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Effect of light activation on tooth whitening efficacy and hydrogen peroxide penetration: An *in vitro* study

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ABSTRACT

Objectives: To determine the effect of light activation on tooth whitening efficacy and hydrogen peroxide penetration into the pulp cavity and correlate tooth color change with penetration levels.

Methods: Extracted human canines (40) were randomized into four groups, Group A: placebo gel, Group B, placebo gel with light activation, Group C: 40% hydrogen peroxide gel, and Group D: 40% hydrogen peroxide gel with light activation. Treatment was performed three times, at 1-week intervals. Hydrogen peroxide penetration (HPP) was estimated spectrophotometrically and specimen color measured using the Vita Easy Shade Compact at baseline, after whitening, 1-h, 1-day, 1-, 4-, 8-, 12-, 16-, 20-, and 24-week post-whitening. Color change was measured per Commission Internationale de l'Eclairage methodology.

ANCOVA was performed to compare color change and HPP level among the four groups. Partial nonparametric correlations between color change and HPP levels were performed with rank transformations. Tests of hypotheses were two-sided with alpha level of 0.05.

Results: Greater HPP was observed in Groups C and D compared to Groups A and B ($p < 0.001$). Highest overall color change (ΔE^*ab) values after treatment were observed in Group D and remained higher than Groups A–C ($p < 0.01$). Changes in lightness and in the yellow-blue dimension (ΔL^* and Δb^*) were higher in Groups C and D compared to Groups A and B from post-whitening until 24 weeks ($p < 0.05$). HPP levels were not correlated to color change ($p > 0.05$).

Conclusions: Light activation enhanced whitening efficacy without affecting hydrogen peroxide penetration levels.

1. Introduction

Tooth whitening is a conservative and effective method to lighten discolored teeth and has become an integral component of aesthetic dentistry. The popularity is reflected by the wide scope of whitening options, ranging from professional in-office procedures, custom fabricated tray-based home whitening to a variety of over-the-counter products.Various factors influencing the efficacy of whitening have been investigated, and many studies have shown that increasing the exposure time and frequency will improve efficacy in

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terms of tooth color change.[1–4] Active concentration of the whitening material is another important factor to consider. Whereas several studies have shown that the higher the concentration the faster the whitening rate,[5–7] other studies did not find significant differences between various concentrations of carbamide peroxide.[8–10]

Activating light sources such as quartz–tungsten–halogen (QTH) lamps, plasma arc lamps, laser systems with a variety of wavelengths, and light emitting diodes (LED) have been used to enhance the chemical decomposition of hydrogen peroxide, thus enhancing whitening efficacy. However, the basic mechanism of action of these lights has not been well documented, and study results have been equivocal due to the variability of study designs and the use of different whitening materials as well as different activating lights.[11]

Whitening efficacy has also been related to the ability of hydrogen peroxide to diffuse into the tooth structure.[12] Penetration of hydrogen peroxide into the pulp cavity was enhanced by higher concentrations of hydrogen peroxide,[13] prolonged bleaching time,[14] heat,[14] and large open dentinal tubules of young teeth.[15] LED light and laser activation demonstrated increased hydrogen peroxide penetration levels into the pulp cavity,[16] however, HPP levels seemed not to be correlated with whitening efficacy.[12]

Thus, it would be ideal to formulate a light activation protocol that enhances whitening efficacy without increasing HPP levels. Henceforth, the purpose of this study was to determine the effect of a light activation protocol on tooth whitening efficacy and hydrogen peroxide penetration into the pulp cavity and correlate tooth color change with penetration levels. The null hypotheses to be tested were that first, light activation would not affect whitening efficacy in terms of tooth color change in ΔE^*ab, ΔL^*, and Δb^*. Second, light activation would not affect hydrogen peroxide penetration levels into the pulp cavity. Third, there would be no correlation between hydrogen peroxide penetration levels and post-whitening tooth color change.

2. Materials and methods

2.1. Sample selection and preparation

Forty extracted human canines were collected prior to the study and stored in 0.1% Thymol at 4 °C. Teeth were cleaned and observed for the absence of anomalies, caries, existing restorations, and deep crack lines. The roots were marked 3 mm apical to the cemento-enamel junction and trimmed off with a sectioning machine (TechCut 4, Allied High Tech Products, Inc., Compton, CA, USA). A cavity was prepared by enlarging the pulp chamber with pointed tapered diamond burs (NeoDiamond, Microcopy, Kennesaw, GA, USA) towards the lingual in order to maintain intact labial tooth structure and encompass 25 μl of acetate buffer. The dimensions of the cavity are illustrated in Fig. 1 with a depth of 7 mm and an oval shaped opening of 1.0–1.5 mm mesio-distally and 2.0 mm bucco-lingually. A circular adhesive label 6 mm in diameter was adhered at the centre of the labial surface to establish a standardized color reading and whitening area. The remaining tooth was painted with grey nail varnish (Sally Hansen, New York, NY, USA), and the adhesive label removed after drying, leaving a standardized window (Fig. 2). At the time of the experiment, the specimens were transferred to vials with artificial saliva made of porcine gastric mucin, calcium chloride, potassium phosphate and tris-hydrochloride.

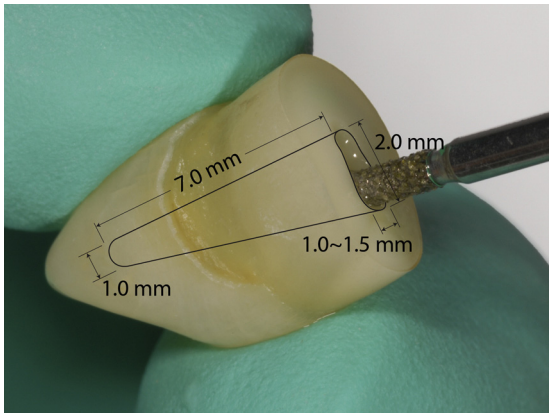

Fig. 1 – Cavity enlargement with diamond burs and cavity dimensions.

2.2. Whitening protocol

The specimens were randomly assigned into four groups (Table 1). Group A: Opalescence Boost base (whitening gel with no active ingredient that was provided by the manufacturer (Ultradent Products, Inc., South Jordan, UT, USA)), Group B: Opalescence Boost base with light activation, Group C: 40% hydrogen peroxide gel (Opalescence Boost, Ultradent Products Inc., South Jordan, UT, USA) and Group D: 40% hydrogen peroxide gel with light activation. A jig was fabricated for each specimen by gently placing the lingual surface of each tooth into a polyvinylsiloxane impression material (Aquasil Ultra Heavy, Dentsply Caulk, Milford, DE, USA) at a 30° angle from the base.

50 μl of whitening or base material was applied onto the labial window and covered with a linear low density polyethylene wrap (LLDPE)(Saran Wrap, S.C. Johnson & Son, Inc. Racine, WI, USA) to prevent evaporation and dehydration

Fig. 2 – Nail varnish painting around 6 mm diameter adhesive tape.