ACTA ODONTOLOGICA SCANDINAVICA, 2017
VOL. 75, NO. 4, 249–254
http://dx.doi.org/10.1080/00016357.2017.1283707

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ORIGINAL ARTICLE

Postoperative pain after the removal of root canal filling material using different techniques in teeth with failed root canal therapy: a randomized clinical trial

Hüseyin Sinan Topçuoğlu[a] and Gamze Topçuoğlu[b]

[a]Department of Endodontics, Faculty of Dentistry, Erciyes University, Kayseri, Turkey; [b]Department of Pedodontics, Faculty of Dentistry, Erciyes University, Kayseri, Turkey

ABSTRACT

Objectives: This study evaluated the intensity and duration of postoperative pain after the removal of root canal filling material in retreatment procedures of upper incisor teeth with chronic apical periodontitis, using different techniques.

Materials and methods: One hundred and thirty-five patients requiring retreatment of upper incisor teeth with chronic apical periodontitis were included in the study. The patients were assigned to three groups of 45 patients, according to the method used to remove old canal filling material. In group 1, canal filling material was removed using hand files. In group 2, the canal filling material was removed with ProTaper universal retreatment (PTUR) instruments. In group 3, Reciproc instruments were used to remove canal filling material. Teeth were then medicated with calcium hydroxide and sealed using temporary filling material. The presence of postoperative pain was assessed after 6, 12, 24, 48 and 72 h, 7 days, and finally after 10 days.

Results: In all time intervals, except for 72 h, 7 days and 10 days, group 1 participants reported more intense postoperative pain than those in groups 2 and 3 ($p = 0.02$). In all time intervals, there was no difference in the pain scores between groups 2 and 3 ($p = 0.08$). In all groups, the intensity of postoperative pain decreased over time. The required time to remove canal filling material was less for the Reciproc group compared to the hand and ProTaper retreatment groups ($p = 0.032$).

Conclusions: Hand files caused greater postoperative pain after non-surgical endodontic retreatment (NSER) of upper incisor teeth with chronic apical periodontitis compared to the ProTaper retreatment and Reciproc files.

ARTICLE HISTORY
Received 3 November 2016
Revised 1 January 2017
Accepted 13 January 2017

KEYWORDS
Endodontics; postoperative pain; retreatment

Introduction

Non-surgical endodontic retreatment (NSER) is primarily performed when initial root canal therapy fails. NSER aims to re-establish healthy periapical tissues by regaining access to the root canal system through removal of the old canal filling, further cleaning and refilling [1]. Dentin chips, pulp tissue, microorganisms and/or irrigants may be extruded into the periradicular tissues during root canal preparation and removal of root canal filling material during NSER. This can be associated with undesirable consequences such as induction of inflammation, postoperative pain and delayed periapical healing [2–4].

Pain following endodontic treatment may be attributed to several factors, including age, sex, pulpal and periradicular status, type of tooth, sinus tracts, preoperative pain and technical factors [5]. Wang et al. [6] stated that the only variables controllable by the operator are the technical aspects, which includes instrumentation, irrigation and obturation protocols.

Various techniques are used for removal of root canal filling material during retreatment procedures. These techniques include hand files, engine-driven rotary retreatment files, ultrasonic tips/files and heat-carrying instruments [7]. The ProTaper Universal Retreatment (PTUR) system (Dentsply Maillefer, Ballaigues, Switzerland) was specifically developed for removal of root canal filling material and includes three instruments as follows: D1 (size 30/.09 taper), D2 (size 25/.08 taper) and D3 (size 20/.07 taper) [8]. Several studies have determined that ProTaper retreatment instruments are more effective in removing root filling material when compared to hand files [9,10]. A new reciprocating motion approach was introduced for instrumentation using nickel–titanium instruments with an M-Wire alloy, which is considered more resistant than conventional alloys. Reciproc (VDW, Munich, Germany) is based on this motion. The Reciproc system consists of three files: R25 (25/0.08 in the first millimetres), R40 (40/0.06 in the first millimetres) and R50 (50/0.05 in the first millimetres) [11]. The effectiveness of instruments that work with a reciprocating motion (i.e. Reciproc and WaveOne files) in the removal of root canal filling material have been evaluated and determined to be effective [12]. Several studies have evaluated the amount of apically extruded debris during removal of root canal filling material using hand files, rotary and reciprocating systems [13–15]. The findings of

CONTACT Hüseyin Sinan Topçuoğlu topcuogluhs@hotmail.com Department of Endodontics, Faculty of Dentistry, Erciyes University, 38039 Melikgazi, Kayseri, Turkey

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these studies showed that all techniques caused apical extrusion of debris during the removal of canal filling material.

