



Postoperative pain after removal of gutta-percha from root canals in endodontic retreatment using rotary or reciprocating instruments: a prospective clinical study

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Received: 5 September 2017 / Accepted: 24 January 2018 / Published online: 2 February 2018
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Abstract

Objectives The aim of this clinical study was to evaluate and compare the incidence and intensity of postoperative pain following removal of gutta-percha from root canals using rotary and reciprocating instruments.

Materials and methods One hundred and sixty patients scheduled for a non-surgical endodontic retreatment were included for evaluation. Preoperative pain was recorded with using a questionnaire with a 10-cm visual analogical scale (VAS). Endodontic filling material was removed with Reciproc (VDW, Munich, Germany) or ProFile (Dentsply Tulsa Dental Specialties, Tulsa, OK) instruments. Patients then recorded their postoperative pain in a VAS pain scale at 4, 8, 16, 24, 48, and 72 h post-treatment. Results were analyzed using the Mann-Whitney *U*, Kruskal-Wallis, and Chi-square tests. Multivariate logistic and a multiple regression analysis were used to detect the effect of confounding factors.

Results Results showed a direct relation between the intensity of pre-operative pain and that of postoperative pain ($P < .05$). No significant differences were observed between the two groups regarding postoperative pain ($P > .05$) as a qualitative variable. As numerical values, statistically significant differences were found regarding sex and the system used ($P < .05$).

Conclusions The method for pain evaluation was determinant in postoperative pain findings. Endodontic retreatment preparation with Reciproc results in lower values of postoperative pain compared with ProFile. Women are more susceptible to postoperative pain than are men.

Clinical relevance One of the most significant contributions of this research is the importance given to the method used for pain evaluation. The present study analyzed postoperative pain resulting from the use of reciprocating or continuous rotary instruments during removal of gutta-percha in retreatment procedures.

Keywords Postoperative pain · Endodontic retreatment · Reciproc · ProFile

Introduction

The aim of nonsurgical endodontic retreatment is to correct errors in previously failed treated teeth. Retreatment is

achieved by first eliminating preexisting filling materials, then gaining access to the apical third to adequately clean and shape the root canal system, and finally seal the root canal [1]. Although the success rate of nonsurgical endodontic retreatment is lower than initial endodontic treatment, the prognosis is still high [2]. Around 80% of endodontically retreated teeth heal and 89–95% remain asymptomatic and functional after 4–6 years [3].

Mechanical instruments can be used to remove filling materials while simultaneously reshaping. This range of instruments includes a number of rotary files that are used to remove root canal filling materials from the root canal. ProFile instruments (Dentsply Tulsa Dental Specialties, Tulsa, OK), which are effective gutta-percha removal [4], have a U-shaped cross-section with cutting edges supported by three radial lands,

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allowing the instrument to remain centered in the canal, thus minimizing root canal transportation and other procedural errors. Single-file reciprocating instruments, although not originally designed for endodontic retreatment, have shown to be effective in removing guttapercha and sealer [5]. Reciproc instruments (VDW, Munich, Germany), made of an M-Wire alloy, are characterized by an S-shaped cross-section with a gradually decreasing taper.

While postoperative pain following an endodontic procedure is distressing for the patient, particularly when he or she arrives asymptomatic at the dental office, it is professionally unacceptable for the clinician. One of the problems of using mechanical techniques to remove root canal filling materials is the extrusion of debris and other material through the apex, which could be related to postoperative pain. Dentinal debris, infected dentin, root canal filling materials, microorganisms, and irrigation solutions can be driven through the apical foramen, causing inflammation and damage to the periradicular tissues [6]. Depending on the amount of damage caused to the periapical tissues, higher or lower levels of postoperative pain can be provoked [7, 8].

There is no consensus as whether rotating or reciprocating systems produce more or less extrusion of detritus. Some studies [9, 10] show that reciprocating systems produce less debris extrusion compared to multife rotary systems. However, Çanakçı et al. [11] claim that desobturation with Reciproc instruments produces a greater amount of debris extrusion through the apical foramen than that produced by rotary systems.

