The effectiveness of sealing technique on in-office bleaching

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Abstract

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Sealed bleaching technique was introduced as a way to improve the effectiveness, safety, and convenience of in-office bleaching. In this study, the clinical effectiveness of sealed bleaching compared to conventional in-office bleaching was investigated.

Ten participants received a chairside bleaching treatment on the upper anterior teeth. For each person, one side was randomly designated as the experimental side. After teeth isolation, one scoop (0.4 ml) of Brite powder, 10 drops (0.4 ml) of 3% hydrogen peroxide, and 0.4 ml of 15% carbamide peroxide gel were mixed and applied to the labial tooth surface. The experimental side was also covered with a linear low density polyethylene (LLDPE) wrap for sealed bleaching. The bleaching gel was light activated for 1 hour. The tooth shades were evaluated by two methods at before treatment, after treatment, and one week check up: a visual shade (VS) assessment by a value oriented shade guide and a spectrophotometer (SP). The obtained data were analyzed by paired t-test. The following results were obtained.

In the control and sealed groups, the visual shade scores after bleaching treatment and at check up showed statistically significant difference from the

preoperative shade scores ($p<.05$). Both the postoperative shade scores ($p<.05$) and the check up shade scores ($p<.05$) showed statistically significant difference between the control and sealed groups. Compared to preop, the ΔE values at postop were 4.35±1.38 and 5.08±1.34 for the control and sealed groups, respectively. The ΔE values at check up were 3.73±1.95 and 4.38±2.08 for the control and sealed groups. There was statistically significant difference in ΔE value obtained by a spectrophotometer between the control and sealed groups both after bleaching ($p<.05$) and at check up ($p<.05$).

In conclusion, both ΔE and shade score changes were greater for the sealed bleaching group than the conventional bleaching group, effectively demonstrating the improvement of effectiveness through sealing.

Keyword: in-office bleaching, sealed bleaching technique, LLDPE wrap, tooth shade

The effect of sealing technique on in-office bleaching

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I. Introduction

Vital bleaching is one of the most conservative, simple, economical, and painless measures to lighten teeth, and it is even a recognized method to improve one's attractiveness and self-esteem (Dunn 1998). Compared to conventional home bleaching, in-office bleaching has the advantage of immediate results while requiring less effort on the patient's side (Papathanasiou et al. 2002). The recent introduction of resin barrier and commercially available bleaching systems consisting of gel, paste, or powder-liquid type mixture of a highly concentrated hydrogen peroxide has also significantly improved the convenience of the process. These in-office bleaching systems also employ specially formulated lights, which accelerate the bleaching process (Hanosh and Hanosh 1992; Lu et al. 2001). As a result, tooth whitening has become one of the most popular esthetic

procedures being performed at the dental office.

However, despite the recent improvements of the current in-office bleaching systems, it is not without drawbacks. The predominant problems encountered with power bleaching are multiple visits to the office and tooth dehydration usually leading to false evaluation of actual shade change (Sulieman 2005). Even more in some countries, the use of high concentrations of hydrogen peroxide is prohibited. Safety issues have been raised regarding the highly concentrated bleaching agents used for in-office bleaching. It is caustic when it comes in contact with soft tissue. Since the bleaching agent is volatile in air, patients often complain of discomfort to the nose. Higher concentrations of peroxide may also produce more cases of thermal sensitivity (Haywood 2003) though it is generally accepted that these side effects are reversible and not permanent (Barghi 1998). In addition, since the activated bleaching agent seems to evaporate, it has to be replenished several times during a single session to produce quicker results. Replenishment of bleaching agent is time-consuming and inconvenient due to dry-out of material, and it adds to the expense of bleaching procedure.

According to Goldstein (Goldstein and Garber 1995), there are several factors that affect the effectiveness of tooth whitening. The effectiveness of bleaching increases as the cleanliness of the tooth surface,

concentration of the hydrogen peroxide, temperature, pH, and the time duration increase. He also added that creating a sealed environment increases the effectiveness. For example, both walking bleaching and home bleaching procedures are widely accepted effective procedures, and in both procedures, whitening is performed in a sealed environment. In home bleaching, the bleaching gel is placed in the bleaching tray, and in walking bleaching, after the placement of bleaching agent, the cavity is sealed with a temporary filling material. A part of the predictable success in these procedures may be attributed to the sealed environment. On the other hand, during conventional in-office bleaching a sealed environment is not created, and this should be considered in order to improve the effectiveness of bleaching procedure.

