Newer Technique of Extra-Coronal Bleaching with Sodium Perborate on Non-Pitted Fluorosis Stains in Permanent Anterior Teeth

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Variety of treatment approaches have been proposed for esthetic management of dental fluorosis. Microabrasion, bleaching using hydrogen peroxide, and etch bleach seal are commonly used methods. Bleaching using sodium perborate has been used for intracoronal bleaching. Till now, no study has used sodium perborate for extracoronal bleaching of discolored stained teeth. ***Objectives****: To evaluate the esthetic improvement of non-pitted fluorosis stains using sodium perborate and compare with etch bleach seal, microabrasion and in-office bleaching with 30% H2O2 on visual assessment scale VAS (primary objective) and to assess any untoward effects including staining, sensitivity, gingival problems within the course of study (secondary objectives).* ***Study design:*** *A randomized control trial with 6 months follow up. Methodology- Twenty children aged 8 to 12 years with non-pitted fluorosis in upper anterior teeth were divided into 4 groups with 5 patients in each group.* ***Results and discussion:*** *All of the techniques showed improvement in esthetics with VAS. However, microabrasion and bleaching using sodium perborate had significantly better results than other 2 techniques.* ***Conclusion:*** *Sodium perborate showed excellent results in extracoronal bleaching of fluorosed teeth. However a randomized study with large sample size is required to draw a definitive conclusion regarding superiority of one technique over others.*

Keywords- dental fluorosis, bleaching, sodium perborate, microabrasion, etch bleach seal

INTRODUCTION

Dental fluorosis is a developmental disturbance caused by exposure of developing teeth to high concentration of fluoride. In fluorosis a diffuse hypomineralisation or porosity in subsurface enamel is seen which is covered by a relatively well mineralized outer surface layer.[1] Teeth affected by dental fluorosis are seen clinically as bilateral symmetrical white spots or opaque white lines (striations) that lack a clear border with unaffected enamel. In moderate to severe fluorosis, brownish stains are seen due to uptake of extrinsic stains. At higher levels, discrete or confluent pitting is seen. In maxillary central incisors, the critical period for clinically significant dental fluorosis is during 15 to 30 months.[1] The classification systems commonly used for dental fluorosis are Dean's index, Thylstrup and Fejerskov index and community fluorosis index. [2-4]

The unesthetic appearance is the primary concern of the patients. Variety of treatment approaches have been proposed for esthetic management of dental fluorosis. Microabrasion, bleaching using hydrogen peroxide, and etch bleach seal are commonly used non-invasive methods. [1, 4-11]

In Microabrasion, outer enamel layer is removed upto a depth of 25-200µm, depending on the type of abrasive, concentration and the duration of the gel application.[4] It re-creates the outer, prism free region due to the compaction of minerals resulting from the simultaneous erosive and abrasive action of the microabrasion compound on the dental enamel and teeth become glassy and this is termed "*Abrosion effect*" (abrasion plus erosion).[5] This layer reflects or scatters the light and masks mild imperfections.

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Etch bleach seal technique using 5% sodium hypochlorite (NaOCl), has been proven successful in removing yellow-brown discolorations from hypomineralized young permanent teeth. This technique uses materials that are readily available in dental clinics and can be used with safety on young permanent teeth.[6,7]

During bleaching, reactive oxygen species (ROS) such as hydroxyl (**OH˙**) and perhydoxyl (HO_2˙) radicals are formed.[12] These free radicals diffuse through enamel and dentine, causing breakage of double bonds of pigmented molecules, which lead to perception of whiter tooth colour. Acidic H_2O_2 based bleaching agents are always associated with hydroxyl radicals (**OH˙**) who have many deleterious effects like post bleach sensitivity and cervical root resorption (intracoronal bleaching).[12] An alternative approach can help to avoid these ill effects. Alkaline sodium perborate produces HO_2˙only which are more biologically compatible.[12] Sodium perborate has been used for intracoronal bleaching only. Till now, no study has used sodium perborate for extracoronal bleaching of discolored fluorosed teeth. The study aims to evaluate the esthetic improvement of non-pitted fluorosis stains using sodium perborate bleaching and compare with etch bleach seal, microabrasion and in-office bleaching with 30% H_2O_2 on visual assessment scale VAS (primary objective) and to assess any untoward effects including staining, sensitivity, gingival problems within the course of study (secondary objectives).

