Clinical Evaluation of Enamel Microabrasion for the Aesthetic Management of Mild-to-Severe Dental Fluorosis

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ABSTRACT

Statement of the Problem: The clinical performance of enamel microabrasion alone for aesthetic management of dental fluorosis is debatable.

Purpose of the Study: This study aimed to compare the clinical efficacy of enamel microabrasion for the aesthetic management of mild-to-severe dental fluorosis.

Methods/Materials: A total of 154 fluorosed incisors and canines in 14 patients on the basis of the fluorosis were included; the teeth were classified as mild (group I, $n=53$), moderate (group II, $n=56$), and severe (group III, $n=45$). All teeth were treated with enamel microabrasion (Opalustre, Ultradent Products, South Jordan, UT, USA). "Improvement in appearance," "changes in brown stains," "changes in opaque white areas," and "requirement for further treatments" were assessed by using visual scale systems. The data were analyzed using nonparametric tests ($\alpha=0.05$).

Results: The "improvement in appearance" score was the worst for group III ($p<0.05$), whereas the "changes in opaque white areas" score was the best for group I ($p<0.05$). Groups II and III did not differ with respect to "changes in brown stains." The proportion of patients who needed further treatment was the highest in Group III ($p<0.05$).

Conclusions: The severity of fluorosis affected the clinical performance of enamel microabrasion except for its performance of removing brown stains. Increase in fluorosis severity led to increased requirements for further treatments.

CLINICAL SIGNIFICANCE

The clinical performance of enamel microabrasion is affected by the severity of dental fluorosis, except for its performance of removing brown stains. Even though its performance of improving appearance decreases with the increase in severity of fluorosis, it may not only remove the fluorosis stains but also may increase the success of additional subsequent treatment.

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INTRODUCTION

Dental fluorosis, which is a dysmineralization of enamel because of the effects of excessive fluoride intake, results in opaque white areas or discolorations ranging from yellow to dark brown, together with porosities on the enamel surface.[1] Fluorosis staining is commonly considered an aesthetic problem because of the psychological impact of unaesthetic maxillary or mandibular anterior teeth.[2] In the past, dental fluorosis cases were generally encountered in settlements with a high concentration of fluoride in the drinking water. However, implementation of effective fluoride programs for prevention of dental caries in many countries has led to a global increase in the prevalence of dental fluorosis. Especially, mild fluorosis cases have been seen more frequently in the populations using fluoride supplements.[3,4] Thus, aesthetic management of fluorosis

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stains has progressed from being a local challenge to a commonly encountered problem.

On the other hand, dental fluorosis is not the only reason for enamel dysmineralization. Opaque white areas or discolorations, even with porosities, might result from some disturbances in the mineralization process, and they might be confused with fluorosis stains.[5] Their differentiation can be done according to their locations where stains caused by dental fluorosis are generally encountered on all teeth mineralizing at the same time, and fluorosis stains are also characterized as non-discrete opaque conditions of enamel.[6] The determination of the etiology of such kind of demineralization is important because considering the etiology of all lesions as dental fluorosis will give rise to antifluoridationist views that may suggest not to use the fluoride for preventive purposes.

Fluorosis stains are generally treated in the light of three concepts: removing the stained enamel, bleaching the stained tooth, and/or covering the stained area.[7] Compatible with these concepts, enamel microabrasion, vital bleaching, combination of both methods, and direct or indirect restorations for treating fluorosed teeth have been reported in the literature.[8–10]

Enamel microabrasion removes the porous subsurface enamel layer as well as the entrapped stains by using a gel that includes hydrochloric acid. It is the first treatment option for the management of fluorosed teeth because it removes the opaque white areas and brown stains, and also smoothens surface irregularities by providing a more regular and lustrous enamel surface.[11] The clinical performance of enamel microabrasion—wherein applying a mixture of hydrochloric acid was proposed to remove intrinsic enamel stains—to eliminate the stains on the enamel has been studied since 1986.[12] However, its clinical performance has been debated in the literature.[7,9,13–16] Some authors have reported high patient satisfaction after they had used this technique alone and defined this technique as an efficient, safe, and simple method for removing fluorosis stains.[7,13,14] On the other hand, some studies used enamel microabrasion with further treatments, such as vital bleaching and composite restorations to correct tooth color, because the results were not satisfactory when enamel microabrasion alone was used.[9,15,16]

