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Original Article

A comparison of three whitening protocols for mild-to-moderate dental fluorosis in anterior teeth

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Abstract: Objective: This research compares the effectiveness of three whitening treatments for mild-to-moderate dental fluorosis in the front teeth. Method: This retrospective study analysis is based on 51 mild-to-moderate dental fluorosis cases. The patients who visited the Dental Hospital of Ningxia Medical University from August 2020 to August 2021 were enrolled as research cases. The patients were classified into three groups according to their treatment plans: Group A (19 cases), Group B (17 cases), and Group C (15 cases). The upper anterior teeth color was assessed immediately after treatment and then at one week, one month, three months, and six months using the VITA Easyshade® V shade guide. Tooth sensitivity was evaluated with a visual analog scale (VAS scale). Results: Three options were applied to treat mild and moderate dental fluorosis. Moderate fluorosis showed higher ΔE and ΔL values but lower Δa and Δb values compared to mild fluorosis, with significant differences noted ($P<0.05$). In cases of mild dental fluorosis, ΔE and ΔL values from the combination of micro-grinding and home bleaching were significantly higher. Conversely, Δa and Δb values for both micro-grinding with home bleaching and micro-grinding with combined bleaching were significantly lower ($P<0.05$). In moderate dental fluorosis cases, ΔE and ΔL values were higher for both micro-grinding combined with bleaching and micro-grinding combined with home bleaching. In contrast, Δa and Δb values for micro-grinding combined with bleaching were lower, showing statistically significant differences ($P<0.05$). The sensitivity of micro-grinding + home bleaching was less than that of micro-grinding + in-office bleaching and micro-grinding + combined bleaching immediately post-op, 1 week after the operation, with statistically significant differences ($P<0.05$). Conclusion: All three options achieve sound whitening effects for mild to moderate dental fluorosis in anterior teeth. The whitening effect is more effective in cases of moderate dental fluorosis than in mild cases. Among the three treatment options, microabrasion combined with home bleaching achieves the best whitening effect for mild dental fluorosis and minimizes sensitivity. When considering the three treatment options for moderate dental fluorosis, both microabrasion combined with home bleaching and microabrasion combined with in-office bleaching can yield better whitening effects. However, it is essential to note that the latter option is linked to higher sensitivity.

Keywords: Dental fluorosis, microabrasion, in-office bleaching, home bleaching, combined bleaching, sensitivity

Introduction

Dental fluorosis is the most prevalent and noticeable early symptom of chronic fluorine poisoning, classified into three clinical manifestations: mild (white chalky), moderate (brown staining), and severe (defective). Each form remarkably impacts patients' physical and mental health [1]. Dental fluorosis varies significantly by region. The Fourth National Oral Health Epidemiological Survey results indicate that the dental fluorosis index for 12-year-olds in China is 0.28, with a prevalence of 13.4% [2]. In this survey, the dental fluorosis index for 12-year-old students in Ningxia was 0.37, with a prevalence of 16.8%. The predominant forms observed were mild and moderate dental fluorosis [3]. It is worth noting that the issue of dental fluorosis is also significant among adults and the elderly. Research shows that the prevalence of dental fluorosis among adults in high-fluoride areas can reach 23.6% to 38.9%. With age, the abnormal enamel mineralization caused by long-term fluoride exposure may further inten-

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sify. Among the elderly over 60 years old, the proportion of moderate to severe dental fluorosis is as high as 19.3% [4, 5]. This phenomenon is closely related to the cumulative effect of fluoride exposure during the permanent tooth development period and the risk of secondary dental defects, indicating that the prevention and treatment of dental fluorosis should cover the entire life cycle.

Modern dentistry endorses "conservative treatment", prioritizing gradual and minimally invasive methods to protect healthy dental tissue [6, 7]. Following this principle, dental fluorosis is primarily treated based on the degree of enamel lesions, with options including teeth whitening, enamel microabrasion, infiltration resin, veneers, and full-coverage crowns [8, 9]. Severe dental fluorosis with significant defects may be treated with restorative techniques such as veneers or crowns [10, 11]. For light and moderate dental fluorosis with chalky or brown staining, conservative techniques such as enamel microabrasion, bleaching, and penetrating resin are more recommended [12, 13]. This study applied three whitening protocols, including micro-grinding plus in-office bleaching, micro-grinding plus home bleaching, and micro-grinding plus combined bleaching, to patients with mild to moderate dental fluorosis in upper anterior teeth and conducted postoperative follow-ups at immediate postoperative, 1 week, 1 month, 3 months, and 6 months to record the changes in tooth color and sensitivity and compare the clinical efficacy of the three protocols, to provide specific reference basis for clinicians to formulate whitening protocols for patients with mild to moderate dental fluorosis.

