

Er: YAG Laser Assisted Bleaching Procedures Effect on Enamel Topography

Ola M. Sakr^{1,2,*}

¹Department of Conservative Dentistry, College of Dentistry, Qassim University, Kingdom of Saudi Arabia

²Department of Operative Dentistry, College of Dentistry, Misr University for science and Technology, Egypt

*Corresponding author: olasakr2004@yahoo.com

Abstract The aim of this study was to evaluate the effect of using Er: YAG laser during in-office tooth bleaching on enamel surface. **Method:** Thirty enamel discs specimens of human anterior teeth and divided into three groups, Group 1: (control) specimens received no bleaching treatment; Group 2: specimens received conventional in-office bleaching treatment using Opalescence Boost PF tooth whitening systems; Group 3: specimens received laser assisted bleaching procedure using low energy Er: YAG laser to assist tested bleaching gels. After bleaching, Specimens were stored for 15 days in artificial saliva. Digital microscope and images analysis used to evaluate surface roughness. Scanning electron micrographs were captured to evaluate enamel surface changes. Data were statistically analyzed using Aasistat 7.6 statistics software with Student t-test. **Results** Conventional in-office bleached enamel showed statistically significant higher enamel surface roughness than unbleached enamel surface with changes in enamel surface morphology were observed. While ER: YAG laser assisted bleached enamel, surfaces showed non-statistically significant higher enamel surface roughness than unbleached enamel surface with minor changes in enamel surface morphology were observed. **Conclusions:** Tested laser assisted bleaching procedures showed safely enamel surface treatment than conventional in-office bleaching procedures.

Keywords: *In office bleaching, laser assisted bleaching, Enamel, Surface roughness*

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1. Introduction

As teeth aesthetic is a public demand, Teeth bleaching is a direct way for teeth discoloration treatment in accordance with minimally invasive and aesthetic dentistry. Teeth Bleaching can be achieved either, vital, by an external approach, at home or in the office techniques [1] or non-vital teeth bleaching by an internal approach [2]. Non-vital teeth bleaching is by either in office bleach technique or walking bleach technique [3]. During in-office bleaching technique. The operator uses relatively high levels of bleaching agents (25-40 % hydrogen peroxide or 35-38 % carbamide peroxide) for shorter time periods. While during at-home bleaching procedures, patient uses low levels of whitening agents (3-6 % hydrogen peroxide or 10-16 % carbamide peroxide) for longer application times [4]. Teeth Bleaching mechanism are based on substances that have a great potential of oxygen release. In dental practice, hydrogen peroxide is the most commonly used as bleaching agent [5,6].

Discolored teeth whitening may be achieved, using free radicals generated from hydrogen peroxide, by oxidation or reduction reaction of teeth colored organic and inorganic compounds chemical structure [7].

As free radicals contain one or more unpaired electrons in their atomic orbital so they are unstable. They tend to

get an electron by oxidation of stains present in adjacent enamel and dentin and more whiter tooth structure [8]. Many researches mentioned that accelerating peroxide bleaching treatment can be achieved by shortening the chemical redox reactions with different sources of light energy such as, lasers, light-emitting diodes (LED), plasma arc lamps, and halogen curing lights, in a variety of wavelengths and spectral power [9-14]. The Er:YAG laser wavelengths (2940 nm) is highly diffused in hydroxyapatite and the highest absorption of water of any dental laser wavelengths [15].

Dimitrios D et al concluded that Er, Cr: YSGG laser is safely used for laser assisted in office bleaching with a slight reduction in enamel surface microhardness and changes in enamel surface morphology [16]. Many studies stated that bleaching procedures have some adverse effects on tooth structure as enamel changes in micro-hardness, surface roughness and modulus of elasticity. All bleaching adverse effects attributed to chemical and morphological changes of dental hard tissues [11,17,18,19,20,21].

Considering the wavelength of the Er: YAG laser at low energy modifies hard dental tissue once it acts on their surface characteristic properties, including microhardness and permeability [22,23].

Therefore, the aim of this in vitro study was to evaluate the effect of using Er: YAG laser to safely assist in-office teeth bleaching on enamel surface.

2. Materials and Methods

2.1. Specimens Selection and Preparation

Fifteen sound extracted human anterior teeth stored in a 0.5 % chloramines T solution at room temperature. The teeth were cleaned with running water, and the roots were removed. Teeth were examined with a 40× stereomicroscope to eliminate structurally damaged and examined radiographically to exclude teeth with calcification or resorption in the pulp chamber and (Leica, Model M165C Microsystem, Germany). Each crown was sectioned into two halves (each sample measuring approximately 3 mm long, 3 mm wide and 1 mm height) using a water-cooled diamond disc (Isomet, Buehler, Lake Bluff, IL, USA). Thirty enamel specimens were randomly distributed into 3 groups (n = 10) and were embedded into chemical-cure acrylic resin surrounded by cylindrical polyvinyl chloride (PVC) molds, 1.5-cm diameter and 1.5-cm high, (Cristal, Piracicaba, SP, Brazil with the facial or lingual surface facing up. The enamel surfaces were ground and polished using 600 and 1200 grit silicon carbide abrasive papers and a 0.4 μm alumina polishing suspension [24].

