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Original Article

Postoperative Pain Following Single-Visit versus Multiple-Visit Root Canal Therapy in Single-Rooted Teeth among Patients with Diabetes Mellitus: Randomized Controlled Trial

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Abstract

Background: Postoperative pain remains a common and clinically significant outcome following root canal therapy (RCT). Patients with diabetes mellitus may exhibit altered pain perception and delayed healing due to metabolic and neuropathic changes. However, evidence comparing postoperative pain outcomes between single-visit and multiple-visit RCT in diabetic populations remains limited.

Objective: To compare postoperative pain following single-visit versus multiple-visit root canal therapy in single-rooted teeth among patients with diabetes mellitus.

Methodology: This exploratory randomized controlled trial included 200 diabetic patients requiring RCT on single-rooted teeth. Participants were randomly allocated to either single-visit or multiple-visit treatment groups. Standardized endodontic procedures were performed in both groups. Postoperative pain was assessed using a 10-point Visual Analogue Scale (VAS) at 1 hour, 24 hours, 72 hours, and 1 week. Data distribution was assessed using the Shapiro–Wilk test, and non-parametric statistical methods were applied accordingly.

Results: Baseline demographic characteristics were comparable between groups ($p > 0.05$). Median postoperative pain scores showed no statistically significant differences at any time interval: 1 hour (7 vs 6; $p = 0.81$), 24 hours (4 vs 3; $p = 0.33$), 72 hours (3 vs 2; $p = 0.13$), and 1 week (2 vs 1; $p = 0.25$) in the multiple-visit and single-visit groups, respectively. Subgroup analyses based on age and gender also demonstrated no significant differences. Pain levels decreased progressively over time in both groups.

Conclusion: Single-visit and multiple-visit root canal therapies result in comparable postoperative pain outcomes in diabetic patients. These findings suggest that treatment decisions may be guided by clinical considerations, patient preference, and logistical factors rather than expectations of postoperative pain.

Keywords: Diabetes mellitus, Endodontics, Multiple-visit root canal treatment, Postoperative pain, Single-visit root canal treatment.

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Introduction

Root canal therapy (RCT) is a fundamental procedure in modern dentistry aimed at eliminating infection, relieving pain, and preserving natural dentition. Advances in endodontic techniques, including improved instrumentation systems and irrigation protocols, have significantly enhanced the success rates and predictability of treatment outcomes [1,2]. Despite these advancements, postoperative pain remains a common and clinically relevant concern, influencing patient satisfaction and overall treatment experience [3].

The debate regarding the optimal number of visits required to complete RCT—single-visit versus multiple-visit—has persisted for decades. Proponents of single-visit root canal therapy (SVRCT) emphasize its advantages in terms of reduced treatment time, improved patient compliance, and immediate resolution of symptoms [4]. In contrast, multiple-visit root canal therapy (MVRCT) allows the use of intracanal medicaments between appointments, which may enhance microbial control and reduce inflammation, potentially leading to improved postoperative outcomes [5]. Previous studies have reported that postoperative pain can occur in both approaches, with incidence rates ranging from 3% to 65% within the first 24 hours, typically declining thereafter [6]. Additionally, approximately 30% of patients may experience postoperative discomfort regardless of whether treatment is completed in a single or multiple visits [7].

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia and associated with multiple systemic complications that may influence healing and pain perception. Altered immune responses, impaired neutrophil function, reduced microcirculation, and delayed tissue repair are common in diabetic individuals, largely mediated by mechanisms such as advanced glycation end products and oxidative stress [8,9]. These pathophysiological changes increase susceptibility to infection and may modify inflammatory responses, thereby potentially affecting postoperative outcomes following dental procedures, including RCT [10,11].

Furthermore, diabetic patients may exhibit altered nociceptive processing due to neuropathic changes, which can either amplify or diminish pain perception. This variability adds complexity to predicting postoperative pain outcomes in this population. Despite strong biological plausibility suggesting that the number of treatment visits may differentially influence postoperative pain in diabetic individuals, there remains a notable lack of direct comparative evidence in this specific patient group.

