

ORIGINAL RESEARCH ARTICLE

CLINICAL EFFICACY AND SAFETY BETWEEN CONTINUOUS ROTARY AND RECIPROCATING ROOT CANAL INSTRUMENTATION SYSTEMS

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ABSTRACT

**Background:** The single file reciprocating system prepares the canal quickly with a better centric ability and has increased resistance to cyclic fatigue compared to the continuous rotary file system. However, the former file system was associated with more postoperative pain than the latter. The goal of the present study was to evaluate and compare the clinical efficacy and safety between continuous rotary and reciprocating instrumentation systems.

**Methods:** Fifty patients who fulfilled specific inclusion criteria were assigned into 2 groups according to the root canal instrumentation technique used, ProTaper Gold and WaveOne Gold. Endodontic treatment was performed in a single visit. Patients were instructed to rate the intensity of postoperative pain on Visual Analog Scale and to record the quantity of prescribed analgesic medication taken after 24 hours, 48 hours, 72 hours, and 7 days. Time of root canal preparation, duration of pain, and incidence of procedural errors such as ledging, transportation, root perforation, and instrument separation were recorded. The data was collected from October 2018 to September 2019. SPSS version 24 was used for data analysis.

**Results:** This study revealed no statistically significant difference between instrumentation groups with relevance to postoperative pain and analgesic medication intake ( $P > 0.05$ ). Canal preparation time was significantly shorter in reciprocating group compared to rotary group ( $P < 0.001$ ). Further, the incidence of procedural errors in both instrumentation group was found statistically insignificant ( $P > 0.05$ ).

**Conclusions:** Continuous rotary and reciprocating systems were both found to have similar clinical efficacy and safety and hence can be used to instrument the root canals.

INTRODUCTION

Postoperative pain is the feeling of discomfort after endodontic treatment which is reported by 25%–40% of patients irrespective of pulp and periradicular status.<sup>1-3</sup> The extrusion of debris apically during canal instrumentation is the principal factor to provoke the onset of post-endodontic pain besides insufficient instrumentation, irritants extrusion, intracanal medicament extrusion, missing of the canal, preoperative pain, periapical pathosis, and hyperocclusion.<sup>4-5</sup>

The variability in terms of debris extrusion has also been observed between different rotary systems due to differences in cross-sectional geometry, cutting blade design, taper, flute depth, tip, and sequence of files, kinematics, and cutting efficacy.<sup>6</sup> All the preparation techniques and instruments available are still associated with some amount of debris extrusion.<sup>7-8</sup> Previous studies suggested that full-sequence rotary instrumentation was associated with less debris extrusion and thus less incidence and severity of postoperative pain compared to single file reciprocating systems.<sup>8-10</sup> However, few clinical studies found no significant differences in postoperative

pain between continuous rotary and single-file reciprocating systems.<sup>11-12</sup>

The purpose of the present study was to understand the influence of different motion kinematics on post-instrumentation pain. The intake of analgesics, canal preparation time, and incidence of procedural errors were also studied.

METHODS

This comparative cross-sectional study, following the approval by the Institutional Review Board of Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh; was carried out in their Department of Conservative Dentistry and Endodontics among the patients of age 18-50 years with irreversible pulpitis (symptomatic and asymptomatic) of first molar teeth. The data was collected from October 2018 to September 2019. A purposive sampling technique was used to select the sample. The exclusion criteria for the study were patients having age less than 18 years and more than 50 years, consumption of any drug before treatment, medically compromised patients, allergy to lidocaine, severely curved root canals, calcified

canals, resorption of roots, open apices, previous endodontic treatment, and perio-endo lesion. A written consent was taken before the start of the procedure.

The sample size calculation was based on an error of  $\alpha=0.05$  and a power of 85%, indicated that a sample size of 22 in each group would be required. To ensure a safe representative sample, 50 teeth, (25 per instrumentation group) were selected.