2.2. Design of the Experiment

Specimens were divided into 3 groups, Group 1: (control) specimens received no bleaching treatment; Group 2: specimens received conventional in-office bleaching treatment using Opalescence Boost PF tooth whitening systems (Table 1), 1.5 mm thick bleaching gel was evenly spread over tested specimens and left for 20 min. The gel was removed using high-speed suction, then flushed water spray to remove any residual gel, Group 3: specimens received Er: YAG laser assisted bleaching procedure.

The Er: YAG laser (KaVo KEY Laser II – KaVo, Biberach, German), Its wavelength was 2.94 μm in infra-red region, and a pulse duration of 250– 400 μs used with the gold handpiece of the laser system.

The output power of ErYAG laser parameters used for bleaching activation was 70 mJ, repetition rate at 2 Hz which is significantly below the ablation threshold of dental tissues.

The activation of the bleaching agent consisted of two intervals of 15 s for each specimen, keeping the laser device handpiece perpendicular and 2.5 cm away of the specimens [25].

Table 1. The tested bleaching gel

Material	Composition wt.%)	Manufacture	Lot number
Opalescence Boost PF tooth whitening systems	Hydrogen peroxide ≈ 40 %	Ultradent® Products, Inc., S. South Jordan, UT, USA	704750

2.3. Roughness Evaluation Methodology

Specimens were photographed using USB digital microscope with a built-in camera (Scope Capture Digital Microscope, Guangdong, China; connected with an IBM compatible personal computer using a fixed magnification of 120X. The images were recorded with a resolution of

1280 × 1024 pixel per image. Digital microscope images were cropped to 350 x 400 pixels using Microsoft office picture manager to specify/standardize area of roughness measurement. The cropped images were analyzed using WSxM software (Ver5 develop 4.1, Nanotec, Electronica, SL). Within the WSxM software, all limits, sizes, frames and measured parameters are expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real-world units. Calibration was made by comparing an object of known size (a ruler in this study) with a scale generated by the software. WSxM software was used to calculate average of heights (Ra) expressed in μm, which can be assumed as a reliable indices of surface roughness).

Subsequently, a 3D image of the surface profile of the specimens was created using A digital image analysis system (Image J 1.43U, National Institute of Health, USA).

2.4. Topographic Analysis

Two specimens from each experimental group were mounted on aluminum stubs, sputter-coated with carbon to a thickness of approximately 200 Å in a vacuum evaporator and examined under QUANTA 200 scanning electron attached with EDX unit.

2.5. V-Statistical Analysis

Data were presented as mean and standard deviation (SD) values. Regression model using two-way Analysis of Variance (ANOVA) was used in testing significance for enamel surface roughness changes.

3. Results

3.1. Results of Surface Roughness

The mean values and standard deviations (SD) for enamel roughness measured by average roughness Ra in (μm) are shown in Table 2. There were no statistically significant differences in Ra values between the group (1) or group (2) when compared with group (3) (p > 0.05). While there were statistically significant differences in Ra values between the group (1) and group (2) p < 0.05.

Table 2. Means and standard deviations of surface roughness (Ra) for each tested group

Group	Ra
Group (1) no bleaching	0.254589±0.0006
Group (2) conventional in office bleaching	0.2565±0.0009
Group (3) bleaching assisted with laser	0.256001±0.0012

3.2. Topographic Observations

Surface morphology of the non-bleached enamel surface (Figure 1) and bleached enamel with Er: YAG laser treatment (Figure 3) showing minimal surface irregularities. While bleached enamel surface morphology (Figure 2) showing variable forms of surface changes as cracks, depressions, porosities and some surface irregularities were observed.

