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Original Article

Comparison of the Postoperative Pain Following Endodontic Irrigation Using 1.3% Versus 5.25% Sodium Hypochlorite in Mandibular Molars with Necrotic Pulps

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ABSTRACT

Endodontic irrigation plays a crucial role in root canal treatment, aiming to disinfect the root canal system be removing debris, bacteria and tissue remnants. **Objective:** To compare the postoperative pain between two concentrations (1.3% and 5.25%) of irrigation using sodium hypochlorite (NaOCl) in lower molars with necrotic pulps. **Methods:** Sixty patients with nonvital pulps in mandibular molars, either gender, mature teeth with a closed apex or age between 18 and 60 years were included. Patients were assessed for postoperative pain in each group at 24 hours. The Chi-square test and student t-test were used to compare the postoperative pain outcome of both groups. **Results:** The mean age of the patients in group A was 33.76 ± 4.06 years, and in group B was 32.10 ± 5.84 years. Pre-operative pain was statistically insignificant in both groups ($p = 0.123$), with an average VAS of 3.16 ± 0.64 in group A and 3.40 ± 0.49 in group B. The average pain was significantly lower at 1.33 ± 0.47 in the 1.3% sodium hypochlorite group compared to 1.63 ± 0.66 in the 5.25% NaOCl group ($p = 0.051$) after 24 hours. The average post-operative pain score was significantly higher in females compared to males in the 1.3% NaOCl group ($p = 0.033$). However, the average post-operative pain score was statistically insignificant between males and females in the 5.25% NaOCl group ($p = 0.445$). **Conclusion:** Endodontic irrigation using 1.3% NaOCl was found to be more effective in reducing post-operative pain compared to endodontic irrigation using 5.25% NaOCl.

INTRODUCTION

In dentistry, pain assumes a pivotal role, often standing as the foremost trigger for dental anxiety [1, 2]. It is defined as a disagreeable sensory and emotional sensation associated with real or potential tissue injury, involving complex pathways such as inflammatory reactions at the affected site and the transmission of action potentials to the central neerceived by patients as one of the most agonizing dental procedures, fueling significant apprehension about postoperative pain [5, 6]. Comprehending postoperative pain following root canal treatment and its determining factors is essential for clinicians to proficiently address pain [7, 8]. This understanding not only aids in minimizing the necessity for tooth extraction but also assists general practitioners in applying evidence-based protocols for managing postoperative pain following non-surgical root canal treatment [9]. Despite the enduring pain relief achieved through root canal treatment, patients frequently encounter postoperative pain shortly after the procedure [10]. Post-endodontic pain, which refers to pain

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experienced after root canal treatment, can stem from various factors throughout the treatment process. These factors encompass pre-treatment considerations, such as the initial condition of the tooth and surrounding tissues, as well as intra-treatment variables, including the number of visits required for treatment completion and the specific techniques employed during the procedure [11, 12]. Additionally, post-treatment factors, such as the type of irrigant and intracanal medication utilized, along with the method of root canal instrumentation and filling, can also influence the likelihood and severity of post-endodontic pain [13]. One of the commonly used agents in endodontic procedures is sodium hypochlorite (NaOCl), renowned for its efficacy in dissolving organic matter and its potent antimicrobial properties. Despite its widespread use over seven decades, it is crucial to note that NaOCl, particularly at higher concentrations, has the potential to irritate the surrounding tissues, leading to periradicular tissue irritation [14]. Complications arising from the extrusion of sodium hypochlorite during endodontic procedures have been linked to increased pain levels, especially in cases involving necrotic teeth. Therefore, while NaOCl remains a valuable tool in endodontic practice, careful attention to its concentration and proper application techniques is imperative to mitigate the risk of associated pain and complications [15]. The investigation contrasts postoperative discomfort after 24 hours following endodontic rinsing utilizing 1.3% versus 5.25% sodium hypochlorite in mandibular molars with necrotic pulps, aiming to address a local gap in information. Root canal-associated pain is a major concern for patients and dentists, with no agreed-upon pain control method. This study aims to identify the most effective treatment for postoperative endodontic pain by comparing both groups simultaneously. The study was aimed to compare the post-endodontic pain scores between 1.3% and 5.25% NaOCl irrigants in necrotic lower permanent molars.