A protocol of creating a sealed environment during in-office bleaching has been introduced by Miara (2000) with claims of increased efficacy. In “compressive bleaching technique,” after a bleaching tray is filled by power bleaching gel and is placed in the mouth, the borders are sealed by a light-cured resin barrier. Power bleaching is thought to work by the permeation of oxygenating perhydroxyl free radicals through enamel micropores along a diffusion gradient and into the dentine where it oxidizes stains and thereby bleaches the teeth (Sulieman 2004; Sulieman 2005). It has

been suggested that the compressive pressure lead the penetration of oxygen radicals into the enamel. However, the effectiveness of this new technique hasn't evaluated in any study.

Recently Kwon (Kwon and Ko 2006) introduced a new protocol of in-office bleaching called "*sealed bleaching technique"*, which prevents the evaporation and dry-out of active agents by placing a linear low density polyethylene (LLDPE) wrap onto the power whitening gel. The mechanism of sealed bleaching is that by creating a sealed environment around the bleaching gel, the activated bleaching agent remains concentrated near the tooth surface so that it is directed into the tooth rather than evaporating into air. This technique not only improves the effectiveness of bleaching but also makes the procedure safer. Sealing prevents the bleaching agent from evaporating into air and unintentional exposure. The activated bleaching agent is also utilized more effectively, and replenishment of bleaching agent is not necessary, making the procedure simple and cost effective. Without reapplication of the bleaching agent, the whole in-office bleaching procedure may be completed without interruption, resulting in shorter chairtime. Another advantage of sealed bleaching is that it may be used with any bleaching system regardless of light activation.

The "sealed bleaching technique" is a relatively new technique, and

there hasn't been any in-vitro or clinical study evaluating this method. This study investigated the effectiveness of sealed bleaching technique in a randomized clinical trial. The purpose of this clinical study was to evaluate the effectiveness of sealing technique on in-office bleaching procedure by comparing the outcome of sealed and conventional bleaching procedure.

II. Materials & Methods

The protocol for this study and the informed consent form were approved by the institutional review board of Yongdong Severance Hospital, Seoul, Korea.

1. Subjects

Patients were asked to volunteer to participate in this research. The upper anterior teeth of the volunteers were examined clinically and radiographically for dental screening. The patients who met the following inclusion and exclusion criteria were selected to participate in this study.

***Criteria of patient selection**

We included patients in this trial if they

-were 18 years of age or older;

-had six sound natural maxillary anterior teeth without restorations on the labial side;

-were willing to sign a consent form.

-didn't require any immediate endodontic or restorative treatment on the upper anterior teeth;

-didn't have any malocclusion or tooth misalignment that prevented them from effective bleaching procedure and shade evaluation;

-were not pregnant or nursing.

After the screening process, 2 men and 8 women qualified to participate in

this study. Written informed consent was obtained from all patients.

2. Materials

1) Bleaching agents and light

The bleaching agent used in this study was 1 scoop (0.4 ml) of Brite powder (PacDent, Walnut, USA) mixed with 10 drops (0.4 ml) of 3% hydrogen peroxide and 0.4 ml of 15% carbamide peroxide gel (KoolWhite, PacDent, Walnut, USA). Brite powder is a mixture of silica powder and light catalyst.

For light-activated bleaching, BT Cool light (P's Med, Seoul, Korea), a high flux blue LED light unit which has a wavelength of 430-490 nm, was activated for 1 hour.

3. Methods

1) Shade evaluation

Color evaluation was performed independently using the following two methods at baseline, immediately after the bleaching procedure, and at the one-week follow-up appointment.

(1) Shade guide matching by an independent shade evaluator using the 16 shade tabs of Vita shade guide (Vita, Bad Sackingen, Germany) arranged by value order from lightest to darkest (Table 1) (Chu et al. 2004). For each

tooth, shades were assessed for the incisal, middle, and cervical 1/3 portion of the tooth. Visual shade assessment was performed under natural daylight.

Table 1. Value oriented Vita Shade Guide

Shade	B1	A1	B2	D2	A2	C1	C2	D4	A3	D3	B3	A3.5	B4	C3	A4	C4
Shade score (unit:sgu*)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

*sgu represents shade guide unit.

