Original Articles

Effect of Bleaching Methods on Resin Impregnated Tooth

Dusit Nantanapiboon[1] **and Chaiwat Maneenut**[1]

[1]Department of Operative Dentistry, Faculty of Dentistry, Chulalongkorn University, Bangkok

Abstract

The purpose of this research was to investigate the effect of bleaching methods on teeth that have a resin impregnated layer. Half of the buccal of 40 extracted maxillary premolars were luted with orthodontic resin cement and smooth polished with a tungsten carbide bur. The other half was used as a control group. The initial color difference between both halves was unnoticed (ΔE<3). Teeth were divided into the following four groups: 1) bleached with 10 % carbamide peroxide for 8 hours per day; 2) bleached with 20 % carbamide peroxide for 8 hours per day; 3) in-office-bleaching with 40 % hydrogen peroxide every 6 days, and 4) in-office-bleaching with 40 % hydrogen peroxide (1 day) followed by 10 % carbamide peroxide for 8 hours per day. The difference of color (ΔE) between the cemented site and the controlled site was evaluated every three days using VITA Easyshade®V. The bleaching procedures were continued until the ΔE less than 3. On day 3 of bleaching, the difference of color between resin impregnated area and controlled area obviously increased in all the groups (ΔE>3). Group 3 showed the highest color contrast followed by groups 2, 4 and 1 respectively. At day 6, the only increase in contrast was with group 1 while the other group decreased. The unnoticeable color difference (ΔE<3) of group 3 was at day 6, of group 4 and 2 were at day 9 and of group 1 was at day 15. All bleaching methods created color-mismatch. A high concentration of bleaching gel caused a high contrast. However, it could reduce the contrast faster.

Keywords: Color, Resin impregnated tooth, Tooth bleaching

Received Date: Jun 15, 2018 **Revised Date:** Jul 11, 2018 **Accepted Date:** Aug 23, 2018

Doi: 10.14456/jdat.2019.7

Corresponding author

Chaiwat Maneenut. Department of Operative Dentistry, Faculty of Dentistry, Chulalongkorn University, Bangkok 10330 Thailand

Tel: 0816979682 Email: mchaiwat@chula.ac.th

Introduction

A common problem in esthetic dentistry is tooth discoloration. Its etiological factors are intrinsic, extrinsic and internalized stains[1] that can be managed by tooth bleaching such as in-office or home bleaching.[2,3] Previous studies showed the safety of the tooth bleaching for the treatment of tooth discoloration.[2,4,5]

In the case of fixed orthodontic treatment, the resin impregnated layer usually remains on the enamel after debonding and polishing. It extends for a distance of 11.8 - 18.9 μm into the enamel surface, sometimes reaching up to 100 μm into the tooth.[6,7] A total removal of this cement would decrease the enamel thickness

and hardness.[8] This resin impregnated layer may interfere with the diffusion of bleaching agents and prolong the process of tooth bleaching.[9,10] Using 10 % carbamide peroxide home bleaching, the mismatched color between the resin impregnated area and the surrounding area are noticeable during the first week which reduced the esthetic and self-confidence of the patient.[9]

Nowadays, there are several methods and procedures used for tooth bleaching, including home bleaching, in-office bleaching and a combination of these two. Therefore, our study is conducted to investigate the effect of different bleaching methods on a resin impregnated tooth.

Materials and Methods

Specimen preparation

Forty extracted human maxillary premolars were collected. The teeth were cleaned using dental scaler and polished with a fine pumice slurry using a low speed handpiece. The teeth were inspected for signs of cracks, decay, and restoration by stereo microscope (Stereo Microscope SZ61, Olympus, Japan). Only sound teeth were included into the experiment. The selected teeth were stored in 0.1 % thymol solution at 37°C (degrees Celsius).

