ORIGINAL ARTICLE

Evaluation of postoperative pain in endodontic treatments, with sodium hypochlorite solution and gel as an auxiliary chemical substance

ABSTRACT

Introduction: *Endodontic treatment aims to clean and fill the root canals to maintain periapical health and alleviate pain, with postoperative pain influenced by multiple clinical factors. Sodium hypochlorite irrigation, although effective, can cause debris extrusion, with gel being an alternative that reduces this risk while maintaining antimicrobial efficiency.*
Objective: *This study aimed to assess postoperative pain incidence in asymptomatic upper premolars with pulp necrosis and chronic periapical lesions undergoing endodontic intervention.*
Materials and Methods: *Sixty-six patients were divided into three groups (n=22): Group SHG/SS used 3% sodium hypochlorite (SH) gel and saline solution (SS). Group SHG/S employed 3% SH gel and 2.5% SH solution (S). Group SHS/S used 2.5% SH solution for both purposes. Procedures lasted 40 to 60 minutes, conducted by the same operator in a single session. Clinical data was recorded, and postoperative pain was evaluated at 24, 48, and 72 hours using a modified Numeric Rating Scale. Statistical analysis was applied to the collected data.*
Results: *Within the first 24 hours, auxiliary chemical substances significantly impacted postoperative pain ($p = 0.021$). SHS/S showed lower pain scores compared to SHG/S, while SHG/SS scores were intermediate. At 48 hours ($p = 0.548$) and 72 hours ($p = 0.127$), postoperative pain did not show statistical significance. SHS/S and SHG/SS did not significantly influence postoperative pain, but SHG/S had an impact.*
Conclusions: *Postoperative pain did not significantly differ at 48 and 72 hours. SHG/S and SHG/SS did not markedly influence postoperative pain. Notably, the use of 3% SH gel with 2.5% SH solution increased postoperative pain levels.*
Clinical Relevance: *The application of 3% sodium hypochlorite gel used as an auxiliary chemical associated with the 2.5% sodium hypochlorite solution used as an irrigant had an impact on postoperative pain, which resulted in higher levels of post-operative pain.*

Marcela Maia Ribeiro[1]
Erica Lean Queiroz[2]
Adriana de Jesus Soares[3]
Alana Pinto Caroso Souza[4]
Marcos Roberto Frozoni[5]

[1]*Department of Dentistry, Endodontics Area, São Leopoldo Mandic Faculty, Campinas, São Paulo, Brazil.*
[2]*Department of Cariology and Comprehensive Care, New York University College of Dentistry, New York, USA*
[3]*Department of Restorative Dentistry - Endodontics Area, State University of Campinas-UNICAMP, Piracicaba, São Paulo, Brazil*
[4]*Department of Restorative Dentistry - Dental Materials Area, Piracicaba Dental School, State University of Campinas - UNICAMP, Piracicaba, São Paulo, Brazil*
[5]*Department of Dentistry, Endodontics Area, São Leopoldo Mandic Faculty, Campinas, São Paulo, Brazil.*

Received 2025, April 25
Accepted 2025, July 03

KEYWORDS *Chemical Substances, Endodontic Treatments, Gel, Postoperative Pain, Sodium Hypochlorite.*

Corresponding Author*
Alana Pinto Caroso Souza *Department of Restorative Dentistry - Dental Materials Area Piracicaba Dental School, Unicamp Av. Limeira, 901 - Areião, Piracicaba - SP, 13414-903, Brazil | Email: alanacaroso@gmail.com | Phone: +55 19 3421 0144*

Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2025.519

Introduction

Endodontic treatment Endodontic treatment aims to perform cleaning, shaping, and obturation of the root canal systems, with the goal of achieving and maintaining the health of the periapical tissues, as well as eliminating signs and symptoms associated with pain (1). In the postoperative period, pain is considered an undesirable perception, since its resolution constitutes one of the criteria for success in pulp therapy (2). Pain is frequently regarded as a negative experience, and its cessation represents an important indicator of success in endodontic treatment (3,4). Apical extrusion of infected debris into the periradicular tissues—including dentinal fragments, pulp tissue remnants, bacteria, and irrigating solutions—may occur during root canal instrumentation, triggering periapical inflammatory response and postoperative pain (5). As emphasized by Mahalakshmi, "postoperative pain results from a synergistic effect of the aforementioned causes and cannot be exclusively attributed to a single definitive cause" (6). During endodontic treatment, the irrigation stage is of fundamental importance, given that the instruments employed are unable to contact all canal walls or reach accessory or lateral canals. Thus, irrigation contributes to reducing friction between the instrument and dentin, promotes cooling of the file-tooth interface, and exerts antimicrobial and antibiofilm effects (7).
The apical third is recognized as a critical zone, where bacterial presence in the apical foramen, often organized in colonies, can extend into the extraradicular region (8). This characteristic poses challenges regarding the efficacy and safety of apical irrigation (7), making this step essential for the success of endodontic treatment (9). Sodium hypochlorite (NaOCl), at various concentrations, is the most widely used irrigant in endodontics due to its antimicrobial properties and ability to dissolve organic tissue (9). Its action consists of hydrolysis and oxidation of cellular proteins, resulting in clinically proven efficacy during biomechanical preparation of the canals (10). However, NaOCl exhibits potential toxicity, being highly irritating to periapical tissues, especially at higher concentrations (9). Its action is not limited to necrotic tissue, as it is a caustic and nonspecific agent, exhibiting cytotoxicity to all cells (10). Studies evaluating the gel form of sodium hypochlorite have reported significantly less debris extrusion compared to the conventional solution. The gel's viscosity restricts its presence to the interior of the root canal, reducing the risk of extrusion and its possible complications, while presenting antimicrobial efficacy comparable to the solution during canal treatment (11). Therefore, the present study aims to evaluate the incidence of postoperative pain in endodontic treatments of asymptomatic maxillary premolars diagnosed with pulp necrosis and chronic apical lesion, using two presentations of sodium hypochlorite: solution and gel. The null hypothesis adopted is that there will be no statistically significant difference between the evaluated groups.

Materials and methods

This was a randomized, prospective, parallel-type clinical trial, where the informed consent form was approved by the Research Ethics Committee of the Faculty of Dentistry, Faculty of Dentistry São Leopoldo Mandic, Campinas, São Paulo, Brazil (Clinical Trial Number CAAE: 43858321.6.0000.5374). This study was conducted in patients who needed endodontic treatment and who were referred to Centro de Especialidade Odontológicas (CEO) in Senhor do Bonfim city, Bahia, Brazil, from January 2021 to December 2022. All patients signed a consent form, informing about the procedure. 66 endodontic treatments of upper first and second premolars were performed. Only first and second premolars were included in this study, with two root canals, with one or two roots, asymptomatic teeth, diagnosed with pulp necrosis, and chronic periapical lesion presence, in one or both roots, performed in a single session, by a single endodontist. Vital teeth, necrotic teeth without injury and premolars with

a single canal, previous endodontic retreatment, teeth with open apex, internal and external root resorption, dental trauma, treatments not completed in a single session or in the procedure time were excluded from the study. between 40 to 60 minutes, and root canals, where it was not possible to patency the apical foramen. Patients with provoked or spontaneous painful symptoms, patients who used analgesic or anti-inflammatory medication in the last 30 days, patients with decompensated systemic diseases, such as heart disease, hypertension and diabetes, and those who refuse to participate in the study. Treatments in which the use of files using the R40 file was required.

Sample calculation

The sample calculation was based on an effect size of 0.185, obtained from pilot study data (n = 6). In order to reach a 80% test power and a 5% significance level, adopting the analysis of variance model for repeated measures, the G*Power 3.1.9.4 program indicated the need for 22 patients for each of the three proposed groups.

Endodontic treatment protocol

The treatment protocol carried out initially consisted of anamnesis, clinical examination, initial radiographic examination, vitality test, diagnosis, treatment planning and execution of endodontic treatment.

All cases were performed in a single session, by a single operator, during a period of 40 to 60 minutes. All patients were previously anesthetized with Lidocaine 2% with adrenaline 1:100,000 (DFL®, Taquara, Rio de Janeiro, Brazil), in the amount of one tube (1.8mL) for each tooth, using a supraperiosteal infiltration technique, through the vestibular and through the palate with a short needle, 30G (Procare, Labor Import Com. Imp. Exp Ltd, Osasco, SP, Brazil). The carious tissue and/or restorations were removed for later surgical access with high-speed diamond burs No. 1014 (KG Sorensen Ind. e Com. Ltda., São Paulo, SP, Brazil), under refrigeration in the treated dental element, following the convenience form with a high-speed diamond bur, n° 3081 (KG Sorensen Ind. e Com. Ltda., São Paulo, SP, Brazil), also under refrigeration.