MATERIALS AND METHOD

The study was conducted at Department of Pedodontics and Preventive Dentistry, Post Graduate Institute of Dental Sciences, Rohtak. Its design was reviewed and approved by the Institutional ethical committee. The inclusion criteria were healthy cooperative children, aged between 8 to 12 years presenting with nonpitted fluorosis in permanent maxillary anterior teeth and have score 1-4 according to Thylstrup-Fejerskov index of fluorosis (Table 1). Written informed consent and assent forms were obtained. The exclusion criteria were children with non-fluoride opacities and pitted fluorosis, history of known allergy towards any dental material, anterior tooth fracture, teeth with direct or indirect restorations in anterior teeth and with past history of treatment for dental fluorosis, any systemic illness, severe sensory and/or motor impairment and local conditions not permitting the intervention, and who were unwilling for participation in the study.

Twenty children were divided into 4 groups with 5 patients in each group.

Group I **(**Control group)**-** In-office bleaching with 30% H_2O_2.

Group II- Intervention with Etch bleach seal.

Group III- Intervention with in-office bleaching using Sodium perborate.

Group IV- Intervention with enamel microabrasion.

Randomization

The children were randomly allocated in four different groups in accordance to the sequence generation table by independent personnel not involved in the sequence generation.

Table 1: Thylstrup and Fejerskov's Fluorosis index (TFI) [3]

Grade	Features on Enamel Surface
0	Normal creamy surface after drying
1	Faint white lines
2	Distinct white lines, with some merged
3	Cloudy opacities with white lines in between
4	Paper white opacities on entire surface
5	Pitted and opaque surface
6	Merged pits form rows <2 mm high
7	Irregular pattern of enamel loss (<½)
8	½ surface enamel lost, remaining enamel being opaque
9	Cervical rim of opaque enamel

Blinding/Masking

The study was double blinded. The individual participant did not know their categorization in various treatment groups. Furthermore, to ensure blinding of the outcome evaluators, the evaluators were not being disclosed about the participant's treatment group. However, the operator was in full possession of the facts regarding subject allotment to study groups.

Prior to the beginning of treatment procedure, full mouth scaling was performed in all the participants and rubber dam was placed to protect the soft tissues and achieve a clean and dry working field. Special attention was given to protecting both the patient and professional with the use of protective goggles and individual protective equipment.

Clinical procedure

Group I- Control group- In-office bleaching with 30% H_2O_2

30% hydrogen peroxide solution (Rankem, Avantor Performance Materials India Ltd, India) was applied onto the buccal surface of teeth using an applicator tip and continuously rubbed for 10 minutes. The remaining solution was washed off thoroughly with water and removed using high quality suction. The teeth were re-examined. A second cycle is repeated for another 10 minutes. Figures 1a and 1b show the change in clinical appearance of teeth after treatment with 30% H_2O_2.

Group II- Intervention with Etch bleach seal

First step includes the application of 37% phosphoric acid gel (Ivoclar EcoEtch, Zurich) for 60 seconds. The etchant was washed away after 30 seconds with water spray and air dried. The second step involves application of 5% NaOCl (Prevest Denpro Hyposol 5%, India) using an applicator tip. The solution was continuously rubbed onto the teeth surface for 10 minutes. The remaining solution was washed off thoroughly with water and removed using high quality suction. The teeth were re-examined. A second cycle was repeated for another 10 minutes. The last step involves the application of low viscosity bonding agent (Adper™ Single bond 2, 3M ESPE Dental products,USA), which was light cured for 40 seconds. Figures 2a and 2b show the change in clinical appearance of teeth after treatment with Etch bleach seal technique.

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Fig 1a: Pretreatment picture showing unaesthetic appearance of maxillary incisors (Group I)

Fig 1b: Post treatment picture after in-office bleaching with 30% H_2O_2 was performed (Group I)

Fig 2a: Pretreatment picture showing unaesthetic appearance of maxillary incisors (Group II)

Fig 2b: Post treatment picture after Etch bleach seal technique was performed (Group II)

Group III- Intervention with in-office bleaching using Sodium perborate

Sodium perborate tablets (Clinsodent, ICPA Health Products Limited, Ankleshwar,India) were crushed and mixed with 0.3 ml of 30% hydrogen peroxide to obtain a paste consistency. Thereafter, a consistent and thick layer was applied onto the teeth buccal surface using an applicator tip. The paste was continuously rubbed onto the teeth surface for 10 minutes. The remaining paste was washed off thoroughly with water and removed using high quality suction. The teeth were re-examined. A second cycle was repeated for another 10 minutes. Figures 3a and 3b show the change in clinical appearance of teeth after treatment with in-office bleaching using Sodium perborate.

Fig 3a: Pretreatment picture showing unaesthetic appearance of maxillary incisors (Group III)

Fig 3b: Post treatment picture after in-office bleaching using Sodium perborate was performed (Group III)

Group IV- Intervention with enamel microabrasion.

