



Assessment of postoperative pain after single-visit root canal treatment using rotary and reciprocating file systems: an *in vivo* study

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Background: Various instrument kinematics used in single-visit endodontics influence the occurrence of pain after endodontic therapy. This study aimed to evaluate the occurrence of pain after mechanical instrumentation with Hyflex EDM (HEDM) and WaveOne Gold (WOG) during single-visit endodontic therapy.

Methods: Sixty patients diagnosed with asymptomatic irreversible pulpitis and normal apical tissues in mandibular premolar teeth were included in the study for single-visit root canal therapy. The patients were divided into two groups (n = 30) according to the rotary instrument used during root canal preparation (group A [HEDM] and group B [WOG]). Pain was evaluated after endodontic therapy at 8, 24, and 48 h intervals using the visual analog scale (VAS). Data obtained were analyzed using the chi-square test, independent t-test, MannWhitney U test, and Wilcoxon matched-pairs test.

Results: Statistically significant differences were observed between the two groups (P < 0.001) at 8, 24, and 48 h, with WOG exhibiting less pain than HEDM files.

Conclusion: Postoperative pain was lower in the WOG file system than in the HEDM file system after single-visit root canal therapy at 8, 24, and 48 h.

Keywords: Hyflex EDM; Postoperative Pain; Reciprocation; Root Canal Therapy; Rotary Instrumentation; WaveOne Gold.



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INTRODUCTION

Pain after endodontic therapy is a routine complication, reported to be 1.4-16% [1-3]. Post-endodontic pain is multifactorial [4]. One underlying cause is debris extrusion during chemomechanical preparation [5-7]. Proper irrigation protocols and aspiration techniques are used to limit instrumentation to the canal's confines, and the extrusion of debris can be minimized using different endodontic files with appropriate kinematics [8,9].

Current mechanical preparation of root canals uses rotary nickel-titanium (NiTi) instruments that employ either of the two kinematics (rotation or reciprocation). Rotary single-file systems, such as Hyflex EDM (HEDM), are produced by a distinctive process called "electric discharging machining." This technique uses spark erosion, which amplifies the fracture resistance and cutting efficiency [10]. The cross-section of the file varies along the length of the file, with triangular, trapezoidal, and quadratic shapes in the coronal third, middle third, and apical third, respectively [10,11]. WaveOne Gold

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(WOG) files are reciprocating files based on M-wire alloy technology with a cross-section of an off-centered parallelogram. This thermal process alters the molecular geometry to increase the cyclic fatigue resistance and improve flexibility [12].

Systematic reviews of postoperative pain when rotary and reciprocating systems were compared after single-visit endodontic therapy have shown different results. Systematic reviews by Hou et al. and Sun et al. stated that rotary instruments result in less postoperative pain, while Martins et al. concluded that reciprocating instruments lead to less pain [13-15]. A systematic review by Spohr et al. stated that no clear conclusion could be drawn regarding the incidence of postoperative pain following the use of rotary and reciprocating instruments, and further well-designed studies are needed in this regard [16]. At this time, the current *in vivo* study was undertaken to assess episodes of pain following endodontic therapy using HEDM (rotary system) and WOG (reciprocating system). The null hypothesis was that there would be no significant difference in the severity of pain following the use of the HEDM and WOG instrumentation systems.

METHODS

This *in vivo* study was approved by the Institutional Ethics Committee (IEC) (14/IEC-SIBAR/CIR/18). Study participants were recruited from the Department of Conservative Dentistry and Endodontics between November 2018 and December 2019. The sample size calculation was performed using G* power 3.1.2. Sixty volunteer patients who met the inclusion criteria were randomized using the sequentially numbered, opaque, sealed envelope method and categorized into two groups of 30 each; group A (HEDM) and group B (WOG) by an endodontist who was blinded to the study protocols. The inclusion criteria were as follows: Patients aged 18-40 years, with single-rooted mandibular premolars diagnosed with asymptomatic irreversible pulpitis with

normal periapical tissue and patients who could understand the use of the pain scale.