There are many studies evaluating the intensity and duration of postoperative pain following root canal preparation using hand files, rotary and reciprocating systems [16–19]. Neelakantan and Sharma [18] evaluated the postoperative pain after instrumentation of root canals with a single-file reciprocating (Reciproc) or rotary file (OneShape) system and determined that Reciproc showed significantly less intensity and duration of postoperative pain compared to OneShape. Shokraneh et al. [20] compared postoperative pain of root canal therapy in patients with asymptomatic mandibular molar teeth with necrotic pulp and periapical lesion using three different instrumentation techniques (hand file, ProTaper Universal and the WaveOne system) and determined that postoperative pain was significantly lower in patients undergoing root canal instrumentation with the WaveOne file, compared to those treated with the ProTaper Universal and hand files. To the best of our knowledge, there is no study evaluating the intensity and duration of postoperative pain after the removal of root canal filling material using hand files, rotary and reciprocating systems. The purpose of this study was to compare the intensity and duration of postoperative pain following the removal of canal filling material using hand files, PTUR and Reciproc instruments. The null hypothesis tested was that there would be no difference amongst the instrumentation systems in terms of the intensity and duration of postoperative pain following the removal of canal filling material.

Materials and methods

This randomized clinical trial was approved by the Ethics Committee of Erciyes University of Medical Sciences (232/2015). Based on the data from a previous study [17], results of power calculations indicated that the sample size for each group should be a minimum of 40. This value was determined by projecting the power as 0.92, effect size = 0.821, and significance level as $a = 0.05$. Finally, 45 participants in each group were selected for this study, allowing for loss due to no follow-up.

Previous canal therapy of patients included in this study had not been performed in our department and teeth to be performed NSER had no periapical lesion during previous root canal therapy. Failed root canal therapy was determined during the application of the patients for routine dental examination, prosthetic needs and coronal restoration missing. Only asymptomatic single-rooted upper incisor teeth with a diagnosis of chronic apical periodontitis were included in the study. The quality of canal obturation and periapical status of the teeth was determined via periapical radiographs, which were taken with paralleling technique. The root canal filling of teeth included in this study was 1–3 mm shorter than radiographic apex. Radiographic examination revealed the presence of chronic apical periodontitis. Periapical lesion size of teeth was 3–5 mm in diameter.

This clinical study included 135 volunteer patients (69 male and 66 female) between the ages of 20 and 52 years (average 39 ± 2 years) with no systemic diseases and no history of having taken analgesics 12 h before the retreatment procedure. Patients were given adequate information regarding the required treatment. Participation in the study was voluntary, and written consent was obtained from the patients.

All patients who agreed to participate in the study were randomly divided into three groups of 45 patients each according to the method used to remove root canal filling material. To randomize the patients, each patient was assigned a number. The numbers in each group were written on paper, and each one was kept in a sealed envelope. Each patient was asked to choose one of the envelopes and was assigned to one of the groups on the basis of the number. Allocation was done by a trained dental assistant who was blinded to the study procedures to prevent bias. The teeth were anesthetized with a local anaesthetic solution containing 4% articaine with 1:200,000 epinephrine (Ultracaine DS fort; Hoechst-Marion Roussel, Frankfurt, Germany). Following rubber-dam isolation, the old coronal restoration was removed using sterile high-speed burs (Dentsply Maillefer). The cavity access preparation was completed, and the canal orifice was localized.

Removal of root canal filling material

After the removal of the obturation material from the coronal third of the root canal, a drop of eucalyptol was introduced into each canal to soften the gutta-percha. Additional drops of eucalyptol were applied, as needed, to reach the working length (WL). In all teeth, 0.1 mL of eucalyptol was used during the removal of the canal filling material. One set of instruments was used per tooth. NSER of all patients was performed in two visits by a single experienced clinician.

Hand file group ($n = 45$)

Gates Glidden drills (Mani, Inc., Tochigi, Japan) size 3 and subsequently size 2 at 2000 rpm was used to remove canal filling material from the coronal third of the root. To electronically determine the WL, a #15 K-file was attached to the clip of a ProPex Pixi apex locator (Dentsply Maillefer). The file was gently inserted into the softened apical gutta-percha until the "0.0" mark of the ProPex Pixi was achieved. The WL was set at 1 mm shorter than the "0.0" mark of the ProPex Pixi. The WL was confirmed using periapical radiograph. The canal was reinstrumented with Hedström files (Dentsply Maillefer), sizes 30, 25, 20 and 15, in a circumferential, quarter-turn, push-pull, filing motion to remove canal filling material until the WL was achieved. Once the WL was reached (with a size 15 file), files sized 20, 25, 30, 35, 40, 45 and 50 were used at the WL.

