

Influence of irrigating solutions on the efficacy of new single-file reciprocation instruments

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Abstract

The aim of this clinical study is to evaluate the impact of two different irrigating solutions—2.5% NaOCl and Dual Rinse HEDP—on the effectiveness of the Direct-R Gold single-file reciprocating system during in vivo root canal treatment. The study was conducted at the Clinical Hospital Center Rijeka, Croatia, and treatments were performed by sixth-year dental students under specialist supervision at the Faculty of Dental Medicine, University of Rijeka. All patients provided informed consent. A total of 98 root canals were included and divided into two groups ($n = 50$) based on the irrigant used: 2.5% sodium hypochlorite (NaOCl) or Dual Rinse® HEDP (prepared by dissolving the HEDP capsule in 10 mL of 2.5% NaOCl). Instruments were used according to the manufacturer's IFU. Students were asked to report canal difficulty and any signs of deformation or fracture, if present. Data were recorded in Excel and statistically analyzed using chi-square tests and multinomial logistic regression.

Out of 98 treated root canals, Direct-R Gold achieved full working length in most cases, regardless of canal complexity or irrigant used. No significant links were found between apex reachability and irrigant type, case difficulty, or periapical status ($p > 0.05$). Therefore, we can conclude that Dual Rinse® HEDP neither improved nor impaired the instrument's ability to reach the apex compared to sodium hypochlorite, and that Direct R Gold's performance minimized the chances of detecting differences across these variables.

Keywords: endodontics, instrumentation, irrigation.

Introduction

Efficient chemo-mechanical preparation in endodontics involves removing both organic and inorganic components from the root canal system. Sodium hypochlorite (NaOCl) is widely used for its excellent tissue-dissolving and antimicrobial properties, while ethylenediaminetetraacetic acid (EDTA) is commonly used at 10/17% concentration to eliminate the smear layer. However, alternating these irrigants during the procedure can cause chemical incompatibilities, reduce effectiveness, and increase clinical complexity. A possible solution is to rinse with water and/or dry the canal after each use of the solutions, but this makes the treatment more complex and time-consuming. Over the past decade, dual-rinse solutions—combinations of NaOCl with biocompatible



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chelators like HEDP (1-hydroxyethylidene-1,1-bisphosphonate)—have emerged as a simpler and effective alternative.

While traditional protocols using NaOCl followed by EDTA can cause a rapid loss of free available chlorine when the two come into contact, compromising the antimicrobial and organic tissue-dissolving properties of NaOCl, HEDP is chemically compatible with NaOCl. Therefore, it allows continuous chelation during the shaping process without neutralizing its oxidizing potential (1). This ensures simultaneous disinfection and smear layer control.

Another significant advantage of using a dual-rinse solution is its ability to remove the smear layer more evenly, particularly in the apical third, which is often the most challenging area to clean. This may lower the risk of apical blockage, especially when using endodontic instruments with a cutting tip that pushes more debris apically. Dual Rinse® HEDP (NaOCl + HEDP) formulations have recently been introduced in Switzerland and have shown in previous studies to provide superior smear layer removal compared to conventional NaOCl-EDTA protocols in several SEM-based studies (2,3). This is due to HEDP's gentle chelating action, which gradually demineralizes the dentin during instrumentation without causing erosion. Additionally, this may improve bonding with obturating materials (4-6).

The combination of NaOCl with HEDP does not diminish its antimicrobial effect. Dual-rinse solutions maintain strong antibacterial and antibiofilm activity, including against resistant microorganisms like *Candida albicans* and *Enterococcus faecalis*. A recent *in vitro* study showed that NaOCl/HEDP solutions achieved better biofilm disruption compared to conventional sequential protocols (7).

The single-file reciprocation technique uses specific

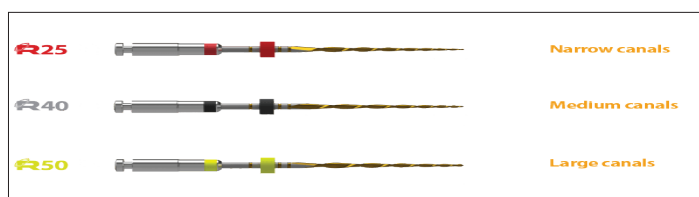
NiTi files with increased variable tapers that move in a reciprocating (back-and-forth) motion within the root canal, unlike traditional rotary files that rotate continuously (9-11). This technique aims to simplify instrumentation, reduce cross-contamination risk, decrease shaping time, and potentially improve efficiency by using a single file for most canal shaping due to the increased mechanical resistance from the motion (12-13). Direct R-Gold® is a new reciprocating instrument (Direct-Endodontics, Paris, France) that is highly effective at cutting because of its specific design and heat treatment (14), and it is also available in a smaller size (R-20), which was proposed to increase the number of canals that can be shaped with a single-file reciprocating technique.

