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Effect of two different concentrations of sodium hypochlorite on postoperative pain following single-visit root canal treatment: a triple-blind randomized clinical trial

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Abstract

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Aim To compare the effects of two different concentrations of NaOCl solution on postoperative pain following single-visit root canal treatment in mandibular molars with irreversible pulpitis.

Methodology A total of 122 patients who had mandibular molars with irreversible pulpitis were treated. The patients were randomly divided into two groups according to the concentration of NaOCl used during root canal instrumentation – either 2.5% or 5.25%. RaCe rotary instruments were used for root canal preparation, and all root canals were filled in one visit. Postoperative pain was evaluated using the visual analogue scale. Data were analysed by independent *t*-test, chi-square and Mann–Whitney tests.

Results Twelve patients were excluded for various reasons. Pain reported by 110 patients who were eligible to be included in the study was analysed. No significant differences were found in the age and gender of the patients between the two groups ($P = 0.50$, $P = 0.51$, respectively). The patients who had 5.25% NaOCl reported significantly lower postoperative pain compared to those who had 2.5% NaOCl during the first 72 h following treatment ($P = 0.021$); however, there was no significant difference in pain felt by the patients during the rest of the study period, that is 4–7 days following treatment ($P = 0.185$) when the four-level pain categorization method was used. When the two-level pain categorization method was used, the results revealed that patients who had 5.25% NaOCl reported significantly less pain for the first 3 days after treatment ($P = 0.026$). The number of analgesics taken by patients who had 2.5% NaOCl was significantly higher than that taken by patients who had 5.25% NaOCl ($P = 0.001$).

Conclusion 5.25% NaOCl was associated with significantly lower postoperative pain compared to 2.5% NaOCl during the first 72 h following one-visit root canal treatment of mandibular molars with irreversible pulpitis.

Keywords: concentration, irrigation, pain, postoperative, single visit, sodium hypochlorite.

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Introduction

Root canal treatment can improve the quality of life in terms of the sense of taste, eating, relaxing, pain and sleep when patients have dental pain (Hamasha & Hatiwsh 2013). However, some patients report moderate-to-severe pain following root canal treatment (Pak & White 2011, Su *et al.* 2011). Therefore,

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pain management during and following root canal treatment is an important issue for both patients and practitioners (Parirokh *et al.* 2010, 2012b, 2013, 2014a,b, Parirokh & Abbott 2014, Tang *et al.* 2015, Cruz Junior *et al.* 2016, Kandemir Demirci & Çalışkan 2016, Kherlakian *et al.* 2016).

Numerous clinical trials have evaluated the effect of several variables on postoperative pain. These investigations have evaluated the effect of instrumentation technique, type of analgesic, method of analgesic prescription, type of rotary instrument, anaesthetic solution, occlusal reduction and method of root canal filling (Pak & White 2011, Su *et al.* 2011, Parirokh *et al.* 2012b, 2013, 2014a, Tang *et al.* 2015, Cruz Junior *et al.* 2016, Kandemir Demirci & Çalışkan 2016, Kherlakian *et al.* 2016).

Despite sodium hypochlorite (NaOCl) being known as the most popular irrigant for root canal treatment (Dutner *et al.* 2012, Savani *et al.* 2014), systematic reviews have not shown the advantages of the irrigant over chlorhexidine because of the heterogeneity amongst investigations (Fedorowicz *et al.* 2012, Gonçalves *et al.* 2016). Various concentrations of NaOCl are used by dental practitioners, although the results of a survey in the USA revealed that the majority of the American Association of Endodontists' members used NaOCl at concentrations higher than 5% (Dutner *et al.* 2012).

Several investigations have evaluated postoperative pain following use of different types of root canal irrigants (Mohd Sulong 1989, Torabinejad *et al.* 2005, Taschieri *et al.* 2009, Paudel *et al.* 2011, Almeida *et al.* 2012, da Silva *et al.* 2015); however, there are concerns over the limited number of evidence-based investigations that compare irrigants. Traditionally, NaOCl is the irrigant of choice because of its high antibacterial activity and potency to dissolve organic tissue. An *in vitro* investigation reported a significant difference in apically extruded debris when different concentrations of NaOCl were used as the irrigant (Parirokh *et al.* 2012a).

A systematic review reported that the type of irrigants had no significant impact on pain following root canal treatment. Comparisons between 5.25% NaOCl, 5.25% NaOCl combined with 3% H_2O_2, and normal saline solution revealed no significant differences in postoperative pain from 3 to 14 days after treatment (Fedorowicz *et al.* 2012).

No evidence-based investigations have evaluated postoperative pain when different concentrations of NaOCl are used as the irrigant. Therefore, the aim of this study was to determine postoperative pain following the use of 2.5% or 5.25% of NaOCl as an irrigant in mandibular molars with irreversible pulpitis that were treated in one visit. The null hypothesis was that the NaOCl concentration has no significant impact on postoperative pain following one-visit root canal treatment.