After absolute isolation, the canal was flooded with 1mL of sodium hypochlorite - with respective presentation of each group and then with a C-Pilot #15 file (VDW, Bayerwaldstrabe, Munich, Germany), in the apparent length of the tooth (4 mm), the conduits were explored, subsequently, the cervical and middle third were instrumented using a Reciproc R25 file (VDW®, Bayerwaldstrabe, Munich, Germany), with 3 movements of penetration and traction of the file from inside the conduit and amplitude of 3 mm at each movement until reaching 4 mm less than the working length (WL). At this time, the conduits were flooded with sodium hypochlorite solution or gel, and every three pecking movements there was irrigation with 5 ml of the auxiliary substance, respectively from each group, using a 10 ml hypodermic syringe (Injex, Ourinhos, São Paulo, Brazil) with 24Gx3/4 -20 mm x 0.55 disposable needles (Labor Import, Osasco, São Paulo, Brazil) under pressure of 1mL/sec. Each time the file was removed from the canal, it was cleaned with sterile gauze. The apical third was explored with a #15 C-Pilot manual file (VDW®, Bayerwaldstraße, Munich, Germany) for progressive decontamination until patency was achieved. The real canal length was defined with an electronic apex locator - VDW GOLD (VDW®, Bayerwaldstraße, Munich, Germany), by withdrawing the patency instrument to the apical binding point. The initial anatomical file was defined by the hand instrument that best fit in the apical foramen, from the patency file (#10 and #15). And then the measurement was established up to the apical foramen (0.0). Afterwards, the instrumentation and modeling of the root canal were carried out with a reciprocating file R25 VDW®, (Bayerwaldstraße, Munich, Germany). The instrument was inserted into the root canal with penetration and traction movements (pecking) with a maximum amplitude of 3 mm each movement, until reaching the WL. 1mL of auxiliary chemical substance from each specific group was introduced into the conduits, and every three pecking

movements, the canal was irrigated with 5 mL of irrigating solution from each group, under pressure, followed by suction.

Irrigation Protocol
The irrigation protocol began with the flooding of the root canal with 1 mL of the designated auxiliary chemical substance—either 2.5% sodium hypochlorite solution or 3% sodium hypochlorite gel, depending on group allocation. Canal instrumentation was performed using Reciproc R25 files (VDW®, Munich, Germany) in a pecking motion with a maximum amplitude of 3 mm. After every three pecking movements, the canal was irrigated with 5 mL of the same assigned irrigant using a 10 mL disposable syringe (Injex®, São Paulo, Brazil) equipped with a 24G x 0.55 mm needle, at a controlled rate of 1 mL/sec. This irrigation sequence was repeated throughout the mechanical instrumentation, ensuring thorough chemical debridement. After reaching the full working length, apical patency was confirmed with a #15 K-file, and real canal length was established using an electronic apex locator (VDW GOLD®). The final irrigation phase consisted of 3 mL of 17% EDTA, delivered in three successive 1 mL portions, each activated with an Easy Clean® plastic tip (EASY, Belo Horizonte, Brazil) in reciprocating motion for 60 seconds per canal. This protocol aimed to optimize smear layer removal and enhance chemical decontamination prior to obturation.

Root canal obturation
With the aid of a silicone cannula (Capillary Tips; Ultradent, South Jordan, Utah, USA) and R25 Reciproc absorbent paper points (VDW, Munich, Bayerwaldstrabe Germany), the root canal was dried and the cone was locked. to 2 mm, short of the WL. For root canal obturation, AH Plus endodontic cement (Dentsplay Maillefer, Chemin du Verger, Ballaigues, Switzerland) was used in conjunction with the single cone obturation technique and hydraulic compression. The gutta-percha cone itself, which had already been disinfected by the auxiliary chemical solution, from each specific group, was used to insert the cement inside the root canal until it was completely filled. After positioning the gutta-percha cone at the locking site, vertical hydraulic compression followed, with a schilder presser foot (Golgran Indústria e Comércio Odontológico, São Caetano do Sul - São Paulo, Brazil). The cervical portion was sealed with temporary obturator cement (Coltosol -Vigodent®, Bonsucesso, Rio de Janeiro, Brazil) and a temporary restoration was performed with glass ionomer cement (Riva ® SDI Lt, Victoria, Australia). Then, the occlusal contacts were checked and adjusted and a final periapical radiograph was obtained.

Postoperative pain assessment
After endodontic intervention, patients received a modified Numerical Rating Scale - NRS (12,13) with numeric values from 0 to 10.

