IDR International Dental Research

Int Dent Res 2025; 15(3): 175-182
https://doi.org/10.5577/intdentres.597

Original Article Open Access

Effects of sonic irrigation activation on postoperative pain following root canal treatment of teeth with apical periodontitis

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Received: 29 October 2025
Accepted: 12 December 2025

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How to cite this article:

Erşahan Ş, Erdem Hepşenoğlu Y, Topbaş C. Effects of sonic irrigation activation on postoperative pain following root canal treatment of teeth with apical periodontitis. Int Dent Res. 2025;15(3):175-182.
https://doi.org/10.5577/intdentres.597

Abstract

Aim: To evaluate postoperative pain of teeth with apical periodontitis after sonic irrigation activation.

Methodology: One hundred five asymptomatic patients with periapical lesions were included in this study. After chemomechanical canal preparation using rotary instruments and NaOCl, the teeth were randomly assigned to three groups (n=35 per group): control (conventional needle irrigation-CNI), manual dynamic irrigation activation (MDI), and sonic irrigation activation (SI). In each group, final irrigation was performed using 3 ml of 2.5% NaOCl and 2 ml of 17% EDTA solution, and the relevant activation method. Patients recorded their pain intensity at 24 h, 48 h, and 7 days after treatment on a modified visual analogue scale (VAS), as well as their analgesic consumption. Demographic data and pain levels were compared across groups using Fisher's Exact and one-way ANOVA tests, with differences of $p < 0.05$ considered statistically significant.

Results: There was a significant increase in pain levels at 24 and 48 hours postoperatively, and no difference was found between the groups ($p = 0.1464$ and $p = 0.0655$, respectively). At day 7 postoperatively, pain intensity and incidence were significantly lower in the SI group compared to the CNI and MDI groups ($p = 0.0435$). However, the frequency of analgesic intake did not differ significantly between the groups ($p = 0.863$). Furthermore, none of the methods resulted in any adverse effects.

Conclusion: The conventional needle irrigation and manual dynamic activation used in this study were associated with a similar intensity of postoperative pain in asymptomatic patients receiving primary root canal treatment. However, on the seventh day, sonically activated irrigation resulted in lower postoperative pain.

Keywords: Apical periodontitis, irrigation, sonic activation, manual dynamic activation, postoperative pain, visual analog scale

Introduction

Infection of periapical tissue that develops after invasion of the dental pulp by pathogenic microorganisms due to trauma or iatrogenic causes is defined as apical periodontitis. Apical periodontitis is an inflammatory disease that progresses with periodontal tissue and alveolar bone loss. Pain and flare-ups are common complications after root canal treatment of such teeth. The causes of postoperative pain have been attributed to acute inflammatory reactions in periapical tissues. It has been shown that intra-operative factors, such as mechanical injury to the periapical tissues during instrumentation, extrusion of microorganisms, dentin debris, or irrigants, can contribute to postoperative pain (1).

Effective control of the intracanal microbial load before obturation is a key element in successful root canal treatment (RCT) (2). However, even with the introduction of modern rotary instrumentation, it is difficult to achieve complete canal debridement. Several studies have shown that large areas of the main root canal, especially in the apical region, remain untouched by instruments during canal preparation (3,4). These areas can harbor pulpal tissue, debris, and bacterial biofilm as well as their by-products, which can cause reinfection or persistent periradicular inflammation (3,4). Therefore, chemical debridement using an irrigant is needed to clean and disinfect any areas that could not be accessed by instrumentation (5). Conventional needle irrigation (CNI) is relatively ineffective at cleaning the apical third of the canal walls, as it cannot deliver solutions beyond 1 mm past the needle tip (6). To address this limitation, various techniques and devices have been developed to improve irrigant delivery throughout the root canal (7). Manual dynamic irrigation activation (MDI), which involves the repetitive insertion of a well-fitting gutta-percha cone to the working length of a previously shaped canal, has been described as a cost-effective technique for cleaning the walls of the entire canal. However, apical pressure generated during the delivery of the irrigant may push it into periapical tissue and cause subsequent postoperative pain, one of the complications of RCT (8). In contrast, sonically activated irrigation (SI), a recently introduced innovation for improving irrigation efficacy, offers safe activation of intracanal reagents as well as vigorous intracanal fluid agitation (9). Simulations have shown SA to better irrigate lateral canals at 4.5 and 2 mm from working length (10), with less extrusion when compared to conventional methods (9).