The material selected for the microabrasion technique i.e. pumice (Prolax, Ammdent, India) was mixed with 37% phosphoric acid gel. Thereafter, a consistent and thick layer was applied onto the buccal surface using an applicator tip. The material was rubbed over the tooth using a low speed rubber cup for 10 minutes. The remaining gel was washed off thoroughly with water and removed using high quality suction. The teeth were re-examined. A second cycle was repeated for another 10 minutes. Figures 4a and 4b show the change in clinical appearance of teeth after treatment with enamel microabrasion technique.

At the end of procedure, in all the groups teeth were polished using ACP-CPP crème (GC tooth mousse, GC Corp., India).

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Fig 4a: Pretreatment picture showing unaesthetic appearance of maxillary incisors (Group IV)

Fig 4b: Post treatment picture after enamel microabrasion technique was performed (Group IV)

Clinical outcomes

The improvement in esthetics (change in white opacities/ brown stains) were evaluated using standardized preoperative and postoperative photographs at immediate, 1 month, 3 months and 6 months time intervals using VAS scales ranging from 1 to 7. To establish blinding of the outcome, the participant's treatment group was not disclosed to the evaluators. Two evaluators were adequately trained by the investigators regarding the scoring criteria and how to evaluate the results. Cohen's Kappa statistics were calculated for intra-examiner and inter-examiner reliability. Any adverse effects including staining, sensitivity, and gingival problems within the course of study were also recorded. The data was compiled and put to statistical analysis.

RESULTS

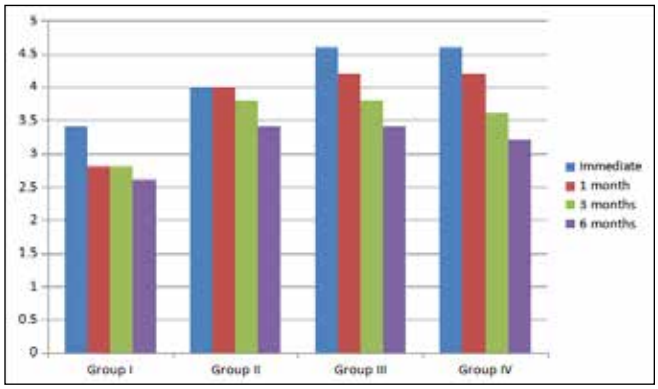
Kruskal-Wallis test was used for Intergroup and Mann-Whitney for intragroup comparisons. All of the techniques showed improvement in esthetics with VAS (Table 2 and Graph 1). However, microabrasion and bleaching using sodium perborate had significantly better results immediate post-operatively as compared to control group i.e. Group I (Table 3). The intergroup difference in aesthetics became non-significant in all groups at 6 months (Table 3). Intragroup comparison showed statistically significant reduction in the VAS scores (recurrence of stain or reduction in esthetic appearance) after 6 months of evaluation in all the groups except Group II (EBS) (Table 4).

Table 2: Inter group comparison of mean improvement in esthetics in study subjects.

Groups	Study subjects (N)	Mean VAS Score for IE	SD	p-value of one way ANOVA
Immediate I	5	3.40	0.548	
II	5	4.00	0.707	
III	5	4.60	0.548	0.034*
IV	5	4.60	0.548	
1 month I	5	2.80	0.447	
II	5	4.00	0.707	
III	5	4.20	0.447	0.007*
IV	5	4.20	0.447	
3 months I	5	2.80	0.447	
II	5	3.80	0.447	
III	5	3.80	0.447	0.029*
IV	5	3.60	0.548	
6 months I	5	2.60	0.548	
II	5	3.40	0.548	0.118
III	5	3.40	0.548	
IV	5	3.20	0.447	

N, number of subjects; VAS, Visual Analog Scale; IE, improvement in esthetics; SD, Standard deviation; *indicates statistical significant ($p<0.05$)

Graph 1: Inter group comparison of mean improvement in esthetics (IE) scores over follow-up time intervals at immediate, 1 month, 3 months and 6 months post operative



*p value is <0.05 (statistically significant) for group I, III and IV

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Table 3: Pair wise comparison of mean improvement in esthetics

Dependent Variable	Group	Group	Difference in Mean VAS Score for IE between groups	p value
Immediate	I	II	-0.6	0.166
	I	III	-1.2	0.020*
	I	IV	-1.2	0.020*
1 month	I	II	-1.2	0.018*
	I	III	-1.4	0.005*
	I	IV	-1.4	0.005*
3 months	I	II	-1.0	0.015*
	I	III	-1.0	0.015*
	I	IV	-0.8	0.042*
6 months	I	II	-0.8	0.058
	I	III	-0.8	0.058
	I	IV	-0.6	0.093