(2) Color measurements using a spectrophotometer (Spectroshade, MHT, Niederhasli, Switzerland) by the spectrophotometer taker. To ensure accurate measurement, the unit was calibrated each time before use, and only images that were accurately taken, signified by the green light on the screen, were used. Most technology-based shade systems use the ΔE from the *Commission Internationale de l'Eclairage* (CIE) $L^*a^*b^*$ color system to determine the color difference between shades (Chu et al. 2004). ΔE is the shortest distance in the CIE L*a*b* color space between the colors being compared as determined by the following equation:

$$\Delta E = \sqrt{\Delta \mathrm{L}^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

ΔE value was obtained using the Spectroshade analysis software (Ver.

2.41).

2) Study design

Each participant received thorough oral prophylaxis and polishing at least 1 week prior to bleaching at the dental screening appointment.

The schematic diagram of the bleaching procedure is shown in Fig. 1.

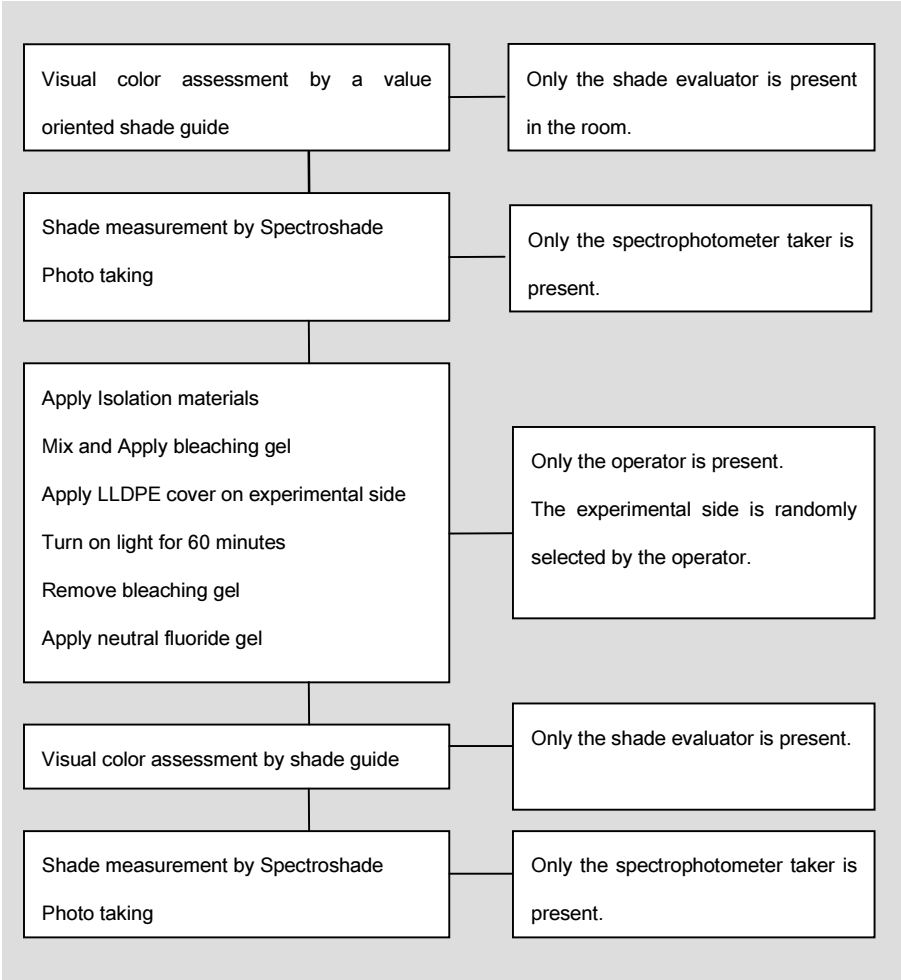

Fig 1. Experimental protocol for the day of the in-office bleaching procedure

At bleaching appointment, the preoperative baseline shade assessment of the upper anterior teeth was made by the shade evaluator and the spectrophotometer taker. Initial photographs were taken at centric occlusion and edge-to-edge bite using a 35-mm camera (Nikon F-801, Kodak Professional Ektachrome transparency film E100).

