undergoes another bleaching procedure. This approach should work based on the concept of refractive indices. The resin has a ‘chameleon effect’ and will closely match the refractive index and colour of the surrounding enamel. This contrasts with restorative materials such as composite-resin filling material, which fills cavitated lesions with a filled resin and may change in colour and structure (e.g. decreased hardness or increased roughness) following bleaching. Restorations may need to be replaced with new filling material that matches the colour of the newly bleached tooth.6,8

There are several other advantages of using the resin infiltration technique. First, it is a microinvasive procedure where etching only erodes 30 to 40 μm of enamel to then be infiltrated with resin.13 This contrasts with the treatment of microabrasion, composite fillings, veneers or crowns, which require a greater portion of the tooth structure to be removed. Second, the technique is a relatively quick and pain-free procedure compared to restorative procedures (e.g. may require local anesthetic and healing process). Third, it is a less expensive procedure than more invasive, tooth-destructive treatments. Furthermore, in this case, a positive outcome of resin infiltration occurred immediately following treatment with no relapse in appearance one day, one week or even six months after the procedure was conducted.

CONCLUSION

The results of this case report demonstrate that the resin infiltration technique is an agreeable microinvasive aesthetic treatment. It has the potential to minimise an individual’s tooth discolouration when diagnosed with mild to moderate levels of dental fluorosis and has shown a long-term (6 months) positive outcome. Clinically controlled studies will need to be conducted to observe the efficacy of this treatment, determine if the positive effects of resin infiltration persist longer than six months and investigate whether other forms of fluorosis can be treated in this way.

REFERENCES

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