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Efficacy of Root Canal Chemomechanical Debridement in Patient Pain Perception: From Preoperative Baseline to 48-Hour Follow-Up

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Abstract

Background: The primary aim of this study was to evaluate the efficacy of root canal chemomechanical debridement in reducing patient pain from preoperative baseline to 48 hours post-treatment and to identify clinical or demographic predictors of postoperative discomfort.

Materials and Methods: In this prospective clinical study, 92 patients requiring non-surgical root canal treatment were enrolled. Canals were prepared using the ProTaper Gold rotary system and 5.25% sodium hypochlorite irrigation. Patients were randomly assigned to receive either calcium hydroxide intracanal medicament or no medicament. Pain intensity was recorded preoperatively, and at 24 and 48 hours using a 4-point visual analog scale (VAS). Data were analyzed using Spearman's rank correlation, Chi-square, and Wilcoxon signed-rank tests ($P < 0.05$).

A highly significant reduction in pain was observed at both 24 and 48 hours ($P < 0.0001$). Preoperative pain severity showed a strong negative correlation with the magnitude of pain reduction at 48 hours ($\rho = -0.8709$, $P < 0.0001$). Demographic factors (age, gender), tooth type, pulpal/periapical diagnosis, and the use of calcium hydroxide did not significantly influence postoperative pain levels ($P > 0.05$).

Conclusion: Chemomechanical debridement is highly effective for immediate pain resolution, particularly in patients with high baseline symptoms. Postoperative pain is independent of anatomical location or the use of interim medications.(**International Journal of Biomedicine. 2026;16(2):259-265.**)

Keywords: endodontics • postoperative pain • chemomechanical debridement • calcium hydroxide

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Introduction

The biological rationale for pain resolution in endodontics rests on the effective reduction of the intracanal microbial load and the removal of inflamed or necrotic pulp tissue, which are the main causes of pulpal and periapical pain. In cases of inflamed pulp and/or periapical tissues, the pulp and periapical tissues are characterized by a significant elevation of inflammatory mediators.[1,2] It is often hypothesized that these patients are more prone to sustained postoperative discomfort due to the "central sensitization" of periapical tissues.[3] However, research into whether these preoperative diagnoses act as definitive predictors of postoperative pain remains inconclusive, as clinical outcomes often vary regardless of the initial pulpal state.[4] Root canal treatment (RCT) is a highly predictable procedure aimed at eliminating microbial infection within the root canal system and preventing apical periodontitis.[5] Despite its high success rate (often exceeding 90%), postoperative pain remains a significant concern for both patients and clinicians. Postoperative pain following root canal treatment is a frequent occurrence, with reported prevalence exceeding 50% in many studies, and is largely influenced by factors including the patient's preoperative pain condition, the periapical diagnosis, and the treatment protocol employed.[6,7] The primary causes of this flare-up pain are thought to be the extrusion of infected debris into the periapical tissues and chemical irritation from irrigants or physical pressure.[8,9]

Endodontic treatment may be completed in either a single visit or multiple visits. Multiple-visit endodontic therapy offers several advantages, including enhanced control of infection using intracanal medicaments, improved management of

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persistent exudation or symptoms, and the opportunity to monitor healing and patient response between appointments. Yet, the correlation of the incidence of postoperative pain in cases treated with single or multiple visits is inconclusive in many studies.[10,11]

The choice of instrumentation plays a pivotal role in managing these inflammatory responses. The ProTaper Gold rotary system utilizes advanced metallurgy that provides high flexibility and cyclic fatigue resistance, enabling a more centered preparation and more efficient debris removal.[12,13] This is critical because the extrusion of infected debris into the periapical space is one of the triggers for postoperative flare-ups. By combining this mechanical efficiency with the robust proteolytic and antimicrobial properties of 5.25% Sodium Hypochlorite, clinicians can achieve a level of disinfection that significantly shifts the patient's experience toward recovery.[14]

Furthermore, the management of the root canal space between appointments often involves the use of intracanal medicaments. Calcium hydroxide ($Ca(OH)_2$) is widely utilized for its high pH, which aids in neutralizing bacterial by-products and potentially dampening the inflammatory cascade.[15] Despite its theoretical benefits, statistical evidence regarding its ability to reduce immediate postoperative pain compared to empty canals is often inconsistent, suggesting that the quality of the initial biomechanical debridement may be the more significant factor in pain perception.[16]