In addition to studies evaluating different irrigation activation techniques in terms of antimicrobial efficacy, dentine tubule penetration, and debris removal (10,11), a few studies have evaluated postoperative pain in patients with symptomatic pulpitis (12,13). However, none of these studies have evaluated postoperative pain in patients with apical periodontitis. Therefore, the present study was conducted to evaluate postoperative pain of teeth with periapical lesions performed using sonic activation and to compare the pain levels with those of syringe irrigation and manual dynamic activation.

The null hypothesis was that teeth treated using the sonic irrigation activation technique would demonstrate comparatively less irritation on periradicular tissues than those treated using CNI, resulting in less postoperative pain following RCT.

Materials and Methods

The study was approved by the Clinical Research Ethics Committee of Istanbul Medipol University in Istanbul, Turkey, with approval number E-10840098-202.3.02-6665. All participants provided written informed consent.

Sample size calculation

In the study by Rao et al. (15), in which chemomechanical preparations of single-rooted teeth with symptomatic apical periodontitis were evaluated for postoperative pain, two groups of 30 patients each were used, and statistically significant results were observed. In the priori power analysis (G*Power version 3.1.9.4; Heinrich-Heine-Universität, Düsseldorf, Germany) of this study, based on baseline 24th-hour pain data (effect size d: 0.7092, α error: 0.05, power: 0.80), at least 26 samples were required. To achieve the planned sample size, approximately 195 patients were examined, and 105 patients were included (35 patients per group).

Patient selection

This randomized, prospective, double-blinded, controlled clinical trial was conducted at a single center. To achieve the planned sample size, approximately 195 patients who applied to the Department of Endodontics of Istanbul Medipol University between January 2024 and August 2024 due to chronic apical periodontitis were included in the study. The collected data included intraoral examinations and demographic characteristics. The diagnosis was established according to the patient's history, electrical pulp test, clinical inspection including palpation and percussion tests, and radiographic examination. As a result of the examination, 105 patients with a non-contributory medical history and posterior teeth diagnosed as chronic apical periodontitis, with a periapical index (PAI) score of 3 to 5. were included in the study (56 women, 49 men; age range: 18-61 years). Patients with clinical symptoms (acute pain), drainage, sinus tract, curvature >20, >3 mm diameter lesion, previous endodontic treatment, severe disease of the marginal periodontium in the related tooth (probing depth> 4 mm), a non-restorable tooth, non-compliance, and inability to return to the office were excluded. Patients who had used any analgesics within the previous

3 days or antibiotics within the previous month were also excluded.

Patient demographics and clinical characteristics were recorded prior to treatment and included patient age and sex, tooth type (premolar/molar), arch location (upper/lower), and number of canals; duration of treatment; and analgesic usage.

Teeth were randomly assigned to one of three groups according to the final irrigation activation method. To ensure that neither the patient nor the observers were aware of the irrigation activation method used, an equal number of assignment numbers were randomly placed in sealed envelopes that were sequentially opened by a trained dental assistant after canal preparation was completed, who then performed the final irrigation procedures accordingly (n = 35).

Clinical procedures

A standardized RCT was performed by a single endodontist (Y.E.H.). After local anesthesia, the teeth were isolated using a rubber dam. A standard access cavity was prepared, and pulp necrosis was confirmed visually by the absence of bleeding. Coronal pre-flaring was performed using ProTaper Universal SX files (Dentsply Maillefer, Ballaigues, Switzerland). The working length to the apical constriction was determined using an electronic apex locator (MM control, MicroMega, Besancon, France) and a diagnostic file radiograph. K-files up to size #15 were used to establish the glide path. The root canals were shaped using VDW Rotate files (.04 taper #35 number) under irrigation with 2.5% NaOCl. Each file was used only once for a single tooth. At each file change, the root canals were irrigated with 5 mL of 2.5% NaOCl solution. Thus, a total of 25 mL of irrigation solution was used. Following the shaping, final irrigation was performed in groups, as indicated below.