METHODS

This comparative cross sectional study was conducted at the Department of Dentistry, Liaquat University of Medical and Health Sciences, Jamshoro/Hyderabad, from January 2022 to October 2023, involving 60 patients selected through non-probability consecutive sampling technique. The sample size was determined using the WHO method, which considered a population size of 1,000,000, an estimated percentage frequency of the outcome factor in the population (p)of 0.3%, and a 95% confidence level with a margin of error (d) of 5%. A design effect of 1 was accounted for. Initially, the calculated sample size was 25. However, to bolster the study's statistical power, an additional 15 samples were included, resulting in a total sample size of 60. The inclusion criteria for the study were mandibular molars with nonvital pulps, individuals of either gender, mature teeth with a closed apex, and ages ranging from 18 to 60 years. Conversely, exclusion criteria comprised non-consenting individuals, patients with a history of allergy to any medications, retreatment cases, and patients who were taking medications for pain. Additionally, individuals with a history of respiratory, cardiovascular, or neurological disorders, as well as primary teeth, were excluded from the study. The study was carried out after obtaining ethical approval from the hospital concerned. Patients undergoing root canal treatment at the dental Department, LUMHS, who met the inclusion criteria, were recruited. During patient's initial c appointment, the study's aim, along with its potential risks and benefits, was thoroughly explained, and informed consent was obtained. Additionally, a brief demographic history was collected from each patient. Subsequently, patients were randomly assigned to either group A (undergoing endodontic irrigation with 1.3% sodium hypochlorite) or group B (undergoing endodontic irrigation with 5.25% sodium hypochlorite) using sealed opaque envelopes. Root canal treatments were performed across two sessions. During the initial session, each tooth received anesthesia using 1.8 ml of 2% lignocaine hydrochloride (Medicaine inj 1:100,000, Huons Co., LTD) administered via the inferior alveolar nerve block technique. Following access preparation, rubber dam isolation was applied to each tooth. Subsequently, the pulp chamber was filled with 3 mL of irrigant. Canal patency was then established, and an initial glide path was created using #10 and #15 K-files (Mani K-files). After canal preparation, the working length was established utilizing an apex locator (Woodpecker Woodpex III) and confirmed radiographically to be 0.5mm occlusally to radiographic apex. The root canal was prepared using a NiTi rotary system (M3-Pro Gold) and a torque-controlled endodontic motor (Tangshan Umg Medical Instrument Co., Ltd), adhering to the manufacturer's guidelines. Canal shaping commenced with the Sx instrument, shaping the coronal two-thirds initially, followed by shaping the apical third with instruments S1, S2, F1, F2, or F3. Before each instrument change, apical patency was ensured with a size 10 K-file. Syringe irrigation with 3 mL of irrigant occurred between instruments, maintaining needle penetration 3mm shorter than the canal's working length. Once preparation reached the master apical instrument, adjusted by a rubber stopper, a final flush with 5 mL of saline was executed. Paper points were utilized to dry the canals, and a dry cotton pellet was placed in the pulp chamber, restored with temporary restorative material (Cavit). During the second visit, following the removal of temporary filling and placement of a rubber dam, the root canals underwent irrigation with the same solution used during the initial visit. Subsequently,