A unique aspect of this study is the isolation of the biomechanical preparation phase, as no root canal obturation was performed. This allows for an assessment of the "cleaning and shaping" efficacy independent of potential pressure or chemical irritation caused by sealer and gutta-percha placement. The present study was therefore designed to evaluate the short-term effect of Chemomechanical Debridement of the root canal on postoperative pain levels at 24 and 48 hours, and to assess potential correlations between pain changes and procedure, patient- or tooth-specific variables.

Materials and Methods

A random sampling method was employed to select participants from the pool of patients referred to the Endodontic Department at Al-Baha Dental Center. All prospective participants were thoroughly informed about the study's aims, design, and procedures. Written informed consent was obtained from every patient prior to their enrollment in the study. Only adult patients aged 18 years or older who were referred for non-surgical root canal treatment and met the diagnostic criteria for non-surgical root canal treatment were included in this study.

To ensure a homogeneous study group and minimize confounding variables, the following cases were excluded: medically compromised patients, teeth with non-healing prior root canal treatment, teeth with procedural mishaps (e.g., perforations, instrument separation), teeth with an open apex, pregnant patients, teeth exhibiting severe periodontitis, teeth with complex root canal anatomy and teeth with calcified root canals.

The primary outcome variable, pain, was assessed preoperatively and at defined postoperative time points (24 and 48 hours) following completion of root canal biomechanical preparation.

Pain intensity was assessed using a four-point visual pain scale. A score of 1 indicated the absence of pain. A score of 2 represented mild pain, defined as tolerable discomfort that typically does not require analgesic medication. A score of 3 denoted moderate pain, characterized by discomfort generally relieved with analgesics. A score of 4 corresponded to severe pain, defined as intense discomfort that is not adequately controlled by analgesic therapy.

A single examiner performed the clinical follow-up to ensure consistency in the assessment and categorization of post-treatment pain and swelling at the 24-hour and 48-hour checkpoints.

A standardized case record form was employed to systematically collect relevant information for each participant, including demographic characteristics (age and gender), clinical variables (tooth category—anterior, upper premolar, upper molar, lower premolar, or lower molar—pulpal and periradicular diagnoses, and the presence and intensity of preoperative pain), as well as the treatment variable concerning the use or non-use of calcium hydroxide as an intracanal medicament.

The root canal treatment (RCT) procedure was performed under strict aseptic conditions, in accordance with the established standard of care. The tooth and surrounding tissues were thoroughly anesthetized via infiltration and/or nerve block using Xylocaine 2% with Epinephrine 1:100,000. Complete rubber dam isolation was achieved to maintain an aseptic field, prevent microbial contamination from saliva, and protect the patient from irritating irrigating solutions. A standard endodontic access cavity was prepared to allow straight-line access to all root canal orifices. The working length (WL) of each canal was precisely determined using a DentaPort ZX electronic apex locator (MORITA). This measurement was confirmed with a verifying intra-oral periapical radiograph to ensure accuracy. The root canals were prepared (Cleaning and Shaping) using the ProTaper Gold rotary file system according to the manufacturer's instructions in a crown-down technique. During the entire shaping process and as a final rinse, the canals were copiously irrigated with 5.25% Sodium Hypochlorite solution to dissolve organic tissue and disinfect the canal system. Following mechanical preparation and final irrigation, the canals were dried using sterile paper points. Based on the study protocol, the prepared canals were managed in one of two ways:

Intracanal Medication Group: A non-setting calcium hydroxide paste was placed into the canal as an antimicrobial intracanal medicament.

Control Group: The canals were left dry and empty. The canal orifices were covered with a small cotton pellet. A layer of Cavit was then placed over the cotton pellet to provide a secure coronal temporary seal. The occlusion of the treated tooth was checked, and any necessary occlusal adjustments were performed to eliminate premature contacts and reduce biting forces on the temporarily restored tooth, thereby

minimizing postoperative discomfort. For pain management, the patients were instructed to take 400 mg of Ibuprofen if needed.