Sonic irrigation activation group: EndoActivator sonic device (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) was used for sonic activation (at 10,000 rpm) in the presence of 2.5% NaOCl solution. The sonic tip was placed 1 mm short of the working length without touching the canal walls. Activation with the sonic tip was performed for 20 s using 1 mL of 2.5% NaOCl in each cycle and was activated in this way a total of three times. Subsequently, 2 mL of 17% EDTA solution was activated for 1 min.

Manual dynamic activation group: After the shaping procedure was completed, irrigation solutions (3 mL of 2.5% NaOCl and 2 mL of 17% EDTA, for 1 min each) were administered by positioning the main gutta-percha cone 1 mm behind the working length and moving it 2 mm back and forth in the coronal-apical direction.

Conventional needle irrigation group (control group): Irrigation was performed with short (2–3 mm) back-and-forth movements of a side-perforated irrigation needle that was placed 1 mm short of the working length (with 3 mL 2.5% NaOCl for 1 min). The same procedures were applied for 2 mL 17% EDTA solution for 1 min. Following the final irrigation with physiological serum in all groups, all teeth were obturated with gutta-percha and AH Plus sealer (Dentsply DeTrey GmbH, Konstanz, Germany) using the cold lateral condensation technique and restored with composite resin in the same session. Occlusion was checked and adjusted, and immediate postoperative radiographs were taken using preset exposure parameters.

Patients were given postoperative instructions to take analgesics (400 mg ibuprofen every 6 hours) in the event of severe pain. To evaluate the pain levels after the treatment and to determine the number of painkillers used, forms were provided to the patients. These forms were collected at a follow-up appointment one week post-treatment. Patients were also informed to come without an appointment in case of excessive swelling and pain.

Pain evaluation

Pain was measured using a modified visual analog scale (VAS) with four levels, as follows: 1, no pain; 2, slight pain (mild discomfort, no treatment needed); 3, moderate pain (pain required analgesics for relief); and 4, severe pain (pain and/or swelling not relieved by simple analgesics and required unscheduled visit) (14). Patients were asked to record preoperative pain as well as pain at 24 h, 48 h, and 1 week postoperatively. They were also asked to record the number of analgesics taken on their form. One week later, the patients returned the completed questionnaires.

Schematic representation of the study is graphically illustrated in Figure 1.

Statistical analysis

All analyses were performed using MedCalc Statistical Software version 12.7.7 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2013), with differences $p \leq 0.05$ considered statistically significant.

Descriptive statistics (mean, standard deviation, minimum, median, and maximum) were used to define continuous variables. Demographic data was analyzed using the chi-square test.

Results

Of the 105 patients enrolled in the study, none were lost to follow-up during the first week (Fig. 2). Sealer extrusion was observed in only four teeth (two in the CNI group, one in the MDI group, and one in the SI group). Given the low and similar distribution of teeth with sealer extrusion across all groups, this confounding factor was not considered in the data analysis. Given the low and similar distribution of teeth with sealer extrusion across all groups, this confounding factor was not considered in the data analysis.

The male/female (M/F) ratios and mean ages of the study groups were as follows, respectively. For the SI group, M/F: 17/18, age: 37.79+11.01 years; for the MDI group, M/F: 16/19, 35.1+12.4 years; for the CNI group, M/F: 16/19, 35.1+12.5 years. No significant differences were observed in sex distribution ($p = 0.458$), tooth type ($p = 0.955$), procedure duration ($p = 0.900$), or analgesic use ($p = 0.863$) (Table 1). PAI scores for the SI, MDI, and CNI groups were 3.63 ± 0.74, 3.91 ± 0.82, and 3.91 ± 0.82, respectively. There was no difference between the groups in terms of PAI scores ($p = 0.308$, Kruskal–Wallis test). Preoperatively, there were also no significant differences between the groups in terms of VAS scores ($p < 0.05$). There were no significant differences in the preoperative pain values among the groups ($p>0.05$). However, pain scores increased at 24- and 48-hours postoperatively marks before decreasing thereafter.

