

Effectiveness of Contemporary Irrigation Protocols in Paediatric Root Canal Treatment

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Abstract

Background: Successful paediatric root canal therapy requires not only mechanical instrumentation, but also excellent irrigation procedures that can disinfect complicated canal architecture while staying safe for young patients. Contemporary irrigation techniques and solutions have been developed to improve antibacterial effectiveness and smear layer removal while minimizing cytotoxicity.

Objectives: To assess and compare the efficacy of current irrigation regimens for paediatric root canal therapy in terms of microbial reduction, canal cleanliness, postoperative discomfort, and clinical outcome.

Materials and Methods: A comparative clinical study included ninety primary and immature permanent teeth that required pulpectomy or root canal surgery. Based on irrigation methods, teeth were separated into three groups: classic syringe irrigation with sodium hypochlorite (NaOCl), NaOCl with EDTA as an adjuvant, and NaOCl activated using a contemporary agitation device. Radiographic and clinical outcomes were assessed over a six-month period.

Results: When compared to traditional syringe irrigation, contemporary activation-based irrigation approaches demonstrated significantly greater microbial reduction and canal cleanliness. The groups that employed activated irrigation had higher clinical success rates and lower postoperative pain scores.

Conclusion: Contemporary irrigation technologies in paediatric root canal therapy significantly improve disinfection and therapeutic outcomes, and they may be considered superior to conventional methods.

Keywords: Ethylenediaminetetraacetic acid (EDTA), Paediatric root canal therapy, Pulpectomy, Sodium hypochlorite (NaOCl).

Introduction

Pediatric root canal therapy has unique therapeutic obstacles due to the complicated structure of primary teeth, physiological root resorption, children's limited cooperation, and the presence of auxiliary canals.¹ The primary goal of endodontic therapy in children is the elimination of microorganisms from the root canal while preserving the integrity of surrounding tissue and emerging permanent successors.² Irrigation is essential to treatment success because mechanical instrumentation alone is insufficient to accomplish sufficient disinfection, especially in irregular canal areas.³

Primary teeth exhibit ribbon shaped canals, numerous lateral canals and thinner dentinal walls compared to permanent teeth.¹ These anatomical variations increase the likelihood of residual bacterial load following instrumentation, thereby predisposing the tooth to treatment failure if irrigation is inadequate.⁴ Additionally, the close proximity of growing permanent tooth buds requires the use of physiologically safe and efficient irrigants and procedures. Therefore, a careful compromise between low tissue damage and antibacterial efficiency is required for pediatric endodontics.⁵ Traditionally, sodium hypochlorite (NaOCl) has been the irrigant of choice because of its broad-spectrum antimicrobial activity and ability to dissolve organic tissue. In pediatric dentistry lower concentrations of sodium hypochlorite are often preferred to minimize the risk of chemical injury and postoperative complications. However reduced concentration may compromise antimicrobial effectiveness, particularly against resistant endodontic biofilms.^{6, 7} Due to this restriction, chelating agents like ethylenediaminetetraacetic acid

(EDTA) have been used more frequently to improve smear layer removal and enable deeper irrigant penetration.⁷

In recent past, the idea of irrigant activation has acquired substantial awareness. Contemporary irrigation protocols include the sonic, ultrasonic, negative pressure & manual dynamic agitation systems designed to improve irrigant flow dynamics within the root canal system.⁸ These devices increase penetration into lateral canals, improve acoustic streaming, and break up biofilms and dentinal tubules, areas that are frequently ignored by instruments. Crucially, these advantages may be attained without raising the amount or concentration of irrigant, which makes them especially appropriate for young patients.⁹

Several in-vitro studies & adult clinical studies have established that superior microbial reduction and smear layer elimination with activated irrigation compared with conventional syringe irrigation.⁸⁻¹⁰ However generalizing these findings to pediatric populations is not straightforward due to the variances in the canal morphology, the root length and treatment objectives. Evidence specifically addressing the effectiveness of contemporary irrigation protocols in primary and immature permanent teeth remains limited.³ Furthermore, in paediatric dentistry, patient-centred outcomes including short-term clinical success and tolerance to postoperative pain therapy are crucial. Reduced postoperative discomfort not only improves the child's experience but also influences parental perception and acceptance of endodontic procedures. Therefore, assessing irrigation protocols from both biological & clinical perspectives is crucial.⁹

