EUROPEAN ENDODONTIC JOURNAL

SYSTEMATIC REVIEW

Effect of Rotary and Reciprocating Instrumentation Motions on Postoperative Pain Incidence in Non-Surgical Endodontic Treatments: A Systematic Review and Meta-Analysis

Behnam RAHBANI NOBAR, Omid DIANAT, Behrad RAHBANI NOBAR, Armin SHIRVANI, Nazanin ZARGAR, Majid KAZEM, Patricia TORDIK

ABSTRACT

Objective: A systematic review and meta-analysis were conducted to determine whether there are postoperative pain differences resulting from rotary and reciprocation engine-driven instrumentation motions in non-surgical endodontic treatment or retreatment at 12, 24, and 48 hours.

Methods: Four electronic databases (PubMed, Embase, Cochrane Library, and Scopus) were searched to identify randomised controlled trials that compared the effects of rotary and reciprocating instrumentation motions on postoperative pain. Two authors independently screened the search results, extracted the data, and assessed the quality using the Cochrane risk of bias tool. Due to numerous variables across studies, the random effect inverse variance method for meta-analysis was applied. When significant heterogeneity among studies was present, the random effects multi-variable meta-regression analysis was performed to determine the source of heterogeneity.

Results: At all time intervals, the incidence of postoperative pain was higher in the reciprocating instrumentation group, but was not statistically significant. There was no significant difference in the analgesic intake between groups. Meta-regression analysis determined study population sizes as a significant heterogeneous factor, while significance was not observed for preoperative pain or the pulpal diagnosis.

Conclusion: There was no difference in postoperative pain at 12, 24, and 48 hours after non-surgical root canal treatment and retreatment, using reciprocating or rotary instrumentation motions.

Keywords: Endodontics, instrumentation kinematics, reciprocating, root canal therapy, rotary, pain

Please cite this article as: Rahbani Nobar B, Dianat O, Rahbani Nobar B, Shirvani A, Zargar N, Kazem M, Tordik P. Effect of Rotary and Reciprocating Instrumentation Motions on Postoperative Pain Incidence in Non-Surgical Endodontic Treatments: A Systematic Review and Meta-Analysis. Eur Endod J 2021; 6: 3-14

From the Department of Endodontics (B.R.N.) School of Dentistry, Alborz University of Medical Sciences, Karaj, Iran; Division of Endodontics, Department of Advanced Oral Sciences and Therapeutics (O.D. ✉ omiddianat@gmail.com, P.T.) University of Maryland Faculty of Dentistry, Baltimore, Maryland; Iranian Center for Endodontic Research, Research Institute of Dental Sciences (B.R.N., A.S.) Shahid Beheshti University of Medical Sciences; Department of Endodontics, School of Dentistry (N.Z., M.K.) Shahid Beheshti University of Medical Sciences, Tehran, Iran

Received 06 July 2020,
Accepted 12 November 2020

Published online: February 02 2021
DOI 10.14744/eej.2020.51523

HIGHLIGHTS

- Despite being insignificant, in all time intervals, the incidence of postoperative pain was higher in reciprocating motion group
- There was no significant difference between the rotary and reciprocating motion groups with regard to the analgesic intake
- Sample size was identified to be the main source of heterogeneity among the studies

INTRODUCTION

Postoperative pain is an unpleasant sensory experience in patients undergoing endodontic treatment and successful management of the pain is a major challenge (1). A 2011 systematic review reported a forty percent 24-hour postoperative pain prevalence. This value substantially decreased in the first two days and was reduced to less than ten percent by the end of day seven (2). Factors such as incomplete debridement, infected debris extrusion, preoperative pain, and periapical inflammation are thought to be responsible for flare-ups and postoperative pain (3, 4). Instrumentation is considered to be an important contributing factor (5) since it may result in debris extrusion (6).

Debris extrusion in the presence of periapical inflammation could intensify the inflammatory response (7). Although it can be minimized by careful determination of working length, it cannot be completely prevented (8). Contemporary advances in endodontic instruments have led to the introduction of a variety of file systems and sequences for root canal cleaning and shaping. Several studies have evaluated the amount of extruded debris when using different rotary or reciprocating file systems. Both rotary and reciprocating files push debris into the periapical tis-

sues (9-11), but to a lesser extent than hand instrumentation techniques (12). Study results regarding the extent of debris extrusion by rotary and reciprocating files are controversial. While some studies show reciprocating filing results in less debris extrusion (13, 14), others found they can cause more extrusion than rotary file systems (9, 15). Likewise, there are contradictory results regarding postoperative pain following the use of rotary and reciprocating file systems. Studies report higher and lower pain outcomes for rotary file use compared to reciprocating filing (16) or even no difference (17). Postoperative pain following root canal retreatment was lower in the reciprocating group in one study (18), lower in the rotary group in another study (19), and no significant difference in postoperative pain between groups in a third study (20).

The mentioned controversies are not only present in randomised controlled trials but are also evident in systematic reviews. While two systematic reviews stated that continuous rotation kinematics result in less postoperative pain (21, 22), another found that reciprocating kinematics leads to lower postoperative pain scores (23). Additionally, the latest published systematic review stated that no clear conclusions can be made and further studies are needed to clarify this matter (24). Further studies have since reached controversial results (19, 25-29). None of the aforementioned systematic reviews completed a separate analysis of non-surgical retreatment procedures and the effects of instrumentation kinematics on the intake of postoperative pain medication.

A more comprehensive systematic review of the literature may clarify and aid clinicians in selecting an optimal root canal preparation system. The aim of this study was to answer the following question through a systematic review and meta-analysis of the literature: in randomised controlled trials, are there differences in postoperative pain at 12, 24, and 48 hours, between continuous rotation and reciprocating instrumentation motions used in non-surgical root canal treatment and retreatment. Postoperative analgesic intake was analysed as a secondary outcome.

MATERIALS AND METHODS

Protocol and registration

The protocol of this systematic review was registered in the PROSPERO database under the registration number CRD42018095572. We adhered to the recommendations of preferred reporting items for systematic reviews and meta-analyses to report the results of this systematic review (30).

PICOS question

The elements of the PICOS question were:

1. Population (P): teeth requiring root canal therapy
2. Intervention (I): using a rotary file system for root canal preparation
3. Comparison (C): using a reciprocating file system for root canal preparation
4. Outcome (O): incidence of postoperative pain and the intake of postoperative analgesics
5. Study Design (S): randomised clinical trial

Literature search strategy

Four electronic databases namely, PubMed, Embase, Cochrane Library, and Scopus were searched for relevant articles published up to March 2020. Queries used for each online database are depicted in Table 1. We manually searched the bibliographies of the included studies and relevant articles for additional, eligible studies.

Eligibility criteria

Inclusion criteria were as follows:

1. Randomised clinical trial
2. Defined sample size
3. Postoperative pain score provided at various time intervals
4. Both rotary and reciprocating groups included
5. Published in an English language journal

Exclusion criteria were as follows:

1. Case report, non-randomised controlled trial, review, cross-sectional, cohort or case-control study
2. Incomplete or selective outcome reporting
3. Postoperative pain outcome not categorized as mild, moderate, or severe
4. Study which incorporated the use of both rotary and reciprocating instrumentation systems in one root canal or tooth
5. Studies on immature teeth

Study selection

After removing the duplicates, two authors (BRN and NZ) independently screened the titles and abstracts of the identified publications. The full texts of the screened articles were reviewed and eligible articles selected by the same authors. Disagreement between the authors regarding the study selection process was discussed with a third author (AS) and resolved.

Data extraction and quality assessment

Two authors (BRN and NZ) independently extracted the following data from the studies: instrumentation motion, author(s) and year of publication, instrumentation subgroup, pulpal/periapical condition, tooth type, sample size, sample characteristics, type of analgesic, and pain assessment. Cohen's Kappa statistic determined the level of agreement between authors.

