

Longevity of Tooth Whitening by Hydrogen Peroxide using Cold Plasma

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Abstract

Atmospheric Pressure Cold Plasma (APCP) showed good effects in tooth whitening. However, the longevity of tooth whitening using different Hydrogen Peroxide (HP) concentrations with APCP has not been reported. Therefore, the aim of this study was to determine the longevity of tooth whitening effect and surface roughness using APCP by high or low concentrations of HP. Specimens were treated with different HP agent and APCP for 20 minutes. After treatment, we were evaluated the color of the specimens. The specimens were then put into distilled water for different time periods. The specimens were re-evaluated. The result of this study, the longevity of tooth whitening effect of APCP with low concentration of HP was not different from that of APCP with high concentration of HP. In addition, the two HP concentrations did not cause any changes to the enamel surface over time.

Keywords: Atmospheric Pressure Cold Plasma, Hydrogen Peroxide, Tooth Whitening Effect, Tooth Whitening Longevity

1. Introduction

Dental Clinic provides patients with tooth whitening that is one of the most preferred by users¹. Hydrogen Peroxide (HP) or Carbamide Peroxide (CP) agents are used for vital tooth whitening. Peroxide releasing agent interacts with any extrinsic or intrinsic stains on the tooth²⁻⁴. Many studies reported that HP concentrations used for teeth whitening have increased to enhance the whitening effect and the longevity⁵⁻⁷. However, a few studies reported that it was unnecessary to modify the whitening agent concentration to improve the whitening effect and the longevity⁸.

Atmospheric Pressure Cold Plasma (APCP) is an excellent tool for tooth whitening. It has been demonstrated that APCP treatment significantly accelerated

tooth whitening effect⁹⁻¹². However, the effect of APCP undergoes various influences. APCP gases commonly include air, argon, nitrogen, oxygen, and mixed gas. The effect of APCP tooth whitening is influenced by the kind of gas used. When air-oxygen mixed gas was used, a large amount of reactive oxygen species were generated in the plasma surroundings. Consequently, the effect of tooth whitening was increased much more than other gases¹³.

Recently, many studies have reported the effect of APCP on tooth whitening. However, the longevity of tooth whitening using different HP concentrations with APCP has not been reported.

Therefore, the aim of this study was to determine the longevity of tooth whitening effect and surface roughness using APCP by high or low concentrations of HP.

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2. Methodology

2.1 Experimental Setup

For whitening treatment using APCP, we prepared specimens that were exposed an enamel labial surface of bovine tooth that embedded in epoxy resin (Figure 1). The experimental group was treated by HP at a low-concentration of 5% HP using APCP for 20 minutes. The control group was treated by HP at a high-concentration of 30% HP using APCP for 20 minutes. APCP used in this study was developed by Plasma Bioscience Research Center. It has been used in our previous studies for different purposes^{12,18-20}. A whitening agent was prepared as a different HP paste type by mixing 0.5 mL HP (experimental group: 5% HP, control group: 30% HP) with dental abrasives 45 mg (Brite powder, Pac Dent International Inc., USA). The whitening agent was applied at a thickness of 1 mm to the enamel surface.

2.2 Experimental Procedure

Tooth whitening process is shown in Figure 2. Specimens were treated with whitening agent and APCP for 20 minutes. After treatment, we were evaluated the color of the specimens. The specimens were then put into distilled water at 37°C thermostat for different time periods: 3, 6, 9, and 12 months. The specimens were washed with distilled water and the color of the tooth was re-evaluated after those time periods.

2.3 Experimental Measurement

The color change of tooth surface was measured by a spectrophotometer (CM 3500d, Minolta, Japan). The result of tooth whitening effect was evaluated by the CIE L*a*b* system. The change of each specimen ΔE^* were computed following the expression¹⁴.

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



Figure 1. Embedded bovine tooth in epoxy resin.

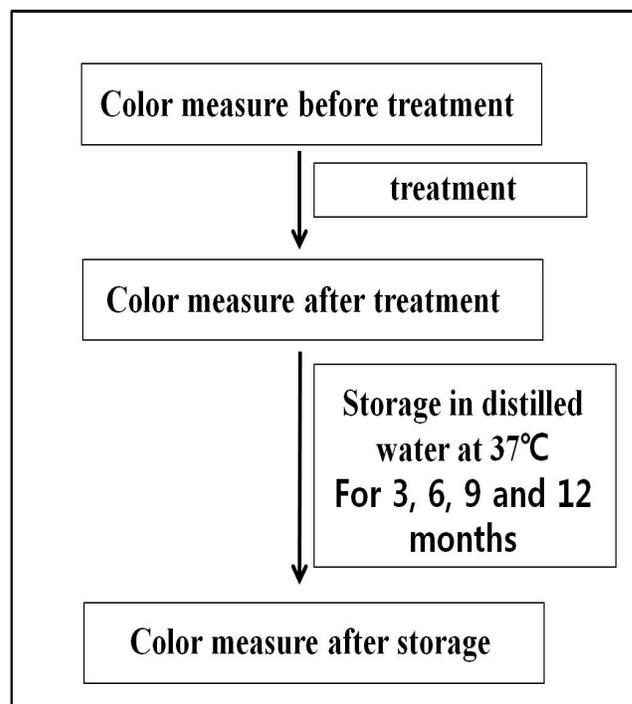


Figure 2. Flow chart of the tooth whitening process.