The present study aimed to comprehensively evaluate the effectiveness of contemporary irrigation protocols in pediatric root canal treatment. This study compared conventional syringe irrigation, chemical adjuvant-based irrigation and activated irrigation protocols with respect to microbial reduction, canal cleanliness, post-operative pain and short term clinical and radiographic success.

Materials and Methods

This clinical study was conducted in the Department of Pediatric Dentistry over a period of 12 months after obtaining the institutional ethical approval (No. 131/BKMC) dated 12/03/2024. The sample size (90) was calculated using Epi Info with an expected frequency of 6%10 and a 95% Confidence interval (CI)

A total of 90 children aged 5–12 years living locally, who required root canal treatment or pulpectomy in primary molars or immature permanent teeth, were included. Teeth with non-restorable crowns,

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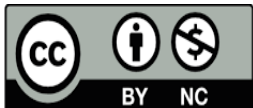
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advanced pathological root resorption, or systemic conditions affecting healing were excluded. After obtaining informed consent from the parents or guardians, the selected teeth were randomly allocated into three groups (n = 30) according to the irrigation protocol used. Standard access cavity preparation and canal instrumentation were performed using hand files under rubber dam isolation by a single specialist. The irrigation protocols differed among the groups, whereas the obturation materials and techniques were standardized.

Group A received conventional syringe irrigation with 1% sodium hypochlorite (NaOCl). Group B received 1% NaOCl followed by a final rinse with 17% EDTA. Group C received 1% NaOCl activated using the Woodpecker Endo 3 Ultrasonic Endo Activator (Guilin Woodpecker Medical Instrument Co., Ltd., Guilin, China). The irrigant was activated for 20 seconds per root canal using the device according to the manufacturer's recommended operating protocol. The activation tip was positioned within the canal without binding against the canal walls, and activation was performed after completion of canal instrumentation. Following irrigation, the canals were dried with sterile paper points and obturated using the standardized obturation technique.

Microbiological samples were collected before instrumentation and after final irrigation using sterile paper points transferred to thioglycolate broth, cultured on blood agar plates, and quantified by counting Colony-Forming Units (CFUs). Canal cleanliness was inferred directly from the percentage reduction of this intracanal microbial load. Postoperative pain was assessed using a modified Wong-Baker FACES pain scale at 24 and 48 hours. Clinical evaluations (absence of pain, swelling, and sinus tracts) and radiographic evaluations (absence of pathologic root resorption and furcal/periapical radiolucency) were performed at three and six months. Data was analyzed using SPSS version 27 for descriptive and inferential statistics with significance set at P value less than 0.05.

Results

The results clearly demonstrated the differences amongst the three irrigation protocols in terms of microbial reduction postoperative pain and overall treatment success. Contemporary activation-based irrigation constantly outperformed conventional methods across all evaluated parameters. Baseline demographic and tooth related characteristics were compared among the three groups ensuring homogeneity and minimizing selection bias (Table 1). All clusters revealed a conspicuous decline in microbial load; however active irrigation approaches produced the most decrease (Table 2). Post comfort (Table 3). At this six-month follow-up, teeth treated with activated irrigation procedures displayed higher clinical & radiographic success rates (Table 4). Operative pain scores were significantly lower in the contemporary irrigation group at both 24 and 48 hours, indicating enhanced patient

Table 1: Baseline Characteristics of the Study Groups

Group	Pre-irrigation CFU	Post-irrigation CFU	% Reduction
Group A	1200	420	65.0
Group B	1180	310	73.7
Group C	1225	180	85.3

