

Effect of Different Concentrations of Sodium Hypochlorite on Post-Operative Pain After Primary Root Canal Treatment in Teeth Diagnosed with Irreversible Pulpitis

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ABSTRACT

Objective: To assess the impact of varying concentrations of sodium hypochlorite (NaOCl) on postoperative pain after primary root canal treatment in teeth with a diagnosis of irreversible pulpitis.

Study Design: Quasi-experimental study.

Place and Duration of Study: Department of Operative Dentistry and Endodontics, Armed Forces Institute of Dentistry Rawalpindi, Pakistan, from Mar 2024 to Sep 2024.

Methodology: This study included 100 participants (18–49 years) divided into two groups: Group A (low concentration, 2% NaOCl) and Group B (high concentration, 5.25% NaOCl). Standardized Root canal treatment protocols as per American Association of Endodontists were followed, including irrigation with respective NaOCl concentrations during canal preparation. Postoperative pain was evaluated 24 hours after treatment using the Visual Analog Scale (VAS) and classified as mild, moderate, or severe.

Results: The study had total of 100 participants divided into two equal groups based on the concentration of sodium hypochlorite (NaOCl) used during root canal treatment. The high-concentration group exhibited significantly higher pain scores [median(IQR): 7.00(5.00-9.00)] compared to the low-concentration group (median(IQR): 5.00(3.00-6.00)]. Severe pain was reported by 66% of participants in the high-concentration group versus 24% in the low-concentration group ($p < 0.001$). The findings indicate a dose-dependent relationship between NaOCl concentration and postoperative pain severity.

Conclusion: Higher concentrations of NaOCl (5.25%) lead to significantly increased postoperative pain compared to lower concentrations (2%). These results suggest that using lower NaOCl concentrations can effectively balance antimicrobial efficacy and patient comfort in root canal treatment for irreversible pulpitis. Further multicenter studies are recommended to validate these findings.

Keywords: Antimicrobial efficacy, Cytotoxicity, Dose-dependent effects, Irreversible pulpitis, Postoperative pain, Visual Analog Scale (VAS).

How to Cite This Article: Naqvi SSEH, Ehsan HRU, Maryum S, Khurshid T, Asif MH, Azad N. Effect of Different Concentrations of Sodium Hypochlorite on Post-Operative Pain After Primary Root Canal Treatment in Teeth Diagnosed with Irreversible Pulpitis. *Pak Armed Forces Med J* 2026; 76(6): 816-821. DOI: <https://doi.org/10.51253/pafmj.v76i6.12921>

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INTRODUCTION

Sodium hypochlorite (NaOCl) is extensively used in endodontic treatment for its potent antibacterial and tissue-dissolving capabilities.¹ Making it the gold standard among root canal irrigants.² Its ability to dissolve organic tissue and kill a wide range of microorganisms helps ensure successful outcomes by effectively cleaning and disinfecting the root canal system.³ Different concentrations of NaOCl, ranging from 0.5% to 5.25%, have been explored, with ongoing debate on the optimal concentration to balance efficacy and safety.⁴

The main objectives of endodontic treatment are to prevent infection, eliminate pain, and promote long-term healing of periapical tissues.⁵ A key component

in achieving these goals is the use of an irrigant that can penetrate dentin tubules, remove the smear layer, and eradicate microorganisms.⁶ NaOCl is effective in dissolving both vital and necrotic pulp tissue,⁷ however the concentration used plays a crucial role in determining clinical outcomes, including antimicrobial efficacy, tissue dissolution, and postoperative pain.

One concern with NaOCl use is its cytotoxicity, especially at higher concentrations. Concentrations like 5.25% are more effective in microbial reduction and tissue dissolution than lower concentrations (e.g., 2%), but they also carry risk of increased cytotoxicity and postoperative pain. High concentrations of NaOCl, when extruded into periapical tissues, can provoke an inflammatory response, resulting in greater discomfort for the patient.⁸ Studies have shown that NaOCl at concentrations above 2.5% causes a stronger inflammatory response in periapical

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Received: 26 Nov 2024; revision received: 19 Feb 2025; accepted: 20 Feb 2025

tissues compared to lower concentrations, due to its toxicity to periapical cells.⁹