Although the pain values of the SI group at the 24th and 48th hours were not statistically significant; they exhibited a trend toward lower levels ($p = 0.1464$ and $p = 0.0655$, respectively). However, on the 7th postoperative day, the pain levels in the patients who received SI were significantly lower than those in the other treatment methods ($p = 0.0435$, Fig. 3).

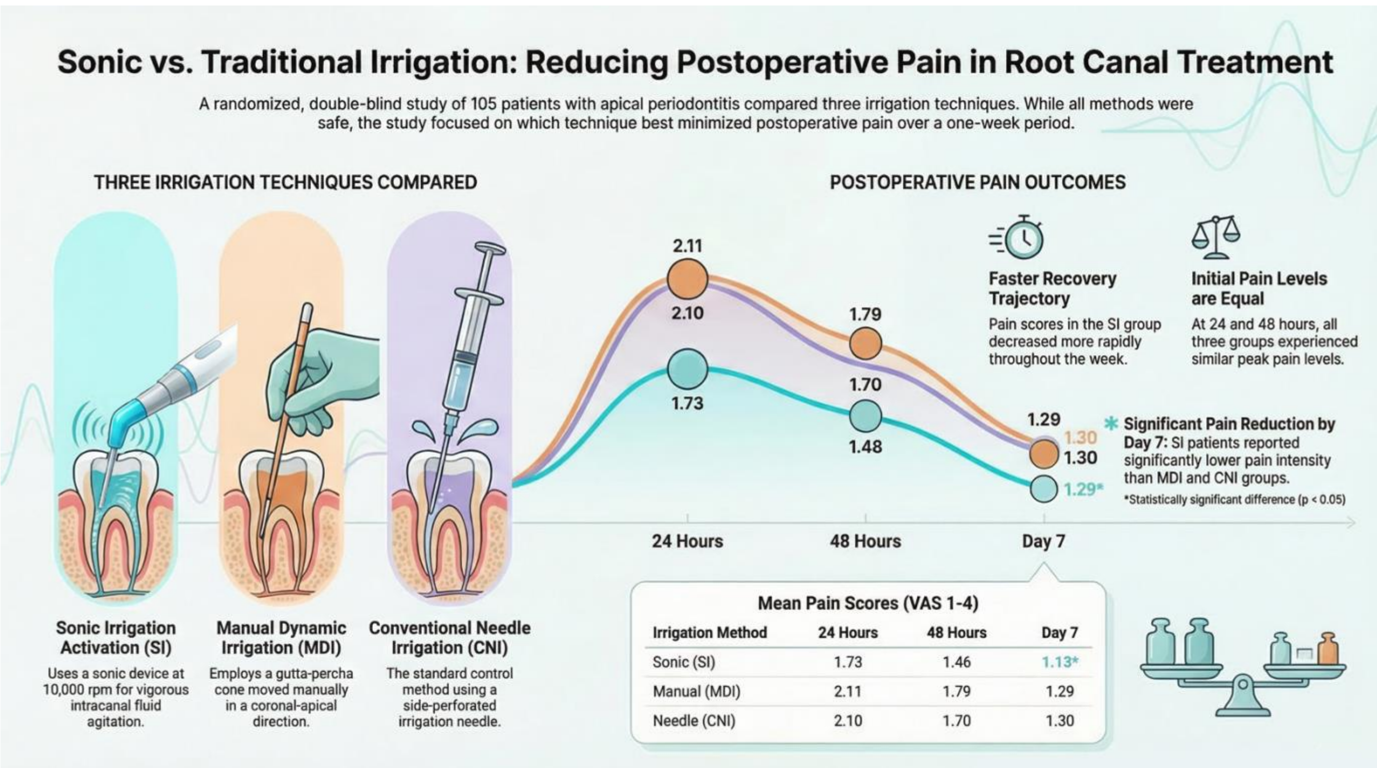

Figure 1. Schematic representation of the study.