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the canals were re-prepared using identical instrument sizes as in the first visit. For canal filling, a modified single cone technique was employed, utilizing Gutta purcha cones matched in size (ProTaper Universal E-Dental Mart) and a non-eugenol calcium hydroxide polymeric root canal sealer (Sealapex Kerr Endodontics). This was followed by temporary cavity filling. Patients were then assessed for postoperative pain at 24 hours. Preoperative pain was assessed using a Visual Analog Scale (VAS) ranging from 0 (no pain) to 10 (unbearable pain). The collected data, encompassing both quantitative and qualitative variables, were recorded in the Performa. SPSS version 20.0 was utilized for the statistical analysis. Mean and standard deviation (SD) were computed for quantitative variables such as age and VAS pain scores in both groups. For qualitative variables like gender and severity of pain, frequency and percentage calculations were performed. Normality was confirmed using the Shapiro-Wilk test, thus allowing for the application of parametric tests. The independent t-test was employed to compare the score of postoperative pain between both groups. Effect modifiers were managed through stratification of age, gender, and duration of root canal treatment to assess their impact on the outcome variables. Post-stratification Chi-square test and independent t-test were conducted, with a significance level set at $p \leq 0.05$.

RESULTS

Table 1 shows distribution of gender and age characteristics within both endodontic irrigation groups. Regarding gender distribution, in the 1.3% NaOCl group, 7 participants (23.3%) were male, whereas in the 5.25% NaOCl group, 12 participants (40.0%) were male. The gender distribution was not different statistically (p=0.165) between the two groups. Conversely, in terms of age, the mean ± standard deviation (SD) in the 1.3% NaOCl group was 33.76 ± 4.06 years, while in the 5.25% NaOCl group, it was 32.10 ± 5.84 years. The difference in age between the two groups was also not statistically significant (p=0.35).

Table 1: Distribution of Gender and Age in Both Groups

Variable	Characteristics	Endodontic Irrigation Group		p-Value
		1.3% NaOCl (n=30)	5.25% NaOCl (n=30)	
Gender N (%)	Male	7 (23.31%)	12 (40.0%)	0.165*
	Female	23 (76.71%)	18 (60.0%)	
Age (Years)	Mean ± SD	33.76 ± 4.06	32.10 ± 5.84	0.35**

**Student t Test, *Chi-Square Test

Table 2 shows the comparison of pre- and post-operative pain scores between the two endodontic irrigation groups comprising a total of 60 participants. For pre-operative pain scores, the mean Visual Analog Scale (VAS) score for the 1.3% NaOCl group was 3.16 ± 0.64, while for the 5.25% NaOCl group, it was 3.40 ± 0.49. The difference in pre-operative pain scores was not statistically significant (p=0.123) between the two groups. However, for post-operative pain scores, the mean VAS score for the 1.3% NaOCl group was 1.33 ± 0.47, significantly lower than the 1.63 ± 0.66 observed in the 5.25% NaOCl group (p=0.036).

Table 2: Comparison of Pre and Post-Operative Pain Score between Irrigation Groups (n=60)

Time	Endodontic Irrigation Group	n	Pain (VAS) Score	p-Value*
Pre-Operative	1.3% NaOCl	30	3.16 ± 0.64	0.123
	5.25% NaOCl	30	3.40 ± 0.49	
Post-Operative	1.3% NaOCl	30	1.33 ± 0.47	0.036
	5.25% NaOCl	30	1.63 ± 0.66	

*Independent test

Table 3 shows the comparison of Post-Operative Pain (VAS) scores between types of irrigation, stratified by age group. For participants aged 18-35 years, the mean post-operative pain score was significantly lower in the 1.3% NaOCl group (1.15 ± 0.37) compared to the 5.25% NaOCl group (2.00 ± 0.65), with a p-value less than 0.001. However, for participants aged 36-60 years, while the mean post-operative pain score was lower in the 1.3% NaOCl group (1.63 ± 0.50) compared to the 5.25% NaOCl group (1.26 ± 0.45), this difference was not statistically significant (p=0.091).