One of the reasons for the debatable clinical performance of enamel microabrasion may be attributed to the severity of the fluorosis stains on which they were applied. This microabrasive method only removes the outer enamel surface (10–200 μm); however, when the severity of fluorosis increases, the width and depth of stains and opaque areas increases, and it probably becomes difficult to eliminate deep, intrinsic stains and porosities.[11,16] Although this technique has been used for nearly 30 years, some concerns still exist related to its performance on fluorosed teeth of different severity.

The aim of this study was to evaluate the effect of severity of fluorosis on the clinical performance of enamel microabrasion. The null hypothesis tested was that the severity of fluorosis did not affect the clinical performance of enamel microabrasion in the aesthetic management of fluorosed teeth.

MATERIALS AND METHODS

Study Design

This study was designed as a prospective clinical trial. All teeth included in this trial were subjected to enamel microabrasion. The study groups were assigned according to the severity of fluorosis: (1) mildly fluorosed teeth (group I), (2) moderately fluorosed teeth (group II), and (3) severely fluorosed teeth (group III) (Figure 1).

Sample Size and Power Analysis

The PASS Sample Size Software (NCSS, LLC, Kaysville, UT, USA) was used to determine the sample size. At least 45 teeth from each group were required to determine the $f = 0.50$ effect difference between study groups with at least 80% power and $\alpha = 0.05$ type I error and $\beta = 0.05$ type II error rates.

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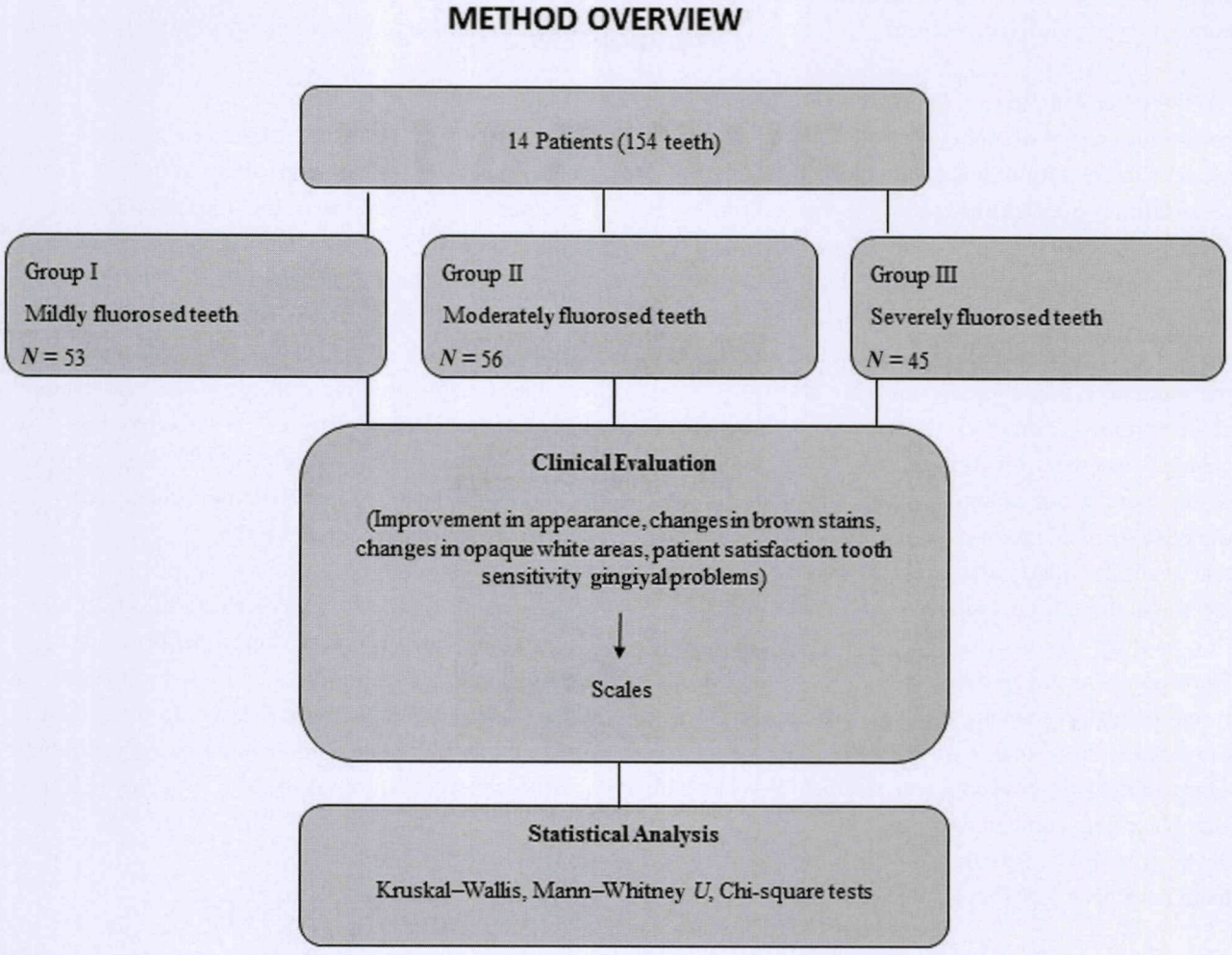