The post-operative pain intensity was assessed using the visual analog scale (VAS) at 24 and 48 hours after treatment.

Statistical Analysis: All collected data were compiled and analyzed using SPSS Statistics, Version 22.0 (IBM Corp., Armonk, New York, USA). Ordinal statistical methods (Spearman's rank correlation [ρ] and chi-square analysis) were used to evaluate the presence and strength of associations between categorical variables. A *P*-value of ≤ 0.05 was considered statistically significant.

Results

The study population (92 patients) demonstrated profound pain resolution across both postoperative assessment periods, revealing the substantial therapeutic efficacy of endodontic treatment. Preoperatively, the cohort presented with a heavily symptomatic distribution: 43 patients (46.7%) experienced severe pain, representing nearly half of all cases. This high baseline symptomatology reflects the nature of endodontic referrals, where patients typically seek treatment due to symptomatic pulpal pathology requiring urgent intervention.

Table 1 illustrates the relationship between demographic and clinical factors and the intensity of postoperative pain at the 24-hour mark. Neither gender ($P = 0.931$) nor age ($P = 0.121$) showed a significant association with postoperative pain. Notably, all cases of severe pain (n=6) were reported by patients under the age of 40, though this did not reach statistical significance. Tooth category ($P = 0.397$), pulpal diagnosis ($P = 0.282$), and periapical diagnosis ($P = 0.451$) did not significantly influence pain levels. Lower molars and premolars accounted for the highest frequency of severe pain (n=5). There was no significant correlation between preoperative pain levels and 24-hour postoperative pain ($P = 0.314$). Furthermore, the use of calcium hydroxide as an intracanal medicament did not significantly affect pain outcomes ($P = 0.700$), with similar "no pain" rates reported in both the $Ca(OH)_2$ group (52.2%) and the group without it (58.3%).

Table 1.

Relationship between demographic and clinical factors and 24-hour postoperative pain level. after treatment.

		n	Postoperative pain			*P*-value	Spearman's ρ
			Mild	Mod	Sev		
Gender	Male	24	13	4	3	0.931	
	Female	27	12	6	3		
Age	<40 years	26	12	6	6	0.121	
	>40 years	25	13	4	0		
Tooth category	Anterior	7	5	3	0	0.397	
	Upper premolars	13	4	2	1		
	Upper molars	13	6	4	0		
	Lower premolars	6	2	0	2		
	Lower molars	12	8	1	3		
Preoperative pain	No	13	7	4	1	0.314	-0.8341
	Mild	7	3	3	0		
	Moderate	4	5	0	2		
	Severe	27	10	3	3		
Pulp diagnosis	SIP	23	7	4	0	0.282	
	AIP	3	2	0	0		
	N	4	3	0	2		
	PI	21	13	6	4		
Periapical diagnosis	NP	12	3	3	1	0.451	
	SAP	28	12	3	4		
	AAP	6	4	2	0		
	AAA	4	3	0	1		
	CAA	1	3	2	0		
$Ca(OH)_2$	Used	23	13	4	4	0.700	
	Not used	28	12	6	2		

P- value derived from Pearson's chi-square test; Mod, moderate; Sev, severe; SIP, symptomatic irreversible pulpitis; AIP, asymptomatic irreversible pulpitis; N, necrosis; PI, previously initiated; NP, normal periapical tissues; SAP, symptomatic apical periodontitis; AAP, asymptomatic apical periodontitis; AAA, acute apical abscess; CAA, chronic apical abscess.

Table 2.

Relationship between demographic and clinical factors and 48-hour postoperative pain level. after treatment.

