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Comparison of different irrigation activation techniques on postoperative pain after endodontic treatment: A randomized clinical trial

Uygar Hızarcı,[1] Sibel Koçak,[2] Baran Can Saglam,[2] Mustafa Murat Koçak[2]

[1]Private Practice, Zonguldak, Turkey
[2]Department of Endodontics, Zonguldak Bülent Ecevit University Faculty of Dentistry, Zonguldak, Turkey

Purpose: To evaluate the effects of different irrigation activation methods on postoperative pain using a visual analog scale (VAS), using XP-endo Finisher (XPF), EndoActivator (EA), and passive ultrasonic irrigation (PUI) activation techniques compared with the conventional irrigation (CI) method.

Methods: Twenty-five maxillary or mandibular nonvital teeth having a single root canal were allocated to each group. The root canals were prepared with the TF-Adaptive system. Three different activation techniques, XPF, PUI, and EA techniques, were applied during the final irrigation. The canal treatments were completed in a single appointment and postoperative pain analysis was evaluated using VAS after 12, 24, and 48 h.

Results: No difference was found in the 12- and 24-h time intervals between the groups ($p > .05$). A statistically significant difference was found between CI and XPF groups at 48 h ($p < .05$).

Conclusion: All activation techniques resulted in postoperative pain. Irrigant activation with XPF caused less postoperative pain than the conventional needle irrigation at 48 h while XPF demonstrated similar and tolerable results with PUI and EA after root canal treatment.

Keywords: Endodontics, instrumentation, irrigation activation, postoperative pain, root canal treatment.

Introduction

Postoperative pain (PP) can be a challenge for clinicians and patients to manage. PP may be related to the absence of preoperative pain, apical debris extrusion by the root canal preparation techniques, and extrusion of irrigation solutions. Thus, various factors may be responsible for occurence of PP that can range from 3% to 58% (1).

Irrigation of root canals is crucial for the lubrication during instrument use, removal of organic and inorganic remnants, and disinfection of the root canal system (2). Various activation techniques have been developed to increase the efficacy of irrigants (3). To prevent PP, the selection of instruments and techniques, irrigation solutions, and activation methods should be well considered (4–6).

Conventional irrigation (CI) is widely used due to the low cost and convenience of the technique. The irrigation solutions are applied into the canal via a syringe with a needle, having various diameters and tip designs (7). However, the CI technique is incapable of cleaning the areas

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Correspondence: Mustafa Murat Koçak. Department of Endodontics, Zonguldak Bülent Ecevit University Faculty of Dentistry, Zonguldak, Turkey.
Tel: +90 372 – 261 45 20 e-mail: mmuratkocak@beun.edu.tr
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that are difficult to access, such as the apical and isthmus regions (2). The entrapped air at the apical third of the canal prevents the contact of irrigants with the dentin surface and affects the cleaning and disinfecting efficacies of solutions (8). Additionally, the CI technique is incapable of delivering the solutions more than 0–1.1 mm beyond the needle tip limiting irrigant penetration (9). Therefore, various irrigation activation techniques have been developed to improve the efficacy of irrigation solutions.

Passive ultrasonic irrigation (PUI) is a commonly used and accepted technique for the irrigation and activation of irrigants. The PUI technique involves the use of an oscillating ultrasonic file at a frequency of 30 kHz (10). The oscillation tip results in cavitation and acoustic micro-streaming, which improve the efficacy of irrigation solutions (11). The tip is used in the canal up to the working length to activate the previously introduced irrigation solution with passive up-and-down movements (12).

The EndoActivator system (EA; Dentsply Sirona, Tulsa, OK) consists of a cordless, battery-powered sonic handpiece and three different sizes of disposable flexible, non-cutting polymer tips, which are designed to improve the activity of irrigation solutions without any dentin cutting effect (7). The design of the tips allows for the safe agitation of intracanal solutions and can produce intracanal fluid activation (13).

A recent nickel–titanium rotary finishing file, the XP-endo Finisher file (XPF; FKG Dentaire SA, La Chaux-de-Fonds, Switzerland), can be used for the activation of irrigants. The XPF file has a small core size of ISO #25 in diameter and zero taper, with an improved flexibility. The XPF file is recommended to be used after root canal instrumentation to enhance the cleaning of the root canal while protecting the dentin (14). The XPF file is straight in the martensitic phase when it is cooled. When the file is inserted into the root canal at body temperature, it converts to the austenitic phase with a spoon shape and reaches difficult to cleans areas (14).

This study aimed to evaluate the influence of CI and different irrigation activation methods, including XPF, EA, and PUI activation techniques, on PP using a visual analog scale (VAS). The null hypothesis was that irrigation activation does not affect the PP.