Afterwards, participants received a chairside bleaching treatment. A split-mouth design was used in this study. One side was randomly designated by the operator as the sealed side, and the contra-lateral teeth were used as control. This knowledge was not shared with others.

To protect the soft tissue, OptraGate (Ivoclar-Vivadent, Schaan, Liechtenstein), cotton rolls, and gauze were used. Resin barrier (Kooldam, PulpDent, USA) was used for gingival isolation so that it covers 0.5 mm of the teeth and 2.0mm of the gingiva. The resin barrier was applied to the gingiva of all teeth to be bleached, and then light cured for 20 seconds. Patients were given protective eye goggles to avoid directly being exposed to the bleaching light. The bleaching agent was mixed according to the manufacturer's instruction, and they were applied to the labial surface of all 6 upper anterior teeth. A 45 mm × 15 mm LLDPE wrap was applied as a tooth whitening cover to the 3 upper anterior teeth of the sealed side. Then all upper anterior teeth were exposed to bleaching light for 1 hour. After 1 hour,

bleaching agent and the resin barrier were removed. The teeth were thoroughly rinsed with water.

Neutral fluoride gel (pH 7 neutral gel, Pascal, Bellevue, USA) was applied to the labial side of upper anterior teeth and rinsed out with water after 5 minutes. After waiting another 5 minutes for rehydration, postoperative photos were taken and the shades assessments were performed as baseline.

One week after the bleaching appointment, the patients were recalled for 1 week check-up. Shade assessments were made and photographs were taken as were done at baseline. Patients were also asked to report any kind of sensitivity experienced during and after treatment.

4. Statistical analysis

The results of subjective shade guide matching were converted to numerical shade score using Table 1. The average shade scores for both the sealed group and control group at each of the three time points were calculated for comparison. The average ΔE values obtained from the spectrophotometer were also calculated for each group for analysis.

Paired t-test was used to compare the average shade score between the sealed side and control side before bleaching, after bleaching, and at check-up using S.A.S. Ver. 8.2. The average ΔE values were analyzed by paired

t-test using Microsoft Excel 2003 software for paired t-test.

III. Results

Table 2. Average visual shade scores obtained through visual color assessment by value oriented shade guide (Mean ± S.D.)

	Control	Sealed
preop	7.00±2.52	6.98±2.49
postop	3.63±1.80	3.37±1.68
check up	3.64±1.83	3.33±1.72

Unit- sgu i.e. shade guide unit

Table 3. Changes of visual shade score at each measurement time (Mean ± S.D.)

	Control	Sealed
preop vs postop	3.36±1.95*	3.61±1.89*
preop vs check up	3.36±1.96*	3.64±1.87*
postop vs check up	0.01±1.35	0.03±1.31

*statistically significant at $p < 0.05$ by paired t-test

Unit- sgu i.e. shade guide unit

Table 4. Comparison of visual shade scores between control and sealed group (Mean ± S.D.)

	Control – sealed
Preop	0.02±0.26
Postop	0.27±0.68*
Check up	0.31±0.76*

*statistically significant at p< 0.05 by paired t-test

Unit- sgu i.e. shade guide unit

Table 5. Comparison of ΔE values obtained through Spectrophotometer measurements (Mean ± S.D.)

	Control	Sealed	mean of difference
ΔE between preop and postop	4.35±1.38	5.08±1.34	0.72±1.17*
ΔE between preop and checkup	3.73±1.95	4.38±2.08	0.65±0.99*

* statistically significant at p <0.05 by paired t-test

The average shade scores obtained from subjective shade matching of each group at three different times were calculated, and they are represented in Table 2.

In the control and sealed groups, the average score in shade guide units after bleaching treatment showed statistically significant difference from

the preoperative shade score (control group, $p<.05$; and sealed group, $p<.05$). In addition, the average shade scores at check up appointment also showed significant difference from preoperative score (control group, $p<.05$; and sealed group, $p<.05$) (Table 3).

Both the postoperative shade scores ($p<.05$) and the check up shade scores ($p<.05$) showed statistically significant difference between the control and sealed groups, while there was no statistically significant difference before the bleaching procedure ($p>.05$) (Table 4).