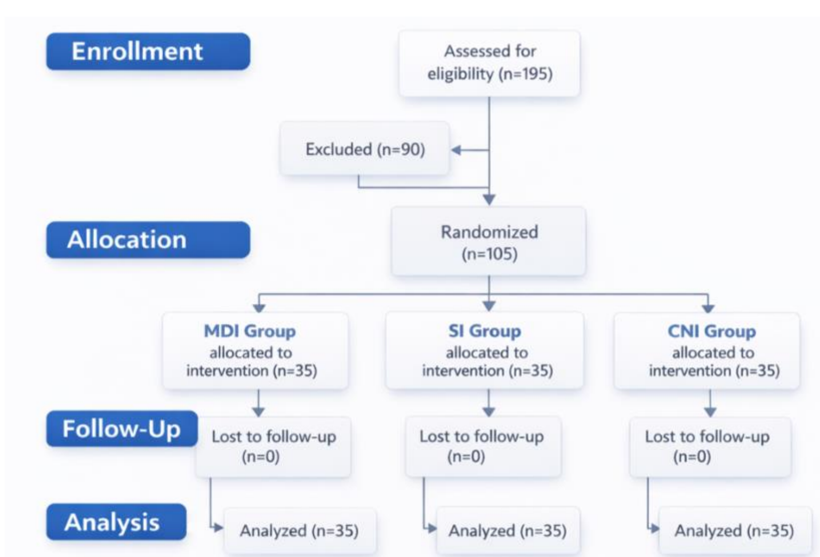

Figure 2. Consort flow diagram.

Table 1. Demographic characteristics.

		SI		MDI		CNI (Control)		p-value
		n	%	n	%	n	%	
Gender	Female	18	51.42	19	54.3	19	54.3	0.458 *
	Male	17	48.58	16	45.7	16	45.7	
Age		35	37.79+11.01 years (19-54)	35	35.1+12.4 years (18-61)	35	35.1+12.5 years (18-61)	0.110 b
PAI		35	3.63+0.74 (3-5)	35	3.91+0.82 (3-5)	35	3.91+0.82 (3-5)	0.308 c
Tooth type	Lower molars	15	37.5	9	25.7	9	25.7	0.955 *
	Upper molars	10	37.5	16	45.7	16	45.7	
	Lower premolars	5	12.5	6	17.1	6	17.1	
	Upper premolars	5	12.5	4	11.4	4	11.4	
Duration of procedure	>45 min	5	12.5	3	8.6	3	8.6	0.900 *
	<45 min	30	87.5	32	91.4	32	91.4	
Use of analgesic	Present	9	25.8	10	28.6	10	28.6	0.863 *
	Absent	26	74.2	25	71.4	25	71.4	

* Fisher's Exact test, b One-Way ANOVA, c Kruskal-Wallis

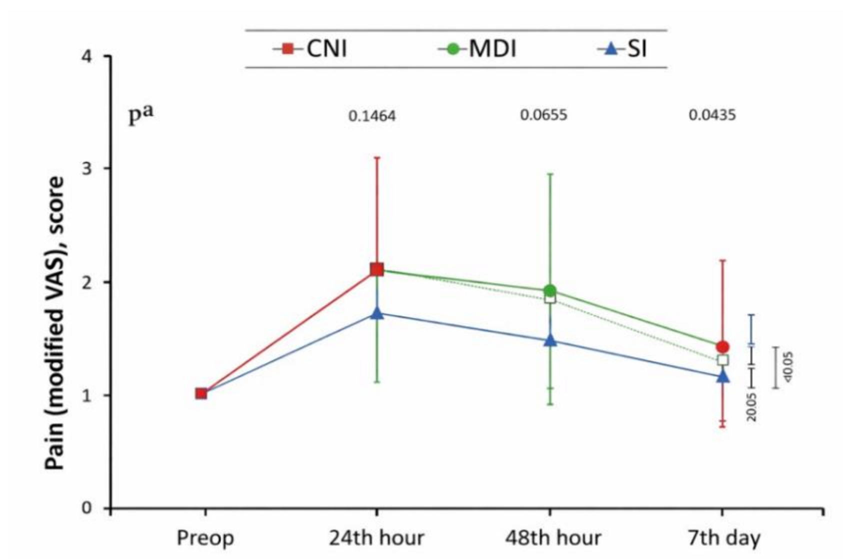

Figure 3. Comparison of groups according to time.