Materials and Methods

This clinical study was performed under the regulations of the ethics committee (protocol number: 2017-100-04/10). The project was registered at www.clinicaltrials.gov (ClinicalTrials.gov ID: NCT04262245). A total of 100 maxillary and mandibular teeth were included in the study.

Inclusion criteria

The inclusion criteria were as follows:

1. Teeth requiring root canal treatment
2. Patients between the ages of 18 and 65 years
3. Maxillary and mandibular molar teeth with asymptomatic necrotic pulps
4. Teeth having a single root and canal
5. Eligibility for rubber-dam application

Exclusion criteria

The exclusion criteria were as follows:

1. Patients younger than 18 and older than 65 years
2. Patients with systemic diseases, including diabetes, auto-immune disease, and cancer
3. Teeth with calcified canals, root resorption, immature/open apex, or previous root canal treatment
4. Teeth with severe damage
5. Teeth of patients with a sinus tract and a periapical abscess
6. Patients who had previously taken any medication

The sensitivity of the pulp was evaluated by electric pulp testing (Elements pulp vitality tester, SybronEndo, Orange, CA, USA) and teeth demonstrating no response were selected. Before the treatment, patients had no symptoms and were in good health; these situations were determined by a written health history and an oral interview. Patients were informed about the treatment protocol. Participation in the study was voluntary, and informed written consent in full accordance with the ethical principles was obtained from each patient. A single operator performed both the diagnosis and the root canal treatment to minimize or eliminate possible variabilities during the treatment. The treatments were completed in a single appointment.

A total of 100 patients meeting the inclusion criteria were divided randomly into four equal groups, according to the irrigation activation technique used (n = 25). The randomization was performed by the selection of balls marked previously with colors (25 red, 25 white, 25 blue, and 25 yellow). Each patient was asked to select a ball placed in a closed bag before the root canal treatment. The age and sex of patients were recorded.

The patients did not receive dental anesthesia by the reason of previously revealed knowledge of non-vitality of the tooth after vitality test. The tooth was isolated by using a rubber-dam. The coronal access cavity was prepared with diamond burs under a water coolant. The patency was established, and size 10 and 15 files (Golden Star, Beraydent

Inc., Ankara, Turkey) were used for initial glide path preparation. The working length (WL) was determined with an apex locator device (Root ZX mini, J. Morita USA, and the WL was also checked with periapical radiographs.

The instrumentation was completed using TF-Adaptive instruments (SybronEndo, Orange, CA, USA) in the sequence of ML1 (25/.08) and ML2 (35/.06), according to the manufacturer's recommendations. The files were used with an adaptive endodontic motor (Elements motor, SybronEndo, Glendora, CA, USA) at full WL, with a gentle in-and-out motion. A volume of 2 ml of 2.5% NaOCl (Imicryl Kimya, Konya, Turkey) was applied between each instrument, before the final irrigation apical patency was rechecked with a size 10 K-file. In the final irrigation, 2.5% NaOCl, 17% EDTA (Imicryl Kimya), and 2% chlorhexidine (CHX; Ceraxidin-c, Imicryl Kimya) solutions were used. Between the irrigation solutions, 5 ml of distilled water was used to prevent any chemical reaction.

The activation of irrigants was applied as follows:

Group 1 (CI): This group served as the control. The tip of a 27-G needle (Genject, Ankara, Turkey) was inserted 3 mm shorter than the WL. The syringe was moved in up-and-down directions during the irrigation. Volumes of 5 ml of NaOCl, 2 ml of EDTA, and 2 ml CHX were used.

For the following activation groups, the final irrigation was performed with the same volume and concentration of all solutions as the control group. The solutions were delivered into the root canal by inserting a needle 3 mm short of the WL.

Group 2 (XPF): The XPF file was used with an endodontic motor (SybronEndo, Orange, CA, USA) at 1000 rpm and 1N of torque settings. The XPF was activated during the application of NaOCl and EDTA for 1 min (3 cycles of 20 s), for each solution. The file was introduced into the root canal to 1 mm short of the WL, and was moved in 7–8 mm, with an in-and-out motion during activation. Finally, the irrigation was completed by using 2 ml of CHX application.

Group 3 (PUI): During the activation, 5 ml of 2.5% NaOCl and 2 ml of 17% EDTA solutions were passively agitated using an ultrasonic device (VDW ultra, GmbH, Münich, Germany) in each canal. The ultrasonic tip (IrriSafe #25/.00, Acteon, Merignac, France) was inserted as centrally as possible into the root canal 1 mm short of the WL, and NaOCl and EDTA solutions were ultrasonically activated for 60 s, for each solution. The irrigation was completed by using 2 ml of CHX application.

