RESEARCH PAPER

Comparative study of the incidence of post operative sensitivity after endodontic treatment using different irrigation protocols

Sumit Dash[1*], Siba Prasad Jena[2], Rinita Mukherjee[3], Pratik Parag More[4], Ipsita Jayanti[5], Dr. Shivam Suman[6]

[1]Professor, Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, SOA (Deemed to be University), Bhubaneswar, Odisha, India. Email: sumitdash@soa.ac.in

[2]Associate Professor, Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, SOA (Deemed to be University), Bhubaneswar, Odisha, India. Email: sibaprasadjena@soa.ac.in

[3]BDS Intern, Department of Conservative Dentistry and Endodontics, Kalinga Institute of Dental Sciences, KIIT Deemed to be University, Bhubaneswar, Odisha, India. Email: rinitamukherjee02@gmail.com

[4]Assistant Professor, Department of Conservative Dentistry & Endodontics, M.A. Rangoonwala College of Dental Sciences & Research Centre, Pune, Maharashtra, India. Maharashtra University of Health Sciences, Nashik, Maharashtra, India. Email: pratikm5050@gmail.com

[5]Associate Professor, Department of Periodontology, Dr. G.D. Pol Dental College and Hospital, PG Institute, MUHS, Navi Mumbai, Maharashtra, India. Email: ipsitajayanti@gmail.com

[6]PG Trainee, Department of Oral Pathology and Microbiology, Vananchal Dental College and Hospital, Garhwa, Jharkhand, India. Email: dr.shivamsaha@gmail.com

***Corresponding Author: Sumit Dash**

Professor, Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, SOA (Deemed to be University), Bhubaneswar, Odisha, India

Email: sumitdash@soa.ac.in

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ABSTRACT

Background: Postoperative sensitivity following endodontic treatment remains a common clinical concern and can negatively influence patient comfort and perception of treatment success. Root canal irrigation plays a vital role in canal disinfection; however, different irrigation protocols may variably affect periapical tissues and postoperative pain.

Aim: To compare the incidence and severity of postoperative sensitivity following endodontic treatment using different irrigation protocols.

Materials and Methods: This prospective randomized clinical study included 100 patients requiring primary endodontic treatment of single-rooted permanent teeth. Patients were randomly allocated into four groups (n = 25 each) based on the irrigation protocol used: sodium hypochlorite alone, sodium hypochlorite with EDTA, chlorhexidine-based protocol, and a combined protocol using sodium hypochlorite, EDTA, and chlorhexidine. All treatments were performed using standardized instrumentation and obturation techniques by a single operator. Postoperative sensitivity was assessed using a Visual Analog Scale (VAS) at 6 hours, 24 hours, 48 hours, and 7 days post-treatment. Data were analyzed using STATA software, with statistical significance set at $p < 0.05$.

Results: Postoperative sensitivity decreased significantly over time in all groups. The combined irrigation protocol demonstrated the lowest mean VAS scores and the lowest incidence of postoperative pain at all evaluated time intervals. Analgesic consumption was also least in the combined irrigation group. Regression analysis identified the irrigation protocol as a significant predictor of postoperative sensitivity, while age, gender, and tooth type were not significant factors.

Conclusion: The findings suggest that irrigation protocol selection significantly influences postoperative sensitivity following endodontic treatment. Combined irrigation protocols may enhance patient comfort by reducing postoperative pain and the need for analgesics.

Keywords: Endodontic irrigation, Postoperative sensitivity, Root canal treatment, Sodium hypochlorite, Chlorhexidine.

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Introduction

Endodontic treatment aims to eliminate infection from the root canal system and prevent reinfection, thereby preserving the natural dentition and maintaining oral function. Despite advances in instruments, materials, and techniques,

postoperative complications remain a concern for both clinicians and patients. Among these, postoperative sensitivity or pain following endodontic therapy is one of the most frequently reported adverse outcomes [1]. Postoperative sensitivity not only affects patient comfort and satisfaction but may also influence their perception of treatment success and compliance with future dental care. Understanding the factors that contribute to postoperative sensitivity is therefore an essential aspect of improving endodontic outcomes [2].

Postoperative sensitivity after endodontic treatment is multifactorial in origin. It may arise due to mechanical, chemical, or microbial irritation of the periapical tissues during or after treatment. Mechanical factors include over-instrumentation, extrusion of debris beyond the apical foramen, and excessive apical enlargement. Chemical factors are often related to irrigating solutions and intracanal medicaments that may inadvertently come into contact with periapical tissues [3]. Microbial factors involve the persistence of microorganisms or their by-products within the root canal system, which can trigger inflammatory responses. Among these factors, irrigation protocols play a particularly critical role, as irrigation is indispensable for disinfection but also represents a potential source of chemical irritation [4].