Classified as follows:
Score 1- Represented by 0, on the scale as without pain: the treated tooth has a normal appearance;
Score 2- Represented from 1 to 3, on the scale, as mild pain: the tooth involved hurt slightly for a while, regardless of the duration, but there was no need to take analgesics;
Score 3- Represented from 4 to 6, on the scale, as moderate pain: the involved tooth caused discomfort and/or tolerated pain. Analgesics stopped the pain;
Score 4- Represented from 7 to 9, on the scale as severe pain: the pain caused by the treated tooth had disturbed sleep and required narcotic analgesics;
Score 5- Represented with 10, on the scale, as unbearable pain: the pain caused by the treated tooth, hindered normal activities and sleep. Analgesics had no effect (12,13).

Postoperative pain assessment was performed in 3 periods: 24, 48 and 72 hours. For each period, a pain scale was created to be evaluated. All patients were contacted by a person who did not participate in the experiment. In moderate symptomatology cases, patients were instructed to take medication for pain control, the choice medication was Ibuprofen 400 mg, 1 tablet

Table 1

Medians and minimum and maximum pain values, according to the auxiliary chemical substance and postoperative time.

Auxiliary chemical substance	Postoerative time		
	24 hours	48 hours	72 hours
Sodium hypochlorite 3% gel + saline solution	1 (1; 3) ABa m.r. of this group in relation to other groups: 32.05	1 (1; 3) Aa	1 (1; 1) Aa
Sodium hypochlorite 3% gel + 2.5% solution	2 (1; 3) Bb m.r. of this group in relation to other groups: 41.23 m.r. of this group in 24 hours in relation to other times: 2.43	2 (1; 3) Aab m.r. of this group in 48 hours in relation to other times: 1.89	1 (1; 3) Aa m.r. of this group in 72 hours in relation to other times: 1.68
Sodium hypochlorite 2.5% solution + 2.5% solution	1 (1; 3) Aa m.r. of this group in relation to other groups 27.23	1 (1; 2) Aa	1 (1; 1) Aa

Source: original authorship.

Legend: m.r. = mean of ranks (provided to prove differences by multiple comparison tests when there was a significant effect of chemicals and time). Means followed by distinct capital letters within each column indicate a significant difference between groups. (comparisons within each column). Means followed by distinct lowercase letters indicate a significant difference in pain over time (comparisons within each line).

every 8 hours for up to 3 days, in which they were instructed to make notes on the record of the amount and time of the medicine ingested.
In severe symptomatology cases, patients were instructed to return to the office for control. The operator was always available to the patient for any assistance in any postoperative complications case.

Statistical analysis
The auxiliary chemical effect on postoperative pain over time was assessed using the Kruskal-Wallis and Friedman tests. For multiple comparisons, Student-Newman-Keuls tests were used. As for the pain association with gender and extravasation, Fisher's and G's exact tests were used.
Statistical calculations were performed using the SPSS 23 (SPSS Inc., Chicago, IL, USA) and BioEstat 5.0 programs (Mamirauá Foundation, Belém, Brazil) at a 5% significance level.

Results

At 24 hours, the Kruskal-Wallis test showed that auxiliary chemical substances significantly affected postoperative pain ($p = 0.021$), and when using 2.5% sodium hypochlorite solution and performing irrigation with sodium hypochlorite 2.5% solution, the pain score was statistically lower than that reported by research participants who received the combination of 3% sodium hypochlorite gel and 2.5% sodium hypochlorite solution (Table 1). When applying 3% sodium hypochlorite gel and saline solution, the indicated pain scores were shown to be intermediate, not significantly different from the other groups (Table 1). At 48 hours ($p = 0.548$) and 72 hours ($p = 0.127$), postoperative pain was not statistically influenced by auxiliary chemical substances. For the groups that received 3% sodium hypochlorite gel and saline solution ($p = 0.168$) or 2.5% sodium hypochlorite solution followed by application of 2.5% sodium hypochlorite solution ($p = 0.753$) there was no difference in the pain score when comparing the times 24, 48 and 72 hours (Table 1). On the other hand, for the group that had sodium hypochlo-

Table 2

Absolute (n) and relative (%) frequencies of pain scores, according to gender. For each auxiliary chemical substance and postoperative time.