Fifty patients who fulfilled the inclusion criteria were randomly divided into two groups ( $n=25$  each) by lottery method based on the type of instruments used during root canal preparation: Group-A (Continuous Rotary System) and Group-B (Reciprocating system). Before initiating the treatment, the treatment plan was explained, and a questionnaire (including the Visual Analogue Scale sheet) to record their pain assessment at 24 hrs, 48 hrs, 72 hrs, and seven days was given. Single visit endodontic treatment of each tooth was performed by a single operator. After achieving local anesthesia, the tooth was isolated using a rubber dam followed by straight line access cavity preparation. All the instruments were driven by the same electric endomotor with torque control (E-Connect Pro, Eighteeth). Torque limits and rotation speed was set individually for each file system used. WaveOne Gold instruments were used in reciprocating mode. Ethylene Diamine Tetraacetic Acid (EDTA) containing gel (Glyde) was used as lubricant during canal negotiation and glide path preparation, whereas all phases of instrumentation for both groups were done under the presence of 2.5 % sodium hypochlorite.

ProTaper Gold was used for Group-A patients. The protocol for ProTaper Gold rotary files were as follows. After gaining straight line access, coronal two third of the canals were negotiated with #10 K-file using a watch-winding motion. Glide path preparation of the secured portion of the canal was done using # 10 K-file followed by glide path expansion using ProGlider (Dentsply Sirona). SX file was used in a brushing motion to pre-enlarge the coronal two-thirds of the canal. After this, the apical one-third of the canal was negotiated using # 10 K-file. When a 10 number K-file reached the estimated length, it was used with ultra-short vertical strokes of 0.5-1 mm, until it became loose. Working length was determined using an electronic apex locator (Epex, Eighteeth) and was again confirmed radiographically. Apical patency was then confirmed followed by apical glide path verification where # 10 K-file reproducibly glided along the length of the apical one-third of the canal. This was followed by further expansion of apical glide path using ProGlider. Then S1 was followed by S2 until the working length in a brushing motion. Change of any given rotary file was followed by irrigation, recapitulation with # 10 K-file, and then again re-irrigation. F1 was used passively in a brushing manner (follow and brush) until the working length reached. When F1 achieved the length, the instrument was removed, and its apical flutes were inspected. Loading of the apical flutes of F1 with dentin supported the completion of the shaping. If the apical flutes of F1 were not fully loaded

with dentin, then F2 was used. Upon reaching the length, F2 was removed followed by inspection of the apical flutes. If its apical flutes were fully loaded with dentine, then the shaping of the canal was being completed. If the apical flutes of F2 were partially loaded or not loaded at all, then F3, F4 and F5 were used simultaneously as indicated.

WaveOne Gold was used for Group-B patients. In this group, after obtaining straight line access # 10 K-file was used to negotiate the coronal two third of the canal. This was followed by glide path preparation of the secured portion of the canal using # 10 K-files. Further expansion of the glide path was done using ProGlider. Shaping of the coronal two third of the canal was done using Primary file (25/0.07) in a brushing motion in the presence of 2.5 % sodium hypochlorite. Shaping of the coronal two-third of the canal was done using a Primary file (25/0.07) in a brushing motion in the presence of 2.5 % sodium hypochlorite. The primary file required 2-3 passes to shape the coronal third of the canal because after shaping every 3 mm of any given canal, it was followed by irrigation, recapitulation and again re-irrigation. Apical one third of the canal was then negotiated using # 10 K-file in the presence of EDTA containing viscous chelator. When a 10 number K-file reached the estimated length, it was used with ultra-short vertical strokes of 0.5-1 mm, until it became loose. Working length was then determined using an electronic apex locator (Epex, Eighteeth) which was confirmed radiographically. Apical patency was then confirmed followed by apical glide path verification where # 10 K-file reproducibly glided along the length of the apical one-third of the canal. This was followed by further expansion of apical glide path using ProGlider. Primary WaveOne Gold file was then carried to the full working length in one or more passes. Primary WaveOne Gold file was used with short 3 mm amplitude strokes in a gentle inward motion, to passively advance the file to the working length. The file was withdrawn after every 3 mm to remove the debris and inspect its cutting flutes. This was followed by irrigation, recapitulation, and then again re-irrigation. Generally, in 3 passes, primary WaveOne Gold file reached the full working length. Once the Primary WaveOne Gold file reached the full working length, it was removed. When the primary file did not progress, small file was used which reached the working length in one or more passes and then again primary file was used up to the working length to optimize the shape. Once the primary file reached the working length, it was removed and its apical flutes were inspected. If the apical flutes were loaded with dentinal debris, then the shaping was finished. But, if the primary file was loose at length with no dentinal debris in the apical flutes, shaping was again continued with medium file and/or large file until the apical flutes were loaded.