Therefore, the present study aimed to compare the severity of postoperative pain following single-visit and multiple-visit root canal therapy in single-rooted teeth among patients with diabetes mellitus. It was hypothesized that multiple-visit treatment, with the use of intracanal medicaments, would result in lower postoperative pain levels due to enhanced infection control and modulation of inflammatory processes.

Methodology

Trial design, ethics, and setting

This study was designed as an exploratory randomized controlled trial conducted at Khyber College of Dentistry, Peshawar, Pakistan, between December 15, 2024, and June 15, 2025. Ethical approval was obtained from the Institutional Review Board (ERB No. 153/ADR/KCD), and the trial was prospectively registered at ClinicalTrials.gov (NCT07271511). Written informed consent was obtained from all adult participants, while for participants aged 12–17 years, parental consent along with child assent was secured in accordance with ethical standards.

Participants

Eligible participants included individuals aged 12–60 years with a confirmed diagnosis of Type 1 or Type 2 diabetes mellitus who required root canal therapy (RCT) on single-rooted permanent teeth with closed apices and presented with either irreversible pulpitis or necrotic pulp. Exclusion criteria comprised pregnancy, allergy to local anesthetics, long-term use of analgesics, presence of acute swelling or sinus tract, large periapical lesions, and systemic conditions known to influence pain perception. Only anatomically suitable canals without severe curvature or structural limitations were included to ensure procedural standardization.

Interventions

Participants were allocated to either single-visit root canal therapy (SVRCT) or multiple-visit root canal therapy (MVRCT). All procedures were performed by a postgraduate trainee under expert supervision using a standardized endodontic protocol. Local anesthesia was administered using 2% lidocaine with 1:100,000 epinephrine, and rubber dam isolation was applied in all cases. Canal preparation was standardized to ProTaper Gold F3 (size 30, 0.09 taper), ensuring adequate apical enlargement for optimal irrigation and microbial reduction. Irrigation protocol included 3% sodium hypochlorite (20 mL), 17% EDTA (5 mL), followed by saline rinse. Obturation was completed using cold lateral condensation with AH Plus sealer and final composite restoration. In the MVRCT group,

calcium hydroxide intracanal medicament was placed for seven days prior to obturation, whereas SVRCT cases were completed in a single visit.

Outcomes

The primary outcome was postoperative pain intensity measured using a 0–10 Visual Analogue Scale (VAS) at predefined intervals: 1 hour, 24 hours, 72 hours, and 1 week postoperatively. Pain assessment was conducted via telephone follow-up by a blinded investigator. Baseline preoperative pain scores were not recorded; therefore, outcomes represent absolute postoperative pain rather than change from baseline. Patients were allowed to take over-the-counter analgesics as needed, although detailed consumption was not systematically documented.

Sample size

Sample size calculation was performed using a two-sample t-test with 90% power and a significance level of $\alpha = 0.05$, estimating a minimum of 85 participants per group to detect a medium effect size (Cohen's d ≈ 0.5). To compensate for potential attrition, 100 participants were recruited in each group, resulting in a total sample size of 200.

Randomization

Participants were randomly assigned to either treatment group using a computer-generated randomization sequence. Allocation concealment was ensured through the use of sequentially numbered, sealed opaque envelopes prepared by an independent researcher not involved in the intervention or outcome assessment.

Blinding

Due to the nature of the interventions, operator blinding was not feasible. However, outcome assessors responsible for pain evaluation were blinded to group allocation to minimize detection bias.