FIGURE 1. Method overview of the clinical study.

Patient Selection

In this clinical trial, a total of 154 fluorosed teeth of 14 patients (4 male and 10 female patients) with a mean age of 24 (range 19–38 years) were included. Maxillary and mandibular incisors and canines of these patients were evaluated to assess the severity of fluorosis by using the Dean's Fluorosis Index (DFI). According to severity of fluorosis, the teeth were classified as mild (group I, 53 teeth), moderate (group II, 56), and severe (group III, 45). Normal and questionable teeth according to DFI were not included the study. Very mildly, fluorosed teeth were assigned into the mild group (group I). The study protocol was approved by the committee for medical ethics of the Cumhuriyet University, Sivas, Turkey. An informed consent form was signed by each patient after the aim and procedures of the clinical trial had been explained at the beginning of the study. The inclusion and exclusion criteria were as follows:

Inclusion criteria:

- Have at least eight fluorosed incisors and canines with scores of 1 to 4, according to the DFI
- Have no caries or restoration on the teeth to be treated
- Ability to return for periodic follow-up

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Exclusion criteria:

- Hypersensitive teeth
- Smoking habit
- Poor general or dental health
- Any fixed orthodontic appliances
- Previous use of bleaching agents
- Pregnant or lactating
- A history of allergies to bleaching agents
- Age of less than 18 years
- Symptoms of pulpitis

Enamel Microabrasion

All teeth with fluorosis stains visible during smiling, laughing, or speaking were treated, although just maxillary and mandibular incisors and canines were included in the current study. Before treatment, the teeth were cleaned with pumice, and initial photographs were taken. For isolation from saliva, a rubber dam was used. In order to provide penetration of microabrasion slurry into enamel, a fine-grit, water-cooled diamond bur was used for 5 to 10 s onto the stained and opaque white areas. An approximately 1-mm thick layer of slurry, including 6.6% hydrochloric acid and silicone carbide microparticles (Opalustre, Ultradent Products, Inc., South Jordan, UT, USA), was applied onto the fluorotic areas. These surfaces were microabraded using rubber prophy cups (OpalCups™, Ultradent Products, Inc.) attached to a gear-reduction contra-angle handpiece with a slight pressure for 60 s. The teeth were rinsed with water spray. The slurry was reapplied five times for mild lesions and 10 times for moderate and severe lesions during the same session.[17] Abrasive discs (coarse/medium, fine, and extra fine, OptiDics, Kerr, Bioggio, Switzerland) were used to polish teeth and fluoride gel (Sultan Topex Neutral Fluoride gel, Englewood, NJ, USA) was applied for 5 min. Photographs were taken 24 h after treatment.

