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Impact of Remineralizing Desensitizers on Whitening Effectiveness, Enamel Integrity, and Color Retention in Tooth Bleaching

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Abstract: ***This study explores the role of fluoride-based desensitizers in enhancing the safety and durability of tooth bleaching treatments. Thirty extracted human teeth were divided into six groups, each subjected to different desensitizer application protocols before and after bleaching. While the bleaching efficacy remained largely unaffected by desensitizer timing, variations were observed in enamel corrosion and post-treatment color stability. Notably, pre-treatment with desensitizers reduced surface erosion, and continuous use helped maintain whitening over time. In my view, this suggests that strategic application of remineralizing agents can improve clinical outcomes in cosmetic dentistry.***

Keywords: Desensitizing agents, tooth bleaching, enamel erosion, color rebound, fluoride therapy

1. Introduction

External tooth bleaching methods include cold light bleaching [1], Er: YAG laser bleaching [2], ozone bleaching [3], etc.Tooth bleaching is to achieve the purpose of teeth whitening by decomposing and desalinizing the surface and deep layer pigments of teeth through the active ingredients in bleaching agents, such as hydrogen peroxide and urea peroxide [4].It is preferred as it avoids removal of tooth tissue, the cost is low, and the effect time is short. However, external tooth bleaching also has its disadvantages. It not only causes a decrease in enamel surface hardness, an increase in roughness, and a risk of tooth sensitivity [5-6], but also increases the porosity of the enamel surface, leading to teeth being more prone to coloring and increasing plaque adhesion, resulting in poor maintenance of tooth bleaching effect [7].Therefore, some studies have shown that 55%-75% of patients report different degrees of tooth sensitivity after clinical application [8-9].How to reduce the adverse effects caused by tooth bleaching and effectively avoid the color rebound after tooth whitening to reduce the frequency of re-bleaching has been the focus of recent research. In particular, there are few studies on methods to maintain the bleaching effect. The purpose of this study is to investigate the effect of using dental desensitizers at different time points of tooth whitening on the effect of tooth whitening, the degree of tooth erosion, and the maintenance of tooth whitening. The purpose of this study is to investigate the effect of using dental desensitizers at different time points.

2. Materials and Methods

2.1 Experimental Materials

2.1.1 Experimental teeth: Thirty caria-free molars extracted for orthodontic treatment were included in the study. The inclusion criteria of teeth were non-tetracycline teeth or fluorosis teeth, partially intact crown, no caries, no filling, no restoration, no orthodontic and bleaching history, and the original color scale of teeth was A3 or D3. After the teeth were removed, the soft tissue around the root of the teeth was immediately cleaned and stored in normal saline at 4℃.

2.1.2 Experimental reagents and materials: Dental bleaching agent (Xiling (Zhenjiang) Medical Technology Co., LTD.), dental desensitizer (Xiling (Zhenjiang) Medical Technology Co., LTD.), VITAPAN Classical shade guide, black tea solution for staining.

2.2 Experimental Methods

2.2.1 Experimental grouping
Thirty isolated premolars were randomly divided into prophylactic use group A (n=5), preoperative use group B (n=5), postoperative use group C (n=5), continuous use group D (n=5), bleaching + staining group E (n=5), bleaching + staining + continuous use group F (n=5). Five teeth of six groups were marked as A-1, A-2, A-3, A-4, A-5, respectively. B-1, B-2, B-3, B-4, B-5; C-1, C-2, C-3, C-4, C-5; D-1, D-2, D-3, D-4, D-5; E-1, E-2, E-3, E-4, E-5; F-1, F-2, F-3, F-4, F-5.

2.2.2 Bleaching chrominance record

Six groups of teeth were removed from normal saline, rinsed with purified water, dried, and placed under the same care and background conditions. The "VITAPAN Classical shade guide" was used to find the hue that matched the color of each tooth in each group and recorded.

2.2.3 Tooth bleaching

Teeth whitening was performed in all groups according to the instructions for the use of tooth bleaching agents.The difference was as follows: preventive treatment group A (5 teeth) applied desensitization agent in the morning and evening for 3 consecutive days before bleaching. After each application, the teeth were left to stand for 5 minutes, washed with purified water, and immersed in 4℃ normal saline for the rest of the time.Before surgery, the 5 teeth in group B were smeared with desensitizer, left for 5 minutes, cleaned with purified water, and dried before tooth whitening. The 5 teeth in group C were smeared with desensitizer after tooth whitening and left for 5 minutes before cleaning and blowing dry.The teeth in group D were treated with desensitizer for 3 consecutive days. After each application, the teeth were left to stand for 5 minutes.Five teeth in bleaching + staining group E were immersed in the staining solution at noon every day for 60 seconds after tooth whitening, and immersed in normal saline at 4℃ for the rest of the time for a week.After tooth whitening, the 5 teeth in group F were immersed in the staining solution at noon every day for 60 seconds, and the desensitizer was applied in the morning and evening every day. After each application, the teeth were left for 5 minutes and cleaned, and the rest of the time was immersed in 4℃ normal saline for a week.

