Tissue Dissolution Ability of Sodium Hypochlorite Activated by Photon-initiated Photoacoustic Streaming Technique

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Abstract

Introduction: The aim of this study was to evaluate the effect of the photon-initiated photoacoustic streaming (PIPS) technique on the pulp tissue-dissolving capacity of sodium hypochlorite (NaOCl) and compare it with the EndoActivator System (Dentsply Tulsa Dental Specialties, Tulsa, OK) and the Er:YAG laser with an endodontic fiber tip. **Methods:** Bovine pulp tissue samples (45 ± 15 mg) and dentin powder (10 mg) were placed in 1.5-mL Eppendorf tubes with 1 mL 5.25% NaOCl (Wizard; Rehber Kimya, Istanbul, Turkey) or distilled water (control) for 5 minutes with activation by the EndoActivator System, the Er:YAG laser with an endodontic fiber tip, and the PIPS technique. Nonactivated NaOCl served as the positive control. All testing procedures were performed at room temperature. The tissue samples were weighed before and after treatment, and the percentage of weight loss was calculated. The differences were statistically analyzed. **Results:** The highest rate of tissue dissolution was observed in the NaOCl + Er:YAG group ($P < .05$). The NaOCl + PIPS group dissolved more bovine pulp tissue than the nonactivated NaOCl group ($P < .05$). There was no statistically significant difference between the rates of tissue dissolution of the NaOCl + EA and the nonactivated NaOCl groups ($P > .05$). **Conclusions:** NaOCl activation with the Er:YAG laser with an endodontic fiber tip was the most effective in bovine pulp tissue dissolution. The PIPS technique also promoted superior tissue-dissolving effects when compared with no activation. However, the EndoActivator System had no direct effect on tissue dissolution. *(J Endod 2015;41:729–732)*

Key Words

Dentin, EndoActivator, Er:YAG laser, photon-induced photoacoustic streaming, pulp tissue dissolution, sodium hypochlorite

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Success in endodontic treatment depends mainly on complete removal of the pulpal debridement and bacterial population from the root canal system by means of chemomechanical preparation (1). Sodium hypochlorite (NaOCl) remains the most recommended and popular irrigant for root canal treatment because it has a superior tissue-dissolving activity (2–7) and antimicrobial effect compared with most other irrigants used in endodontics (8, 9). However, the root canal system often has a very complex anatomy, with lateral canals, isthmuses, complex branching, and deltas making complete debridement and disinfection impossible (10). Thus, irrigant activation is suggested to increase the efficacy of irrigant delivery and improve root canal cleanliness (6, 7, 11–15).

The EndoActivator System (Dentsply Tulsa Dental Specialties, Tulsa, OK) has been shown to safely clean the complex root canal system by sonic activation of the root canal irrigants with a flexible, noncutting polymer (16) that does not cause detectable canal transportation. On the other hand, it has been shown to have no effect on necrotic pulp tissue dissolution in simulated accessory canals (17).

Laser-activated irrigation has also been proposed as an alternative to the conventional debridement and disinfection procedures (11–14, 18). Among several laser devices, the Er:YAG laser is promising because of its cleaning mechanism within the root canal, which depends on rapid fluid motion caused by expansion and implosion of laser-induced bubbles (13). The Er:YAG laser with an endodontic fiber tip effectively removes the smear layer and intracanal debris (19), especially on the apical thirds, without causing any structural damage or anatomic alteration inside the root canal or periodontal tissues (20).

Recently, photon-initiated photoacoustic streaming (PIPS), a light energy phenomenon, has been introduced to improve irrigation. The PIPS technique differs from other agitation techniques in that only the tip is placed into the pulp chamber, thereby preventing contact with the root canal wall (12, 21). This technique is attributed to photoacoustic and photomechanical activities, which make it different than other techniques. In this method, an Er:YAG laser is used with a newly designed tapered tip with a radial firing end and 3 mm of the polyamide sheath. When activated in a limited volume of irrigant, the high absorption of the Er:YAG wavelength in water, combined with the high peak power achieved from using subablative parameters (0.3 W, 20 mJ at 15 Hz), results in a photomechanical phenomenon. The strong photoacoustic shock wave promotes 3-dimensional movement of the irrigation solutions (21). Therefore, the PIPS technique shows better root canal debridement than conventional irrigation modalities (11, 12). Peeters and Mooduto (22) reported that using a plain fiber tip in the coronal portion can drive the irrigation solution to the end of the canal without any harmful effects on the apical tissues. In another study, PIPS was more effective in the removal of antibiotic pastes from the root canal compared with the EndoActivator System (23). At present, however, data on its organic tissue-dissolving capacity are lacking. Therefore, the aim of the present study was to compare the effectiveness of the EndoActivator System, the Er:YAG laser with an endodontic fiber tip, and the PIPS technique on the pulp tissue-dissolving capacity of NaOCl.

Materials and Methods

Bovine Pulp Tissue Preparation

Eighty intact, freshly extracted, young bovine maxillary central incisors were used. This investigation was not classified as an animal study because our work had no

influence on the premortal fate of the animals or the slaughtering process. The teeth were extracted within 24 hours after slaughter and immediately placed in glass vials with distilled water. Two longitudinal grooves were cut on the proximal surfaces of teeth with a diamond bur (MANI Inc, Tochigi, Japan), and the teeth were then split in half. Pulp tissue was removed carefully with a cotton plier, washed with distilled water to remove excess blood, and then blotted dry. All pulps were combined to create a random mix of tissue. The pulp tissue samples were adjusted to similar weights of 45 ± 15 mg each with a no. 15 surgical blade.