Table 2. Mean value and mean changes (standard deviation) in pain scores during the study period. and over the 1-week follow-up period.

		SI		MDI		CNI		
		Mean+SD	Median (min-max)	Mean+SD	Median (min-max)	Mean+SD	Median (min-max)	p-value
Postoperative pain score	24 h	1.73+0.78	2 (1-4)	2.11+1.02	2 (1-4)	2.1+1	2 (1-4)	0.1464 a
	48 h	1.46+0.6	1 (1-3)	1.79+0.81	2 (1-4)	1.7+0.9	2 (0-3)	0.0655 a
	Day 7	1.13+0.41	1 (1-3)	1.29+0.52	1 (1-3)	1.3+0.5	1 (1-3)	**0.0435 a**
	Comparison p			<0.05, >0.05, >0.05				

a Kruskal-Wallis test. When the p-value is <0.05, comparison between groups (Comparison p) is made (SI-MDI, SI-CNI, MDI-CNI, respectively)

Discussion

Performing activation in addition to chemomechanical preparation has been proposed as a method to improve the outcome of RCT in teeth with periapical lesions. This study investigated and compared the effects of sonic irrigation activation with those of manual dynamic activation and conventional needle irrigation on postoperative pain following RCT. Considering that pain is usually manifested within a few hours or days after root canal treatment (16), this study monitored postoperative pain for 1 week. Moreover, to minimize potential confounding factors (17), patients with preoperative pain were excluded. One of the most difficult

Patient subjectivity is involved in the evaluation and measurement of pain. As previous studies have noted, questionnaire design is essential to ensure that all questions are fully understood by the patients and that their responses are easily interpreted by researchers (16, 17). To address this issue of subjectivity in pain evaluation, this study used a modified VAS with four categories ("no pain," "slight pain," "moderate pain," and "severe pain") that have been evaluated as adequate in validity and reliability (14).

A low incidence of postoperative pain was detected in this study, consistent with several previous studies (18, 19). This finding can be attributed to the fact that advanced endodontic devices and systems used during routine endodontic procedures provide more appropriate chemo-mechanical disinfection and reduce iatrogenic and procedural errors. In this study, modified VAS scores of 4 were accepted as severe pain and flare-up. No swelling or flare-ups were observed. This can be explained by our strict inclusion criteria (asymptomatic teeth and teeth with lesions <3 mm in diameter) and the flow of the irrigation solution, which results in better disinfection.

It is important to note that there were no significant differences among the three groups in any of the other measured demographic or clinical characteristics (age, sex, tooth type, duration of procedure, baseline pain score, and baseline PAI score). Therefore, the effects of these confounding variables were considered to be minimized. To further control for variability, only posterior teeth were included in the study. Postoperative pain was evaluated exclusively in premolars and molars because endodontic treatment of posterior teeth includes several challenges and difficulties, such as complex root canal anatomy. Additionally, limiting this prospective study to teeth with similar pathology, i.e., chronic apical periodontitis, helped facilitate the evaluation of irrigation protocols.

In terms of postoperative pain, the present study found that all three groups had the highest pain ratings at 24 h post-treatment, with significant reductions at 48 h and 7 days. The reduction in postoperative pain observed over time in the present study is consistent with numerous previous studies (14-16, 20, 21). Although pain levels at 24 and 48 h among groups were not different in the present study, pain levels tended to be lower in the SI group over the study period. Additionally, by the 7th postoperative day, pain levels in the SI group were statistically lower than those in the conventional needle irrigation (CNI) and manual dynamic agitation (MDI) groups, a finding supported by several other studies (21, 22). Although the intensity of postoperative pain was similar for all groups at 24 h and 48 h following RCT, the pain values of the SI group (although not statistically significant) tended to be lower. Therefore, our null hypothesis was accepted. This finding may be attributed to better disinfection of uninstrumentable areas provided by the sonic system. Several previous studies have similarly found that MDA produced higher pain levels than SI (20-22). While the oscillation movement that occurs in the sonic system pushes the irrigation solution to the canal walls with lateral movements, the movement of the liquid is constantly apical in irrigation activation with MDA and CNI (22). This results in a higher amount of liquid extrusion from the apex in the MDA and CNI groups and, thereby, higher pain scores.

