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Comparison of Enamel Microabrasion with a Combined Approach to the Esthetic Management of Fluorosed Teeth

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Clinical Relevance

Although enamel microabrasion improves the appearance of teeth with brown stains or white opaque areas, the combination of enamel microabrasion and in-office bleaching results in better esthetics.

SUMMARY

Objective: To compare *in vivo* the efficacy of enamel microabrasion alone or in combination with vital tooth bleaching for the management of tooth discoloration caused by fluorosis.

Methods: A total of 118 maxillary and mandibular fluorosed incisors and canines in 10 patients, scored from 1 to 7 according to the Tooth Surface Index of Fluorosis, were included in this study. All of the teeth were initially treated with enamel microabrasion (Opalustre, Ultradent Products Inc, South Jordan, UT, USA), and after 24 hours, an in-office bleaching technique (Opalescence Boost, Ultradent) was utilized (n=118). Standardized images of the teeth were taken using a digital camera prior to treatment and 24 hours after the enamel microabrasion and after the in-office bleaching therapy. The study groups were assigned according to evaluation time: a) after enamel microabrasion (Group 1) and b) after the combined approach (enamel microabrasion and in-office bleaching) (Group 2). Two calibrated and blinded examiners scored Group 1 and Group 2 images by comparing each with baseline images for "improvement in appearance," "changes in brown stains," and "changes in white opaque areas" using the visual analogue scales (VAS) that range from 1 to 7.

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"Patient satisfaction," "tooth sensitivity," and "gingival problems" were also recorded. The data were analyzed using two sample paired Wilcoxon signed-rank, Kruskal-Wallis, and Mann-Whitney *U*-tests (α=0.05).

Results: The combined therapy revealed significantly higher scores than the enamel microabrasion procedure in terms of all of the evaluated criteria ($p<0.001$). Enamel microabrasion provoked less tooth sensitivity but led to lower patient satisfaction scores than the combined therapy ($p<0.001$); however, in terms of gingival problems, no differences were found between both groups.

Conclusion: The combined therapy, including enamel microabrasion and in-office bleaching, was more effective than enamel microabrasion alone in the esthetic management of fluorosed teeth.

INTRODUCTION

Dental fluorosis is a form of enamel dysplasia caused by excessive fluoride intake during enamel formation. Teeth affected by fluorosis have white opaque areas or discoloration ranging from yellow to dark brown, together with porosity on the enamel surface. The white opaque areas and stains caused by fluorosis lead to mild to severe esthetic problems, and studies[1,2] conducted on the health-related quality of lives and the psychosocial aspects of fluorotic staining revealed that esthetic treatment is needed in cases of dental fluorosis.

In the past, fluorosed teeth were restored with direct or indirect restorative techniques. Although satisfactory results have been obtained with veneers or crowns, the main problem with these invasive procedures is that most patients referred to clinics to treat fluorosis are young adults, and the use of invasive procedures results in excessive loss of tooth structure, thereby increasing the likelihood of tooth destruction at an early age. Thus, there has been a tendency toward conservative approaches, even in severely fluorosed teeth.[3-5]

Two primary conservative approaches have been proposed to remove the white opaque areas and stains caused by dental fluorosis: the microabrasive method[6,7] and vital bleaching,[8] along with a combination of both methods.[9] Enamel microabrasion removes the porous subsurface enamel layer, including entrapped stains, when a gel that includes hydrochloride acid (HCl) is used. It is the first treatment option in cases involving teeth that have white opaque areas, staining, and surface irregularity because it not only removes the white opaque areas and brown stains but it also smoothens surface irregularities and results in a more regular, lustrous enamel surface.[10] However, depending on the concentration of HCl, the type of abrasive contained in the gel, and the application duration of the gel, the microabrasive method only removes the outer enamel surface (10 to 200 μm); it cannot eliminate deep, intrinsic stains and porosities.[10,11] Some authors reported a darker or yellowish color on teeth subjected to enamel microabrasion. This was attributed to the fact that teeth become thinner and the underlying dentin changes color after treatment.[10] In addition, some studies[12,13] claim that this technique is more successful in removing brown stains than white opaque areas.

