Effect of Laser-activated Irrigation of 1320-Nanometer Nd:YAG Laser on Sealer Penetration in Curved Root Canals

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Abstract

Introduction: The purpose of this study was to investigate the efficacy of laser-activated irrigation (LAI) of 1320-nm neodymium-doped:yttrium-aluminum-garnet (Nd:YAG) laser on sealer penetration into dentinal tubules in the presence of 5.25% sodium hypochlorite (NaOCl) or 17% ethylenediaminetetraacetic acid (EDTA). **Methods:** The curved root canals (>20°) from 63 extracted human molars (negative control, n = 3) were prepared to size #30.06 with NaOCl irrigation. Teeth were divided into 4 groups (n = 15) as follows: group N, NaOCl irrigation without LAI; group E, EDTA irrigation without LAI; group NL, LAI with NaOCl; group EL, LAI with EDTA. In all groups, the laser fiber was inserted and withdrawn 4 times for 5 seconds each. Teeth were obturated with gutta-percha and fluorescent-labeled sealer. Transverse sections at 2 and 5 mm from root apex were examined with confocal laser scanning microscopy, and the percentage of sealer penetration into dentinal tubules was measured. **Results:** Groups E, NL, and EL showed higher percentage of sealer penetration than group N ($P < .05$). With NaOCl as irrigant, LAI (group NL) resulted in significantly higher amount of sealer penetration than nonactivated group (group N) in both levels ($P < .05$). However, with EDTA, no significant differences in sealer penetration were observed between the laser-activated group (group EL) and its nonactivated counterpart (group E) in both levels ($P > .05$). **Conclusions:** The 1320-nm Nd:YAG laser activation with either NaOCl or EDTA was much better than NaOCl irrigation alone and as effective as EDTA final flush for sealer penetration into dentinal tubules. Additional use of laser with EDTA did not improve the quality of obturation in the curved canals. *(J Endod 2012;38:531–535)*

Key Words

EDTA, laser-activated irrigation, NaOCl, Nd:YAG laser, sealer penetration

Removal of necrotic pulp tissue, dentin debris, and residual microorganisms from the root canal system is a prerequisite for endodontic success (1, 2). After endodontic instrumentation, a smear layer containing inorganic dentin debris and organic substances is formed (3). Several studies (4, 5) demonstrated that the smear layer might harbor bacteria and could inhibit the penetration of root canal irrigants and/or intracanal medicaments into the dentinal tubules.

Use of chelating agent such as ethylenediaminetetraacetic acid (EDTA) has been advocated for removal of inorganic components of the smear layer that are not effectively removed by sodium hypochlorite (NaOCl) alone (3, 6). The majority of studies (6–8) that evaluated the efficacy of EDTA application on the smear layer removal were carried out in single-rooted teeth with straight canal or in sectioned dentin. Neither of them could simulate clinical situations such as the apical portion of the curved root canals in molars, which is the challenging part of debridement.

In this regard, Moon et al (9) evaluated the effect of final irrigation regimen in curved root canal by measuring the extent of sealer penetration into the dentinal tubules. They showed that 1-minute application of EDTA for final irrigation resulted in greater penetration in coronal part of the canal than that of NaOCl irrigation alone. However, there was no significant difference in depth of penetration in apical part of the canal, although final irrigation of EDTA resulted in higher percentage of canal circumference of sealer penetration. This implies that future studies should focus more on finding effective debridement methods in apical portion of the curved root canals. In addition, this research method can be used for evaluation of the efficacy of final irrigation in removing smear layer because this dentin debris-containing structure can prevent sealer from penetrating into the tubules (10).

Recently, laser-activated irrigation (LAI) by mid-infrared erbium lasers has been introduced as an agitation method for smear layer removal (11–16). Use of neodymium-doped: yttrium-aluminum-garnet (Nd:YAG) laser with 1064-nm wavelength was also reported to enhance cleansing of the root canals compared with NaOCl irrigation (17, 18). It is presumed that the smear layer removal effect has a close linkage with absorption coefficient in water of certain type of laser (11). Because 1320-nm Nd:YAG laser is more strongly absorbed in water than previously investigated 1064-nm Nd:YAG laser, it is assumed that this laser might have a better smear layer removal effect. However, LAI efficacy on the smear layer removal or sealer penetration into the dentinal tubules for 1320-nm Nd:YAG laser in the apical portion of the curved canal has not been studied so far.

Therefore, the purpose of this study was to investigate the effect of 1320-nm Nd:YAG laser activation with different final irrigation regimens on the sealer penetration into dentinal tubules in the curved root canals.

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Materials and Methods

Sample Preparation

Sixty-three extracted human molars that had mesiobuccal roots (maxillary or mandibular molars) or distobuccal roots (maxillary molars) with more than 20° of curvature with fully formed apices were used in the current study. The teeth were prepared as described in the previous study (9). Each tooth was decapitated to a 12-mm length. Access cavities were made, and #10 K-file (Dentsply Maillefer, Zurich, Switzerland) was inserted to confirm the patency. Working length was established by subtracting 1 mm from the length to the apical foramen.

Radiographs of teeth into which #15 K-files were inserted in the canals were used, and the technique of Schneider (19) was applied to measure the canal curvature. Those teeth with root canal curvatures of more than 20° were selected.

