

Masking of Enamel Fluorosis Discolorations and Tooth Misalignment With a Combination of At-Home Whitening, Resin Infiltration, and Direct Composite Restorations

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Clinical Relevance

Successful masking of enamel fluorosis discolorations can be achieved conservatively using a combination of at-home whitening with 10% carbamide peroxide and resin infiltration after enamel etching, resulting in a very satisfactory result.

SUMMARY

This clinical report illustrates a conservative technique to mask enamel discolorations in maxillary anterior teeth caused by hypomineralization associated with enamel fluorosis and

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subsequent direct resin composite to improve the anterior esthetics. The treatment consisted of at-home whitening with 10% carbamide peroxide gel with potassium nitrate and sodium fluoride in a custom-fitted tray to mask the brown-stained areas, followed by resin infiltration to mask the white spot areas. An existing resin composite restoration in the maxillary right central incisor was subsequently replaced after completion of the whitening and resin infiltration procedures, whereas the two misaligned and rotated maxillary lateral incisors were built up with direct resin composite restorations to provide the illusion of adequate arch alignment, as the patient was unable to use orthodontic therapy.

INTRODUCTION

Excessive fluoride intake may result in dental fluorosis, which is a hypomineralization of enamel

characterized by opaque white areas or discolorations ranging from light yellow to dark brown.¹ The dosage and duration of fluoride ingestion during tooth development determines the severity of fluorosis.² The degree of enamel hypomineralization may vary in different parts of the tooth surface due to the variation in enamel thickness.³ Not all white or brown demineralized enamel areas are caused by fluorosis; therefore, they may be considered idiopathic.^{4,5} The term enamel “dysmineralization” has been used when referring to fluorosis-like enamel discolorations.⁶

Although the corresponding enamel abnormality had been described in the beginning of the 20th century,^{7,8} the etiology of dental fluorosis was not independently established until 1930.⁹ In 1901 J. M. Eager, of the US Marine Hospital service, reported in Public Health Reports⁷ and the following year in *The Dental Cosmos*⁸ a frequent dental abnormality among the inhabitants of Naples, Italy, known as “denti di Chiaie” (named after Prof Chiaie who first described the condition) and attributed the enamel discoloration to the water supply. Dr Eager also noticed that the incidence of the condition among infants had greatly diminished since water brought from a distant mountain had been in use in lieu of the water from local wells. In 1916, McKay and Black¹⁰ described the same condition, calling it “mottled enamel,” localized to the area of Colorado Springs, CO. The authors also hypothesized that the water supply might be the cause of this condition.

The esthetic imbalance caused by enamel fluorosis has been treated with enamel macroabrasion or microabrasion, alone or combined with in-office or at-home whitening.¹¹⁻¹⁶ The enamel microabrasion technique was described by Croll and Cavanaugh¹⁷ in 1986. The microabrasion paste, which contains hydrochloric acid (HCl) and silicon carbide, is applied by rubbing it onto the enamel surface and removing a microscopic layer of enamel,^{18,19} therefore combining chemical erosion with mechanical abrasion. Depending on the concentration of HCl, the abrasive material, and the duration of each application, enamel microabrasion removes up to 200 μm of the outer enamel surface.^{20,21} In some cases, a residual yellow color has been reported after the enamel microabrasion treatment, which may be a result of the thinner enamel exposing more of the underlying dentin.²⁰ Although a few applications of a microabrasion suspension have been recommended to mask white spots,^{17,22} the technique is more successful in removing brown stains than white opaque areas.^{23,24} However, it is difficult to predict when

enamel microabrasion will remove a stain completely from a tooth,²⁵ as the defect may be deeper than microabrasion can reach.

