ORIGINAL ARTICLE

Postoperative pain after foraminal enlargement in teeth with necrosis and apical periodontitis: a prospective and randomized clinical trial

ABSTRACT

Aim: *To evaluate the effect of working length (WL) on postoperative pain in root canal treatment with foraminal cleaning (FC).*
Methods: *One hundred patients with an indication for root canal treatment of teeth diagnosed with pulp necrosis were selected for the study. The teeth were divided into two groups according to the established WL: in group I (n=50), the WL was established at the 0.0 mark on the electronic apex locator (EAL) display. In group II (n=50), the WL was established 1 mm beyond the 0.0 mark on the EAL display. Both groups were treated with the WaveOne Gold reciprocating system (Dentsply Maillefer).*
Results: *Postoperative pain was measured 12, 24 and 48 h using a modified verbal descriptor scale ranging from no pain to maximum pain. In both groups, a significant difference in postoperative pain was observed between all time points analyzed. There was no statistically significant difference in postoperative pain between the two groups. FC performed in single-visit root canal treatment with WL measurement at the 0.0 mark on the EAL display or 1 mm beyond results in a similar intensity of postoperative pain in teeth with pulp necrosis.*
Conclusion: *The working length did not influence endodontic postoperative pain.*

Aline de Oliveira Escócio[1]
Silvia Kaoru Hamasaki[1]
Élida Mendes[1]
Bruna Milaré Angelieri[2]
Aline Cristine Gomes Matta[2*]
Adriana de Jesus Soares[2]
Marcos Frozoni[1]

[1]*Department of Endodontics, São Leopoldo Mandic Faculty, Center of Pesquisa São Leopoldo Mandic, Campinas, São Paulo, Brazil*

[2]*Department of Restorative Dentistry, Division of Endodontics, Piracicaba Dental School, State University of Campinas, Piracicaba, São Paulo, Brazil*

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Corresponding Author
Aline Cristine Gomes Matta | Faculty of Odontologia de Piracicaba – UNICAMP, Avenida Limeira, 901, CEP: 13.414-903 – Piracicaba, SP | Brasil
Phone: +55 (19) 2106-5706
E-mail: linecristine@msn.com

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Introduction

Although the apical limit of root canal instrumentation is a controversial topic in root canal treatment, studies have shown a high prevalence of bacterial biofilms in the region of the cemental canal and apical foramen. In certain cases, these biofilms can extend to the extraradicular apical surface (1, 2). Therefore, root canal disinfection as close as possible to the major apical foramen keeps this region clean and free of debris and provides a favorable environment for periapical repair [3]. Root canal instrumentation short of the apical foramen might leave pulp remnants, infected tissue, bacteria, biofilm, and unfilled and unprepared areas that can result in endodontic failure (4-7). The endodontic filling materials should stop on the cemento-dentinal junction, otherwise overfilling would cause inflammatory responses in periapical tissues (8).

For a correct determination of working length (WL), an electronic apex locator (EAL) has been shown to accurately detect the apical constriction and the major apical foramen (9). However, the measurements provided by the EAL can vary from -0.5 to +0.5 mm from the apical foramen and may therefore underestimate the position of the major apical foramen in some cases (10-12).

The apical third of the canal is considered a critical zone, as it can concentrate a large number of microorganisms that will perpetuate periradicular inflammation (13, 14). Bacterial biofilms are found in the apical third of the root canal system in up to 80% of teeth with apical periodontitis (15). Removal of bacterial biofilms from the apical foramen is achieved by foraminal cleaning (FC) and may lead to successful results of endodontic treatment in cases of apical periodontitis (16, 17). FC consists of intentional mechanical widening of the apical foramen diameter in order to reduce the bacterial load in the apical ramifications by removing contaminated cementum and dentin and by filling up the apex to promote tissue repair (4, 16, 17, 19).