Statistical methods

Data analysis was performed using appropriate statistical techniques based on data distribution. The Shapiro–Wilk test confirmed non-normal distribution of continuous variables ($p < 0.05$); therefore, non-parametric methods were employed. The Mann–Whitney U test was used for comparison of continuous variables, including pain scores and age, while the Chi-square test was applied for categorical variables. Pain outcomes were analyzed at each time point independently rather than using longitudinal modeling, acknowledging the limitation of not accounting for within-subject correlations. Effect sizes (r) for non-parametric comparisons were calculated as $Z/\sqrt{N}$ to quantify the magnitude of differences. Statistical significance was set at $p < 0.05$. Additionally, exploratory subgroup analyses based on age and gender were conducted to assess consistency of treatment effects across demographic strata.

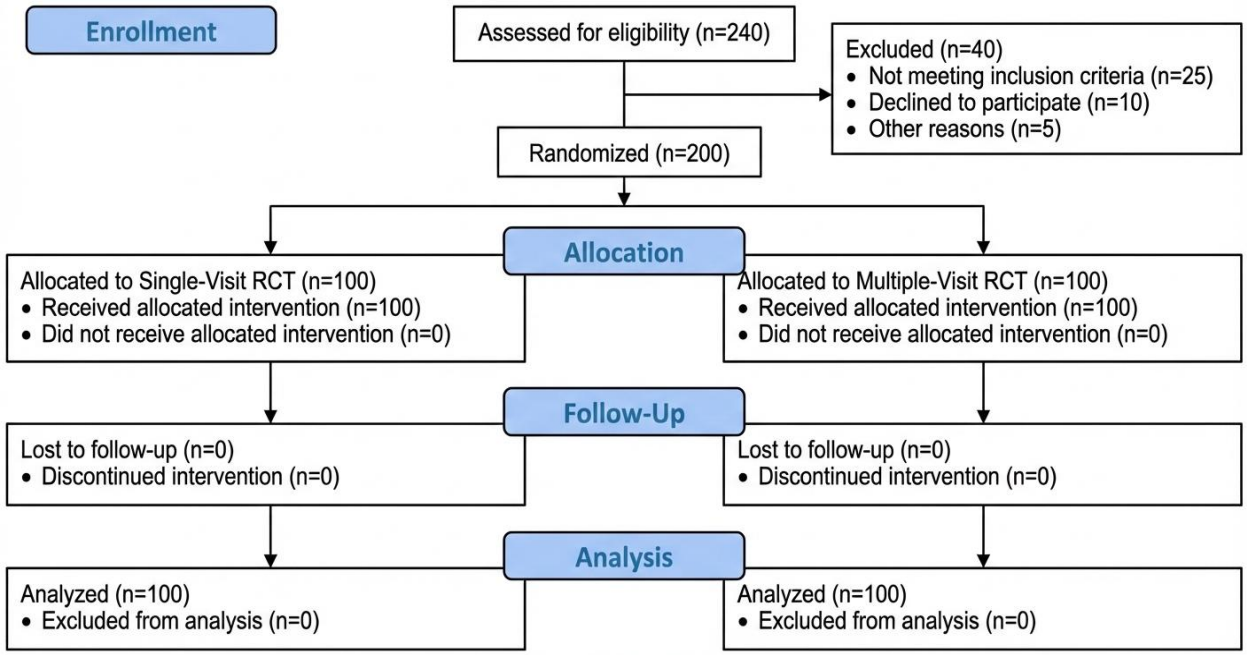


Figure 1: CONSORT Flow Diagram

Results

Recruitment

A total of 200 participants meeting the eligibility criteria were enrolled and randomized equally into two groups (single-visit and multiple-visit root canal therapy) during the study period. Recruitment was completed within the predefined timeline, and all participants successfully completed follow-up assessments at 1 hour, 24 hours, 72 hours, and 1 week post-treatment. There was no loss to follow-up or attrition, as continuous telephone-based monitoring ensured complete data collection. The participant flow through the study is illustrated in the CONSORT flow diagram (Figure 1).