The combination of HCl enamel etching with the infiltration of a low-viscosity resorcinol-formaldehyde resin into etched enamel was introduced in 1976 as a potential cariostatic treatment.²⁶ Croll²⁷ used a clear resin sealant on phosphoric acid-etched enamel to saturate the surfaces with resin for smooth surface enamel defects. In 2009, the masking of white spots with resin infiltration using 15% HCl etching followed by a drying step with ethanol, and the application of a low-viscosity light-cured resin (tetraethylene glycol dimethacrylate [TEGDMA]) was described in the literature, which is the current technique recommended for resin infiltration.²⁸ Compared with enamel microabrasion, the enamel resin infiltration technique is more conservative.²⁹ The sequential combination of at-home whitening in a custom-fitted tray with enamel resin infiltration described in this article has not been often reported in the dental literature. Therefore, the purpose of this clinical report is to describe the technique used to mask the discoloration of the maxillary anterior teeth in a patient with dental fluorosis, through the combination of at-home whitening with 10% carbamide peroxide in a custom-fitted tray and enamel resin infiltration, followed by recontouring the teeth with direct resin composite restorations.

CASE REPORT

The chief complaint of this 20-year-old male patient was “I want to get permanent crowns on my front teeth.” The patient was not satisfied with the yellowish color of his teeth.

The patient’s medical history was noncontributory. The periodontal status of the patient was normal and being monitored every six months. The patient had class I molar classification bilaterally, with anterior overbite of 5 mm and 3-mm overjet. Clinically, teeth 7 and 10 were retroclined relative to teeth 8 and 9. Tooth 7 was mesially rotated in relation to tooth 10. There was a history of trauma to the right maxillary central incisor (tooth 8) within the last six years, with fracture of the incisal border, but the pulp responded to vitality tests within normal limits. This tooth had been restored with resin composite. Radiographically, teeth 8 and 9 displayed a uniform periodontal ligament space and intact lamina dura consistent with the other anterior teeth. A normal generalized pattern of bone trabeculation was observed. Tooth 8 had a coronal



Figure 1. (a) Baseline frontal view of compromised esthetics as a result of fluorosis brown and white stains and misaligned maxillary incisors. (b) Closer view of maxillary central incisors. Tooth 8 has an incisal resin composite restoration that includes the distal angle.

radiopacity consistent with the clinical presence of a resin-based restorative material.

In addition to the clinical and radiographic findings, from the medical history we noticed that the patient was born in an area that has been described as a naturally fluoridated region (for privacy issues, we decided to keep this geographic reference confidential), which led us to the diagnosis of enamel fluorosis (Figure 1). The enamel fluorosis in this case corresponds to a tooth surface index of fluorosis (TSIF) of 4.¹

The initial treatment plan presented to patient included at-home whitening with 10% carbamide peroxide gel with potassium nitrate and sodium fluoride (Opalescence PF 10%, Ultradent Co., South Jordan, UT, USA) in a custom-fitted tray overnight for a minimum of 5-10 weeks to mask the brown stains, followed by resin infiltration of the white spot areas with Icon (DMG America, Englewood, NJ, USA). The patient was informed that the existing resin composite restoration of tooth 8 would have to be replaced after successful completion of the



Figure 2. Clinical aspect after 5 weeks of at-home whitening overnight with 10% carbamide peroxide with potassium nitrate and sodium fluoride (Opalescence PF 10%, Ultradent Co) in a custom-fitted tray. Compare with Figure 1a to evaluate the significant improvement of the brown stains.

whitening and resin infiltration procedures. A consultation with Orthodontics concerning the misaligned maxillary anterior teeth was also recommended at this time.

The list of materials used is provided in Table 1. After intraoral photographs and preliminary alginate impressions to fabricate bleaching trays, a 0.035-in-thick ethylene vinyl acetate sheet was heated prior to forming the tray around the stone model in a vacuum device. The tray was then trimmed in a horseshoe shape and trimmed following the scalloped contour of the free gingival margin.³⁰ The tray was kept slightly short of the free gingival margin (0.5-1.0 mm) to prevent possible irritation caused by the contact of the gel with the soft tissues.^{31,32} Spacers were not used to create reservoirs for the bleaching gel, as they do not increase the success of at-home bleaching.^{33,34} It has been shown that the bleaching gel remains active for longer periods when reservoirs are used,³⁴ which may be the reason why tray reservoirs result in higher rates and higher intensity of gingival inflammation during at-home bleaching.³⁵ After demonstrating how to insert the gel into the tray, eight syringes of 10% carbamide peroxide gel were prescribed to patient, with the respective take-home written instructions.

