Management of Fluorosis Using Macro- and Microabrasion

Water fluoridation is considered to be one of the significant public health measures of the 20th century. During tooth development, fluoride becomes incorporated into the enamel matrix as fluorapatite, making the enamel more resistant to acid attack by bacteria and subsequent tooth demineralization. Further, fluoride is protective of enamel for erupted teeth through an equilibrium of demineralization-remineralization during early caries formation. Through the use of water fluoridation there has been a significant decline in dental caries in the United States.

Despite the evidence that supports the benefits of fluoride in caries prevention, when higher than necessary levels of fluoride are present, enamel fluorosis can pose an aesthetic problem for some patients. This article will discuss enamel fluorosis, the aesthetic challenges it can present for certain patients, and a conservative aesthetic treatment modality for a patient who presented with mild to moderate fluorosis.

**ENAMEL FLUOROSIS**

Dental fluorosis is defined as hypomineralization of enamel resulting from excessive ingestion of fluoride during tooth development. It is characterized by diffuse opacities on the enamel surface. These are differentiated from other conditions by the characteristic bilaterally symmetric distribution of the enamel defects. The degree in which the enamel is affected is dependent upon the duration, timing, and intensity of the fluoride concentration. In its mild form, most commonly the teeth present with small white streaks and the enamel appears mottled (Figure 1). As the severity of the condition increases, black and brown stains develop. Moderate fluorosis will demonstrate white streaking with brownish staining (Figure 2). Severe fluorosis has the appearance of very dark brown staining and in some cases enamel surface defects (Figure 3).

For a small number of patients, the degree of fluorosis can be an aesthetic concern. The primary author has found over the years that in many cases, patients with very mild and mild to moderate fluorosis are not aware of the minor discoloration present and have no aesthetic concerns. In those cases where patients have moderate to severe fluorosis, the discoloration can be of aesthetic concern.

Fluorosis is a developmental phenomenon of the enamel that presents in both primary and permanent teeth. The origins of fluorosis are not completely understood; however, current research suggests that superfluous amounts of fluoride cause retention of amelogenin proteins in the developing tooth structure, thereby inhibiting enamel maturation. This interference results in porosities in the enamel at the time of tooth eruption. Specifically, recent animal and human studies indicate that the role of fluoride is likely due to its interaction with Ca²⁺ ions; excess F intake has been shown to indirectly reduce the amount of available Ca²⁺ ions, which in turn limits the number of calcium-dependent proteases available to remove enamel matrix proteins. This elimination of enamel matrix proteins is necessary for adequate enamel maturation.

Studies in United States school children have reported fluorosis as high as 50% to 60% in the 1980s and in the range of 40% to 48% through the 1990s and 2000s. Dental fluorosis has been evaluated by the US Department of Health and Human Services Centers for Disease Control and Prevention (CDC) and Prevention National Center of Health Statistics using the dental fluorosis classification described by Dean (Table 1). The findings were characterized as unaffected, questionable, very mild, mild, and moderate/severe. From the data reported for dental fluorosis for adolescents and adults from 1999 to 2002, the majority of persons examined were either unaffected or had questionable fluorosis (Table 2). For persons with a diagnosis of dental fluorosis, the rate that was mild was twice as prevalent for 16- to 19-year-olds when compared to 20- to 39-year-olds (6.7% versus 3.3%). Moderate/severe fluorosis also was higher for the 16- to 19-year-olds when compared to the 20- to 39 year olds (4.0% versus 1.8%).

**MULTIPLE SOURCES OF FLUORIDE**

Recommendations for fluoride supplements for children and adolescents have been endorsed by the ADA and the Academy of Pediatric Dentistry for many years. In 1994, a change in the recommendations for fluoride supplements based upon the child’s age was made in response to concerns about the increase in the prevalence of fluorosis. These changes are noted in Table 3.
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The majority of fluoride ingestion is typically thought to be through foods, beverages, and supplements.17-24 Water is the primary provider of fluoride. Recommendations for total dietary fluoride intake should be calculated based upon body weight using the formula of 0.05 mg/kg/day.25 An analysis of fluoride exposures and ingestion from multiple sources may be responsible for higher than optimal amounts of fluoride required for caries prevention.6,27 Even children in non-fluoridated areas benefit from foods and beverages processed in fluoridated areas.28 Sources of fluoride exposure and ingestion for children from dietary and nondietary sources include toothpastes,4,26-29 bottled soft drinks,22 infant formula,43-34 prescribed supplements,26,28,35-37 and fluoride mouthrinses and gels. Recent recommendations concerning use of reconstituted infant formula and a fluoridated dentifrice point to the recommendation that parents monitor their use.4

Heilmann and coworkers47 examined the fluoride content of 332 carbonated beverages in Iowa. Their results revealed that fluoride levels ranged from 0.02 to 1.28 parts per million (ppm) with a mean level of 0.72 ppm. Fluoride levels exceeded 0.60 ppm for 71% of the products. Further, from this study no generalization could be made about same company/same product results. Different sites of bottling production revealed different fluoride levels. Variation in fluoride content reflects the fact that bottling of beverages utilizes the local water supply.