Regarding the relationship between desobturation procedures and postoperative pain, to our knowledge, only two studies have evaluated and compared postoperative pain after endodontic retreatment using rotary instruments with different kinematics [12, 13]. However, one study evaluates only post-operative pain after complete retreatment, whereas the other study takes into account only patients without preoperative pain. There are many discrepancies in the literature regarding the results of postoperative pain; these may be due to whether postoperative pain is measured quantitatively or qualitatively. Therefore, the present study assesses pain from both a quantitative and qualitative viewpoint in order to observe whether the method of pain measurement shows significant differences between the two groups.

Therefore, the primary objective of this clinical study was to compare the incidence and intensity of postoperative pain following the removal of gutta-percha from the root canals in the first visit of endodontic retreatment using ProFile and Reciproc instruments. The null hypothesis tested was that there is no difference in postoperative pain following the removal of gutta-percha between among the two systems used.

Materials and methods

The present clinical study included patients who had been scheduled for non-surgical endodontic retreatment. This study

was approved by the Institutional Ethics in Research Committee (END-ECL-2013-01). All patients included in this study were previously given an informed consent about the procedure, risks and benefits, as well as their right to decide whether to participate or not.

Sample size calculation

The sample size calculation, based on an error of alpha of 0.05 and a power of 80%, indicated that a minimum sample size of 78 individuals per group would be required to detect differences.

Patient selection

Prior to treatment, patients were asked to fill in a questionnaire on their clinical status and demographic data. The inclusion criteria were as follows: patients over 18 years old, who had read, accepted, and signed the informed consent form; patients who had been scheduled for an endodontic retreatment considered as the best treatment plan choice; and teeth with an initial root canal filling between 2 and 4 mm short from the apex. The exclusion criteria were as follows: patients who did not meet the above mentioned criteria; teeth with an open apex; patients with allergies to nonsteroidal anti-inflammatory drugs or local anesthetic agents; patients with external or internal root resorptions; patients who had taken analgesics within the last week; patients undergoing antibiotic treatment 2 weeks before the scheduled retreatment appointment; patients with pacemakers; pregnant women; patients who failed to complete the pain evaluation form; patients who did not return to complete the root canal retreatment.

Patient questionnaire and analysis of preoperative pain

All treatments were performed by second- or third-year endodontic residents in no particular order, in accordance with the retreatment procedure protocol established by the Department of Endodontics of the University. Pain assessment was evaluated with a visual analog scale (VAS) [14]. Before beginning treatment, all patients were given a pain report form on which they would report their preoperative level of pain. The clinician first filled in an example together with each patient to confirm that they understood the instructions.

Root canal retreatment procedure

Teeth were anesthetized using Articaine 4% and epinephrine 1:100,000 (Ultracain, Normon, Madrid, Spain). The anesthetic technique that was used was the following: labial infiltration using 3.6 mL (two standard cartridges) for Maxillary teeth and Premolar Mandibular teeth.

Administration of a conventional inferior alveolar nerve block, using 1.8 mL, adding a labial infiltration (1.8 mL) for mandibular molars.

Each tooth was isolated with a rubber dam. Caries removal and access cavity were performed with sterile high-speed burs. When considered necessary, the operator performed a cervical margin elevation with resin composite to ensure adequate isolation.

ProFile and Reciproc were used for guttapercha removal as follows:

ProFile group: The instruments that were used for removing the gutta-percha filling were 40/.06, 35/.06, 35/.04, and 30/.04 in a crown-down technique. The working length (WL) was established 0.5 mm short of the apical foramen with a #10 K-file using an apex locator (VDW Gold Reciproc motor, Munich, Germany) and confirmed with a periapical radiograph. All instruments were used in a continuous movement with a slight apical pressure, with a range of 2–3 mm. When the instrument did not advance or met resistance in the root canal, the instrument was removed and the gutta-percha remains were removed; the instrument was then cleaned with a sterile alcohol-soaked gauze and reintroduced into the root canal or changed to another instrument accordingly to each root canal.

Reciproc group: Gutta-percha fillings were removed using R25 files with a slow in-and-out pecking motion, and the amplitude of pecking movements did not exceed 3–4 mm. After three in-and-out movements, the instrument was removed. The gutta-percha remains on the file were removed using an alcohol-soaked gauze. This procedure was repeated until the R25 reached the WL.