Figure 2 depicts the clinical aspect after five weeks of at-home whitening overnight. The patient reported no sensitivity, and no alterations were observed in the soft tissues. The patient had been informed that an interval of two weeks would be necessary between the final application of the bleaching gel and the

Table 1: <i>Materials used in the clinical case</i>	
Material (manufacturer)	Composition
Opalescence 10% PF (Ultradent Co)	10% carbamide peroxide, potassium nitrate, 0.25% sodium fluoride, xylitol, polyacrylic acid thickener, sodium hydroxide
Icon (DMG America)	Icon Etch: 15% hydrochloric acid
	Icon Dry: 100% ethyl alcohol
	Icon Infiltrant: TEGDMA, additives, and initiators
Scotchbond Universal Adhesive (3M ESPE)	10-MDP, dimethacrylate resins, HEMA, methacrylate-modified polyalkenoic acid copolymer, nanofiller, ethanol, water, initiators, silane
Filtek Supreme Ultra (3M ESPE)	Bis-GMA, UDMA, TEGDMA, Bis-EMA, silanated silica, silanated zirconia; photoinitiators
Abbreviations: 10-MDP, methacryloyloxydecyl dihydrogen phosphate; Bis-EMA, bisphenol A ethoxylated dimethacrylate; Bis-GMA, bisphenol glycidyl methacrylate; HEMA, 2-hydroxy ethylmethacrylate; TEGDMA, tetraethylene glycol dimethacrylate; UDMA, urethanedimethacrylate.	

resin infiltration session. Figure 3a-c illustrates the resin infiltration clinical procedure. Figure 4a is the clinical aspect of the dehydrated teeth immediately after the resin infiltration treatment and rubber dam removal. After 48 hours, the teeth had rehydrated (Figure 4b). At this point, we informed patient that additional at-home whitening might mask slightly better the residual yellow color from the anterior teeth but that he would have to apply the whitening gel from the lingual aspect of the teeth, as a thin transparent resin layer was now coating the labial surfaces. The patient agreed with the plan and started another whitening treatment sequence.

Two weeks after the resin infiltration session, we noticed that the four maxillary incisors had become lighter (Figure 5). The patient returned to the clinic three weeks later, at which point further lightening of teeth 7 and 8 (Figure 6) was even more evident. At this stage, we informed the patient that the resin composite restoration on tooth 8 would have to be replaced after a few weeks. The patient did not pursue orthodontic treatment for the misaligned anterior teeth due to financial constraints. An alternative plan, which included a more affordable solution, was presented to the patient including advantages and disadvantages. This alternative consisted of minimal enamel reduction and building the maxillary lateral incisors with direct resin composite to change the labial alignment of the anterior teeth.

A waxed-up model was shown to patient for the patient’s approval, which included the following: (1) labial realignment of the lateral incisors with direct resin composite; (2) increase of the length of the clinical crown of tooth 8 by adding resin composite to the incisal aspect while performing the replacement of the existing resin composite restoration; (3) a slight reduction of enamel (0.5 mm) on the distal and

incisal aspects of the labial surface of tooth 7; and (4) adjustment of the central portion of the incisal edge of tooth 9 with a Sof-Lex XT (3M ESPE, St Paul, MN, USA) disk to establish symmetry between the two central incisors from a frontal aspect.