The exclusion criteria were as follows: Patients with acute and chronic apical abscess or cellulitis; known allergies to opioids, non-opioids, NSAIDs, analgesics, lidocaine; pregnant or lactating mothers; teeth with complex root canal morphology; teeth with poor prognosis; patients with systemic diseases; unwilling to participate in the study and those receiving premedication with analgesics; and patients with active pain in other than the tooth to be tested.

A thorough treatment protocol was briefed to the participants and informed consent was obtained from all participants. Based on the group assigned to the sealed envelope paper, the respective treatments were performed as described below. The study protocol is shown in Fig. 1.

1. Treatment protocol

The entire clinical procedure was performed by a single surgeon. Local anesthesia was administered with 2% lignocaine (1:80,000 epinephrine) (Astra Zeneca Pharma India Limited, Bangalore, India), followed by reduction in occlusal. After the rubber dam application and access opening, a #10 stainless steel hand K-file was used to establish the glide path. The working length was obtained using the Root ZX apex locator (J. Morita, Kyoto, Japan) and was confirmed using an intraoral periapical radiograph. Mechanical preparation was performed up to size 20 using a stainless steel hand K-file.

Group A (n = 30): The canals were instrumented with HyflexEDM (25/~) (COLTENE/Whaledent AG, Switzerland) NiTi file with a gentle apical stroke and pecking movement with Endomotor X SMART[®] Plus (DentsplyMaillefer, Ballaigues, Switzerland) according to the manufacturer's instructions at 500 rpm and 2.5 Ncm torque.

Group B (n = 30): Mechanical instrumentation with WaveOne Gold primary file (25/0.07) (DENTSPLY Tulsa Dental Specialties, Tulsa, USA) with pecking in and out motion with Endomotor X SMART[®] Plus

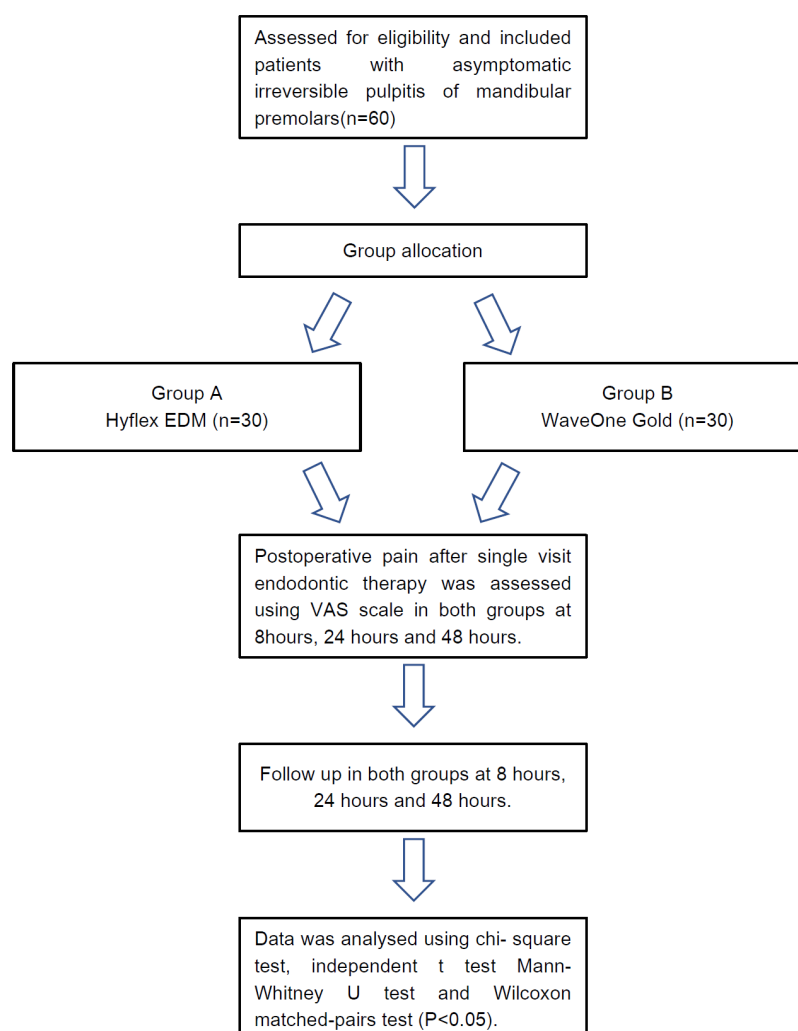


Fig. 1. Flowchart of the study.