		Postoperative pain				*P*-value	Spearman's ρ
		n	Mild	Mod	Sev		
Gender	Male	29	7	7	1	0.929	
	Female	32	8	6	2		
Age	<40 years	31	7	9	3	0.227	
	>40 years	30	8	4	0		
Tooth category	Anterior	11	3	1	0	0.806	
	Upper premolars	15	3	1	1		
	Upper molars	15	3	5	0		
	Lower premolars	6	2	2	0		
	Lower molars	14	4	4	2		
Preoperative pain	No	16	5	3	1	0.098	-0.8709
	Mild	8	2	3	0		
	Moderate	3	5	2	1		
	Severe	34	3	5	1		
Pulp diagnosis	SIP	27	4	3	0	0.368	
	AIP	3	2	0	0		
	N	6	1	1	1		
	PI	25	8	9	2		
Periapical diagnosis	NP	13	4	1	1	0.611	
	SAP	33	6	7	1		
	AAP	6	3	3	0		
	AAA	6	1	0	1		
	CAA	3	1	2	0		
$Ca(OH)_2$	Used	31	7	4	2	0.538	
	Not used	30	8	9	1		

P- value derived from Pearson's chi-square test; Mod, moderate; Sev, severe; SIP, symptomatic irreversible pulpitis; AIP, asymptomatic irreversible pulpitis; N, necrosis; PI, previously initiated; NP, normal periapical tissues; SAP, symptomatic apical periodontitis; AAP, asymptomatic apical periodontitis; AAA, acute apical abscess; CAA, chronic apical abscess.

Table 2 summarizes the relationship between various demographic and clinical factors and the intensity of postoperative pain recorded 48 hours after treatment. Consistent with the 24-hour data, none of the variables examined reached statistical significance ($P<0.05$), indicating that none of these factors were significant predictors of pain intensity at the 48-hour mark. No significant association was found between gender (P = 0.929) or age (P = 0.227) and postoperative pain.

Similar to the 24-hour findings, all reported cases of severe pain (n=3) occurred in patients under the age of 40. Tooth category (P = 0.806), pulpal diagnosis (P = 0.368), and periapical diagnosis (P = 0.611) showed no statistically significant impact on pain levels. Lower molars remained the category with the highest frequency of moderate-to-severe pain. Preoperative pain levels did not significantly influence 48-hour postoperative outcomes (P = 0.098). Notably, the majority of patients presented with severe preoperative pain (34 out of 43) reported "No pain" by the 48-hour mark. The use of $Ca(OH)_2$ did not result in a significant difference in pain outcomes compared with cases without it (P = 0.538). Both groups showed similar rates of being pain-free at 48 hours (70.4% in the "Used" group vs 62.5% in the "Not used" group).

To analyze the change in pain from the preoperative state to the postoperative intervals (24 and 48 hours), a Wilcoxon signed-rank test was used. This test is appropriate for comparing paired ordinal data (e.g., pain levels) within the same group of patients at different times.

Analysis of pain progression over time revealed highly significant clinical improvement following treatment (Table 3 and Figure 1). When comparing preoperative baseline levels to the 24-hour mark, 56 patients experienced improved (lower) pain levels (P < 0.0001). This trend of resolution persisted through the 48-hour mark, with 58 patients reporting improved pain scores compared with their preoperative state (P < 0.0001). While most of the cohort showed immediate relief, a small subset of patients experienced either the same level of discomfort or a temporary worsening of symptoms at 24 hours (19 and 17 patients, respectively) and 48 hours (21 and 13 patients, respectively).

The graphs in Figure 2 illustrate a strong negative correlation between initial pain levels and the degree of pain change after treatment. Spearman's rank correlation revealed ρ = -0.8341 at 24 hours and ρ = -0.8709 at 48 hours (both P < 0.0001), indicating that patients with higher preoperative pain experienced the greatest reductions in symptoms following the procedure.

Table 3.

Comparison of pain level transitions from preoperative baseline to 24 and 48 hours post-treatment.

Time Comparison	Improved (Lower pain)	Same pain	Worsened (Higher pain)	*P*-value
Pre-op vs. 24 hours	56	19	17	<0.0001
Pre-op vs. 48 hours	58	21	13	<0.0001