Group 4 (EA): For activation of NaOCl and EDTA solutions, the tip of the EA (15/.02) was placed in the canal at a depth 1 mm shorter than the WL. Then, the device was applied for 60 s at a speed of 10,000 rpm, with 3–4 mm vertical strokes, for each solution. The irrigation was completed by using 2 ml of CHX application.

After the irrigation activation, the canals were dried with paper points and obturated using the cold lateral compaction technique with a sealer (ADSeal, MetaBiomed, Korea). The coronal access cavities were sealed with a resin-based filling material (Point4, KerrHawe, Bioggio, Switzerland).

The PP values were evaluated using the VAS at 12, 24, and 48 h after the treatment. Initially, the participants were informed and trained about the use of the VAS. The scale consisted of a 100-mm line, with marks at every 10 mm without any number. At the beginning and end of the scale, "no pain/0" and "severe–intolerable pain/10" statements were written, respectively. According to the scale, the pain levels were classified as no pain (0–4), mild pain (5–44), moderate pain (45–74), or severe pain (75–100) (15).

Descriptive analysis as means, and standard deviations were calculated using SPSS 19.0 for Windows (SPSS, Chicago, IL, USA). Descriptive statistics were expressed as the mean and standard deviation. The normality of the data was analyzed with the Shapiro–Wilk test. Differences among the groups were analyzed using the Kruskal–Wallis and Mann–Whitney U tests. A p value <5% was considered statistically significant for all tests.

Results

Pain was recorded in all groups. Moderate or severe pain scores were not observed in any group. The PP reduced significantly as the time progressed in all groups ($p < .05$). No difference was found at 12- and 24-h time intervals between groups ($p > .05$). At the 48-h interval, a significant difference was found between groups 1 and 2 ($p = .041$). The XPF demonstrated less PP than CI, whereas no difference was found between the other groups (Fig. 1).

The mean ages and sex of patients are presented in Table 1. No difference was found between female and male patients at 12-, 24-, and 48-h time intervals ($p > .05$).

Discussion

Irrigation during root canal treatment is critical to achieve effective cleaning and disinfection. Recently, the activation of irrigation solutions has been commonly used during the treatment to improve the efficacy of the irrigant. The irrigation technique may affect the amount of debris extrusion or irrigation solution (16). The reduction of extrusion with the aid of an activation technique may eliminate PP-related discomfort (17). Thus, adverse

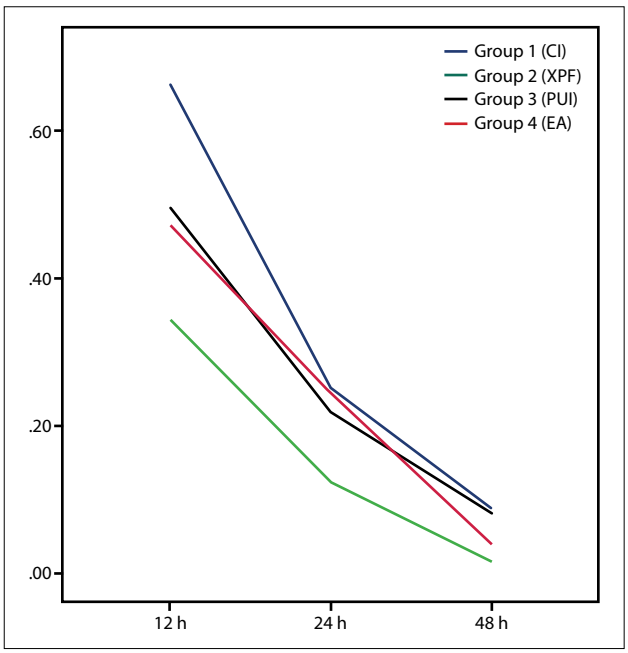

Fig. 1. The mean PP values of groups.

Table 1. The mean ages and sex of patients

	CI	XPF	PUI	EA
Mean ages	41.4	38.8	36.28	44.36
Sex				
Female	14	13	19	16
Male	11	12	6	9

CI: Conventional irrigation; XPF: Xp-endo Finisher; PUI: Passive ultrasonic irrigation; EA: EndoActivator.

effects of irrigation activation techniques should be examined well.

All treatment procedures were completed by a single operator for standardization. The instrumentation, irrigation, and obturation of the teeth were completed in a single appointment. It is well documented that the healing rate of single- and multiple-appointment root canal treatment is similar (18). Recently, single-appointment root canal treatment is preferred, to eliminate leakage or loss of temporary fillings, and to decrease the chair time. Various reports have demonstrated that patients treated in a single visit experienced less short-term PP, and that the requirement of analgesics was lower than in patients treated in multiple visits (19,20).