The goal of this study is to assess how two different irrigating solutions—2.5% NaOCl and Dual Rinse HEDP—affect the performance of the Direct-R Gold single-file reciprocating system during *in vivo* root canal treatment. Specifically, it examines whether the type of irrigant influences the instrument's ability to reach full working length in root canals of different complexities, as well as overall instrumentation results when treatment is carried out under clinical conditions by supervised dental students.

Materials and Methods

This clinical study was conducted at the Clinical Hospital Center Rijeka, Croatia, involving patients referred for primary endodontic therapy. Treatments were performed by sixth-year dental students under specialist supervision at the Faculty of Dental Medicine, University of Rijeka. All patients provided informed consent. A total of 98 root canals were included and divided into two groups (n=50) based on the irrigant used: 2.5% Sodium Hypochlorite (NaOCl) or Dual Rinse® HEDP (prepared by dissolving an HEDP

Patient name				
Tooth No.				
Working diagnosis	Without periapical radiolucency	With periapical radiolucency	Vital tooth	
Initial difficulty	Canal 1	Canal 2	Canal 3	Canal 4
Canal 1	RA	NRA	NRAM	IE
Canal 2	RA	NRA	NRAM	IE
Canal 3	RA	NRA	NRAM	IE
Canal 4	RA	NRA	NRAM	IE
Irrigation	NaOCl	Dual rinse		
Unwinding of instrument	Y/N	Fracture of instrument	Y/N	



capsule in 10 mL of 2.5% NaOCl). Procedures followed ESE S3 guidelines. After rubber dam isolation, patency was checked with an ISO #10.02 file. Working length was determined with the Endometer ES-02. Mechanical preparation was performed using the Direct-R Gold R25 with the X-Smart endomotor (Dentsply Sirona) in reciprocal mode, without initially creating a glide path. Root canal complexity was assessed based on the passive insertion depth of the R25 file: 0–2 mm was considered simple, 3–5 mm moderate, and over 6 mm difficult. After preparing each canal, the operator recorded on a sheet the diagnosis (vital versus nonvital, with or without periapical radiolucency), the initial difficulty level, and whether the single-file instrument reached the working length (RA) or not (NRA). If the working length was not reached, it was also noted whether manual stainless-steel instruments failed to get it (NRA). Instruments were used according to the manufacturer's instructions (IFU) and are available online at www.directendodontics.com. Students were asked to report any signs of deformation or fracture. Final irrigation was performed using Dual Rinse and activation. Root canals were obturated with cold lateral

compaction using Direct-R Gold size 25 gutta-percha and a resin-based sealer, then temporarily restored with glass ionomer. Instrument effectiveness and potential visible damage were evaluated after treatment.

Data were recorded in Excel and analyzed statistically using chi-square tests and multinomial logistic regression. An example of clinical treatments in multi-rooted and single-rooted cases performed in the present study is shown in Figures 1 and 2.

Results

Out of 98 treated root canals, Direct-R Gold achieved full working length in the majority of cases, regardless of canal complexity or irrigant used. Statistical analysis showed no significant difference between the instrument reaching the apex and canal difficulty ($p = 0.2719$), or between the instrument reaching the apex and irrigant type ($p = 0.2109$). The use of Dual Rinse® HEDP neither improved nor impaired the instrument's ability to reach the apex compared to sodium hypochlorite. Additionally, Direct-R Gold demonstrated reliable performance even in challenging canals, reaching the working length in 37 out of 43 cases.