Methods

Research subjects

This is a retrospective study analysis based on 51 mild-to-moderate cases of dental fluorosis. The included patients had mild to moderate dental fluorosis and chose to receive care at the Dental Whitening Special Clinic of Ningxia Medical University General Hospital from August 2020 to August 2021. The patients were classified into three groups according to their treatment plans: Group A (19 cases of micro-grinding + in-clinic bleaching), Group B (17 cases of micro-grinding + home bleaching), and Group C (15 cases of micro-grinding + combined bleaching). The study was approved by the Ethics Committee of Ningxia Medical University General Hospital.

Inclusion criteria

The inclusion criteria were as follows: Patients had to meet diagnostic criteria for mild or moderate dental fluorosis on the upper anterior teeth [14, 15] and maintain good oral hygiene and have healthy periodontal tissues. Additionally, their upper anterior teeth had to exhibit no enamel defects, caries, resin restorations, or other restorative procedures, and they must not have undergone any previous whitening treatments or experienced adverse reactions to peroxides. Severe dentin hypersensitivity was also an exclusion factor, and all participants were required to be at least 18 years old. Patients needed to express a desire for teeth whitening, provide complete clinical follow-up records, and be long-term residents in Ningxia.

Exclusion criteria

Patients were excluded from the study if they presented with severe dental fluorosis or failed to complete the treatment and follow-up. Additional exclusion factors included the presence of dental caries, pulp disease, periapical disease, and periodontitis in the upper anterior teeth. Pregnant or lactating women, as well as patients with severe systemic diseases or a history of allergies to the study materials, were also ineligible. Furthermore, individuals with severe dental conditions, those undergoing orthodontic treatment, or those wearing removable partial dentures were excluded to ensure homogeneity in the study population.

Materials and equipment

In this study, we utilized Opalustre Micro-Polishing Paste, OpalCups Polishing Cups, Opalescence Boost 40% HP, OpalDam Photocurable Barrier Resin, Opalescence PF 10% CP, LC Block-Out Interproximal Resin (Ultradent, USA), Erkoform-3 Vacuum Heat Forming Machine (Erkodent, Germany), and VITA Easyshade® V Shade Guide (VITA Zahnfabrik, Germany).

Treatment options

All subjects underwent scaling and root planning one week prior to dental procedures.

The micro-grinding procedure began with the placement of a rubber dam to isolate the maxillary anterior teeth. Opalustre polishing compound was then applied to the teeth's labial surface, which was subsequently treated using OpalCups bristle polishing cups operating at 350-500 RPM. Each tooth underwent three polishing cycles of 60 seconds duration per cycle. Following polishing, all treated surfaces were thoroughly rinsed with water for 15 seconds and dried using compressed air.

The in-office bleaching procedure was performed as follows: First, a 4 mm wide, 1 mm thick layer of OpalDam light-curing barrier resin was applied evenly on the gum of the upper anterior teeth to protect the gum. Next, the prepared mixed Opalescence Boost (40% HP) was uniformly applied on the labial surface of the teeth with a thickness of 0.5-1 mm. After allowing 20 minutes of contact time, any residual bleaching agent on the teeth surface was completely removed with a strong suction and dry cotton swab. This treatment cycle was repeated once, resulting in a total application time of 40 minutes.

The home bleaching procedure was performed as follows: First, alginate impressions of maxillary dentition were taken and cast in superhard gypsum to create study models. A 0.5 mm thick layer of LC Block-Out gap resin was uniformly applied to the labial surface of the upper anterior teeth at a distance of 0.5 mm from the gum margin. A custom-fabricated tray was then fabricated, with reservoir spaces corresponding to the resin-coated labial surfaces of the teeth to accommodate the whitening agent. Patients were instructed to thoroughly clean their teeth before inserting the tray each night. They were directed to fill the tray reservoirs with the whitening agent OpalescenceTM PF 10% CP into the storage space of the personal tray and wear it in the mouth, remove the excess whitening gel, and take out the personal tray in the morning. The patients were notified that they were required to wear the device for 8 hours each night over the course of 10 nights, followed by a scheduled follow-up appointment. For combined bleaching treatment, home bleaching commenced the day after in-office bleaching treatment, with the same treatment process, operational steps, dosage, and treatment time as before.