Debris was removed from the instrument using alcohol-soaked gauze, either immediately after each instrument change (ProTaper Gold system) or after 3 in-and-out (pecking) motions (WaveOne Gold). Patency of the apical foramen was maintained during all the techniques by introducing a #10 or #15 K-type file (Dentsply) to a point 1 mm beyond the working length at each instrument change. Irrigation was done

with 2mL of 2.5 % sodium hypochlorite (NaOCl) after every instrument change and 10 ml of 2.5 % sodium hypochlorite (NaOCl) after completion of the preparation using side vented needle. Normal saline was used as neutralizing solution before proceeding to irrigation with 17% liquid EDTA. 17% Liquid EDTA was used for one minute to remove the smear layer. A final flush with 2.5 % NaOCl (2 ml per canal) was done followed by normal saline. After drying the canals with paper points, master cone radiograph was taken, and then the root canals were finally obturated by single cone obturation technique using respective gutta-percha cone of the instrument system with Sealapex sealer. The treatment phase was concluded by sealing the access cavity using Zinc oxide eugenol filling.

The patients were instructed to take analgesics (400 mg

of ibuprofen), if they experience pain. The assessment of postoperative pain was carried out at 24 hours, 48 hours, 72 hours and 7 days. The number of intakes of analgesic tablet was recorded at that particular time interval. The patients were instructed to call the operator if adequate pain relief was not obtained with the prescription.

The recorded data of postoperative pain severity, duration of pain relief, analgesic dose and time of root canal preparation were statistically analyzed using unpaired student t-test. The data expressed as frequency and percentage were analyzed using the Chi-square test. The results were expressed in the form of table and figure. 95% confidence interval (p value <0.05) were followed for testing the level of significance. SPSS version 24 was used to do the statistical analysis.

## RESULTS

**Table 1: Association of incidence of postoperative pain between two instrumentation groups at different time intervals (N=50)**

Incidence of Postoperative pain at different time intervals		Rotary Group (n=25) N (%)	Reciprocating Group (n=25) N (%)	p-value
24 hours	Present	22 (88%)	22 (88%)	1.000 <sup>ns</sup>
	Absent	3 (12%)	3 (12%)	
48 hrs	Present	8 (32 %)	13 (52%)	0.156 <sup>ns</sup>
	Absent	17 (68 %)	12 (48%)	
72 hours	Present	2 (8 %)	0 (0%)	0.153 <sup>ns</sup>
	Absent	23 (92%)	25 (100%)	
7 days	Present	0 (0%)	0 (0%)	1.000 <sup>ns</sup>
	Absent	25 (100%)	25 (100%)	

Data were expressed as frequency and percentage

Chi-square test was performed to see the association between two groups

ns=significant

The incidence of postoperative pain at various time intervals in each group is shown in Table 1.

No significant difference was found in the association of incidence of postoperative pain between Continuous Rotary and Reciprocating instrumentation system at any of the four time points assessed. The incidence of postoperative pain

was highest (88%) in both instrumentation groups at 24 hours after treatment with a significant decline thereafter. The mean VAS scores at the various time intervals associated with each instrumentation group are shown in Table 2. No significant difference (P > 0.05) was found in the intensity of postoperative pain among patients in Rotary group and Reciprocating group at any of the four time points assessed (Table 2).

