Penetration of hydrogen peroxide into the pulp chamber after conventional and laser-assisted bleaching

ABSTRACT

Background: Bleaching is a conservative approach to improve tooth colour. Laser irradiation accelerates the process by activating the hydrogen peroxide (HP) bleaching agent. However, there is little data examining whether this might result in pulp injury by enhancing HP penetration and diffusion. This study measured HP penetration into the pulp chamber with different bleaching techniques.

Methods: Fifty extracted central maxillary incisors were collected, disinfected, root treated and stored in sterile saline solution. The pulp chambers were filled with an acetate buffer solution. Bleaching was performed with one of four methods: 1. Conventional in-office bleaching; and accelerated bleaching using 2. Neodymium:yttrium-aluminium-garnet (Nd:YAG), 3. 1w Diode, and 4. 1.5w Diode lasers. A fifth control Group received no treatment. The buffer solution was drained and stained by colourimetric spectrophotometry to determine optical densities, which were analyzed by one-way ANOVA followed by Tukey honest significant difference (HSD) test.

Results: The greatest penetration occurred with the conventional in-office bleaching procedure (2.232 ± 0.39μg), while the least was seen with Diode (1w) laser-assisted bleaching (0.31 ± 0.28μg). Conclusion: Provided the manufacturer’s recommendations are followed, laser acceleration does not exacerbate penetration of HP into the pulp chamber.

Key words: hydrogen peroxide, tooth bleaching, Nd:YAG laser, Diode laser

INTRODUCTION

Bleaching is a simple, conservative, non-invasive, and inexpensive way of lightening tooth colour, and is a popular way of enhancing beauty and youthfulness. New methods and materials are currently being developed and introduced.

Bleaching may either be done in-office or at home by the patient. Hydrogen peroxide (HP) at a concentration in the range of 10%-40% or other chemicals capable of producing HP (e.g., carbamide peroxide, sodium perborate) are most commonly used to oxidize organic materials, inducing tooth colour change. Perhydroxyl radicals can break down large compounds into simpler molecules, with weaker light reflecting properties, thus giving a brighter appearance to the teeth. About 30%-35% HP application for up to 30min is considered standard in order to minimize any surface changes to the enamel. Bleaching gels should have a pH of

ACRONYMS

CEJ: cemento enamel junction
HP: hydrogen-peroxide
HSD: honest significant difference
LCV: leucocrystal violet
Nd:YAG: neodymium:yttrium-aluminium-garnet

1. Ladan Ranjbar Omrani: DDS, MSc. Assistant Professor, Department of Restorative and Esthetic Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.
2. Abbas Taher: MSc, MBA, MFD, RGS, FADCMS, FDC, FOM. Department of OMF Surgery, Faculty of Dentistry, University of Kufa.
3. Ammar Albujeer: DDS. School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.
4. Milad Parvin: DDS. School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.
5. Ghazaleh Daryakenari: DDS. School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.
6. Sattar Gorgani-Firuzjaee: DDS. Department of Medical Laboratory Sciences, School of Allied Health Medicine, AJA University of Medical Sciences, Tehran, Iran.
7. Hamid Kermanshah: DDS. Associate Professor, Department of Restorative and Esthetic Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.
8. Nasim Chiniforush: DDS, PhD. Laser Research Center of Dentistry, Dental Research Institute, Tehran University of Medical Sciences, Tehran, Iran.

Corresponding author

Kermanshah Hamid:
Associate Professor, Department of Restorative and Esthetic Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.
E-mail: kermanshah.hamid@yahoo.com
9.8–10.5, which enhances perhydroxyl radical production while reducing reactive oxygen radicals.7

Power bleaching is one approach that contributes to the efficacy of bleaching procedures.8 This method was pioneered by Abbot, who used high-intensity light to accelerate the whitening process.9 This was later followed by other acceleratory methods.10–12 The application of laser light, specifically 810 or 980nm Diode laser, and Nd:YAG with 1064nm wavelength, has been found to possess photochemical whitening effects.13

Two theories are proposed to explain the action of light on bleaching efficacy: (1) light and heat might accelerate HP breakdown14,15 and (2) light and heat might facilitate HP penetration into tooth structure.16

According to these theories, the laser-accelerated bleaching methods may encourage more HP penetration into pulp, which would induce oxidative stress,17 inhibition of pulpal enzymes,18 inflammatory pulp reaction;19 and subsequently postoperative dental hypersensitivity.20

The present study aimed to quantify the penetration of HP into the pulp chamber during different in-office bleaching methods, including laser-accelerated approaches.

