Effect of Combining Minimal Invasive Modalities on Treating Mild Dental Fluorosis: An In vivo Study

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Abstract

BACKGROUND: Fluorosis is intrinsic tooth discoloration which compromises esthetics depending on its severity.

AIM: The aim of the study was to assess the efficiency of various treatment modalities in esthetic improvement of mild fluorosed teeth.

MATERIALS AND METHODS: Four patients with 48 mild fluorosed teeth were randomly assigned to four treatment modalities (n = 12). The modalities included Mₗ; power bleaching, Mₘ; microabrasion and power bleaching, Mₑ; power bleaching and resin infiltration and Mᵢ; microabrasion, power bleaching and resin infiltration. Color parameters (L, a, b) and visible color change (ΔE) were measured by spectrophotometer (VITA Easyshade® spectrophotometer) at baseline, immediately after the treatment, after 3, 6, and 9 months.

RESULTS: All the treatment modalities showed significant color change (ΔE) at all-time points compared to baseline. The highest color change was recorded in the resin infiltration treatment modalities compared to the other treatment modalities. Bleaching alone had the lowest change.

CONCLUSION: Resin infiltration treatment modalities were more effective in the esthetic improvement of dental fluorosis compared to either power bleaching alone or combination of microabrasion and power bleaching.

Introduction

Fluoride plays an important role in the prevention of dental caries. However, if the total amount of ingested fluoride exceeds the optimal limits, it results in dental fluorosis [1]. Dental fluorosis is intrinsic tooth discoloration which is caused by high fluoride absorption (>0.05 mg/kg/BW/day) during tooth development in the maturation stage of amelogenesis. Accidental ingestion of fluoride-containing dental products and >1 ppm of fluoride in drinking water are considered possible risk factors for the development of fluorosis [2], [3]. Thus with the worldwide decline of caries, the prevalence of dental fluorosis has increased in the last two decades [4].

Fluorosis is an esthetic disturbance, where enamel development is disrupted and the resulting enamel is hypomineralized. Fluoride reduces calcium ion concentration in the matrix, thus indirectly interfering with protease activity, inhibiting enamel matrix protein degradation. An abnormal growth of apatite crystals is seen, which consequently has optical and physical tooth surface changes [4]. Beneath a sound surface, the enamel structure is characterized by microporosities, which leads to air and water inclusions. These inclusions change the refractive index which results in a change in internal reflection and increased opacity of tooth enamel [2].

The severity of fluorosis varies depending on the duration and amount of fluoride uptake [4]. Mild fluorosis are seen as narrow white lines following the perikymata that lack a clear border with the unaffected enamel [1]. The white opaque appearance of fluorosed enamel is caused by a hypomineralized enamel subsurface [5]. While in moderate fluorosis, yellow to light brown staining is frequently a disfiguring feature. In severe cases, the major diagnostic sign is pitting of the surfaces which leads to secondary brown staining [1]. [5]. Several indices have already been used to characterize the clinical appearance of dental fluorosis such as Dean's fluorosis index and Thylstrup and Fejerskov index (TF index) which was used in the study [2].

The choice of treatment options available for fluorosis depends on fluorosis severity. In reference to TF index, various treatment options include minimal invasive methods for TF scores 1–4. Minimal invasive methods include teeth bleaching, microabrasion, resin infiltration, and combination approaches. These treatment modalities have shown varying degrees of success and have been used with different combinations and techniques [1]. Thus, this study was...
concerned with assessment of efficiency of different treatment modalities in esthetic improvement of mild fluorosed teeth. The null hypothesis is that there is no significant difference between the treatment modalities of the study in esthetic improvement of mild fluorosis.

Methods

Study design and participants

This study is a randomized and clinical trial with four parallel arms with 1:1 allocation ratio followed the guidelines of the Consolidated Standards of Reporting Trials (CONSORT) [6]. The study was carried out after the approval of Ethical Committee of the Faculty of Dentistry, Suez Canal University. Before participating in the study, each participant signed a written consent that detailed the study protocol and role of each participant in the study. The participants were allocated in four treatment modalities using block randomization. The website http://www.randomization.com was used to generate the random sequence generation [1].