The disparity in findings between studies could be related to differences in inclusion criteria (irreversible pulpitis vs. necrotic pulp with periapical lesions), irrigating solutions (NaOCl vs. EDTA and distilled water), needle selection (27-gauge open-ended needle vs. 30-gauge side-perforated needle), and pain scales used (VAS vs. modified 4-grade VAS). Another recent study showed that MDI caused significantly more postoperative pain than CNI, PUI, and SI in the first 24 h post-treatment (21). However, this study did not include patients with asymptomatic necrotic pulp and periapical lesions, leaving it unclear whether the irrigation activation method was the primary factor influencing postoperative pain.

In this study, posterior teeth, including both molars and premolars, were preferred because of the complex structure of the pulp anatomy and difficulty accessing extra root canals (23). Studies have reported high failure rates for root canal treatment in posterior teeth (24). Of the included teeth, 30 were premolars: 17 lower premolars and 13 upper premolars. Of the included teeth, 75 were molars (33 lower molars and 42 upper molars). All teeth had straight root canal anatomy (< 20°) and chronic apical periodontitis lesions with a PAI score of 3-5. Apical constriction was observed in nearly all cases. The initial apical file was #20 in 82 cases and #15 in the remaining cases. Our aim was to prepare an apical size at least three file sizes larger than the first file that bound at the apex. As varied apical sizes could affect the penetration of irrigants in the apical third, debridement and disinfection (25), and the apical root canal preparation size and taper were standardized in the present study (35/.04). Standard chemomechanical preparation (35/.04) significantly reduced pain levels, which can be explained by the fact that larger preparations permit a larger volume of irrigant in the canal, increasing the chances for improved chemical effects.

Limitations

Several limitations of the present study should be acknowledged. First, the follow-up period was relatively short, precluding the evaluation of the long-term effects of the sonic activation methods used on the clinical success of root canal treatment. Therefore, further longitudinal clinical studies are needed to investigate the relationship between postoperative pain associated with sonic irrigant activation and subsequent periapical tissue healing. Second, only teeth with straight root canal anatomy (<20° curvature) were included in the study. Accordingly, future research should assess the efficacy of irrigation activation systems in teeth with curved root canals to enhance the generalizability of the findings. Finally, the study did not include early postoperative pain assessment time points. Additional investigations evaluating pain levels at earlier intervals—such as 4, 6, and 12 hours postoperatively—alongside a 1-week follow-up period are warranted to provide a more comprehensive understanding of postoperative pain dynamics.

Conclusion

Although the use of sonic irrigation activation during root canal treatment of teeth with apical periodontitis showed no significant difference from that of manual dynamic agitation and needle irrigation in terms of postoperative pain or analgesic intake at 24 h and 48 h, it resulted in lower postoperative pain levels by day 7. Overall, postoperative pain in the sonic activation group decreased more rapidly than in the other groups, suggesting that it may offer superior long-term pain relief.

Disclosures

Ethical Approval: Ethics committee approval for this study was received from the Institutional Ethics Committee of Istanbul Medipol University, in accordance with the World Medical Association Declaration of Helsinki, with approval number E-10840098-202.3.02-666.

Peer-review: Externally peer-reviewed.

Author Contributions: Conception – S.E., Y.E.E., C.T.; Design – S.E., Y.E.E., C.T.; Supervision – S.E., C.T.; Materials – S.E.; Data Collection and/or Processing – S.E., Y.E.E., C.T.; Analysis and/or Interpretation – S.E., Y.E.E., C.T.; Literature Review – S.E., Y.E.E., C.T.; Writer – S.E.; Critical Review—S.E.

Conflict of Interest: No conflict of interest was declared by the authors.

Funding: The authors declared that this study has received no financial support.

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