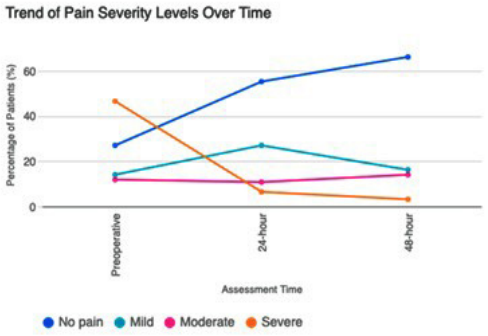

Figure 1. *This line graph illustrates the percentage of patients experiencing various pain intensities (No pain, Mild, Moderate, Severe) across three assessment intervals: Preoperative, 24-hour, and 48-hour postoperative. A significant upward trend is observed in the "No pain" category, while "Severe" pain shows a sharp decline following treatment, confirming the procedure's overall clinical efficacy (P < 0.0001).*

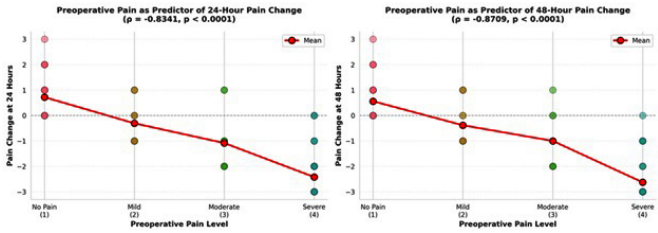

Figure 2. *Scatter plots with mean regression lines showing the relationship between baseline pain severity and subsequent pain level changes.*

Discussion

The primary objective of this study was to determine the patients' pain perception before and after biomechanical preparation of the root canal system. The results demonstrated a clear, clinically significant trend toward overall pain reduction in the sample studied (n=92). At 24 hours, 55.4% of patients reported an improvement in pain, and this figure rose to 63.04% at 48 hours, with a mean pain change of -1.25 on the scale. Furthermore, the most the most clinically important finding of this study is the strong negative correlation between preoperative pain severity and the magnitude of pain reduction following treatment. At 24-hour post-treatment, this correlation reached ρ = -0.8341 (P < 0.0001) and strengthened further to ρ = -0.8709 (P < 0.0001) at 48 hours. These are extraordinarily strong correlations in biomedical research, indicating a robust and highly statistically significant relationship. The negative direction means that patients presenting with the highest preoperative pain experienced the greatest absolute reduction in pain following treatment—a counterintuitive but clinically profound finding. This overall positive outcome aligns with the established efficacy of standard root canal procedures, which, through mechanical debridement and disinfection, successfully remove the primary cause of inflammation—the microbial load and high levels of endotoxins, thereby

relieving pressure and chemical irritation.[17] This finding has profound implications for patient counseling and expectations management. A patient presenting severe pulpal pain should be informed that endodontic treatment will likely provide substantial and rapid pain relief, with the expectation of achieving no pain or minimal discomfort within 24-48 hours. Conversely, a patient requiring elective endodontic treatment despite minimal or no symptoms should be counseled that the procedure itself may produce postoperative discomfort, even though no preoperative pain existed. The extraordinary strength of this correlation (ρ = -0.87) makes it one of the most predictive relationships in the entire dataset, far outweighing the weak associations observed with anatomical or demographic variables.

Pulpal diagnosis showed no correlation with postoperative pain outcomes, as previously reported by Harrison et al.[18] Yet this finding contrasts sharply with the previous study by Segura-Egea et al.,[19] which identified pulpal diagnosis as a significant predictor. Furthermore, these results challenge the hypothesis that patients diagnosed with symptomatic irreversible pulpitis exhibit an increased propensity for prolonged postoperative pain. Conventional theories suggest that such cases involve an elevated release of inflammatory mediators and neuropeptides—specifically Substance P and Calcitonin Gene-Related Peptide—into the periapical tissues, potentially leading to persistent discomfort despite comprehensive chemomechanical debridement. This suggests that other factors—potentially including operator technique, individual inflammatory response capacity, and psychological pain perception—are more influential than the pulpal diagnosis category.

Periapical diagnosis, representing the extent or severity of apical pathology visible radiographically, showed no significant correlation with postoperative pain at either assessment time point. These results indicate that the radiographic appearance of periapical pathology—traditionally considered indicative of the chronicity and severity of apical inflammation—does not meaningfully predict the acute postoperative pain response.[20] This finding suggests a dissociation between the chronic periapical inflammatory burden and the acute inflammatory response generated by endodontic instrumentation. A patient with extensive apical lesions may experience minimal postoperative pain, while a patient with minimal periapical findings might experience substantial discomfort. This emphasizes that postoperative pain is driven by acute procedural inflammation rather than by the pre-existing chronic pathological burden.