The study was conducted on forty eight mild fluorosed anterior teeth (TFI 1-3). Patients aged from 18–30 years with good oral and general health having no caries or restoration on the teeth to be treated were included in the study. Patients with any fixed appliances, hypersensitive or tetracycline-stained teeth, smoking habit, and symptoms of pulpitis were excluded from the study.

Sample size calculation

A minimum total sample size of 44 samples will be sufficient to detect the effect size of 0.25, a power (1-β = 0.90) of 90% at a significance level of p < 0.05 partial eta squared of 0.06. A total sample size of 48 samples would be applied. Each group would be represented by 12 samples. The sample size was calculated according to G*Power software version 3.1.9.2. [7], [8].

Interventions

Four interventions included power bleaching (M1), enamel microabrasion and power bleaching (M2), power bleaching and resin infiltration (M3), and microabrasion, power bleaching, and resin infiltration (M4). Before the interventions, ultrasonic scaling was performed for patients followed by polishing with a polishing paste and polishing brushes. In M1, power bleaching was performed. Teeth were subjected to light-activated in-office bleaching with 37.5% hydrogen peroxide (Pola office plus®, SDI products, victoria, Australia), Gingival barrier gel (Opaldam®, SDI products, victoria, Australia) was applied on gingival margin of both arches and light cured. LED light was applied by a whitening accelerator (COXO C- Bright. Medical Instrument Co. Ltd, Foshan, China) [9]. The light intensity and time buttons of the whitening accelerator were adjusted to high+ and 8 min respectively. The bleaching gel was directly applied to labial surfaces of teeth. Three applications of gel, each for 8 min were done [10]. After the last application, all the gel was suctioned off and rinsing was done.

In M2, microabrasion was performed followed by power bleaching. Slurry composed of 6.6% hydrochloric acid and silicon carbide microparticles (Opalustre, Ultradent Products, Inc., South Jordan, UT, USA) was used for microabrasion. Rubber dam was applied. A 1 mm thick layer of the slurry was applied to labial surfaces of teeth. OpalCups™ (Ultradent Products, Inc.) were used to microabrade teeth surfaces using slight pressure for 60 s for each tooth at a low speed. This procedure was repeated 3 times [11]. Following each application, the teeth were rinsed and evaluated. Then, power bleaching was done as in M1. Teeth were polished with a polishing paste and polishing brushes at the end of the procedures.

In M3, power bleaching was performed as in M1, followed immediately by resin infiltration. Rubber dam was applied. The labial enamel was etched by 15% HCL acid gel (ICON-Etch, DMG, Hamburg, Germany). Three etching cycles for 2 min each were done. After each cycle, the etching gel was then washed away for 30 s and air dried. 99% ethanol (ICON-Dry, DMG, Hamburg, Germany) was then applied to etched enamel and was left for 30 s, followed by air drying. A low-viscosity resin (ICON-Infiltrant DMG, Hamburg, Germany) was applied to etched enamel surfaces and was left for 3 min allowing it to penetrate. Excess material was removed with gentle air drying and dental flossing before light curing for 40 s with an intensity of 1500 mw/cm² using COXO LED Curing Light Wireless DB-686 DELI® (COXO, China). A second layer of infiltrating resin was applied, left for 1 min and light cured for 40 s. Surfaces were polished with polishing rubber points (KENDA, USA) and with diamond impregnated polishing brushes, high-luster polishing pastes using goat-hair brushes, and aluminium oxide paste using felt wheels from ENA HRI polishing system (ENA HRI, Italy).

To perform resin infiltration immediately after bleaching, an antioxidant must be applied. About 10% of alpha tocopherol solution was prepared by diluting 10 g alpha tocopherol (Puritan’ Pride, INC. Ronkonkoma, USA) in 100 ml ethanol to make 10% solutions [12]. It was applied on labial surfaces of teeth for 10 min by microbrushes and then rinsed with ethanol for 30 s [13].