Evaluation

Photographs were taken using a digital camera (Coolpix 8800, Nikon, Tokyo, Japan) at the same distance in a dark room under controlled lighting conditions both before and 24 h after the enamel microabrasion (Figures 2–4). The same camera, light source, and exposure were used. The post-treatment images of all teeth were scored in comparison with the corresponding pretreatment images for "improvement in appearance," "changes in brown stains," and "changes in opaque white areas" by using visual analog scales (VASs) ranging from 1 to 7 by two calibrated examiners who did not perform the enamel microabrasion (Table 1). The VAS ranging from 1 to 7 was also used to evaluate "patient satisfaction," "tooth sensitivity," and "gingival problems" (Table 1). "Requirements for further treatments" for each tooth was evaluated using a three-point scale (Table 1). Five pairs of post-treatment/pretreatment images were randomly selected for testing intraexaminer and interexaminer reliability.

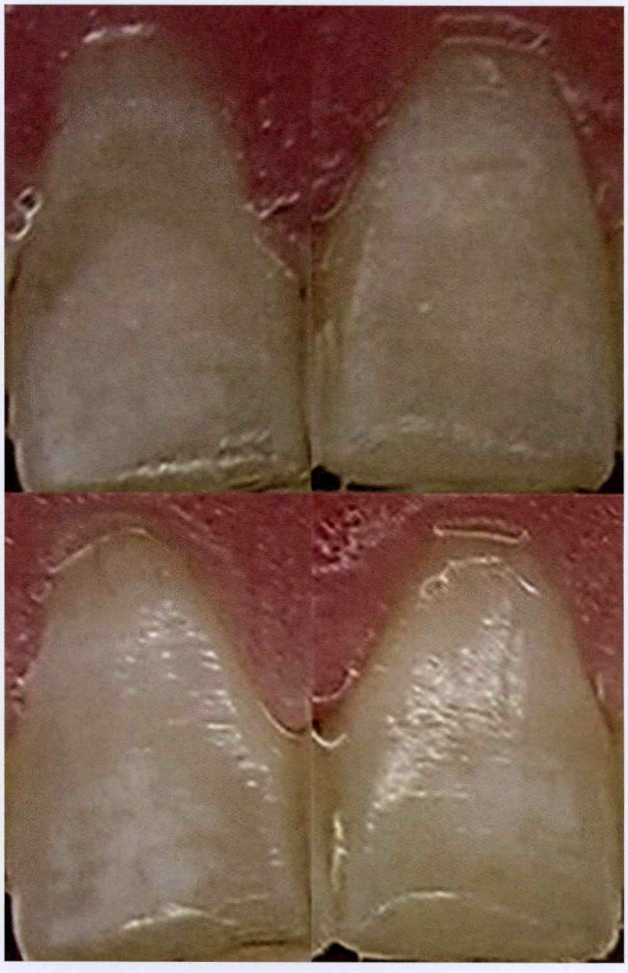

FIGURE 2. Pretreatment and post-treatment views of midly fluorosed teeth.

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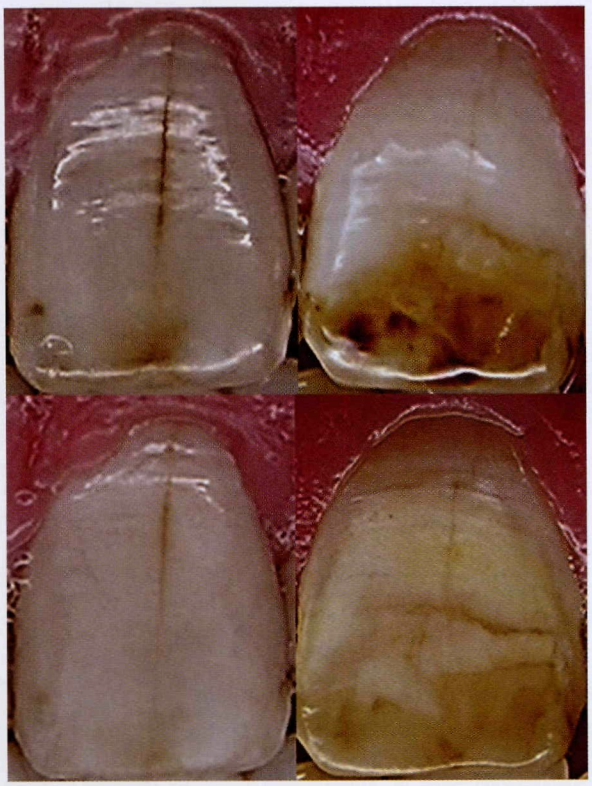

FIGURE 3. Pretreatment and post-treatment views of moderately fluorosed teeth.