One of the main concerns regarding enlargement of the apical foramen is the possibility of postoperative pain caused by instrumentation and irritation of periapical tissue (18, 19). Pain after root canal treatment can be defined as a feeling of discomfort and occurs in 3% to 58% of patients, regardless of pulp and periapical status (20). Silva (2013) found the same rate of postoperative pain in the presence or absence of FC. Other authors reported increased pain within the first days after treatment (21). Postoperative pain can be caused by tissue debris, dentin scrapings, microorganisms, and irrigating solutions that are extruded from the apical foramen to the periapical tissues during root canal preparation (22).

FC can be performed with the root canals instrumented at the 0.0 reading on the EAL display or beyond this measure in cases of teeth with necrotic pulp and periapical pathosis (8, 9, 20, 21). The aim of the present randomized clinical trial was to evaluate the incidence of postoperative pain in root canal treatment with FC performed at different WL on teeth with pulp necrosis. The null hypothesis tested was that there is no significant difference in the incidence of postoperative pain after FC performed with WL measured at the 0.0 reading on the EAL display or 1 mm beyond.

Materials and Methods

Sample size calculation

The sample size was calculated (G*Power 3.1.9.4, Heinrich-Heine University, Düsseldorf, Germany) using the results of Silva (16). In that study the smallest effect size between groups was 0.1335. Assuming α=0.05 and a power of 0.80, a sample size of 46 teeth per group would be needed in the current study considering two groups and three time points. The number of teeth per group was increased to 50 to compensate for dropouts.

Sample selection

The institutional Ethics Committee on Research Involving Humans of the Review Board of the Centro de Pesquisas

Odontológicas São Leopoldo Mandic approved this randomized clinical trial (Protocol No. 2.065.851). The study was registered in the Brazilian Clinical Trials Registry (ReBEC) under registration number RBR-6bv5hy.

Three hundred consecutive patients of both sexes aged 17-69 years, who attended a private practice between July and November 2017 and who had maxillary and mandibular (anterior or posterior) teeth with a diagnosis of pulp necrosis, were scheduled for primary endodontic treatment. The canal was considered narrow when a #15 hand flexo file reached the working length, and a #20 hand flexo file did not reach this point. The canal was considered wide when a #25 hand flexo file reached the working length, and a 30 flexo file did not reach this point. If a #35 hand flexo file reached de working length the tooth was excluded from the experiment. After exclusion criteria one hundred teeth were randomly assigned to two groups according to the established WL. The WL was established at the 0.0 reading on the EAL display in group (0.0) (n=50) and at 1 mm beyond the 0.0 reading in group (+1.0) (n=50) (Fig. 1).

Randomization was carried out according to the order of patient appointment, i.e., the first patient was selected for group (0.0), the second for group (+1.0), and so on. The participants were blinded and not informed about the allocation. However, the operator was not blinded to the interventions because of the nature of the interventions.

Inclusion criteria

The criteria for inclusion in this study were necrotic teeth with or without apical radiolucency (maximum size of 2.0x2.0 mm), without clinical signs such as fistula, edema and sensitivity to palpation, and without a history of endodontic management. Patients who had taken anti-inflammatory agents or analgesics in the last 10 days, patients requiring antibiotic premedication for dental treatment, patients with systemic diseases, and patients allergic to ibuprofen were excluded from the study. Teeth with an incomplete apex, teeth in which a Wave One Gold 35/06 file (Dentsply Maillefer, Tulsa, OK, USA) has reached working length without any resistance, teeth with a maximum periodontal probing depth of 3 mm, and teeth with internal and external root resorption were also excluded. Furthermore, patients with a history of dental trauma or endodontic management, patients whose treatments could not be completed in a single session or lasted more than 90 min, and patients in whom the apical patency of the root canals could not be established were excluded.

The treatment protocol was explained to all patients who signed a written informed consent form. Endodontic treatments were performed in a single session by a single operator with 10 years of experience. The maximum duration of each session was 90 min.