When additional apical enlargement was needed, ProFile instruments 35/0.04, 40/0.04, and R40 file were used in the two groups. The instruments in both groups were used in a torque control endodontic motor (VDW Gold Reciproc motor, VDW GmbH), in Reciproc All Mode or ProFile Mode. No solvent was used. Complete removal of the filling material was considered complete when no gutta-percha remains were observed, and a radiograph was taken for confirmation. Apical patency was verified using a # 10 K-file 1 mm beyond the apex.

The canals in both groups were irrigated with 4.2% NaOCl solution with a plastic syringe and a closed-end Max-i-Probe needle (Kerr-Hawe, Bioggio, Switzerland). Root canals were dried, and a calcium hydroxide paste (Calcicur, Voco GmbH, Germany) was placed as an intracanal medication until the following visit 15 days later. Finally, the access cavity was sealed with a temporary restoration (Cavit, 3M ESPE, Seefeld, Germany).

Analysis of postoperative pain

At the end of the visit, each patient was asked to determine the level of pain at in a VAS at 4, 8, 16, 24, 48, and 72 h after the procedure. Although no medication was prescribed, ibuprofen 600 mg every 8 h was recommended in case of need. If patients deemed medication necessary, they were asked to indicate the analgesic, dosage, and evolution of pain following administration.

At the second visit, the patient gave the completed form to the operator. Pre and postoperative pain values were recorded as a numerical scale between 0 and 10. These numerical values were also converted into a qualitative scale [7] as follows: no pain (0), slight pain (0.1–3.9), moderate pain (4–6.9), and severe pain (7–10). In addition, postoperative pain was recorded as the highest value of pain within the first 72 h after the procedure. This value was registered as the mean value of postoperative pain [7].

Statistical analysis

Statistical analysis was performed using Statgraphics Centurion XV software 15.2.06 (SPSS Inc., Chicago, IL). The Shapiro-Wilk test was used to determine result distribution. If no normal distribution was observed, the Mann-Whitney *U* test or the Kruskal–Wallis test was performed. The Chi-square test was used to evaluate differences between categorical variables. A multivariate logistic regression was used to identify a relation between the different independent variables (gender, type of teeth, location in the arch, age, system) and the patient's perception of pain or lack thereof (incidence). A multiple regression analysis was conducted to detect the effect of the different variables related to the level of pain as the maximum value recorded of postoperative pain (intensity). Significance was set at $P < .05$.

Results

Group distribution

A total of 160 subjects with one root canal retreatment were included for evaluation (81 retreatments performed with ProFile and 79 with Reciproc). Table 1 shows the demographic variables and clinical features of the patients. The mean age of the patients in the ProFile group was 45.8 years and in the Reciproc group, 46.1 years ($P > .05$).

Table 2 shows the mean values of preoperative pain between the different categories of variables. Preoperative pain was present in 53.1% of the participants. No statistically significant differences were observed within the distribution of the two groups (ProFile and Reciproc) in the different variables evaluated ($P > .05$).

Table 1 Baseline demographic and clinical features of patients in the study groups

Baseline demographic and clinical features	Reciproc, <i>n</i> (%) (<i>n</i> = 79)	ProFile, <i>n</i> (%) (<i>n</i> = 81)	Total
Male	33 (52.4)	30 (47.6)	63
Female	46 (47.4)	51 (52.6)	97
Maxillary teeth	49 (46.7)	56 (53.3)	105
Mandibular teeth	30 (54.5)	25 (45.5)	55
Anterior	27 (55.1)	22 (44.9)	49
Premolar	27 (46.6)	31 (53.4)	58
Molar	31 (58.5)	22 (41.5)	53
Absence of preoperative pain	45 (53)	40 (47)	85
Presence of preoperative pain	34 (45.3)	41 (54.7)	75

Postoperative pain

When considering pain as a dichotomous variable (incidence), the multivariate logistic regression analysis revealed that only the preoperative pain influenced the experience of postoperative pain after the procedure with an OR of 11.5 ($P < .00001$) (Table 3).

When considering postoperative pain as a quantitative variable (intensity), multiple regression analysis suggested that the level of preoperative pain, the system used, and the patient's gender were also significantly related with postoperative pain ($P < .05$) (Table 4).