Demographic characteristics of the patient population demonstrated complete independence from postoperative pain outcomes. Whether a patient was in their twenties or their seventies, endodontic postoperative pain was equally likely or unlikely. Similarly, patient sex showed no significant association with postoperative pain levels. This finding supports the principle of sex-neutral clinical care for endodontic treatment and suggests that clinical decision-making regarding pain management should not be predicated on patient sex. This finding contrasts with some clinical assumptions about sex and age-related pain sensitivity and suggests that biological age does not fundamentally alter the postoperative pain response to endodontic treatment.2[1]While preoperative pain severity is an extraordinary predictor of pain reduction (as discussed previously), it surprisingly does not predict the absolute magnitude of postoperative pain itself. Spearman's ρ between preoperative and postoperative pain levels were -0.8341 at 24 hours and -0.8709 at 48 hours (both $P < 0.0001$), indicating that patients with higher preoperative pain experienced the greatest reductions in symptoms following the procedure. This apparent paradox reveals important information about the distribution of outcomes..

The explanation lies in the ceiling and floor effects of the ordinal scale. Patients who present with severe preoperative pain (category 4) experience large reductions but often end at no pain (category 1), while patients who present with no preoperative pain (category 1) experience small increases and may remain at mild pain (category 2). The absolute postoperative pain values thus converge toward the middle-to-lower range regardless of starting point. A patient with severe preoperative pain and another with mild preoperative pain may both achieve no pain by 24 hours, resulting in identical postoperative values despite markedly different pain trajectories. This demonstrates why examining pain change rather than absolute postoperative pain is more informative for understanding treatment effects—the clinical reality is that endodontic treatment benefits patients across the spectrum of preoperative severity, but with different magnitudes of change.

Despite widespread clinical use of calcium hydroxide as an interim dressing between appointments, the analysis revealed no significant correlation between dressing application and postoperative pain levels. These findings suggest that calcium hydroxide dressing does not substantially mitigate postoperative pain in this patient population. This suggests that while the entire treatment protocol effectively reduces pain, the specific use of $CaOH_2$ as the medicament may not be the overriding factor influencing immediate pain relief compared to other variables. This is consistent with studies suggesting that the major decrease in pain after the first visit is attributable to thorough instrumentation and irrigation, which drastically reduce intracanal pressure and endotoxin levels, rather than the subsequent action of the medicament over the short 48-hour period.[20] While the most dramatic pain changes occur in this window, the full antimicrobial and tissue-healing benefits of $CaOH_2$ may require a longer duration,[22] especially in promoting the healing of periapical lesions.

The anatomical location or number of the treated tooth demonstrated no significant correlation with postoperative pain levels. This finding contradicts potential clinical assumptions that anterior teeth might experience different postoperative pain than posterior teeth, or that teeth in different positions might have varying pain propensities due to biomechanical or vascular differences.[23] The null finding regarding tooth position emphasizes that postoperative pain is determined by patient and procedure factors rather than anatomical location. Whether treatment involved an anterior

incisor or a posterior molar, postoperative pain patterns were statistically indistinguishable. This suggests that clinicians can apply consistent pain management protocols across all tooth positions without the need for location-specific modifications based solely on anatomical considerations.

A limitation of this study is the short, 48-hour follow-up period. Future research should utilize a randomized controlled design with a standardized placebo group and extend the observation period.

Conclusion

Root canal chemomechanical debridement provides statistically significant pain reduction within 24 to 48 hours. The procedure is most effective for patients presenting with severe preoperative pain. Clinical variables, including tooth location and intracanal medicaments, do not significantly influence short-term pain perception.

Ethics Statement

This study adhered to the ethical guidelines established by the Declaration of Helsinki and was formally approved by the Research and Ethics Committee of Al-Baha University under the reference number [74110179].

Author Contribution Statement

Mohammed S. Alzahrani confirms sole responsibility for all aspects of the research.

Conflicts of Interest

The author has declared no conflict of interest.

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