MATERIALS AND METHODS

Fifty central maxillary human incisors were collected during a three-month period. They had been extracted due to periodontal problems, and all patients had provided informed consent to their use. Teeth were cleansed of soft tissues and calculus; and the absence of cracks, abrasion, or defects was verified by stereomicroscope (Nikon, SMZ800, Japan). The specimens were soaked in saline solution until required.

Using a separating disk (Shofu, Japan), the root of each specimen was truncated 2mm apical to the cemento enamel junction (CEJ). Pulp chambers were cleaned using headstrom files (Mailiefer, MI, USA), irrigated with saline, and then widened using a round bur to allow micro-pipette access.

A standard size (4 × 6mm) area was marked on each tooth surface by applying two coats of nail varnish to the surrounding surface.

After drying the pulp chambers with paper cones, the specimens were fixed vertically on a wax plate. A micro-tube. The pulp chamber was then irrigated twice with 2700μl distilled water, bringing the contents to a volume of 3ml. The process was followed for every specimen.

For each tooth, the extracted solution was transferred into a micro-tube. The pulp chamber was then irrigated twice with 50μl distilled water, and that 100μl was also transferred to the tube. One hundred micro litres of 0.5mg/ml leuco-crystal violet (Aldrich; Sigma-Aldrich Chemie GmbH, Steinheim, Germany) and 50μl of 1mg/ml horseradish peroxidase enzyme (Sigma; Sigma Chemical Co., St Louis, MO, USA) were added to the micro-tube, which was then filled with 2700μl distilled water, bringing the contents to 3ml volume. The process was followed for every specimen. The resulting blue solutions were examined with an UV-visible spectrophotometer (Novaspec 2, Pharmacia) at a wavelength of 596 m at room temperature, to measure the optical density (OD).26 The ODs which were obtained were then converted to micrograms using the spectrophotometer calibration curve, which was drawn up from the values resulting from spectrophotometer evaluation of different HP concentrations. The results were analyzed with one-way ANOVA, followed by Tukey’s HSD test for pairwise comparison between Groups.

RESULTS

The deepest HP penetration was observed in Group A (2.232 ± 0.39µg) while the lowest values were observed in Group C (0.31± 0.28µg) (Table 1).
The amount of HP that had entered the buffer solution of the control Group was negligible (0.001 µg) on the spectrophotometer absorption curve; this was deemed to be due to mild contamination in procedural errors and was considered as zero.

A statistically significant difference was found between each pair of study Groups (P < 0.001) except for Groups C and D (P = 0.954) (Figure 1).

The highest HP penetration was observed in Group A. This might be the result of the extended bleaching gel application time, allowing more penetration into dental structures, and inducing a destructive effect on dental structure that further increases permeability.

The present findings are in agreement with other studies. Haywood showed that 35% HP can reach the pulp tissue within 15 min, a finding similar to that found in this study.

Another finding was that HP penetrated to a greater extent in the Nd:YAG laser Group. This laser is reported to be capable of greater activation of the bleaching gel, due to the fact that its wavelength is higher than that of the Diode laser (1064 vs. 810–830nm), which reduces its penetration depth but allows absorption in the bleaching gel. Most of the laser energy therefore heats the gel, resulting in higher HP release. Pulpal penetration may therefore be expected. However, 1w and 1.5w Diode lasers did not significantly alter the penetration rates, showing that, at those wavelengths, altering the laser power has little significance.

Camargo et al. reported that application of Nd:YAG or LED laser during the bleaching process increased HP penetration as compared with their control Group which received no activation protocol. The bleaching gel application period was the same in the three test Groups in their study, making the results clinically irrelevant, because the purpose of activating agents is to achieve better results in a shorter time.

The present in vitro study, obviously, merely offers a possible window into what might happen in vivo, which has yet to be clarified. There are at least two possible in vivo mechanisms that could act to stop the penetration of HP molecules, namely: positive pulp pressure and the possible window into what might happen in vivo

**CONCLUSION**

This study appears to show that, provided the manufacturer's recommendations are followed, using laser activation for bleaching will not result in increased HP penetration into the dental pulp system.

**Conflicts of Interest:** None declared

**Acknowledgments:** Thank you to Benedicenti Stefano and Angiero Francesca, University of Genoa, Department of Surgical Sciences and Integrated Diagnostics, Genoa, Italy for their collaboration in this research.
This article was supported by grant no. 91-04-97-19814 (Laser Research Center of Dentistry, Dental Research Institute, Tehran University of Medical Sciences, Tehran, Iran).

References