ΔE values were obtained from the Spectroshade analysis software. The average values of each group were calculated and are shown in Table 5. Compared to preop, the ΔE values at postop were 4.35±1.38 and 5.08±1.34 for the control and sealed groups, respectively. The ΔE values at check up were 3.73±1.95 and 4.38±2.08 for the control and sealed groups. Paired t-test revealed that there were statistically significant differences in ΔE value between the control and sealed groups immediately after the bleaching procedure ($p<.05$) and at 1 week check up ($p<.05$).

IV. Discussion

Sealed bleaching was developed to increase the efficacy, safety, and convenience of in-office bleaching procedure, and the objective of this investigation was to evaluate the effectiveness of the sealed bleaching compared to the conventional in-office bleaching technique.

The results demonstrate that sealed bleaching improved the effectiveness of bleaching protocol used in this investigation. In terms of the visual shade assessment made by a value oriented shade guide, there was a significant difference between the shade scores of the control and sealed groups after immediately bleaching and at the check-up appointment. The shades of the sealed group were significantly lighter at both times. The ΔE values obtained from Spectroshade also showed significantly greater ΔE value in the sealed group compared to the control group at both immediately after treatment and check up.

The convenience of sealed bleaching was also evaluated. As the sealed side was covered by LLDPE wrap, the bleaching agent remained moist until the completion of the bleaching procedure, while the bleaching gel on the control side was relatively dry. Under actual clinical conditions since the bleaching agents would be replenished during a single session, the bleaching gel wouldn't be allowed to dry out to this extent. However, under the

conditions of this experiment, the bleaching gel was removed more easily on the sealed side, which is another advantage of sealed bleaching.

Although the main purpose of this investigation was to objectively measure the shade change and compare the effectiveness between techniques, possible side effects of sealed bleaching, especially increased hypersensitivity, were considered. With regard to sensitivity, one patient reported a slight sensitivity on the canine of the control side during the initial stage of in-office bleaching treatment. The sensitive area was checked to see if there was any leakage of whitening gel. After verification, the patient was instructed that the initial slight sensitivity usually disappears after a few minutes, and the treatment was continued. The patient indicated that the sensitivity disappeared after 5 more minutes. None of the patients reported any sensitivity during the one week following bleaching treatment on either side. The sealed bleaching protocol used in this study didn't cause any sensitivity in any of the patients. This may be attributed to the low concentration of hydrogen peroxide used in this study.

In this study the hydrogen peroxide concentration of the bleaching gel was about 3~4%. This may seem low considering various studies done in the past using higher concentrations of office bleaching agents (Papathanasiou et al. 2002; Zekonis et al. 2003; Luk et al. 2004). However,

although highly concentrated bleaching agents are produced and marketed, a controversy over the safety of using highly concentrated hydrogen peroxide still remains (Greenwall 2001; Sulieman 2004). Higher concentrations of hydrogen peroxide produce quicker whitening results (Goldstein and Garber 1995), but it may also produce more cases of thermal sensitivity (Haywood 2003). There is a general trend in seeking methods to effectively whiten teeth while using lower concentrations hydrogen peroxide. Despite the low concentration of hydrogen peroxide used in this study, the results of this investigation indicated that in both the control group and sealed group, there were significant shade changes after the bleaching treatment. The patient's perception of the bleaching result was also noted in this study. All the patients were asked if the bleached upper teeth seemed lighter than the lower teeth after the bleaching procedure, and all of the patients indicated that the teeth appear to be lighter. When the same question was asked at the check-up appointment, although four patients indicated that they noticed some relapse of color, all patients responded that the upper teeth were still lighter than the lower teeth.

Although the results from this study showed the effectiveness of the sealed bleaching technique on the bleaching protocol used, more studies are needed in the future in order to further clarify its mechanism. There were

statistically significant differences in average shade scores or ΔE values between the groups, but the difference between the groups was less than the human perception threshold of 4 E units (Chu et al. 2004; Kwon and Ko 2006). This is probably due to the fact that low concentration of hydrogen peroxide was used for only one session. In clinical settings usually multiple visits are required for in-office bleaching procedure, and the cumulative effects may add up to increased effectiveness of sealed bleaching. More studies using different concentrations of hydrogen peroxide and multiples visits are necessary to verify the cumulative effects. Moreover, the quantity of oxygen radical that permeates into enamel during in-office bleaching procedure with or without sealing needs to be determined, and its correlation with hypersensitivity needs to be investigated.