Two authors (BRN and NZ) independently determined the risk of bias of the selected studies using the Cochrane Collaboration's risk of bias assessment tool for randomised controlled

TABLE 1. Search strategy for each online database

PubMed

#1	#2	#3	#4
(endodontics[MeSH Terms]) AND (postoperative pain[MeSH Terms])	(root canal instrumentation OR root canal therapy OR endodontic treatment OR endodontic retreatment OR root canal retreatment OR glide path)	(pain OR postoperative pain OR post-endodontic pain OR post-treatment pain OR post-preparation pain)	(continuous rotation OR rotary OR OneShape OR race OR profile OR ProTaper OR Mtwo OR Hyflex OR ProTaper Next OR nickel-titanium OR nickel-tita nium instrumentation OR recip rocating OR Reciproc OR WaveOne OR ScoutRace OR ProGlider OR path file OR WaveOne gold glider OR R-pilot OR one G OR WaveOne Gold OR Reciproc Blue)

#1 or (#2 and #3 and #4)

Embase

#1	#2	#3	#4
'endodontics'/exp/mj AND 'postoperative pain'/exp/mj	('root canal instrumentation' OR 'root canal therapy' OR 'endodontic treatment' OR 'endodontic procedure'OR 'endodontic retreatment' OR 'root canal retreatment' OR 'glide path')	('continuous rotation' OR rotary OR oneshape OR race OR profile OR protaper OR mtwo OR hyflex OR 'protaper next' OR 'nickel-titanium' OR 'nickel-titanium instrumentation' OR reciprocating OR reciproc OR waveone OR scoutrace OR proglider OR 'path file' OR 'waveone gold glider' OR 'r-pilot' OR 'one g' OR 'waveone gold' OR 'reciproc blue')	(pain OR 'postoperative pain' OR 'post-endodontic pain' OR 'post-treatment pain' OR 'post-preparation pain')

#1 or (#2 and #3 and #4)

Scopus

#1	#2	#3
("root canal instrumentation" OR "root canal therapy" OR "endodontic treatment" OR "endodontic retreatment" OR "root canal retreatment" OR "glide path")	(pain OR "postoperative pain" OR "post-endodontic pain" OR "post-treatment pain" OR "post-preparation pain")	("continuous rotation" OR rotary OR oneshape OR race OR profile OR protaper OR mtwo OR hyflex OR "protaper next" OR "nickel-titanium" OR "nickel-titanium instrumentation" OR reciprocating OR reciproc OR waveone OR scoutrace OR proglider OR "path file" OR "waveone gold glider" OR "R-pilot" OR "one G" OR "waveone gold" OR "re ciproc blue")

#1 and #2 and #3

Cochrane

#1	#2	#3
('root canal instrumentation' OR 'root canal therapy' OR 'endodontic treatment' OR 'endodontic retreatment' OR 'root canal retreatment' OR 'glide path')	(pain OR 'postoperative pain' OR 'post-endodontic pain' OR 'post-treatment pain ' OR 'post-preparation pain')	('continuous rotation' OR rotary OR oneshape OR race OR profile OR protaper OR mtwo OR Hyflex OR 'protaper next' OR 'nickel-titanium' OR 'nickel-titanium instrumentation' OR reciprocating OR reciproc OR waveone OR scoutrace OR proglider OR 'path file' OR 'waveone gold glider' OR 'R-pilot' OR 'one G' OR 'waveone gold glider' OR 'reciproc blue')

#1 and #2 and #3

studies (31). The following bias domains were evaluated: random sequence generation, allocation concealment, blinding of participants and providers/assessors, blinding of outcome assessment, incomplete outcome data, selective reporting, other biases and consequently the overall risk of bias. Any disagreement between the authors regarding the data extraction and the quality assessment of the studies was discussed with a third author (AS) and resolved.

Meta-analysis

All analyses were completed using Stata software version 12.0 (Stata Corporation, College Station, USA). A random effect inverse variance method to perform the meta-analysis was used because it considers the heterogeneity across the studies. The average values were converted to standardised mean differences (SMD) (i.e. Cohen's d value). Studies having an overall high risk of bias were not included in the meta-analysis. If the selected studies had only reported p-values, they were converted to z-values and subsequently to Cohen's d values. The study outcomes that reported results in binary form were converted to Cohen's d value using the following formula: d=log (OR)/1.814 (OR=odds ratio).

Outcomes of the selected studies were analysed at 12, 24 and 48 hours, postoperatively. If more than one rotary or reciprocating instrumentation group was featured, all groups were compared separately. No control group was included in our analysis.

Meta-regression analysis

If there was significant heterogeneity in the results, as determined by the Q statistic test, the random effects multivariable meta-regression analysis assessed the heterogeneity source. Significance was set at P≤0.05. The effects of the following covariates on postoperative pain outcomes in the studies were analyzed according to sample size, vital/necrotic tooth ratio, and symptomatic/asymptomatic tooth ratio.

RESULTS

Literature search and study selection

Figure 1 is the flowchart of the article search strategy and selection process. Duplicate articles were removed, and the remaining 1063 studies were screened by title and abstract. The remaining 27 articles were evaluated by full-text screening, and 19 articles were selected for inclusion in the review. The reasons for excluding eight articles are listed in Table 2.

Of the selected 19 studies, four were excluded from quantitative data analyses for the following reasons: one study had contradictory results (32), one had a high risk of bias (25), another failed to provide the mean, standard deviations and p-values despite contacting the authors (29). And, one study used Gates-Glidden drills alongside rotary and reciprocating files to remove gutta-percha from root canals (19). A total of 15 studies underwent data synthesis.

Characteristics of the included studies

Table 3 summarizes the characteristics of the reviewed studies. In two studies, the root canal treatment was completed in

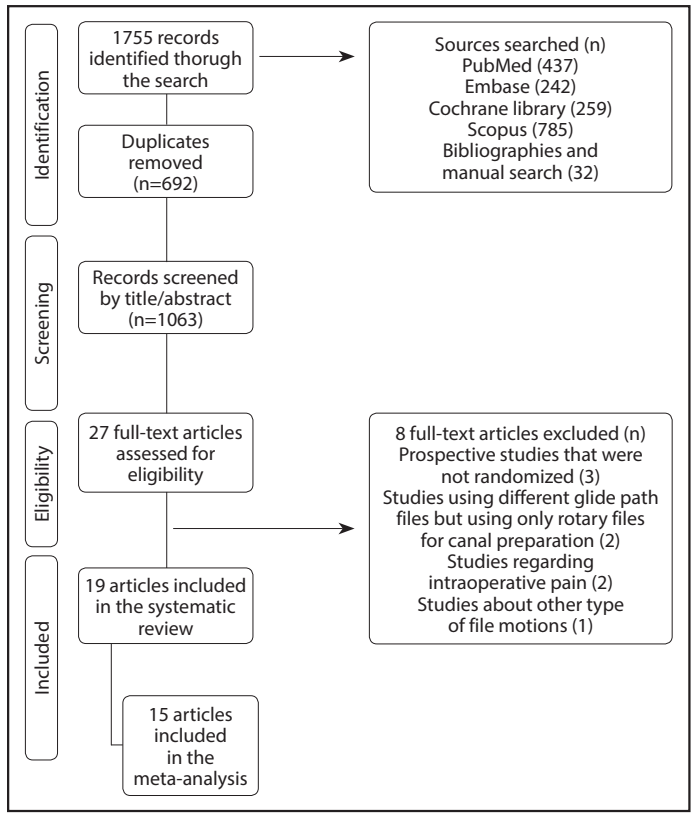

Figure 1. Search flowchart as instructed by PRISMA

two sessions (26, 33), two other studies utilized a single-session design without obturation (34, 35), and the remaining studies utilized a single-visit design with obturation. Four studies included hand file instrumentation as the control group (35-38), and two other studies used self-adjusting files in conjunction with rotary and reciprocating instrumentation (29, 39). The rotary and reciprocating root canal preparation systems used in the studies were WaveOne (17, 19, 25, 27, 33, 34, 36, 37, 39, 40), WaveOne Gold (29), Reciproc (17, 20, 26, 32, 38, 41, 42), Reciproc Blue (28), Neolix (25), OneShape (19, 38, 39, 41), Mtwo (20, 34), ProTaper Universal (33-36, 40, 42), ProTaper Next (17, 26, 27, 29, 37), RaCe (32), iRaCe (28), Revo-S (19) and XP-endo shaper (28). A total of 2767 teeth were instrumented, of which 1366 and 1401 were instrumented by the reciprocating and rotary instrumentation techniques, respectively. In the meta-analysis, 1198 teeth instrumented by rotary instruments and 1196 teeth instrumented by reciprocating instruments were included, making a total number

