

Original Article

A Comparative Evaluation of Smear Layer Removal by Using Different Er: YAG Lasers Parameters: An *In-vitro* Scanning Electron Microscopic Study

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ABSTRACT

Introduction: The purpose of this in-vitro study was to investigate the effect of irrigation activation methods using different laser parameters on microhardness and push-out bonding strength of root canal dentin. This study evaluates and compares the efficacy of different laser parameters in smear layer removal using the scanning electron microscopic image analysis. **Materials and Methods:** In this in-vitro study, 60 newly extracted human teeth with extraction indications were used. Later, the teeth were randomly divided into three groups ($n = 20$). In Group 1, irrigation was performed using 2 Er:YAG laser (Fotona Laser AT Fidelis Plus III, Slovenia) with 0.6 W, 15 Hz, and 40 mJ parameters. In Group 2, irrigation was performed at 0.3 W, 15 Hz, and 20 mJ. In Group 3 (control group), conventional syringe irrigation method was performed without activation. After irrigation activation, horizontal sections were taken from the teeth, sections from the coronal, middle, and apical triplets were selected and subjected to the Vicker's microhardness test. The Kruskal–Wallis and Wilcoxon signed-rank tests were performed on the obtained data. **Results:** There was no statistically significant difference between the control group and the laser group ($P > 0.05$). As a result of the push-out bonding strength test performed on the coronal and apex regions of laser treated and untreated groups, the values of the coronal region were found to be higher than the apex region, and it was found that the bonding strength of the coronal part of the laser group was increased ($P < 0.05$). The change in parameters between the laser groups did not produce a statistically significant difference between the groups ($P > 0.05$). **Conclusion:** According to this study the laser group increases the bonding strength without a negative change in microhardness. In this study the further research is needed on this subject.

KEYWORDS: Laser; microhardness, photon-induced photoacoustic streaming, push-out, scanning electron microscopic

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INTRODUCTION

Root canal irrigation plays an important role in the cleaning and disinfection of the root canal system. During mechanical preparation, rotary instruments create debris in the root canal. During the removal of this debris from the canal, the structure of the root should not be impaired.^[1-3]

The use of the traditional syringe method fails in the adequate application and diffusion of the irrigation solutions to the complex three-dimensional

microstructure of the root canal. Because the root canal system consists of the coronal, middle, and apical regions, access to the apical region is limited in the traditional syringe system.^[4-7]

A new and revolutionary system has been developed for cleaning, disinfecting, and shaping the root canal

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system. Inamoto *et al.*^[8-10] called this system, they developed together, photon-induced photoacoustic streaming (PIPS). After the root canal is expanded by conventional methods, a laser beam is transmitted to the root canal using optical fibers. PIPS are used at sub-ablative power level in lasers of 2940 nm wavelength. Fiber tip is used with various irrigation agents such as sodium hypochlorite (NaOCl) or ethylenediamine tetraacetic acid (EDTA).^[11-14]

Fiber tips create photomechanical and photoablation on the tooth and remove the smear layer and open the dentin tubules by generating high power in short bursts.^[15] PIPS are suitable for use with Er:YAG lasers, because the rate of absorption of these lasers by water is high. The thermal effect is minimized by the PIPS tip. The sub-ablative power level eliminates the risk of demineralization.^[16-19]

In root canal treatment, lasers may be used to remove the dental pulp and organic debris, and to modify the dentinal walls by inducing melting and resolidification cycles resulting in the enlargement of the walls of the root canal system. Once the preparation is completed, the root canal is obturated, and the laser may be used to soften and mold the obturating material to the prepared root canal system.^[18,19]

Mineral changes in the root canal dentin may have an effect on the permeability and solubility of the root canal. As a result, adherence of dental materials to root canal dentin can be adversely affected. Microhardness is an indirect indicator of mineral changes in the dentin.^[20,21]

The purpose of this in-vitro study is to investigate the effect of irrigation activation methods using different laser parameters on microhardness and push-out bonding strength of root canal dentin. The null hypothesis was that the using different lasers parameters will change the dentin microhardness and does not affect the bond strength to root canal dentin.

MATERIALS AND METHODS

In this in-vitro study, 60 newly extracted human teeth with single and flat roots were used. The teeth with decays, cracks, restoration, dilaceration, or open apex were excluded from the study. After the entry cavity was opened under water cooling, the root canal preparation of the teeth were performed by endomotor (Endo Mate TC2, NSK, Japan), rotary instruments, and Ni-Ti files (S1-S2-F1-F2-F3; ProTaper Universal, Dentsply DeTrey, Konstanz, Germany) according to the crown-down technique. During the shaping process, the root canal was washed with a syringe injected

with normal saline at each file change. After this procedure, the teeth were randomly divided into three groups ($n = 20$).