The resin composite shade was selected using a Vita EasyShade Advance 4.0 spectrophotometer (VITA Zahnfabrik H. Rauter GmbH, & Co KG, Bad Säckingen, Germany). A direct mockup was performed with the selected resin composite shades (A1D and A1E, Filtek Supreme Plus, 3M ESPE). The existing restoration of tooth 8 was removed, and the peripheral enamel was roughened with a diamond bur. The enamel was etched with 35% phosphoric acid gel (Ultra-Etch, Ultradent Co) (Figure 7) for 15 seconds, rinsed with water for 10 seconds, and gently air-dried. Scotchbond Universal Adhesive (3M ESPE) was applied in a rubbing motion for 15 seconds (Figure 8) and gently air dried for 10-15 seconds³⁶ to evaporate water and ethanol, followed by light-curing from the labial and lingual surfaces for 20 seconds each using a QHL75 halogen curing light (Dentsply Caulk, Milford, DE, USA). A putty-consistency polyvinyl siloxane guide was prepared from the waxed-up model and used to build tooth 8 in layers starting with A1E (A1 enamel shade) from the lingual aspect, followed by A1D (A1 dentin shade) to replace missing dentin and A1E on the labial aspect. Each layer was irradiated with the same curing light for 40 seconds from the both facial and lingual aspects. Finishing and polishing were carried out with fine diamond points and Sof-Lex XT disks (3M ESPE). The enamel in the lateral incisors was roughened with a medium-grit Sof-Lex XT disc (3M ESPE), followed by etching with 35% phosphoric acid gel (Ultra-Etch, Ultradent Co) for 15 seconds and the application of Scotchbond Universal Adhesive (3M ESPE) exactly as described above. Filtek Supreme Ultra (3M ESPE) resin composite, A1 body shade (A1B), was applied and light-cured on tooth 7,

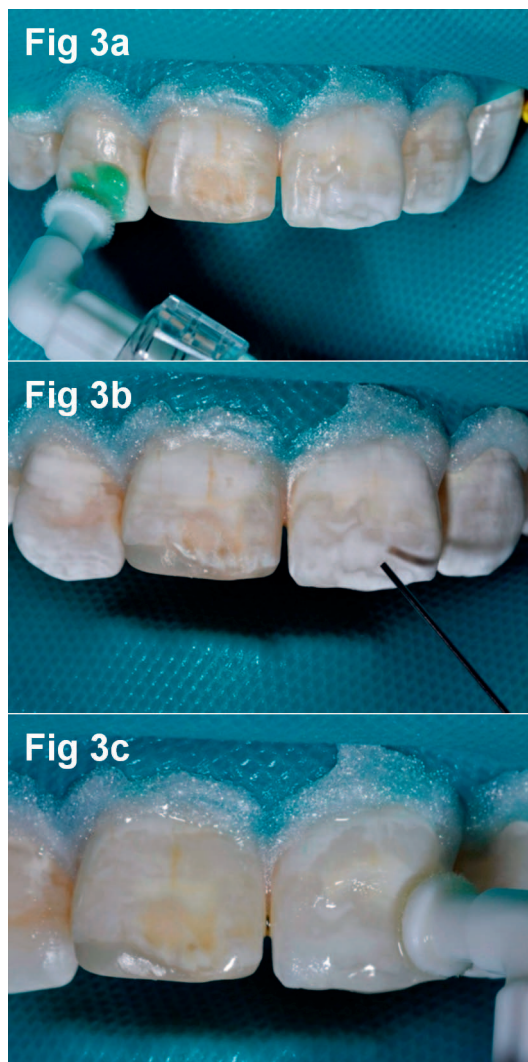


Figure 3. (a) Teeth were cleaned with a suspension of pumice and water and thoroughly washed with water. The rubber dam was sealed cervically with a light-cured resin barrier (OpalDam, Ultradent Co). A 15% HCl gel (Icon-Etch, DMG America) was applied to the white spot areas and left undisturbed for two minutes. The manufacturer provides an application tip in the respective kit. The gel was thoroughly rinsed with water for 30 seconds with the high-speed suction tip positioned as close as possible to the area being washed. The teeth were air-dried with water- and oil-free air for 15 seconds. (b) The tip of the Icon-Dry (DMG America) syringe was positioned over the etched areas. A generous amount of Icon-Dry, which is composed of ethanol, was applied to the white spot areas and left undisturbed for 30 seconds. The teeth were air-dried with water- and oil-free air for 15 seconds. (c) An abundant amount of Icon-Infiltrant (DMG America), which contains tetraethylene glycol dimethacrylate (TEGDMA) (Table 1) initiators and stabilizers, was applied and left undisturbed for three minutes. Excess material was gently air-blown for five seconds to prevent pooling around the incisal edge. Excess resin was removed with cotton pellets and dental floss. The resin was light-cured for 40 seconds in each tooth.