After the bleaching treatment, all the groups were placed in the same light and background conditions, and the "VITAPAN Classical shade guide" was used to find and record the hue that matched the color of each tooth in each group. The bleaching effect of each tooth was calculated by comparing the color level before and after bleaching. The bleaching + staining E and bleaching + staining + continuous use F groups were placed again under the same light and background conditions after one week of continuous use, and the tooth color scale was determined against the "VITAPAN Classical shade guide".

2.2.4 Scanning electron microscopy

The bleaching teeth of groups A-D were dried, fixed on the specimen stage, placed in vacuum and sprayed with gold film. The surface microstructure and enamel roughness of the teeth were observed by scanning electron microscope (SEM) under 5000 times electron microscope.

2.3 Statistical Methods

2.3.1 Statistical method of bleaching effect: Raw data and mean values of bleaching effect research data were recorded, and paired P test and one-way ANOVA were used. The test level was set as 0.05 for significant difference and 0.01 for extremely significant difference.

2.3.2 Corrosion degree statistical methods: According to the flatness of the tooth surface under scanning electron microscope, the corrosion degree of the tooth surface was divided into 5 grades: corrosion degree 0 grade < 1 grade < 2 grade < 3 grade < 4 grade. The raw data and the average value of the corrosion degree data were recorded, and paired T test and one-way ANOVA were used. The test level was set at 0.05 for a significant difference and 0.01 for a very significant difference.

3. Results

3.1 Bleaching effect of groups A-D

According to the following data, the four groups A-D had A certain bleaching effect on the teeth before and after tooth bleaching, and the bleaching effect was 3-4 color levels, and there was no significant difference in the bleaching effect of each group.

Table 1: Efficacy of tooth bleaching in groups A-D

Group	A-1	A-2	A-3	A-4	A-5	B-1	B-2	B-3	B-4	B-5
Change in shade level	3	4	3	4	4	4	3	4	4	3
Average value	3.6					3.6				
Group	C-1	C-2	C-3	C-4	C-5	D-1	D-2	D-3	D-4	D-5
Bleach the color gradation	4	3	3	4	3	4	4	3	3	3
Average value	3.4					3.4				
Statistical differences among groups: There were no statistical differences among the groups										

3.2 Tooth surface corrosion conditions in groups A-D

From the corrosion grade scores of the four groups and the SEM scanning electron microscope images, it can be known that the degree of tooth surface corrosion is as follows: the group using dental desensitizing agent for 3 days preventatively < the group using desensitizing agent before surgery = the group using desensitizing agent continuously for 3 days after surgery < the group using desensitizing agent after surgery. Therefore, it is confirmed that using desensitizing agent before tooth bleaching can better reduce the damage of bleaching active components to teeth.

Table 2: Table of Tooth Corrosion Grades in Each Group

Group	A-1	A-2	A-3	A-4	A-5	B-1	B-2	B-3	B-4	B-5
Degree of corrosion	0	1	0	1	0	1	2	1	2	2
Average value	0.4					1.6				
Group	C-1	C-2	C-3	C-4	C-5	D-1	D-2	D-3	D-4	D-5
Bleach the color gradation	3	3	3	3	3	1	2	2	1	2
Average value	3					1.6				
P values of each group	PA-B		0.016	PA-C		0.016	PA-D		0.004	
	PB-C		1.000	PB-D		0.004	PC-D		0.004	