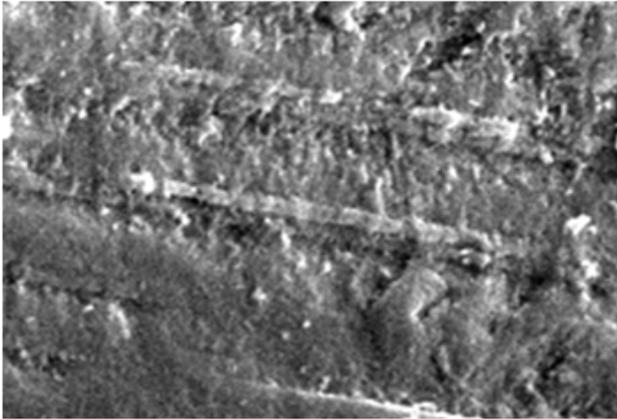


Figure 1. Scanning electron micrograph, magnification 1500 of non-bleached enamel surface specimen

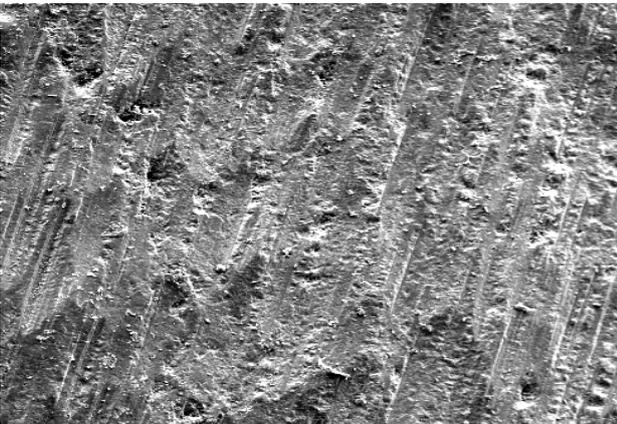


Figure 2. Scanning electron micrograph, magnification 1500 of conventional in office -bleached enamel surface specimen

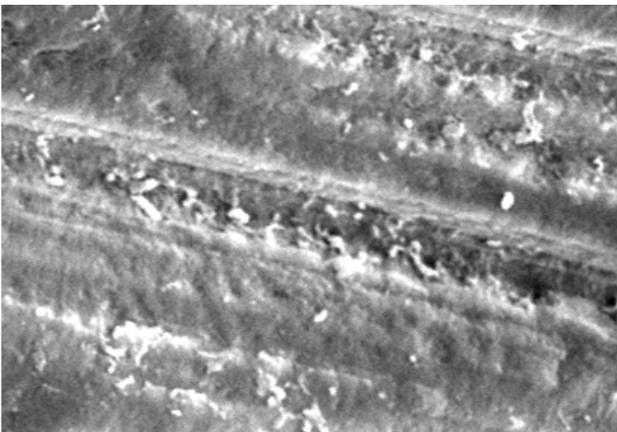


Figure 3. Scanning electron micrograph, magnification 1500 of Er:YAG laser assisted -bleached enamel surface specimen

4. Discussion

According to our findings of enamel surface roughness results that there was statistical significance increase of bleaching procedures on surface roughness of the exposed enamel. This enamel surface roughness may be attributed to acidity of tested bleaching agent ($\text{pH} \approx 4.4$) which may lead to greatest changes in enamel topography. Our roughness results agree with those of previous researchers

that investigated surface roughness changes after hydrogen peroxide in-office bleaching sessions [26,27,28].

Previous studies stated that higher concentrations of hydrogen peroxide bleaching agents lead to more enamel surface roughness than lower concentrations [29,30].

Hosoya et al. concluded that bleached enamel surface showed increased colonies of *Streptococcus mutans* as a result of increased enamel surface roughness [30].

Our finding outcomes showed that no statistical significance decrease of Er: YAG laser assisted bleaching procedures on surface roughness of the exposed enamel. Scanning Electron micrographs showed that laser assisted bleaching showed less increase in surface roughness in comparison with the conventional in-office bleaching technique. Er: YAG Laser assisted bleached enamel surfaces showed less porosities, depressions, and surface irregularities than conventional in-office bleaching technique. These findings may be attributed to low-energy Er: YAG laser enamel tissue exposure converted to localized heat increase with subsequent microexplosions lead to the ejection of organic and inorganic with slight melting of organic enamel content of superficial enamel particles that can be noted in the scanning electron micrographs and also causing an increase in surface enamel-acid resistance [31,32].

We can report that Er: YAG laser assisted bleaching induced melting of superficial enamel organic matrix may result in decrease of surface roughness than conventional in-office bleaching technique. This was in acceptance with Maung et al, who mentioned that It was indicated that Er: YAG laser induced melting of organic matrix may blocking the diffusion pathway and result in a reduced efficiency in ion diffusion and subsequent increase enamel acid resistance [33]

Our findings are coinciding to Anaraki et al who studied the effects of a conventional in-office versus a laser bleaching treatment on surface roughness of enamel, they found that laser-assisted tooth bleaching showed less increase in surface roughness when compared with the conventional in-office bleaching technique [34].

5. Conclusions

Er:YAG laser assisted bleaching procedures showed safely enamel surface treatment than conventional in-office bleaching procedures.

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