**Table 2: Comparison of mean postoperative pain VAS scores between two instrumentation groups at different time interval (N=50)**

VAS score at different time intervals	Rotary group (n=25) Mean ± SD	Reciprocating group (n=25) Mean ± SD	p-value
At 24 hours	45.1±18.1	47.4±18.5	0.656 <sup>ns</sup>
At 48 hours	25.0±13.6	28.3±15.2	0.420 <sup>ns</sup>
At 72 hours	12.1±6.5	12.5±6.0	0.822 <sup>ns</sup>
At 7 days	2.7±1.7	3.5±3.4	0.315 <sup>ns</sup>

Data were expressed as mean ± SD

Unpaired student t-test was performed to compare between two groups

ns = not significant

The highest mean postoperative pain scores were observed 24 hours after treatment in both instrumentation groups with a significant decline thereafter. The duration of pain relief

between the patients treated in each instrumentation group was also found insignificant statistically ( $P > 0.05$ ) (Tables 3).

**Table 3: Comparison of mean duration of pain relief between two instrumentation groups (N=50)**

Duration of pain relief (hours)	Rotary group (n=25) Mean ± SD	Reciprocating group (n=25) Mean ± SD	p-value
Duration of pain relief (hours)	31.7±15.1	34.6±12.2	0.460 <sup>ns</sup>

Data were expressed as mean ± SD

Unpaired student t-test was performed to compare between two groups

ns = not significant

**Table 4: Comparison of mean analgesic dose (frequency x dosage of 1 tablet, 400 mg) to control postoperative pain after instrumentation in each group at different time intervals**

Time Interval	Rotary group (n=25) Mean ± SD	Reciprocating group (n=25) Mean ± SD	p-value
24 hours	304.0±370.2	304.0±404.6	1.000 <sup>ns</sup>
48 hours	48.0±132.7	64.0±189.0	0.731 <sup>ns</sup>
72 hours	-	-	-
7 days	-	-	-

Data were expressed as mean ± SD

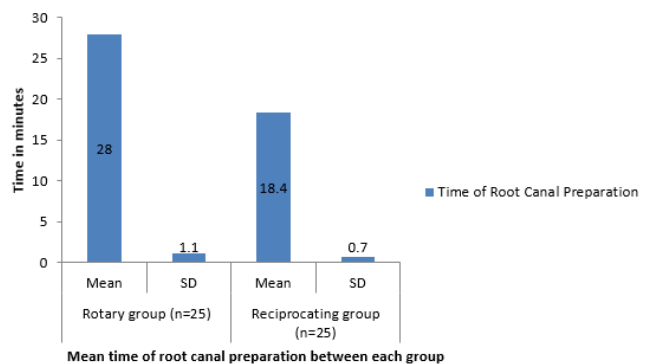
Unpaired student t-test was performed to compare between two groups

ns= not significant

The comparison of mean analgesic dose in both groups at different intervals of time is shown in table 4. No significant difference ( $P > 0.05$ ) was found in the mean analgesic dose in each group at 24 hour and 48-hour time-intervals. No analgesic tablets were consumed by the patients in each group assessed after 48 hours i.e. at 72 hours and 7 days' time-interval. The canal preparation time was significantly shorter in Reciprocating group compared to Rotary group ( $P < 0.001$ ) (Figure 1).

Further, there was no incidence of procedural errors in each instrumentation group except one instrument separation in Reciprocating group (4%) which was found statistically insignificant ( $P > 0.05$ ) (Table 5).