Treatment protocol

All treatments were performed using an operating microscope (Alliance, São Paulo, São Carlos, Brazil) at 10X to 25X magnifications by an endodontic specialist with 8 years of experience. Pulp status was determined by a negative cold test (Endo-Frost, Coltene-Whaledent) and was confirmed by the absence of bleeding when entering the pulp chamber. Rubber dam

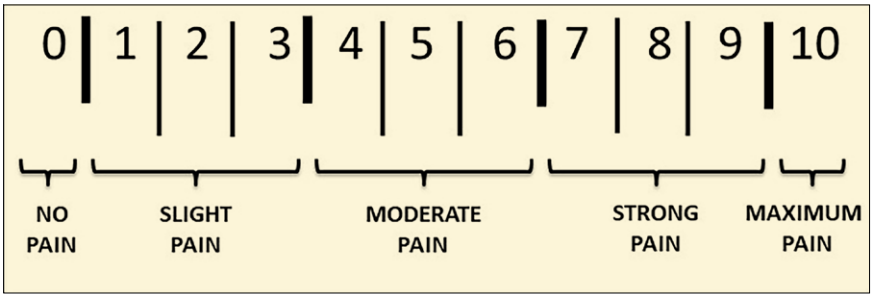

Figure 1
Modified verbal descriptor scale.

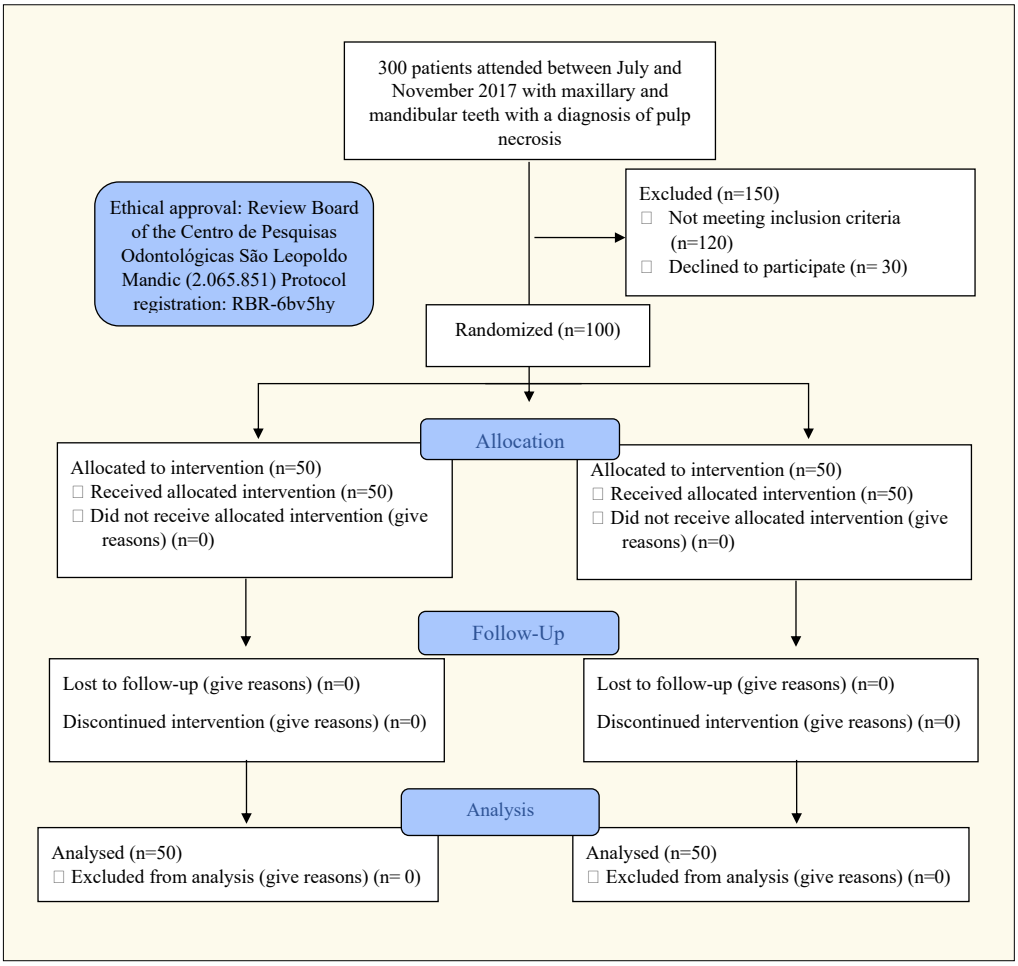

Figure 2
Flowchart of participants through the trial according to the Consolidated Standards of Reporting Trials.