In M4, microabrasion was performed followed by power bleaching and resin infiltration as described for the previous treatment modalities. All modalities were performed in a single visit. Patients were instructed to decrease the consumption of colored food and drinks with adequate tooth brushing in all the modalities.
Evaluation

Color change was evaluated by Spectrophotometer (VITA Easyshade®) based on Commission Internationale de l’Eclairage (CIE Lab) color system. Measurements were taken in daylight for standardization. They were performed in the middle region of labial surfaces of tooth. For each tooth, measurements were repeated 3 successive times and the mean was taken. The obtained values were translated to the manufacturer’s L, a, and b values at each time. Measurements were based on CIE Lab color system involving three parameters to define color: L (lightness), a (red/green chromaticity), and b (yellow/blue chromaticity). Teeth were clinically evaluated 5 times (T): Baseline (T₀), immediately after treatment (T₁), after 3 months (T₂), after 6 months (T₃) and after 9 months (T₄). Color change was calculated from the formula of \( \Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2} \), where \( \Delta L \), \( \Delta a \), and \( \Delta b \) were the difference between mean values of readings at different timepoints from baseline readings [14].

Statistical analysis

Data were be subjected to normality statistical test. ANOVA repeated measures were be followed by Duncan multiple range tests (DMRTs) to compare between groups. Data analyses were carried out using computer software Statistical Package for the Social Science SPSS (IBM-SPSS ver. 26.0 for Mac OS).

Results

The \( \Delta E \) values of different treatment modalities (\( M_1-M_4 \)) and different timepoints (\( T_1-T_4 \)) were evaluated by two-way ANOVA (Table 1). Two-way ANOVA revealed that treatment modalities and time induced highly significant changes in \( \Delta E \), and the interaction between treatment modalities (\( M_i-M_j \)) and time (\( T_k-T_l \)) were statistically significant (\( p<0.001^{***} \)). Differences were assessed using one-way ANOVA. Data represented as mean ± SD standard deviation (Figure 1).

![Figure 1: The \( \Delta E \) values of different Treatment modalities (\( M_i-M_j \)) at different time-points (\( T_k-T_l \)). Differences were assessed using one-way ANOVA. Data represented as mean ± SD standard deviation, error bars represent the standard deviation.](https://oamjms.eu/index.php/mjms/index)

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Regarding evaluation time

A significant difference was observed in all treatment modalities at all evaluation times from baseline.

Immediately after treatment (\( T_1 \))

The highest \( \Delta E \) mean values were recorded in \( M_4 \) followed by \( M_2 \) and \( M_1 \) with significant difference between them. The lowest \( \Delta E \) mean value was recorded in \( M_1 \).

After 3 months (\( T_2 \))

The highest \( \Delta E \) mean values were recorded in \( M_1 \) followed by \( M_2 \) and \( M_4 \) with significant difference between them. The lowest \( \Delta E \) mean value was recorded in \( M_1 \).

After 6 months (\( T_3 \))

The highest \( \Delta E \) mean values were recorded in \( M_4 \) followed by \( M_2 \) with significant difference between them. The lowest \( \Delta E \) mean values were recorded in \( M_2 \) and \( M_4 \) with no significant difference between them.

After 9 months (\( T_4 \))

The highest \( \Delta E \) mean values were recorded in \( M_1 \) followed by \( M_4 \) with significant difference between them. The lowest \( \Delta E \) mean values were recorded in \( M_4 \) and \( M_1 \) with no significant difference between.

Regarding treatment modality

The highest \( \Delta E \) mean value was recorded at \( T_1 \) in all the treatment modalities. The lowest \( \Delta E \) mean values were
value was recorded at $T_4$ in $M_1$ and $M_2$, while in $M_3$ and $M_4$ the lowest $\Delta E$ mean value was recorded at $T_4$.

**Power bleaching ($M_3$)**

The highest $\Delta E$ mean values were recorded at $T_1$ followed by $T_2$ and $T_3$ with significant difference between them. The lowest $\Delta E$ mean value was recorded at $T_4$.

**Microabrasion and power bleaching ($M_4$)**

The highest $\Delta E$ mean values were recorded at $T_1$ followed by $T_2$ and $T_3$ with significant difference between them. The lowest $\Delta E$ mean value was recorded at $T_4$.

**Power bleaching and resin infiltration ($M_1$)**

The highest $\Delta E$ mean values were recorded at $T_1$ followed by $T_2$ and $T_3$ with significant difference between them. The lowest $\Delta E$ mean value was recorded at $T_4$.

**Microabrasion, power bleaching, and resin infiltration ($M_2$)**

The highest $\Delta E$ mean values were recorded at $T_1$ followed by $T_2$ and $T_3$ with significant difference between them. The lowest $\Delta E$ mean value was recorded at $T_4$.