Vital bleaching techniques are also used in the treatment of fluorosed teeth as a way to change the perception of the white opaque areas and stains. Vital tooth bleaching can be performed at home or in the dental office. In-office bleaching agents contain high concentrations of carbamide peroxide (35%-37%) or hydrogen peroxide (30%-35%), while at-home agents consist of low concentrations of both peroxides and are employed in a custom tray under the supervision of a dentist.[14] These techniques remove brown stains and they change the perception of white opaque areas by lightening the adjacent enamel surface, but they cannot eliminate irregularities on the tooth's surface.[15] Thus, a combination of enamel microabrasion and vital bleaching is generally preferred to both reduce the contrast between the white opaque areas and the surrounding tooth surface and to eliminate surface irregularities.[9,15]

Performance of a combination of enamel microabrasion and vital bleaching techniques to esthetically manage fluorosed teeth has been studied since 1986,[16] wherein applying a mixture of hydrochloric acid was proposed to remove intrinsic enamel stains. All of the proposed techniques improved the esthetics to some degree, depending on the type of technique used or the severity of the fluorosis.[6,7,9,12,17] However, most of the articles on this topic are case reports, and many questions exist related to concerns, such as the following: 1) Are all methods effective in the esthetic management of fluorosed teeth; 2) Which method is the best: enamel microabrasion, vital bleaching, or a combination of both methods; 3) Do all methods eliminate white opaque areas and brown stains; and 4) Do all methods eliminate the mottled surface of teeth and improve the appearance perfectly?