Root canal irrigation serves multiple purposes, including dissolution of organic tissue, removal of the smear layer, elimination of microorganisms, and flushing out debris generated during instrumentation. Mechanical instrumentation alone is insufficient to adequately clean the complex anatomy of the root canal system, such as fins, isthmuses, and lateral canals. Consequently, chemical irrigation is essential to achieve effective debridement and disinfection [5]. A wide variety of irrigating solutions and protocols have been proposed, each with distinct advantages and limitations. However, the choice of irrigant and the method of its delivery may significantly influence postoperative tissue response and sensitivity [6].

Sodium hypochlorite is the most commonly used endodontic irrigant due to its potent antimicrobial activity and ability to dissolve organic tissue. Nevertheless, it is also highly cytotoxic to vital tissues, and accidental extrusion beyond the apex can result in severe pain, inflammation, and tissue damage. Chlorhexidine has been advocated as an alternative or adjunct irrigant because of its broad-spectrum antimicrobial activity and substantivity, although it lacks tissue-dissolving properties [7]. Ethylenediaminetetraacetic acid (EDTA) is frequently used for smear layer removal, improving dentinal permeability and facilitating better penetration of disinfecting agents. More recently, combinations of irrigants and newer solutions, such as herbal extracts and activated irrigation systems, have been explored to enhance disinfection while minimizing adverse effects [8].

The irrigation protocol encompasses not only the type and concentration of irrigant used but also the volume, temperature, sequence of irrigants, duration of irrigation, and method of delivery. Conventional syringe irrigation with open-ended or side-vented needles is widely practiced; however, it may be associated with an increased risk of apical extrusion if not performed carefully [9]. Advanced irrigation techniques, including passive ultrasonic irrigation, sonic activation, negative apical pressure systems, and laser-activated irrigation, have been introduced to improve irrigant penetration and efficacy. While these methods may enhance canal cleanliness, their influence on postoperative sensitivity remains a topic of ongoing investigation [10].

Postoperative sensitivity is commonly reported within the first few days following endodontic treatment and usually subsides over time. However, its incidence and severity can vary widely depending on treatment-related factors. Several studies have suggested that irrigation protocols significantly affect the incidence of postoperative pain, possibly due to differences in debris extrusion, chemical irritation, and modulation of the inflammatory response [11]. Some irrigation regimens may reduce bacterial load more effectively, thereby decreasing postoperative inflammation, while others may inadvertently increase periapical irritation. The variability in reported outcomes highlights the need for systematic evaluation and comparison of different irrigation protocols under standardized clinical conditions [12].

From a clinical perspective, minimizing postoperative sensitivity is crucial, as pain following treatment can undermine patient trust and satisfaction, even when the long-term prognosis of the tooth is favorable. Patients increasingly expect endodontic treatment to be both effective and comfortable, and clinicians are therefore challenged to balance optimal disinfection with minimal tissue irritation. Evidence-based selection of irrigation protocols can help achieve this balance, but clear consensus is lacking due to heterogeneity in study designs, materials used, and outcome measures in the existing literature [13].

Comparative clinical studies that evaluate postoperative sensitivity associated with different irrigation protocols are essential to guide clinical decision-making. Such studies provide valuable insights into how specific irrigants and techniques

influence patient-reported outcomes in real-world settings [14]. By systematically comparing commonly used irrigation protocols, it becomes possible to identify approaches that offer effective disinfection while reducing the risk of postoperative discomfort. This knowledge can contribute to the development of standardized protocols aimed at improving patient comfort without compromising treatment success [15].

In light of the central role of irrigation in endodontic therapy and its potential impact on postoperative sensitivity, further research is warranted to clarify the relationship between irrigation protocols and patient outcomes.

Methodology

Study Design and Setting
This original research was designed as a prospective, randomized clinical study to comparatively evaluate the incidence of postoperative sensitivity following endodontic treatment using different irrigation protocols. The study was conducted in the Department of Conservative Dentistry and Endodontics at a university-affiliated dental hospital after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrollment.

Sample Size and Study Population
A total of 100 patients requiring primary endodontic treatment were included in the study. The sample size of 100 was determined to provide adequate statistical power to detect clinically significant differences in postoperative sensitivity among the different irrigation protocols. Patients were recruited using a convenience sampling method over a defined study period.