Patients were instructed to document tooth color changes and the degrees of tooth sensitivity at five postoperative intervals: immediately after treatment and at 1-week, 1-month, 3-month, and 6-month follow-up visits.

Observing indicators

Evaluation of whitening effect: According to the literature reports [16], the patients' central incisors, lateral incisors, and canines were selected as measurement objects, and the L, a, and b parameters were obtained by measuring the target teeth's color vertically on the dental surface under natural light using the VITA Easyshade® V colorimeter's built-in standard calibration slot. To ensure the stability of the measurement results, the entire color measurement operation was performed by the same researcher, with each target tooth being measured three times and the average value taken. According to the color difference formula $\Delta E = [(\Delta L)2 + (\Delta a)2 + (\Delta b)2]1/2$, $\Delta L = L_{\text{after surgery}} - L_{\text{Before surgery}}$, $\Delta a = a_{\text{after surgery}} - a_{\text{Before surgery}}$, $\Delta b = b_{\text{after surgery}} - b_{\text{Before surgery}}$. We calculated the color difference value ΔE, brightness difference value ΔL, red-green difference value Δa, and yellow-blue difference value Δb at five evaluation time points immediately after the operation, 1 week, 1 month, 3 months, and 6 months, and evaluated the teeth whitening effect.

Tooth sensitivity comparison [17]: The patients evaluated the degree of tooth sensitivity after treatment using a visual analogue scale (VAS). The left endpoint of the scale's numerical axis was set at 0 mm, indicating no pain, and the right endpoint was set at 100 mm, representing intolerable severe pain for the patient. The assessment time points were immediately postoperatively, 1 week, 1 month, 3 months, and 6 months.

Statistical analysis

Data analysis was conducted using statistical software SPSS 25.0 and R version 4.1.0. At the five postoperative evaluation time points, the whitening effects of the three treatment regimens were compared using the Kruskal-Wallis test. The whitening effects of mild and moderate dental fluorosis were compared using the Mann-Whitney U test. The sensitivity of the three regimens was compared using the Tamhane test. The statistical significance level was

Table 1. Comparison of baseline data among the three groups of patients

Baseline data	A Group (n=19)	B Group (n=17)	C Group (n=15)	F/x^2	*P*
Gender [n (%)]					
Male	3 (15.79)	3 (17.65)	1 (6.67)	0.698	0.485
Female	16 (84.21)	14 (82.35)	14 (93.33)		
Age (years, $\overline{x}$±s)	27.39±7.45	28.94±9.10	28.05±7.89	0.162	0.851
State of an illness [n (%)]					
Mild	10 (52.63)	8 (47.06)	7 (46.67)	0.360	0.719
Moderate	9 (47.37)	9 (52.94)	8 (53.33)		

set at α=0.05, and P<0.05 was considered statistically significant.

Results

Baseline information

In Group A, there were 3 males and 16 female patients, with an average age of (27.39±7.45) years. There were 10 mild cases and 9 moderate cases. In Group B, there were 3 male patients and 14 female patients, with an average age of (28.94±9.10) years. There were 8 mild cases and 9 moderate cases. In Group C, there was 1 male patient and 14 female patients, with an average age of (28.05±7.89) years. There were 7 mild cases and 8 moderate cases. There were no significant differences in baseline data among the three groups (*P>0.05*), as shown in **Table 1**.

Evaluation of teeth whitening effect

The ΔE values of microgrinding + home bleaching, microgrinding + combined bleaching, and microgrinding + dental clinic bleaching were significantly higher than those of microgrinding + dental clinic bleaching at the 5 evaluation time points (*P<0.05*). There was no statistically significant difference between microgrinding + home bleaching and microgrinding + combined bleaching (*P>0.05*). The ΔE values of microgrinding + home bleaching and microgrinding + combined bleaching were relatively stable within 6 months afterwards, compared with microgrinding + dental clinic bleaching. There was no statistically significant difference in the ΔE values between the upper central incisors, lateral incisors, and canine teeth (*P>0.05*). The ΔE values of moderate dental fluorosis were significantly higher than those of mild dental fluorosis, and the difference was statistically significant (*P<0.05*). See **Figure 1**.