VAS, Visual Analog Scale; IE, improvement in esthetics; *indicates statistical significant (p<0.05)

DISCUSSION

Dental fluorosis is a form of enamel hypoplasia leading to enamel with lower mineral content, an increased organic content and increased porosity.[1,4] It has social and psychological effects on the quality of life of person.[13,14] Non invasive/minimally invasive treatment approaches are preferred in children with young permanent teeth. The major benefits with these treatment approaches include no or minimal tooth reduction, mild transient or no instance of post operative sensitivity, painless, fast and easy procedures. These methods are more successful in milder degrees of fluorosis as compared to severe stains as lesser the degree of fluorosis, the less porous is the enamel surface.

Prevalence and severity of dental fluorosis is more in permanent dentition as compared to primary teeth probably because of placental barrier to fluoride, shorter duration of enamel formation and maturation of primary teeth, and thinner enamel of primary teeth. Therefore, only permanent teeth of patient in age group of 8 to 12 years were taken in study.

The greatest improvement in esthetics was obtained with microabrasion and bleaching using sodium perborate. Alkaline sodium perborate releases perhydroxyl ($HO_2^{\bullet}$) **radicals** only that too very slowly during bleaching process which make it more biocompatible to oral tissues.[12] So, the disadvantages of H_2O_2 based bleaching systems can be overcome by this. The esthetic improvement by sodium perborate in our study shows promising future for it in extra-coronal bleaching. *Lewinstein et al.* compared the effect of 30% H_2O_2 alone or mixed with sodium perborate on microhardness of enamel and dentine.[15] They suggested to limit the use of high concentration H_2O_2 and recommended sodium perborate as less damaging to enamel. Other advantages of perborate-based bleaching agents are: perborates are gentler on surrounding gums and tissues, and they can be used in countries that do not permit the use of hydrogen peroxide or carbamide peroxide for dental bleaching,

Sodium perborate is commonly used for intracoronal bleaching and cervical root resorption is one undesirable consequence of intracoronal bleaching. The exact mechanism for this effect is unclear, but it has been suggested that this may be attributed to excessive hydrogen peroxide diffusing into the periradicular tissues through the dentinal tubules which initiates an inflammatory reaction. [12,16-18] It has also been speculated that the peroxide, by diffusing through the dentinal tubules, denatures the dentin, which then becomes an immunologically different tissue and is attacked as a foreign body. [19] However, in the present study no undesirable consequences were seen when sodium perborate was used in combination with hydrogen peroxide. It may be because it was used for extracoronal bleaching of enamel and no diffusion into the periradicular tissues occurred during extracoronal bleaching.

Ari and Üngor (2002) related that sodium perborate should be mixed with water rather than with hydrogen peroxide in order to prevent or minimize the occurrence of bleaching related external root resorption.[20] Weiger, *et al* (1994) and Rotstein *et al* (1991) reported that the esthetic results of teeth bleached with a mixture of tetrahydrate sodium perborate and water or hydrogen peroxide were similar.[21,22] Oliveira *et al* [21] (2006) also verified that the mixture of sodium perborate and hydrogen peroxide presented similar esthetic results compared to the combination with distilled water.[23]

In the present study, least scores for the aesthetic improvement were recorded for the group where bleaching was done with 30% H_2O_2. The reasons could be-(1) H_2O_2 is used without any accelerator or catalyst (light source like LED); (2) Results were after a single sitting procedure, whereas multiple appointments and multiple applications in each sitting might be required to achieve satisfactory results; (3) H_2O_2 was used in solution form whose retention on

Table 4: Intra group comparison of mean improvement in esthetics scores over 6 months post operative follow-up.

Study Groups	Follow-up Time	Study Subjects (N)	Mean VAS score of IE	SD	p-value of ANOVA
Group I	Immediate	5	3.40	.548	0.04*
	6 months	5	2.60	.548	
Group II	Immediate	5	4.00	.707	0.08
	6 months	5	3.40	.548	
Group III	Immediate	5	4.60	.548	0.03*
	6 months	5	3.40	.548	
Group IV	Immediate	5	4.60	.548	0.03*
	6 months	5	3.20	.447	

N, number of subjects; VAS, Visual Analog Scale; IE, improvement in esthetics; SD, Standard deviation; *indicates statistical significant (p<0.05)