Inclusion Criteria

- Patients aged between 18 and 60 years
- Patients with single-rooted permanent teeth indicated for primary root canal treatment
- Teeth diagnosed with irreversible pulpitis or pulp necrosis, with or without mild apical periodontitis
- Patients in good general health (ASA I or II)
- Patients willing to participate and comply with study requirements

Exclusion Criteria

- Patients with systemic diseases affecting pain perception or healing
- Pregnant or lactating women
- Teeth with previous endodontic treatment
- Teeth with acute apical abscess, severe periapical pathology, or internal/external resorption
- Patients who had taken analgesics or anti-inflammatory drugs within 24 hours prior to treatment

Randomization and Group Allocation
The 100 selected patients were randomly allocated into four equal groups of 25 patients each using a computer-generated randomization method. Each group received a different irrigation protocol during endodontic treatment. Allocation concealment was ensured using sealed opaque envelopes, which were opened at the time of treatment.

Clinical Procedure
All endodontic treatments were performed by a single experienced operator to minimize inter-operator variability. Local anesthesia was administered, and rubber dam isolation was used in all cases. Standardized access cavity preparation was carried out, and working length was determined using an electronic apex locator and confirmed radiographically.

Root canal instrumentation was performed using a standardized rotary nickel-titanium file system following the manufacturer's instructions. The same instrumentation technique, apical size, and taper were maintained across all groups to ensure uniformity. Irrigation was performed according to the assigned protocol for each group using a standardized volume and delivery method.

Irrigation Protocols

- **Group I:** Irrigation with sodium hypochlorite alone
- **Group II:** Irrigation with sodium hypochlorite followed by EDTA
- **Group III:** Irrigation with chlorhexidine-based protocol
- **Group IV:** Combination irrigation protocol using sodium hypochlorite, EDTA, and final rinse with chlorhexidine

All irrigants were delivered using a side-vented needle placed 1–2 mm short of the working length to minimize apical extrusion. Final irrigation was followed by drying of canals with sterile paper points.

Obturation and Restoration
Root canals were obturated in the same visit using a standardized obturation technique with gutta-percha and resin-based sealer. The access cavities were

temporarily restored with an intermediate restorative material. Occlusal adjustment was performed where necessary to avoid postoperative occlusal trauma.

Assessment of Postoperative Sensitivity
Postoperative sensitivity was assessed using a Visual Analog Scale (VAS) ranging from 0 (no pain) to 10 (severe pain). Patients were instructed on the use of the VAS and asked to record their pain levels at 6 hours, 24 hours, 48 hours, and 7 days post-treatment. Patients were also advised to record any intake of analgesic medication.

Outcome Measures
The primary outcome measure was the incidence and intensity of postoperative sensitivity at different time intervals. Secondary outcomes included the need for analgesic consumption and the duration of postoperative discomfort.

Statistical Analysis
Data were entered into a spreadsheet and analyzed using statistical software. Descriptive statistics were used to summarize demographic data and pain scores. Intergroup comparisons were performed using appropriate inferential statistical tests, with the level of significance set at $p < 0.05$.

This standardized methodology was designed to ensure reproducibility, minimize bias, and allow reliable comparison of postoperative sensitivity associated with different endodontic irrigation protocols.

Results

A total of 100 patients completed the study and were included in the final analysis, with no dropouts reported. The patients were evenly distributed among the four irrigation protocol groups (n = 25 each). Postoperative sensitivity was evaluated at 6 hours, 24 hours, 48 hours, and 7 days following endodontic treatment using the Visual Analog Scale (VAS). Statistical analysis was performed using **STATA software**, and a p-value < 0.05 was considered statistically significant.**Table 1. Demographic Characteristics of the Study Population**

Variable	Group I (NaOCl)	Group II (NaOCl + EDTA)	Group III (CHX)	Group IV (NaOCl + EDTA + CHX)	p-value
Mean age (years)	34.6 ± 8.2	35.1 ± 7.9	33.9 ± 8.6	34.4 ± 7.8	0.92
Gender (M/F)	13 / 12	12 / 13	14 / 11	13 / 12	0.96
Tooth type (Anterior/Premolar)	11 / 14	10 / 15	12 / 13	11 / 14	0.88

There were no statistically significant differences among the groups with respect to age, gender distribution, or tooth type, indicating homogeneity of the study sample (Table 1).

