Effect of light intensity and powder/liquid ratio on bleaching efficiency of the Hi-Lite vital bleaching system

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[Received : May 30, 2006 ; Accepted : June 20, 2006]

Abstract : We evaluate the effect of the light intensity and powder/liquid ratio on bleaching efficiency of the Hi-lite vital bleaching system using a hematoporphyrin stained model. Hi-Lite paste was mixed in the powder/liquid ratios that should be 1 : 2 and 1 : 3, and placed onto the filter paper stained with 0.1% hematoporhyrin alcohol solution. The specimen was left for 3 minutes. Visible light (irradiances of 300 or 600 mW/㎠) was applied to the paste for 3 minutes. The control specimen was left for 3 minutes without light irradiation. The color difference (ΔE) values between the stained paper and bleached paper were calculated. The higher light intensity, the increased liquid ratio, and the interaction between the higher light intensity and the increased liquid ratio increased the bleaching efficiency of the Hi-Lite.

Key words : Bleaching efficiency, Powder/liquid ratio, Light intensity,

Introduction

Recently, the demand for esthetic dentistry has grown dramatically and tooth bleaching treatment plays an important part in dentistry today. Vital bleaching continues to have a great impact on both the patients who are concerned about their discolored teeth and the dental practitioners. Peroxide was extensively used to bleach vital teeth and non-vital teeth. Thirty-five percent hydrogen peroxide is used for in-office bleaching procedures for vital teeth.

The bleaching mechanism is based on the ability of hydrogen peroxide to penetrate into the tooth structures and produce free radicals to oxidize organic stains within the teeth[1]. Heating[2], lighting[3], laser[4] or high frequency current[5] have been involved to accelerate decomposition of the hydrogen peroxide and to increase the total amount of free radicals. All these procedures could increase the bleaching efficiency of vital bleaching materials .

In Japan, Hi-Lite (Shofu Inc., Kyoto, Japan) is the only dental product approved as a vital bleaching material by the Ministry of Health, Labor, and Welfare. Hi-Lite is a

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two-component, powder and liquid, system with chemical catalysts and light-activating catalysts[3]. The application of visible light energy with a light curing unit is required for bleaching procedures with Hi-Lite to increase the bleaching efficiency. Hi-Lite has made esthetic practice more profitable and has resulted in total patient satisfaction[3, 6]. However, no study has investigated what kind of usage is responsible for the bleaching efficiency of Hi-Lite.

The purpose of this investigation was to evaluate the effect of different light intensities and powder/liquid ratios on the bleaching efficiency of Hi-Lite using a hematoporphyrin discolored model.

Materials and Method

The discolored model was a filter paper (Toyo filter Paper Qualitative 15CM2 : Toyo Roshi Co. Ltd., Tokyo, Japan) stained with 0.1% hematoporphyrin (Wako Pure Chemical Industries Ltd., Osaka, Japan) alcohol solution for 2 minutes. The stained paper was dried in a Dry-Oven Stac S-45K (Shimazu Rika Instruments Co. Ltd., Tokyo, Japan) at 60 ℃ for 5 minutes. The vital bleaching material used was Hi-Lite, the components of which are listed in Table 1. Hi-Lite paste was mixed in the powder/liquid ratios that should be 1 : 2 and 1 : 3 following the manufacturer's instruction. The paste was placed onto the stained paper in a plastic mold (diameter 6 ㎜, height 2 ㎜). After the specimen was left at room temperature for 3 minutes, visible light (irradiances of 300 or 600 mW/㎠) was applied to the paste for 3 minutes with a VIP curing light unit (Bisco Inc., Illinois, USA). The control specimen was left at room temperature for 3 minutes without light irradiation. After the specimen was left at room temperature for 2 minutes, the bleached paper was rinsed with distilled water for 1 minute and dried in a drying-oven at 60 ℃ for 5 minutes. The color reading guide was directly put on the paper and the change of color was measured with Color and Color Difference Meter Model ND101DC (Nippon Denshoku Kogyo Co., Ltd, Tokyo, Japan. Accuracy : ΔE of standard white board <0.34). The color difference (ΔE) values between the stained paper and bleached paper were calculated ; $\Delta E = \{\Delta L^2 + \Delta a^2 + \Delta b^2\}^{1/2}$. Data were statistically analyzed with the Two-Factor Factorial ANOVA and Tukey Kramer procedure ($p < 0.05$).