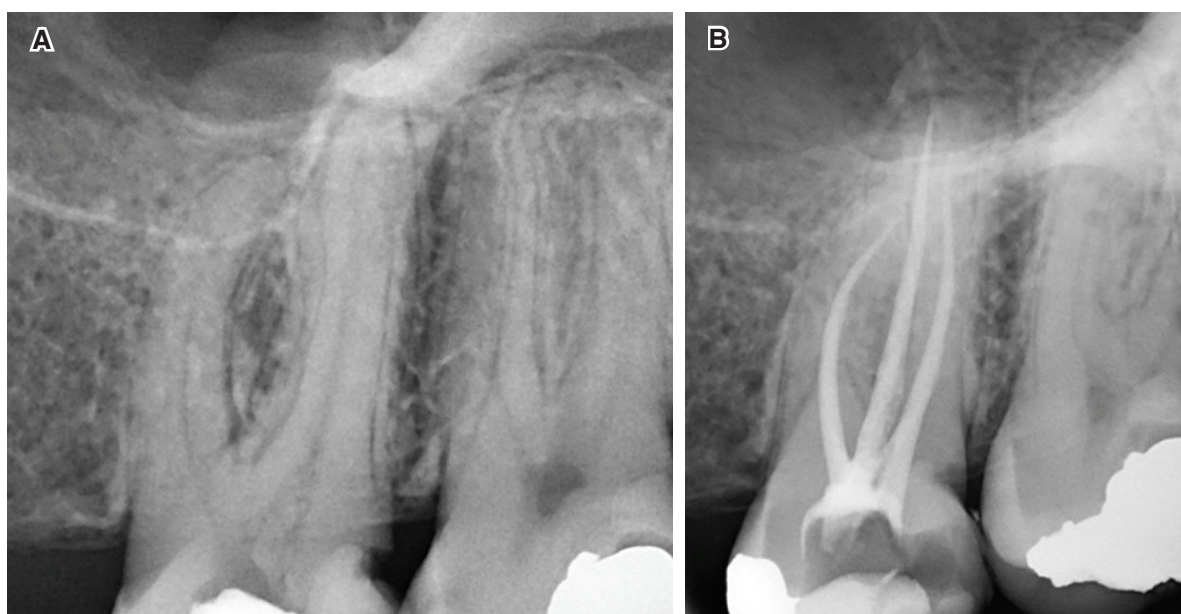


Figure 1. Tooth 17 with apical periodontitis **A**. Following obturation **B**, the tooth was restored with a temporary filling. The patient was asymptomatic and was referred back to the general dentist for further prosthetic rehabilitation.

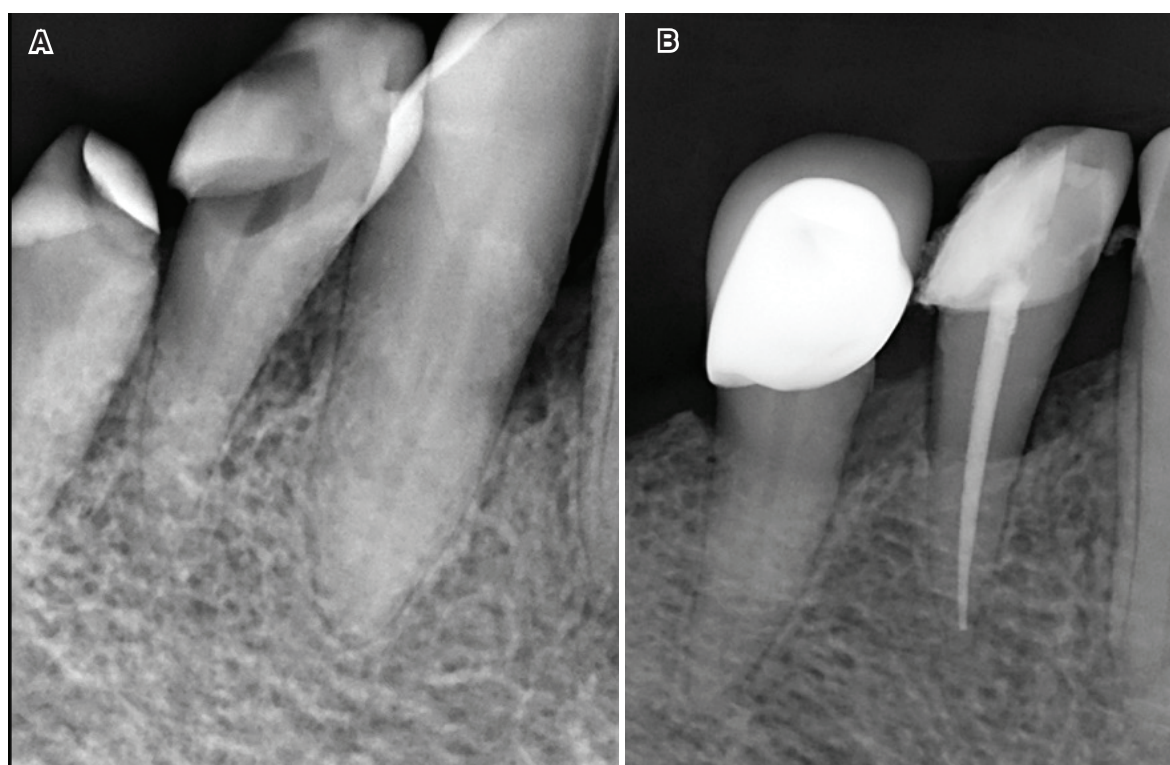


Figure 2. A) Tooth 44 with pulp necrosis. B) After the endodontic treatment, the patient was asymptomatic and referred to a prosthodontic specialist for rehabilitation.