Baseline data

Baseline demographic characteristics were comparable between the two groups, indicating successful randomization (Table 1). The median age in the multiple-visit group was 37.5 years (IQR 25.0–48.5), while in the single-visit group it was 34.5 years (IQR 23.5–43.0), with no statistically significant difference (p = 0.08). Gender distribution was also similar, with females comprising 44.0% and 45.0%, and males 56.0% and 55.0% in the multiple- and single-visit groups, respectively (p = 0.89). Age category distribution (12–30 years and 31–60 years) showed no significant difference between groups (p = 0.31), further confirming baseline comparability.

Numbers analyzed

All randomized participants (N = 200) were included in the final analysis, with 100 participants analyzed in each group. No participants were excluded after randomization, and complete outcome data were available for all predefined time points, ensuring robust statistical validity and eliminating attrition bias.

Outcomes and estimation

Postoperative pain scores, measured using the Visual Analogue Scale (VAS), did not differ significantly between single-visit and multiple-visit groups at any time point (Table 2). At 1 hour, median pain scores were 7.0 (IQR 3.0–9.0) in the multiple-visit group and 6.0 (IQR 4.0–9.0) in the single-visit group (p = 0.81; effect size r = 0.02). At 24 hours, scores decreased to 4.0 (IQR 2.0–5.0) and 3.0 (IQR 2.0–5.0), respectively (p = 0.33; r = 0.07). At 72 hours, further reduction was observed with median scores of 3.0 (IQR 1.0–4.0) in the multiple-visit group and 2.0 (IQR 1.0–4.0) in the single-visit group (p = 0.13; r = 0.11). After one week, pain levels declined to 2.0 (IQR 0.0–3.0) and 1.0 (IQR 0.0–3.0), respectively (p = 0.25; r = 0.08). Across all time points, differences were not statistically significant and effect sizes were negligible, indicating comparable pain outcomes between both treatment approaches.

Ancillary analyses

Exploratory subgroup analyses stratified by gender and age demonstrated consistent findings across demographic categories (Tables 3 and 4). Among females, pain scores were slightly lower in the single-visit group at later time points; however, these differences did not reach statistical significance (e.g., 24 hours: p = 0.09; 72 hours: p = 0.10; 1 week: p = 0.14). Among males, pain scores were nearly identical between groups at all time intervals (p > 0.05). Similarly, age-stratified analysis revealed no statistically significant differences between treatment modalities in either the 12–30 years or 31–60 years groups at any assessed time point. Across all subgroups, pain demonstrated a consistent declining trend over time, with no evidence of interaction between treatment type and demographic variables.

Harms

No adverse events, complications, or treatment-related harms were reported in either group during the study period. Both single-visit and multiple-visit root canal therapies were well tolerated by participants, and no cases required emergency intervention or withdrawal due to treatment-related complications.

Table 1. Comparison of demographic characteristics between multiple and single visit groups

Characteristic	Multiple visits (N = 100)	Single visit (N = 100)	p-value
Age	37.5 (25.0, 48.5)	34.5 (23.5, 43.0)	0.08
Gender			0.89
Female	44 (44.0)	45 (45.0)	
Male	56 (56.0)	55 (55.0)	
Age category (years)			0.31
12–30	36 (36.0)	43 (43.0)	
31–60	64 (64.0)	57 (57.0)	

Median (IQR); n (%); Mann–Whitney U test; Pearson's Chi-squared test

Table 2. Comparison of postoperative pain in two groups, in diabetic patients (n=200)

Characteristic	Multiple visits N = 100	Single visit N = 100	p-value
Pain at 1 hour	7.0 (3.0, 9.0)	6.0 (4.0, 9.0)	0.81
Pain at 24 hours	4.0 (2.0, 5.0)	3.0 (2.0, 5.0)	0.33
Pain at 72 hours	3.0 (1.0, 4.0)	2.0 (1.0, 4.0)	0.13
Pain after one week	2.0 (0.0, 3.0)	1.0 (0.0, 3.0)	0.25

Median (IQR); Mann–Whitney U test

Table 3. Comparison of postoperative pain in two groups in, diabetic patients by genders (n=200)