**Figure 1: Bar Diagram showing the mean time of root canal preparation between each group**



**Table 5: Association of incidence of procedural errors between two instrumentation groups (N=50)**

Incidence of procedural errors		Rotary group (n=25) N (%)	Reciprocating group (n=25) N (%)	p-value
Ledging	Yes	0(0.0%)	0(0.0%)	-
	No	25(100.0%)	25(100.0%)	
Transportation	Yes	0(0.0%)	0(0.0%)	-
	No	25(100.0%)	25(100.0%)	
Root perforation	Yes	0(0.0%)	0(0.0%)	-
	No	25(100.0%)	25(100.0%)	
Instrument separation	Yes	0(0.0%)	1(4.0%)	0.312 <sup>ns</sup>
	No	25(100.0%)	24(96.0%)	

Data were expressed as frequency and percentage

Chi-square test was performed to see the association between two groups

ns=significant

## DISCUSSION

In the present study, the clinical efficacy and safety of continuous rotary instrumentation system (ProTaper Gold) and reciprocating instrumentation system (WaveOne Gold) were compared in respect to the incidence, severity and duration of postoperative pain; quantity of analgesic intake; time required for canal preparation, and incidence of procedural errors. Various clinical studies found increase incidence, severity and duration of postoperative pain in patients undergoing canal instrumentation with reciprocating system compared to continuous rotary system<sup>8, 10, 13</sup> However, the results of the present study revealed that both continuous rotary system (ProTaper Gold) and reciprocating system (WaveOne Gold) were equivalent in regard to the incidence, severity, duration of postoperative pain and intake of analgesic medication at the time points assessed which is in accordance with the results of clinical trial by Relvas et al.<sup>12</sup> and Kherlakian et al.<sup>11</sup>

Regarding the incidence of postoperative pain in the present study, it was found to be highest (88%) in both instrumentation groups at 24 hours after treatment with a significant decline thereafter, particularly over the first 48 hours (32% in Rotary Group and 52 % in Reciprocating group), and reaching levels of 8 % in Rotary group and 0 % in Reciprocating group at 72 hours followed by 0% in each group after 7 days. Similar declining trend in postoperative pain was also observed in a systematic review conducted by Pak and White<sup>14</sup> where the incidence of postoperative of pain in the first 24 hours was 40%, falling to 11% after 7 days. The highest mean pain in both study groups occurred in the first 24 hours, with a significant decrease in pain ratings at the subsequent observation time points of 48 hours, 72 hours, and 7 days. In the current study, only 4 % of the patients experienced severe pain in both instrumentation groups after 24 hours of the treatment with no severe pain (0%) in both instrumentation groups after 48 hours of the treatment which is in accordance with the study by Ng et al.,<sup>15</sup> where they found less than 12 % of patients with severe pain after 48 hours. The higher incidence of postoperative pain (88%) after first 24 hours in the present study might be due to the inclusion of patients with both symptomatic and asymptomatic irreversible pulpitis as preoperative pain is considered to be strong predictor of postoperative pain.<sup>16</sup> In this study, cases with symptomatic irreversible pulpitis were chosen as it could be accomplished in single visit with no pain once the inflamed pulp (the source of the pain) is removed.<sup>17</sup> Further in this study, the records of both mild and moderate pain were considered for the incidence of postoperative pain because we needed to verify when the patient felt pain, regardless of the use of analgesics. Study by Nekoofar et al.<sup>9</sup> and ElMubarak et al.<sup>18</sup> conducted a similar analysis of the results. However, Wang et al.<sup>19</sup> considered postoperative pain as moderate pain since the patient required the use of oral medication.

Nekoofar et al.<sup>9</sup> reported increased incidence, severity and duration of postoperative pain in patients undergoing canal instrumentation with reciprocating system (WaveOne) compared to rotary system (ProTaper Universal). This variation

of their results with the current study might be attributed to type of study design (Randomized Controlled Trial vs Cross-sectional comparative study), pain rating scale (numerical rating scale vs. visual analogue scale), the number of appointment sessions (two vs. one), irrigating solutions (chlorhexidine vs. sodium hypochlorite), and the type of teeth (mandibular/maxillary premolars and molars vs mandibular and maxillary first molars).