Figure 4. (a) Clinical aspect of the dehydrated teeth immediately after the resin infiltration procedure and rubber dam removal. (b) After 48 hours, the teeth had rehydrated. The patient was informed that additional at-home whitening might improve the residual yellow color from the front teeth.

whereas tooth 10 was restored with Filtek Supreme Ultra (3M ESPE), shade A1E. Finishing and polishing procedures were carried out as described above. The final clinical aspect is shown in Figure 9a,b. Figure 10 shows the nine-month postoperative view.

DISCUSSION

Haywood and Heymann introduced the nightguard vital bleaching technique in 1989³⁷ using a vacuum-formed custom-fitted soft plastic night guard filled with a 10% carbamide peroxide gel that was available over the counter. Several clinical studies have validated the effectiveness and safety of this bleaching modality.^{38,39} Other authors have advocated the use of higher concentrations of carbamide peroxide.⁴⁰ Although higher concentrations of peroxides may result in a faster rate of whitening than that of 10% carbamide peroxide, they all reach a similar final result.^{41,42} Higher concentrations, however, increase the incidence of tooth sensitivity.^{41,42} Overnight tray whitening with 10% carbamide peroxide results in whiter teeth and more durable results than whitening for a few hours during the daytime.^{43,44} The efficacy of at-home whitening to treat enamel discolorations caused by fluorosis or of



Figure 5. Clinical aspect two weeks after the resin infiltration procedure. Due to the presence of a coating of resin infiltrant on the labial surfaces, the patient applied the carbamide peroxide gel from the lingual aspect of the teeth for 2 weeks. No sensitivity was reported. Soft tissues did not present any alteration.

Figure 6. Patient returned to clinic after three weeks of further at-home whitening. The patient was very satisfied with the color of his teeth. We reminded the patient that a minimum interval of two weeks was necessary between the final whitening treatment and the restorative procedure.

idiopathic origin depends on the type of stain.³¹ At-home whitening usually lightens enamel brown stains, but it may not work so well for some white areas.⁴⁵⁻⁴⁷ At-home whitening may emphasize the whitish areas in cases of deeper white spots.

Recent clinical reports have recommended masking the enamel fluorosis stains by removing enamel with microabrasion or macroabrasion, followed by whitening.¹¹⁻¹⁶ Pontes and others¹¹ used an ultra-fine diamond bur (macroabrasion) to remove the outer layer of the fluorotic enamel, followed by eight applications of 10 seconds each of an enamel microabrasion compound, with water rinsing between applications. One week later, the enamel microabrasion technique was repeated, followed by three sessions of in-office whitening with 35% hydrogen peroxide. Although the final result was pleasant, it is questionable whether this was a conservative treatment as enamel was removed with a diamond bur and two separate sessions of enamel microabrasion. In another clinical report,¹² enamel fluorosis stains were treated using micro-