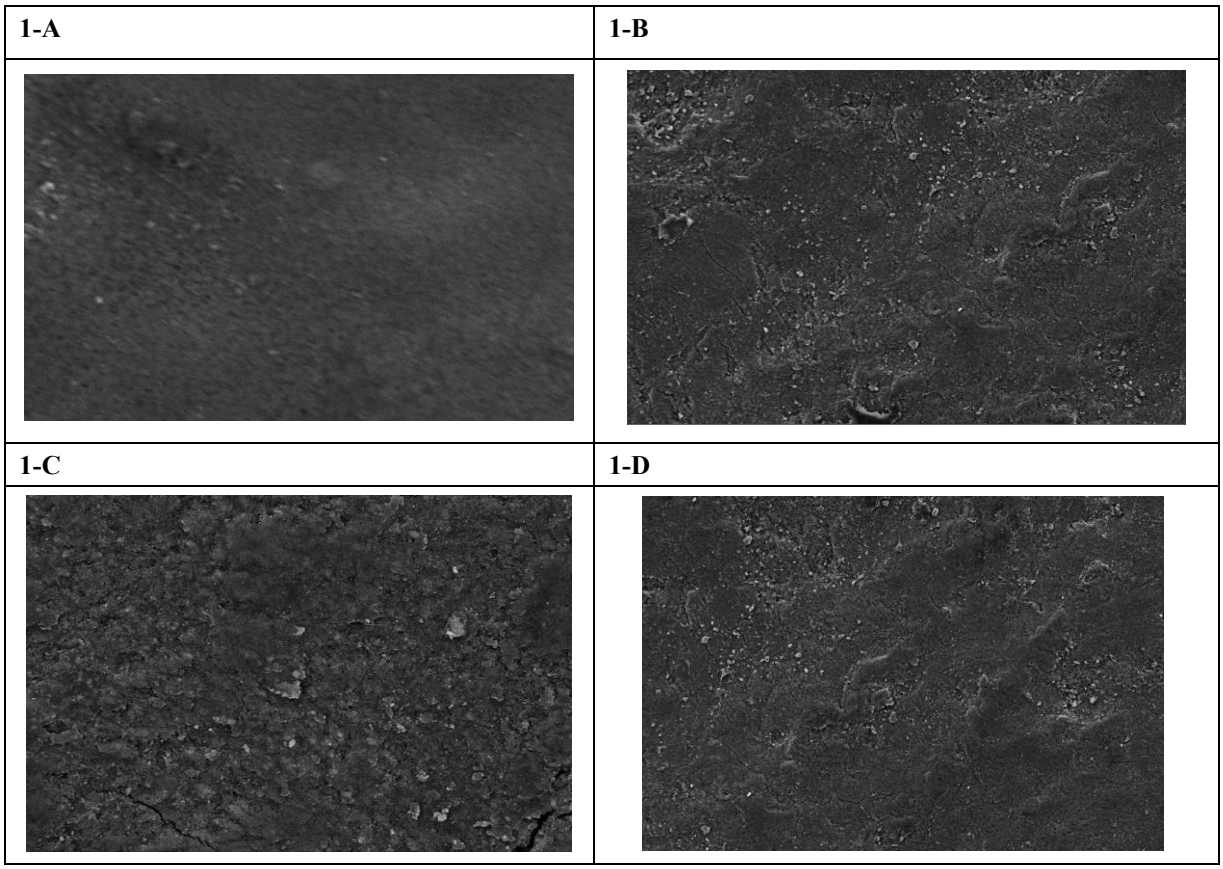

Figure 1: SEM electron microscope images of tooth surface corrosion in groups A-D

3.3 Teeth bleaching effects and anti-staining effects in groups E and F

It can be seen from the results in Table 3 that the five isolated teeth in Group E and Group F all showed a bleaching effect of 3-4 color levels after bleaching. However, after a week of simulated staining, among the five teeth in the group that continuously used desensitizing agents, only two teeth had a slight color rebound compared to before bleaching, while the color of the remaining teeth remained unchanged. The overall difference was not obvious. However, in the group without desensitizing agents, the colors of the five teeth all rebounded by 1-2 color scales, showing an obvious color rebound phenomenon.

Table 3: Bleaching and Staining Conditions of Group E and Group F (The bleaching color scales are all relative to the teeth color scales before bleaching)

	E-1	E-2	E-3	E-4	E-5	F-1	F-2	F-3	F-4	F-5
The teeth whiten immediately after bleaching	3	3	4	4	4	4	3	3	4	3
Average value	3.6					3.4				
Bleach the color scale one week after dyeing	2	2	2	2	2	3	3	3	3	3
Average value	2					3				
P	0.016									

4. Discussion

The main active ingredients in the Yiminling desensitizer used in the experiment are sodium fluoride and potassium nitrate, etc. Among them, sodium fluoride achieves desensitization by forming precipitates, calcium salts and other precipitates in the dentinal tubule fluid during the action process, thereby sealing the dentinal tubules [5, 10]. Some scholars have questioned that the function of desensitizing agents in blocking dentinal tubules may affect