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teeth was unpredictable as compared to gel form. Our findings are in accordance with Knoesel *et al* who found that a single 1-hour session of in-office bleaching with 30% hydrogen peroxide did not significantly affect the color and luminosity of fluorotic teeth.[8]

The inter group comparisons showed that there was a statistically significant improvement ($p<0.05$) in esthetics, in enamel microabrasion group. The reason could be that in the mild fluorosis, fluorotic lesions lie in the outer 80–100 μm of enamel as demonstrated by Thylstrup and Fejerskov.[4] This outer layer of enamel can be easily removed during microabrasion, leaving smooth, glassy, prism-free enamel that reflects and refracts light in such a way that underlying stains are believed to be camouflaged.[1,24] This type of treatment does not weaken the enamel surface, rather renders the surface more resistant to demineralization and reduces colonization by Streptococcus mutans.[1] The results are in accordance with various authors such as Sundfeld *et al,*[5,25] Celik *et al*[4] and Train *et al*[9] who had demonstrated positive long term follow up results of microabrasion procedure in mild to moderate fluorosis stains.[4] However, in contrast to the present study, Shahroom *et al*[10], and Castro *et al*[11], stated that microabrasion resulted in less aesthetic improvement compared to bleaching. The microabrasive method only removes the outer enamel surface; it cannot eliminate deep, intrinsic stains and porosities.[4] Some authors reported a darker or yellowish color on teeth subjected to enamel microabrasion.[5] This was attributed to the fact that teeth become thinner and the underlying dentin changes color after treatment.

Enamel microabrasion can be done using 18% HCL and pumice or 6.6% and 10% HCL with silica carbide particles or even 37% phosphoric acid with pumice.[5] However, care should be taken while using HCl, being it more corrosive. Sinha *et al* [26] found H_3PO_4 clinically superior to HCl; however, the difference was nonsignificant. We preferred the use of phosphoric acid for two reasons. Firstly, it is readily available in most dental offices. Second, and more important, 37% phosphoric acid removes less enamel compared with hydrochloric acid. Nahsan *et al* (2011)[27] suggested the application of 37% phosphoric acid gel associated with extra fine grain pumice in proportions of equal volume in order to make this technique safer and more practical.

Etch bleach seal group showed better results than H_2O_2 bleaching group however, the difference was not statistically significant ($p<0.05$). The possible reasons may be phosphoric acid denudes the microcavities containing the organic elements, facilitating the penetration of bleaching agents. The bleaching agent is sodium hypochlorite, which is highly effective in removing organic material by oxidizing it (Hypochlorous acid releases chlorine forming chloramines).[1] Another critical step is resin perfusion which prevents re-staining of the lesion.[6,7]

All of the techniques showed improvement in esthetics with VAS scores immediate post-operatively. However, change in tooth color was observed after 1 month, 3 months and 6 months. This may be because teeth were dehydrated immediately after bleaching causing an illusionary effect of whitening of teeth, which tended to disappear after rehydration as observed in follow-up periods. Etch bleach seal technique showed most stable esthetic results even after 6 months. This may be attributed to the sealing step in EBS technique by resin perfusion of the hypomineralized lesion to prevent future chromogens from entering the porous enamel causing a re-staining of the lesion. [6,7]

Evaluation of Tooth Sensitivity and Gingival Irritation

Only 2 patients of group I (30% H_2O_2) reported mild sensitivity which subsided within a week. It may be due to high peroxide concentrations, acidic pH of bleach which can lead to a surface roughness of enamel surface and the presence of nascent oxygen free radicals, which can enter in the dentinal tubules causing fluid movement.[28-30] None of the patients reported gingival irritation or staining in any of the groups during the course of our study, most probably because all the procedures were done under rubber dam isolation. Our findings are in accordance with many studies that recorded only very mild transient tooth sensitivity after the use of either microabrasion or bleaching which was not clinically relevant and subsided after about a month. It has also been suggested that the darker the teeth, the increased risk of hypersensitivity. Darker teeth have a higher amount of organic content which retains the hydrogen peroxide in the enamel and dentin. In the present study, the teeth were polished using ACP-CPP crème (GC tooth mousse) at the end of the treatment procedure with the purpose of reducing post operative sensitivity and promote remineralization.

CONCLUSION

The results of all the techniques were satisfactory. Sodium perborate showed excellent results in extracoronal bleaching of fluorosed teeth and can be a suitable alternative. However, a randomized study with large sample size and longer follow-up is required to draw a definitive conclusion regarding superiority of one technique over others.

Compliance with Ethical Standards

Funding:

No Funding received

Conflict of Interest

None

Ethical approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent:

Informed consent was obtained from all individual participants included in the study.

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