TABLE 2. Excluded articles and reasons for the exclusion at the full-text assessment stage

Exclusion reason	Studies
Prospective studies that were not randomised controlled trials	Gambarini et al. (16) Gambarini et al. (54) Garcia-Font et al. (18)
Studies using different glide path files but using only rotary files for canal preparation	Adıgüzel et al. (55) Keskin et al. (49)
Studies regarding intraoperative pain	Gomes et al. (48) Tüfenkçi et al. (56)
Studies about other type of file motions	AlOmari et al. (57)

TABLE 3. Characteristics of the Included studies

Author(s) and year of publication	Instrumentation file types	Pulpal/periapical condition	Type of teeth	Sample size	Sample characteristics	Analgesic	Pain assessment	Risk of bias	Number of visits
Neelakantan and Sharma 2015 (41)	Reciproc, OneShape	Symptomatic irreversible pulpitis with symptomatic apical periodontitis	Two mandibular molars in different arches	1210 605,605	Healthy, 25-40 years old	400mg Ibuprofen q8-12h	Visual analog scale daily for 7 days (none, mild, moderate, severe)	Low	Single visit
Nekoofar et al. 2015 (33)	WaveOne, ProTaper Universal	Irreversible pulpitis	Maxillary or mandibular premolar and molar teeth	42 21,21	Healthy, 15-55 years old	400mg Ibuprofen immediately post-operation and PRN. In case of severe pain, Ibuprofen 400mg q4h and Paracetamol 325mg q4h alternatively	Numerical rating scale 6, 12, 18, 24, 48,72 hours postoperatively	Low	Two sessions
Pasqualini et al. 2015 (40)	WaveOne, ProTaper Universal	Asymptomatic irreversible pulpitis, symptomatic irreversible pulpitis or pulp necrosis with or without apical periodontitis	Single or multirooted teeth	47 24,23	Healthy subjects, age not specified	Prescription of optional analgesics for 7 days	Visual analog scale evaluation	Low	Single visit
Kherlakian et al. 2015 (17)	WaveOne, Reciproc, ProTaper Next	Vital teeth/ prosthetic reasons	Maxillary or mandibular molar or premolar teeth	210 70,70,70	Healthy, 19-73 years old	400mg Ibuprofen in case of pain q6h	Visual analog scale 24. 48, 72 hours and 7 days postoperatively	Low	Single visit
Relvas et al. 2015 (42)	Reciproc, ProTaper Universal	Asymptomatic pulp necrosis with or without periapical lesion	Mandibular molar teeth	78 39,39	Healthy male subjects, 18-64 years old	Not mentioned	Verbal rating scale 24, 72 hours and 7 days postoperatively	Low	Single visit
Shokraneh et al. 2016 (36)	WaveOne, ProTaper Universal, hand files	Asymptomatic necrosis with periapical lesion	First or second mandibular molars	93 32,31,30	Healthy, 20-45 years old	400mg Ibuprofen q6h in case of pain	Heft-parker visual analog scale 6, 12, 18, 24, 48, 72 hours postoperatively	Low	Single visit
Krithikadatta et al. 2016 (34)	WaveOne, ProTaper Universal, Mtwo	Asymptomatic irreversible pulpitis, symptomatic irreversible pulpitis, or pulp necrosis with or without apical periodontitis	Premolars and molars with fully matured roots	148 49,49,50	Healthy, 18-55 years old	400mg Ibuprofen in case of severe pain	Visual analog scale pre-operatively and 2 ,4, 6, 8, 12, 36, 48 hours postoperatively	Low	Single visit

TABLE 3. Cont.

Author(s) and year of publication	Instrumentation file types	Pulpal/periapical condition	Type of teeth	Sample size	Sample characteristics	Analgesic	Pain assessment	Risk of bias	Number of visits
Jain et al. 2016 (39)	WaveOne, OneShape, SAF	Vital: symptomatic irreversible pulpitis or intentional pulpectomy for prosthetic reasons	First or second molars	141 47, 47, 47	Healthy or controlled systemic diseases, 30-55 years old	400mg Ibuprofen q6h	Functional pain scale 24, 48, 72 hours postoperatively	Unclear	Single visit
Zand et al. 2016 (32)	Reciproc, Race	Necrosis, absence of pain before treatment, normal periapical status or radiographic lesions under 2 mm in size	Mandibular molars	90 45, 45	Healthy, 19-59 years old	Not mentioned	Visual analog scale 4, 12, 24, 48, 72 hours postoperatively	High	Single visit
Çiçek et al. 2017 (37)	WaveOne, ProTaper Next, hand files	Asymptomatic necrotic teeth with periapical lesions. Non tender to percussion nor palpation	Maxillary and mandibular teeth with single straight root canal	90 30, 30, 30	Healthy, 21-65 years old	No analgesic prescribed	Verbal rating scale 12, 24, 48 (none, mild, moderate, severe)	Low	Single visit
Topçuoğlu and Topçuoğlu. 2017 (35)	Reciproc, ProTaper Universal, hand files	Failed root canal therapy and chronic apical periodontitis (asymptomatic)	Single-rooted upper incisor teeth	135 45, 45, 45	Healthy, 20-52 years old	Ibuprofen or Paracetamol in case of severe pain, dose not specified	Visual analog scale 6, 12, 18, 24, 48, 72 hours and 7 and 10 days postoperatively	Low	Single visit
Comparin et al. 2017 (20)	Reciproc, Mtwo	Retreatment Pericapical index=4	Maxillary or mandibular anterior, premolar and molar teeth	65 33, 32	Healthy, more than 18 years old	400mg Ibuprofen PRN	Verbal rating scale 24, 48, 72 hours postoperatively	Unclear	Single visit
Mollashahi et al.2017 (38)	Reciproc, OneShape, hand files	Symptomatic irreversible pulpitis	Maxillary or mandibular molars	150 50, 50, 50	Healthy, 20-50 years old	400 mg Ibuprofen PRN	Visual analog scale at 6, 12, 24, 48, 72 hours postoperatively	Unclear	Single visit
Ganguly Saha et al. 2018 (29)	WaveOne Gold, ProTaper Next, SAF	Symptomatic irreversible pulpitis with/ without apical periodontitis, with no periapical lesion	Maxillary and mandibular permanent premolar and molar teeth with fully matured roots	210 70, 70, 70	Healthy, 18-55 years old	Ibuprofen 400mg q6h in case of pain	Visual analog scale 24, 48, 72 hours and 7 days postoperatively	Unclear	Single visit
Hussein et al. 2018 (25)	WaveOne, Neolix	Symptomatic irreversible pulpitis	Mandibular premolars	44 22, 22	Healthy, 20-35 years old	Not mentioned	Number rating scale at 6, 12, 24, 48 hours postoperatively	High	Single visit

TABLE 3. Cont.