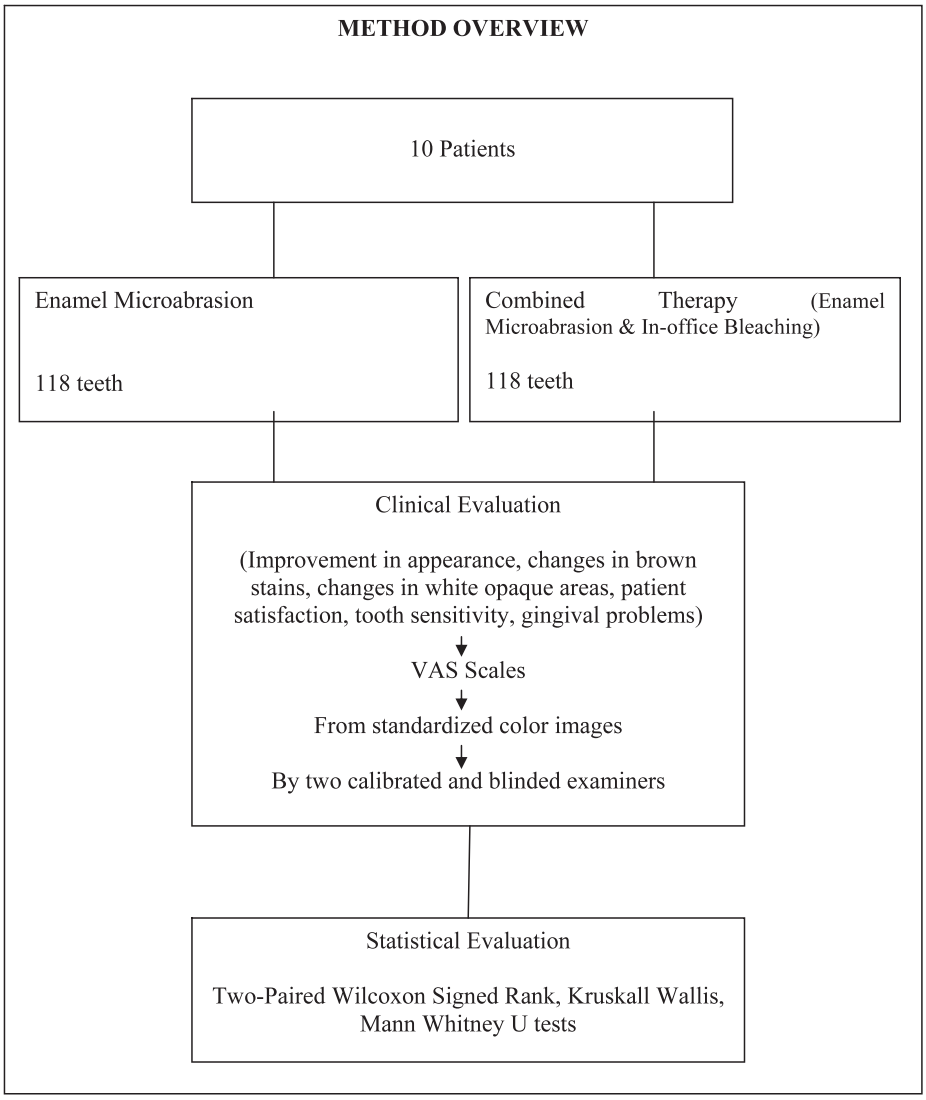

Figure 1. *Method overview of the clinical study.*

The aim of this study was to compare *in vivo* the efficacy of enamel microabrasion alone or in combination with vital tooth bleaching for the management of tooth discoloration caused by fluorosis using clinical photographs and a visual analogue scale (VAS). The null hypothesis tested was that there were no differences between the clinical performance of enamel microabrasion and the combined approach in the esthetic management of fluorosed teeth.

MATERIALS AND METHODS

Study Design

All patients were subjected to both enamel microabrasion and in-office bleaching therapy. The study groups were assigned according to evaluation time, as follows: 1) after enamel microabrasion (Group 1) and 2) after the combined approach (enamel microabrasion and in-office bleaching) (Group 2) (Figure 1).

Sample Size and Power Analysis

The G*Power (G*Power Ver 3.0.10, Franz Faul, Üniversität Kiel, Kiel, Germany; http://www.psycho.uni-duesseldorf.de/aap/projects/gpower) program was used to determine the sample size. At least 102 teeth from each group were required to determine the $f = 0.30$ effect difference between study groups with 90% power and $\alpha = 0.05$ type I error and "$\beta = 0.05$ type II error rates.

Patient Selection

Ten patients (three males and seven females) with 118 fluorosed teeth, ranging in age from 18 to 41

years (with a mean age of 25 years), recruited from the university hospital, were included in this clinical trial. The committee for medical ethics of Cumhuriyet University Sivas Province, Turkey, approved the study protocol (No. 2011-04/19). Each patient signed an informed consent form after the nature and objectives of the clinical trial had been explained at the beginning of the study. The distribution of patients according to gender, age, oral hygiene status, and Tooth Surface Index of Fluorosis (TSIF) scores is presented in Table 1.

The inclusion/exclusion criteria were the following. Participants had to

- Have at least eight fluorosed maxillary and mandibular incisors and canines with scores of 1-7, according to the TSIF.
- Have no caries or restorations on the teeth to be treated.
- Be able to return for periodic recalls.

The exclusion criteria included the following:

- Poor general or dental health.
- Any fixed orthodontic appliances.
- Hypersensitive teeth.
- Smoking habit.
- Current or previous use of bleaching agents.
- Status as a pregnant or lactating woman.
- Tetracycline-stained teeth.
- A history of allergies to tooth-whitening products.
- Age of less than 18 years.
- Symptoms of pulpitis, such as spontaneous pain or sensitivity to pressure.

Table 1: *Distribution of Patients According to the Gender, Age, Oral Hygiene Status, and Tooth Surface Index of Fluorosis (TSIF) Scores*

	Number of Patients	Number of Teeth
Gender		
Male	3	36
Female	7	82
Age		
18-25 y	7	82
25-35 y	1	12
35-50 y	2	24
Oral hygiene		
Good	6	70
Moderate	4	48
Poor	—	—
TSIF score		
0	0	0
1	0	0
2	3	7
3	7	37
4	8	48
5	3	6
6	2	8
7	3	12

Enamel Microabrasion

Even though only maxillary and mandibular fluorosed incisors and canines were included in the current study, all fluorosed teeth visible during smiling, laughing, or speaking were treated in this trial. The teeth were cleaned with pumice before treatment. Initial photographs of the teeth were taken (Figure 2). They were isolated with a rubber dam and then a fine-grit, water-cooled diamond bur was applied to the stained and white opaque enamel region for five to 10 seconds to enable penetration of the gel into the enamel. An approximately 1-mm–thick layer of 6.6% hydrochloric acid slurry with silicone carbide microparticles (Opalustre, Ultradent Products Inc, South Jordan, UT, USA) was applied to the affected tooth surfaces. OpalCups™ prophy cups (Ultradent Products Inc) attached to a gear-reduction contra-angle were used to microabrade the surfaces of the teeth using slight pressure for 60 seconds. The teeth were then rinsed, and this procedure was repeated five times for mild lesions and 10 times for moderate and severe lesions during the same session.[18] Fluoride gel (Sultan Topex Neutral Fluoride gel, Englewood, NJ, USA) was

Figure 2. *Pretreatment view of a patient with fluorosed teeth.*

applied for five minutes. Photographs were taken 24 hours after treatment (Figure 3).