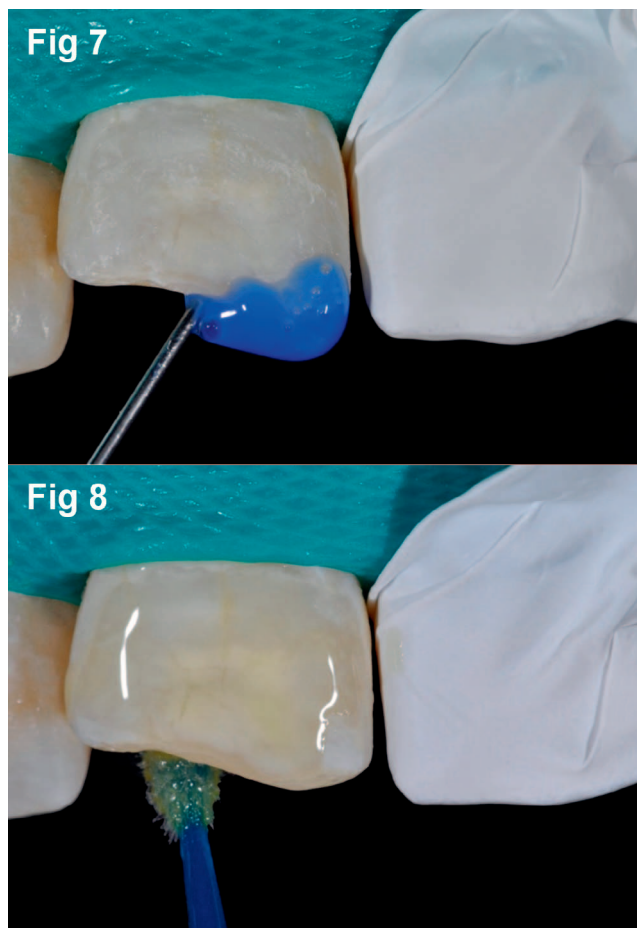


Figure 7. The resin composite shade was selected with a Vita EasyShade Advance 4.0 spectrophotometer (VITA Zahnfabrik H. Rauter GmbH, & Co) prior to inserting the rubber dam. After removal of the existing restoration of tooth 8, a long bevel was prepared on the enamel labial surface with a diamond bur. All prepared enamel was etched with 35% phosphoric acid gel for 15 seconds (Ultra-Etch, Ultradent Co), rinsed with water for 10 seconds, and gently air-dried.

Figure 8. Scotchbond Universal Adhesive (3M ESPE) was applied in a rubbing motion for 15 seconds and gently air-dried for 10-15 seconds to evaporate water and ethanol, followed by light curing from the labial and lingual surfaces for 20 seconds. Filtek Supreme Ultra (3M ESPE) was then inserted and light-cured, and the restorations were finished, as described in the text.

abrasion to eliminate the superficial enamel layer, followed by at-home bleaching and direct resin-based composite restorations. According to these authors, they started with enamel microabrasion and then prescribed a home bleaching technique “to better harmonize tooth color and produce whiter teeth.”

One clinical case¹⁶ started with two sessions of in-office whitening with three applications of 35% hydrogen peroxide in each session. The second phase of the treatment was enamel microabrasion with a paste of 12% HCl with silicon carbide that

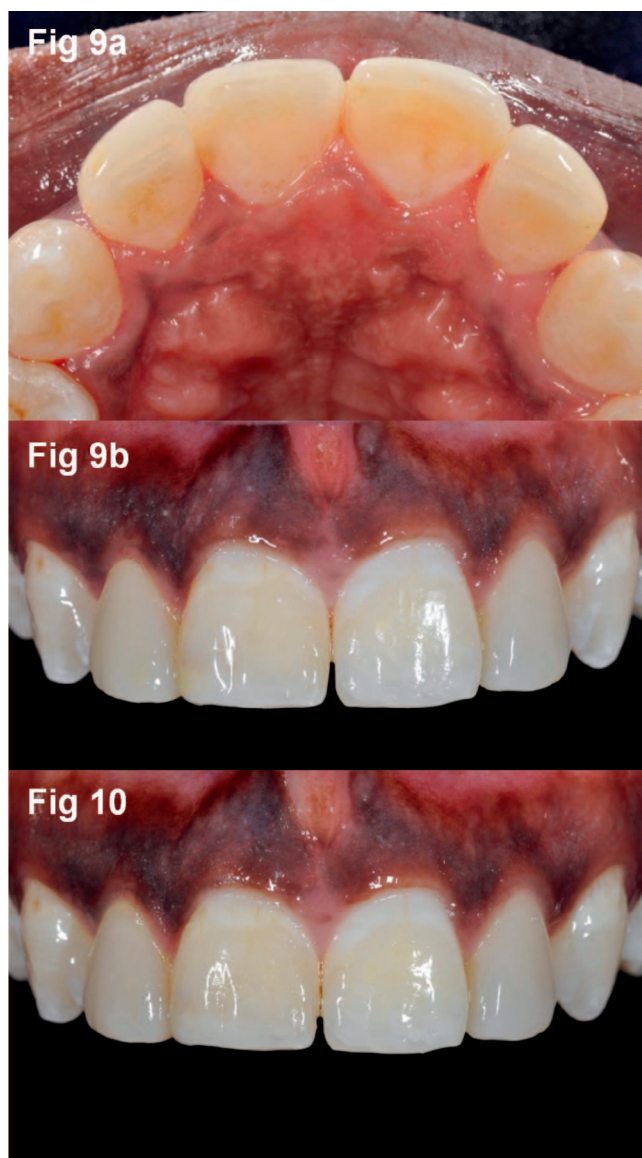


Figure 9. (a) Final clinical aspect, mirror lingual view. (b) Final clinical aspect, frontal view.