the penetration of bleach, thereby influencing the bleaching effect. However, experiments have proved that since the molecular weight of peroxides is extremely small and they can penetrate between the enamel and the tubules of dentin, they will not affect the effect of bleaching agents [11]. The desensitizing effect of potassium salts is achieved by inhibiting the conduction of nerve impulses. Potassium ions can pass through the dentinal tubules, thereby enhancing the concentration of potassium ions outside local nerve cells, inhibiting the depolarization of dental pulp nerves, and reducing the sensitivity of dental pulp nerves to relieve pain. Therefore, it does not affect the bleaching effect of hydrogen peroxide on teeth.In addition, studies [12-13] have reported that desensitizers containing 5% potassium nitrate and 2% sodium fluoride can effectively reduce the occurrence of dentin sensitivity after teeth whitening, including both unfilled and filled teeth, and have no significant effect on the whitening effect. Some studies have also found that using desensitizers such as sodium fluoride and potassium nitrate before bleaching treatment can reduce tooth sensitivity without affecting the bleaching effect of the affected teeth [14-15].In this experiment, the isolated tooth samples of groups A-D all achieved similar tooth bleaching effects after tooth bleaching. Therefore, it was confirmed that the preventive use of desensitizers before tooth bleaching, and the use of desensitizers before or after tooth bleaching would not affect the bleaching effect, which is consistent with the conclusions of the above multiple research results.

During the process of tooth sensitivity caused by oral whitening, various changes occur in the tooth tissues. High concentration of HP can cause demineralization of enamel in a short period of time, making the tooth surface rough and uneven, promoting the flow of fluid in the dentinal tubules, and causing tooth sensitivity. In addition, demineralization will increase the probability of other irritants entering the dentinal tubules after the operation, aggravating tooth sensitivity during and after the operation [16-17]. Therefore, in this study, the degree of tooth corrosion was evaluated by the roughness of the tooth surface in groups A-D, thereby reflecting the degree of tooth sensitivity from the side. It can be known from the results that the degree of tooth surface corrosion is as follows: the group using dental desensitizing agent for 3 days preventatively < the group using desensitizing agent before surgery = the group using desensitizing agent continuously for 3 days after surgery < the group using desensitizing agent after surgery. Therefore, it is confirmed that using desensitizing agent before tooth bleaching can better reduce the damage of bleaching active ingredients to teeth. Li Zong [18] et al. confirmed that the prophylactic use of the desensitizing agent Jegudin significantly reduced the incidence of tooth sensitivity after tooth bleaching and alleviated the symptoms of tooth sensitivity. Navarra[19] 's research indicates that before using whitening agents, when desensitizers containing sodium fluoride and potassium nitrate were prophylactively applied, patients reported that the intensity of their tooth sensitivity decreased to varying degrees, suggesting that this drug helps alleviate the tooth sensitivity problems caused by teeth whitening. These studies have all confirmed that using desensitizers before tooth bleaching can better reduce the damage of bleaching active ingredients to teeth, which is consistent with the results of this study.

Tooth color rebound after bleaching treatment is a common problem. Affected by factors such as the cause and degree of tooth discoloration, as well as the bleaching plan, in clinical practice, this issue often leads patients to believe that the bleaching treatment is "ineffective", thus causing dissatisfaction. The color of teeth after bleaching is unstable, especially in a single clinic bleaching. Although it can be observed that the brightness of teeth significantly increases and the saturation decreases after the operation, it is common in clinical practice that the color of patients shows obvious rebound at the 1-week follow-up [20]. Clinical studies [21] have also found that the tooth color begins to rebound immediately after a single clinic bleaching treatment. The rebound rate slows down after one week, and the color stabilizes about six weeks, showing a significant improvement compared to the baseline color. Long-term color rebound usually begins 6 months after the operation, but under the premise of a reasonable initial bleaching plan, the bleaching effect lasts approximately 2 years [22]. The degree of long-term rebound is related to factors such as the baseline level of teeth, the causes of discoloration, and the dietary habits of patients. Therefore, how to inhibit color rebound after tooth bleaching is also one of the challenges in current clinical research. This study compared the maintenance of bleaching effects in ex vivo teeth that continuously used desensitizers for one week after tooth bleaching with those that did not use desensitizers, under the premise of daily fixed contact with staining solution. It confirmed that continuous use of desensitizers after bleaching helps inhibit color rebound. However, since this experiment used ex vivo teeth, it cannot truly simulate the oral environment and people's actual eating habits. Meanwhile, the staining method adopted has not been verified many times. Therefore, the experimental results need to be further confirmed. This research is significant in addressing a common clinical concern—post-bleaching sensitivity and color instability—by offering evidence-based strategies to improve patient outcomes and minimize repeat procedures.

5. Summary

Using desensitizing products before or after tooth bleaching does not affect the bleaching effect; Instead, it can reduce the damage to teeth caused by tooth bleaching. Meanwhile, this study confirmed that using desensitizing products before tooth bleaching is more effective in reducing tooth sensitivity compared to using them after bleaching. Moreover, continuous use of desensitizing products with remineralization effects after bleaching can maintain the whitening effect of teeth and inhibit color rebound after whitening. These findings provide valuable guidance for clinicians seeking to optimize bleaching procedures while minimizing tooth sensitivity and preserving long-term whitening effects.

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