Materials and methods

The protocol of this study was approved by the Ethics Committee of Kerman University of Medical Sciences (Ir.kmu.rec.1394.293 and Iranian Registry of Clinical Trials ID No. IRCT201601202016N6).

Sample size calculation

The sample size was calculated based on a type I error of 0.05 with power = 0.8, indicating that 55 patients would be required in each group to detect an absolute difference of 20% between the groups.

Inclusion criteria

Inclusion criteria were as follows: individuals without systemic diseases and with a first and second mandibular molar diagnosed with irreversible pulpitis due to caries where the pulps were exposed during excavation, normal periapical radiographic appearance, mild sensitivity to percussion, no spontaneous pre-treatment pain, not having taken any medication for at least 6 h before the treatment visit, at least 18 years of age and no allergic reaction to lidocaine containing epinephrine at a concentration of 1 : 80 000, Gelofen (a gelatin form of ibuprofen) and NaOCl.

Exclusion criteria

Exclusion criteria were as follows: pregnancy and lactation, severe periodontal disease, overinstrumentation or overfilling beyond the root canal space, teeth that could not be isolated with rubber dam, root canal calcification, root resorption and teeth that were not suitable for further restoration.

Procedural steps

A prolonged exaggerated response (more than 10 s) to a cold pulp sensibility test (Cool Spray, Aeronova GmbH & CO., Dresden, Germany) and a positive response to the electric pulp tester were considered

evidence for irreversible pulpitis. All the treatment procedures were performed in the Postgraduate Clinic of the Endodontic Department, Kerman Dental School, Iran, from January to May 2016. A total of 122 teeth were randomly assigned to two groups using a random-digit table. Before initiating treatment, the patients were asked to rate their pre-treatment pain on a visual analogue scale from 0 to 9. A nurse was in charge to prepare NaOCl at two different concentrations of 2.5% and 5.25% and to place them in single-use syringes that were covered with opaque paper. All random-digit numbers were written on the papers. The papers were folded and placed in a jar. For each number, one of the concentrations of NaOCl as root canal irrigant was selected. Each patient chose one of the papers, and based on the number, the nurse supplied one of the irrigants for the treatment visit. Therefore, neither the patients nor the practitioner was aware of the concentration of the irrigant used during the treatment visit.

The patients received two cartridges of 2% lidocaine with 1 : 80 000 epinephrine in an inferior alveolar nerve block injection prior to commencement of the root canal treatment. All treatment procedures were performed by one practitioner (SF). After isolation with a rubber dam, followed by access cavity preparation, working length was determined with a Root ZX apex locator (Morita Corporation, Kyoto, Japan) and confirmed radiographically. In case of unsuccessful anaesthesia, intraperiodontal ligament and intrapulpal injections were employed as supplementary anaesthetic techniques. The working length was set between 0.5 and 1 mm short of the radiographic apex based on the information obtained by the electronic apex locator and the radiograph taken following pre-flaring of the coronal portion of the root canals. After preparing the root canals with hand instruments to at least a size 15 K-file (Mani, Togichi, Japan), RaCe rotary instruments (FKG Dentaire, La Chaux-de-Fonds, Switzerland) were used for the remainder of the root canal preparation. Apical patency was performed with a size 10 K-file between each rotary instrument. The apical preparation was completed up to size 30, .04 taper. Between instruments, the root canals were irrigated with 2 mL of either 2.5% or 5.25% NaOCl with a 30-gauge side-perforated needle (Endo-Top, PPH Cerkamed, Stalowa Wola, Poland). The needle was inserted up to 2 mm short of the working length, using a rubber stop as a guide, and the root canal was irrigated, whilst the needle was moved up and down.

During irrigation, the needle was repeatedly moved up and down to prevent locking in the canals. The volume of irrigant used was 2 mL between each instrument. At the end of root canal preparation and before canal filling, the smear layer was removed from the root canal walls by irrigating with 3 mL 17% ethylenediaminetetraacetic acid (EDTA; Asia Chimi Teb Co., Tehran, Iran) followed by 5 mL normal saline irrigation.

At the same visit, the root canals were dried with paper points (Meta Biomed Co., Chungcheongbuk, Korea) and then filled with gutta-percha (Meta Biomed Co.) and AH26 (Dentsply De Tery, Konstanz, Germany) cement using the cold lateral condensation technique. At the end of the treatment, each patient received one capsule of Gelofen (400 mg) (Daana Pharma Co. Tabriz, Iran). The patients also received a rescue bag of 10 Gelofen in case they had pain with instructions for on-demand use.