Desobturation with ProFile instruments resulted in a higher mean of postoperative peak pain (2.50 ± 2.41) compared with Reciproc (2.03 ± 2.92) ($P < .05$). At all interval times, the ProFile group showed higher values of postoperative pain compared with Reciproc group. The mean value of postoperative pain at 4, 8, and 16 h was higher for the ProFile group than for the Reciproc group ($P < .05$). No statistically significant differences were observed at 24, 48, and 72 h ($P > .05$) (Table 5).

The frequency of pain after root canal filling removal was 46.2% (74/160 of the patients). Figure 1 shows the total frequency of postoperative pain between the two groups, and

Table 2 Mean values and SD of preoperative pain and clinical variables

		Mean and SD preoperative pain			<i>P</i> value
Sex	Men	Total	1.24 ± 2.22		0.09
		RC	1.05 ± 2.17	PF 0.89 ± 2.28	
	Women	Total	1.56 ± 2.32		0.60
		RC	1.40 ± 2.42	PF 1.71 ± 2.25	
Type of teeth	Molar	Total	1.08 ± 2.44		0.60
		RC	1.05 ± 2.50	PF 1.11 ± 2.41	
	Premolar	Total	1.50 ± 2.12		0.60
		RC	1.56 ± 2.37	PF 1.46 ± 1.78	
	Anterior	Total	1.29 ± 2.03		0.60
		RC	1.36 ± 2.08	PF 1.21 ± 2.01	
Location in the arch	Maxillary	Total	1.59 ± 2.46		0.76
		RC	1.56 ± 2.63	PF 1.61 ± 2.63	
	Mandibular	Total	1.48 ± 2.25		0.76
		RC	1.23 ± 2.04	PF 1.78 ± 2.49	
Age	18–30	Total	1.22 ± 1.86		0.85
		RC	1.17 ± 1.66	PF 1.49 ± 2.08	
	31–50	Total	1.15 ± 2.36		0.85
		RC	1.01 ± 2.41	PF 1.27 ± 2.34	
	+ 51	Total	1.36 ± 2.32		0.85
		RC	1.27 ± 2.61	PF 1.46 ± 2.02	
System	ProFile		1.42 ± 2.07		0.83
	Reciproc		1.34 ± 2.85		

RC Reciproc group,

PF ProFile group

Table 3 Logistic regression analysis of relationship of the different variables and the postoperative pain as a dichotomous variable

Variable	Estimated	Standard error	Inferior limit CI 95%	Superior limit CI 95%	OD	P value
Sex	1,98,515	0,432,261	0,845,083	4,66,325	1,98,515	0,1098
Type of teeth	0,816,955	0,284,644	0,465,547	1,43,361	0,816,955	0,4771
Location in the arch	0,730,029	0,443,537	0,785,975	1,67,321	0,730,029	0,2464
Preoperative pain	11,4943	0,628,136	3,32,292	32,7599	11,4943	0,0001
Age	0,700,268	0,28,829	0,396,188	1,23,773	0,700,268	0,2127
System	0,577,007	0,48,015	0,223,458	1,48,993	0,577,007	0,2442

Fig. 2 is its distribution both in a time line and in time intervals. The highest level of pain in the two groups was recorded at 4 h after the first visit and decreased over time ($P < .05$).

Patients with higher values of preoperative pain were more likely to experience postoperative pain ($P < .05$). In the Reciprocal group, the mean value of postoperative pain in patients with a history of preoperative pain was 3.39 ± 2.45 , whereas asymptomatic patients showed a mean value of 1.57 ± 2.61 . These results were similar in the ProFile group with mean values of 4.22 ± 2.31 and 1.58 ± 2.17 for symptomatic and asymptomatic patients before the treatment, respectively.

Table 6 shows the relation between pre and postoperative pain experienced by the patients in the present study in general and according to the system used for removal of the root canal filling. Overall, the patients in the group without preoperative pain, 48.2% (41/85), remained asymptomatic after the procedure, while only 4.9% (2/85) experienced severe postoperative pain ($P < .05$). The incidence of pain after the removal of the root canal filling measured 51.7% (50% in the ProFile group and 53.3% in the Reciprocal group) ($P > .05$). All of the patients who had severe preoperative pain experienced postoperative pain, and 71.4% (5/7) of these experienced severe pain.