Characteristic	Female			Male		
	multiple visits N = 44	single visit N = 45	p-value	multiple visits N = 56	single visit N = 55	p-value
Pain at 24 hours	4.0 (2.0, 5.0)	3.0 (2.0, 4.0)	0.09	4.0 (2.0, 5.0)	4.0 (2.0, 5.0)	0.82
Pain at 72 hours	3.0 (1.0, 4.0)	2.0 (1.0, 3.0)	0.10	3.0 (1.0, 4.0)	3.0 (1.0, 4.0)	0.65
Pain after one week	2.0 (0.0, 3.0)	1.0 (0.0, 2.0)	0.14	2.0 (0.0, 3.0)	1.0 (0.0, 3.0)	0.89

Median (IQR); Mann–Whitney U test

Table 4. Comparison of postoperative pain in two groups, in diabetic patients by age groups (n=200)

Characteristic	12- 30 years			31- 60 years		
	multiple visits N = 36	single visit N = 43	p-value	multiple visits N = 64	single visit N = 57	p-value
Pain at 24 hours	4.0 (2.0, 5.0)	3.0 (2.0, 5.0)	0.67	4.0 (2.0, 5.0)	3.0 (2.0, 4.0)	0.41
Pain at 72 hours	3.0 (1.0, 4.0)	2.0 (1.0, 4.0)	0.55	3.0 (1.0, 4.0)	2.0 (1.0, 3.0)	0.15
Pain after one week	1.5 (0.0, 3.0)	1.0 (0.0, 3.0)	0.40	2.0 (0.0, 3.0)	1.0 (0.0, 2.0)	0.42

Median (IQR); Mann–Whitney U test

Discussion

The present randomized controlled trial aimed to compare postoperative pain following single-visit and multiple-visit root canal therapy in diabetic patients with single-rooted teeth. The primary finding of this study was that there were no statistically significant differences in postoperative pain scores between the two treatment approaches at any assessed time point (1 hour, 24 hours, 72 hours, and 1 week).[12] These findings are consistent with existing literature indicating that postoperative pain following root canal therapy is generally comparable between single-visit and multiple-visit protocols, with pain typically peaking within the first 24–48 hours and subsequently declining over time [13,14].

Most previously published studies have focused on non-diabetic populations; therefore, the present study contributes important evidence by specifically evaluating diabetic individuals, a group often characterized by altered inflammatory responses and impaired healing [15]. While some reports suggest that poorly controlled diabetes may exacerbate postoperative pain due to prolonged inflammation and delayed tissue repair, other studies have demonstrated no consistent association between diabetic status and pain outcomes [16]. The findings of this trial suggest that, within an unstratified diabetic population, the number of visits does not significantly influence postoperative pain, potentially due to the use of standardized treatment protocols that minimized procedural variability across groups.

The absence of significant differences in pain outcomes may also be explained by the complex and bidirectional effects of diabetes on pain perception. Diabetic neuropathy, a common complication of long-standing diabetes, may lead to reduced pain sensitivity (hypoesthesia) due to small fiber nerve damage [17]. Conversely, chronic inflammation and neuroinflammatory processes associated with diabetes can enhance nociceptive signaling and contribute to hyperalgesia [18,19]. These opposing mechanisms may coexist within the study population, resulting in heterogeneous pain responses that could obscure subtle differences between treatment modalities. Furthermore, variability in glycemic control, disease duration, and presence of neuropathy—factors not stratified in this study—may have contributed to the observed neutral effect.

From a clinical perspective, interpretation of these findings should also consider the concept of the Minimal Clinically Important Difference (MCID) for pain measurement. For a 0–10 Visual Analogue Scale, the MCID is typically reported to range between 1 and 2 points [20], with some studies suggesting a threshold of approximately 1.2 points for meaningful clinical change [21,22]. In the present study, the observed differences in median pain scores between groups at all time points were below these thresholds, indicating that even numerically observed differences were unlikely to be clinically perceptible. This reinforces the conclusion that both treatment approaches are clinically equivalent in terms of postoperative pain outcomes in diabetic patients.