In-office Bleaching

Patients received the in-office bleaching treatment 24 hours after the enamel microabrasion procedure. All patients returned for in-office bleaching. Gingival protector gel (OpalDam, Ultradent Products Inc) was applied 4-6 mm high and 1.5-2.0 mm thick along the gingival margin, overlapping approximately 0.5 mm onto the enamel. It was light-cured for 20 seconds per arch using a scanning motion. After mixing two syringes, a 0.5-1.0-mm–thick layer of 38% hydrogen peroxide gel (Opalescence Boost, Ultradent Products Inc) was applied to the labial surfaces of the teeth. The gel was allowed to remain on the teeth for 20 minutes and then it was removed using suction. The teeth were then cleaned with water. These steps were repeated up to three times per visit, depending on tooth sensitivity. The treatment was repeated in three- to five-day intervals until no differences were observed between two consecutive visits. The mean application duration of gels in both groups is given in Table 2. After in-office bleaching, the teeth were polished with abrasive discs, and fluoride gel was applied for five minutes. Photographs were taken 24 hours after treatment (Figure 4).

Table 2: *Mean Application Duration of Gels in Both Groups*

Material	Mean Number of Visits	Mean Duration, min
Opalustre	1	9.7
Opalescence Boost	2.5	96

Evaluation

Standardized images of the teeth were taken with a digital camera (Coolpix 8800, Nikon, Tokyo, Japan) before each treatment and 24 hours after the enamel microabrasion and in-office bleaching therapy. The images were taken at the same distance in a dark room under controlled lighting conditions. The same background, camera, light source, and exposure were used. Two calibrated and blinded examiners scored the Group 1 and Group 2 images by comparing each with pretreatment images for "improvement in appearance," "changes in brown stains," and "changes in white opaque areas," using VAS ranging from 1 to 7 (Figure 5). "Patient satisfaction," "tooth sensitivity," and "gingival problems," ranging from 1 to 7, were also evaluated using VAS (Figure 5). Five pairs of pretreatment–Group 1 or pretreatment–Group 2 images were randomly selected and used to test for intra- and interexaminer reliability.

Statistical Analysis

The statistical analysis was processed with the SPSS 15.0 software system (SPSS Inc, Chicago, IL, USA). The Shapiro-Wilk test was used to assess the

Figure 3. *View of patient after microabrasion.*

Figure 4. *View of patient after microabrasion and in-office bleaching.*

VISUAL ANALOGUE SCALES

Improvement in Appearance

1 2 3 4 5 6 7
1=No Improvement 7=Exceptional Improvement

Changes in Brown Stains

1 2 3 4 5 6 7
1=Not at All 7=Totally Removed

Changes in White Opaque Areas

1 2 3 4 5 6 7
1=Not at All 7=Totally Dissappeared

Patient Satisfaction

1 2 3 4 5 6 7
1= Totally, expectations not fullfilled 7=Complete Satisfaction

Tooth Sensitivity During or After Bleaching

1 2 3 4 5 6 7
1=Not acceptable 7=No side effects

Gingival Problems During or After Bleaching

1 2 3 4 5 6 7
1=Not acceptable 7=No side effects

Figure 5. *Visual analogue scales*.

likelihood that the given data set came from a normal distribution. The data could not be assumed to be distributed normally; thus, median and Interquartile Range (IQR) values were used to display the descriptive statistics. Differences in the "improvement in appearance," "changes in brown stains," and "changes in white opaque areas" scores for Group 1 and Group 2 were respectively tested with the two-sample paired Wilcoxon signed-rank test.