Several factors were considered in designing this study in order to as objectively assess the effects of sealed bleaching as possible. First of all, a split-arch design, where comparisons are made on contralateral teeth of the same arch, was used. One of the most significant variables in the evaluations of in-office bleaching systems is the human test subject. Teeth with the same shade in two different people may react differently to the same bleaching procedure. This is due to the difference in genetics and/or the inherent causes of the tooth's discoloration. A split-arch design was used in order to

keep all these variables as constant as possible (Hein et al. 2003).

Moreover, a double blind protocol was used. While shade assessment was performed by a shade evaluator and a spectrophotometer taker working independently, the operator performed the in-office bleaching procedure and randomly selected the sealed side. This protocol was used to ensure that the evaluator who assessed the shade using the shade guide was not biased. Since the patients were also blind to this information, the patients were asked if they experienced any sensitivity and if so, one side was more severe than the other.

The shade assessments were made using two methods to complement one another. First, visual color assessments were made using a value-oriented shade guide. By choosing the shade tab that most closely matches the shade of the tooth, it is possible to quantify the shade of the tooth. Although it has been shown that the Vita Classic shade tabs are not systemically distributed in the color space relevant to the human teeth and that there is even over lapping (Miller 1987), the human visual perception of tooth whitening may be argued as the most clinically relevant and significant method of assessing performance since it most closely matches the patient's perspective (Chu 2003).

Spectrophotometer was also used as an additional method of shade

measurement. Spectrophotometer is highly precise and accurate while being relatively easy to use. This instrument generates a spectral curve indicating the exact color of the tooth. Spectrophotometers measure the reflectance of light within the entire visible spectrum, whereas colorimeters measure reflected light in only three wavelengths (red, green, and blue). The evaluation isn't influenced by illumination, metamerism, or simultaneous contrast effects as human visual perception(Chu 2003). The respective images taken before treatment, after treatment, and at check-up, and ΔE values were taken from the middle of each tooth because it is the area where spectrophotometer reading is the most accurate. The incisal third area of the tooth is affected by the translucency of the tooth, and the two dimensional information obtained from the spectrophotometer might not be accurate enough (Paul et al. 2002). In addition, spectrophotometer is designed to evaluate flat surface, and the curved area of the cervical third area may offer less accurate reading (Chu 2003). Therefore, as a result of technical considerations, while three shade scores of the cervical, middle, and incisal portions were obtained from each tooth for visual shade assessment, spectrophotometer value was taken from only the middle 1/3 area of each tooth at each time.

Paired t-test was used for statistical analysis since the contra-lateral teeth of the same subject were being compared. For spectrophotometer

readings, postoperative and check up ΔE values were used for comparison since E value can be considered as a uniform unit of measurement evenly distributed in color space. However, the changes in shade scores could not be compared directly between groups since the difference in shades between each shade tab of the vita shade guide are not equal. The shade tabs are not evenly distributed in color space. Therefore, the shade scores at the time of each measurement were compared directly between groups.

Tooth dehydration is a probable cause of immediate tooth lightening, and it presumably is greater with increased tooth heating (Luk et al. 2004). The final shade assessment was made at 1 week after the final whitening session in order to account for the shade rebound. It also takes time for oxygen to be released completely and not interfere with the optical properties of the tooth structure (Zekonis et al. 2003; Deliperi et al. 2004), Therefore, an immediate postoperative shade taking may not accurately represent the shade change. On the other hand, as the follow-up period increases, the effectiveness of bleaching becomes more affected by other variables. The relapse of the bleaching effect is affected by the habits of the patient such as smoking or coffee drinking. Therefore, in order to limit this study to evaluating the effect of sealed bleaching, a one-week follow-up period was used.

Sealed bleaching technique was introduced as a way to improve on

the effectiveness, safety and convenience of in-office bleaching procedure, and this study is the first to investigate the effectiveness of sealed bleaching technique in a randomized clinical trial. The results of this study demonstrate that sealed bleaching increased the effectiveness of in-office bleaching procedure used in this study. This innovative technique may be used to improve the efficacy of power bleaching without increasing the concentration of hydrogen peroxide used.