In cases of irreversible pulpitis, where patients often present with significant preoperative pain, the choice of NaOCl concentration becomes particularly important. Irreversible pulpitis is characterized by inflammation of the dental pulp, leading to spontaneous and prolonged pain episodes.¹⁰ Endodontic treatment aims to eliminate the infection and relieve pain as quickly as possible. While NaOCl is essential for reducing bacterial load and preventing postoperative infection, the concentration must be carefully chosen to avoid exacerbating pain after the procedure. While in vitro studies have provided valuable insights into the antimicrobial properties and tissue-dissolving capacity of different NaOCl concentrations, their relevance to clinical outcomes, particularly postoperative pain, is still debated. Clinical studies on the impact of NaOCl concentration on postoperative pain have produced conflicting results. Some report higher concentrations being associated with more pain, while others find no significant differences between various concentrations. These discrepancies could be attributed to variations in study design, patient populations, and pain assessment methods. The search of literature revealed that most of the research on sodium hypochlorite is based on antimicrobial effectiveness and endodontic outcome. This study was conducted to evaluate the incidence and intensity of postoperative pain following the use of two different concentrations of NaOCl (2% and 5.25%). We could not find any previous study on this topic in context of Pakistani population.

METHODOLOGY

This quasi-experimental study received approval from the Institutional Ethical Committee of Armed Forces Institute of Dentistry, Rawalpindi Pakistan, via letter no. 918/Trg dated 13 May 2020. Patients referred for nonsurgical root canal treatment at the Operative Dentistry and Endodontics Department were chosen for this study. The study spanned six months, from March 2024 to September 2024.

With reference to the mean pain score in high and low conc NaOCl groups as 4.07 ± 0.83 and 3.77 ± 0.78 respectively,¹¹ sample size of $n=54$ for each group was calculated by using WHO sample size calculator. The power of study was kept at 80% with 5% margin of error.

Inclusion Criteria: Patients requiring primary root canal treatment for irreversible pulpitis with normal periodontium in mature mandibular molars, with age ranging from 18 to 49 years, pulpal status was confirmed through cold and electrical pulp tests, along with bleeding in the pulp chamber.

Exclusion Criteria: Patients with diabetes, immunocompromised conditions, pregnancy, recent analgesic (within 3 days) or antibiotic (within a month) use, and teeth that were periodontally compromised, previously accessed, or unsuitable for rubber dam isolation.

After obtaining informed consent, patients were assigned by the assistant to one of two groups according to the concentration of sodium hypochlorite (Cerkamed, Poland) used: Group A, the low-concentration (LC) group with 2% NaOCl, or Group B, the high-concentration (HC) group with 5.25% NaOCl (Figure). Using a computer-generated sequence created in Microsoft Excel with the =RAND() function to ensure equal allocation in each group and to control bias. To maintain blinding, the irrigation syringes were covered by the assistant to conceal the concentration of sodium hypochlorite, ensuring that neither the operator nor the patient had any knowledge of the group allocation during the procedure.

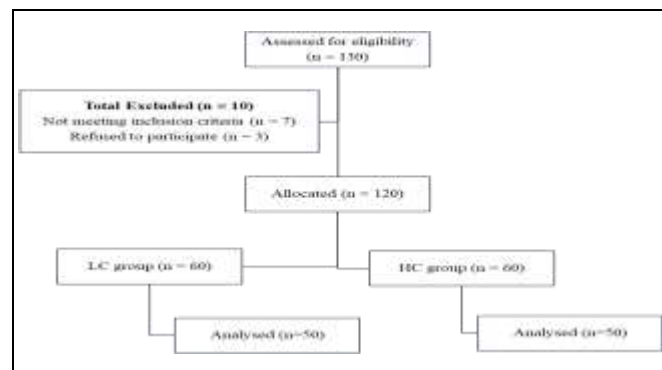


Figure: Flow Diagram of Study Participants

All treatments were conducted by a single operator (N.V.), a second-year resident at the Department of Operative Dentistry and Endodontics, who has two years of clinical experience. Patients received local anesthesia through an inferior alveolar nerve block using 2% lidocaine with 1:100,000 epinephrine (Septodont, USA). After isolating the tooth with a rubber dam, caries were removed, and the access cavity was prepared. The pulp chamber was

cleaned, and the working length was determined using an electronic apex locator (Root ZX, J Morita, Tokyo) with a size 15 K-file. The file was advanced until "APEX" appeared, then retracted to the flashing bar between "APEX" and "1," where the working length was recorded. The working length was subsequently confirmed with a periapical radiograph.