The changes were compared in tooth color ΔL (**Figure 2A**, **2B**), Δa (**Figure 2C**, **2D**), Δb (**Figure 2E**, **2F**), and ΔE (**Figure 2G**, **2H**) at 5 evaluation time points after treatment in mild and moderate dental fluorosis patients. In the treatment of mild dental fluorosis with three protocols, the ΔE value (**Figure 2G**) and ΔL value (**Figure 2A**) of Group B were greater than those of Groups A and C, with statistically significant differences (P<0.05) in immediate postoperative period, 1 week, 1 month, and 3 months, the Δa value (**Figure 2C**) of Groups B and C was smaller than that of Group A, with statistically significant differences (P<0.05), but no statistically significant difference was found at 6M (P>0.05); the Δb value (**Figure 2E**) of Groups B and C was smaller than that of Group A, with statistically significant differences (P<0.05). In the treatment of moderate dental fluorosis with three protocols, the ΔE value (**Figure 2H**) and ΔL value (**Figure 2B**) of Groups B and C were greater than those of Group A, with statistically significant differences (P<0.05); the Δa value (**Figure 2D**) and Δb value (**Figure 2F**) of Group C were smaller than those of Groups A and B, with statistically significant differences (P< 0.05). After the Mann-Whitney U test, the differences in ΔE, and ΔL values between moderate and mild dental fluorosis were statistically significant (P<0.05). In contrast, the differences in Δa and Δb values were not statistically significant (P>0.05). For details, please refer to **Figure 2A-H**.

Tooth sensitivity comparison

The analysis of tooth sensitivity following the three treatment plans presented in **Figure 3** and **Table 2** reveals that the VAS value was the highest right after the operation, followed by a significant decrease during the first week after the procedure. There was no significant tooth