Author(s) and year of publication	Instrumentation file types	Pulpal/periapical condition	Type of teeth	Sample size	Sample characteristics	Analgesic	Pain assessment	Risk of bias	Number of visits
Oliveira et al. 2019 (26)	Reciproc, ProTaper Next	Asymptomatic irreversible pulpitis, chronic hyperplastic pulpitis, symptomatic apical periodontitis	Maxillary or mandibular molar teeth	58 29, 29	Healthy, 18-66 years old	400mg Ibuprofen q4h in case of severe postoperative pain	Visual analog scale 24 hours postoperatively	Low	Two sessions
Adiguzel et al. 2019 (28)	Reciproc blue, Xp-endo shaper, iRace	Asymptomatic pulp necrosis	First or second mandibular molars	69 23, 23, 23	Healthy, 21-65 years old	Ibuprofen (400 mg)	Visual analog scale 24, 48 and 72 hour and 1 week postoperative intervals	Low	Single visit
Eyuboglu and Özcan 2019 (19)	One Shape, Revo-S, WaveOne	Failed root canal therapy, asymptomatic teeth with periapical lesions	Maxillary and mandibular teeth	99 33, 33, 33	Healthy, mean age: 45.7±13.9	Naproxen sodium (550mg) Acetaminophen (500 mg)	Self-administered questionnaire 6, 12, 18, 24, 48, and 72 hours, 7 days, and 1 month	High	Single visit
Kurnaz 2019 (27)	ProTaper Next, WaveOne	Asymptomatic pulp necrosis and radiographic evidence of apical periodontitis	Maxillary and mandibular incisors and canines, mandibular premolars	60 30, 30	Healthy, mean age: 33.3±7.1 (WO), 31.7±8.6 (PTN)	Ibuprofen (400 mg)	Visual analog scale 1-7 days	Low	Single visit

of 2394 of teeth for the quantitative analysis. Three selected studied nonsurgical endodontic retreatment (19, 20, 35) while other studies were of initial endodontic treatment. Visual analog scale, numerical rating scale, verbal rating scale, self-administered questionnaire and functional pain scale were used in studies to assess pain outcomes. Ibuprofen, paracetamol or naproxen sodium were used for pain relief whenever any analgesics were prescribed.

Quality assessment

Table 4 presents the results of risk of bias assessment. Out of the 19 articles included in this systematic review, 12 articles had an overall low risk of bias (17, 26-28, 33-37, 40-42), four had an overall unclear risk of bias (20, 29, 38, 39), and three had an overall high risk of bias (19, 25, 32). Allocation concealment was the most commonly noted source of bias across the studies.

Meta-analysis

In six studies, pain scores were assessed at 12 hours, postoperatively. Although the mean pain scores were higher in the reciprocating motion group, there were no significant differences between the reciprocating and rotary instrumentation groups at 12 hours, postoperatively (SMD=0.128; CI: -0.078 to 0.334; P=0.224) (Fig. 2). The pooled data analysis was not affected by heterogeneity (Q=6.376 on six degrees of freedom; P=0.382).

In 15 studies, pain scores were assessed at 24 hours, postoperatively. Although the pain scores were higher in the reciprocating motion groups, there were no significant differences between the reciprocating and rotary instrumentation groups at 24 hours, postoperatively (SMD=0.157; CI: -0.073 to 0.387; P=0.182) (Fig. 3). The pooled data analysis was affected by heterogeneity (Q=37.567 on 14 degrees of freedom; P=0.001).

In 12 studies, pain scores were assessed at 48 hours, postoperatively. The mean pain scores were higher in the reciprocating motion groups but there were no significant differences between the reciprocating and rotary instrumentation groups at 48 hours, postoperatively (SMD=0.169; CI: 0.017 to 0.322; P=0.030) (Fig. 4). The pooled data analysis was affected by heterogeneity (Q=37.567 on 14 degrees of freedom, P=0.001).

Additionally, the meta-analysis of the analgesic intake showed that there was no significant difference between the rotary and reciprocat-

TABLE 4. Risk of bias assessments

Author, year	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias	Overall risk of bias
Neelakantan and Sharma 2015 (42)	+	+	+	+	+	+	+	+
Nekoofar et al.2015 (34)	+	+	+	+	+	+	+	+
Pasqualini et al. 2015 (41)	+	+	+	+	+	+	+	+
Kherlakian et al.2015 (17)	+	+	+	+	+	+	+	+
Relvas et al. 2015 (43)	+	+	+	+	+	+	+	+
Shokraneh et al. 2016 (37)	+	+	+	+	+	+	+	+
Krithikadatta et al. 2016 (35)	+	+	+	+	+	+	+	+
Jain et al.2016 (40)	?	?	+	+	+	+	+	?
Zand et al. 2016 (33)	+	?	+	+	+	+	-	?
Çiçek et al. 2017 (38)	+	+	+	+	+	+	+	+
Topçuoğlu and Topçuoğlu. 2017 (44)	+	+	+	+	+	+	+	+
Comparin et al. 2017 (20)	+	?	+	+	+	+	+	?
Mollashahi et al.2017 (39)	?	+	+	+	+	+	+	?
Ganguly Saha et al. 2018 (30)	+	+	+	+	?	+	+	?
Hussein et al. 2018 (25)	+	+	+	-	+	+	+	-
Oliveira et al. 2019 (27)	+	+	+	+	+	+	+	+
Adiguzel et al. 2019 (29)	+	+	+	+	+	+	+	+
Eyuboglu and Özcan 2019 (19)	+	+	+	+	+	+	-	-
Kurnaz 2019 (28)	+	+	+	+	+	+	+	+

+, low risk of bias; ?, unclear risk of bias; -, high risk of bias

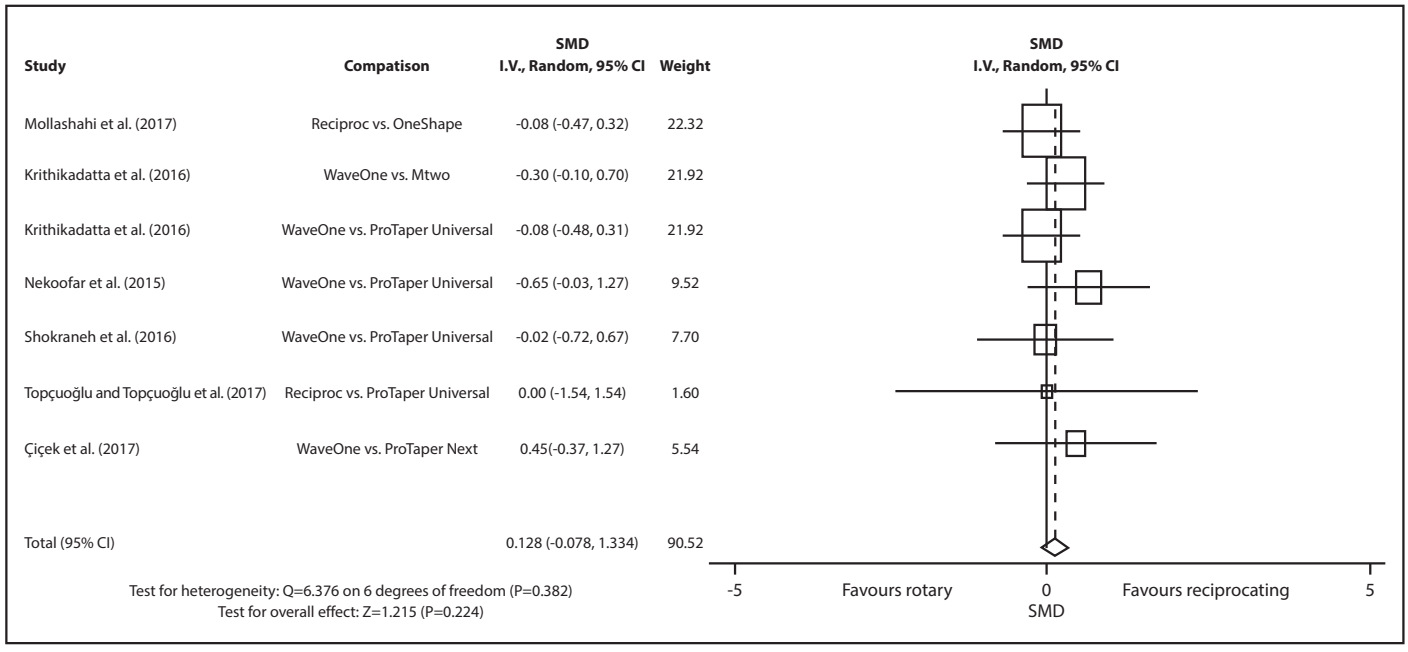

Figure 2. Forest plot showing postoperative pain. Standardised mean differences of rotary versus reciprocating instruments at 12 hours