Group 1: Irrigation was performed with Er:YAG laser (Fotona Lazer AT Fidelis Plus III, Slovenia) at 2940 nm wavelength. The fiber tip (R13) was placed parallel to the surface in the coronal one-third region of the tooth. 0.6 W, 15 Hz, and 40 mJ parameters were used. The activation protocol was as follows:

1. 2 mL of 5% NaOCl was activated for 2–3 s
2. 2 mL of 5% NaOCl was used for 2–3 s without activation
3. 2 mL of 5% NaOCl was activated for 2–3 s.

During the activation process, NaOCl was continuously sent through the canal mouth. The total activation time was 60 s, and the total washing solution volume was 6 mL. Final irrigation was performed [Figure 1].

Group 2: Irrigation was performed with Er:YAG laser at 2940 nm wavelength. The conical tip was placed to the coronal region of the tooth. 0.3 W, 15 Hz, and 20 mJ parameters were used. Activation protocol was performed as in Group 1.

Group 3: This group was selected as the control group for the traditional syringe irrigation method. The 28-gauge size injector tip was positioned to be 1 mm shorter than the working height. In total, 6 mL of 5% NaOCl was used for 60 s without activation.

After final irrigation, 10 teeth were randomly selected from each group and a horizontal cross-section was taken from the teeth using a water-cooled cutting device (Isomet1000; Buehler, Lake Forest, IL) ($n = 10$). A sample was selected from the coronal, middle, and apical triplet regions and embedded in autopolymeric acrylic blocks. Prior to microhardness measurement, the root surfaces of the samples were sanded and polished using a circular grinding machine under water cooling with 400, 800, and 1200 grit silicon carbide abrasive papers, respectively. The Vicker's microhardness tester (Schimadzu, Kyoto, Japan) was used to measure the surface microhardness. The Vickers hardness gauge in the form of a top-angled diamond pyramid was applied to the canal lumen at a distance of 100 μ m, with a force of 200 g for 20 s. The diagonals of the pyramid shaped mark formed on the surface were measured under a stereomicroscope at $\times 35$ magnification. The same procedure was repeated three times per sample and the average was taken.

After final irrigation, 10 teeth from each group were randomly selected and glass fiber posts (Snowpost, Carbotech, Ganges, France) were applied to the post

cavities with a special endodontic tip with Clearfil SA (Kuraray Medical, Tokyo, Japan) cement. They were carefully placed in the post cavity by being calibrated with slight finger pressure. Thus, it was allowed for excess cement to overflow. Polymerization of the resin cement was provided by a LED (L. E. Demetron I/Kerr Corporation, Orange, CA, USA) beam device for 40 s while finger pressure was applied in this manner. All samples were kept in distilled water at 37°C for 24 h.

Ten teeth from each of the prepared groups were used for the push-out bonding strength test. Teeth were embedded in methacrylate resin molds [Figure 2].

Six sections from each tooth were taken from the acrylic blocks using a slow-rotating cutting machine (Minitom, Struers, Copenhagen, Denmark) under distilled water cooling and 60 sections were obtained in each group for the push-out test. The thickness of each section was approximately 1 mm. The first two sections were taken from coronal region of the post cavity, the following two sections were taken from the middle, and the last two sections were taken from the apical region. When the push-out test was applied, a mold was used, which was prepared from autopolymeric acrylic material and had a cavity with a diameter of 2.5 mm in the middle, to support the root sections. Push-out test was applied to the prepared specimens in the universal test device (Lloyd LR 50K, Lloyd Instruments PIC, England), at a rate of 0.5 mm/min from the apical to the coronal. The maximum breaking value was determined as Newton (N) and this value was divided by the area of the post's bonding surface and converted to megapascals and recorded.

In this study, descriptive statistics and analyses were performed using the SPSS 15.0 Windows computer package program (IBM 2010), and $P < 0.05$ was considered statistically significant. The Kruskal–Wallis and Wilcoxon signed-ranks test were used for comparison of the parameters between the groups when study data were evaluated.

In addition, Friedman multiple comparison test was used to compare push-out values within the groups.