PTUR group ($n = 45$)

In this group, the root canal filling material was removed using PTUR D1, D2 and D3 (Dentsply Maillefer) files. The files were used at the 500-rpm speed and a torque setting of up to 2 N/cm using a 16:1 reduction hand piece powered by a

torque-controlled electric motor (X-Smart; Dentsply Maillefer). PTUR files were used with brushing movements against the canal walls in a crown-down manner at the cervical (D1), middle (D2) and apical (D3) thirds until the WL was reached, as recommended by the manufacturer. The WL was measured as for the hand file group, using an apex locator, after removal of the coronal part of the root canal filling material. The WL was confirmed using periapical radiograph. Finally, apical preparation was performed with F2, F3, F4 and F5 ProTaper instruments (Dentsply Maillefer).

Reciproc file group (n = 45)

In this group, the root canal filling material was removed using Reciproc R25 and R40 files (VDW, Munich, Germany) with the RECIPROC ALL mode of an endodontic motor (VDW Silver; VDW). The WL was measured as for the hand file group, using an apex locator, after the removal of the coronal part of the root canal filling material. The WL was confirmed using periapical radiograph. Finally, apical preparation was completed with a Reciproc R50 (size 50) instrument.

In all groups, when instruments reached the WL, the irrigation needle was placed into the canal 1 mm short of the WL. Irrigation solution was then delivered into the canal using a syringe and a 29-G double-side port NaviTip irrigation needle. During removal of the root canal filling material, 15 mL of 2.5% sodium hypochlorite (NaOCl) was used as an irrigant. After final irrigation with 10 mL of 17% ethylenediaminetetraacetic acid (EDTA) followed by normal saline solution, the canal was dried and dressed with calcium hydroxide paste (Calcicur, Voco GmbH, Germany) for 10 days. The calcium hydroxide paste was placed in the canal using # 30 K-file (Dentsply Maillefer) and radiographs were taken from the two dimensions to confirm the complete filling of the canal. The access cavity was then sealed with temporary filling material (Cavit; 3M ESPE, Seefeld, Germany). All procedures were performed using a dental operating microscope (Zeiss Opmi; Carl Zeiss, Jena, Germany).

Patient questionnaire

A questionnaire was given to the participants to note the intensity of postoperative pain at 6, 12, 24, 48 and 72 h, 7 days, and finally 10 days after the retreatment procedure. Each patient was given a prescription for ibuprofen (if contraindicated, paracetamol), with instructions to take only if needed for severe pain. Postoperative pain was recorded as none, slight, moderate, or severe, by using a visual analogue scale, validated in previous studies [17,21]: 1–no pain; 2–slight pain; 3–moderate pain; and 4–severe pain. Ten days after the first appointment, the patients returned to the clinic with their questionnaire forms. Teeth were evaluated for the presence of clinical symptoms (i.e. tenderness to percussion and palpation). The root canals were then filled with gutta-percha and a resin-based sealer (MM-Seal; MicroMega, Besançon, France) using the cold lateral compaction technique.

Data were analysed statistically using Kruskal–Wallis test followed by Mann–Whitney *U* test for multiple comparisons.

Table 1. Demographics and clinical features.

	Hand file	PTUR	Reciproc	*p* value
Gender				
Female	22	21	23	0.43[a]
Male	23	24	22	0.37[a]
Age (years)				
Mean + SD	38 ± 8	40 ± 7	36 ± 9	0.48[a]

[a] $p > 0.05$ statistically not significant
PTUR: ProTaper universal retreatment; SD: standard deviation

Statistical analyses were performed using SPSS software version 20.0 (SPSS Inc., Chicago, IL). Statistical significance was set at *p* value less than 5%.