	Postoperative time			p value
		Male	Female	
24 hours	Sodium hypochlorite 3% gel + saline solution			
	Score 1	8 (80.0%)	6 (50.0%)	0.025
	Score 2	2 (20.0%)	1 (8.3%)	
	Score 3	0 (0.0%)	5 (41.7%)	
	Sodium hypochlorite 3% gel + 2.5% solution			
	Score 1	4 (80.0%)	4 (23.5%)	0.024
	Score 2	1 (20.0%)	4 (23.5%)	
	Score 3	0 (0.0%)	9 (52.9%)	
	Sodium hypochlorite 2.5% solution + 2.5% solution			
	Score 1	5 (100.0%)	12 (70.6%)	0.394
	Score 2	0 (0.0%)	3 (17.6%)	
	Score 3	0 (0.0%)	1 (5.9%)	
	Score 5	0 (0.0%)	1 (5.9%)	
48 hours	Sodium hypochlorite 3% gel + saline solution			
	Score 1	9 (90.0%)	9 (75.0%)	0.274
	Score 2	1 (10.0%)	1 (8.3%)	
	Score 3	0 (0.0%)	2 (16.7%)	
	Sodium hypochlorite 3% gel + 2.5% solution			
	Score 1	4 (80.0%)	11 (64.7%)	0.554
	Score 2	1 (20.0%)	4 (23.5%)	
	Score 3	0 (0.0%)	2 (11.7%)	
	Sodium hypochlorite 2.5% solution + 2.5% solution			
	Score 1	5 (100.0%)	13 (76.5%)	0.510
	Score 2	0 (0.0%)	2 (11.8%)	
	Score 3	0 (0.0%)	1 (5.9%)	
	Score 4	0 (0.0%)	1 (5.9%)	
72 hours	Sodium hypochlorite 3% gel + saline solution			
	Score 1	10 (100.0%)	12 (100.0%)	$\frac{3}{4}$
	Sodium hypochlorite 3% gel + 2.5% solution			
	Score 1	5 (100.0%)	13 (76.5%)	0.315
	Score 2	0 (0.0%)	2 (11.8%)	
	Score 3	0 (0.0%)	2 (11.8%)	
	Sodium hypochlorite 2.5% solution + 2.5% solution			
	Score 1	5 (100.0%)	15 (88.2%)	0.580
	Score 3	0 (0.0%)	1 (5.9%)	
	Score 4	0 (0.0%)	1 (5.9%)	

Source: original authorship.
Legend: The sum may fall short or in excess of 100.0% due to decimal approximations in the % calculation.

rite 3% gel as an auxiliary chemical solution and the irrigator was sodium hypochlorite 2.5% solution, there was a significant difference (p = 0.037) in pain scores at evaluation times (Table 1). For this group, postoperative pain was significantly higher at 24 hours than at the end of 72 hours, while at 48 hours the pain score was intermediate, not differing from that reported by the participants after 24 and 72 hours (Table 1). Whether using 3% sodium hypochlorite gel and saline solution (p = 0.025) or 3% sodium hypochlorite gel and 2.5% sodium hypochlorite solution (p = 0.024), within 24 hours, a significantly higher proportion of men than women had postoperative pain score 1 and only female patients reported pain score 3. When the combination of 2.5% sodium hypochlorite solution and 2.5% sodium hypochlorite solution was used (p = 0.394), there was no significant difference between men and women in postoperative pain terms felt within 24 hours. At 48 and 72 hours, as shown in Table 2, postoperative pain was not significantly affected by participant gender for any of the auxiliary chemical substances. Postoperative pain was also not associated with extravasation, either after 24, 48 or 72 hours and whether 3% sodium hypochlorite gel and saline solution, 3% sodium hypochlorite gel and 2.5% sodium hypochlorite were used solution or 2.5% sodium hypochlorite solution and 2.5% sodium hypochlorite solution (Table 3).