Another important consideration is the potential influence of unrecorded analgesic consumption. Although patients were permitted to use over-the-counter analgesics, the absence of systematic documentation of dosage and frequency introduces the possibility of outcome dilution. Analgesic use may mask underlying differences in inflammatory responses between treatment groups, potentially contributing to the lack of observed statistical significance [23]. Therefore, the relatively low pain scores observed at later time points should be interpreted cautiously, as they may reflect pharmacological modulation rather than true biological equivalence.

Exploratory subgroup analyses by gender and age further supported the primary findings, demonstrating no statistically significant differences between treatment modalities across demographic strata. This consistency suggests that the effect of treatment type on postoperative pain is robust across these variables within the studied population. However, it is important to note that these analyses were exploratory in nature and not powered for definitive subgroup comparisons.

Methodologically, several aspects of the study design may have influenced the results. The inclusion of an unstratified diabetic population without accounting for glycemic control, duration of disease, or presence of neuropathy may have introduced heterogeneity, potentially diluting treatment effects. Additionally, the restriction to single-rooted teeth—typically associated with less complex anatomy and lower postoperative pain—may have reduced the likelihood of detecting differences between treatment approaches [24,25]. While procedural standardization enhanced internal validity, it may have also limited the ability to capture patient-specific variability in pain responses.

Future research should aim to incorporate stratification based on glycemic control, diabetic complications, and baseline pain characteristics, as well as extend analyses to more complex endodontic cases. Longitudinal analytical

approaches, such as mixed-effects modeling, may also provide deeper insights into pain trajectories over time and interaction effects between treatment and patient-related variables.

Limitations

Several limitations of this study should be acknowledged. First, the absence of preoperative (baseline) pain assessment represents a significant methodological limitation. Baseline pain is a well-established predictor of postoperative pain outcomes in endodontic procedures, and its omission limits the ability to assess changes in pain and may affect internal validity. Without baseline comparability, it is not possible to determine whether postoperative pain reflects true treatment effects or pre-existing differences between groups.

Second, important diabetes-related variables—including glycemic control (e.g., HbA1c levels), duration of disease, and presence of diabetic neuropathy—were not recorded. These factors are known to influence inflammatory responses, healing capacity, and pain perception, and their omission may have introduced confounding and heterogeneity in the results.

Third, postoperative analgesic consumption was not systematically documented. Although standardized instructions were provided, the lack of detailed recording of analgesic use prevents adjustment for its potential confounding effect and may have masked true differences between groups.

Fourth, the statistical approach relied on independent non-parametric comparisons at each time point rather than longitudinal modeling. This limits the ability to account for within-subject correlations and to evaluate temporal trends or interaction effects between treatment and time.

Additionally, the study was conducted at a single center and included only single-rooted teeth, which may limit generalizability to broader clinical settings and more complex cases. The relatively short follow-up duration (one week) further restricts assessment of long-term outcomes and delayed complications.

Future studies should address these limitations by incorporating baseline pain assessment, detailed metabolic profiling, analgesic tracking, and advanced statistical modeling, along with multicenter designs and broader inclusion criteria.

Conclusion

This randomized controlled trial demonstrated that single-visit and multiple-visit root canal therapies result in comparable postoperative pain outcomes in diabetic patients with single-rooted teeth. No statistically or clinically significant differences were observed between the two treatment approaches at any assessed time point. These findings suggest that, in an unstratified diabetic population, the number of treatment visits should not be a primary determinant of postoperative pain expectations. Instead, clinical decision-making should be guided by case complexity, patient preference, and logistical considerations.

Authors' Contributions:

All authors meet the ICMJE criteria for authorship.

Author 1: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 2: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 3: Analysis and interpretation of data, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 4: Analysis and interpretation of data, critical revision, final approval, agreed to be accountable for all the work.
Author 5: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 6&7: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.

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