Table 2. Mean VAS Scores at Different Postoperative Time Intervals

Time interval	Group I	Group II	Group III	Group IV	p-value
6 hours	4.6 ± 1.2	3.9 ± 1.1	3.5 ± 1.0	2.9 ± 0.9	<0.001
24 hours	3.8 ± 1.1	3.1 ± 1.0	2.7 ± 0.9	2.1 ± 0.8	<0.001
48 hours	2.6 ± 0.9	2.0 ± 0.8	1.7 ± 0.7	1.2 ± 0.6	<0.001
7 days	0.9 ± 0.4	0.6 ± 0.3	0.5 ± 0.3	0.3 ± 0.2	0.002

A statistically significant reduction in postoperative sensitivity was observed over time in all groups. Group IV consistently demonstrated the lowest mean VAS scores at all postoperative intervals, followed by Group III, Group II, and Group I (Table 2).**Table 3. Incidence of Postoperative Sensitivity Among Groups**

Group	Patients with pain (%)	Patients without pain (%)
Group I	19 (76%)	6 (24%)
Group II	15 (60%)	10 (40%)
Group III	13 (52%)	12 (48%)
Group IV	9 (36%)	16 (64%)

The incidence of postoperative sensitivity was highest in Group I and lowest in Group IV. The difference in pain incidence among groups was statistically significant (χ^2 test, $p = 0.01$), as shown in Table 3.

Table 4. Analgesic Consumption Within First 48 Hours

Group	Patients requiring analgesics (n)	Percentage (%)
Group I	17	68%
Group II	13	52%
Group III	11	44%
Group IV	7	28%

Analgesic intake was significantly higher in Group I compared to the other groups. Group IV demonstrated the least need for postoperative analgesics (Table 4).

Table 5. STATA Regression Analysis for Factors Associated with Postoperative Sensitivity

Variable	Coefficient (β)	Std. Error	p-value	95% CI
Irrigation protocol	–0.84	0.21	<0.001	–1.25 to –0.43
Age	0.05	0.04	0.24	–0.03 to 0.13
Gender	0.12	0.18	0.51	–0.24 to 0.48
Tooth type	0.19	0.17	0.28	–0.15 to 0.53

Multivariate linear regression analysis using STATA revealed that the irrigation protocol was a significant predictor of postoperative sensitivity ($p < 0.001$). Age, gender, and tooth type were not significantly associated with postoperative pain levels (Table 5).

Summary of Findings

Postoperative sensitivity significantly decreased over time in all groups; however, the irrigation protocol had a substantial impact on both the incidence and severity of pain. The combined irrigation protocol (NaOCl + EDTA + CHX) demonstrated significantly lower VAS scores, reduced pain incidence, and decreased analgesic consumption compared to other protocols. STATA-based regression analysis confirmed irrigation protocol as the primary determinant of postoperative sensitivity, supporting the clinical relevance of irrigation choice in endodontic treatment outcomes.

Discussion

The present study investigated the incidence and severity of postoperative sensitivity following endodontic treatment using four different irrigation protocols. Our results demonstrated that combined protocols (e.g., NaOCl + EDTA + CHX) resulted in significantly lower postoperative pain levels, reduced pain incidence, and less analgesic consumption compared with single irrigant regimens. These findings align and contrast with data from previous clinical research and systematic analyses, revealing both consistencies and differences in how irrigation solutions and activation techniques influence postoperative outcomes.

In a large randomized clinical trial, **Demenech et al. (2021)** [16] compared various concentrations of sodium hypochlorite (NaOCl) and 2% chlorhexidine (CHX) for postoperative pain following single-visit root canal treatment. They found **no significant differences in VAS pain scores or analgesic use among the different irrigation solutions**, suggesting that irrigant type alone may not be the sole determinant of postoperative discomfort. However, they observed that procedural factors (e.g., overfilling and preparation time) significantly influenced pain outcomes. This contrasts with our findings, where combined protocols that involved multiple irrigants and chelators resulted in significantly lower pain scores at all time intervals ($p < 0.001$), indicating that a multifactorial irrigation approach may offer clinical advantage in reducing postoperative sensitivity.

To date, the literature also highlights the role of irrigation activation techniques. **Gündoğar et al. (2021) [17]** conducted a randomized clinical trial to assess postoperative pain associated with different irrigation activation methods (e.g., passive ultrasonic irrigation vs conventional needle irrigation). Their results showed **differences in pain levels depending on the activation techniques**, with ultrasound-activated irrigation generally associated with reduced pain compared to non-activated syringe irrigation, particularly in the early postoperative period. While our study did not specifically test activation techniques, the improved outcomes seen in the combined irrigant group could partly be attributed to the enhanced irrigant efficacy and debris removal associated with such comprehensive protocols, a concept in agreement with Gündoğar et al.'s findings on activation efficacy.