It is difficult to monitor fluoride ingestion levels for children. When one considers that fluoride uptake can occur from the water supply, prescribed fluoride supplements, infant formula, dentifrices, fluoride mouthrinses, soft drinks, and reconstituted juices, among other sources, it is not surprising that the incidence of fluorosis in the United States has been increasing.34,47-41 Further, with the increase in new immigrants to the United States, fluorosis can be observed due to endemic fluorosis in other countries.47-50 For example, an unusual source of fluoride (not from foods or beverages) has been reported in Kenya and affects other east African nations as well. A 1986 epidemiological study of dental fluorosis in Kenya stated that in fact “dental fluorosis has been endemic to Eastern Africa and in particular Kenya for many years since the Great Rift Valley, which is known to have volcanic activity, passes through Kenya.” Although it is believed that the main source of fluoride is from the drinking water (in some rural parts of Kenya there is 2 ppm fluoride in the drinking water with the corresponding incidence of fluorosis being 100%), the volcanic soil of Kenya has been found to also have very high concentrations of fluoride. During the dry season in Kenya, the dust contains fluoride concentrations between 2,800 ppm and 5,600 ppm.51

MINIMALLY INVASIVE AESTHETIC TREATMENT OPTIONS FOR MILD TO MODERATE DENTAL FLUOROSIS

Concerns about the aesthetic appearance of teeth with fluorosis have led to proposed new guidelines for fluoridation of drinking water.52 The goal of fluoride supplements is to provide an optimal amount of fluoride to reduce the risk of dental caries. Recent recommendations reflect changes from the previous levels of fluoride to a more optimal level of fluoride of 0.7 mg/L.53 These changes reflect the fact that the ingestion of fluoride can come from multiple sources, resulting in a need for a lower level of fluoride in optimally fluoridated drinking water. The recommendations also take into account that fluoride supplements need only be considered for patients at moderate to high risk for dental caries and even then may be unnecessary if patients are receiving adequate fluoride from other sources. The majority of patients with fluorosis have mild and very mild conditions. Depending on the severity of fluorosis and its clinical appearance, restorative treatments can change the aesthetic appearance of teeth. Decisions for changes should be based upon the patient’s perception regarding whether there is a need for treatment. Fluorosis staining is within the enamel. In cases of mild fluorosis, the enamel discoloration is superficial. For moderate and severe fluorosis, the enamel staining and motting can penetrate to deeper enamel levels. For cases of mild fluorosis of aesthetic concern to the patient, vital bleaching can be successful in achieving a change that the patient desires.53 When the patient presents with mild-moderate fluorosis, there may be the need for a microabrasion or macro-abrasion technique.

Microabrasion refers to the use of a hydrochloric acid abrasive paste to remove the superficial enamel staining.54-57 In those cases where the fluorosis may be deeper in the superficial enamel but still mild in discoloration, a combined use of a fine abrasive diamond (50-75 μm grit size) in a high-speed handpiece with water spray provides for a more rapid removal of the discolored enamel and has been referred to as macroabrasion.59 When the superficial enamel is removed, the white speckled motting of enamel reveals a more yellow enamel color beneath the surface. For some patients, the loss of the white speckled enamel to yellow is not acceptable. For these cases, a combined microabrasion-macroabrasion with vital bleaching is an aesthetically acceptable treatment.59,60

CASE REPORT
A 20-year-old female patient was screened at the dental clinic for routine dental care. Her chief complaint was to remove and/or minimize the noticeable brown/yellow staining of her teeth. She wanted the least invasive and most cost effective treatment to change her smile. A review of her medical history and past dental history revealed no contraindications to dental treatment. In consideration of her age, the patient was not interested in treatment options that involved significant removal of tooth structure, such as porcelain or composite resin veneers which had previously been suggested to her from her previous dentist. The patient’s desire to change the appearance of her teeth in