Discussion

The most used irrigant in endodontic treatments is sodium hypochlorite solution, as it has antimicrobial activity, with a wide range of activities against bacteria, gram positive and gram negative, it is antifungal and can destroy the microbial biofilm effectively, in addition to the tissue dissolution capacity (14). Due to its high pH, sodium hypochlorite causes biological damage to bacterial cells and the release of hydroxyl ions irreversibly alters the cytoplasmic membrane integrity (15). Sodium hypochlorite, although a very effective proteolytic solvent, is extremely cytotoxic and for this reason, it must be used judiciously and with caution in endodontic therapy (10). When NaOCl extravasation occurs, severe pain, immediate edema, profuse bleeding in the root canal, possible secondary infection and ecchymosis may occur (16). During mechanical instrumentation and irrigation with auxiliary chemical substances, which do not have biocompatibility, debris and irrigants extrusion may occur, in periradicular tissues, thereby increasing acute inflammation resulting in postoperative pain (9). There are few studies that use sodium hypochlorite gel to assess pain, one of them is Karatas et al. (17), which used teeth without periapical lesions, with vitality and in molars, so this article presents a new study proposal , with necrotic teeth and periapical lesion presence, to assess pain from using the gel. In the present study, the irrigations performed by the SHG/SS, SHG/S, SHS/S groups significantly affected postoperative pain (p = 0.021) in the first 24 hours, which agrees with Graunaite et al. and Machado et al. (18,19), who reported that pain, when it occurs, is more relevant during this period, when it can be justified by the inflammation presence in the periapical region (20), resulting from an immune response to the irrigant and microorganisms present in extruded debris (21). Pain begins within a few hours (22). In the SHS/S group, the postoperative score was lower than that reported by the participants who received irrigation with SHG/S, which is in agreement with the study results by Demenech et al. (23). In their study, no significant difference was observed in the postoperative pain presence during endodontic treatment when using sodium hypochlorite solution as an auxiliary and irrigating chemical substance, across different solution concentrations. The group that used SHG/S caused a higher pain score, among the other irrigations studied, a hypothesis for what happened would be the increase in pressure when inserting the solution to remove the gel, thus causing a greater amount of irrigant, both in the gel form, as in the solution form, in the periradicular tissues, which may have extravasated, causing

Table 3

Absolute (n) and relative (%) frequencies of pain scores, according to the occurrence of extravasation. for each auxiliary chemical substance and postoperative time.

	Postoperative time	Overflow		p value
		Yes	No	
24 hours	Sodium hypochlorite 3% gel + saline solution			
	Score 1	4 (44.4%)	10 (76.9%)	0.291
	Score 2	2 (22.2%)	1 (7.7%)	
	Score 3	3 (33.3%)	2 (15.4%)	
	Sodium hypochlorite 3% gel + 2.5% solution			
	Score 1	4 (44.4%)	4 (30.8%)	0.783
	Score 2	2 (22.2%)	3 (23.1%)	
	Score 3	3 (33.3%)	6 (46.1%)	
	Sodium hypochlorite 2.5% solution + 2.5% solution			
	Score 1	8 (80.0%)	9 (75.0%)	0.393
	Score 2	1 (10.0%)	2 (16.7%)	
	Score 3	1 (10.0%)	0 (0.0%)	
	Score 5	0 (0.0%)	1 (8.3%)	
48 hours	Sodium hypochlorite 3% gel + saline solution			
	Score 1	7 (77.8%)	11 (84.6%)	0.921
	Score 2	1 (11.1%)	1 (7.7%)	
	Score 3	1 (11.1%)	1 (7.7%)	
	Sodium hypochlorite 3% gel + 2.5% solution			
	Score 1	6 (66.7%)	9 (69.2%)	0.102
	Score 2	1 (11.1%)	4 (30.8%)	
	Score 3	2 (22.2%)	0 (0.0%)	
	Sodium hypochlorite 2.5% solution + 2.5% solution			
	Score 1	9 (90.0%)	9 (75.0%)	0.459
	Score 2	1 (10.0%)	1 (8.3%)	
	Score 3	0 (0.0%)	1 (8.3%)	
	Score 4	0 (0.0%)	1 (8.3%)	
72 hours	Sodium hypochlorite 3% gel + saline solution			
	Escore 1	9 (100.0%)	13 (100.0%)	¾
	Sodium hypochlorite 3% gel + 2.5% solution			
	Score 1	7 (77.8%)	11 (84.6%)	0.058
	Score 2	0 (0.0%)	2 (15.4%)	
	Score 3	2 (22.2%)	0 (0.0%)	
	Sodium hypochlorite 2.5% solution + 2.5% solution			
	Score 1	10 (100.0%)	10 (83.3%)	1.000
	Score 3	0 (0.0%)	1 (8.3%)	
	Score 4	0 (0.0%)	1 (8.3%)	

Source: original authorship.
Legend: The sum may fall short or in excess of 100.0% due to decimal approximations in the % calculation.