Conversely, Shokraneh et al.<sup>20</sup> in a similar type of study found decrease in the incidence, severity and duration of postoperative pain in the reciprocating file system (WaveOne) compared to continuous rotary file system (ProTaper Universal). This variation of their results with the current study might be attributed to type of study design (Prospective, randomized, double-blind study vs Cross-sectional comparative study), pain rating scale (Heft-Parker visual analogue scale vs. visual analogue scale), irrigating solutions (5.25% sodium hypochlorite vs 2.5% sodium hypochlorite), pulpal and periodontal status (Asymptomatic necrotic tooth with periapical lesion vs symptomatic and asymptomatic irreversible pulpitis), type of teeth (mandibular molar vs mandibular and maxillary first molars) and time interval for evaluation (6 hr, 12 hr, 18 hr, 24 hr, 48 hr, 72 hr vs 24 hr, 48 hr, 72 hr and 7 days). The significant difference in postoperative pain between WaveOne and ProTaper Universal was found at 6, 12 and 18 hours with no significant differences at other time intervals.

The assessment of time required for root canal preparation revealed that Reciprocating system (WaveOne Gold) prepared the canal in a significantly shorter time because it required the use of only one file in most of the canals except distal and palatal canals. Moreover, it has been shown that the application of reciprocating movement instead of full rotation decreases the preparation time. On the other hand, Continuous rotary system (ProTaper Gold) required the use of 5-6 files.

In respect to the procedural error, the result showed that no incidence of ledging; transportation and root perforation was found in both instrumentation groups which are in accordance with the results of clinical trial by Farmer<sup>21</sup> where no incidence of ledging and root perforation between continuous rotary system (ProTaper Next) and reciprocating system (WaveOne) was reported. Further Yildiz et al.<sup>22</sup> in an in-vitro study also found no difference in root canal transportation and centric ability between continuous rotary system (ProTaper Gold) and reciprocating system (Reciproc). However, according to in-vitro study by Al-Dhbaan et al.,<sup>23</sup> WaveOne Gold (reciprocating system) demonstrated fewer canal aberrations with better shaping ability compared to Protaper Gold (continuous rotary system) which is in contrast to the results of the present study. This difference might be due to in-vivo comparison using two dimensional digital radiographs in the present study which is not a gold standard method to evaluate and verify the incidence of ledging, transportation and root perforation. Use of Cone beam computed tomography (CBCT) is advised to compare the incidence of ledging, transportation and root perforation of the canals between these two-instrumentation system in the future

studies.

Further regarding the incidence of instrument separation, no incidence of instrument separation was reported in both instrumentation groups except one case of instrument separation in the WaveOne Gold group (4%) which was found statistically insignificant. According to the various in vitro studies, it has been well established that reciprocating file system possesses better cyclic fatigue resistance and thus decrease risk of instrument separation compared to continuous rotary system.<sup>41</sup> However in the current study, one case of instrument separation in the WaveOne Gold group might be attributed to multiple uses of the file (one file for five cases). The concept of multiple uses of the file was taken from the results of an in-vitro study by Karova and Topalova<sup>42</sup> and Wu et al.<sup>24</sup> According to study by Karova and Topalova,<sup>25</sup> the average lifespan of one WaveOne file (Predecessor of WaveOne Gold) was found to be  $17.50 \pm 2.12$  canals. Further in a study by Wu et al.,<sup>26</sup> low incidence of instrument separation after multiple uses of the ProTaper Universal (Predecessor of ProTaper Gold) was reported. Before reuse in the next patient, each file in both groups was sterilized by autoclaving because according to study by Silvaggio and Hicks,<sup>27</sup> heat sterilization of rotary nickel-titanium files up to 10 times does not increase the likelihood of instrument fracture.

The reasons behind the comparable results observed between ProTaper Gold and WaveOne Gold in terms of incidence of procedural errors is that both of these files are manufactured from innovation in the NiTi systems with advanced metallurgy and modification in the design and cross-section of the instruments.

The limitations of this study were difficulty to measure the pain due to its subjective nature, preoperative pain was not taken into the consideration in this study because cases of symptomatic irreversible pulpitis can be accomplished in single visit with no

pain once the source of pain (inflamed pulp) is removed and use of cone beam computed tomography (CBCT) for three dimensional assessment and comparison of the incidence of ledging, transportation and root perforation between both instrumentation systems was not considered in this study due to time restraint as well as financial constraints.

