

REMOVING SMEAR LAYER DURING ENDODONTIC TREATMENT BY DIFFERENT TECHNIQUES - AN IN VITRO STUDY. A CLINICAL CASE - ENDODONTIC TREATMENT WITH ER:YAG LASER

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ABSTRACT

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Introduction: Cleaning and shaping the root canal system during endodontic treatment produces a smear layer and hard tissue debris. Removing smear layer through irrigation is a critical adjunct.

Objectives: The aim of this study was¹ to evaluate in vitro the effect of irrigation techniques, irrigation with syringe-needle and laser-activated irrigation with 17% EDTA in root canals and² to demonstrate the effect of laser activated irrigation in a patient case.

Materials and Methods: Sixty extracted teeth were divided into three equal groups; Group 1: treated only with ProTaper™ F3 Ni-Ti files. Group 2: positive-pressure irrigation: 17% EDTA was used for 60-second irrigation, with a syringe. Group 3: Er:YAG laser-activated irrigation with 17% EDTA irrigation was used for 60 second, Laser flat tip was inserted in the upper coronal third of the root canal.

Results: Scanning electron microscopy showed that the smear layer is removed most efficiently using laser-activated irrigation with a 17% EDTA.

Conclusion: Smear-layer removal was most effective when the root canals were irrigated using Er:YAG laser at low energy with 17% EDTA solution. This effect was not observed with the positive-pressure techniques. A clinical case demonstrate the effect of using Er:YAG laser activated 17% EDTA inside root canal.

Keywords: endodontic, root canal irrigants, Er-YAG laser, scanning electron microscope, smear layer.

1. Introduction

Root canal treatment is performed to prevent or treat apical periodontitis. Effective endodontic treatment includes cleaning and shaping complex three-dimensional microstructure in which irregular structures such as isthmuses, apical deltas, and lateral canals may be present. The shaping phase aims to enlarge the canal. However creates a smear layer along the root canal walls¹. The smear layer consists of a superficial layer on the surface of the root canal wall approximately 1-2 μ thick and a deeper layer packed into the dentinal tubules to a depth of up to 40 μ ². It contains inorganic and organic substances, including microorganisms and necrotic debris³. In addition to the possibility that the smear layer may be infected, it can also protect the bacteria already present in the dentinal tubules by obstructing intra-canal disinfection agents⁴.

Pashley⁵ considered that a smear layer containing bacteria or bacterial products might provide a reservoir of irritants. Thus, complete removal of the smear layer would be consistent with the elimination of irritants from the root canal system⁶. Peters et al. clearly⁷ demonstrated that more than 35% of the surface area of the canals remained unchanged following instrumentation of the root canal using four Ni-Ti preparation techniques. Mechanical instrumentation is always combined with irrigation in order to clean the areas that cannot be reached by instruments, to remove the smear layer, and to promote disinfection. Irrigation of the root canal is traditionally performed using a syringe-needle combination. However, the penetration of the irrigant in the apical third is limited⁸⁻⁹. Activation of the irrigation solution is suggested to improve their distribution in the canal system and increase irrigation effectiveness. Recent

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advances in dental research have incorporated laser technology as a novel modality for use in endodontic therapy¹⁰.

In 1917, Albert Einstein wrote: "a special kind of light could be created under the right conditions - a light nobody had seen before. The light would be a single color, it would not scatter the way normal light does and it would be very intense". This kind of light would later be called laser. The use of laser at different wavelengths has been proposed to supplement conventional endodontic cleaning procedures¹¹⁻¹⁴. Lasers pulsed infrared have been shown to cause cavitation-bubbles and pressure waves within the root canal space when combined with irrigants¹⁵⁻¹⁶. The cleaning effect of LAI (Laser Activated Irrigation) is based on cavitation: when a pulsed erbium laser is emitting in a root canal brimful of irrigant, strong absorption of the laser energy by the irrigant results in the formation of vapor bubbles at the fiber tip. These vapor bubbles expand during the pulse and then collapse soon after termination of the laser pulse¹⁷. Erbium lasers are effective in activating irrigating solutions: the absorption coefficients for water at 2,940 nm (Er:YAG laser) and at 2,790 nm (Er,Cr:YSGG laser) are 12,000 and 6,000 respectively¹⁸ and cause formation of vapor bubbles at the fiber tip. For LAI to be effective, high absorption of laser energy into the irrigating liquid is necessary.

The aim of this study was (1) to evaluate in vitro the effect of irrigation techniques, irrigation with syringe-needle and laser-activated irrigation with 17% EDTA in root canals and (2) to demonstrate the effect of laser activated irrigation in a patient case.

2. Materials and methods

2.1. Tooth Samples

Sixty single-rooted human teeth extracted for periodontal reasons were used. (Ethics committee approval, Hadassah Hospital (No 0118-14-HMO). Root canal preparation was carried out using ProTaper™ (Dentsply Maillefer, Baillaigues, Switzerland) F3 Ni-Ti files with 2.5% NaOCl irrigation. The apices of all teeth were sealed with

Super-EBA (Harry J. Bosworth Co., Skokie, IL, USA) to prevent irrigant leakage.