The Mann-Whitney *U*-test was used to analyze 1) differences between the maxillary and mandibular teeth in terms of their "improvement in appearance," "changes in brown stains," and "changes in white opaque areas" scores in Group 1 and Group 2; 2) differences between the "improvement in appearance," "changes in brown stains," and "changes in white opaque areas" scores of Group 1 and Group 2 in maxillary and mandibular teeth; and 3) differences between the "tooth sensitivity," "gingival prob-

Table 3: *Descriptive Values and Statistical Results of Group 1 and Group 2 Comparisons*

	Group 1			Group 2			Group 1 vs Group 2	
	Minimum-Maximum	Median (IQR)	Mean (SD)	Minimum-Maximum	Median (IQR)	Mean (SD)	*Z*	*p*
Improvement in appearance	1.0–6.0	3.0 (2.0)	3.4 (1.4)	1.0–7.0	6.0 (2.0)	5.8 (1.4)	9.241	<0.001
Changes in brown stains	1.0–7.0	5.0 (2.0)	4.8 (1.5)	3.0–7.0	7.0 (1.0)	6.5 (0.9)	9.107	<0.001
Changes in opaque white areas	1.0–7.0	4.0 (2.0)	4.2 (1.4)	1.0–7.0	5.0 (1.0)	5.5 (1.2)	8.294	<0.001

Abbreviations: IQR, interquartile range; SD, standard deviation.

lems," and "patient satisfaction" scores for Group 1 and Group 2.

The Kruskal-Wallis test was used to analyze differences among the scores of "improvement in appearance," "changes in brown stains," and "changes in white opaque areas" criteria in both groups. For all tests, the probability level for statistical significance was at $\alpha = 0.05$.

RESULTS

The test of intraexaminer and interexaminer agreement resulted in Cohen's Kappa statistics of 84 and 81, respectively. The mean (standard deviation [SD]) and median (interquartile range [IQR]) scores of Group 1 and Group 2 were given for "improvement in appearance," "changes in brown stains," and "changes in white opaque areas" in Table 3. Group 1 revealed significantly lower scores than Group 2 in terms of all of the evaluated criteria ($p<0.001$).

In Group 1 and Group 2, no differences were found between the maxillary and mandibular teeth in all evaluated criteria, except for "changes in white opaque areas" scores in Group 1. Maxillary teeth had higher scores than mandibular teeth in terms of "changes in white opaque areas" in Group 1 ($p<0.001$). In maxillary and mandibular teeth, Group 1 had significantly lower scores than Group 2 related to all evaluated criteria ($p<0.001$) (Table 4).

Both groups revealed the highest scores in "changes in brown stains" ($p<0.001$). The "changes in white opaque areas" scores of Group 1 were higher than

Table 4: *Statistical Results of Comparisons Between Maxillary and Mandibular Teeth*

	Tooth	Group 1	Max vs Man	Group 2	Max vs Man	Group 1 vs Group 2	
		Median (IQR)	*Z* (*p*)	Median (IQR)	*Z* (*p*)	*Z*	*p*
Improvement in appearance	Max	3.0 (2.0)	0.662 (0.508)	6.0 (1.3)	1.411 (0.158)	6.669	<0.001
	Man	3.0 (3.0)		6.0 (2.8)		6.449	<0.001
Changes in brown stains	Max	4.0 (1.0)	1.327 (0.185)	6.0 (1.0)	1.495 (0.135)	6.523	<0.001
	Man	6.0 (3.0)		7.0 (1.0)		6.498	<0.001
Changes in opaque white areas	Max	4.0 (1.0)	4.521 (<0.001)	5.5 (1.0)	0.892 (0.373)	5.655	<0.001
	Man	3.0 (2.0)		5.0 (1.0)		6.135	<0.001

Abbreviations: IQR, interquartile range; Man, mandibular; Max, maxillary.

the "improvement in appearance" scores ($p<0.001$), while the "improvement in appearance" scores of Group 2 were higher than the "changes in white opaque areas" scores ($p<0.05$).

Group 1 experienced less tooth sensitivity and reflected lower patient satisfaction scores than Group 2 ($p<0.001$); however, no differences were found between both groups in terms of gingival problems.

DISCUSSION

In the current study, VAS ranging from 1 to 7 was preferred to evaluate "improvement in appearance," "changes in brown stains," and "changes in opaque white stains," in lieu of any dental spectrophotometer evaluation. This was similar to the study by Price and others,[6] even though it was a subjective technique for shade measurement. Shade evaluation by spectrophotometers depends on the CIELAB color difference, which is determined by calculating the Euclidean distance (ΔE) between the two colors in the CIELAB color space. In the formula used to find the color difference, the squared differences among the L*, a*, and b* measures are summed up.[19] Although it is a quantitative technique, esthetic management related to determining any change in color parameters is not enough in fluorosed teeth, as the primary aims are to remove all stains and improve the mottled surface. Knösel and others[20] used the CIE L*a*b* evaluation to report the effects of bleaching therapy on fluorotic enamel stains. Using this evaluation method, these authors could only report the rate of all fluorotic areas that showed detectable color change ($\Delta E>3.7$) after bleaching. They could not comment on the stain removal performance, improvement in mottled appearance, and esthetic management level that resulted from this quantitative technique.