Each patient was given two forms to complete. One was a numerical visual analogue scale (VAS) form to record the severity of pain from 0 to 9 during the 7-day period following treatment, and the other form was used to record analgesic consumption and the effect of analgesics on any pain they felt after taking the analgesic (Rosenberg *et al.* 1998, Parirokh *et al.* 2012b, 2013, 2014b). In the second form, the following criteria were used: 0, none or mild pain that did not require analgesics; 1, moderate pain that was fairly well controlled with analgesics and did not interfere with sleep or daily activities; 2, unbearable pain that was not controlled with analgesics and interfered with daily activities. They were also asked to contact the clinic if they suffered severe pain or had any question regarding the treatment.

To carry out a blind data analysis, the data were coded. A *t*-test was used for normally distributed continuous data (i.e. age), and for nonparametric data (i.e. number of analgesics), the Mann–Whitney *U*-test was used. Chi-square test was employed to compare categorical data between the two groups. To compare pain felt by the patients in the two groups, the average severity of pain scores reported by the patients was compared during the first 72 h of postoperative intervals and the rest of the study period, separately. Differences between the groups were considered significant at $P < 0.05$.

Results

Based on the inclusion and exclusion criteria, a total of 122 patients were eligible to participate in the

study. Twelve patients from both groups were excluded because of the following reasons (Fig. 1): treatment could not be completed in one visit (2.5% group, $n = 3$; 5.25% group, $n = 2$); root canal cement extruded beyond the apical foramen (5.25% group, $n = 2$); the subject did not return the VAS form (2.5% group, $n = 2$); and the pulp had partial necrosis (2.5% group, $n = 2$; 5.25% group, $n = 1$). Finally, 110 patients were included for data analysis.

No adverse effects were reported by the patients receiving either concentration of the irrigants up to 7 days following the treatment visit.

The mean age of the patients in the 2.5% and 5.25% NaOCl groups was 28.56 ± 8.68 and 28.34 ± 7.61 years, respectively. None of the patients had spontaneous pain at the treatment visit.

In the 2.5% NaOCl group, 20 males and 35 females participated, whilst in the 5.25% NaOCl group, 19 males and 36 females were treated. There were no significant differences in age and gender of the patients between the two groups ($P = 0.50$ and $P = 0.51$, respectively).

To carry out reasonable comparisons between the two groups, the pain felt by the patients was categorized as no pain: 0; mild pain: 1–3; moderate pain: 4–6; and severe pain: 7–9; the results showed that during the first 72 h following treatment, the patients receiving 5.25% NaOCl as the irrigant had significantly lower pain compared to those who had 2.5% of the same irrigant ($P = 0.021$); however, no significant difference was found between the group for the rest of the study period ($P = 0.185$) (i.e. 4–7 days). When the pain was categorized as no pain to mild pain and moderate pain to severe pain, the patients who received 5.25% NaOCl had significantly less pain during the first 72 h following the treatment ($P = 0.026$); however, during the rest of the study period, no significant difference was observed between the groups ($P = 1$; Figs 2 and 3).

Figure 4 shows the mean scores of pain reported by the patients during the 7-day period following treatment. The mean number of analgesics taken by the patients who received 2.5% NaOCl was significantly higher than that taken by the patients

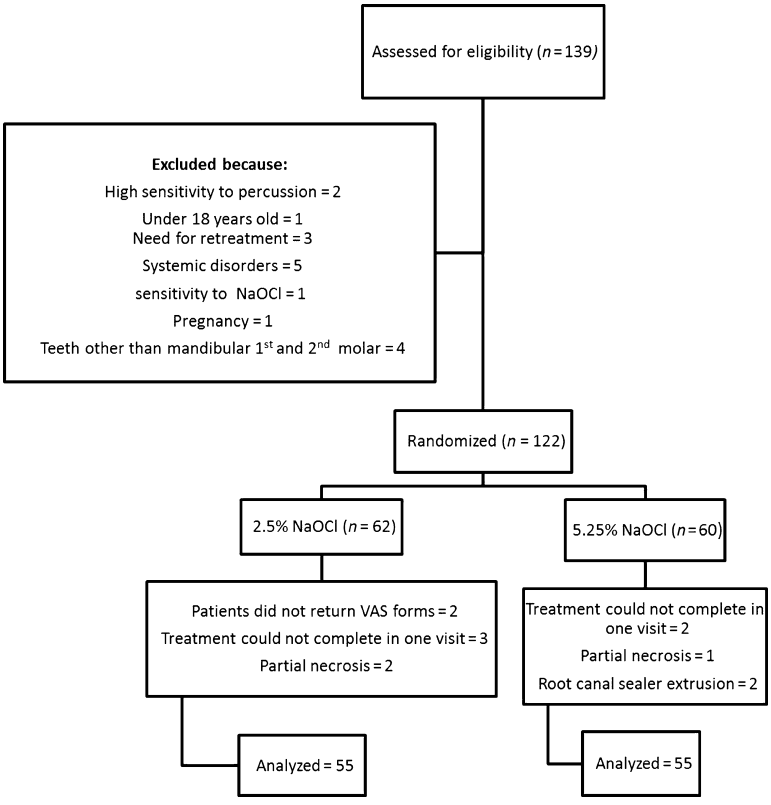

Figure 1 Flow diagram.

who received 5.25% NaOCl ($P = 0.001$; Table 1). However, there was no significant difference between the groups in the response to the analgesics ($P = 0.125$).