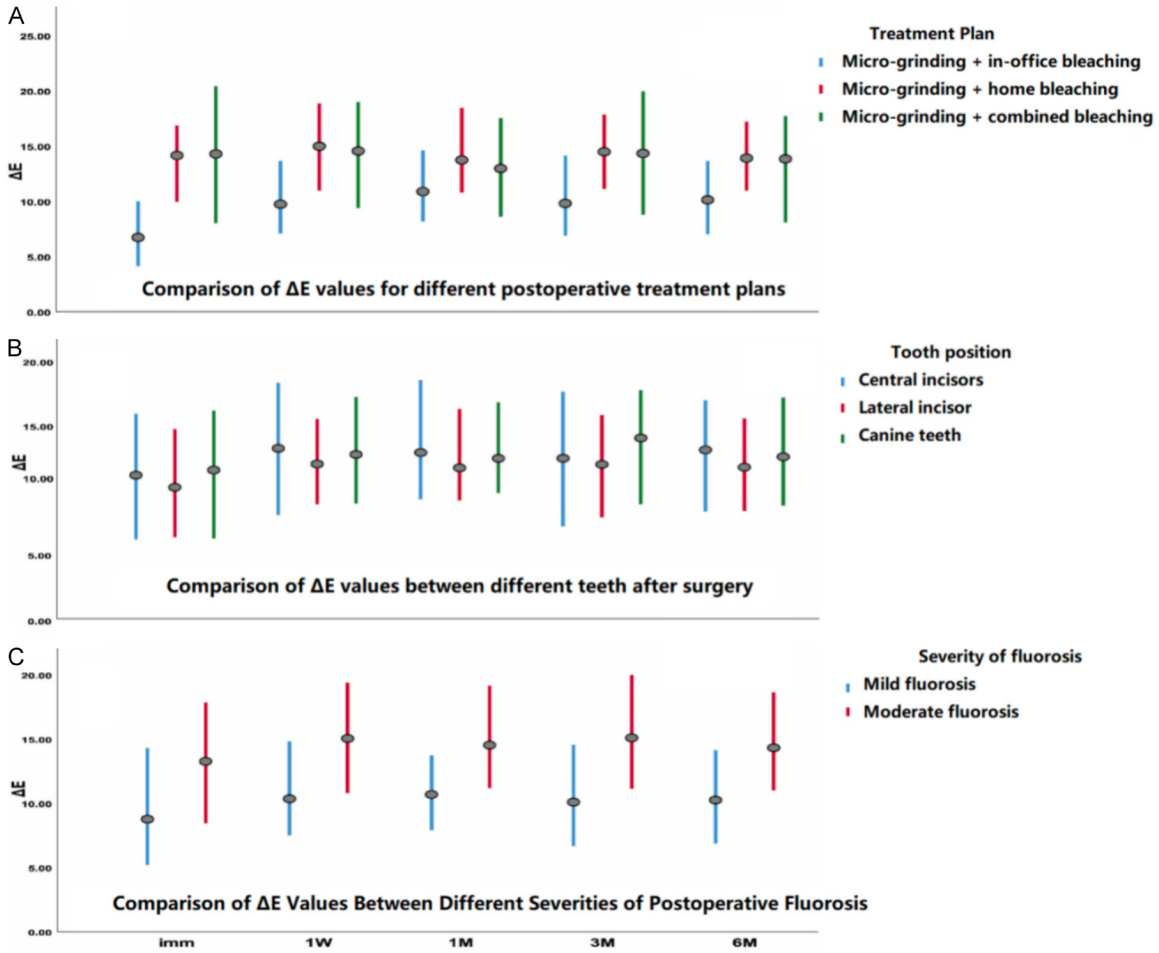

Figure 1. Comparison of ΔE values at different postoperative time points for different treatment methods, tooth types, and dental fluorosis severity. Note: A: Comparison of ΔE values for different postoperative treatment; B: Comparison of ΔE values between different teeth after treatment; C: Comparison of ΔE values between different severities of postoperative Fluorosis.

sensitivity after 1, 3, and 6 months after the operation. Among them, the VAS values of immediate postoperative and 1-week postoperative were lower in Group B than in Groups A and C, with a statistically significant difference ($P<0.05$). Still, there was no statistically significant difference between Groups A and C.

Discussion

In 1976, the International Commission on Illumination recommended the CIELAB color system for evaluating colors quantitatively. Three coordinates define this system: L indicates an object's brightness from black to white, while a and b represent chromaticity on the red-green and yellow-blue axes, respectively [17]. The color change is generally quantified and evaluated using the color difference formula $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$, where $\Delta L = L_{\text{after surgery}} - L_{\text{Before surgery}}$, $\Delta a = a_{\text{after surgery}} - a_{\text{Before surgery}}$, and $\Delta b = b_{\text{after surgery}} - b_{\text{Before surgery}}$. The larger the color difference value ΔE, the greater the color difference, and the more noticeable it is to the human eye [18]. The color difference formula is widely used in the study of teeth whitening effects, and several studies have shown that after teeth whitening, the L value increases. In contrast, the a and b values decrease. That is, the larger the ΔE and ΔL values, the smaller the Δa and Δb values, and the more significant the teeth-whitening effect [19-22].

Paravina et al.'s [23] survey study on dental color thresholds indicates that the ΔE value calculated using the color difference formula can be used to evaluate the whitening effect, with the following grades: $\Delta E \leq 1.2$ is ineffec-