(DentsplyMaillefer, Ballaigues, Switzerland) according to the manufacturer's instructions using WOG mode.

In both groups, irrigation was performed intermittently with a 30G side vented needle kept short of working length by 1 mm in the following sequence: 5 ml of 5.25% NaOCl followed by saline (NS, sodium chloride injection, 0.9% W/V) and followed by 5 ml of 17% EDTA solution. With each irrigation flush of NaOCl and EDTA, sonic agitation of the irrigant was performed using an EndoActivator (EA-A0913 022-025 Medium tip Dentsply Sirona, India) for 1 min. Distilled water (10 ml) was used as the final irrigant. Absorbent paper points were used to dry the canals, and the canals were obturated using the corresponding master gutta-percha cone, accessory cones, and a resin sealer (AH Plus, DentsplyMaillefer,

Ballaigues, Switzerland) using the cold lateral compaction technique. A nanohybrid composite resin (Filtek Z250 XT, 3M ESPE, Saint Paul, MN, USA) was used to seal the access openings. The patient's occlusion was evaluated to ensure that the restoration did not interfere with the occlusion. Representative intraoral X-rays of both groups are shown in Figs. 2 and 3.

A visual analog scale (VAS) was used to measure pain after endodontic therapy. Based on this scale, the pain level was numerically documented in the range of 0-100. The following VAS classifications were used: no pain, 0-24; mild pain, 25-49; moderate pain, 50-74; severe pain, 75-100. Pain scoring based on the VAS questionnaire was recorded at 8, 24, and 48 h by telephone inquiry. All patients were prescribed 400 mg of ibuprofen and asked

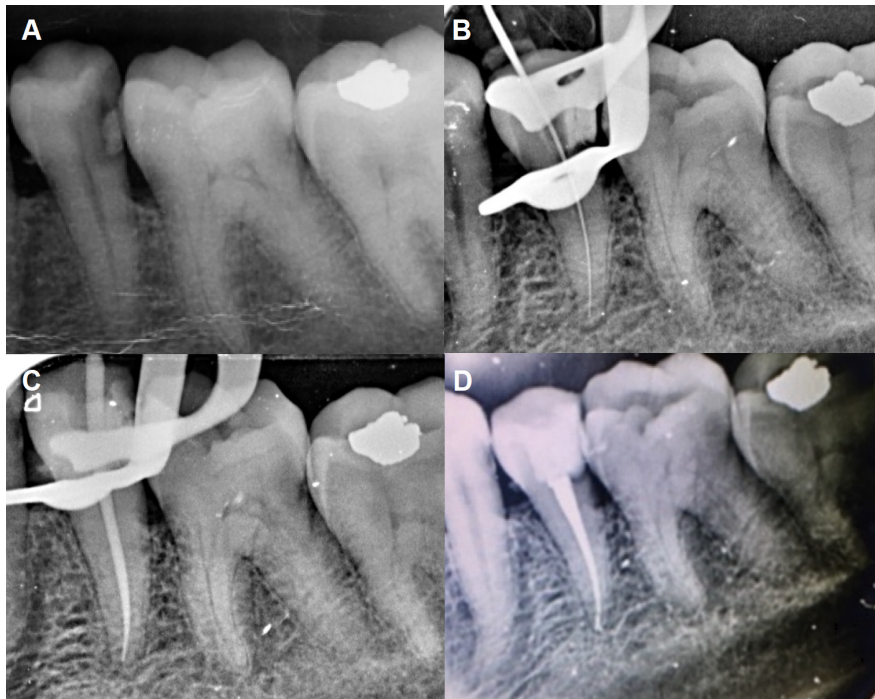


Fig. 2. Representative Intraoral Periapical radiographs of Hyflex EDM group. (A) Preoperative radiograph, (B) Working length determination, (C) Mastercone selection, (D) Postoperative radiograph.