The existing preoperative pain associated with a treated tooth influences the incidence and severity of PP (21). Berggren et al. (22) stated that patients experiencing preoperative pain may report incorrect information because of their physiological situation and anxiety. Therefore, teeth without preoperative pain were included.

The effects of demographic variables, including age and sex, on the incidence of PP reveal conflicting results. It has been stated that age and sex may play a significant role in PP (6,23). In contrast to this result, this study demonstrated no relationship between PP and age or sex. Similarly, the location of teeth had no effect on PP, as no difference was found between maxillary and mandibular teeth. This finding was compatible with previous results, which demonstrated no correlation between PP and demographic variables (2,17).

The penetration of the needle may affect the amount of apically extruded debris and thereby the occurrence and incidence of PP. In all groups, the needle was penetrated to a depth of 3 mm short of the WL. This was applied because of the safety protocol as stated in previous studies, specifying that inserting needles 3 mm short of the WL during the final irrigation might prevent debris extrusion (9,24). Further activation procedures were applied 1 mm short of the WL. Previously, Rodríguez-Figueroa et al. (25) stated that using a PUI or EA tip within 1 mm of the WL appears to be fairly safe. Based on these findings, both PUI and EA tips were used 1 mm short of the WL, similar to a recent report (2).

Different scales have been used to evaluate the pain after root canal treatment. The VAS has been validated and proven to be reliable as a well-researched tool for measuring pain (26,27). Therefore, in this clinical study, the incidence and severity of PP were evaluated using the VAS as the outcome measurement method.

A well-cleaned and disinfected root canal space is the target of activation without extruding the debris apically. Various studies have evaluated the effects of activation techniques on PP (2,17,28). There is a growing consensus of opinion on the reducing effects of machine-assisted activation techniques on PP compared to syringe irrigation with needles in nonsurgical root canal treatment (27). Recently, the benefit of using activation techniques for the elimination of bacteria and debris is accepted. Although PP is generally associated with extruding irrigant or debris through the apical foramen, the infected remnants in the root canal system should not be ignored. The syringe irrigation is lack of eliminating the entire debris, smear layer, and thereby microorganisms, especially in the apical part of the root canal (29). The XPF and EA techniques appear to be more effective than the CI method on debris and smear layer removal during the irrigation of root canals, even in curved root canals (14). Another recent study supporting this result showed that the EA and PUI techniques were more effective in removing the smear layer than CI (30). The incidence of PP in the CI group was high during all time periods compared to activation techniques. The null

hypothesis was rejected. This finding may be related to uncleaned areas and remaining infected debris after CI. Thus, we may conclude that improved mechanical cleaning and disinfection may be essential during root canal treatment. The higher PP scores in the CI group may also be related to the occurence of positive pressure because of the tips' vertical movements, which potentially increases the amount of extruded solution (28).

Remnants of canal debris may be considered a clinically potential harbor of bacterial contents even after the disinfection procedures (31). Various studies have demonstrated that the XPF, EA, and PUI techniques demonstrated comparable results in terms of canal cleaning and disinfection (14,31). De-Deus et al. (31) reported that XPF and PUI showed similar effectiveness in the removal of hard-tissue debris from oval-shaped canals. In addition, although PUI and XPF instruments demonstrated similar cleaning efficacy, both techniques were associated with significantly higher levels of reduction of hard-tissue debris than CI (32). The present results demonstrated no difference between activation techniques in terms of PP. The aforementioned similar cleaning efficacy of the tested techniques may lead to comparable results in PP.

A novel instrument, XPF, demonstrated promising results for PP, similar to commonly used EA and PUI activations. At the 48-h period, the XPF group showed significantly less PP than the CI group. The straight martensitic phase instrument converts its shape and phase (austenitic phase) at body temperature (14). The austenitic phase shape enables a greater contact of the instrument with areas difficult to reach using conventional instruments. The irrigants should be in contact with the root canal to enhance cleanliness (33). The converted shape of the instrument may improve the contact of solutions with the canal walls.

Conclusion

All activation techniques caused PP, without any significant difference. Moderate or severe pain was not recorded and all techniques caused, at most, mild PP. XPF demonstrated significantly less pain than CI at 48 h. However, when compared with the 12- and 24-h periods, the difference was small and may not reach the threshold for clinical significance. The activation of irrigation solution with the novel XPF instrument demonstrated similar and tolerable results with PUI and EA on PP after root canal treatment.

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Informed consent: Written informed consent was obtained from patients who participated in this study.

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