The canals were prepared by a crown-down technique by using ProFile (Dentsply Tulsa Dental, Tulsa, OK) rotary instruments to a size #30, 0.06 taper to working length. The canals were irrigated with 1 mL of 5.25% NaOCl between successive files during instrumentation. All irrigation in the present study was performed by using 30-gauge irrigation needles (Vista-Probe; Vista Dental, Racine, WI), and they were used with an up-and-down motion to 1–2 mm short of the working length. Three teeth that were not irrigated during preparation were used as negative controls.

Laser Application

A Nd:YAG laser with a wavelength of 1320 nm (Slimlift MPX; B&B Systems, Seoul, Korea) was used for laser irradiation. The standardized settings were 150 mJ/pulse and 10 Hz (average power, 1.5 W) and were delivered into a 200-μm flexible endodontic fiber. During irradiation, the laser fiber was used with constant motion in apical-coronal direction and kept 3 mm away from the root apex.

Irrigation Protocols

After the chemomechanical preparation, the teeth were randomly divided into 4 groups according to the final irrigation protocols.

In group N (n = 15) the laser fiber was inserted but not activated in the presence of 5.25% NaOCl. Laser fiber was inserted and withdrawn 4 times for 5 seconds each, with 10-second intervals between each. Fresh 5.25% NaOCl (3 mL) flushing was performed during intervals. In group E (n = 15) samples were treated as in group N, with 17% EDTA as an irrigant. In group NL (n = 15) samples were treated as in group N, with laser activation. In group EL (n = 15) samples were treated as in group E, with laser activation.

Root Canal Obturation

After the final irrigation, each canal was flushed with 5 mL of distilled water and then dried with paper points. All canals were obturated with gutta-percha and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) by using the continuous wave of condensation technique. For fluorescence under confocal laser scanning microscopy (CLSM), sealer was mixed with 0.1% fluorescent rhodamine B isothiocyanate (Sigma-Aldrich, St Louis, MO). The labeled sealer was thoroughly applied into the canal to the level of 1 mm short of the working length with #30 lentulo spirals. After the medium-sized gutta-percha cone tip was adjusted, the cone was lightly coated with the sealer and placed into the canal. A heated plugger (SuperEndo-α^2; B&L Biotech, Ansan, Korea) was activated and inserted to a point 4–5 mm short of working length. Next, down-pack was carried out in an inactivated state for approximately 10 seconds, and the coronal portion of the gutta-percha cone was immediately removed in an activated state. The coronal portion of the canal was backfilled by using an injectable gutta-percha system (Super-Endo-β; B&L Biotech), and then gutta-percha was compacted with Obtura S-Kondenser (Obtura Corp, Fenton, MO). The access cavities were sealed with Caviton (GC, Tokyo, Japan). Subsequently, the teeth were kept in incubator at 37°C and 100% humidity for 24 hours to allow the sealers to set.

CLSM Investigation

The samples were prepared and evaluated with CLSM (Zeiss LSM-Pascal; Carl Zeiss, Göttingen, Germany). Each tooth was embedded in an acrylic block, and 500-μm-thick transverse sections of each mesiobuccal or distobuccal root were obtained with a slow-speed, water-cooled diamond saw (Isomet Low Speed Saw; Buehler, Lake Bluff, IL) at 2 and 5 mm from the root apex. All samples were then polished with silicone carbide abrasive papers.

The samples were then mounted on glass slides and examined by using CLSM with excitation by a He/Ne G laser (543 nm). The samples were observed by using a 2.5× (numeric aperture, 0.075) oil lens with additional zooms of 2× (total magnification, 50×). The images were acquired and analyzed by using Zeiss LSM Image Examiner software (Carl Zeiss). The percentage of the sealer penetration was determined by the similar method described by Gharib et al (20) and Moon et al (9). In each image, the circumference of the root canal wall was measured with the measuring tool software. Next, areas along the canal circumference into which the sealer penetrated the dentinal tubules with any distance were outlined and measured. The percentage of any canal wall where sealer had penetrated was calculated by dividing outlined length by the canal circumference.

Statistical Analysis

For overall comparisons, a nonparametric test was performed by using Kruskal-Wallis analysis, and a series of Mann-Whitney tests were used for multiple comparisons. Differences in the percentage of sealer penetration between 2-mm and 5-mm levels for each group were analyzed with Wilcoxon signed rank sum test. The level of significance was set at 5%.

Results

A consistent fluorescent layer of sealer around the root canal wall was observed in all sections. The results of the percentage of sealer penetration into dentinal tubules are reported in Figure 1, and representative pictures from each group are shown in Figure 2. The mean percentage of sealer penetration at 2-mm level was group N, 15.97%; group E, 22.31%; group NL, 35.28%; group EL, 39.96%; and at 5-mm level it was group N, 34.87%; group E, 57.22%; group NL, 68.47%; and group EL, 76.59%. The samples in the negative control showed no sealer penetration into the dentinal tubules.

The Kruskal-Wallis tests showed a statistical difference among the final irrigation protocols at each level (2-mm level, $P = .003$; 5-mm level, $P = .001$). Mann-Whitney tests revealed that groups E, NL, and EL resulted in significantly higher percentage of sealer penetration than group N at both 2-mm and 5-mm levels ($P < .05$). When NaOCl was used as irrigating solution, laser-activated group (group NL) showed significantly higher penetration than nonactivated group (group N) at both levels ($P < .05$). On the other hand, there were no significant differences whether laser was used or not in the presence of EDTA (group E versus group EL) at both levels ($P > .05$). The Wilcoxon signed rank sum test showed a significantly lower percentage of sealer penetration at 2-mm level than at 5-mm level ($P < .05$).