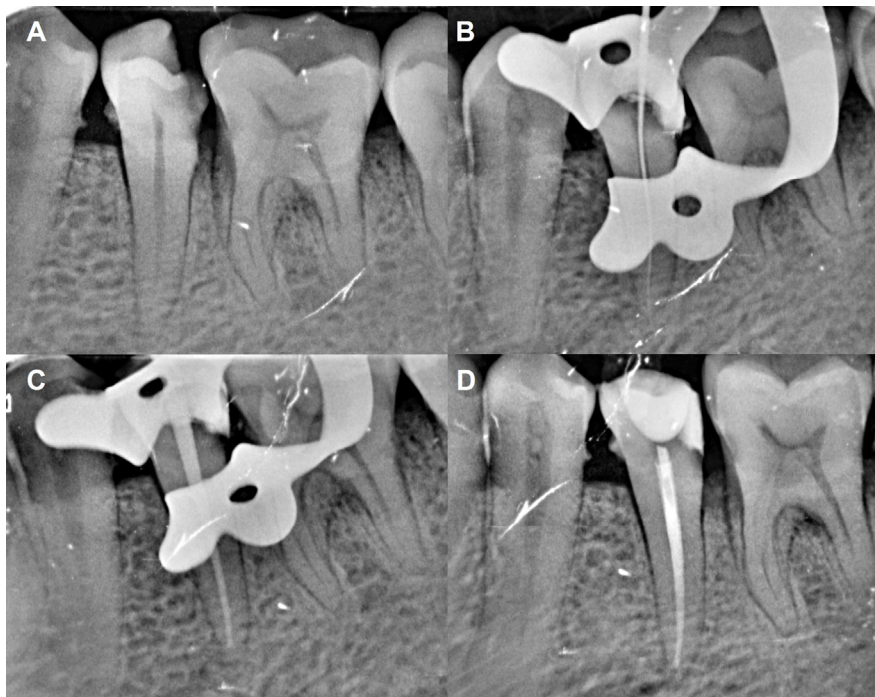


Fig. 3. Representative Intraoral Periapical radiographs of WaveOne Gold group. (A) Preoperative radiograph, (B) Working length determination, (C) Mastercone selection, (D) Postoperative radiograph.

to take it only for unbearable pain. They were advised not to take medications without the knowledge of the

investigator. The researcher conducted the telephone interview and performed the data entry, and the

Table 1. Comparison between group A (Hyflex EDM) and group B (WaveOne Gold) regarding sex

Gender	Group A	%	Group B	%	Total	%
Male	7	23.33	6	20.00	13	21.67
Female	23	76.67	24	80.00	47	78.33
Total	30	100.00	30	100.00	60	100.00

Chi-square = 0.0980, P = 0.7540

Independent t-test, P < 0.05 is considered statistically significant.

Table 2. Comparison between group A (Hyflex EDM) and group B (WaveOne Gold) regarding mean age

Groups	Mean	SD	SE	t-value	P-value
Group A	34.43	6.26	1.14	0.5398	0.5914
Group B	33.57	6.18	1.13		

Independent t-test, P < 0.05 is considered statistically significant. SD, standard deviation; SE, standard error.

Table 3. Comparison between group A (Hyflex EDM) and group B (WaveOne Gold) regarding tooth type

Tooth number	Group A	%	Group B	%	Total	%
34	3	10.00	3	10.00	6	10.00
35	10	33.33	12	40.00	22	36.67
44	1	3.33	1	3.33	2	3.33
45	16	53.33	14	46.67	30	50.00
Total	30	100.00	30	100.00	60	100.00

Chi-square = 0.3152, P = 0.9570.

Table 4. Comparison between group A (Hyflex EDM) and group B (WaveOne Gold) on postoperative pain using a 0-100 visual analog scale at 8, 24, and 48 h

Treatment time points	Group	N	Mean	SD	Mean rank	U value	Z value	P Value
8 hours	A	30	33.23	14.090	42.00	105	5.113	< 0.001*
	B	30	10.73	9.752	19.00			
24 hours	A	30	26.70	12.140	45.50	.000	6.69	< 0.001*
	B	30	3.03	2.606	15.50			
48 hours	A	30	23.73	8.212	45.50	.000	6.8	< 0.001*
	B	30	1.07	1.574	15.50			

*P < 0.05 is considered statistically significant. N, number; SD, standard deviation.

statistician was blinded to the type of intervention performed. The patients were recalled for definitive restoration after 2 weeks.