The individual silicone jig for locating the experimental area was prepared for each tooth. Two circular holes, 6 mm. in diameter, were made at mesio-buccal and disto-buccal aspects of the tooth. The color of the tooth at both holes was measured using a spectrophotometer (VITA Easyshade® V, Vivadent, Brea, CA, USA) and the average values, from the four measurements, of both holes were compared and calculated for color difference (ΔE). A tooth that has a color difference between both areas less than 3 (ΔE<3) was included into the experiment. The disto-buccal area was used as the control and the mesio-buccal area was used as the experimental area. A bleaching tray with 1 mm.-thick space at buccal aspect, for each tooth, was fabricated. The positioning of the silicone jig and bleaching tray on each tooth could be repeatable. The specimen preparation flow chart was shown in Figure 1.

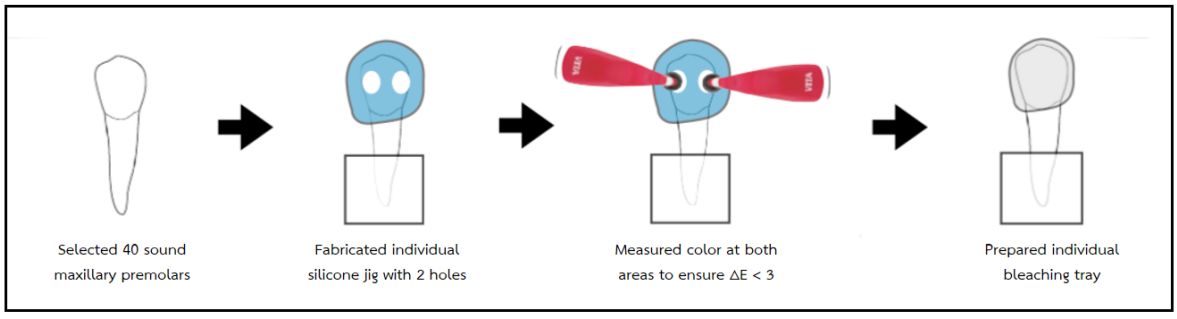

Figure 1 *Specimen preparation.*

Resin Impregnated layer preparation

A silicone jig was placed on the tooth and a mesio-buccal area was etched with 37 % phosphoric acid for 30 seconds, rinsed with spray-water for 30 seconds, primed and luted with a clear light-cured orthodontic adhesive cement (Transbond XT, 3M/Unitek, Monrovia, CA, USA) of about 0.5 mm. thick. The cement was pressed against the tooth surface using a transparent cylindrical crystal with a diameter of 6 mm. Light (1,100-1,330 mW/mm^2) from the light curing unit (DemiTM Plus, Kerr, USA) was applied through the crystal for 40 seconds. The silicon jig was removed and light from the light curing unit was applied on the cement for 20 seconds. The specimen was stored in distilled water for 24 hours at 37°C.

The cement polishing was carried out with a slow speed 30-fluted tungsten carbide bur (Shofu dental

corporation, Japan) without water.[11] The bur was changed after 5 specimens were polished. The polishing was stopped when the cement was reduced to the same level of the tooth surface. The specimen was polished with a pumice without fluoride for 30 seconds and was rinsed with 20 ml of distilled water. The polished area was checked to confirm the resin impregnated layer using stereomicroscope (Stereo Microscope SZ61, Olympus, Japan) at X40 magnification. The silicone jig was re-positioned and the color at mesio-buccal and disto-buccal areas of the tooth was measured again. Tooth with a color difference between both areas was less than 3 (ΔE<3) was subjected to the next procedure (bleaching). A resin Impregnated layer preparation flow chart was shown in Figure 2.