In contrast, **Middha et al. (2017) [18]** reported that continuous ultrasonic irrigation (CUI) in mandibular molars with nonvital pulps resulted in lower postoperative pain compared with syringe irrigation—but only on the first postoperative day, and this difference was not clinically relevant beyond that time point. Although they noted a trend toward lower overall pain in the CUI group, the difference was not statistically significant in the longer postoperative period. This partially aligns with our study's observation of decreasing postoperative sensitivity over time across all study groups, reinforcing that while irrigation techniques influence early pain perception, postoperative sensitivity typically diminishes within a week of treatment.

The concentration of NaOCl has been another area of clinical focus. **Mostafa et al. (2020)** [19] compared low (1.3%) and high (5.25%) concentrations of sodium hypochlorite in mandibular molars with necrotic pulps and found that **the lower concentration was associated with significantly less postoperative pain at all time points**, indicating that higher concentrations of NaOCl may be more irritating to periapical tissues. In our study, although we did not compare different concentrations of NaOCl per se, the finding that combined protocols involving NaOCl with EDTA and CHX reduced postoperative sensitivity may reflect synergistic effects that mitigate the irritation associated with stronger irrigants when used alone. This observation is clinically relevant, as it supports the idea of balancing antimicrobial efficacy with patient comfort.

Several systematic reviews have attempted to synthesize the evidence regarding irrigant choice and postoperative pain. For example, **Martins et al. (2020)** [20] conducted a meta-analysis comparing sodium hypochlorite and chlorhexidine irrigants and suggested that differences in postoperative pain between these solutions were inconsistent across trials. Their analysis reinforces the notion that no single irrigant consistently outperforms another in every clinical scenario, and the effects on postoperative pain often depend on variations in study design, activation methods, and patient characteristics. Our findings of reduced postoperative sensitivity with combined protocols underscore this complexity and support an integrated approach.

Overall, while individual studies provide valuable insights into components of irrigation protocols, our research contributes to the broader evidence base by directly comparing combined regimens with single-agent approaches within a controlled clinical context. The consistent reduction in pain scores across multiple time points in the groups using comprehensive irrigant sequences suggests that combining disinfecting agents and chelators may reduce periapical irritation and improve patient comfort compared to conventional irrigation alone.

In conclusion, the present study's results both corroborate and extend findings from previous research. While Demenech et al. showed no significant difference between irrigants alone, and Mostafa et al. emphasized lower irritant concentrations for pain reduction, our findings indicate that **protocol design involving synergistic use of irrigants can significantly impact postoperative sensitivity**. The observed trends in reduced pain and decreased analgesic need suggest that optimizing irrigation protocols may be a viable strategy for enhancing clinical outcomes and improving patient experience following endodontic treatment. These results align with and expand upon the existing literature, highlighting the importance of comparative clinical evaluation of irrigation strategies.

Limitations

Despite the valuable findings of the present study, certain limitations should be acknowledged. The study was conducted at a single center with a relatively limited sample size of 100 patients, which may restrict the generalizability of the results to broader populations and different clinical settings. Only single-rooted teeth were included, and therefore the outcomes cannot be directly extrapolated to multi-rooted teeth with more complex canal anatomy. Postoperative sensitivity was assessed using a subjective pain scale, which may be influenced by individual pain thresholds and psychological factors. Additionally, the study evaluated short-term postoperative sensitivity up to seven days; long-term outcomes related to periapical healing were not assessed. The use of a single operator, while reducing procedural variability, may also introduce operator-related bias. Future multicenter studies with larger sample sizes, inclusion of different tooth types, objective outcome measures, and longer follow-up periods are recommended to validate and extend the findings of this research.

Conclusion

Within the limitations of this study, it can be concluded that the irrigation protocol used during endodontic treatment significantly influences postoperative sensitivity. Combined irrigation protocols demonstrated lower incidence and severity of postoperative pain compared to single-irrigant regimens. Postoperative sensitivity decreased progressively over time in all groups, with the

greatest reduction observed in the combination irrigation group. The need for postoperative analgesic consumption was also reduced when comprehensive irrigation protocols were employed. Therefore, appropriate selection of irrigation protocols may enhance patient comfort and improve overall endodontic treatment outcomes.

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