ing motion groups (SMD=-0.026; CI: -0.288 to 0.236; P=0.846) (Fig. 5). The pooled data analysis was affected by heterogeneity (Q=30.255 on 11 degrees of freedom, P=0.001).

Meta-regression analysis

Results of the meta-regression analysis indicated that sample size affected the heterogeneity among the studies for pain scores in 24 hours (P≤0.05) and 48 hours (P<0.05). Pulpal diagnosis (P>0.05) and preoperative pain (P>0.05) did not affect the heterogeneity among the studies of 24 and 48-hour pain and analgesic intake. Only one study (42) contributed to heterogeneity in analgesic intake analysis. Upon removal of this study, the result of the analgesic intake analysis was no longer affected by heterogeneity (Q=15.378 on 10 degrees of freedom, P=0.119).

DISCUSSION

Although pain is subjective, biological and clinical factors are often responsible for its' initiation (43, 44). We conducted a systematic search on the effect of instrumentation motions on postoperative pain after non-surgical root canal therapy, and conducted a meta-analysis when possible. Our findings revealed no statistically significant difference between postop-

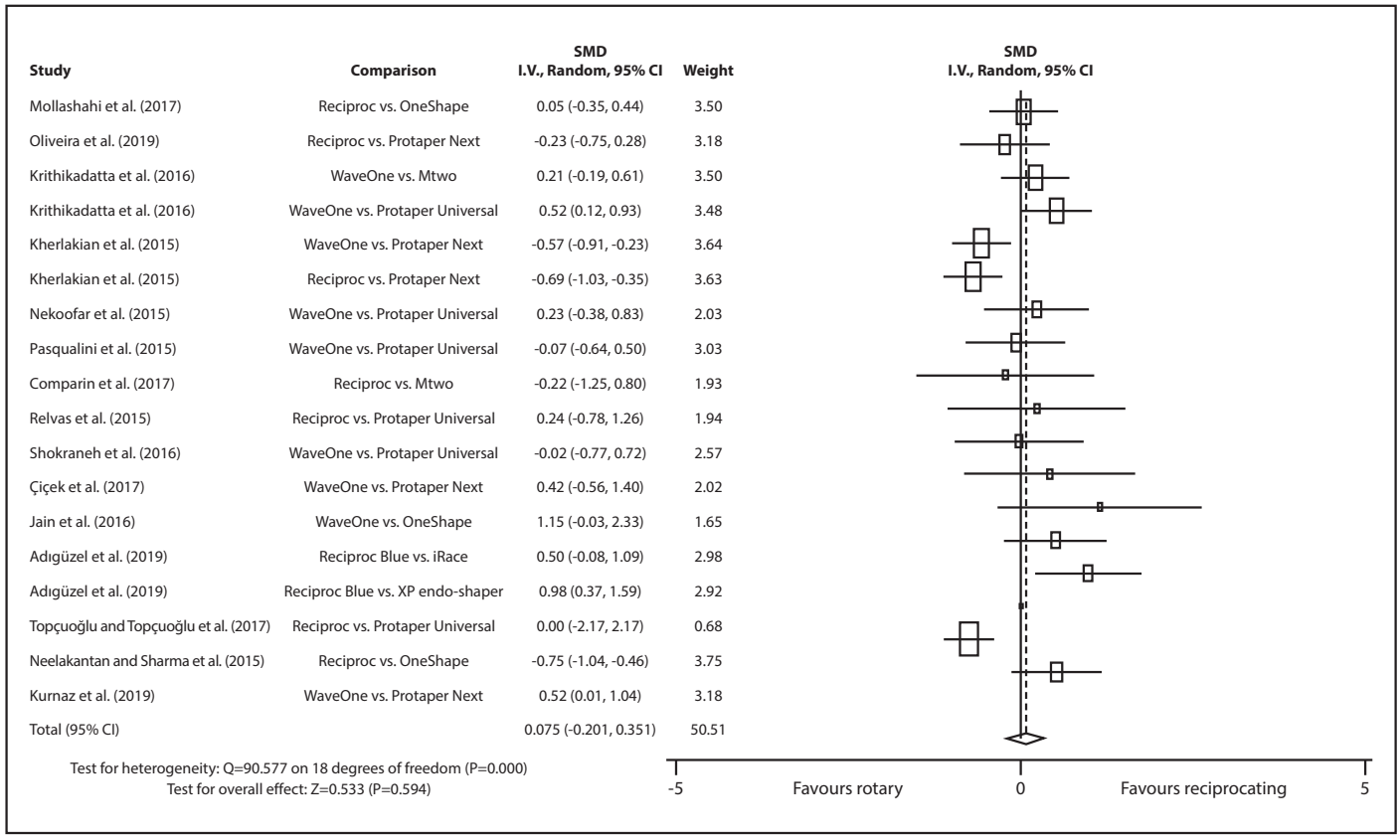

Figure 3. Forest plot showing postoperative pain. Standardised mean differences (SMD) of rotary versus reciprocating instruments