Postoperative pain was significantly higher in females ($P = .008$) regardless of the system used to remove gutta-percha.

Of the 160 patients treated, only 41 (25.6%) reported having taken analgesics after the treatment. The intake of analgesics in both groups was significantly higher in the patients who experienced more pain ($P < .001$) (Table 7).

Table 4 Multiple regression analysis of relationship of the different variables and the postoperative pain as a quantitative variable

Variable	Estimated	Standard error	Inferior limit CI 95%	Superior limit CI 95%	P value
Sex	0,814,544	0,322,394	0,177,689	1,4514	0,0125
Type of teeth	-0,270,945	0,213,995	-0,693,735	0,151,845	0,2074
Location in the arch	0,00830017	0,370,622	-0,723,938	0,740,538	0,9822
Preoperative pain	1,55,102	0,373,505	0,813,198	2,28,884	0,0001
Age	-0,347,574	0,217,931	-0,778,139	0,082991	0,1828
System	-0,77,977	0,339,874	-1,45,115	-0,108,385	0,0231

Discussion

Postoperative pain is multifactorial and modulated both by factors related to the patients themselves and by the characteristics or condition of the teeth [15]. Thus, in addition to the presence and intensity of preoperative pain, demographic and tooth-related variables were also recorded. Statistical analysis indicated an adequate group distribution with no differences in any preoperative variable between groups ($p > .005$).

Root canal retreatment procedures can be completed in a single or multiple visit(s). However, there is no clear consensus as to which procedure is considered the best. High rates of clinical and radiographic success can be achieved after a one-visit root canal retreatment [16]. There is some controversy over the need for calcium hydroxide intracanal medication between visits. It has been claimed that an adequate bacterial reduction cannot be achieved without using an intracanal dressing of calcium hydroxide between visits, thus possible compromising healing potential [17]. Using calcium hydroxide as an intracanal medication between visits results in a reduction of bacteria when compared with a single-visit treatment [18]. In spite of the advantages of a single-visit treatment, Yoldas et al. [19] indicate that a two-visit treatment cannot be considered as an inadequate approach to pain relief. This is especially true in symptomatic cases where a two-visit approach resulted in a statistically significant reduction of postoperative pain compared with a one-visit treatment.

When evaluating the presence or sensation of pain as a qualitative variable, only the presence of preoperative pain resulted in a statistically significant difference in postoperative pain ($p > .005$). This result is in agreement with several studies

Table 5 Mean values and SD of postoperative pain at different time intervals

Previous pain	<i>n</i>	4 h no pain/pain (mean ± SD of pain)	8 h no pain/pain (mean ± SD of pain)	16 h no pain/pain (mean ± SD of pain)	24 h no pain/pain (mean ± SD of pain)	48 h no pain/pain (mean ± SD of pain)	72 h no pain/pain (mean ± SD of pain)
Profile	75	(1,76 ± 2,12)	(1,49 ± 1,73)	(1,31 ± 1,77)	(0,98 ± 1,50)	(0,70 ± 1,18)	(0,54 ± 0,95)
No pain	40	(1,40 ± 2,08)	(1,19 ± 1,97)	(1,05 ± 1,89)	(0,92 ± 1,73)	(0,88 ± 1,65)	(0,56 ± 1,19)
Pain	41	(2,63 ± 2,18)	(1,81 ± 1,78)	(1,55 ± 1,61)	(1,33 ± 378)	(0,91 ± 1,19)	(0,71 ± 0,98)
Reciproc	85	(1,40 ± 2,08)	(1,19 ± 1,97)	(1,05 ± 1,89)	(0,92 ± 1,73)	(0,88 ± 1,65)	(0,56 ± 1,19)
No pain	45	(1,09 ± 2,32)	(0,87 ± 1,80)	(0,88 ± 1,84)	(0,92 ± 1,90)	(0,73 ± 1,78)	(0,56 ± 1,66)
Pain	34	(2,38 ± 2,18)	(1,53 ± 1,74)	(1,12 ± 1,30)	(0,74 ± 1,74)	(0,56 ± 0,99)	(0,45 ± 0,70)
<i>P</i> value		0.04*	0.04*	0.03*	0.23	0.58	0.20

that show a higher presence of post-endodontic pain when patients experienced preexisting pain [20–22]. According to Yesilsoy et al. [23], patients who experience pain related to a treated tooth for the first time are psychologically less likely to expect pain than patients who already have experienced different levels of preoperative pain; therefore, their response may be conditioned. Besides, preoperative pain may indicate a preexisting inflammation of the periapical tissues that may be exacerbated after the procedure.