Results

Statistical analysis showed that there was no significant difference in age and gender distribution between the three groups ($p > 0.05$) (Table 1). Five patients (two from the hand file group, one from the PTUR group and two from the Reciproc group) were excluded from the study because they did not attend the recall visit and could not be contacted. Four patients (two from the hand file group, one from the PTUR group, and one from the Reciproc group) reported taking analgesics. The postoperative pain prevalence associated with each technique used at the various time intervals are shown in Figure 1. Among the three groups, the highest postoperative pain scores were recorded 6 h after the procedure; the postoperative pain scores decreased over time (Figure 2). The mean postoperative pain level at each of 6, 12, 24 and 48 h was higher for the hand file group compared to the PTUR and Reciproc groups ($p = 0.02$), but the difference was not significant at 72 h, 7 days and 10 days ($p = 0.074$). Among all time intervals, there was no significant difference regarding the intensity of postoperative pain between the PTUR and Reciproc groups ($p = 0.08$).

The required time to remove canal filling material was significantly shorter for the Reciproc group (202 ± 48 s) in comparison with the hand file (432 ± 21 s) and PTUR groups (314 ± 15) ($p = 0.032$). Additionally, PTUR required less time to remove canal filling material than hand files ($p = 0.045$).

Discussion

Postoperative pain is associated with inflammation in the periradicular tissues and is caused by irritants exuded from the root canal during treatment. It was stated that irritation of periradicular tissues could be of biological (microorganisms) or non-biological (chemical or mechanical) origin [22]. This study is the first to evaluate the intensity and duration of postoperative pain after the removal of canal filling material using hand files, ProTaper retreatment and Reciproc systems.

The limitations of the research evaluating postoperative pain are related to the difficulty and differences in the study designs, preoperative conditions of the tooth, treatment protocol, definition of pain, pain measurement and result collection methods [23]. One of the main problems in studies evaluating pain is a patient's subjective evaluation and pain

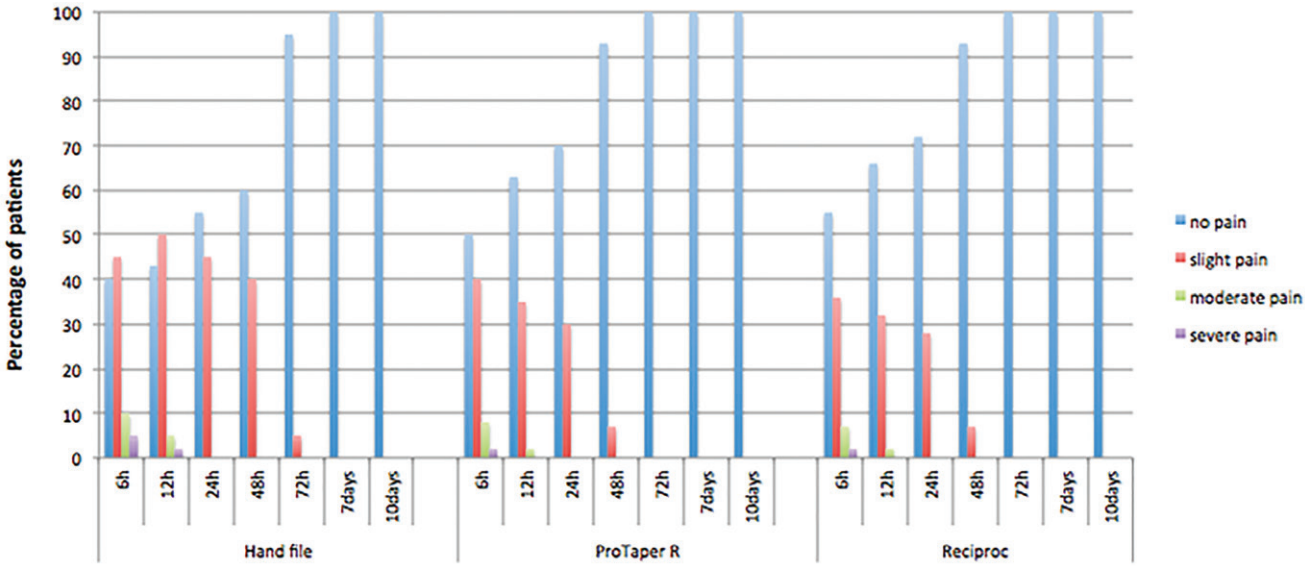

Figure 1. Postoperative pain prevalence.