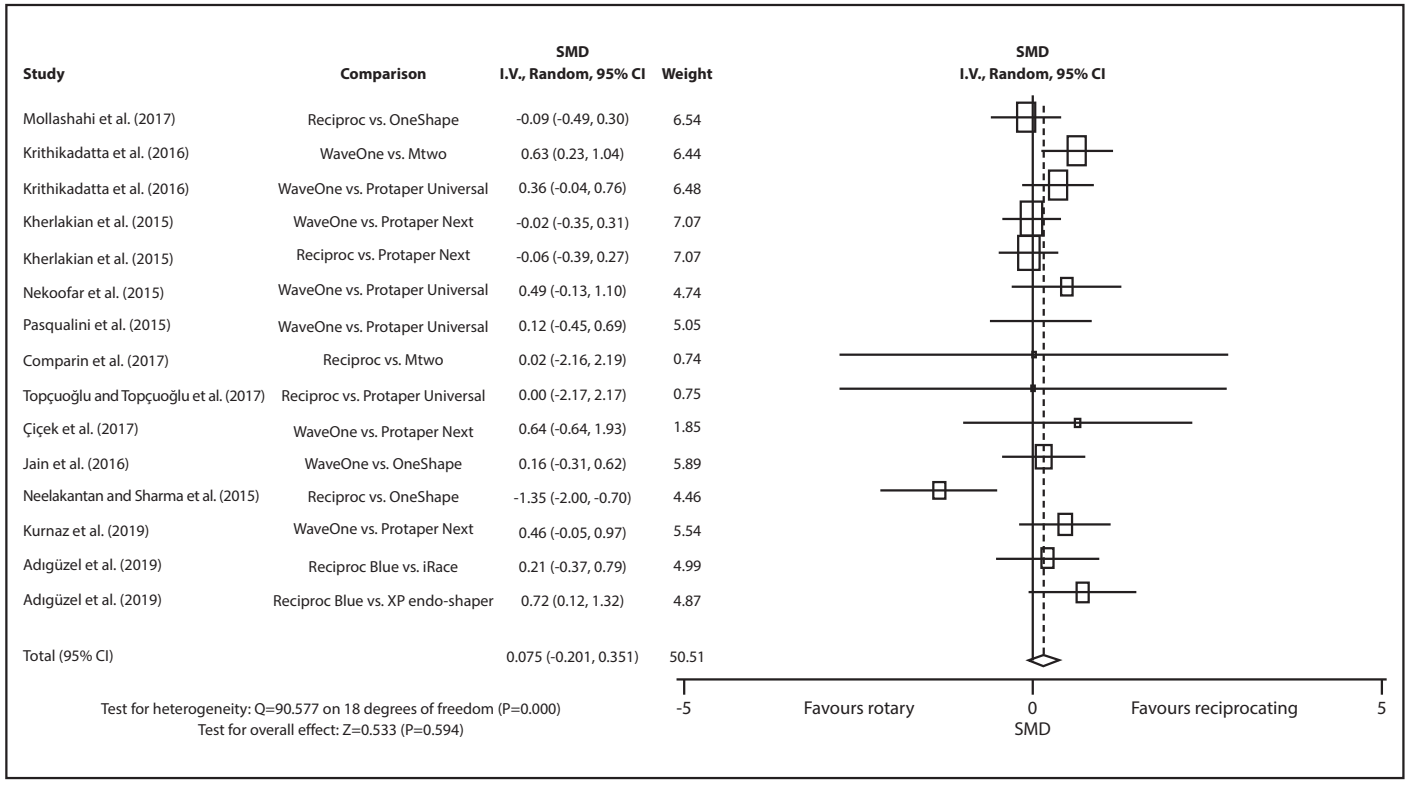

Figure 4. Forest plot showing postoperative pain. Standardised mean differences (SMD) of rotary versus reciprocating instruments at 48 hours

erative pain outcomes at 12, 24, and 48 hours. Additionally, the total amount of pain medication intake did not differ between the two instrumentation motions.

The results of the meta-analysis regarding postoperative pain values were consistent with that of the included studies. No controversies were present in the 12-hour group. However,

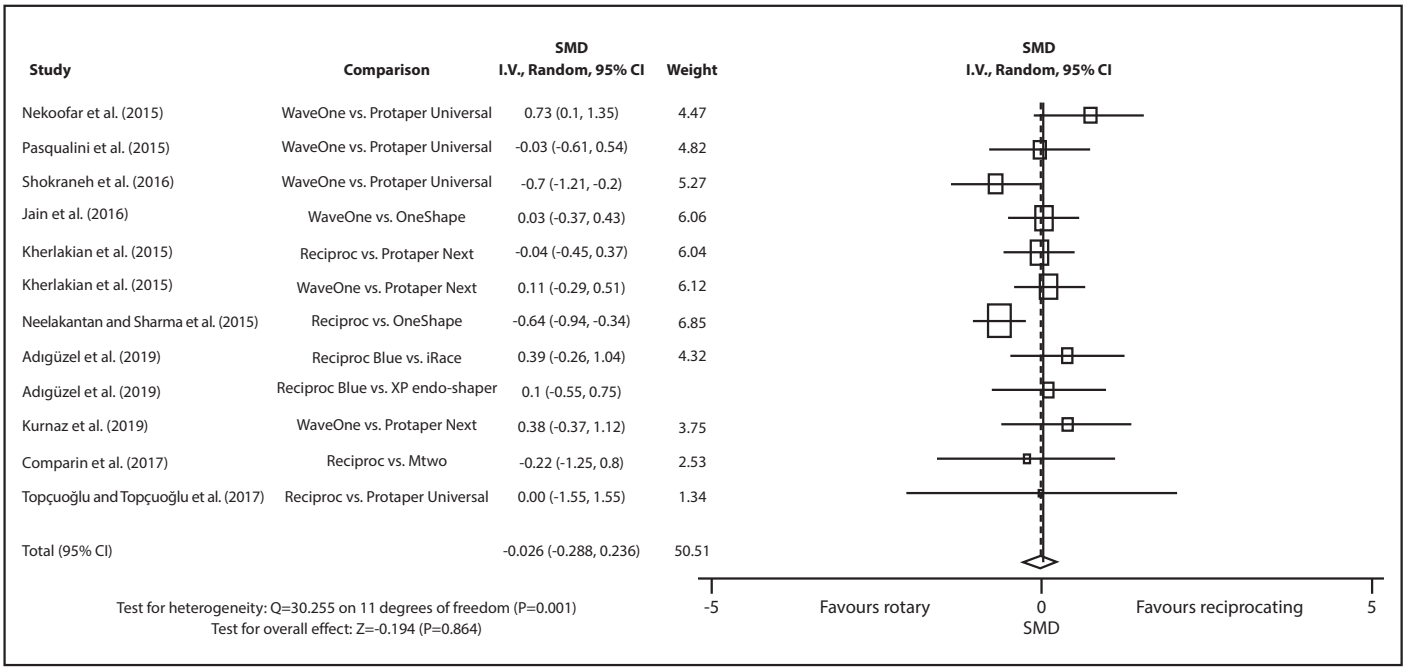

Figure 5. Forest plot showing postoperative pain. Standardised mean differences (SMD) of total analgesic intake

there were some conflicting studies in the 24-hour (17, 28, 34, 41) and 48-hour (28, 34, 41) groups where two studies reported lower pain values for reciprocating motions (17, 41), while the others stated the opposite (28, 34). Root canal treatment is complex and consists of several procedural steps. Complications in any step may affect the treatment outcome. Individual procedural problems can compound to alter the treatment outcome. The studies reviewed in this meta-analysis have different methodologies and parameters such as, but not limited to, type and dosage of local anesthetic, injection technique, type and volume of irrigants used, preparation systems, and use of a single file or multiple files for instrumentation, inclusion criteria, canal sizes, canal tapering, and obturation methods. Any one or combination of these can lead to differences between the results of this meta-analysis and other studies.

Although the meta-analysis showed insignificant differences between the groups regarding postoperative pain incidences, a meta-regression analysis showed that the highly variable number of participants across the studies was a significant heterogeneous factor that contributed to the overall heterogeneity of the studies at 24 and 48 hours. Other factors, such as pretreatment symptoms and pulp vitality, did not significantly contribute to the overall heterogeneity. In other words, if the included studies had larger sample sizes, such as in the studies of Neelakantan et al. (41) and Kherlakian et al. (17), significantly higher postoperative pain would have been observed in the rotary group. The pooled estimate of the meta-analysis was in favor of postoperative pain in the reciprocating group, although statistically insignificant, because of the cumulative effects of random errors caused by a high number of studies with small population sizes. Once again, this emphasizes the need for studies with larger sample sizes.

Ultimately, the best clinical predictor of pain may be the analgesic intake. The meta-analysis showed that the two groups did not differ in the overall pain medication intake. Therefore, it seems that while differences between postoperative pain outcomes may reach statistical significance, it might not be clinically significant, considering the total postoperative analgesic intake.

Regarding methods across the studies, most of them used the visual analog, numerical rating, or verbal rating scale, all of which are both valid and reliable (45). The difference between the statistical and clinical outcomes may be related to pain measurement methods that are subjective across studies. Newly developed objective pain measures (heart rate variability, functional magnetic resonance imaging, electroencephalography, and electromyography) are also valid, reliable, and feasible (46). Future research should include these measures with conventional pain measurement scales for more comprehensive comparisons.