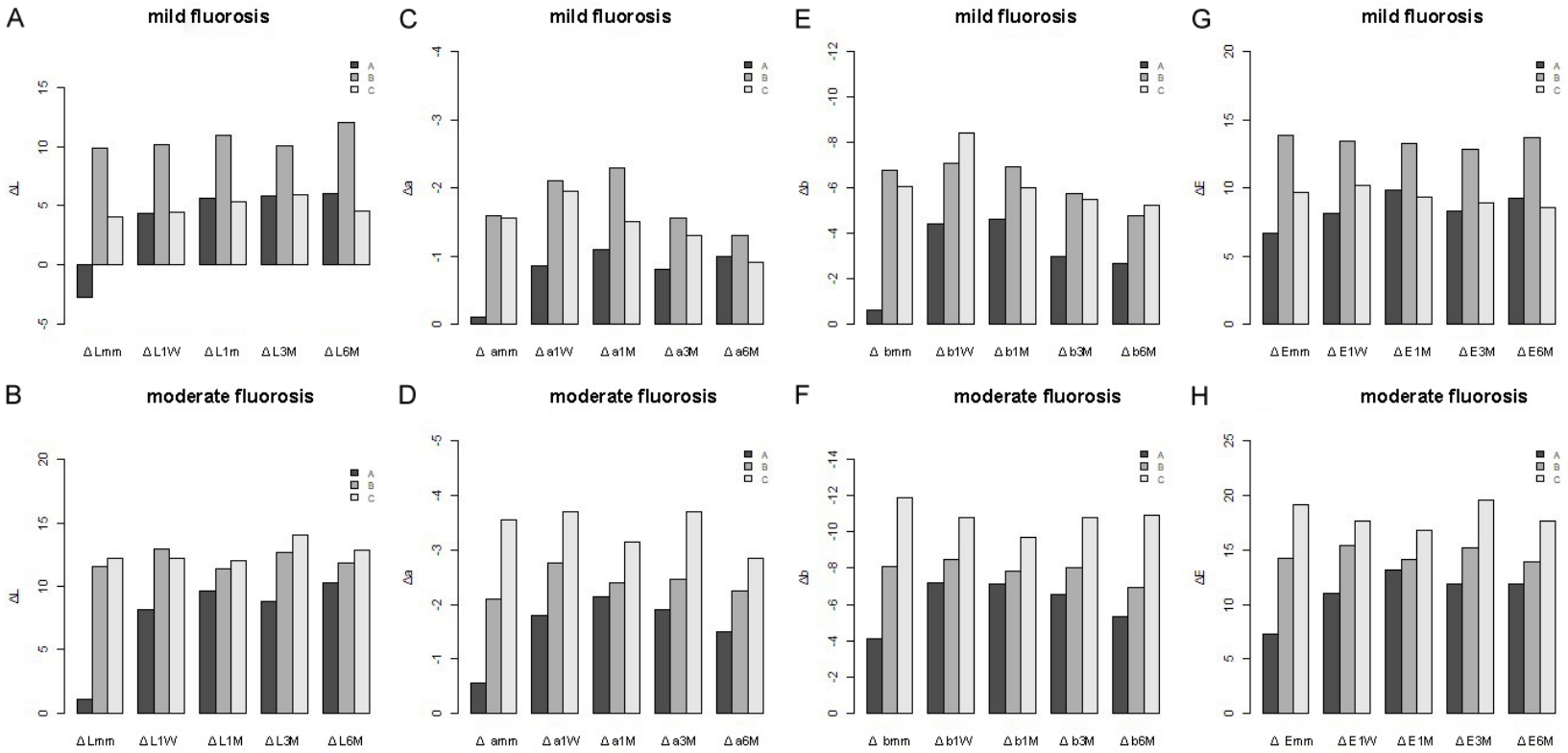

Figure 2. The changes in ΔL (A, B), Δa (C, D), Δb (E, F), and ΔE (G, H) at 5 evaluation time points for the three treatment schemes in mild and moderate dental fluorosis. Note: A': Micro-polishing + In-Office Whitening. B': Micro-polishing + Home Whitening. C': Micro-polishing + Combined Whitening. (A) ΔL of mild dental fluorosis. (B) ΔL of moderate dental fluorosis. (C) Δa of mild dental fluorosis. (D) Δa of moderate dental fluorosis. (E) Δb of mild dental fluorosis. (F) Δb of moderate dental fluorosis. (G) ΔE of mild dental fluorosis. (H) ΔE of moderate dental fluorosis.

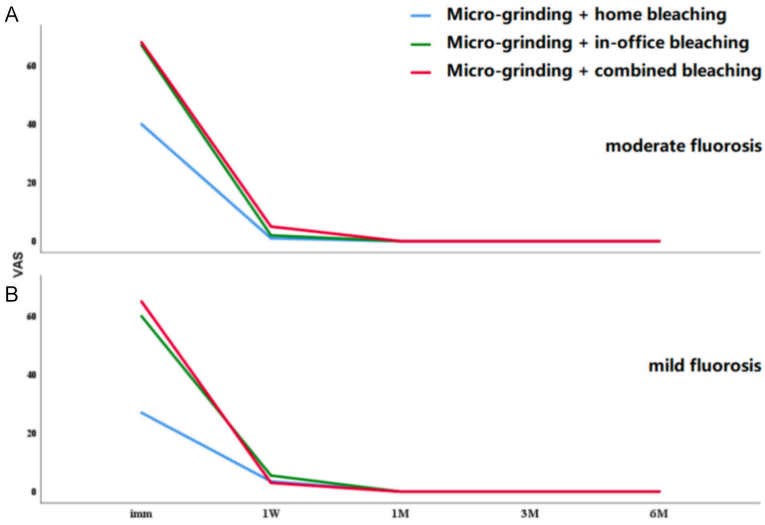

Figure 3. Comparison of tooth sensitivity at five time points after light and moderate dental fluorosis treatment with three whitening protocols. Note: imm, 1W, 1M, 3M, 6M refer to immediately postoperatively, 1 week, 1 month, 3 months, and 6 months postoperatively, respectively. VAS refers to the median VAS value of patients at different time points after treatment. A: VAS of moderate fluorosis; B: VAS of mild fluorosis.