Root canal preparation was done using Protaper Gold rotary files (Dentsply, USA). An electric endomotor (X-Smart Dentsply, Switzerland) was used for rotary preparation with recommended speed (300 rpm), torque (2.5 Ncm), and motion (clockwise rotation) settings. In the A group, 5 mL of 2% NaOCl (Cerkamed, Poland) was used for irrigation after each instrument change, while in the B group, 5 mL of 5.25% NaOCl (Cerkamed, Poland) was used. Irrigation was performed with a 30-gauge side-vented irrigation needle (PD, Switzerland). After canal preparation, canals were irrigated with 5 mL of 17% EDTA (PD, Switzerland) for 1 minute, followed by Normal saline and a final rinse with 5 mL of either 2% or 5.25% NaOCl for 1 minute. The canals were dried using absorbent paper points (Dentsply, USA) and obturated with the lateral condensation technique, employing gutta-percha (Dentsply, USA) and a resin-based sealer (Dentsply, USA) applied with a lentulo spiral (Dentsply, USA). Following obturation, the cavity was permanently restored with a composite resin restoration (Coltene, Switzerland), and a postoperative radiograph was obtained. Occlusion was checked with articulating paper (PD, Switzerland) to prevent postoperative pain due to high-spot.

For pain assessment, patients recorded their postoperative pain levels using a visual analog scale (VAS) after 24 hours following the procedure, where 0 indicated no pain and 10 indicated maximum pain. Patients returned the completed Data collection form one week later. Pain levels were classified into mild (1-3), moderate (4-6), and severe (7-10) to aid in clinical interpretation.

All data were presented and organized using Microsoft Excel. Descriptive analysis and the calculation of median and inter-quartile range were computed using the Statistical Package for the Social Sciences (SPSS) version 23.0. Normality was checked by Shapiro-wilk test for age that revealed its non-normal distribution. Mann Whitney-U test was utilized to compare the pain scores between the two groups, while a Chi-square test was conducted to examine the association between sodium hypochlorite

concentrations and the categorical distribution of pain levels (mild, moderate, severe). A *p*-value of less than 0.05 was considered statistically significant.

RESULTS

This study included hundred patients with composite age range 18-49 years. Majority of the participants were males 66(66.0%) while females were 34(34.0%). The demographic breakdown of the study participants by NaOCl concentration groups: low concentration (2%) and high concentration (5.25%) has shown in Table-I. Each group was comprised of 50 participants. The gender distribution within each group indicates a predominance of male participants. The overall age distribution (range:18-49 years), shows that participants in the low and high concentration group had slight median difference of age.

Table I: Demographics of study participants (n=100)

NaOCl Groups	Gender		Age (years) Median(IQR)
	Male; n(%)	Female; n(%)	
Group A Low Concentration (2%) (n=50)	29(43.9%)	21(61.8%)	31.00(22.00-41.00)
Group B High Concentration (5.25%) (n=50)	37(56.1%)	13(38.2%)	30.00(24.00-37.00)

Table II compares pain levels between the two study groups. The low concentration group experienced lower levels of pain documented at 24 hours, with 24% of patients experienced severe pain. In contrast, the high concentration group reported significantly higher levels of pain, with 66% reported severe pain. The median pain score for the low concentration group was 5.00(3.00-6.00), whereas the high concentration group had significantly higher median pain score of 7.00(5.00-9.00), with statistically significant difference between the two groups. The findings indicated that a higher concentration of NaOCl is linked to increased pain, highlighting a potential dose-dependent relationship. Overall, the data indicates that lower NaOCl concentrations may be preferable for minimizing pain among participants.

Table II: Comparison of pain level in study groups (n=100)

Pain	NaOCl Groups		p-value
	Group A Low Concentration (2%) (n=50)	Group B High Concentration (5.25%) (n=50)	
Mild (1-3)	18(36.0%)	4(8.0%)	<0.001
Moderate (4-6)	20(40.0%)	13(26.0%)	
Severe (7-10)	12(24.0%)	33(66.0%)	
Mean Pain Score [Median(IQR)]	5.00(3.00-6.00)	7.00(5.00-9.00)	<0.001

DISCUSSION

This study investigated the effect of varying concentrations of sodium hypochlorite (NaOCl) on postoperative pain after primary root canal treatment in teeth diagnosed with irreversible pulpitis. The results showed that a higher concentration (5.25%) caused significantly more postoperative pain than a lower concentration (2%). After 24 hours, 33 patients in the Group B-higher concentration reported severe pain compared to only 12 patients in the Group A-lower concentration, aligning with previous research linking higher NaOCl concentrations to increased discomfort. Numerous studies have examined the impact of varying NaOCl concentrations on postoperative pain in patients undergoing root canal treatment for irreversible pulpitis. Some advocate for higher concentrations (5.25%) for greater bacterial reduction, while others report increased postoperative pain associated with these higher concentrations. For instance, higher NaOCl concentrations have been linked to more significant apical extrusion of debris and a stronger inflammatory response, which can lead to increased discomfort to the patient. Lower concentrations, such as 2%, may reduce postoperative pain by minimizing the cytotoxic effects on periapical tissues, while still providing adequate antimicrobial action.¹¹