A meta-analysis of *in vitro* studies utilising different instrumentation systems found no significant difference between rotary and reciprocating motions regarding apical debris extrusion (11). It is hypothesized that several factors cause postoperative pain, with a high amount of extruded debris being one suggested etiology (3, 26). Additionally, it has been shown that the use of rotary instruments leads to greater accumulation of pro-inflammatory mediators in the periapical region than reciprocating instruments. This is in line with the results of our meta-regression analysis (47). Instrumentation motion may not have been the only factor determining postoperative pain values. Hand instrumentation at the initial stages of treatment, among other variables, might have contributed to the amount of extruded debris, resulting in postoperative pain. However, we could not analyze hand preparation properties due to the lack of data regarding the motions, diverse morphology of root canals, and the different glide path preparation sizes.

This systematic review also included three trials (19, 20, 35) on non-surgical root canal retreatment of which two were included in the meta-analysis (20, 35). Although the two clinical trials showed no significant differences regarding postoperative pain scores in different treatment groups, their results should be interpreted with caution because of the limited number of patients. The study which was not included in the meta-analysis reported lower pain values in the rotary group. However, use of Gates Glidden drills in this study might have affected the results.

More effort should be made to control the number of variables and to utilize concise methodologies in clinical investigations. For example, when evaluating postoperative pain, combining instrumentation motions within one root canal or tooth, or measuring pain immediately post-treatment and not afterwards, leads to an erroneous conclusion. These results have limited value when conducting a systematic review (48, 49).

As discussed earlier, some of the studies provided endodontic treatment in two sessions (26, 33). Since our study measured the pain outcome only after the first visit, the number of sessions did not affect our results. No significant postoperative pain differences exist between single and multiple-visit root canal treatment (50). Data regarding sealer extrusion and other obturation mishaps affecting post-operative pain (51) were not provided in the studies reviewed. Therefore, these variables should be carefully considered when designing future studies.

Even though we excluded four relevant studies from the meta-analysis, our systematic review and meta-analysis included more studies comparing rotary and reciprocating groups than any previously published paper on this topic. Moreover, we are the first to explain, using statistical measures, why there are so many conflicting results reported in earlier published studies.

Although we acquired the included studies via a comprehensive literature search and a reasonable population size was obtained, this study did not analyse file systems separately and did not include the self-adjusting file systems. Another shortcoming of this study is that we did not attempt to analyse pain at longer time intervals. Future *in vivo* trials should apply different instrumentation motions to files with identical properties (52, 53). Well-controlled clinical studies with similar methodologies and large sample sizes are required to assess the relationship between endodontic instrumentation kinematics and postoperative pain.

CONCLUSION

This systematic review and meta-analysis did not find a difference in 12, 24, or 48-hour postoperative pain when reciprocating or rotary instrumentation was used for non-surgical root canal treatment. There was also no difference found in the amount of pain medication used by the patient.

Disclosures

Conflict of interest: No conflict of interest.

Ethics Committee Approval: The protocol was registered in PROSPERO database under the registration number CRD42018095572.

Peer-review: Externally peer-reviewed.

Financial Disclosure: No financial support requested from any institution.

Authorship contributions: Concept – N.Z., M.K.; Design – B.R.N., Behrad R.N.; Supervision – O.D., M.K., N.Z.; Funding - None; Materials - None; Data collection &/or processing – B.R.N., A.S., Behrad R.N.; Analysis and/or interpretation – B.R.N., A.S., N.Z., Behrad R.N.; Literature search – A.S., M.K., O.D., N.Z., B.R.N.; Writing – O.D., B.R.N., P.T.; Critical Review – O.D., P.T.

REFERENCES

1. Goodale DB. Inhibition of substance P release is the key to successful management of oral pain. Anesth Prog 1982; 29(4):103–7.
2. Pak JG, White SN. Pain prevalence and severity before, during, and after root canal treatment: a systematic review. J Endod 2011; 37(4):429–38.
3. Alves Vde O. Endodontic flare-ups: a prospective study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010; 110(5):e68–72.
4. Siqueira JF Jr. Microbial causes of endodontic flare-ups. Int Endod J 2003; 36(7):453–63.
5. Harrington GW, Natkin E. Midtreatment flare-ups. Dent Clin North Am 1992; 36(2):409–23.
6. Seltzer S, Naidorf IJ. Flare-ups in endodontics: I. Etiological factors. 1985. J Endod 2004; 30(7):476–81; discussion 475.
7. Bidar M, Rastegar AF, Ghaziani P, Namazikhah MS. Evaluation of apically extruded debris in conventional and rotary instrumentation techniques. J Calif Dent Assocs 2004; 32(9):665–71.
8. Seltzer S, Naidorf IJ. Flare-ups in endodontics: I. Etiological factors. J Endod 1985; 11(11):472–8.
9. Bürklein S, Schäfer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. J Endod 2012; 38(6):850–2.
10. Kirchhoff AL, Fariniuk LF, Mello I. Apical extrusion of debris in flat-oval root canals after using different instrumentation systems. J Endod 2015; 41(2):237–41.
11. Western JS, Dicksit DD. Apical extrusion of debris in four different endodontic instrumentation systems: A meta-analysis. J Conserv Dent 2017; 20(1):30–6.
12. Tanalp J, Güngör T. Apical extrusion of debris: a literature review of an inherent occurrence during root canal treatment. Int Endod J 2014; 47(3):211–21.
13. Uzunoglu E, Turker SA. Impact of different file systems on the amount of apically extruded debris during endodontic retreatment. Eur J Dent 2016; 10(2):210–4.
14. Dincer AN, Er O, Canakci BC. Evaluation of apically extruded debris during root canal retreatment with several NiTi systems. Int Endod J 2015; 48(12):1194–8.
15. Çanakçi BC, Ustun Y, Er O, Genc Sen O. Evaluation of apically extruded debris from curved root canal filling removal using 5 nickel-titanium systems. J Endod 2016; 42(7):1101–4.
16. 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. Ann Stomatol (Roma) 2013; 4(1):152–5.
17. Kherlakian D, Cunha RS, Ehrhardt IC, Zuolo ML, Kishen A, da Silveira Bueno CE. 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.
18. Garcia-Font M, Durán-Sindreu F, Morelló S, Irazusta S, Abella F, Roig M, et al. Postoperative pain after removal of gutta-percha from root canals in endodontic retreatment using rotary or reciprocating instruments: a prospective clinical study. Clin Oral Investig 2018; 22(7):2623–31.
19. Eyuboglu TF, Özcan M. Postoperative pain intensity associated with the use of different nickel-titanium shaping systems during single-appointment endodontic retreatment: a randomized clinical trial. Quintessence Int 2019; 50(8):624–34.
20. Comparin D, Moreira EJL, Souza EM, De-Deus G, Arias A, Silva EJNL. Postoperative pain after endodontic retreatment using rotary or reciprocating instruments: a randomized clinical trial. J Endod 2017; 43(7):1084–8.
21. Hou XM, Su Z, Hou BX. Post endodontic pain following single-visit root canal preparation with rotary vs reciprocating instruments: a meta-analysis of randomized clinical trials. BMC Oral Health 2017; 17(1):86.