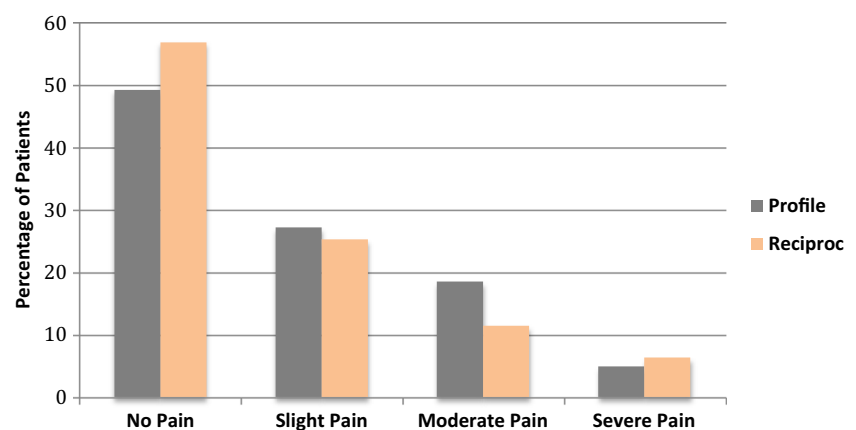
There are multiple studies regarding the relation of different variables that may influence postoperative endodontic-related pain [7, 21, 24, 25]. However, information regarding postoperative pain following a root canal retreatment is limited. No difference was found in postoperative pain regarding the rotary instruments and reciprocating instruments used to remove the root canal filling material ($p > .005$). These results are in agreement with the only two studies that have compared rotary and reciprocating instruments with postoperative pain after a non-surgical retreatment [12, 13]. Accordingly, this could lead us to conclude that the two systems can be used during endodontic retreatment with no difference to postoperative pain.

However, differences were observed when analyzing pain as a quantitative variable for statistical analysis in patients who have undergone a non-surgical retreatment. After a multiple

regression analysis of numerical pain values, statistical differences were found between desobturation instrument groups. In our study, non-surgical retreatment with Reciproc instruments resulted in a lower intensity of postoperative pain compared with ProFile instruments ($p < .005$). This difference demonstrates the importance of how postoperative pain is measured and evaluated.

A total of 66.3% of the patients experienced postoperative pain after the removal of the root canal filling. No statistical differences were observed regarding the system used (61.7% in the ProFile group and 64.5% in the Reciproc group). However, it has to be taken into account that the eligibility of the system used was performed in a parallel-arm study and was not randomized. This fact can be considered as a limitation and should be taken into account when analyzing the results. In addition, as a clinical study, apical enlargement was not standardized and was performed according to each specific case. According to Yaylali et al. [26], there are differences in postoperative pain regarding the apical enlargement size. However, Silva et al. [27] reported that apical enlargement did not influence the experience of postoperative pain.

The minimum intensity of a stimulus that awakens the sensation of pain in each patient is variable. In pain assessment, we try to objectify a phenomenon that is mainly subjective and subject to a high individual variability. This highlights how