RESULTS

The values of microhardness measurements in the coronal, middle, and apical triplet regions are shown in Figure 3. There was no statistically significant difference between the control group (Group 3) and the laser groups (Group 1 and 2) according to the results ($P > 0.05$) [Figure 3]. Based on the push-out bonding strength test performed on the teeth sections taken from the coronal and apex regions of laser-treated

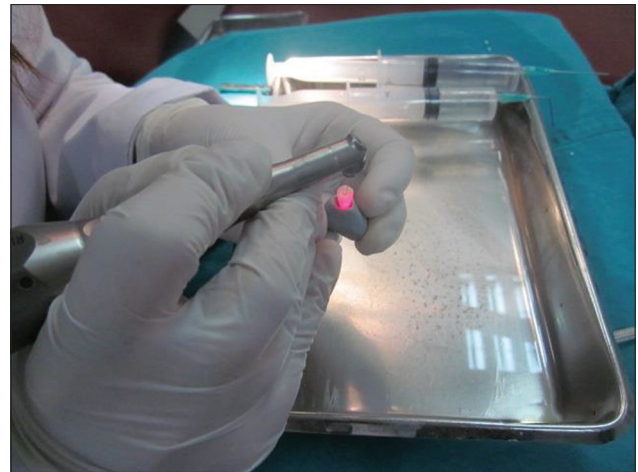


Figure 1: Laser application



Figure 2: Samples on acrylic molds for push-out test

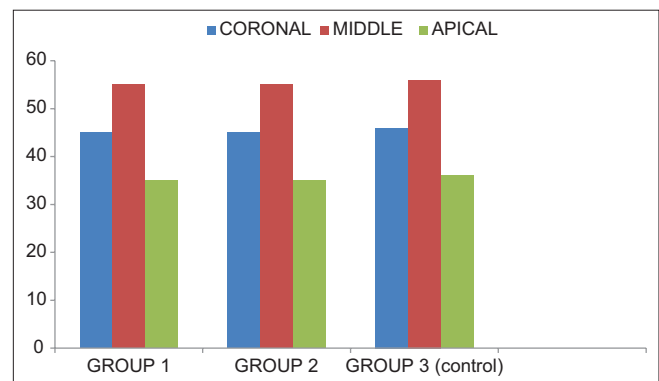


Figure 3: Microhardness values of laser-treated and untreated groups according to regions

and untreated groups, it was found that the values of the coronal region were higher than the apex region, and the bonding strength of the coronal region of the laser group was increased ($P < 0.05$) [Figure 4]. The change in parameters between the laser groups did not produce a statistically significant difference between the groups ($P > 0.05$).

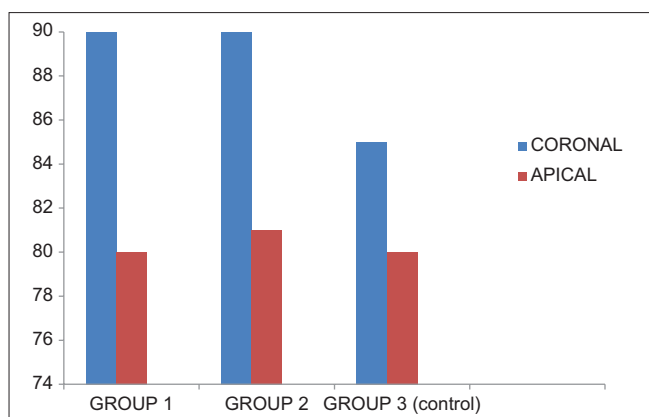


Figure 4: Push-out test values of sections taken from the coronal and apical regions