2. Statistical analysis

The data were entered into an Excel sheet and analyzed using SPSS version 16.0 (IBM Corporation, India). Data were analyzed using the chi-square test, independent t-test, Mann-Whitney U test, and Wilcoxon signed-rank test. The level of statistical significance was set at 0.05 (P < 0.05).

RESULTS

The sample distribution was revealed to be similar without any statistically significant differences between the two groups regarding sex, age, and tooth type (Tables 1, 2, and 3).

Table 4 shows the comparison of postoperative pain between group A (HEDM) and group B (WOG) at different time intervals (8, 24, and 48 h) using the Mann-Whitney U test. The results showed statistically significant differences between the two groups (P <

Table 5. Comparison of different treatment time points on postoperative pain in group A (Hyflex EDM)

Treatment time points	N	Mean	SD	Mean difference	Z-value	P-Value
8 hours	30	33.23	14.090	6.53	2.265	0.024*
24 hours	30	26.70	12.140			
8 hours	30	33.23	14.090	9.5	3.52	< 0.001*
48 hours	30	23.73	8.212			
24 hours	30	26.70	12.140	2.97	0.773	0.44
48 hours	30	23.73	8.212			

*P < 0.05 is considered statistically significant. N, number; SD, standard deviation.

Table 6. Comparison of different treatment time points on postoperative pain in group B (WaveOne Gold)

Treatment time points	N	Mean	SD	Mean difference	Z-value	P-Value
8 hours	30	10.73	9.752	7.70	3.458	0.001*
24 hours	30	3.03	2.606			
8 hours	30	10.73	9.752	9.66	4.214	< 0.001*
48 hours	30	1.07	1.574			
24 hours	30	3.03	2.606	1.96	3.057	0.002*
48 hours	30	1.07	1.574			

*P < 0.05 is considered statistically significant. N, number; SD, standard deviation.

0.001) at 8, 24, and 48 h.

Table 5 shows the comparison of different treatment time points with postoperative pain in group A (HEDM) using the Wilcoxon signed-rank test, which showed a gradual reduction in pain intensity with an increase in follow-up time. Group A (HEDM) was shown to have a statistically significant difference between 8 and 24 h ($P = 0.024$) and between 8 and 48 h ($P < 0.001$), but the comparison between 24 and 48 h did not show a significant difference ($P = 0.44$).

Table 6 shows a comparison of different treatment time points with postoperative pain in group B (WOG) using the Wilcoxon signed-rank test, which showed a reduction in postoperative pain with an increase in follow-up time. Group B (WOG) showed a statistically significant difference between 8 and 24 h ($P = 0.001$), 8 and 48 h ($P < 0.001$), and 24 and 48 h ($P = 0.002$).

DISCUSSION

Efficient chemomechanical preparation, three-dimensional filling of root canals, and the degree of postoperative discomfort will influence the success of

endodontic therapy. The subjective nature of pain is difficult to evaluate. Therefore, participants in this study received an adequate description of postoperative pain and VAS scores. This scale is considered a decisive and valid method for assessing pain [2,17].

Most participants interpreted the VAS scale smoothly and estimated their pain intensity appropriately. The two groups were comparable in terms of age, sex, tooth type, and pulpal and periapical status. In this study, a single operator performed endodontic therapy for all participants during a single visit to control the technique and operator-related variables. The only difference was the rotary files used for the mechanical preparation between the two groups.

The file systems used were similar in size to maintain standardization and rule out the effect of varying tapers on postoperative pain [18,19]. Both systems differ in kinematics. Previous studies have reported that postoperative pain is significantly influenced by preoperative pain and periapical status [4]. Therefore, this study admitted teeth with asymptomatic irreversible pulpitis with normal periapical status to evaluate pain after the completion of endodontic therapy.