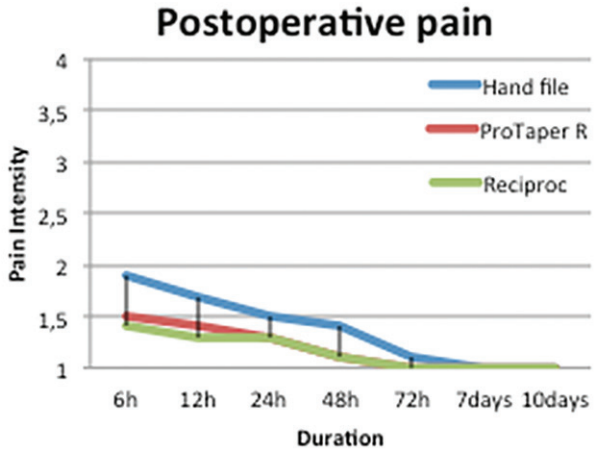

Figure 2. Mean postoperative pain scores of groups at the various time intervals.

measurement [24]. Therefore, questionnaire design is critical and should ensure that it will be clearly understood by patients and easily interpreted by investigators. The design of this study was explained in detail to each participant. This study included upper incisor teeth that had chronic apical periodontitis to ensure standardization and to eliminate variables such as tooth type and preoperative pain. One operator performed all retreatment procedures, and pain measurement was evaluated using the method used in previous studies [21,25]. Clinically, the retreatment procedure is generally completed using files with an apical diameter larger than the apical diameter of the master apical file used in the initial canal preparation. Final apical preparation size was determined as #50 in thist study because the master apical size of the teeth retreated in this study ranged from #35 to #45.

There is no consensus about how many visits should be scheduled to complete the NSER. Ashraf et al. [26] evaluated the success rate of single-visit NSER and reported that NSER in a single-visit had high success rate. Based on the results of their study, they stated that single-visit retreatment of symptom less teeth is recommended. Eyuboglu et al. [27] stated that single-visit NSER could be considered as a viable treatment option for orthograde retreatment cases with periradicular lesion size smaller than 5 mm. Vera et al. [28] analysed the *in vivo* microbiological status of root canal systems of teeth with apical periodontitis after one- or two-visit endodontic treatments and reported that two-visit treatments incorporating an interappointment medication with calcium hydroxide resulted in improved microbiological status of the root canal system when compared with a one-visit treatment. It is well known that teeth with a failed endodontic treatment contain more bacterial species compared to the bacterial population presenting during an initial endodontic treatment [29]. Yoldas et al. [30] evaluated the effect of 1- or 2-visit treatments on the postoperative pain in the NSER and determined that two-visit NSER with intracanal medication was found to be effective in reducing postoperative pain.

In this study, the intensity of postoperative pain after NSER was significantly higher among patients in the hand file group than those in the PTUR and Reciproc groups. On the basis of these findings of this study, the null hypothesis is rejected. Previous studies evaluated the amount of debris extrusion during the removal of root canal filling material using hand files and different rotary and reciprocating files [13,31,32]. They determined that hand files extruded more debris than the rotary and reciprocating files. This may explain why the hand files group experienced greater postoperative pain compared to the PTUR and Reciproc file groups in this study.

A recent study [33] evaluated the cytotoxic effect of apically extruded debris during the removal of root canal filling using different techniques (hand files, Reciproc and MTwo retreatment instruments) and determined that only the hand-file technique caused a significant increase in TNF-α, an inflammatory mediator that plays a role in the development of different patterns of clinical features, such as pain and bone resorption. In this study, participants in the hand file group reported greater postoperative pain compared to those in the PTUR and Reciproc groups. This could be

associated with the TNF-α expression, probably as a result of greater amounts of apically extruded debris in the hand file group compared to the other groups.

The findings of this study showed that the greatest postoperative pain level in all groups occurred at 6 h after the removal of canal filling material and pain scores decreased over time. This is compatible with the findings of previous studies evaluating the incidence and severity of postoperative pain at different time intervals [17,34,35].

Conclusions

This study showed that the removal of root canal filling material using hand files caused greater postoperative pain in patients having upper incisor teeth requiring NSER compared to PTUR and Reciproc files in specified time intervals during the first two days. The limitations of studies evaluating postoperative pain must be considered when interpreting the results of this study. Pain is subjective in nature and has multiple confounding factors that cannot be controlled adequately in an *in vivo* setting. Further studies evaluating the effects of different variables (i.e. tooth type and preoperative pain) on postoperative pain during NSER are required.

Acknowledgements

The authors deny any conflicts of interests related to this study.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Disclosure statement

The authors report no conflict of interest. The authors alone are responsible for the content and writing of this article.

Notes on contributors

Hüseyin Sinan Topçuoğlu, DDS, PhD, is associate professor in the Department of Endodontics, Erciyes University. His research interest focuses mainly on Endodontic instruments.

Gamze Topçuoğlu is specialized pedodontist since 2016. His research interest focuses mainly on vital pulp therapies and endodontic therapy.

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