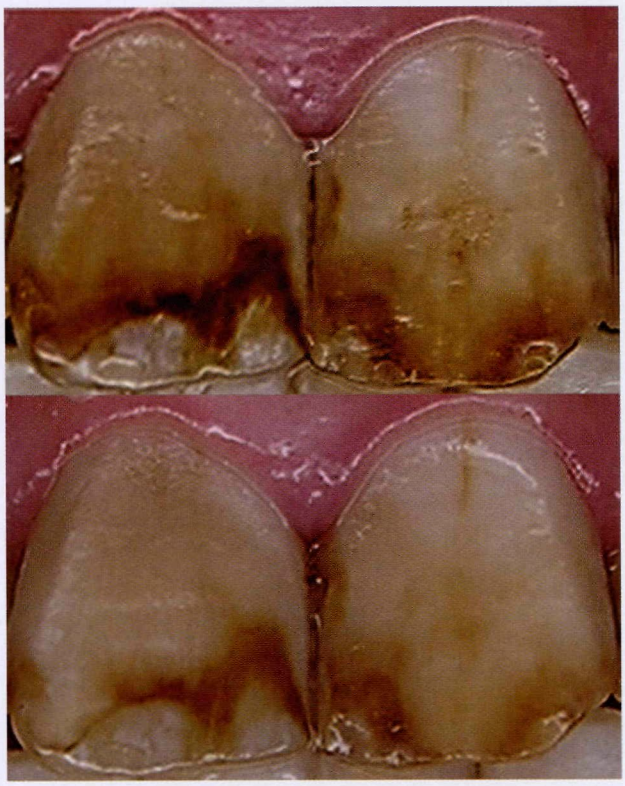

FIGURE 4. Pretreatment and post-treatment views of severely fluorosed teeth.

Statistical Analysis

The statistical analysis was processed with the SPSS 20 software system (IBM Corporation, New York, NY, USA). In order to assess the fact that the likelihood of the given data set came from a normal distribution, the Shapiro–Wilk test was used. The data could not be assumed to be distributed normally; thus, median and interquartile range (IQR) values were used for descriptive statistics. Differences in the "improvement in appearance" and "changes in brown stains" scores for groups I, II, and III were analyzed with the Kruskal–Wallis test. The Mann–Whitney *U* test was used for the binary comparisons. Differences in the "changes in brown stains" scores for groups II and III were tested with the Mann–Whitney *U* test.

The Chi-square test was used to analyze differences between "requirements for further treatments" scores for groups I, II, and III. The *Z* test with Bonferroni adjustment was used to compare column proportions.

The Mann–Whitney *U* test was used to analyze differences between the scores of "changes in brown stains" and "changes in opaque white areas" criteria in groups II and III. For all tests, the probability level for statistical significance was at $\alpha = 0.05$.

RESULTS

The test of intraexaminer and interexaminer agreement resulted in a Cohen's Kappa statistic of 0.78 and 0.75, respectively. The mean (standard deviation) and median (IQR) scores of study groups are given for "improvement in appearance," "changes in brown stains," and "changes in opaque white areas" in Table 2 and detailed statistical results are given in Tables 3 and 4. The "improvement in appearance" score was significantly lower for group III than for groups I and II ($p = 0.003$ and 0.025, respectively). Groups II and III did not differ in "changes in brown stains." Group I showed a statistically higher mean score for "changes in opaque

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TABLE 1. Visual scale sytems

Improvement in appearance						
No improvement		**Slight**		**Moderate**		**Exceptional Improvement**
1	2	3	4	5	6	7
"Changes in brown stains" or "Changes in opaque white areas"						
Not at all		**Slight**		**Moderate**		**Totally removed/ disappeared**
1	2	3	4	5	6	7
"Tooth sensitivity" or "Gingival problems"						
No side effects		**Slight**		**Moderate**		**Severe**
1	2	3	4	5	6	7
"Patient satisfaction"						
Non-satisfied		**Slight**		**Moderate**		**Very satisfied**
1	2	3	4	5	6	7
"Requirements for further treatments"						
No need	**May need**	**Need**				
0	1	2				