V. Conclusions

This study investigated the effectiveness of the sealed bleaching technique compared with conventional in-office bleaching technique. Ten participants received a chairside bleaching treatment on the upper anterior teeth for one hour. For each person, one side was randomly designated as the sealed side, and the sealed side was also covered with a LLDPE (linear low density polyethylene) wrap for sealed bleaching technique. The tooth shades before treatment, after treatment, and at check up were evaluated by two methods: a visual shade assessment by a value oriented shade guide and a spectrophotometer. The obtained data were analyzed by paired t-test. The following results were obtained.

1. In both the control and sealed groups, the shade scores assessed by a visual shade guide after bleaching treatment showed statistically significant difference from the preoperative shade scores (control group, $p<.05$; and sealed group, $p<.05$). In addition, the shade scores at check up appointment also showed significant difference from preoperative scores (control group, $p<.05$; and sealed group, $p<.05$).
2. Both the postoperative shade scores ($p<.05$) and the check up shade scores ($p<.05$) showed statistically significant difference between the control and sealed groups.

3. Compared to preop, the ΔE values at postop were 4.35±1.38 and 5.08±1.34 for the control and sealed group, respectively. The ΔE values at check up were 3.73±1.95 and 4.38±2.08 for the control and sealed group.
4. There were statistically significant differences in ΔE value between the control and sealed groups at both immediately after bleaching procedure ($p<.05$) and checkup ($p<.05$).

In conclusion, both ΔE and shade score changes were greater for the sealed bleaching group than the conventional bleaching group. Therefore, the effectiveness of the in-office bleaching protocol increased when the sealed bleaching technique was used.

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국문 요약

전문가 미백시 sealing technique의 효율성에 관한 연구

전문가 미백의 여러 단점에도 불구하고, 많은 환자들이 자가 미백 보다는 전문가 미백을 선호한다. 따라서 환자의 기대에 맞추어 더욱 편리하고 효율적인 치아 미백 술식을 개발하는 것이 필요하다. Sealed bleaching technique은 전문가 미백의 효율과 안정성을 증대시키기 위해 개발되었다. 이 연구에서는 sealed bleaching의 효과를 평가하기 위해 split arch design의 randomized clinical trial을 시행하였다.

지원자들의 임상적, 방사선학적 검사 후 10명의 성인 환자가 이 연구에 참여하였다. 환자들은 상악 전치부에 전문가 미백 술식을 시행을 받았다. 각 환자마다 무작위로 좌우 중 편측의 세 치아를 대조군으로 지정하였고, 반대측의 세 치아를 실험군으로 하였다. 이 연구에서는 Brite powder (PacDent, Walnut, USA) 한 스푼에 10 방울의 3% 과산화수소수와 0.4 ml의 carbamide peroxide gel (KoolWhite, PacDent, Walnut, USA)을 혼합하여 미백제로 사용하였다. 치아에 미백제를 적용시킨 후, 실험군에는 linear low density polyethylene (LLDPE) wrap을 적용하였다. BT Cool light 을 1시간 동안 적용하여 광활성화 하였다. 치아의 색조는 shadeguide를 이용하여 평가하는 방법과 spectrophotometer를 이용하여 측정하는 두가지

방법을 이용하였으며, 술전, 술후, 체크시의 색조 측정 결과 다음의 결과를 얻을 수 있었다.

Shade guide로 평가한 결과 실험군과 대조군 모두에서 술후와 체크시의 색조와 술전의 색조와는 유의적으로 차이가 있었다. (control group, $p<.05$; and sealed group, $p<.05$). 또한 술전에는 대조군과 실험군 간의 색조의 유의차가 없었던 반면, 술후($p<.05$) 와 체크($p<.05$) 시 모두에서 두 군간의 차이가 있었다. Spectrophotometer로 측정한 ΔE 값의 경우, 술후에는 대조군에서 4.35±1.38, 실험군에서 5.08±1.34로 나타났으며, 체크시에는 대조군에서 3.73±1.95, 실험군에서는 4.38±2.08 로 나타났다. ΔE는 술전과 술후를 비교한 값($p<.05$), 그리고 술전과 체크시를 비교한 값($p<.05$) 모두에서 실험군과 대조군 간의 유의차가 있었다. 따라서 이 연구에서 사용된 미백 술식을 사용할 경우, sealed bleaching technique이 미백의 효율성을 높인다고 결론지을 수 있다.

핵심되는 말: in-office bleaching, sealed bleaching technique, 전문가 미백, LLDPE wrap, tooth shade