Table 3: Comparison of Post- Operative Pain (VAS) Score between Types of Irrigation Stratified by Age Group

Age Group	Endodontic Irrigation Group	n	Post-Operative Pain (VAS) Score	p-Value*
18-35 years	1.3% NaOCl	19	1.15 ± 0.37	<0.001
	5.25% NaOCl	11	2.00 ± 0.65	
36-60 years	1.3% NaOCl	15	1.63 ± 0.50	0.091
	5.25% NaOCl	15	1.26 ± 0.45	

*Independent t test

Table 4 presents the comparison of Post-Operative Pain (VAS) scores between types of irrigation, stratified by gender. For male participants, the mean post-operative pain score was significantly lower in the 1.3% NaOCl group (1.00 ± 0.01) compared to the 5.25% NaOCl group (1.75 ± 0.45), with a p-value less than 0.001. However, for female participants, while the mean post-operative pain score was slightly higher in the 1.3% NaOCl group (1.43 ± 0.50) compared to the 5.25% NaOCl group (1.55 ± 0.78), this difference was not statistically significant (p=0.62).

Table 4: Comparison of Post- Operative Pain (VAS) Score between Types of Irrigation Stratified by Genders

Gender	Endodontic Irrigation Group	n	Post-Operative Pain (VAS) Score	p-Value*
Male	1.3% NaOCl	7	1.00 ± 0.01	<0.001
	5.25% NaOCl	12	1.75 ± 0.45	
Female	1.3% NaOCl	23	1.43 ± 0.50	0.62
	5.25% NaOCl	18	1.55 ± 0.78	

*Independent t test

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DISCUSSION

The observation of frequent postoperative pain after root canal treatment can be attributed to a combination of mechanical manipulation, chemical irritation, and residual bacterial infection, particularly in teeth with nonvital pulps. Addressing these factors through careful technique, appropriate medication, and thorough disinfection can help minimize postoperative discomfort and improve patient outcomes following root canal treatment [16]. It is deemed essential by clinicians to focus on effective pain management during both endodontic procedures and the post-operative period. Our study's average age in group A was 33.76 ± 4.06 years and in group B was 32.10 ± 5.84 years with a statistically insignificant difference (p = 0.352). Regarding gender distribution, in group A, 23.3% were males and 76.7% were females, whereas in group B, 40.0% were males and 60.0% were females. Nonetheless, these gender differences were also statistically non-significant (p = 0.165). The observations made in this study parallel those reported by Mostafa *et al.*, in their research, out of 308 patients, 178 were females and 130 were males, spanning an age range of 25 to 45 years, with an average age of 31.88 ± 5.821 years [17]. This study sought to evaluate and compare the levels of post-endodontic pain using two different concentrations of NaOCl, specifically 1.3% and 5.25%, in necrotic lower molars. Results showed a significantly lower average Post-Endodontic Pain (VAS) score of 1.33 ± 0.47 in the 1.3% NaOCl group compared to 1.63 ± 0.66 in the 5.25% NaOCl group, with a p-value of 0.036. These findings suggest that using 1.3% NaOCl for irrigation during root canal treatment may offer superior post-operative pain management compared to using 5.25% NaOCl. A study by Mostafa *et al.*, was conducted in Egypt, involving 308 patients, each presenting with both asymptomatic and symptomatic molars [17]. They were randomly assigned into two equal groups, utilizing the permuted-block method, based on NaOCl concentration: 1.3% or 5.25% (n = 154). The study findings suggested that the utilization of 1.3% NaOCl resulted in diminished intensity and frequency of post-endodontic pain when compared to 5.25% NaOCl in mandibular molars with nonvital pulps treated through a two-visit root canal approach. The study by Farzaneh S *et al.*, in Iran, involving 122 patients with irreversible pulpitis in mandibular molars, compared the effects of 2.5% and 5.25% NaOCl during root canal treatment [18]. Results showed significantly lower post-endodontic pain in patients treated with 5.25% NaOCl during the first 72 hours (P = 0.021). Additionally, these patients required fewer analgesics (P = 0.001). This suggests that using 5.25% NaOCl may reduce early post-endodontic pain in one-visit root canal treatment for mandibular molars with irreversible pulpitis. In this study, there was a significant difference in the average Post-Endodontic Pain (VAS) scores between the 18-35 years age group (p < 0.001) for the two irrigation groups, whereas no significant difference was observed in the 36-60 years age group (p = 0.091). However, it's worth noting that several previous studies have reported no association between age and postoperative pain [18, 19]. Our results showed that in males, 5.25% NaOCl was more effective than 1.3%, indicating sexual dimorphism for our outcome variable. Notably, within each group, females consistently reported higher mean post-endodontic pain levels than males. These findings echo previous research, which has presented conflicting evidence regarding the impact of gender on postoperative pain. Some studies, such as that conducted by Mostafa *et al.*, suggest that females are more prone to experiencing heightened pain levels [17]. However, contrary to this, Middha *et al.*, found no correlation between gender and post-endodontic pain following endodontic treatment. Acknowledging the limitations inherent in our study, such as its small sample size and single-c enter design, it is important to note that our study exclusively enrolled patients with non-vital pulps [20]. Expanding the scope to include a more diverse patient population could enhance the generalizability of our findings. Thus, we recommend future large-scale studies to thoroughly investigate the effects of various irritant concentrations on both short- and long-term outcomes.