<p>| Table 1. Criteria for Dean’s Fluorosis Index |
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<tr>
<td><strong>Normal</strong></td>
<td>The enamel represents the usual translucent semi-vitriform type of structure. The surface is smooth, glossy, and usually of a pale creamy white color.</td>
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<td><strong>Questionable</strong></td>
<td>The enamel discloses slight aberrations from the translucency of normal enamel, ranging from a few white flecks to occasional white spots. This classification is utilized in those instances where a definite diagnosis of the mildest form of fluorosis is not warranted and a classification of “normal” is not justified.</td>
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<td><strong>Very Mild</strong></td>
<td>Small, opaque, paper-white areas scattered irregularly over the tooth but not involving as much as 25% of the tooth surface. Frequently included in this classification are teeth showing no more than about one to 2 mm of white opacity at the tip of the summit of the cusps of the bicuspids or second molars.</td>
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<tr>
<td><strong>Mild</strong></td>
<td>The white opaque areas in the enamel of the teeth are more extensive but do not involve as much as 50% of the tooth.</td>
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<td><strong>Moderate</strong></td>
<td>All enamel surfaces of the teeth are affected, and the surfaces subject to attrition show wear. Brown stain is frequently a disfiguring feature.</td>
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<tr>
<td><strong>Severe</strong></td>
<td>Includes teeth formerly classified as “moderately severe and severe.” All enamel surfaces are affected and hypoplasia is so marked that the general form of the tooth may be affected. The major diagnostic sign of this classification is discrete or confluent pitting. Brown stains are widespread and teeth often present a corroded-like appearance.</td>
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Figure 4. Preoperative view of moderate fluorosis with patient desiring a color change and treatment.

continued on page xx
the aesthetic zone was to improve her smile and thereby her confidence. From the appearance of her teeth, a diagnosis of mild to moderate fluorosis staining (determined by using Dean’s Fluorosis Index) was present on the anterior and posterior teeth in the aesthetic zone (white mottled enamel hypomineralization), with the most significant staining occurring on the maxillary anterior teeth; teeth Nos. 8 and 9 contained dark brown streaks in the middle third of the facial surfaces (Figure 4).

A review of her past history and a complete dental examination revealed her country of origin as Kenya. She reported childhood friends as having the same discoloration of their teeth. As previously noted, Kenya is associated with endemic fluorosis. A treatment plan was presented to the patient that would fulfill her request for minimally invasive treatment which proposed macroabrasion/microabrasion of the superficial enamel staining. Upon completion of treatment, the tooth shade would be evaluated. If the patient desired further whitening, it was decided that at-home bleaching treatment would be provided.

**Phase 1: Enamel Abrasion Phase**

After receiving a routine oral prophylaxis, the maxillary teeth in the aesthetic zone (Nos. 4 to 13) were isolated with a dental dam to protect the gingival tissues when the acid microabrasion paste was to be used (Figure 5). A combined enamel macroabrasion/microabrasion technique was decided to be the most effective way to treat the hypomineralized defects of the maxillary first premolars, canines, lateral and central incisors. Enamel macroabrasion refers to the use of either medium or fine grit diamond abrasives or multifluted finishing burs with a high-speed handpiece with air-water spray to remove the superficial layer of the enamel.58,60 Enamel microabrasion refers to the use of a low concentration acid combined with an abrasive agent as a water soluble gel or paste that would be applied to the enamel surface with an extremely low-speed rotary handpiece pressure applicator for precise compression of the compound on the tooth surface so that splattering of the compound would be eliminated or minimized.

For this case, speed reduction was accomplished with an electric handpiece (Bien-Air Dental). Specialized torque converter speed reduction adapters can also be used. Use of the ultra-low-speed rotary application makes the procedure safer, easier, and quicker.60,61 The current formulation for microabrasion pastes is a low concentration hydrochloric acid (6.6%), silicon carbide abrasive, and silica gel as a binding agent. This paste in fact etches the enamel surface more aggressively than the use of phosphoric acid used for adhesive restorative dentistry.61