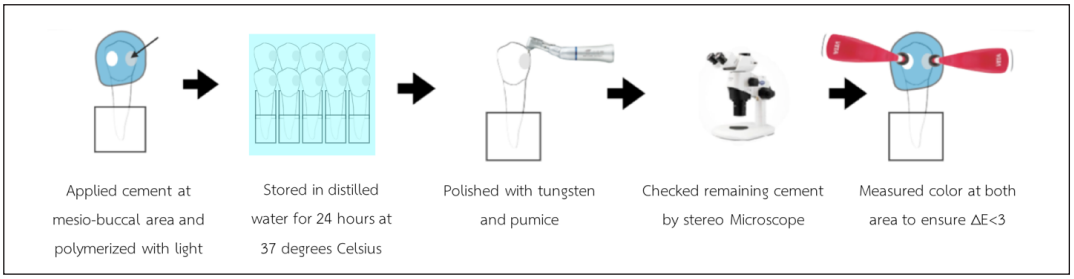

Figure 2 *Resin Impregnated layer preparation flow chart.*

Bleaching protocols

The teeth were mounted on acrylic resin blocks and assigned into 4 groups of 10 teeth each (Table 1).

Table 1 *Groups of experiment*

Group	Bleaching agent	Bleaching time	Teeth
1	10 % Carbamide peroxide (Home bleaching)	8 hours a day	10
2	20 % Carbamide peroxide (Home bleaching)	8 hours a day	10
3	40 % Hydrogen peroxide (In-office bleaching)	2 cycles in day 1 and repeated the same procedure every 6 days	10
4	40 % Hydrogen peroxide (In-office bleaching) + 10 % Carbamide peroxide (Home bleaching)	2 cycles in day 1 and 8 hours a day for home bleaching	10

Group 1: Specimens were bleached with 10 % carbamide peroxide (Opalescence 10 %, Ultradent, USA)
Group 2: Specimens were bleached with 20 % carbamide peroxide (Opalescence 20 %, Ultradent, USA)
Group 3: Specimens were bleached with 40 % hydrogen peroxide (Opalescence Boost 40 %, Ultradent, USA)
Group 4: Specimens were bleached with 40 % hydrogen peroxide (Opalescence Boost 40 %, Ultradent, USA) in day 1 followed by 10 % carbamide peroxide (Opalescence 10 %, Ultradent, USA)
The mean of ΔE of all groups before being subjected to the bleaching procedure was not significantly different ($p<0.05$) using one-way ANOVA.

In group 1 and group 2, the bleaching tray with gel was applied to the tooth. All specimens were stored in artificial saliva without fluoride (Artificial saliva, Faculty of Dentistry, Chulalongkorn University, Thailand) for 8 hours in a closed container with 100 % humidity at 37°C. After bleaching, all specimens were stored in artificial saliva without fluoride for 16 hours in a closed container at 37°C. The bleaching agent and artificial saliva was changed every day. The tooth color at both areas was measured every 3 days until the color difference was less than 3 (ΔE<3).

In group 3, at day one, the bleaching agent was applied in a bleaching tray and applied to the tooth for 2 cycles (20 minutes per cycle).[12] The tooth color at both areas was measured after each cycle. All specimens were stored in artificial saliva without fluoride in a closed container at 37°C. The same bleaching protocol was repeated every 6 days. The tooth color at both areas was measured after each cycle of bleaching and every 3 days after bleaching. The same procedure was repeated until the color difference was less than 3 (ΔE<3).

In group 4, at day one, the 40 % hydrogen peroxide bleaching agent was applied in a bleaching tray and applied to the tooth for 2 cycles (20 minutes per cycle).[12] The tooth color at both areas was measured after each cycle. All specimens were stored in artificial saliva without fluoride in a closed container at 37 °C for 1 day. After that, specimens were bleached with 10 % carbamide peroxide for 8 hours a day. During and after bleaching, specimens were stored in artificial saliva without fluoride in a closed container at 37°C. The bleaching with 10 % carbamide peroxide for 8 hours a day was continued and tooth color at both areas was measured every 3 days until the color difference was less than 3 (ΔE<3). The research proposal was approved by the Ethics Committee of the Faculty of Dentistry, Chulalongkorn University. The study code was HREC-DCU 2017-090.