TABLE 2. Descriptive values of study groups

	Group I			**Group II**			**Group III**		
	Min.–Max.	**Median (IQR)**	**Mean (SD)**	**Min.–Max.**	**Median (IQR)**	**Mean (SD)**	**Min.–Max.**	**Median (IQR)**	**Mean (SD)**
Improvement in appearance	4.0–7.0	6.0 (1.0)	5.7 (0.7)	1.0–6.0	4.0 (2.25)	4.1(1.5)	1.0–5.0	3.0 (3.0)	3.3 (1.4)
Changes in opaque white areas	4.0–7.0	5.0 (2.0)	5.8 (1.1)	2.0–6.0	3.0 (1.0)	3.4 (0.9)	2.0–5.0	3.0 (2.0)	3.12 (0.9)
Changes in brown stains	—	—	—	1.0–7.0	5.0 (3.5)	4.9 (1.8)	1.0–6.0	4.0 (2.0)	4.1 (1.3)

IQR; interquartile range, SD; standard deviation.

white areas" than groups II and III ($p = 0.004$ and 0.005, respectively). Groups II and III revealed higher scores in "changes in brown stains" as compared with "changes in opaque white areas" ($p = 0.017$ and $p = 0.041$, respectively).

There were significant differences between study groups regarding "requirements for further treatments" ($p = 0.001$). The proportion of patients who did not need further treatment was significantly lower in group III than in groups I and II ($p < 0.05$). The patients who may need further treatment was the highest in group II ($p < 0.05$), with no differences found between groups I and III. The proportion of patients who needed further treatment was significantly higher in group III than in groups I and II, and higher in group II as compared with group I ($p < 0.05$).

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TABLE 3. Statistical results regarding "improvement in appearance", "changes in opaque white areas" and "changes in brown stains"

	Group I versus II		Group I versus III		Group II versus III	
	Z	*p*	*Z*	*p*	*Z*	*p*
Improvement in appearance	2.490	**0.011**	2.927	**0.003**	2.238	**0.025**
Changes in brown stains	—	—	—	—	1.664	0.096
Changes in opaque white areas	2.914	**0.004**	2.838	**0.005**	1.310	0.190

Bold values are *p* values which are <0.05. This means statistically significant difference between groups.

TABLE 4. Percentage of teeth requiring further treatment

Requirements for further treatments	Mild fluorosis	Moderate fluorosis	Severe fluorosis
No need	63.5[a*]	33[b]	12.1[c]
May need	21.3[a]	35[b]	27.3[a]
Need	15.2[a]	32[b]	60.6[c]

*Different letters in the rows indicate the differences between study groups.

Three of 15 patients had mild or moderate tooth sensitivity (2–4), and 5 of 15 patients revealed mild gingival problems (1–3). The mean patients' satisfaction score was moderate after this treatment (mean 4.3).

DISCUSSION

Even though it was a subjective technique, visual scales were used to evaluate "improvement in appearance," "changes in brown stains," and "changes in opaque white areas," in lieu of any dental spectrophotometer evaluation, in the current study, similar to the study by Price and colleagues,[18] and Loguercio and colleagues[19] The reason for using a subjective technique relies on the clinical appearance of fluorosed teeth. Shade evaluation by spectrophotometers depends on the CIE L*a*b* color difference, and it is calculated using the formula in which the squared differences among the L*, a*, and b* measures are summed up.[20] Although it is a quantitative technique, a detectable color change ($\Delta E > 3.7$) in fluorotic areas is not enough in fluorosed teeth, as the primary aims are to remove all stains and improve the mottled surface.