**Discussion**

Conditions like dental fluorosis are known to affect esthetics of teeth. It has an aesthetic concern to many people particularly in the anterior region where it is more visible to others [3]. Many researchers reported that even the mild forms of fluorosis can cause deviations in the esthetic appearance of teeth [1].

In power bleaching only ($M_1$), the highest color change ($\Delta E$) was recorded immediately after treatment. This is may be explained by the breakdown of organic chromophores to non-colored organic compounds increasing lightness ($L$) [15], [16]. While color relapse was noted after 3-, 6-, and 9-month follow-up. This may be due to teeth being dehydrated immediately after bleaching, especially when light was used. This produced a great whitening effect on the teeth, which decreased after rehydration, as observed after 3-, 6-, and 9-month follow-up [17], [18]. In addition to increased liability of enamel surface to demineralization and adherence of pigments as a result of the microstructural changes and increased surface roughness after bleaching [19], [20].

These results came in agreement with Gupta et al., 2017, who found that Inoffice bleaching with 35% hydrogen peroxide (Pola Office®) activated by lightemitting diode (LED) bleaching unit was successful in bleaching and removal of fluorosis stains with 3 months color relapse [17]. In combination of microabrasion and power bleaching treatment modality ($M_3$), the highest color change ($\Delta E$) was recorded immediately after treatment which was higher than power bleaching alone. This may be explained by the removal of superficial enamel layer by microabrasion which may increase the success of further treatments such as bleaching as this removal increases the enamel permeability allowing greater penetration of bleaching agent into enamel enhancing its effect [17], [21], [22]. While color relapse was also observed after 3-, 6-, and 9-month follow-up. This may be due to structural changes and surface porosity in the enamel surface caused by microabrasion and bleaching. [19], [20].

These results came in agreement with Román-Rodríguez et al., 2020, who reported that the combination of microabrasion and bleaching techniques successfully reduced the appearance of white spots [23]. However, these results came in disagreement with Gupta et al. 2017, who found that 35% hydrogen peroxide in-office bleaching activated by LED bleaching unit and the combination of microabrasion and bleaching were equally effective in elimination of fluorosis stains in children. This conflict may be attributed to different methodologies as the study was done on moderate fluorosis in children with 10–17 years of age. [17].

The highest color change ($\Delta E$) was found in combination of microabrasion, power bleaching and resin infiltration treatment modality ($M_4$), and combination of power bleaching and resin infiltration ($M_5$). The highest color change ($\Delta E$) was recorded immediately after treatment. This may be explained by infiltration of resin into the microporosities of enamel, masking the white spots because the refractive index of resin (1.52) is very close to that of healthy enamel (1.62) [24], [25], [26]. In addition, the penetrability of enamel increases after bleaching due to the release of free radicals enhancing the masking effect of resin infiltration. Color relapse was noted after 3-month follow-up. This may be explained by increased liability to discoloration after resin infiltration because the chemical composition of the infiltrant may lead to water sorption. Furthermore, the high consumption of colored food and drinks by the patient may contribute to staining [2]. However, slight color improvement was observed after 6- and 9-month follow-up compared to 3 months. This improvement may be explained by water absorption by the resin over time, which was not removed completely by the alcohol. This absorption can result in minimizing the optical interfaces in the light path thus improving the lesion translucency [24], [26], [27].

These results came in agreement with Gugnani et al., 2017, who reported that combination of bleaching...
and resin infiltration was more effective than bleaching alone in the esthetic improvement of mild-to-moderate fluorosis [1]. Furthermore, in agreement with Horuztepe and Baseren, 2017, who found that the combination of bleaching and resin infiltration treatment resulted in the highest color change of white spot lesions compared to either using bleaching alone [20]. Furthermore, in agreement with Saxena et al., 2021, who reported that the combination of microabrasion, bleaching and resin infiltration had the best esthetic results compared to resin infiltration alone or combination of microabrasion and resin infiltration in mild to moderate fluorosis [28]. Thus resin infiltration treatment modalities seemed to be very effective in the esthetic treatment of mild fluorosis, despite slight relapse may occur.

**Conclusion**

Under the limitations of the present study, it was concluded that resin infiltration treatment modalities were more effective in treating mild dental fluorosis with more color stability compared to either power bleaching alone or combination of microabrasion and power bleaching.

**References**