CONCLUSIONS

Based on our findings, it can be concluded that endodontic irrigation with 1.3% NaOCl was more effective in reducing post-operative pain compared to irrigation with 5.25% NaOCl.

Authors Contribution

Conceptualization: MM
Methodology: MM, ER, SP
Formal analysis: MM
Writing, review and editing: PM, AMNQ, AGS

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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REFERENCES

[1] Kiran A, Chidanadappa RN, Kaur A. Pattern of postoperative pain during endodontic treatment-A randomized control study. Indian Journal of Dental Sciences. 2022 Oct; 14(4): 165-70. doi: 10.4103/ijds.ijds_107_21.

DOI: https://doi.org/10.54393/pjhs.v5i04.1403

[2] Topçuoğlu HS, Topçuoğlu G, Arslan H. The effect of apical positive and negative pressure irrigation methods on postoperative pain in mandibular molar teeth with symptomatic irreversible pulpitis: a randomized clinical trial. Journal of Endodontics. 2018 Aug; 44(8): 1210-5. doi: 10.1016/j.joen.2018.04.019.

[3] Pigg M, Nixdorf DR, Law AS, Renton T, Sharav Y, Baad-Hansen L *et al.* New international classification of orofacial pain: what is in it for endodontists?. Journal of Endodontics. 2021 Mar; 47(3): 345-57. doi: 10.1016/j.joen.2020.12.002.

[4] Chalub LO, Nunes GP, Ferrisse TM, Strazzi-Sahyon HB, Dos Santos PH, Gomes-Filho JE *et al.* Postoperative pain in root canal treatment with ultrasonic versus conventional irrigation: a systematic review and meta-analysis of randomized controlled trials. Clinical Oral Investigations. 2022 Apr; 26(4): 3343-56. doi: 10.1007/s00784-022-04386-0.

[5] Hepsenoglu YE, Eyuboglu TF, Özcan M. Postoperative pain intensity after single-versus two-visit nonsurgical endodontic retreatment: a randomized clinical trial. Journal of Endodontics. 2018 Sep; 44(9): 1339-46. doi: 10.1016/j.joen.2018.05.017.

[6] Arias A, De la Macorra JC, Hidalgo JJ, Azabal M. Predictive models of pain following root canal treatment: a prospective clinical study. International Endodontic Journal. 2013 Aug; 46(8): 784-93. doi: 10.1111/iej.12059.

[7] Aksoy U, Pehlivan S, Buhara O. The top risk factors for endodontic flare-up: a Monte Carlo simulation. Clinical Oral Investigations. 2021 Jun; 25: 3681-90. doi: 10.1007/s00784-020-03692-9.

[8] Zehravi M, Maqbool M, Ara I. An update on pain control in conservative dentistry and endodontics: a review. The Indian Journal of Nutrition and Dietetics. 2022 Jan: 114-25. doi: 10.21048/IJND.2022.59.1.28600.