The teeth were randomly divided into three groups. Group 1 was treated with ProTaper™ F3 Ni-Ti files as described above, and served as a negative control. Group 2 was treated with ProTaper™ F3 Ni-Ti files, at the end of mechanical procedure, root canal was irrigated with 10 ml of 17% EDTA using a syringe with a 27-G needle (Navitip) for 60 seconds. Group 3 was treated with ProTaper™ F3 Ni-Ti files, at the end of mechanical procedure, root canal was subjected to LAI with Er:YAG laser at a wavelength of 2940 nm (LiteTouch™, Light Instruments, Yokneam, Israel) equipped with a 17 mm 400-µm plan-ended sapphire tip. Radiation was set to 0.5 W, 50 mJ, 10 HZ for 60 seconds. The water spray of the laser was closed. An irrigation solution of 17% EDTA was injected during radiation. The laser tip was inserted 3 mm in the upper coronal third of the root canal.

After the various treatments, two longitudinal cuts were made with a high speed bur and the teeth were split in half.

2.2. Scanning Electron Microscopy (SEM)

All samples were dried and mounted on stubs and then coated with Au/Pd using a Polaron SC7640 Sputter Coater (Polaron, Hertfordshire, UK). The effects of the irrigation treatments on the smear layer were examined by SEM at a magnification of 10,000X of the root canal. The samples were examined using FEI Sirion High Resolution SEM and FEI Magellan Ultra-High Resolution SEM (FEI, Eindhoven, The Netherlands).

3. Results

3.1. Examination of Surface Morphology

Fig. 1 shows SEM micrographs of the dentin wall at 10,000 magnification of the root canal present smear layer covered the root canal surface after endodontic preparation. In the second group, irrigation with 17% EDTA through a syringe for 60 seconds removed only part of the smear layer, at the apical part smear layer is present no dental tubules can be seen (Fig. 2).



Figure 1. SEM X 10,000 picture presents smear layer after cleaning and shaping the root canal system during endodontic treatment

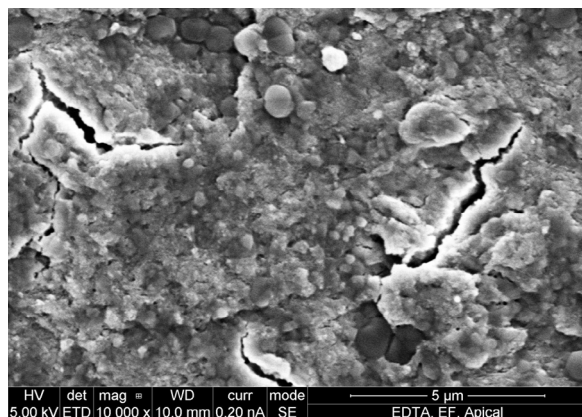
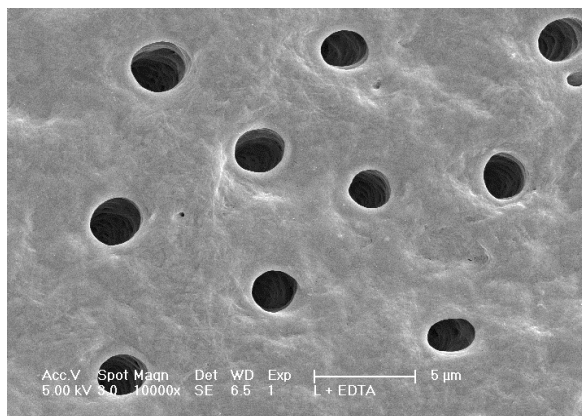


Figure 2. SEM X 10,000 picture presents smear layer at the apical part after irrigation with 10 ml of 17% EDTA using a syringe for 60 seconds

In group 3. Er:YAG LAI with 17% EDTA showed the best smear-layer removal from the entire root canal surface, including apical area with open dentinal tubules (Fig. 3).



The best effect on smear-layer removal and tubules were open in all parts of the canal was present when we used 17% EDTA with Er:YAG LAI.

Figure 3. SEM X 10,000 picture presents clean root canal wall with open dentinal tubules after Er:YAG laser with 17% EDTA for 60 seconds

4. Discussion

This ex vivo study was designed to evaluate the effectiveness of using a 17% EDTA irrigation solution with laser irradiation compared to conventional syringe irrigation. Intact teeth were used to simulate the clinical situation as closely as possible. The maximum irrigation time was 1 minute of 10 ml to minimize detrimental effects on the dentin surface. Prolonged application of the EDTA solution might increase Ca²⁺ removal from the root dentin. Spangberg²⁵ showed that EDTA solution removes the smear layer within 1 minute of reaching the canal surface. In our study, exposure to 17% EDTA was limited to 1 minute to prevent potential changes in the dentin's microhardness, permeability, and solubility characteristics²⁶.