22. Sun C, Sun J, Tan M, Hu B, Gao X, Song J. Pain after root canal treatment with different instruments: A systematic review and meta-analysis. Oral Dis 2018; 24(6):908–19.
23. Martins CM, De Souza Batista VE, Andolfatto Souza AC, Andrada AC, Mori GG, Gomes Filho JE. Reciprocating kinematics leads to lower incidences of postoperative pain than rotary kinematics after endodontic treatment: A systematic review and meta-analysis of randomized controlled trial. J Conserv Dent 2019; 22(4):320–31.
24. Spohr AR, Sarkis-Onofre R, Pereira-Cenci T, Pappen FG, Morgental RD. A systematic review: effect of hand, rotary and reciprocating instrumentation on endodontic postoperative pain. G Ital Endod 2019; 33(2).
25. Hussein YHY, Marzouk AM, El baz AA. A Comparative evaluation of the effect of root canal preparation by wave one and neolix on post-operative pain in mandibular premolars with acute irreversible pulpitis: a blinded randomized clinical trial study. Acta Sci Dent Sci 2019; 3(1):57–64.
26. Oliveira PS, da Costa KNB, Carvalho CN, Ferreira MC. Impact of root canal preparation performed by ProTaper Next or Reciproc on the quality of life of patients: a randomized clinical trial. Int Endod J 2019; 52(2):139–48.
27. Kurnaz S. Comparison of postoperative pain after foraminal enlargement of necrotic teeth using continuous rotary system and reciprocating instrument: A randomized clinical trial. Niger J Clin Pract 2020; 23(2):212–8.
28. Adiguzel M, Tufenkci P, Pamukcu II. Comparison of postoperative pain intensity following the use of three different instrumentation techniques: A randomized clinical trial. J Dent Res Dent Clin Dent Prospects 2019; 13(2):133–40.
29. Saha SG, Gupta RK, Bhardwaj A, Misuriya A, Saha MK, Nirwan AS. Comparison of the incidence of postoperative pain after using a continuous rotary system, a reciprocating system, and a Self-Adjusting File system in single-visit endodontics: A prospective randomized clinical trial. J Conserv Dent 2018; 21(3):333–8.
30. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009; 151(4):264–9.
31. Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, et al; Cochrane Bias Methods Group; Cochrane Statistical Methods Group. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ 2011; 343:d5928.
32. Zand V, Milani AS, Hassani Dehkharghani A, Rahbar M, Tehranchi P. Treatment of necrotic teeth using two engine-driven systems and patient's postoperative pain: a double-blind clinical trial. Iran Endod J 2016; 11(4):267–72.
33. Nekoofar MH, Sheykhrezae MS, Meraji N, Jamee A, Shirvani A, Jamee J, et al. 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.
34. Krithikadatta J, Sekar V, Sudharsan P, Velumurugan N. Influence of three Ni-Ti cleaning and shaping files on postinstrumentation endodontic pain: A triple-blinded, randomized, controlled trial. Journal of conservative dentistry . J Conserv Dent 2016; 19(4):311–6.
35. Topçuoğlu HS, Topçuoğlu G. Postoperative pain after the removal of root canal filling material using different techniques in teeth with failed root canal therapy: a randomized clinical trial. Acta Odontol Scand 2017; 75(4):249–54.
36. 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 2017; 21(1):413–8.
37. Çiçek E, Koçak MM, Koçak S, Sağlam BC, Türker SA. Postoperative pain intensity after using different instrumentation techniques: a randomized clinical study. J Appl Oral Sci 2017; 25(1):20–6.
38. Mollashahi NF, Saberi EA, Havaei SR, Sabeti M. Comparison of postoperative pain after root canal preparation with two reciprocating and rotary single-file systems: a randomized clinical trial. Iran Endod J 2017; 12(1):15–9.
39. Jain N, Pawar AM, Naganath M, Gupta A, Daryani H. Incidence and severity of postoperative pain after canal instrumentation with reciprocating system, continuous rotary single file system, versus SAF system. ENDO (Lond Engl) 2016; 10(3):153–60.
40. Pasqualini D, Corbella S, Alovisi M, Taschieri S, Del Fabbro M, Migliaretti G, et al. Postoperative quality of life following single-visit root canal treatment performed by rotary or reciprocating instrumentation: a randomized clinical trial. Int Endod J 2016; 49(11):1030–9.
41. Neelakantan P, Sharma S. Pain after single-visit root canal treatment with two single-file systems based on different kinematics--a prospective randomized multicenter clinical study. Clin Oral Investig 2015; 19(9):2211–7.
42. Relvas JB, Bastos MM, Marques AA, Garrido AD, Sponchiado EC Jr. Assessment of postoperative pain after reciprocating or rotary NiTi instrumentation of root canals: a randomized, controlled clinical trial. Clin Oral Investig 2016; 20(8):1987–93.
43. Nixdorf DR, Law AS, Lindquist K, Reams GJ, Cole E, Kanter K, et al; National Dental PBRN Collaborative Group. Frequency, impact, and predictors of persistent pain after root canal treatment: a national dental PBRN study. Pain 2016; 157(1):159–65.
44. Fillingim RB. Individual differences in pain: understanding the mosaic that makes pain personal. Pain 2017; 158 Suppl 1(Suppl 1):S11–8.
45. Karcioglu O, Topacoglu H, Dikme O, Dikme O. A systematic review of the pain scales in adults: Which to use? Am J Emerg Med 2018; 36(4):707–14.
46. Wagemakers SH, van der Velden JM, Gerlich AS, Hindriks-Keegstra AW, van Dijk JFM, Verhoeff JJC. A systematic review of devices and techniques that objectively measure patients' pain. Pain Physician 2019; 22(1):1–13.
47. Caviedes-Bucheli J, Rios-Osorio N, Rey-Rojas M, Laguna-Rivero F, Azuero-Holguin MM, Diaz LE, et al. Substance P and Calcitonin gene-related peptide expression in human periodontal ligament after root canal preparation with Reciproc Blue, WaveOne Gold, XP EndoShaper and hand files. Int Endod J 2018; 51(12):1358–66.
48. Gomes AC, Soares AJ, Souza EM, Zaia AA, Silva EJNL. Intraoperative discomfort associated with the use of a rotary or reciprocating system: a prospective randomized clinical trial. Restor Dent Endod 2017; 42(2):140–5.
49. Keskin C, Sivas Yilmaz Ö, Inan U, Özdemir Ö. Postoperative pain after glide path preparation using manual, reciprocating and continuous rotary instruments: a randomized clinical trial. Int Endod J 2019; 52(5):579–87.
50. Manfredi M, Figini L, Gagliani M, Lodi G. Single versus multiple visits for endodontic treatment of permanent teeth. Cochrane Database Syst Rev 2016; 12(12):CD005296.
51. Shashirekha G, Jena A, Pattanaik S, Rath J. Assessment of pain and dissolution of apically extruded sealers and their effect on the periradicular tissues. J Conserv Dent 2018; 21(5):546–50.
52. Jin SY, Lee W, Kang MK, Hur B, Kim HC. Single file reciprocating technique using conventional nickel-titanium rotary endodontic files. Scanning 2013; 35(6):349–54.
53. You SY, Bae KS, Baek SH, Kum KY, Shon WJ, Lee W. Lifespan of one nickel-titanium rotary file with reciprocating motion in curved root canals. J Endod 2010; 36(12):1991–4.
54. Gambarini G, Al-Sudani D, Di Carlo S, Pompa G, Pacifici A, Pacifici L, et al. Incidence and intensivity of postoperative pain and periapical inflammation after endodontic treatment with two different instrumentation techniques. Eur J Inflamm 2012; 10(1):99–103.
55. Adiguzel M, Yilmaz K, Tufenkci P. Comparison of postoperative pain intensity after using reciprocating and continuous rotary glide path systems: a randomized clinical trial. Restor Dent Endod 2019; 44(1):e9.
56. Tüfenkçi P, Adiguzel M, Yilmaz K. Intraoperative pain during glide path creation with the use of a rotary or reciprocating system. Cumhuriyet Dent J 2019; 22(1):66–73.
57. AlOmari T, AlThobiti G, AlThobaiti S, AlOufi F, Masuadi E, Jamleh A. Incidence of postoperative pain after canal shaping by using Reciproc and Twisted File Adaptive systems: a prospective, randomized clinical trial. Clin Oral Investig 2020; 24(7):2445–50.