tive, $1.2<\Delta E\leq 2.7$ is moderately effective, $2.7<\Delta E\leq 5.4$ is good, $5.4<\Delta E\leq 8.1$ is very good, and $\Delta E>8.1$ is excellent. All experimental groups in this study showed ΔE values greater than 5 at all 5 evaluation time points after treatment, indicating that the three treatment protocols of microabrasion plus in-office bleaching, microabrasion plus home bleaching, and microabrasion plus combined bleaching can achieve sound whitening effects for mild and moderate dental fluorosis on the anterior teeth.

Teeth whitening, broadly defined as any method that increases the visual whiteness of teeth, primarily includes chemical bleaching with peroxides and mechanical cleaning with abrasives such as polishers [24]. The latest "Teeth Whitening Treatment Technology Guideline" in 2021 by the Chinese Stomatological Association defines teeth whitening as a method of changing the structural discoloration of teeth caused by diseases (dental fluorosis, tetracycline teeth, necrosis of dental pulp, etc.), aging, smoking, and staining by food and beverages, and classifies teeth whitening methods into in-clinic bleaching, home bleaching, combined bleaching, and endodontic bleaching treatment [25]. Enamel microabrasion is a minimally invasive and effective treatment that enhances the mineralization of weakened and localized enamel lesions [26]. Celik believes that microabrasion treatment for dental fluorosis can remove the superficial dental fluorosis spots and increase the success rate of subsequent bleaching treatment [27, 28]. Microabrasion combined with teeth whitening for treating dental fluorosis is widely used in clinical practice. Still, most current studies compare the bleaching effects of in-clinic bleaching, home bleaching, and combined bleaching techniques or validate the efficacy of enamel microabrasion combined with a specific bleaching technique for treating dental fluorosis. This study compares the efficacy of three vital teeth bleaching techniques combined with dental enamel microabrasion. Additionally, considering the influence of the severity of dental fluorosis on teeth whitening effect, this study includes the light and moderate dental fluorosis cases that meet the bleaching indications and are more commonly seen in clinical practice in the experimental groups to discuss their whitening effects.

Matis [29] demonstrated in a clinical trial of extrinsic anterior tooth staining that combined bleaching was superior to single-visit bleaching. Another study on a treatment protocol for dental fluorosis showed that both microabrasion plus in-office bleaching and microabrasion plus home bleaching achieved sound whitening effects. Still, the latter achieved better whitening effects [30, 31]. The results of this experiment comparing the ΔE, ΔL, Δa, and Δb values of the three treatment protocols are generally consistent with the above research findings. The whitening effect of the microabrasion plus home bleaching group is the best for mild dental fluorosis. For moderate dental fluorosis, the whitening effects of both the microabrasion plus home bleaching and microabrasion plus combined bleaching are better than those of microabrasion plus in-office bleaching.

In previous studies, scholars compared the efficacy of combined natural tooth bleaching and home bleaching with simple home bleaching.

Table 2. Multiple comparisons of postoperative tooth sensitivity VAS scores among the three treatment options

		VASimm				VAS1W			
		Mean Difference	*P*	95% *CI*		Mean Difference	*P*	95% *CI*	
				Lower	Upper			Lower	Upper
A	B	28.703	0.000	19.86	37.55	1.622	0.032	0.11	3.13
	C	-5.407	0.332	-14.08	3.27	-0.389	0.899	-1.95	1.17
B	A	-28.703	0.000	-37.55	-19.86	-1.622	0.032	-3.13	-0.11
	C	-34.110	0.000	-42.75	-25.47	-2.012	0.004	-3.44	-0.59
C	A	5.407	0.332	-3.27	14.08	0.389	0.899	-1.17	1.95
	B	34.110	0.000	25.47	42.75	2.012	0.004	0.59	3.44

Note: A: Micro-polishing + in-office bleaching; B: Micro-polishing + home bleaching; C: Micro-polishing + combined bleaching. VASimm: VAS immediate, that is, the tooth sensitivity score immediately after treatment. VAS1W: VAS 1 Week, that is, the tooth sensitivity score one week after treatment.