In the future, a study comparing the postoperative pain experienced after root canal preparation in a necrotic tooth with periapical lesion and the incidence of instrument separation in a severely curved canal between the Continuous rotary system and the Reciprocating system is suggested.

## CONCLUSION

The reciprocating system prepared the canal in a significantly shorter time compared to continuous rotary system. No significant differences were found in the incidence and intensity of postoperative pain as well as intake of analgesic, duration of pain relief and incidence of procedural errors. Thus, it can be concluded that both continuous rotary system and reciprocating system can be used to instrument the root canals with similar clinical efficacy and safety.

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**CONFLICT OF INTEREST:** None

**FINANCIAL DISCLOSURE:** None

## REFERENCES:

1. Nekoofar M, Sadeghipanah M, Dehpour A. Evaluation of Meloxicam (A Cox-2 Inhibitor) for Management of Postoperative Endodontic Pain: A Double-blind Placebo-controlled Study. *J Endod*, 2003; 29(10): 634-7. [\[DOI\]](#)
2. Pochapski M, Santos F, de Andrade E, Sydney G. Effect of pretreatment dexamethasone on postendodontic pain. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, 2009; 108(5): 790-5. [\[DOI\]](#)
3. Ince B, Ercan E, Dalli M, Dulgergil CT, Zorba YO, Colak H. Incidence of post-operative pain after single- and multi-visit endodontic treatment in teeth with vital and non-vital pulp. *Eur J Dent*, 2009; 3(4): 371-4. [\[DOI\]](#)
4. Seltzer S, Naidorf I. Flare-ups in endodontics: I. Etiological factors. *J Endod*, 1985; 11(11): 472-8. [\[DOI\]](#)
5. Alves V. Endodontic flare-ups: a prospective study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, 2010; 110(5): 68-72. [\[DOI\]](#)
6. Koçak S, Koçak M, Sağlam B, Türker S, Sağsen B, Er Ö. Apical Extrusion of Debris Using Self-Adjusting File, Reciprocating Single-file, and 2 Rotary Instrumentation Systems. *J Endod*, 2013; 39(10): 1278-80. [\[DOI\]](#)
7. Ferraz C, Gomes N, Gomes B, Zaia A, Teixeira F, Souza-Filho F. Apical extrusion of debris and irrigants using two hand and three engine-driven instrumentation techniques. *Int Endod J*, 2001; 34(5): 354-8. [\[DOI\]](#)
8. Bürklein S, Schäfer E. Apically Extruded Debris with Reciprocating Single-File and Full-sequence Rotary Instrumentation Systems. *J Endod*, 2012; 38(6): 850-52. [\[DOI\]](#)
9. Nekoofar M, Sheykhrezae M, Meraji N, Jamee A, Shirvani A, Jamee J, Dummer P. Comparison of the Effect of Root Canal Preparation by Using WaveOne and ProTaper on Postoperative Pain: A Randomized Clinical Trial. *J Endod*, 2015; 41(5): 575-8. [\[DOI\]](#)
10. Pasqualini D, Corbella S, Alovisei M, Taschieri S, Del Fabbro M, Migliaretti G, Carpegna G, Scotti N, Berutti E. Postoperative quality of life following single-visit root canal treatment performed by rotary or reciprocating instrumentation: a randomized clinical trial. *Int Endod J*, 2015; 49(11): 1030-9. [\[DOI\]](#)
11. Kherlakian D, Cunha R, Ehrhardt I, Zuolo M, Kishen A, da Silveira Bueno C. Comparison of the Incidence of Postoperative Pain after Using 2 Reciprocating Systems and a Continuous Rotary System: A Prospective Randomized Clinical Trial. *J Endod*, 2016; 42(2): 171-6. [\[DOI\]](#)
12. Relvas J, Bastos M, Marques A, Garrido A, Sponchiado E. Assessment