isolation was used in all cases. Local anesthesia 2% lidocaine with 1:100,000 epinephrine (DFL, Rio de Janeiro, Rio de Janeiro, Brazil) was administered as needed for patient comfort, using the infiltrative technique for maxillary teeth and inferior alveolar nerve block for mandibular teeth. No supplemental injections were used. The canals of the groups were instrumented by the crown-down technique. The cervical and middle thirds were decontaminated and enlarged using a single-file reciprocating instrumentation technique with WOG primary 25/07 files (Dentsply Maillefer) driven by a 6:1 reduction handpiece (Sirona Dental Systems) that was powered by a torque-controlled motor (VDW Silver Motor, Munich, Germany). The "WAVE-ONE ALL" pre-set reciprocating program was used.

The root canals were irrigated with a syringe (20 mmx0.55 mm needle) containing 1 mL of 2% chlorhexidine gel (VisNature, Itajaí, Santa Catarina, Brazil) before the use of each file and after the use of each instrument and the root canals were then rinsed with 5 mL saline solution (23, 24). The WL was established by introducing #10 and #15 K-files up to the apical foramen and confirmed with a Romipex A-15 apex locator (Romidam Ltd., Kiryat Ono, Israel).

Apical preparation was performed using WOG primary 25/07 reciprocating instruments for narrow root canals and WOG medium 35/06 instruments for wider canals. The manufacturer's recommendations were followed, the file is chosen according to the working length adjustment (Figure 3).