Table 1. NaOCL group

Difficulty	RA/ Canal No.	NRA/ Canal No.	NRAM/ Canal No.
Difficult >6mm	18	5	0
Moderate 3-5mm	17	1	1
Simple 0-2mm	6	0	1

Table 2. Dual Rinse group

Difficulty	RA/ Canal No.	NRA/ Canal No.	NRAM/ Canal No.
Difficult >6mm	19	2	0
Moderate 3-5mm	12	2	0
Simple 0-2mm	14	0	0

Discussion

This study aligns with previous research indicating that canal complexity has a greater impact on shaping success than the choice of irrigant alone. In the present cases, R25 reached the working length in all simple cases (100% of 20 cases), in 90% of moderate canal cases (29/32), and in 84% of difficult canal cases (37/44). These excellent results are related to the proper

combination of flexibility and cutting efficiency, which allows for a simplified and reliable shaping procedure in the majority of cases. In a few cases (NRAM), it was not possible to instrument the canal to the working length independently of manual or reciprocating files due to complex apical configurations.

The relevance of this study also lies in the fact that treatments were carried out by students rather than specialist clinicians. These results support the idea that the single-file reciprocation technique is easy to learn and simple to perform. Using just one instrument reduces the risk of iatrogenic errors if the instrument has the appropriate mechanical properties. Additionally, no unwinding of flutes or intracanal fractures were reported in this study. These findings are significant because they demonstrate excellent safety results among all teeth and students.

The finding that Direct-R Gold performed consistently across both irrigant groups highlights the versatility of modern reciprocating instruments in real clinical settings. Studies by authors (12-13) stress the importance of the mechanical and metallurgical design of modern reciprocating systems as key factors in their performance, especially when dealing with curved or calcified canals. However, it is also crucial to understand canal complexities and avoid overstressing instruments (15-16).

Meanwhile, evidence on continuous chelation (e.g., with Dual Rinse HEDP) indicates it maintains canal cleanliness and prevents smear layer formation, although without significantly affecting the instrument's shaping ability. Importantly, this study adds to the limited body of in vivo research comparing irrigants in

student-performed clinical cases, providing practical insights into educational and procedural outcomes. Dual-rinse solutions provide a practical advantage by removing the need to switch irrigants. This simplifies irrigation protocols, shortens treatment time, and reduces the risk of human error or cross-contamination. Since HEDP is stable in NaOCl solutions, a single irrigant can be used throughout instrumentation and irrigation, avoiding the need for intermediate water flushes common in traditional protocols (6).

Dual rinse irrigants like NaOCl/HEDP represent a major advancement in endodontic irrigation. They allow for simultaneous tissue dissolution, smear layer removal, and microbial control in one stable formulation. This streamlines clinical workflow while enhancing cleaning effectiveness, sealer adaptation, and overall treatment results. With the growing focus on efficiency and biological effectiveness in modern endodontics, particularly during irrigation procedures (17), dual-rinse solutions are likely to become a standard part of root canal therapy.

The positive results of this study showed that both the instrumentation and irrigation techniques used were easy for students to learn and understand. They improved the quality and efficiency of their treatments, reducing reliance on manual instrumentation. Additionally, it decreased the risk of iatrogenic errors and made treatment more predictable, whether in vital or non-vital cases.

These findings are highly relevant in an academic setting, where procedural simplicity, clinical safety, and reproducibility are essential for effectively teaching and acquiring endodontic skills. The lack of file deformation, unwinding, or intracanal fracture further underscores the safety profile of the single-file reciprocation system when used with an irrigation protocol. The proposed technique achieved excellent clinical results, especially considering that all treatments were performed by undergraduate students. Great attention should be paid to the clinical training of students to ensure optimal results in both preclinical and clinical education (18-20).

Additionally, the use of a dual rinse irrigant (NaOCl/HEDP) seems to support consistent clinical results across different case complexities, providing effective debris removal and smear layer control without damaging the instrument's mechanical strength. Therefore, the findings not only confirm the effectiveness of reciprocating systems like Direct-R Gold with dual-rinse solutions but also strengthen their use in routine clinical training and practice.

Conclusion

The Direct R gold size 25 successfully reached the working length in most cases, including the most challenging ones, due to its favorable design and mechanical properties. No significant associations were found between apex reachability and irrigant type, case difficulty, or periapical status ($p > 0.05$), indicating that Direct R gold's performance minimized the potential to detect differences across these variables. The system demonstrated consistent performance across

various levels of canal complexity, supporting its use in clinical and educational settings. Dual-rinse solutions offer a practical advantage by eliminating the need to switch irrigants. This simplifies irrigation protocols, reduces the treatment time required for irrigation, and streamlines the final cleaning procedures after shaping.

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