In vitro demineralization of tooth enamel subjected to two whitening regimens

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Esthetic awareness causes patients to seek more vibrantly white teeth, leading to an increased demand for tooth bleaching. Because of bleaching's simple implementation, dental professionals find it an attractive elective procedure to offer. Two main effective methods for tooth bleaching exist: dentist-supervised, home-based bleaching involving the use of a nightguard and in-office professionally applied bleaching.[1,2] Home bleaching (HB) systems typically contain 10 percent carbamide peroxide, which dissociates into a low concentration of hydrogen peroxide and carbamide on exposure to saliva.[3] By comparison, office bleaching (OB) typically involves the application of a 35 percent hydrogen peroxide formulation to the enamel surface under various energizing sources.[4] As the amount and timing of peroxide applications can be managed strictly, OB regimens involve a higher concentration of peroxide to reduce the total OB time, with the expectation of achieving a better result.[5] The whitening effect of these bleaching regimens remains controversial.[6-13] Investigators in previous studies reported

ABSTRACT

Background. The resistance of bleached enamel to demineralization has not been elucidated fully. In this study, the authors aimed to examine the level of in vitro demineralization of human tooth enamel after bleaching by using two common bleaching regimens: home bleaching (HB) and office bleaching (OB) with photoirradiation.

Methods. The authors bleached teeth to equivalent levels by means of the two bleaching regimens. They used fluorescence spectroscopy to measure the reduction in enamel density and the release of calcium into solution after storing the treated teeth in a demineralizing solution for two weeks. They also visualized and quantified mineral distribution in demineralized bleached enamel over time by using a desktop microcomputed-tomographic analyzer.

Results. Enamel subjected to HB or to photoirradiation without bleaching showed increased demineralization. In contrast, enamel treated with OB was more resistant to demineralization. This resistance to demineralization in teeth treated with OB presumably is due to peroxide's permeating to deeper layers of enamel before being activated by photoirradiation, which enhances mineralization.

Conclusions. The mineral distribution pattern of enamel after treatment plays a critical role in providing resistance to demineralization in whitened teeth.

Practical Implications. OB confers to enamel significant resistance to in vitro demineralization. Dentists should supervise the nightguard HB process.

Key Words. Tooth; enamel; bleach; demineralization; microcomputed tomography; fluorescence spectroscopy.

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that the whitening effect was due to decomposition of organic colored elements and therefore was deemed noninvasive,[1,2] whereas others showed that peroxide diffuses deep into the tooth microstructure,[5,14] thus enabling a mineral distribution change in the enamel. Although investigators have proved the effectiveness of whitening procedures, whitening still is considered a cosmetic procedure and, consequently, there are no detailed clinical guidelines to ensure that the structural integrity of the tooth is maintained after treatment.

In 2010, we[12] reported distinct microstructural differences in the enamel after the use of two major bleaching regimens, despite equal changes in the color parameter. HB achieved color modification by means of demineralization, whereas OB enhanced mineralization by redistributing the minerals in the enamel. The enamel microstructure is important in the pattern of demineralization because the hydroxylapatite (HAP) structure can either enhance or reduce enamel's susceptibility to erosion.[15,16] We therefore sought to test the hypothesis that, under in vitro demineralizing conditions, enamel treated by using an OB regimen would show increased resistance to erosion owing to the enhancement of its surface mineralization after treatment, as compared with the resistance of sound enamel or enamel treated by using the HB system.

METHODS

Specimen preparation and treatment regimens. In this study, we used 30 human premolars without stain or defect that had been extracted for orthodontic indications, under a protocol approved by the ethics committee of the School of Dentistry, Showa University, Tokyo (reference no. 2008-38). We varnished the tooth roots with a resin material (Super Bond C&B, Sun Medical, Shiga, Japan) and stored the teeth in a salt solution (Hank's Balanced Salt Solution, Sigma-Aldrich, St. Louis) until required for testing (not longer than one month). Investigators have recommended using this salt solution to store teeth because it does not alter tooth mineralization substantially.[11,17]

Before baseline readings, we transferred the teeth into artificial saliva (AS) for one day. The AS was composed of 0.08 weight percent sodium chloride, 0.12 weight percent potassium chloride, 0.01 weight percent magnesium chloride, 0.03 weight percent dipotassium hydrogen phosphate, 0.01 weight percent calcium chloride, 0.10 weight percent sodium carboxymethyl cellulose and 99.6 weight percent pure distilled water, and we adjusted it to pH 7.0 with carbon dioxide (as described by Yamaguchi and colleagues[18]). We coated the buccal surface of each tooth with a 1 millimeter–thick layer of silicone (Exafine, GC, Tokyo) and cut a 5-mm–diameter hole into the silicone to expose the buccal enamel surface of each tooth. We then treated this exposed surface with either HB or OB according to the manufacturer's instructions.[12]

We performed each procedure on the buccal surface of different teeth. For the HB group, we combined 20 microliters of a 10 percent carbamide peroxide (pH 6.0) HB gel (Nite White Excel, Discus Dental [now a part of Philips Oral Healthcare], Culver City, Calif.) with 5 µL of AS so that 10 percent of the carbamide peroxide theoretically decomposed into 3.6 percent hydrogen peroxide and 6.4 percent carbamide (Tanaka and colleagues[12] described the decomposition process). We applied this mixture to the buccal tooth enamel for two hours every day for seven days. Between exposures, we replaced the teeth in AS. The HB regimen involves direct contact of a lower concentration of hydrogen peroxide with the tooth surface, which allows an improved whitened appearance after application of the agent for two hours daily over seven days.[12]

For the OB group, we exposed teeth to 20 µL of a 35 percent hydrogen peroxide (pH 3.4) OB agent (Hi-Lite, Shofu, Kyoto, Japan) that we activated by means of a standard halogen light-curing (LC) unit (DP-075, Morita, Tokyo) for three minutes. We assessed the intensity (470 nanometers and > 500 milliwatts per square centimeter) of the halogen lamp by means of the photoelectric sensor before use and maintained the intensity consistently throughout the study. We performed the treatment three times on each sample. We maintained a minimum distance of 1 mm between the light source and the sample enamel because of the thickness of the silicone applied during tooth preparation. We prepared two groups of OB samples for this study: one that we maintained in AS at 37°C before demineralization (OB + AS group) and another that we did not store in AS (OB group).

We also included two control groups. The first was a control specifically for the OB and OB + AS groups and contained teeth that were not subjected to any bleaching agent but were

ABBREVIATION KEY. AS: Artificial saliva. **CIE:** Commission Internationale de l'Eclairage. **CT:** Computed tomography. **ΔE:** Color difference value. **HAP:** Hydroxylapatite. **HB:** Home bleaching. **LC:** Light curing. **MOH:** Mineral density of hydroxylapatite. **OB:** Office bleaching. **ROI:** Region of interest. **3-D:** Three-dimensional.