Statistical Analysis

Significant difference of the mean of ΔE of all groups before subject to bleaching procedure was analyzed using one-way ANOVA.

The data after bleaching was analyzed using descriptive statistical analysis.

Results

Mean and standard deviation of color difference (ΔE) between the resin impregnated area and the controlled area before and after bleaching is shown in Figure 3.

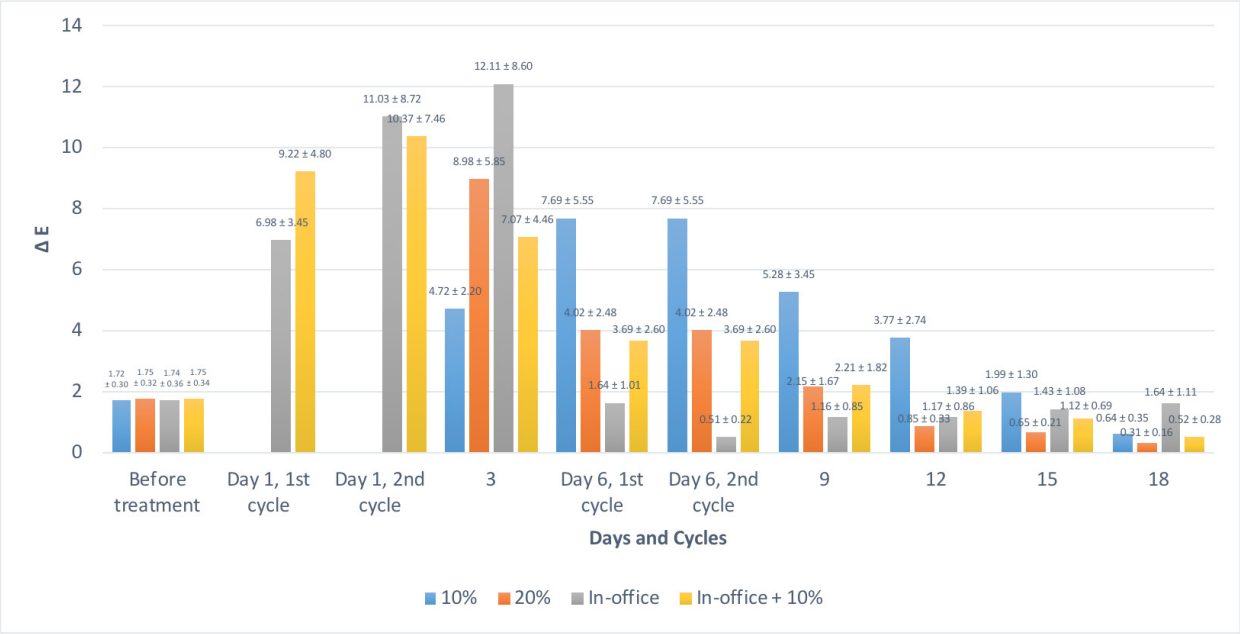

Figure 3 *Mean and standard deviation of ΔE.*

In Group 1, the color difference between two areas was increased during bleaching. The highest color difference (ΔE = 7.69±5.55) was shown on day 6. After that, the color difference was reduced and the ΔE was less than 3 at day 15 (ΔE = 1.99±1.30). On day 18, the ΔE was decreased.

In Group 2, the color difference between two areas was increased during bleaching. The highest color difference (ΔE = 8.98±5.85) was shown on day 3. When the bleaching continued, the color difference was reduced and the ΔE was less than 3 at day 9 (ΔE = 2.15±1.67). From day 9 to day 18, the ΔE is still decreased.

In Group 3, the obvious color difference (ΔE>3) was shown after bleaching gel was applied. The highest color difference (ΔE = 12.11±8.60) was shown on day 3. When bleaching was continued, the color difference was reduced and the ΔE was less than 3 at first cycle of bleaching of day 6 (ΔE = 1.64±1.01). After day 6, the ΔE was increased but still less than 3.