tissue irritation and greater inflammatory responses, this response being one of the main postoperative pain causes (21). Which in this case would become a study limitation, since it is not possible to measure the extruded debris amount. For this group, SHG/S, postoperative pain, was greater at 24 hours -score 2, than at the end of the observation period of the study, 72 hours - score 1, which is in line with Pak's study et al., who report that the pain prevalence decreased substantially over days immediately (24). In the SHG/SS group, the pain score was statistically intermediate, not significantly different from the other groups, which can be explained by the lower extrusion of sodium hypochlorite gel in relation to liquid sodium hypochlorite as an advantage of providing better control and prevent the adverse extravasation effects, especially in the periradicular tissues resulting in the reduction of apical extrusion of debris and irrigant, thus decreasing, the postoperative pain degree, along with the use of saline as an irrigant during system instrumentation (25). In the study by Karatas et al. (17), their results showed that the use of sodium hypochlorite gel caused less pain than the sodium hypochlorite solution use. However, this finding contradicts the present study, in which no difference in pain was observed during the evaluation of these two analyzed groups. As seen in Table 2, the values obtained are related to a study by Arias et al. (3), in which the female sex is associated with more pain compared to the male sex. EDTA was used as a final irrigant due to its chelating ability to remove the smear layer, thereby enhancing the penetration of sealers into dentinal tubules. This contributes to more effective disinfection of the root canal system and improved obturation (Zehnder, 2006). Although the Numerical Rating Scale (NRS) is commonly used to assess pain intensity, it has limitations. It is a unidimensional measure and does not account for the affective or qualitative aspects of pain. Moreover, variations in individual pain perception and interpretation can affect its reliability (Breivik et al., 2008). To the best of our knowledge, this is the first clinical trial comparing postoperative pain following the use of sodium hypochlorite in gel and solution forms in single-session endodontic treatments of necrotic upper premolars with chronic apical lesions. The null hypothesis of this study was rejected due to the presence of a statistical difference in pain between the studied groups. There are limited studies related to sodium hypochlorite gel, both in terms of its effectiveness and its impact on postoperative pain. Further studies are required to comprehensively explore this substance. Within the limitations of this study, it can be concluded that while the SHG/S group induced slightly more pain compared to the other groups, this pain was characterized as mild and diminished over time.

Conclusions

Postoperative pain did not significantly differ at 48 and 72 hours. SHG/S and SHG/SS did not markedly influence postoperative pain. Notably, the use of 3% SH gel with 2.5% SH solution increased postoperative pain levels.

Declarations section

Clinical Relevance

The application of 3% sodium hypochlorite gel used as an auxiliary chemical associated with the 2.5% sodium hypochlorite solution used as an irrigant had an impact on postoperative pain, which resulted in higher levels of post-operative pain.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical Approval

Ethical approval was waived by the local Research Ethics Committee of Faculty of Dentistry, Faculty of Dentistry São Leopoldo Mandic, Campinas, São Paulo, Brazil (Ethics approval number CAAE: 43858321.6.0000.5374) in view of a randomized, prospective, parallel-type clinical

trial.

Author contribution

Ribeiro M.M., Queiroz E.L., Soares A.de J. and Frozoni M.R. conceived of the presented idea. Queiroz E.L., Soares A.de J. and Frozoni M.R. verified the analytical methods. Ribeiro M.M and Souza A.P.C. wrote the paper with input from all authors. All authors discussed the results and contributed to the final manuscript.

References

1 *Sathorn C, Parashos P, Messer H (2008) The prevalence of postoperative pain and flare-up in single-and multiple-visit endodontic treatment: a systematic review. International endodontic jornal 41(2), 91-99.*

2 *Aoun C, El Osta N, Naaman A, Zogheib, C, Khalil, I (2019) Post-endodontic flare-ups after a single-visit treatment using the fui scoring method and associated factors: a clinical prospective study. The Journal of Contemporary Dental Practice 20(9), 1033-1040.*

3 *Arias A, De la Macorra JC, Hidalgo JJ, Azabal, M (2013) Predictive models of pain following root canal treatment: a prospective clinical study. International endodontic jornal 46(8), 784-793.*

4 *Rossi-Fedele G, Ng, YL (2022) Effectiveness of root canal treatment for vital pulps compared with necrotic pulps in the presence or absence of signs of periradicular pathosis: A systematic review and meta-analysis. Int Endod J 00:1–25.*

5 *Siqueira JF Jr (2003) Microbial causes of endodontic flare-ups. Int Endod J 36(7):453-63.*

6 *Nandakumar M, e Nasim I (2020) Effect of intracanal cryotreated sodium hypochlorite on postoperative pain after root canal treatment-A randomized controlled clinical trial. Journal of Conservative Dentistry: JCD 23(2), 131.*

7 *Haapasalo M, Shen Y, Qian W, Gao Y (2020) Irrigation in endodontics. Dental Clinics 54(2), 291-312.*