The files were introduced into the root canal with in-and-out movements (pecking

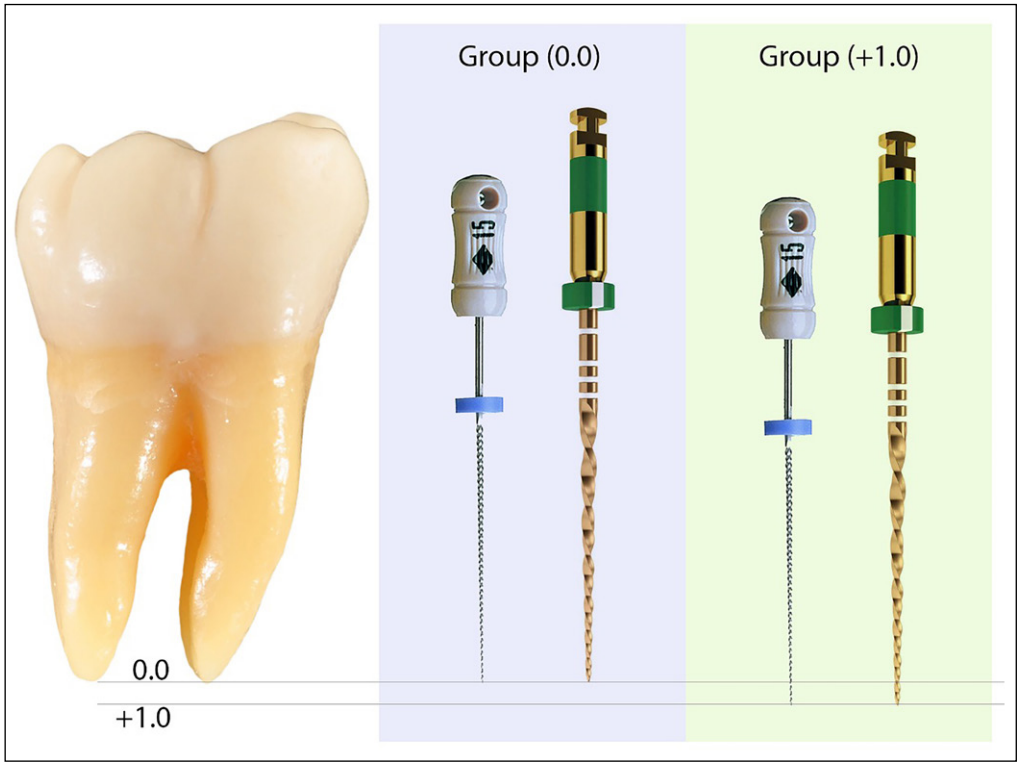

Figure 3
Foraminal Cleaning Protocols.

motion) at an amplitude of 1-3 mm per movement until the WL predefined for each instrument was reached. After the completion of root canal instrumentation, each canal was irrigated with 1 mL of 17% EDTA (Biodinâmica, Ibiporã, Paraná, Brazil) by ultrasonic activation with an E-1 Irrisonic tip (Helse Dental Technology) for 30 seconds, with three successive changes for a total of 3 mL EDTA per canal. The root canals were then dried with a silicone cannula (Capillary Tips, Ultradent) and paper points (Dentsply Maillefer, Tulsa, OK, USA) and filled with gutta-percha (Odous De Deus Ltda.) and the AH Plus sealer (Dentsply Maillefer, Tulsa, OK, USA) using warm vertical compaction with a thermocompactor (Odous Touch). The 3-mm cervical portion of the root canal was sealed with Coltosol (Vigodent) and the coronal access cavity was restored using resin composite. The occlusion was checked and adjusted.

Assessment of postoperative pain

For accurate assessment of pain intensity, each patient received a modified verbal descriptor scale (VDS), which is the combination of a verbal rating scale measuring pain from no pain to maximum pain and a numerical rating scale scoring pain from 0 to 10 (25). The level of pain was rated as follows: (0) no pain: the treated tooth felt asymptomatic; (1 to 3) slight pain: the tooth was slightly painful for a short period of time, but there was no need to take analgesics; (4 to 6) moderate pain: the tooth caused pain which was tolerable or was rendered tolerable by analgesics; (7 to 9) strong pain: the tooth caused long-lasting pain that disturbed normal sleep and required narcotic analgesics; (10) maximum pain: the tooth caused continuous pain that disturbed normal activity or sleep and analgesics had no effect (26) (Fig. 2).

The patients were instructed to place a mark on the number of the scale (from 0 to 10) that represented the intensity of the experienced pain. The level of discomfort was rated 12, 24 and 48 h after endodontic treatment (18). The patients were instructed to take ibuprofen (400 mg, one tablet every 8 hours for 3 days) in cases of moderate pain or to return to the clinic for

Table 1
Characteristics of the groups studied

	Group (0.0)		Group (+1.0)		
	n	%	n	%	
Male	19	38.0	16	32.0	
Female	31	62.0	34	68.0	P=0.675
Maxillary teeth	31	62.0	36	72.0	
Mandibular teeth	19	38.0	14	28.0	P=0.395
Anterior teeth	24	48.0	26	52.0	
Posterior teeth	26	52.0	24	48.0	P=0.842
Analgesic consumption	11	22.0	11	22.0	P=1.000
Presence of apical lesion	23	46.0	18	36.0	P=0.405
Sealer extrusion	18	36.0	32	64.0	p=0.005

Chi-square test with significance at p<0.05.

A significant difference was only observed in endodontic sealer extrusion from the apical foramen (p=0.005).

control in cases of severe pain. All patients were contacted by phone or by instant messaging (WhatsApp Messenger, WhatsApp Inc.) after 48 h to record the level of postoperative pain at the three time points analyzed. The patients were asked whether or not they had taken medication after treatment and how much.