Two different conservative approaches, enamel microabrasion and a combined therapy (enamel microabrasion and in-office bleaching), were evaluated to esthetically manage mild to severely fluorosed teeth in this trial. In order to eliminate the patient-dependent variable, the current study was designed to apply enamel microabrasion and in-office bleaching therapy onto the same teeth, respectively. Thus, Group 1 included scores from images taken after enamel microabrasion, and Group 2 included scores from images taken after in-office bleaching, followed by enamel microabrasion.

Although both methods improved the appearance of and removed stains and white opaque areas at different levels, enamel microabrasion revealed significantly lower scores than did combined bleaching therapy in terms of all of the evaluated criteria. In the literature, there is no article that compares the effectiveness of enamel microabrasion to vital bleaching techniques. In case reports that evaluated the effectiveness of microabrasion, it was considered an effective and minimally invasive procedure.[21] On the other hand, in clinical articles, this technique removed stains and white opaque areas from the outermost layer of enamel and improved the appearance of teeth to some degree; however, similar to the results of the current study, the technique could not entirely improve esthetics. Price and others[6] reported that enamel microabrasion resulted in a score of 5.38 for "improvement of appearance" and a 5.06 score for "stain removal," according to the VAS scale, which ranged from 1 to 7. Loguercio and others[22] obtained scores of 3.4 and 2.4, respectively, for "improvement of appearance" using different products for enamel microabrasion. This technique claims to remove the outermost layer of enamel and change the optical properties of the enamel surface. When the enamel surface is abraded with an acid gel, a densely compacted prism-free layer is formed on the enamel surface. This prism-free layer reflects and refracts light in such a way that underlying stains are believed to be camouflaged.[10]

Vital bleaching techniques, including in-office and at-home bleaching, were mostly used together or with enamel microabrasion to esthetically manage fluorosed teeth, except as demonstrated in some early articles.[8,23] A sufficient amount of esthetic management was mainly provided by using a combined approach (in-office and at-home bleaching, enamel microabrasion and in-office and at-home bleaching or enamel microabrasion, in-office and at-home bleaching). Knösel and others[20] applied in-office bleaching to 18 subjects using 30% hydrogen peroxide, followed by 14 days of at-home bleaching. They reported that in-office bleaching does not lead to a significant change in the color and luminosity of fluorotic teeth, whereas the application of at-home bleaching therapy after an in-office bleaching regime provided detectable color change in fluorotic areas. Ardu and others[3] reported successful results after the application of enamel microabrasion followed by the at-home bleaching technique on a patient with severe dental fluorosis. Ng and Manton[5] could reduce dark brown stains using a combination of enamel microabrasion and in-office and at-home bleaching techniques in a severe fluorosis case;

however, they required the use of composite veneers to achieve further improvement in the esthetics of the patient. Pontes and others[9] used an enamel microabrasion technique followed by in-office bleaching. They revealed that enamel microabrasion was an efficient method for removing white opaque areas, whereas dental bleaching can be used to obtain a uniform tooth shade. Similar to previous articles, an in-office bleaching regime conducted after enamel microabrasion increased the efficacy of the current study's therapy, as was used for the esthetic management of fluorosed teeth in the present research.

In the current trial, when the efficacy of both methods of "improvement in appearance," "changes in brown stains," and "changes in white opaque areas" were compared, it was observed that utilizing both methods to remove brown stains offered the best solution. Enamel microabrasion revealed the worst performance in "improvement in appearance," probably because it could not achieve a uniform tooth shade, similar to bleaching techniques. Similar to the current study, previous articles[15,21] on enamel microabrasion documented being successful in removing fluorosis stains, while bleaching methods were preferred as a way to harmonize the shade of the tooth and provide a more esthetic appearance.

CONCLUSIONS

With regard to our results, the hypothesis was rejected. To some degree, enamel microabrasion improves the appearance of teeth and removes brown stains or white opaque areas; however, the combination of enamel microabrasion and in-office bleaching techniques results in better performance in all of the evaluated criteria and provides a better esthetic appearance.

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Note

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Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service and/or company that is presented in this article.

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