NaOCl's potential to cause postoperative discomfort may also be influenced by factors such as the method of irrigation, the volume of solution used, and the presence of preoperative pain.¹² Extrusion of NaOCl into periapical tissues, even in small amounts, can trigger an exaggerated inflammatory response, particularly when higher concentrations are used.¹³ Research has shown that high-concentration NaOCl solutions are associated with increased debris extrusion, which may further contribute to postoperative pain.¹⁴

Consistent with our findings, Akua B. Konadu *et al.* demonstrated that NaOCl concentrations above 1% were effective for bacterial elimination while minimizing postoperative pain. Their study, which examined concentrations between 1.0% and 2.6%, concluded that lower concentrations strike a balance between antimicrobial efficacy and patient comfort.¹⁷ Although conducted in Ghana, their results support the broader applicability of using less concentrated solutions to enhance treatment outcomes and reduce discomfort.

Similarly, Neha Verma *et al.* observed that 1% NaOCl was sufficient for effective root canal treatment, with no added benefits from higher concentrations.¹⁶ In their study, increasing the concentration failed to improve clinical outcomes and was instead associated with greater pain. This aligns closely with the findings of the present study, emphasizing that higher NaOCl concentrations not only fail to offer superior therapeutic benefits but also contribute to increased postoperative discomfort.

Further support comes from Hadi Mokhtari *et al.*, whose randomized, double-blind trial assessed the effects of 0.5% and 1% NaOCl concentrations and temperatures on postoperative pain.¹⁸ Their findings showed no significant difference in pain levels between these lower concentrations, reinforcing the notion that concentrations exceeding 1% may not provide added clinical advantages. This evidence collectively underscores the viability of low-concentration NaOCl solutions in achieving effective outcomes while minimizing patient discomfort.

In agreement, M. Mostafa *et al.* reported significantly greater postoperative pain with 5.25% NaOCl compared to lower concentrations, such as 1.3%.¹⁹ These findings support the current study's conclusion that lower concentrations are preferable for reducing postoperative discomfort, particularly in cases of irreversible pulpitis. The consistency across these studies highlights the critical role of NaOCl concentration in optimizing clinical outcomes and patient satisfaction.

However, not all studies align with these findings. For instance, Demenech LS *et al.* evaluated 2.5%, 5.25%, and 8.25% NaOCl concentrations and reported no significant differences in postoperative pain across these groups.²⁰ The authors suggested that factors such as prolonged preparation time and overfilling of materials could have contributed to postoperative discomfort, indicating that concentration alone may not be the sole determinant of pain. These conflicting findings highlight the need for further research to explore how procedural factors interact with NaOCl concentration to influence patient outcomes.

The clinical relevance of this study is evident. Higher NaOCl concentrations (5.25%) are associated with significantly greater postoperative pain, making lower concentrations (e.g., 2%) a more favorable choice in practice. Lower concentrations maintain effective antibacterial action and tissue dissolution

while reducing cytotoxicity and minimizing patient discomfort. This is particularly critical in cases of irreversible pulpitis, where managing postoperative pain is a priority.

Clinicians should carefully consider the concentration of NaOCl used during root canal treatment, not only to optimize antimicrobial efficacy but also to enhance patient comfort. Adopting evidence-based protocols that favor lower concentrations can improve the overall patient experience without compromising treatment outcomes. Future research should continue to explore the interplay of concentration, procedural variables, and individual patient factors to further refine these recommendations.

By prioritizing patient-centered approaches in endodontic care, this study contributes to a growing body of evidence that supports using lower NaOCl concentrations to balance efficacy with comfort, ultimately enhancing both clinical success and patient satisfaction.

CONCLUSION

This study adds to the evidence that higher NaOCl concentrations, such as 5.25%, increase postoperative pain. While some studies report no significant differences between concentrations, the majority, including this study, advocate for using lower concentrations (2%) for optimal treatment outcomes with minimal discomfort. Further research, particularly multi-center trials, is needed to refine the ideal NaOCl concentration to balance efficacy with patient comfort.

Conflict of Interest: None.

Funding Source: None.

Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

SSEHN & HRUE: Data acquisition, data analysis, drafting the manuscript, critical review, approval of the final version to be published.

SM & TK: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MHA & NA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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