The generation of shockwaves by dental lasers inside the root canals can play an important role in smear layer removal^{19,24}. Similarly, smear layer removal can be achieved when water is activated in root canals using erbium lasers (Er,Cr:YSGG or Er:YAG)^{19,23,24}, causing the formation of vapor bubbles that expand and implode^{19,21,22,24}. Apparently, there is no difference in the efficacy of both wavelengths in terms of smear layer removal. In our study we used the laser light here at subablative settings, which does not damage the root canal wall. (we tested before the EDX at this energy).

The position of the laser tip inside the root canal is important. when using the laser fibers in the root canal, as apical extrusion of the irrigant after laser activation has been described²⁰. A previous study by George et al.²⁰ showed that there was twice as much dye penetration through the apical constriction with the fiber tip at 4 mm than at 5 mm. Therefore, in our vitro study, we insert the laser tip at upper part of the root canal, to avoid

the irrigation extrusion.

The standard irrigation technique during endodontic treatment employs a syringe and needle. Its effectiveness is unpredictable in the apical part of the canal, since the solution is only effective 1.5 mm beyond the needle tip^{27,28, 31,32}. The depth of needle penetration depends on the size and morphology of the canal²⁸. The results of the present study confirm that 17% EDTA irrigation with a syringe does not affect the apical segment of the root and the smear layer remains intact on this important part of the root surface.

5. Conclusion

Smear-layer removal was most effective when the root canals were irrigated using Er:YAG laser at low energy with 17% EDTA solution.

6. A Clinical case - Endodontic treatment with Er: YAG laser

A clinical case of a male, 42 years old suffers from diabetes .

The clinical examination demonstrated maxillary lateral incisor tooth no 12# with metal ceramic crown. The sinus - tract was present in the apical area. There was no pain to percussion, pocket depth was normal.

According to the patient story the sinus-tract was there for over 2 years.

The radiographic examination revealed a large radiolucency at the apical part of the lateral incisor tooth. (Fig. 4). The crown was removed and endodontic retreatment was started .

During cleaning and shaping the root canal system with inter-appointment intracanal medicaments such as : Calcium hydroxide, 3mix (it is mixing of 3 antibiotic: Metronidazole, Minocycline, and Ciprofloxacin), and with Ledermix, the Sinus-tract



a.



b.

Figure 4. a. Radiograph and b. Photograph demonstrated maxillary lateral incisor tooth #12 with radiolucency and sinus-tract at the apical area



a.

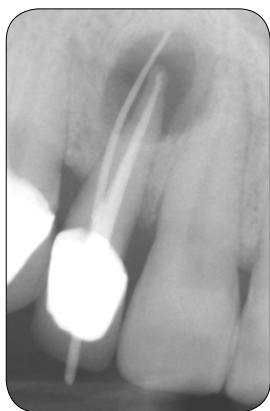


b.

Figure 5. a. LAI with Er:YAG laser. Radiation was set to 0.5 W, 50 mJ, 10 HZ for 60 seconds. b. Rubber-dam on tooth #12 with laser safir tip

persisted. We decided to treat this patient with Laser Activated Irridation, using the Er:YAG laser (LiteTouch™, Light Instruments, Yokneam, Israel) at energy, 0.5 W, 50 mJ, 10 HZ for 60 seconds with 17% EDTA as an irrigation solution. (Fig.5)

The final obturation was accomplished at the same appointment. Approximately 2 years later, the radiograph demonstrates that radiolucency ceased and the periapical tissues heal normally. (Fig. 6) and there is no evidence of the sinus-tract.



a.



b.

Figure 6. Radiograph tooth #12
a. Before endodontic treatment, with radiolucency and sinus-tract at the apical area
b. 2 years folow up, after LAI with Er:YAG laser

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Currently, Dr. Sharonit Sahar-Helft also works in private practice, limited to endodontics.

Questions

The smear layer is packed into the dentin tubules at a depth of:

- a. 1. Less than 40μ ;
- b. Up to 40μ ;
- c. $1-2\mu$;
- d. Only at the infected areas on the root canal.

To remove the smear layer after endodontic preparation you have to:

- a. Clean the root canal wall with bigger file in order to remove the smear layer;
- b. Use irrigation solution like 17% EDTA in order to remove the smear layer;
- c. Use all kinds of lasers to remove smear layer;
- d. Use LAI (Laser Activated Irrigation) Er:YAG laser with 17% EDTA to remove smear layer.

Lasers pulsed infrared cause cavitation-bubbles and pressure waves within the root canal space when combined with irrigants. Which laser you will prefer:

- a. CO₂ laser;
- b. Er:YAG laser;
- c. Diode laser;
- d. Blue laser.

The position of the laser tip inside the root canal is important: chose the correct answer:

- a. The irrigation solution can penetrate through the apical constriction when the laser tip was close to the apical area;
- b. To have efficient effect the laser tip should be insert till the apical area;
- c. You should use the laser tip as much as it penetrates into the root canal;
- d. You should initiate the laser tip before treatment.