The enamel microabrasion procedure was repeated five times for mild lesions and 10 times for moderate and severe lesions in this study. Different repetition amounts for this procedure depending on the severity of fluorosis was preferred in accordance with the studies on the application duration of enamel microabrasion gels. Train and colleagues[17] recommended different application duration for mildly (5 times), and moderately and severely (10 times) fluorosed teeth, similar to our study. In addition, the amount of enamel removal capacity of this technique was considered before the study, so as not to thin enamel too much, which may lead to postoperative sensitivity. In a study by Sundfeld and colleagues,[11] application of Opalustre to enamel 5 to 10 times of 60 min each leads to enamel removal of 10 to 200 μm, and these amounts were considered as acceptable for clinical conditions.

Enamel microabrasion is the first treatment option in patients who prefer the least invasive approach. In the literature, a number of articles have evaluated the performance of enamel microabrasion on fluorosed teeth.[7,9,10,14,15,21,22] Some of them achieved improved appearance in mild and moderate cases with enamel microabrasion and considered this technique an effective and minimally invasive procedure.[7,14] On the other hand, some authors used enamel microabrasion with vital bleaching to aesthetically manage fluorosed teeth.[9,21,22] They revealed that enamel microabrasion was a good alternative for removing opaque white areas and brown stains, whereas vital bleaching can provide a uniform tooth shade. In addition, teeth exposed to enamel microabrasion can acquire a yellowish or non-homogenous color after treatment,

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and in such cases, vital bleaching may produce a lighter and more homogenous tooth structure.[11] In some severely fluorosed cases, further improvement in aesthetics was achieved with composite veneers after microabrasion and enamel microabrasion.[10,15]

Differing performance of enamel microabrasion on fluorosed teeth may be attributed to the severity of fluorosis. For mild fluorosis, the enamel staining or opacity is superficial. In cases of moderate and severe fluorosis, the enamel staining and opacities can penetrate to deeper enamel levels. Thus, when the patient presents with moderate-to-severe fluorosis, it may become difficult to remove all the mottled areas by using the enamel microabrasion technique. Decisions for treatment should be based on clinical effectiveness and the patient's perception regarding the need for treatment. For this reason, clinicians should basically have information as to whether a technique is effective in all fluorosis cases, and if not, why a certain technique is used in severe cases. However, there is limited information regarding the effect of severity of fluorosis on the basic treatments used for this purpose, such as enamel microabrasion, vital bleaching, and composite veneers. Train and colleagues[17] compared, *in vivo*, the effectiveness of microabrasion on fluorosed teeth of differing severity. According to this article, despite aesthetic improvement in all groups, this technique was advised to be used as a definitive treatment for only mildly fluorosed teeth. However, the article did not evaluate the need for further treatment for each group.

Similar to the study of Train and colleagues,[17] our study showed that enamel microabrasion remarkably improved the appearance of mildly fluorosed teeth, moderately improved the appearance of moderately fluorosed teeth, but slightly improved the appearance of severely fluorosed teeth. Change in opaque white areas was moderate in the mildly fluorosed teeth and statistically better than the other groups in which the change was only slight. Enamel microabrasion moderately removed the brown stains on moderately and severely fluorosed teeth. This technique yielded more improvement in brown stains than in opaque white areas. The reason for this result may be attributed to the origin of brown stains. They are formed by the discoloration of dysmineralized surface and subsurface areas from the external sources; in other words, the origin of discoloration is external. Thus, the depth of brown stains may probably be associated with the penetration capacity of staining agents.

The need for further treatment was the highest in the severely affected teeth, whereas a considerably higher amount did not require any further treatment among teeth with mild fluorosis. From this point of view, enamel microabrasion seems to be a good alternative for aesthetic improvement of mildly fluorosed teeth but can be an inefficient and redundant option for moderate and severe fluorosis. Nevertheless, removal of opaque white areas and brown stains with help of enamel microabrasion may increase the success of further treatment. For instance, it may shorten the duration of subsequent vital bleaching, which may reduce the cost and adverse effects of this treatment or may provide more aesthetic results using more conservative preparation when a composite resin is required after microabrasion.

Regarding our results, the null hypothesis was accepted, except for the performance of enamel microabrasion for removing brown stains. The mildly fluorosed teeth showed more improvement in appearance after enamel microabrasion. In severely stained teeth, the need for further treatment was the greatest. Nevertheless, when benefits of the enamel microabrasion, including removal of opaque white areas and brown stains, were considered, it should be the first option in the management of fluorosis stains.

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