Dentin Powder

Dentin powder was obtained using spherical dental burs #4 (MANI Inc) inside the root canals of previously split bovine teeth without water coolant and in a low-speed handpiece. All dentin powder was stored in plastic flasks.

NaOCl Solution

A stock solution of 5.25% NaOCl solution (Wizard; Rehber Kimya, Istanbul, Turkey) was tested. The pH of the solution was measured using a pH meter (HI 2211 pH-ORP Meter; HANNA Instruments, Woonsocket, RI) at room temperature (21°C) and adapted to a pH of 12 with 1 N HCl. The amount of final active chlorine content was also verified just before starting each test using an iodine/thiosulfate titration method as previously described (24).

Experiment

The initial weight of each pulp sample was measured with a precision balance (ME204; Mettler-Toledo, Columbus, OH). After the weights were recorded, the pulp samples were randomly divided into 4 experimental groups (n = 10) and 4 control groups (n = 10). The samples were then individually placed in 1.5-mL Eppendorf tubes (volume = 1.5 mL, diameter = 2.5 mm, taper = 4%, length = 25 mm).

The experimental groups (n = 10) were as follows:

1. 5.25% NaOCl + EndoActivator System activation (NaOCl + EA)
2. 5.25% NaOCl + Er:YAG laser with an endodontic fiber tip activation (NaOCl + Er:YAG)
3. 5.25% NaOCl + PIPS activation (NaOCl + PIPS)
4. 5.25% NaOCl + no activation (nonactivated NaOCl, positive control group)

The negative control groups were as follows (n = 10):

1. Distilled water + EndoActivator System activation (distilled water + EA)
2. Distilled water + Er:YAG laser with an endodontic fiber tip activation (distilled water + Er:YAG)
3. Distilled water + PIPS activation (distilled water + PIPS)
4. Distilled water + no activation (nonactivated distilled water)

One milliliter 5.25% NaOCl solution and 10 mg dentin powder were added to tubes containing tissue samples for the experimental groups. For negative control groups, 40 Eppendorf tubes were prepared with an additional 1 mL distilled water and 10 mg dentin powder. All testing procedures were performed at room temperature.

The EndoActivator System Activation. The EndoActivator System was used for passive sonic activation of 5.25% NaOCl. It was performed using the EndoActivator handpiece set at 10,000 cycles per minute with a medium polymer tip (#25/.04).

Er:YAG Laser with an Endodontic Fiber Tip Activation. Er:YAG laser activation was performed with a wavelength of 2,940 nm (Fidelis AT; Fotona, Ljubljana, Slovenia) and an R14 handpiece with a 300-μm endodontic fiber tip (Preciso, Fotona). The fiber tip was used with an output power of 1 W, energy of 50 mJ, and a frequency of 20 Hz as specified by the manufacturer. The water and air on the laser system were turned off.

PIPS Activation. The PIPS protocol was performed with an Er:YAG laser with a wavelength of 2.940 nm (Fidelis AT). A 12-mm-long, 400-μm quartz tip was tapered and had 3 mm of the polyamide sheath stripped back from its end. The tip was applied with 0.3 W, 15 Hz, and 20 mJ per pulse as specified by the manufacturer without water/air spray.

For all devices tested, the tips were immersed in Eppendorf tubes containing irrigating solutions throughout their working length. All samples were activated for 30 seconds, with resting times of 45 seconds after activation. The application was repeated 4 times. In between these activation procedures, the 5.25% NaOCl solution and distilled water in each Eppendorf tube were removed, and 1 mL fresh solution was added. Fresh dentin powder was also added to Eppendorf tubes for each irrigant application. Consequently, the total solution exposure time was 5 minutes with a total volume of 4 mL irrigant and 40 mg dentin powder for each sample in all groups.

After an exposure time of 5 minutes, the pulp samples were removed and washed with distilled water to remove dissolved/suspended tissue remnants or dentin powder. The samples were blotted dry and weighed again. The difference in weights of the tissue sample before and after exposure to 5.25% NaOCl solution or distilled water was divided by the original tissue weight and multiplied by 100 to obtain the percentage of tissue weight loss. The data were then analyzed statistically using 1-way analysis of variance and Tukey post hoc tests with a 95% confidence level (P = .05).

Results

The comparison of the rates of tissue dissolution for all groups with 5.25% NaOCl and distilled water is shown in Table 1. Because no pulp tissue dissolution was observed in any negative control groups with distilled water, statistical analysis was applied only to the NaOCl groups. One-way analysis of variance showed statistically significant differences between the NaOCl groups (P < .05). The highest rate of tissue dissolution was obtained with the NaOCl + Er:YAG group (P < .05). The NaOCl + PIPS group dissolved more bovine pulp tissue than the nonactivated NaOCl group (P < .05), whereas there was no statistically

TABLE 1. Effect of 3 Different Methods of Activation on Tissue Dissolution (% Tissue Weight Loss ± Standard Deviation) by the 5.25% NaOCl Solution and Distilled Water

	EndoActivator	Er:YAG	PIPS	No activation
5.25% NaOCl	47.77 ± 8.17^{bc}	71.59 ± 6.95^{a}	57.29 ± 14.41^{b}	43.41 ± 8.31^{c}
Distilled water	0.17 ± 1.08	0.42 ± 0.83	0.36 ± 0.32	−1.12 ± 1.65

NaOCl, sodium hypochlorite; PIPS, photon-initiated photoacoustic streaming.

Groups identified by different superscript letters are significantly different (P < .05). Groups identified by the same superscript letters are not significantly different (P > .05).