Statistical analysis

Another operator analyzed the data. The incidence of postoperative pain was recorded and is expressed as percentage. Data were submitted to statistical analysis using Fisher's exact test and the Mann-Whitney test for nonparametric data. The Statistical Package for the Social Sciences 20.0 (SPSS Inc., Chicago, 2006) was used to determine significant differences at p<0.05.

Results

The demographic and clinical features of the patients of the two groups are presented in Table 1. The mean age of the patients enrolled in this study was 36.5 years. There was no significant difference in gender (p=0.675), tooth position [upper or lower (p=0.395), anterior or posterior (p=0.842)], radiographic presence of apical radiolucency (p=0.405), or medication use (p=1.000) between groups. However, a significant difference was observed in endodontic sealer extrusion from the apical foramen (p=0.005), which was more frequent in group (+1.0).

The number of patients who experienced pain was small and the pain did not exceed the slight level. There was no statistically significant difference in the incidence of postoperative pain between group (0.0) and group (+1) (p>0.05) at any of the three time points analyzed (Table 2). In both groups, postoperative pain was significantly reduced (p < 0.05) at 12, 24 and 48 h after root canal treatment (Table 2).

Discussion

The radiolucency of a periapical lesion caused by endodontic infection may only be visible on radiographs in the case of extensive cortical bone destruction or erosion (27). Consequently, periapical ra-

Table 2
Mean and standard deviation of pain intensity in the treatment groups after 12, 24 and 48 h

	12 h	24 h	48 h
Group (0.0)	1.10 (±1.97)a	0.24 (±1.14)b	0.02 (±0.14)c
Group (+1.0)	1.22 (±2.14)a	0.50 (±1.25)b	0.20 (±0.70)c
***p-value**	0.906	0.118	0.089

**Significant difference between groups (0.0) and (1.0).*
Pain scores in the same row followed by different letters differ significantly between time points.
Mann-Whitney test with significance at p<0.05.
Chi-square test or Fisher's exact test with significance at p<0.05.

diographs alone do not permit to confirm the presence or absence of periapical lesions (27, 28). Therefore, teeth diagnosed with pulp necrosis with or without apical radiolucency were included in the present study (28) and no significant difference in the radiographic presence of apical radiolucency was observed between groups. Only asymptomatic teeth were included because preoperative pain can exacerbate the postoperative pain and influence the reliability of the results (29). There was no significant difference in tooth position [upper or lower, anterior or posterior] between groups.

The success of apex locators is accepted in the 0.5- to 1.5-mm range from the tip of the file to the radiographic apex. This acceptable radiographic range occurs in 81.5% and 97% of cases. However, when we evaluate the effectiveness for the determination of apical constriction the success rate changes to between 43.9% and 89.1% (30). Several authors have suggested that apical preparation plays an important role in eliminating a larger number of microorganisms from the root canal (19, 31-33). Failure in measuring WL can impair root canal preparation.

Teeth with pulp necrosis and apical periodontitis have been associated with a high frequency of biofilms in the cemental canal and apical foramen (6, 34). Within this context, disinfection procedures as close as possible to the apical foramen keep this region clean and free of debris and provide a favorable environment for periapical repair (3). In this study, FC was performed with the root canals instrumented at the 0.0 reading on the EAL display or 1 mm beyond this measure, as reported in previous studies that proposed penetration into the apical foramen or beyond to debride and to remove contaminated dentin and bacteria in the lateral canals and apical ramifications and to completely fill the root canal (4, 8, 35, 36).

In a study with dogs, De-Souza Filho (4) demonstrated tissue repair in cases of pulp necrosis after foraminal enlargement 2 mm beyond the apical foramen (4). Foraminal enlargement improves healing of teeth with periapical lesions (4, 37) and enlargement three size larger is of benefit in endodontic treatment and increases the rate of successful healing of periapical lesions (37, 38).