In Group 4, at the second cycle of bleaching of day 1, the highest color difference (ΔE = 10.37±7.46) was shown. When the bleaching continued, the color difference was reduced and the ΔE was less than 3 at day 9 (ΔE = 2.21±1.82). After day 9, the ΔE was decreased.

Discussion

The specific colorimetric measurement devices are faster, more accurate, and more consistent in color assessment compared to the human eye.[13,14] The device applied in this research was Vita Easyshade® V which is reliable, user-friendly and accurate. This device is combined with the CIELAB color system which is widely used in dental research to measure the color of teeth, restorative material and the alteration of the tooth color after tooth bleaching.[15,16] Data from the CIELAB color system can be used to calculate color differences (ΔE) between areas.

ΔE can be related to the visual perception and the clinical significance. The higher number of ΔE represents more difference of color between the two areas. The eye of a normal people can distinguish color differences in the range of 3.018-5.234[17] while the eyes of a dentist can distinguish the color in the range of 2.2-4.4.[18] So, our study used ΔE which was less than 3 to determine the effect of bleaching procedures on the resin impregnated area.

A bleaching agent composed of hydrogen peroxide that could penetrate into the enamel and dentin to interact with the organic chromophore molecules. When hydroxyl radicals encounter the stain molecule, they convert the chains into simple structure and alter the optical properties resulting in the diminished appearance of stain.[19] Previous studies that investigated the effects of a high concentration bleaching agents showed alterations of the enamel morphology and properties. Microhardness and fracture toughness was decreased, while surface roughness was increased. A high concentration gel could penetrate into the dentin more than one with a low concentration.[20-22] In a clinical situation, both low and high concentration bleaching gels could give similar results in terms of color change. However, the use of low concentration bleaching agents took a longer period of treatment.[23]

The data from our study showed that the resin impregnated area responded to tooth bleaching more slowly than the normal area. This layer may prevent the movement of bleaching agents and prolong the process of tooth bleaching. The color contrast between the two areas was visible. Using a high concentration gel created a higher contrast than using a low concentration gel. This mismatch in color is influenced mostly by the color of the normal tooth area which is more responsive to the bleaching gel. When the bleaching was continued, the difference in color decreased gradually. Active free radicals from the gel may freely move to the enamel underneath the resin impregnated layer from other directions. Previous research[10] stated that when the resin impregnated tooth was bleached with 10 % carbamide peroxide, the color was mismatched during the first 15 days. However, when the bleaching continued, the

mismatched color was reduced in 30 days.

Using a customized tray over the bleaching agent in an in-office bleaching, also referred to as "sealed in-office bleaching", could reduce the amount of peroxide and its penetration into pulp. However, this technique did not affect the level of sensitivity reported by the patient during the procedures. Intensity of tooth sensitivity for the first 24 hours was reported after in-office bleaching.[12] The 40 % hydrogen peroxide bleaching could give a better result in color change but there was a higher contrast between the two areas more quickly. Apart from that, it may also cause higher tooth sensitivity.[24] In clinical practice, in-office bleaching performed without a tray results in the use of more peroxide compared to the sealed in-office bleaching. Thus, color contrast and its decreasing way be shown faster. Bleaching by combination of high and low concentration gels (group 4) could decrease the color mismatch faster than using a low concentration gel only. The result of this study was in accordance with a previous research which found that in-office bleaching with 40 % hydrogen peroxide followed by home bleaching with 10 % carbamide peroxide could whiten the normal tooth surface faster than only using home bleaching.[25]