- of postoperative pain after reciprocating or rotary NiTi instrumentation of root canals: a randomized, controlled clinical trial. *Clin Oral Investig*, 2015; 20(8): 1987-93. [\[DOI\]](#)
13. Gambarini G, Testarelli L, De Luca M, Milana V, Plotino G, Grande NM et al. The influence of three different instrumentation techniques on the incidence of postoperative pain after endodontic treatment. *Annali di Stomatologia* 2013; 4(1): 152-5. [\[DOI\]](#)
  14. Pak J, White S. Pain prevalence and severity before, during, and after root canal treatment: a systematic review. *J Endod*, 2011; 37(4): 429-38. [\[DOI\]](#)
  15. Ng Y, Glennon J, Setchell D, Gulabivala K. Prevalence of and factors affecting post-obturation pain in patients undergoing root canal treatment. *Int Endod J*, 2004; 37(6): 381-91. [\[DOI\]](#)
  16. Glennon J, Ng Y, Setchell D, Gulabivala K. Prevalence of and factors affecting post preparation pain in patients undergoing two-visit root canal treatment. *Int Endod J*, 2004; 37: 29–37. [\[DOI\]](#)
  17. Torabinejad M, Walton R, Fouad A. *Endodontics Principles and Practice*. 5th ed. St. Louis, Missouri: Elsevier Saunders; 2015.
  18. ElMubarak A, Abu-bakr N, Ibrahim Y. Postoperative Pain in Multiple-visit and Single-visit Root Canal Treatment. *J Endod*, 2010; 36(1): 36-9. [\[DOI\]](#)
  19. Wang C, Xu P, Ren L, Dong G, Ye L. Comparison of post-obturation pain experience following one-visit and two-visit root canal treatment on teeth with vital pulps: a randomized controlled trial. *Int Endod J*, 2010; 43(8): 692–7. [\[DOI\]](#)
  20. Shokraneh A, Ajami M, Farhadi N, Hosseini M, Rohani B. Postoperative endodontic pain of three different instrumentation techniques in asymptomatic necrotic mandibular molars with periapical lesion: a prospective, randomized, double-blind clinical trial. *Clin Oral Investig*, 2016; 21(1): 413-8. [\[DOI\]](#)
  21. Farmer J. Efficiency and Safety of a Continuous Rotation Instrumentation System and a Reciprocating Motion Instrumentation System: A Randomized Clinical Trial. Master's Theses, 2015; 790. [\[LINK\]](#)
  22. Yildiz E, Arslan H, Gunduz H, Sumbullu M, Bayrakdar I, Karatas E, Sumbullu M. Comparative study of ProTaper gold, reciproc, and ProTaper universal for root canal preparation in severely curved root canals. *J Conserv Dent*, 2017; 20(4): 222. [\[DOI\]](#)
  23. Al-Dhbaan A, Al-Omari M, Mathew S, Baseer M. Shaping ability of ProTaper gold and WaveOne gold nickel titanium rotary file in different canal configurations. *Saudi Endod J*, 2018, 8: 202-7. [\[DOI\]](#)
  24. You S, Bae K, Baek S, Kum K, Shon W, Lee W. Lifespan of One Nickel-Titanium Rotary File with Reciprocating Motion in Curved Root Canals. *J Endod*, 2010; 36(12), pp. 1991-4. [\[DOI\]](#)
  25. Karova E, Topalova-Pirinska S. Instrument life of two rotary NiTi single-file techniques with reciprocating and continuous rotation used in curved canals after a glide path creation. *J IMAB*, 2014; 20(1): 494-9. [\[DOI\]](#)
  26. Wu J, Lei G, Yan M, Yu Y, Yu J, Zhang, G. Instrument Separation Analysis of Multi-used ProTaper Universal Rotary System during Root Canal Therapy. *J Endod*, 2011; 37(6): 758-63. [\[DOI\]](#)
  27. Silvaggio J, Hicks M. Effect of heat sterilization on the torsional properties of rotary nickel-titanium endodontic files. *J Endod*, 1997; 23(12):731-4. [\[DOI\]](#)