The roughness of tooth surface was measured by a VIS mode with 10x magnification using an optical profilometer (ContourGT-X3, Bruker AXS, USA).

2.4 Statistical Analysis

We analyzed the color change and roughness with SPSS program (SPSS Inc., IBM, Chicago, US). To present a significant difference between experimental and control group, Mann-whitney test were used. The significant difference in results was determined as $P < 0.05$.

3. Findings

3.1 The Longevity of the Whitening Effect using APCP

Table 1 showed that the ΔL^* values at baseline (after tooth whitening for 20 minutes) and after storage for 3, 6, 9 and 12 months. The ΔL^* values of 3 months for control group and specimen group were -6.1 and -6.3, respectively. After 6 months the ΔL^* values for control group and specimen group were -6.3 and -6.4, respectively. After 9 months, ΔL^* values for control group and specimen group were -6.4 and -6.5, respectively. After 12 months, ΔL^* values for control group and specimen group were

-6.4 and -6.6, respectively. The differences were not significant ($p>0.05$).

Table 2 showed that the ΔE^* values at baseline (after tooth whitening for 20 minutes) and after storage for 3, 6, 9 and 12 months. The ΔE^* values of 3 months for control group and specimen group were 7.4 and 7.5, respectively. After 6 months, ΔE^* values for control group and specimen group were 7.5 and 7.6, respectively. After 9 months, ΔE^* values for control group and specimen group were 7.5 and 7.6, respectively. After 12 months, ΔE^* values for control group and specimen group were 7.6 and 7.7, respectively. The differences were not significant ($p>0.05$).

APCP has shown great potential as a multi-functional outcome in medical and dental field concerned about safety¹⁵. In combination with HP, APCP could effectively remove colors from stained teeth¹⁰. However, the longevity of tooth whitening with APCP has not been reported.

Our results revealed that the ΔE^* values after storage for 3, 6, 9, and 12 months were not significantly different between the control and experimental group. Therefore, the longevity of tooth whitening by APCP with high or low HP concentration was not difference. Many previous reported that the whitening effect by 10% CP had a long-lasting effect as an effective and predictable method of whitening teeth¹⁶⁻¹⁷. In other studies reported that CP concentrations (10% and 16%) continued a lighter color than at baseline measures at

two years after tooth whitening⁸. They reported that it was unnecessary to increase the concentration of CP to improve the whitening effect or the longevity of the treatment because there was no difference between treatment groups. Our results also revealed that there was no difference in longevity of the whitening effect between the low HP concentration and the high HP concentration group.

3.2 Surface Roughness (Ra)

Surface roughness data are summarized in Table 3. Ra values were obtained at 3, 6, 9, and 12 months after storage. There was no significant ($p>0.05$) difference in Ra between the control group and the specimen group. Some studies reported that the tooth whitening groups by HP with APCP results in a smoother surface than HP only^{11,12}. Hence, the concentration of HP did not cause any changes to the enamel surface over time.

There are some limitations of this study. Although the teeth were stored in 37°C after whitening, it did not mimic the changes due to saliva and food consumption. Therefore, this study did not perfectly recreate a normal oral environment. However, this study can be used as a basis for future tooth whitening and sustaining studies.

Consequently, the longevity of tooth whitening effect of APCP with low concentration of HP was not different from that of APCP with high concentration of HP. In addition, the two HP concentrations did not cause any changes to the enamel surface over time.

Table 1. Change of ΔL^* values after storage for 3, 6, 9, and 12 months

	3 months	6 months	9 months	12 months
Control	-6.1 ± 1.7	-6.3 ± 1.6	-6.4 ± 1.4	-6.4 ± 1.1
experimental	-6.3 ± 1.1	-6.4 ± 1.3	-6.5 ± 1.2	-6.6 ± 1.4

Table 2. Change of ΔE^* values after storage for 3, 6, 9, and 12 months

	3 months	6 months	9 months	12 months
Control	7.4 ± 1.9	7.5 ± 1.5	7.5 ± 1.6	7.6 ± 1.4
experimental	7.5 ± 1.6	7.6 ± 1.3	7.6 ± 1.5	± 1.6

Table 3. The average surface roughness (Ra) after storage for 3, 6, 9, and 12 months

	3 months	6 months	9 months	12 months
Control	140.5 ± 19.1	139.7 ± 18.4	140.1 ± 20.1	141.3 ± 19.8
experimental	142.1 ± 12.4	142.8 ± 13.7	141.4 ± 13.4	141.5 ± 12.9

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