The FC has numerous advantages such as cleaning the apical region and cemental canal and decontamination of the apical major foramen, with the possibility of greater contact of irrigating substances with the apical filling (39). The irrigation protocol of the present study was the same as that reported in previous clinical studies in which chemical agents were used in gel form during instrumentation (either hypochlorite or chlorhexidine). The root canals were irrigated with saline after the introduction of each instrument to flush out the remaining gel and debris from the root canal (23, 24, 34, 40). Chlorhexidine gel (2%) was used as a chemical agent because it exerts antimicrobial effects

similar to those of 5.25% sodium hypochlorite (NaOCl) (41, 42) and due to its exclusive property of substantivity, which results in long-lasting antimicrobial activity (43, 44). In addition, chlorhexidine has biocompatibility with periapical tissues (45, 46), which is interesting for FC. Tamaru-Filho (2002) observed a lower cellular inflammatory response to 2% chlorhexidine when compared to 0.5% NaOCl. Despite the cellular cytotoxicity of NaOCl and chlorhexidine, 5.25% NaOCl was found to elicit a greater inflammatory response (47).

A major concern in some studies is the possibility of postoperative pain after FC related to physical damage to the periapical tissues and extrusion of infected debris from the root canal into the periapical space, which can cause irritation and inflammation (18, 19). The canals were prepared by preflaring the coronal portion prior to negotiation of the apical portion and WL determination, reducing the amount of apically extruded debris and postoperative pain (48).

The evaluation of pain is difficult because pain is a subjective and individual experience of each patient. A major concern is to assign the inconvenient symptomatic sensation to any specific factor of the root canal treatment because this treatment comprises complex procedures such as injection of a local anesthetic, pressure from the rubber dam clamps, and prolonged mouth opening (18, 49). The scale used for pain assessment must be clear and precise, must be fully understood by the patient, and must provide accurate data for analysis (26, 50). A modified VDS was used for the accurate assessment of pain after root canal treatment. This scale is the combination of a verbal rating scale and a numerical rating scale with a 11-cm line divided into 11 intervals (from 0 to 10), which are divided into five categories: no pain, slight pain, moderate pain, strong pain, and maximum pain (26). This scale is a simple, sensitive, and effective method for assessing pain intensity from the patient's perspective. The patients completely understood the categories.

Postoperative symptoms after root canal treatment are usually short-lived and tend to increase within 24 to 48 h (51,52), and this may be a limitation of this type of study. In the present study, postoperative pain was significantly reduced ($p<0.05$) in both groups at 12, 24 and 48 h after root canal treatment. The number of patients who experienced pain was small and the pain did not exceed a slight level. There was no statistically significant difference in the incidence of postoperative pain between group (0.0) and group (+1.0) ($p>0.05$) at any of the three time points analyzed (Table 2). Despite the significant difference in endodontic sealer extrusion from the apical foramen ($p=0.005$), which was more frequent in group (+1.0), no significant difference in postoperative pain or analgesic consumption was observed between groups at the different time points evaluated. These findings suggest that sealer extrusion was not associated with pain (40) and that instrumentation at or beyond the apical foramen promotes better disinfection, with no increase in postoperative pain (4, 8, 17, 20).

The findings of the current clinical trial are in contrast to a previous study (21) that reported a significant increase of pain levels in the FC group. Saini (21) performed two-visit root canal treatment and used 3% NaOCl, while 2% chlorhexidine gel with saline was used in the present study. The latter reduces the irritant potential of the extravasated substance in contact with the apical tissue (44, 45).

In other studies, FC and non-enlargement techniques resulted in the same postoperative pain (20). These results show that neither FC nor apical extrusion of the endodontic sealer increase the incidence or duration of endodontic pain during the postoperative period. The results suggest that FC has no influence on postoperative pain.

Conclusion

FC performed with WL measured at the 0.0 reading on the EAL display or 1 mm beyond his clinical trial did not influence postoperative endodontic pain.

Clinical Relevance

Cleaning the root canal along its entire length, including the apical foramen, is essential for successful endodontic treatment. This cleaning cannot cause post-operative pain. No significant difference in the incidence of postoperative pain was found for the evaluated working lengths.

Conflict of Interest

None.

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