To accomplish macroabrasion/microabrasion, the facial surfaces of the teeth treated were lightly abraded with a flame-shaped fine grit (50 µm) diamond (8862F [Brasseler USA]) using a high-speed handpiece with air and water spray (Figure 6) to remove the superficial enamel dysmineralization layer to a depth of approximately 0.2 to 0.3 mm. After completion of the rotary macroabrasion, the microabrasion paste (Opalustre [Ultradent Products]) was applied to the facial surfaces of the treated maxillary teeth (Figure 7). Using a right angle latch type slow-speed handpiece running the motor at 1,000 rpm, a hybrid bristle brush-cup was applied to the microabrasion paste for 3 separate applications of 30 to 40 seconds each (Figure 8). Between each application the microabrasion paste was rinsed and dried from the tooth surfaces (Figure 9). This procedure was repeated 3 times (Figure 10). At the completion of the macroabrasion/microabrasion technique the etched enamel surfaces were polished with a cup-shaped porcelain polishing rubber abrasive (Jazz [SS White Burs]) to smooth and polish the enamel surface (Figure 11). To remineralize the acid attached enamel surface the teeth were treated with a topical sodium fluoride (NuPro [DENTSPLY International]) in a fluoride tray. Then an amorphous calcium phosphate paste (MI Paste Plus [GC America]) was rubbed onto the enamel surfaces with a gloved finger.

The dental dam was removed and the patient viewed the result of treatment.

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**Table 2. Dental Fluorosis in the United States 1999 to 2002 Based Upon Characteristics—CDC Data** (from cdc.gov/mmwr/PDF/ss/ss5403.pdf)

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<th>Age group</th>
<th>Unaffected</th>
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<th>Mild</th>
<th>Moderate/Severe</th>
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<td>6 to 11</td>
<td>59.8%</td>
<td>11.8%</td>
<td>19.8%</td>
<td>5.8%</td>
<td>2.7%</td>
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<td>12 to 15</td>
<td>51.5%</td>
<td>12.0%</td>
<td>25.3%</td>
<td>7.7%</td>
<td>3.6%</td>
</tr>
<tr>
<td>16 to 19</td>
<td>58.3%</td>
<td>10.2%</td>
<td>20.8%</td>
<td>6.7%</td>
<td>4.0%</td>
</tr>
<tr>
<td>20 to 39</td>
<td>74.9%</td>
<td>8.8%</td>
<td>11.1%</td>
<td>3.3%</td>
<td>1.8%</td>
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ment. She was pleased with the result from the immediate removal of the dark staining on her maxillary anterior teeth (Figure 12). The patient was informed that because of the dental dam isolation and the etching process of the microabrasion paste, evaluation of the final color and appearance of the teeth was to be done one week after treatment. In case there would be the need for postoperative tooth bleaching, maxillary and mandibular impressions were made for subsequent bleaching tray fabrication if indicated. The patient did not return until 3 weeks after treatment because of travel plans.

**Phase 2: Tray Bleaching**

The second phase of the treatment was initiated approximately 3 weeks later (the patient traveled back to Kenya in the interim). Using a Class I Sia Shade Guide (Vident) it was determined that the teeth treated were now predominantly an A2 shade. When removing the superficial brownish-white enamel demineralization hypomineralization, it is not unusual for the final shade of the teeth to be slightly yellower than the original appearance (whitish speckled discoloration due to fluorosis of the teeth). This was observed with this patient. The patient elected to whiten her teeth further using vital tray bleaching.

Fabricated bleaching trays were delivered to the patient along with a 15% carbamide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium nitrate and fluoride bleaching gel 15% carbam ide peroxide with potassium 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1. During tooth development fluoride becomes incorporated into which portion of the tooth making it more resistant to acid attack by bacteria?
   a. Periodontal ligament.
   b. Enamel.
   c. Dentin.
   d. Pulp.

2. Water fluoridation has been described as being a significant public health measure. Through the use of fluoridation there has been a significant decline in what oral pathology?
   a. Periodontal disease.
   b. Tooth crowding and misalignment.
   c. Tooth anomalies.
   d. Caries.

3. Dental fluorosis is defined as:
   a. Hypomineralization of enamel resulting from excessive ingestion of fluoride during tooth development.
   b. Hypersensitivity of enamel resulting from excessive ingestion of fluoride during tooth development.
   c. Hypomelanosis of dentin resulting from excessive ingestion of fluoride during tooth development.
   d. Hypersensitivity of dentin resulting from excessive ingestion of fluoride during tooth development.

4. According to the article, the degree in which enamel is affected by fluoride causing fluorosis is dependent on the all the following EXCEPT:
   a. Duration of exposure to fluoride.
   b. Timing of when fluoride is administered.
   c. Intensity of fluoride concentration.
   d. Person’s sex.

5. The clinical appearance of mild fluorosis is:
   a. Dark yellowing of the enamel.
   b. Dark brown and black stains oriented with horizontal streaks within the enamel.
   c. Small white streaks with enamel mottling.
   d. Bluish translucency to the enamel.