Table 1. Components of Hi-Lite

Powder	Potassium peroxohydrogensulfate
	Potassium hydrogensulfate
	Manganese sulfate
	Hydrated amorphous silica
	Poly gantrez Ms-955
	Guinea green dye
Liquid	35% Hydrogen peroxide

Results

Table 2 shows the ΔE values between the stained paper and the bleached paper with Hi-Lite mixed in the powder/liquid ratios of 1 : 2 and 1 : 3. Two-Factor Factorial ANOVA indicated the light intensity ($p < 0.0001$), the powder/liquid ratio ($p < 0.0001$), and the interaction between the light intensity and the powder/liquid ratio ($p < 0.0001$) affected the bleaching efficiency of Hi-Lite. In each level of powder/liquid ratio, the ΔE was increased by the increase in the light intensity. At each irradiance setting except 0 mW/㎠, the ΔE values of the 1 : 3 group were greater than those of the 1 : 2

Table 2. Color Difference between stained paper and bleached paper at various light intensities and powder / liquid ratios

(ΔE : Mean ± S.D., n = 10)

Powder / liquid ratio	Light intensity 0 mW/㎠	300mW/㎠	600mW/㎠
P/L 1 : 2	5.0±1.3	10.0±2.2	13.9±2.3
P/L 1 : 3	5.7±0.9	14.0±2.6	21.9±4.2

vertical line : no significant difference between the two groups ($p<0.05$)

group.

Discussion

This study used the discolored model with hematoporphyrirm[7]. What makes this model very advantageous is that hematoporphyrin is insoluble in water and the test specimen is easily rinsed out for the measurement of the color change after application of a vital bleaching material on the model. In many studies[8-11] discolored teeth have been used to evaluate the bleaching efficiency. Discolored teeth may cause misjudgment of the results due to influence of individual differences such as thickness of enamel and dentin, surface properties of enamel, diameter and sclerosis of dentinal tubules, aging, and sex. The discolored model with hematoporphyrin is a simple and improved method to evaluate the bleaching efficiency without any confounding influences.

The results of this investigation indicated the bleaching efficiency of Hi-Lite was affected by the light intensity, the powder/liquid ratio, and the interaction between the light intensity and the powder/liquid ratio. Hi-Lite contains manganese sulfate as a light-activated catalyst. The catalyst becomes considerably more active at the higher level of the light intensity and a greater amount of hydrogen peroxide would then be decomposed. The increased liquid ratio also helps to achieve a higher level of hydrogen peroxide decomposition. Both factors acted in concert to produce more free radicals and increased bleaching efficiency. The powder/liquid ratio can be altered depending on the desired consistency of the paste[3]. The increased liquid ratio decreased the consistency of the paste which made its handling properties more difficult. Therefore, the higher level of light intensity was practically effective to increase bleaching efficiency.

Yamaguchi et al[6] reported that no severe problems concerning safety or side effects due to application of Hi-Lite to vital teeth were found, while effectiveness varied depending on the cases. There existed the possibility that varying the light intensity could alter the efficiency of the bleaching. Burgh et al[12] reported more than 45 % of the curing lights evaluated had an output of less than 300 mW/㎠. The output of the light units was significantly reduced by a drop in the line voltage[13], degradation of the light bulb[14] and reflector[15], blistered or cracked filters[16], breakage of optical fibers and the tip[17-19]. The distance from the exit window of the light unit to treated teeth also effected the light intensity. Low light intensity is not appropriate for vital bleaching with Hi-Lite[20], therefore, prior to each bleaching treatment, the light intensity should be checked.

Hydrogen peroxide diffuses through the organic matrix of enamel and dentin[21-23]. The low molecular weight of hydrogen peroxide and its capability to denature proteins enhances its ability to penetrate teeth[24]. It is feared that hydrogen peroxide can cause some pulpal and periradicular inflammation. Bowles and Thompson[21] have shown that a hydrogen peroxide concentration as low as 5 % can significantly inhibit pulpal enzyme activity. Glickman et al[25] reported acute flare-up of toothache following a vital bleaching procedure. Prior to bleaching treatment, the pulpal and periradicular status of teeth should be meticulously examined. Discolored teeth must be treated by subscribing to a careful and thorough treatment planning and diagnostic protocol[26].

It is difficult to discern the harmful and worthless treatment from the safe and beneficial treatment. Further investigations must be continued, including not only clinical research, but also basic research for efficient and beneficial vital bleaching.

Acknowledgement

This study was supported by Grant-in-Aid for Encouragement of Young Scientists No. 12771148, Grant-in-Aid Scientific Research (C) No. 14571819, Grants-in-Aid for High Performance Bio-Medical Materials Research by the Japanese Ministry of Education, Science, Sports and Culture and scholarship of Japan Society of Dental Whitening.

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光強度および粉液比が生活歯漂白剤ハイライトの漂白効果に及ぼす影響

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（受付：2006年5月30日）
（受理：2006年6月20日）

抄録：光強度および粉液比が生活歯漂白剤ハイライトの漂白効果に及ぼす影響を，ヘマトポルフィリン変色モデルを用いて検討した。0.1%濃度のヘマトポルフィリンエタノール水溶液を濾紙に染み込ませ変色モデルとし，この上に粉液比1：2および1：3で練和した松風ハイライトを填入し3分間放置し，光照射器にて光強度300，600mW/㎠で3分間光照射を行った。対照群として，光照射を行わず3分間放置したもの用いた。漂白前後の変色モデルの色差ΔE（以下ΔE）を算出した。

松風ハイライトの漂白効果は，より強い光強度，液量の増加，およびその両者の相乗効果によって増加することが明らかとなった。

キーワード：漂泊効果，粉液比，光強度