[9] Yu VS, Messer HH, Yee R, Shen L. Incidence and impact of painful exacerbations in a cohort with post-treatment persistent endodontic lesions. Journal of Endodontics. 2012 Jan; 38(1): 41-6. doi: 10.1016/j.joen.2011.10.006.

[10] Azim AA, Aksel H, Margaret Jefferson M, Huang GT. Comparison of sodium hypochlorite extrusion by five irrigation systems using an artificial root socket model and a quantitative chemical method. Clinical Oral Investigations. 2018 Mar; 22: 1055-61. doi: 10.1007/s00784-017-2187-y.

[11] Saba K, Maxood A, Abdullah S, Riaz A, Uddin S. Comparison of frequency of pain in root canal treatment using sodium hypochlorite and chlorhexidine as root canal irrigants. The Journal of the Pakistan Medical Association. 2018 Sep; 68(9): 1334-8.

[12] Ramamoorthi S, Nivedhitha MS, Divyanand MJ. Comparative evaluation of postoperative pain after using endodontic needle and EndoActivator during root canal irrigation: A randomised controlled trial. Australian Endodontic Journal. 2015 Aug; 41(2): 78-87. doi: 10.1111/aej.12076.

[13] Demenech LS, de Freitas JV, Tomazinho FS, Baratto-Filho F, Gabardo MC. Postoperative pain after endodontic treatment under irrigation with 8.25% sodium hypochlorite and other solutions: a randomized clinical trial. Journal of Endodontics. 2021 May; 47(5): 696-704. doi: 10.1016/j.joen.2021.02.004.

[14] Nandakumar M and Nasim I. Effect of intracanal cryotreated sodium hypochlorite on postoperative pain after root canal treatment-A randomized controlled clinical trial. Journal of Conservative Dentistry and Endodontics. 2020 Mar; 23(2): 131-6. doi: 10.4103/JCD.JCD_65_20.

[15] Sarmento EB, Guimarães L, Tavares S, Thuller KA, Antunes L, Gomes C *et al.* The influence of sodium hypochlorite and chlorhexidine on postoperative pain in necrotic teeth: a systematic review. European Endodontic Journal. 2020; 5(3): 177. doi: 10.14744/eej.2020.94830.

[16] Di Spirito F, Scelza G, Fornara R, Giordano F, Rosa D, Amato A *et al.* Post-operative endodontic pain management: An overview of systematic reviews on post-operatively administered oral medications and integrated evidence-based clinical recommendations. InHealthcare 2022 Apr; 10(5): 760. doi: 10.3390/healthcare10050760.

[17] Mostafa ME, El Shrief YA, Anous WI, Hassan MW, Salamah FT, El Boghdadi RM *et al.* Postoperative pain following endodontic irrigation using 1.3% versus 5.25% sodium hypochlorite in mandibular molars with necrotic pulps: a randomized double blind clinical trial. International Endodontic Journal. 2020 Feb; 53(2): 154-66. doi: 10.1111/iej.13222.

[18] Farzaneh S, Parirokh M, Nakhaee N, Abbott PV. Effect of two different concentrations of sodium hypochlorite on postoperative pain following single visit root canal treatment: a triple blind randomized clinical trial. International Endodontic Journal. 2018 Jan; 51: e2-11. doi: 10.1111/iej.12749.

[19] Nagendrababu V and Gutmann JL. Factors associated with postobturation pain following single-visit nonsurgical root canal treatment: A systematic review. Quintessence International. 2017 Mar; 48(3): 193. doi: 10.3290/j.qi.a36894.

DOI: https://doi.org/10.54393/pjhs.v5i04.1403

[20] Middha M, Sangwan P, Tewari S, Duhan J. Effect of continuous ultrasonic irrigation on postoperative pain in mandibular molars with nonvital pulps: a randomized clinical trial. International Endodontic Journal. 2017 Jun; 50(6): 522-30. doi: 10.1111/iej.12666.