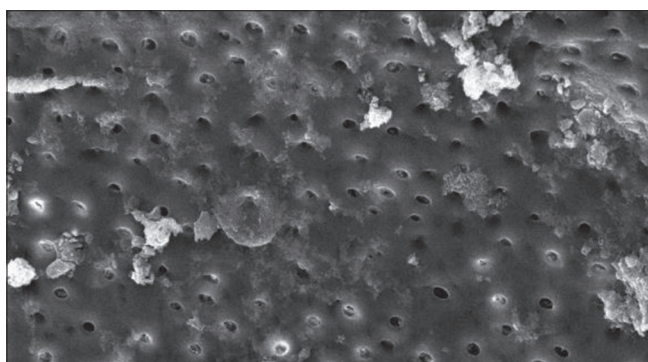


Figure 5: Group 1 coronal triplet level SEM image

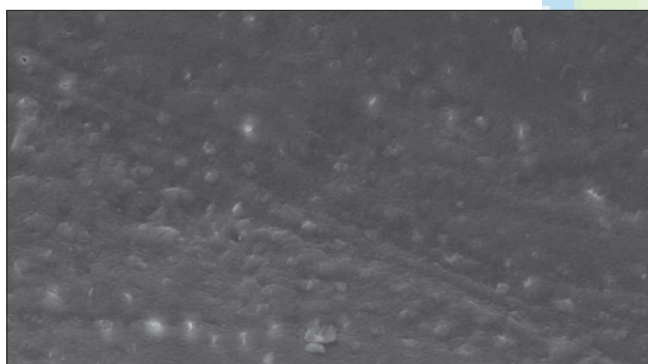


Figure 6: Group 3 coronal triplet level SEM image

Smear results

Scanning electron microscopic (SEM) analysis results of the laser group showed relatively clean and rough tooth surfaces and low smear layer amount compared to the control group. In this group, dentin tubes with larger diameter and distinct appearance are seen [Figure 5].

SEM analysis results of the control group reveal that the application was ineffective in removing the smear layer at all levels of root surface. Root surfaces and ducts of dentin tubules are covered with thick smear layer and debris [Figure 6].

DISCUSSION

In this in-vitro study, the effects of irrigation activation methods on root canal dentin microhardness and push-out bonding strength were examined using different laser parameters.

Irrigation has an important role in a successful endodontic treatment. Along with developments in laser technology, laser-assisted irrigation systems have been used and evaluated in many studies for the activation of wash solutions.^[7] However, there is limited information about the effect of laser-assisted irrigation on root canal dentin. Today, PIPS tips have begun to be used in the irrigation of the root canal. The PIPS protocol used in the root canal is based on the creation of photo-acoustic shock waves on the irrigant in the root canal causing rapid fluid movement, and creating a secondary cavitation effect without thermal effect.^[9,10,12]

Topçuoğlu *et al.*^[2] reported that the Er:YAG laser did not alter the mineral content of root canal dentin. Tokonabe *et al.*^[3] evaluated the morphological change after Er:YAG laser application and reported that the surface structure did not change. In our study, there was no significant difference in dentin microhardness between the laser-activated groups and the control group. According to this study these results are consistent with the literature.

PIPS tips with different parameters were used in our study. There was no significant difference between these two groups. According to this study, this result is due to the limited side effects of the parameters used on the dentin.

Patterson^[4] reported that the microhardness of the root canal decreases as we move toward the apical region. In our study, a decrease in dentin microhardness was found in all groups in the apical direction. When the groups were evaluated within themselves, it was found that the coronal and medium triple segments had significantly higher microhardness values than the apical triple segment.

The presence of debris and smear layer in the root canal walls affects the bonding strength negatively.^[1,11,13] Takeda *et al.*^[22] reported that the smear layer was removed from both the middle and apical triplet in Er:YAG laser-treated specimens. Inamoto *et al.*^[8] reported that the smear layer was not observed in the root canals prepared using Er:YAG laser with 30 mJ energy and it was an effective method for root canal preparation. Tanboğa *et al.* also applied Er:YAG laser on root canals at 10 Hz/80 mJ energy for 15 s using a 200 µm thick flexible fiber tip, and reported that the smear scores of the laser-treated specimens were significantly lower than the control group.^[23] In our study, a significant difference was observed in the push-out

bonding test performed on the laser-treated group and the control group where conventional syringe method was applied. It was found that the laser-treated group had a higher bonding strength. The traditional syringe method only affects the organic structure. The laser group also acts on the inorganic structure, and it changes the Ca/P ratio in hydroxyapatite and increases the roughness on the surface. In this study, the high bonding strength values obtained in the laser group are due to these properties. SEM analysis results also support this.

In this present study, there was no change in the dentin hardness in all three groups, but the push-out bonding strength increased. The Er:YAG laser changes the proportion of organic and inorganic structure that forms the root dentin. This change affects the permeability, solubility, and adhesion properties of hard tissues of the teeth. In order for adhesion to take place, cavities must be formed without disrupting the dentin structure. According to the present study, this is possible with enough water cooling and parameters used. Therefore, in the present study the push-out bonding strength of the laser group significantly increased without a change in the microhardness of root dentin in our study.

CONCLUSION

According to the present study, the laser group increases the bonding strength without a change in microhardness. Further research is needed on this subject. There was no significant difference in dentin microhardness between the laser-activated groups and the control group.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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