8 *Bourreau MLS, Frozoni MRS, Mota MJBB, Zaia AA, Lima CO, Prado M, Soares AJ (2020) Evaluation of single visit endodontic treatment and non-surgical retreatment with foraminal enlargment of teeth with apical periodontitis. Rev. Bras. Odontol 77:e1484.*

9 *Khateeb SU, Algarni YA, Baba SM, Mir S, Yaqoob A, Jeri SY (2019) Assessment of postoperative pain using different root canal irrigants in mandibular molars with symptomatic irreversible pulpitis: an observational study. Journal of Advanced Oral Research 10(1), 49-52.*

10 *Pashley EL, Birdsong NL, Bowman K, Pashley DH (1985) Cytotoxic effects of NaOCl on vital tissue. Journal of endodontics 11(12), 525-528.*

11 *Zand V, Lotfi M, Soroush MH, Abdollahi AA, Sadeghi M, Mojadadi A (2016) Antibacterial efficacy of different concentrations of sodium hypochlorite gel and solution on Enterococcus faecalis biofilm. Iranian endodontic jornal 11(4), 315.*

12 *Wang C, Xu P, Ren L, Dong G, Ye L (2010) Comparison of post-obturation pain experience following one-visit and two-visit root canal treatment on teeth with vital pulps: a randomized controlled trial. International endodontic jornal 43(8), 692-697.*

13 *Ferreira-Valente MA, Pais-Ribeiro J L, Jensen MP (2011) Validity of four pain intensity rating scales. Pain 152(10), 2399-2404.*

14 *Kanagasingam S, Blum IR (2020) Sodium hypochlorite extrusion accidents: management and medico-legal considerations. Primary Dental Journal 9(4), 59-63.*

15 *Estrela C, Estrela CR, Barbin EL, Spanó JCE, Marchesan MA, Pécora JD (2002) Mechanism of action of sodium hypochlorite. Brazilian dental jornal 13, 113-117.*

16 *Guivarc'h M, Ordioni U, Ahmed HMA, Cohen S, Catherine JH, Bukiet F (2017) Sodium hypochlorite accident: a systematic review. Journal of endodontics 43(1), 16-24.*

17 *Karatas E, Kirici DÖ, Arslan H (2021) Postoperative Pain After the use of Sodium Hypochlorite gel and Solution Forms: A Randomized Clinical Study. EUR Endod J 6: 34-7.*

18 *Graunaite I, Skucaite N, Lodiene G, Agentiene I, Machiulskiene V (2018) Effect of resin-based and bioceramic root canal sealers on postoperative pain: a split-mouth randomized controlled trial. Journal of endodontics 44(5), 689-693.*

19 *Machado R, Comparin D, Ignácio SA, Neto UXS (2021) Postoperative pain after endodontic treatment of necrotic teeth with large intentional foraminal enlargement. Restorative Dentistry & Endodontics. 46(3).*

20 *Martins CM, da Silva Machado NE, Giopatto BV, de Souza Batista VE, Marsicano JA, Mori GG (2020) Post-operative pain after using sodium hypochlorite and chlorhexidine as irrigation solutions in endodontics: Systematic review and meta-analysis of randomised clinical trials. Indian J Dent Res 31(5):774-781.*

21 *Kherlakian D, Cunha RS, Ehrhardt IC, Zuolo ML, Kishen A, Silveira, CEB (2016) Comparison of the incidence of postoperative pain after using 2 reciprocating systems and a continuous rotary system: a prospective randomized clinical trial. Journal of Endodontics 42(2), 171-176.*

22 *ElMubarak AHH, Abu-bakr NH, Ibrahim YE (2010) Postoperative pain in multiple-visit and single-visit root canal treatment Journal of endodontics 36(1), 36-39.*

23 *Demenech LS, Freitas JV, Tomazinho FSF, Filho FB, Gabardo MCL (2021) Postoperative pain after endodontic treatment under irrigation with 8.25% sodium hypochlorite and other solutions: a randomized clinical trial. Journal of Endodontics 47(5), 696-704.*

24 *Pak JG, White SN (2011) Pain prevalence and severity before, during, and after root canal treatment: a systematic review. Journal of endodontics 37(4), 429-438.*

25 *Ozlek E, Gunduz H, Kadi G, Taşan A, Akkol E (2021) The effect of solution and gel forms of sodium hypochlorite on postoperative pain: a randomized clinical trial. Journal of Applied Oral Science 29.*