Table 2: Mean Percentage Reduction in Microbial Load

Parameter	Group A	Group B	Group C
Mean age (years)	7.8 ± 1.6	8.1 ± 1.4	7.9 ± 1.5
Primary teeth (%)	21 (70)	22 (73)	23 (76)
Immature permanent teeth (%)	9 (30)	8 (27)	7 (24)

Table 3: Postoperative Pain Scores (Mean ± SD)

Time Interval	Group A	Group B	Group C
24 hours	3.1 ± 0.9	2.4 ± 0.8	1.6 ± 0.6
48 hours	1.9 ± 0.7	1.3 ± 0.5	0.8 ± 0.4

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Table 4: Clinical and Radiographic Success at 6 Months

Outcome	Group A (%)	Group B (%)	Group C (%)
Clinical success	23 (76.6)	26 (86.6)	28 (93.3)
Radiographic success	22 (73.3)	25 (83.3)	27 (90)

Discussion

The findings of the current study clearly reveal the contemporary irrigation protocols significantly improving the efficiency of syringe irrigation pediatric root canal treatment when evaluated to conventional.

The superior microbial reduction reduced post-operative pain and higher clinical success rates detected with activated irrigation highlights the critical role of irrigant dynamics in achieving optimal disinfection, particularly in anatomically complex pediatrics root canal systems.¹¹

The much larger decrease in microbial load attained with activated sodium hypochlorite was one of the most noteworthy findings. This is explained by better acoustic streaming and increased irrigant penetration into dentinal tubules and lateral canals. Previous studies by Orozco-Gallego et al, (2025)¹¹ add Chavan et al, (2025)¹² reported similar improvements in bacterial reduction using ultrasonic and Sonic activation in permanent teeth, reinforcing the application of activated irrigation in pediatric endodontics.¹³ These findings are consistent with reports by Patil et al, (2025)¹⁴, who emphasized the importance of smart layer management in achieving long-term endodontic success. The adjunctive use of EDTA following sodium hypochlorite also resulted in improved outcome compared to conventional irrigation alone. Removal of the smear layer allows better penetration of disinfecting agents and improves the adaptation of obturation materials¹⁵⁻¹⁸. However, the results of the current studies suggest that while chemical adjuncts improve outcomes, they may not be as effective as activation-based protocols.¹⁹

For young children, postoperative discomfort is a crucial consideration since it may make future dental visits less cooperative. Reduced apical extrusion of debris and irrigant, as well as more effective clearing of necrotic tissues and germs, may explain the lower pain levels observed in the contemporary irrigation group.²⁰⁻²¹ The therapeutic importance of these findings is bolstered by reports of comparable reductions in post-operative pain in adult trials utilizing negative pressure and triggered irrigation systems.²² Another notable result of this study is the improved short-term clinical and radiological success associated with contemporary irrigation strategies. The absence of clinical symptoms and greater epical healing indicate that the intracanal infection has been eradicated more successfully. Because primary teeth have a limited lifespan, achieving continuous short-term success is especially important in maintaining arch integrity and function until exfoliation.²³

The 6 month follow up time in the current study might not be enough to reflect the long-term outcomes. Furthermore, just one type of mechanism was examined. To enhance the evidence based clinical decision making, future studies should compare varies types of current irrigation technologies, including longer follow up duration and asses the cost effectiveness.

Conclusion

Contemporary irrigation approaches in pediatric root canal therapy significantly improve the reduction of bacteria, canal cleanliness, and short-term clinical success while reducing the most important postoperative pain. It should be regarded as an effective alternative to the conventional irrigation procedure in paediatric endodontics.

CONFLICT OF INTEREST: None

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Author Contributions

1. **Usman Nazir:** Study design, data collection and/or processing, analysis and/or interpretation, and critical review.
2. **Hajra Safeer:** Conception, supervision, and materials/resources.
3. **Suffiyan Saleem:** Conception, funding/resources, literature review, and manuscript writing.
4. **Danish Shahnawaz:** Materials/resources.
5. **Bushra Ghani:** Funding/resources, literature review, and manuscript writing.