Single-visit endodontic procedures are preferred to

minimize the effects of related variables. Su et al. reported that the occurrence of pain after endodontic therapy in a single visit was minimal compared with multiple-visit endodontic treatment [20].

In this study, an activator was used in both groups to agitate NaOCl and EDTA for 1 min. EndoActivators can break bacterial biofilms by generating bubbles that expand and collapse, producing miniature shockwaves, thus reducing bacterial stagnation. A study by Vishwakarma et al. reported an improved efficiency in reducing postoperative pain at 8, 24, and 48 h in the EndoActivator group compared to the group with an open-ended needle [21]. Ramamoorthi et al. also found that the EndoActivator group experienced significantly less postoperative pain than the conventional needle protocol at 8, 24, and 48 h [22]. Therefore, activation of irrigants using an EndoActivator can be considered an effective method of reducing postoperative pain.

In the present study, the cold lateral compaction technique was used, as this technique has been shown to cause less postoperative pain than the warm compaction technique [23]. The teeth of both groups were relieved of occlusal contact, as trauma from occlusion would impact the results.

The results of this study revealed significantly less pain in the WOG group than in the HEDM group at 8 h, which was subsequently reduced at 24 h and 48 h. When comparing the VAS between HEDM and WOG in three different time slots, it was found that WOG had higher success than HEDM among participants in terms of the least post-endodontic pain. Therefore, this study showed that WOG was better at minimizing postoperative pain than HEDM.

A systematic review by Pak et al. stated that, during the initial phase, pain after single-visit endodontic treatment was found to be preponderant. According to this review, the mean posttreatment pain severity was greater at 24 h. After 7 days, the severity of the pain gradually reduced [4]. In the present study, the incidence of pain tracked a similar curve, which was greater at 8 h in both groups, followed by a significant reduction in

pain at 24 and 48 h.

A routine prescription of analgesics was not provided in this study, as this would have affected the outcome. Analgesics were advised only on demand. None of the patients in this study required the use of analgesics, as none of them experienced severe pain.

Differences in cleaning and shaping procedures, immune response to extruded root canal debris, irrigants, instrumentation beyond the apex, or foreign body reactions to obturating materials have been reported to cause postoperative pain [19,20]. Therefore, in this study, great care was taken to avoid the influence of these factors.

Superior results were observed for the WOG system compared to the HEDM system. Similarly, the WOG system showed better results than the Protaper system in a study by Saha et al. [24].

The reasons for the lower postoperative pain in the WOG group could be attributed to the following:

1. The WOG has fixed and progressively decreased tapers in D1-D3 and D4-D16, respectively, conserving dentin and maintaining space for more debris to collect and push coronally [25].
2. The off-centric design of WOG with one point of contact with the canal wall results in adequate space for debris collection and removal [26,27].
3. HEDM uses continuous rotational motion with a variable cross-section design, reducing the space for debris clearance [28].

There are various etiological factors for post-endodontic pain, of which the amount of apically extruded debris is the most contributing factor [29,30]. Rotary files have also been shown to cause a greater accumulation of proinflammatory mediators at the periapex than reciprocating files. This could also have contributed to higher pain scores in the HEDM group. The limitations of this study include the sample size and the subjective nature of pain, which are difficult to quantify. The use of hand instruments before the rotary and reciprocating instruments could also be attributed to debris extrusion, resulting in pain. Therefore, more large-scale studies are needed to compare this two

kinematics, focusing on their limitations.

In conclusion, pain after single-visit endodontic treatment was less in patients treated with the WOG system than with the HEDM system. Higher pain scores were observed at 8 h, which gradually decreased in intensity after 24 and 48 h. Since the present *in vivo* study revealed the influence of geometric characteristics of the files on postoperative pain following single-visit endodontic therapy, the findings may help in clinical decision-making in selecting the NiTi instruments and providing a pain-free outcome.

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Anila Bandlapally: Formal analysis, Supervision, Visualization, Writing - review & editing

Sayesh Vemuri: Data curation, Formal analysis, Project administration, Resources, Writing - review & editing

Nagesh Bolla: Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision

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