Fig. 1 Severity of postoperative pain according to VAS

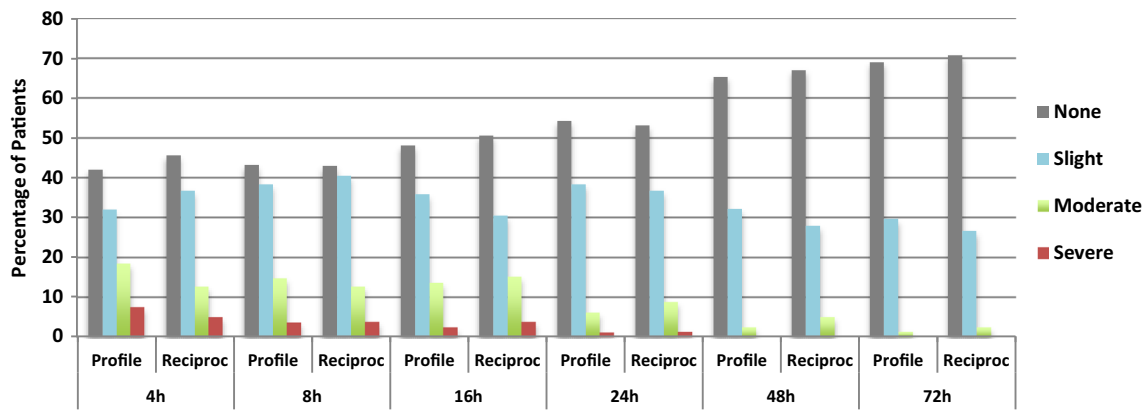


Fig. 2 Postoperative pain point prevalence

Table 6 Frequency and percentage of pre- and postoperative pain

Level of preoperative pain n (%)		Level of postoperative pain n (%)	
No pain 85 (53.1%)		No pain: 41 (48.2%) PF 20 (50%) RC 21 (46.7%) Slight pain: 28 (32.9%) PF 12 (30%) RC 16 (35.6%)	
ProFile (PF) 40 (49.4%)	Reciproc (RC) 45 (57%)	Moderate pain: 12 (14.1%) PF 6 (15%) RC 6 (13.3%) Severe pain: 4 (4.7%) PF 2 (5%) RC 2 (4.4%)	
Slight pain 41 (25.6%)		No pain: 10 (24.4%) PF 5 (20.8%) RC 5 (29.4%) Slight pain: 22 (53.7%) PF 14 (58.3%) RC 8 (47.1%)	
ProFile (PF) 24 (29.6%)	Reciproc (RC) 17 (21.5%)	Moderate pain: 7 (17.1%) PF 4 (16.7%) RC 3 (17.6%) Severe pain: 2 (4.9%) PF 1 (4.2%) RC 1 (5.9%)	
Moderate pain 27 (16.9%)		No pain: 3 (11.1%) PF 1 (7.7%) RC 2 (14.3%) Slight pain: 6 (22.2%) PF 3 (23.1%) RC 3 (21.4%)	
ProFile (PF) 13 (16%)	Reciproc (RC) 14 (17.7%)	Moderate pain: 15 (55.6%) PF 8 (61.5%) RC 7 (50%) Severe pain: 3 (11.1%) PF 1 (7.7%) RC 2 (14.3%)	
Severe pain 7 (4.4%)		No pain: 0 PF 0 (0%) RC 0 (0%) Slight pain: 0 (0%) PF 0 (0%) RC 0 (0%)	
ProFile (PF) 4 (5%)	Reciproc (RC) 3 (3.8%)	Moderate pain: 2 (28.6%) PF 1 (25%) RC 1 (33.3%) Severe pain: 5 (71.4%) PF 3 (75%) RC 2 (66.6%)	

complex it is to report results when evaluating pain. Methods of reporting patients' pain must be clear enough to be easily understood by patients and easily interpreted by investigators. VAS was used in this study because it fulfills these criteria and has been widely used in numerous studies [7, 25].

Mechanical, chemical, or microbial damage through the root canal system to the periapex may lead to an inflammatory response [8]. As a result of iatrogenic factors such as overinstrumentation or the extrusion of contaminated detritus, an acute inflammatory response can be generated as a result of forcing microorganisms and their products to the periradicular tissues and cause a long-term failure [28, 29]. The intensity of this response will depend on the amount and the virulence of microorganisms that are extruded [30].