Figure 10. Clinical aspect after nine months.

was rubbed 12 consecutive times for 10 seconds each, with a 20-second water rinse between each application. However, the effect of the in-office whitening component of the treatment was not clear in this article, as no preoperative image was published. Additionally, two sessions of in-office whitening with 35% hydrogen peroxide (with three applications in each session) are more damaging to the pulp tissue than at-home whitening with 10% carbamide peroxide use in the clinical case described in the present article. For carbamide peroxide, the application of a 10% concentration from 1.5 to 8.0 hours onto enamel does not result in

significant toxic effects on both odontoblast-like cells and human dental pulp cells.⁴⁸⁻⁵⁰ When teeth were treated in-office with 35% hydrogen peroxide for three consecutive periods of 15 minutes each, 76.6% of lateral incisors, 53.3% of central incisors, and 30% of canines experience posttreatment sensitivity, with no discomfort reports for premolars.^{51,52} The thinner enamel and dentin of anterior teeth may be a strong contraindication for in-office whitening, especially in young patients, as pulp necrosis may occur.⁵³

For the resin infiltration technique, 15% HCl applied for 120 seconds removes $\approx 40 \mu\text{m}$ of enamel from the surface.²⁹ Using scanning electron microscopy, Sundfeld and others reported that Opalustre (Ultradent Co), which contains 6.6% HCl and silicon carbide, resulted in enamel loss ranging from 25 to 200 μm corresponding to one and 10 applications of the product for 60 seconds on each tooth, respectively.²⁰ Thus, the enamel surface loss is more pronounced with the enamel microabrasion technique compared with the resin infiltration technique, most likely because no pressure is applied with resin infiltration, which results in a more uniform enamel removal.

Taking into account that resin infiltration after enamel etching with HCl is a more conservative technique, it is the current treatment modality recommended for masking white spots.^{28,54} The clinical sequence that we currently prescribe for yellow or brown enamel fluorosis stains starts with at-home whitening with 10% carbamide peroxide in a custom-fitted tray. In the past, we used enamel microabrasion as the second step of the treatment sequence. Currently, we prescribe enamel resin infiltration in case residual white areas persist after the whitening treatment. In this clinical report, we recontoured teeth 7 and 10 with direct resin composite restorations. This option offers an excellent solution for misaligned teeth in the anterior region,^{55,56} especially in patients unwilling or unable to use orthodontic treatment. This treatment provides a very conservative approach compared with porcelain restorations, despite resin composite restorations being more susceptible to chipping and staining than ceramic restorations.^{55,56} Through the selective addition of resin composite, an illusion of alignment can be created, which, in many cases, provides a very satisfactory result to our patients. Limitations include the potential interference with a balanced occlusal relationship or when the periodontal condition is affected by changes of

the emergency profiles. A short-term nine-month postoperative evaluation (Figure 10) highlighted the patient's satisfaction with the treatment outcome, without any clinical signs of soft tissue inflammation caused by change in the profile of the maxillary lateral incisors.

CONCLUSION

Successful esthetic treatment of brown and white stains caused by enamel fluorosis is possible using at-home whitening with 10% carbamide peroxide in a custom-fitted tray to whiten the brown enamel areas, followed by resin infiltration to camouflage the white spots. Direct resin composite restorations may be used to augment the esthetic outcome in cases of replacement of existing restorations and create an illusion of alignment of slight tooth misalignments.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the University of Minnesota.

Conflict of Interest

Dr. Perdigao has received compensation for speaking at events sponsored by 3M ESPE. This relationship has been reviewed and managed by the University of Minnesota in accordance with its conflict of interest policies. All other authors certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service and/or company presented in this article.

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