The results suggested no significant difference in the whitening effect, but greater tooth sensitivity was associated with the combined method. In clinical practice, it is recommended to use individual home bleaching schemes [32-34]. The same conclusion was reached in this experiment for treating moderate dental fluorosis as in the above studies. Still, the advantage of microabrasion + combined bleaching in treating mild dental fluorosis was not reflected. This may be because the color change of teeth in moderate dental fluorosis patients is more serious than in mild dental fluorosis patients. The enamel structure is looser; 40% of the in-office bleaching agent penetrates deeper and has a broader range of penetration in the enamel of the microabrasion + combined bleaching treatment scheme, making it easier to demonstrate the whitening effect.

Regarding the influence of different tooth types on ΔE, there was no statistically significant difference between the central incisors, lateral incisors, and canines (P>0.05). However, the results of Rezende [35] and Rodrigues [36] showed that the color change of the canines was greater than that of the incisors in natural tooth bleaching treatment, which was inconsistent with the conclusion of this experiment. The possible reasons are: (1) The whitening protocol used in this study combined micro-grinding technology, which may impact the bleaching treatment of different tooth types of upper anterior teeth. (2) The color of teeth is related to the reflectance, light scattering, and enamel thickness of teeth. The color of different types of upper anterior teeth in natural teeth is often non-uniform and consistent [37, 38]. However, there are structural differences in enamel structure between natural teeth and dental fluorosis, and the amount of bleaching agent penetrating the enamel during treatment differs. (3) Dental fluorosis is characterized by low mineralization of enamel and significant changes in color and structure. The microscopic structure of the enamel of the same degree of dental fluorosis may be similar, and the reflectance and light scattering of the same degree of dental fluorosis may be consistent in optical terms. However, the position of the teeth is different.

In the same treatment plan, the whitening effects of mild and moderate dental fluorosis were comparatively indicated, with moderate dental fluorosis being better than mild dental fluorosis. One possible reason is that the principle of teeth whitening is that the bleaching agent reacts with the discolored dental tissue through an oxidation-reduction reaction, breaking down the long chain molecules of the colored base groups and converting the deep-colored carbon rings and double carbon ring compounds into light-colored compounds to change the color of the teeth [39]. Its mechanism is that the bleaching agent works by entering the dental hard tissue, and the thickness and permeability of the enamel affect the whitening effect [40]. The microhardness and pore number of the enamel surface layer of different degrees of dental fluorosis differ for dental fluorosis. The enamel layer structure is thinner, the microhardness is lower, and the pore number is higher in the more severe dental fluorosis [41, 42]. The pores of the enamel layer of moderate dental fluorosis are larger than those of mild dental fluorosis, and the bleaching agent is

more likely to penetrate the enamel, which is why light-colored compounds more easily replace the pigment of moderate dental fluorosis.

Sensitivity induced by whitening treatment refers to patients' discomfort during and after in-vivo tooth whitening. This discomfort is typically mild to moderate in severity. The discomfort usually subsides within one week after the treatment and is the most common adverse reaction of in-vivo tooth whitening [43]. Some studies have shown that the risk of tooth sensitivity caused by in-office whitening is 62.9%, while that of home whitening is 51% [44]. In this study, none of the subjects reported tooth sensitivity at the assessment times of 1M, 3M, and 6M. The comparison of tooth sensitivity among the three treatment regimens suggests that the microabrasion plus home whitening group had the least tooth sensitivity immediately post-treatment and one-week post-treatment. One possible reason is that the home whitening agent OpalescenceTM PF 10% CP contains potassium nitrate, effectively reducing tooth sensitivity in teeth whitening [45]. Another reason is that tooth sensitivity caused by whitening is often due to different degrees of inflammatory reactions in dental pulp tissue caused by peroxides and their products approaching the dental pulp cavity. The home whitening agent used in this study (10% CP containing 3.5% HP) has a lower concentration of peroxides than the in-office whitening agent (40% HP). The low concentration of whitening agents results in fewer peroxides and their products during the process of pigment replacement, leading to less tooth sensitivity [46].

However, due to the relatively small sample size included in this study and the relatively short follow-up period, the sample size will be further expanded, and the follow-up period will be extended to more than one year in the future to observe the long-term stability of tooth color and sensitivity. In conclusion, a micro-grinding and home-bleaching solution with low sensitivity and a desirable whitening effect is recommended for the clinical treatment of mild and moderate dental fluorosis.

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Disclosure of conflict of interest

None.

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