Tooth dehydration can affect tooth color, translucency of enamel, and the dynamics of water in enamel and dentin. The bleaching products have a component that is used as a vehicle for active peroxide substances called glycerin. Glycerin can absorb water on its own and produces dehydration of tooth. Previous study[26] that used bleaching gel contains 86 % glycerin and ethanol showed the dehydration in bovine teeth, which may result in a lighter tooth color. All bleaching gels used in our study contain glycerin, so dehydration of tooth may occur and lighten the tooth color. To rehydrate the tooth, it was recommended that the tooth should be soaked in artificial saliva or distilled water for at least one hour to complete the hydration.[27] In our study, all specimens in the home bleaching groups were stored in artificial saliva without fluoride for 16 hours to rehydrate before color measurement. Therefore, the change of color in these groups was due to tooth bleaching only. On the other hand, the tooth color in the in-office groups was immediately measured after every cycle of bleaching. Therefore, the change of tooth color was the effect of tooth bleaching and dehydration. Color relapse after bleaching could happen. Many factors might be involved in the relapse of tooth whitening such as extrinsic staining from food and beverages and the continuous deposition of secondary yellowish dentin by the pulp.[28] After bleaching procedure was finished, we found the color relapse in the group that bleaching only with 40 % hydrogen peroxide which the ΔE was increased. In this study, a relapse from dietary intake could be eliminated. Though, it could not be established for certain, it seemed tooth relapse seems to be associated with the rehydration of teeth in artificial saliva or due to the remnants of adhesive cements.

For clinical applications, all bleaching protocols used in this study were effective for whitening the resin impregnated tooth. The differences among these protocols was the time duration of mismatch and whitening of color. Apart from the color result, other side effects such as sensitivity and soft tissue irritation should be considered. Moreover, a limitation of this study that should be considered was the age of the resin impregnated layer. In a clinical situation, this layer would be older, at least 1-2 years, and be subjected to the oral environment resulting in some defects in the layer. Its response to bleaching agent might be different from the resin layer in our study.

Conclusion

All bleaching methods used in this study affected the resin impregnated area differently. A highly concentrated bleaching gel caused higher color contrast than low concentration gel. However, the color contrast decreased faster.

Acknowledgement

The authors do not have any financial interest in the companies whose materials are discussed in this article.

The authors would like to gratefully acknowledge the Dental Material Science Research Center, Faculty of Dentistry, Chulalongkorn University for their valuable service.

References

1. Sulieman M. An overview of tooth discoloration: extrinsic, intrinsic and internalized stains. ***Dent Update*** 2005 ;32(8):463-4, 466-8, 471.

2. Kihn PW. Vital tooth whitening. ***Dent Clin North Am*** 2007;51 (2):319-31, viii.

3. Dahl JE, Pallesen U. Tooth bleaching--a critical review of the biological aspects. ***Crit Rev Oral Biol Med*** 2003;14(4):292-304.

4. Haywood VB, Leonard RH, Nelson CF, Brunson WD. Effectiveness, side effects and long-term status of nightguard vital bleaching. ***JADA*** 1994;125(9):1219-26.

5. Alonso de la Pena V, Balboa Cabrita O. Comparison of the clinical efficacy and safety of carbamide peroxide and hydrogen peroxide in at-home bleaching gels. ***Quintessence Int*** 2006;37(7):551-6.

6. Diedrich P. Enamel alterations from bracket bonding and debonding: a study with the scanning electron microscope. ***Am J Orthod*** 1981;79(5):500-22.

7. Menezes LFS, O C. Sealant and resin viscosity and their influence on formation of resin tags. ***Angle Orthod*** 1995;64(5):383-8.

8. Tufekci E, Merrill TE, Pintado MR, Beyer JP, Brantley WA. Enamel loss associated with orthodontic adhesive removal on teeth with white spot lesions: an *in vitro* study. ***Am J Orthod Dentofacial Orthop*** 2004;125(6):733-9.

9. Gomes Lde O, Mathias P, Rizzo P, de Araujo TM, Cangussu MC. Effect of dental bleaching after bracket bonding and debonding using three different adhesive systems. ***Dental Press J Orthod*** 2013;18(2):61-8.

10. Hintz JK, Bradley TG, Eliades T. Enamel colour changes following whitening with 10 percent carbamide peroxide: a comparison of orthodontically-bonded/debonded and untreated teeth. ***Eur J Orthod*** 2001;23(4):411-5.