Although the presence of microorganisms is associated with postoperative pain after endodontic procedures, there may be other causes. All retreatment techniques have reported extruding a certain amount of detritus through the apex. A lower amount of detritus has been reported after using Reciproc when compared with other crown-down techniques with rotary multi-file systems [9, 10, 30]. Silva et al. [30] concluded that possible explanations could be the differences in motion kinematics of both systems and the number of instruments used. Access to the working length terminus with a higher number of instruments could result in more extrusion of debris. Furthermore, differences in the cross-section of the instruments can also be related to differences in postoperative

Table 7 Analgesic intake and postoperative pain

	Analgesic, n (%)	Mean ± SD postoperative Pain	P value
Total (n = 160)	Intake 41 (25.6) No intake 119 (74.4)	4.61 ± 2.61 1.32 ± 1.90	< .05
ProFile (n = 81)	Intake 25 (30.9) No intake 56 (69.1)	4.84 ± 2.61 1.91 ± 2.30	< .05
Reciproc (n = 79)	Intake 16 (20.3) No Intake 63 (79.7)	3.83 ± 2.13 1.08 ± 1.40	< .05

pain [31]. A greater amount of the neuropeptides SP and CGRP were found after using systems that had a triangular cross-sectional design when compared with instruments with an S-shaped cross-section. The presence of these neuropeptides could indicate the relation between the extrusion of detritus and the inflammation of the periodontal ligament after root canal procedures [32].

Patient gender was statistically related to pain experience after first-visit root canal retreatment when evaluating pain as a quantitative variable. The results of this study showed that females compared with males experienced higher levels of postoperative pain ($P = .001$). This finding is in agreement with other studies where males experienced lower levels of postoperative pain after endodontic procedures [17, 33]. However, a recent study [12] reported the duration of pain with an OR of 14.33 (95% CI, 2.7–76.6) in males compared with females.

Gender has been suggested to have an influence on postoperative pain. Wise et al. [33] found a higher pain tolerance, a lower unpleasantness with pain, and a higher pain threshold in men in response to noxious thermal stimuli. In addition, Robinson et al. [34] reflected on the influence of gender-related expectations in pain response in their findings. They found that men are less pain-sensitive, more capable of bearing pain, and less disposed to reporting pain than are women.

It is worth highlighting that the incidence of postoperative pain understood as the sensation of pain after the procedure in patients with no previous symptoms was relatively high (51%). However, from this 51%, only 20% for ProFile and 17.7% for Reciproc were at levels considered moderate or severe pain. Similar results were reported by Yoldas et al. [19] with 19% of asymptomatic cases that resulted in different levels of postobturation pain after the first visit for a root canal retreatment. In asymptomatic apical periodontitis, a balance is often created between the host immune system and the bacterial microflora. Postoperative pain in these cases may appear due to a change in bacterial environment, over instrumentation, debris or irrigant extrusion, and removal of remaining pulp tissue [8].

Despite low percentages of moderate or severe postoperative pain reported in this study and others after a first visit for root canal retreatment, the recommendation to prescribe analgesics after the procedure should be taken into consideration, even in previously asymptomatic patients. The patients who took analgesics before the treatment were excluded, but the patients who took analgesics after the procedure were not. This issue could alter the results obtained; however, one of the secondary objectives of our study was to evaluate the need for analgesics after the treatment. However, in both the desobturation procedure groups (RC and PF) of this study, the patients who took some analgesics reported higher levels of pain compared with patients who took no analgesics. Although the level of pain was determinant in the analgesic

intake, some patients with a slight degree of pain also took painkillers, and only 41 (25.6%) out of the 108 (67.5%) patients who experienced any level of pain reported having taken analgesics. This value is lower than that of the patients who experienced a moderate or severe level of pain, indicating that that pain is a subjective sensation.

Patients who did not correctly fill in the questionnaire and those that did not return to finish the root canal retreatment were excluded from the statistical analysis. This could be considered as a limitation of the study because experience of a severe pain could be a reason for the patient not completing the questionnaire. However, patients that had pre-operative pain that ceased after the initial procedure might also have not returned to finish the treatment.

Conclusions

Within the limitations of this study, we conclude that preoperative pain influences the incidence of postoperative pain. Preoperative pain, the system used, and the patient's gender have an influence on the intensity of postoperative pain following the removal of gutta-percha from root canals.

Compliance with ethical standards

This study was approved by the Institutional Ethics in Research Committee (END-ECL-2013-01). All patients included in this study were previously given an informed consent about the procedure, risks and benefits, as well as their right to decide whether to participate or not.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. Project n. END-ECL-2013-01 was approved by the Committee of Research and Ethics of the Universitat Internacional de Catalunya, Barcelona, Spain.

Informed consent Informed consent was obtained from all individual participants included in the study.

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