6. The clinical appearance of moderate fluorosis is:
   a. Dark yellowing of the enamel.
   b. Small translucent-bluish streaks on the enamel surface.
   c. White streaking with brownish staining of the enamel.
   d. Dark black streaks with white halos surrounding them within the enamel surface.

7. The clinical appearance of severe fluorosis is:
   a. Dark yellowing of the enamel.
   b. Very dark brown staining with some cases having enamel defects.
   c. Slight white streaking of the enamel.
   d. Bluish translucency to the enamel.

8. The majority of patients with enamel fluorosis have mild or very mild conditions. All conditions of mild and very mild enamel fluorosis require an esthetic restorative intervention.
   a. Both statements are true.
   b. The first statement is true and the second statement is false.
   c. The first statement is false and the second statement is true.
   d. Both statements are false.

9. In cases where the patient is concerned about the aesthetic appearance of mild-moderate fluorosis, conservative, minimally invasive treatment technique(s) that can be used is (are):
   b. Macroabrasion-microabrasion.
   c. Macroabrasion-microabrasion followed by vital bleaching.
   d. All are conservative, minimally invasive treatment techniques for mild-moderate fluorosis.

10. Microabrasion refers to the use of a hydrochloric acid abrasive paste to remove the superficial enamel staining. In those cases where the fluorosis may be deeper in the superficial enamel but still mild in discoloration, a combined use of a fine abrasive diamond (50- to 75-µm grit size) in a high-speed handpiece with water spray provides for a more rapid removal of the discolored enamel and has been referred to as macroabrasion.
    a. Both statements are true.
    b. The first statement is true and the second statement is false.
    c. The first statement is false and the second statement is true.
    d. Both statements are false.

11. Source(s) for fluoride exposure and ingestion for children from dietary and nondietary as reported in the dental literature include:
    a. Toothpaste.
    b. Carbonate soft drinks.
    c. Infant formula.
    d. All the above are sources for fluoride exposure and ingestion for children.

12. When evaluating children for ingestion of fluoride it is not uncommon for the dental professional to not include carbonated beverages as a potential source of fluoride. From the study by Hellman and coworkers their conclusion was that:
    a. Carbonated beverages are not a source for fluoride ingestion.
    b. Different sites of bottling production for carbonated beverages can reveal different fluoride levels.
    c. Variation in fluoride content reflects the fact that bottling of beverages utilizes the local water supply.
    d. B and C.

13. Because fluoride is ingested from multiple sources, there have been recent recommendations to lower the amount of fluoride in optimally fluoridated drinking water. These proposed changes are to lower the optimal level of fluoride to:
    a. 0.005 mg/L.
    b. 0.7 mg/L.
    c. 1.1 mg/L.
    d. 7.0 mg/L.

14. Microabrasion as an aesthetic treatment technique refers to the use of:
    a. Hydrochloric acid abrasive paste to remove superficial enamel staining.
    b. Hydrofluoric acid abrasive powders in an air abrasion device to remove superficial enamel staining.
    c. Mild fluoride rinse (1.1% sodium fluoride) to treat mottled enamel and dentin.
    d. Phosphoric acid gel to remove brown and black stains in the superficial enamel and root surfaces.

15. Macroabrasion refers to an aesthetic treatment technique that uses:
    a. 50-µm aluminum oxide particle in an air abrasion device to remove fluorosis discoloration.
    b. Abrasive pumice paste with phosphoric acid with a prophylaxis brush to remove fluorosis discoloration.
    c. Fine abrasive diamond (50- to 75-µm grit size) in a high-speed handpiece with water spray.
    d. A 10% sodium peroxide gel to whiten the enamel surfaces.

16. When treating fluorosis discoloration that has a white speckled mottling of enamel, it is not uncommon that once the superficial enamel discoloration has been removed the enamel has a more yellow appearance. In these cases a conservative treatment to achieve an acceptable aesthetic result as described in the article is:
    a. Full-coverage all-ceramic crowns.
    b. Combined microabrasion-macroabrasion with vital bleaching.
    c. No treatment is necessary the patient will have to live with the yellow enamel shade.
    d. Three quarter crown preparations then restored with zirconia veneers.
Test 142
for “Management of Fluorosis Using Macro- and Microabrasion”
beginning on page xx.

Please circle your answers below.

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Check one of the following:

☐ Enclosed is $40
☐ I am using a credit card.
☐ My information is provided below.

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