11. Howell S, Weekes WT. An electron microscopic evaluation of the enamel surface subsequent to various debonding procedures. ***Aust Dent J*** 1990;35(3):245-52.

12. Correa AC, Santana TR, Nahsan FP, Loguercio AD, Faria ESAL. The Impact of a Customized Tray on In-Office Bleaching Tooth Sensitivity: A Randomized Clinical Trial. ***Oper Dent*** 2016;41(1):15-22.

13. Alshiddi IF, Richards LC. A comparison of conventional visual and spectrophotometric shade taking by trained and untrained dental students. ***Aust Dent J*** 2015;60(2):176-81.

14. Lasser JF, Pop-Ciutrila IS, HA C. A comparison between a new visual method of colour matching by intraoral camera and conventional visual and spectrometric methods. ***J Dent*** 2011;39(Suppl3):e29-e36.

15. Dietschi D, Campanile G, Holz J, Meyer JM. Comparison of the color stability of ten new-generation composites: an *in vitro* study. ***Dent Mater*** 1994;10(6):353-62.

16. Guan YH, Lath DL, Lilley TH, Willmot DR, Marlow I, Brook AH. The measurement of tooth whiteness by image analysis and spectrophotometry: a comparison. ***J Oral Rehabil*** 2005;32(1):7-15.

17. Knezovic D, Zlataric D, Illes IZ, Alajbeg M, Zagar. *In Vivo* Evaluations of Inter-Observer Reliability Using VITA Easyshade(R) Advance 4.0 Dental Shade-Matching Device. ***Acta Stomatol Croat*** 2016;50(1):34-9.

18. Dozic A, Kleverlaan CJ, Aartman IH, Feilzer AJ. Relation in color of three regions of vital human incisors. ***Dent Mater*** 2004;20(9):832-8.

19. Kwon SR, Wertz PW. Review of the Mechanism of Tooth Whitening. ***J Esthet Restor Dent*** 2015;27(5):240-57.

20. Oltu U, Gurgan S. Effects of three concentrations of carbamide peroxide on the structure of enamel. ***J Oral Rehabil*** 2000;27(4):332-40.

21. Cavalli V, Arrais CA, Giannini M, Ambrosano GM. High-concentrated carbamide peroxide bleaching agents effects on enamel surface. ***J Oral Rehabil*** 2004;31(2):155-9.

22. Pinto CF, Oliveira R, Cavalli V, Giannini M. Peroxide bleaching agent effects on enamel surface microhardness, roughness and morphology. ***Braz Oral Res*** 2004;18(4):306-11.

23. Matis BA, Mousa HN, Cochran MA, Eckert GJ. Clinical evaluation of bleaching agents of different concentrations. ***Quintessence Int*** 2000;31(5):303-10.

24. de Geus JL, Wambier LM, Kossatz S, Loguercio AD, Reis A. At-home vs In-office Bleaching: A Systematic Review and Meta-analysis. ***Oper Dent*** 2016;41(4):341-56.

25. Reis A, Kossatz S, Martins GC, Loguercio AD. Efficacy of and effect on tooth sensitivity of in-office bleaching gel concentrations: a randomized clinical trial. ***Oper Dent*** 2013;38(4):386-93.

26. Betke H, Kahler E, Reitz A, Hartmann G, Lennon A, Attin T. Influence of bleaching agents and desensitizing varnishes on the water content of dentin. ***Oper Dent*** 2006;31(5):536-42.

27. Zhang D, Mao S, Lu C, Romberg E, Arola D. Dehydration and the dynamic dimensional changes within dentin and enamel. ***Dent Mater*** 2009;25(7):937-45.

28. Tay LY, Kose C, Herrera DR, Reis A, Loguercio AD. Long-term efficacy of in-office and at-home bleaching: a 2-year double-blind randomized clinical trial. ***Am J Dent*** 2012;25(4):199-204.