Discussion

In the present study, the results of single-visit root canal treatment of mandibular molars with irreversible pulpitis with the use of either 2.5% or 5.25% NaOCl as root canal irrigants revealed that the latter solution was associated with significantly less pain during the first 72 h after treatment.

There is no general agreement regarding the optimal concentration of NaOCl for root canal preparation. Higher concentrations of NaOCl exhibit more cytotoxicity, whilst providing more tissue-dissolving properties (Gonçalves *et al.* 2016). Most studies of postoperative pain have used 2.5–5.25% or higher concentrations of NaOCl (Torabinejad *et al.* 2005, Gondim *et al.* 2010, Ali *et al.* 2012, Almeida *et al.* 2012, Parirokh *et al.* 2013, 2014a, Kara Tuncer & Gerek 2014, Raju *et al.* 2014, Sethi *et al.* 2014, da Silva *et al.* 2015, Cruz Junior *et al.* 2016). In addition, these concentrations of NaOCl were the most commonly used irrigants reported by AAE members and dentists in the USA (Dutner *et al.* 2012, Savani *et al.* 2014). Several clinical investigations have compared 2.5% and 5.25% concentrations of NaOCl to evaluate their efficacy in eliminating microorganisms from infected root canals (Ercan *et al.* 2004, Siqueira *et al.* 2007, Gonçalves *et al.* 2016, Rôças *et al.* 2016). Therefore, in the present study, two common concentrations of NaOCl (i.e. 2.5% and 5.25%) were used.

The patients who received 5.25% NaOCl reported significantly lower pain during the first 72 h following the treatment. The higher antibacterial activity of 5.25% compared to 2.5% concentration may not have significant impact on lowering pain following endodontic treatment because only patients with irreversible pulpitis without periapical pathosis were included. The exact reason for less pain when a

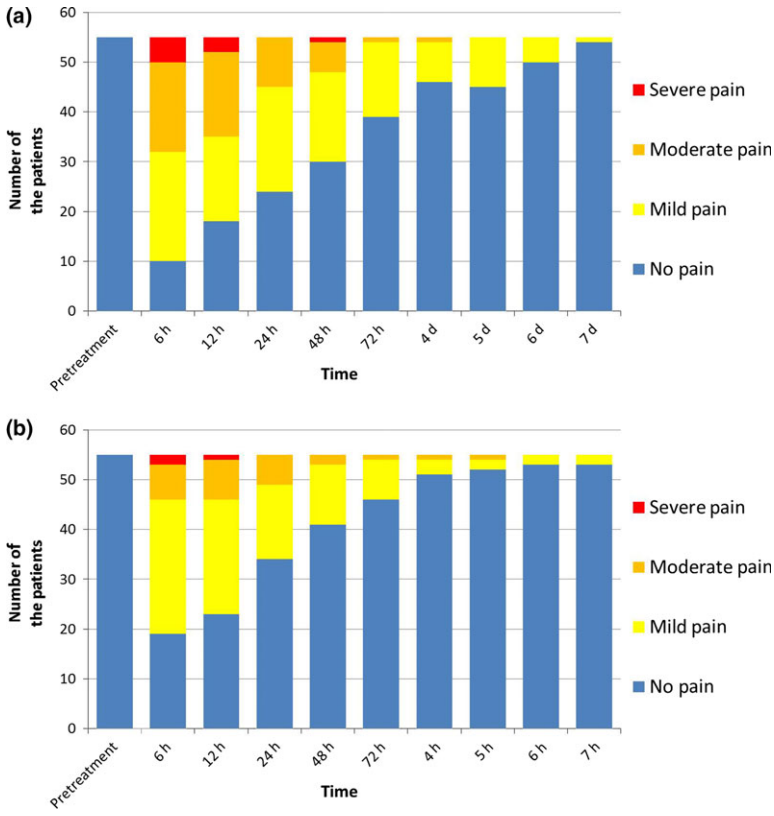

Figure 2 (a) Pain felt by the patients who received 2.5% NaOCl as irrigant when categorized in four different levels (no pain, mild pain, moderate pain and severe pain). (b) Pain felt by the patients who received 5.25% NaOCl as irrigant when categorized in four different levels (no pain, mild pain, moderate pain and severe pain).

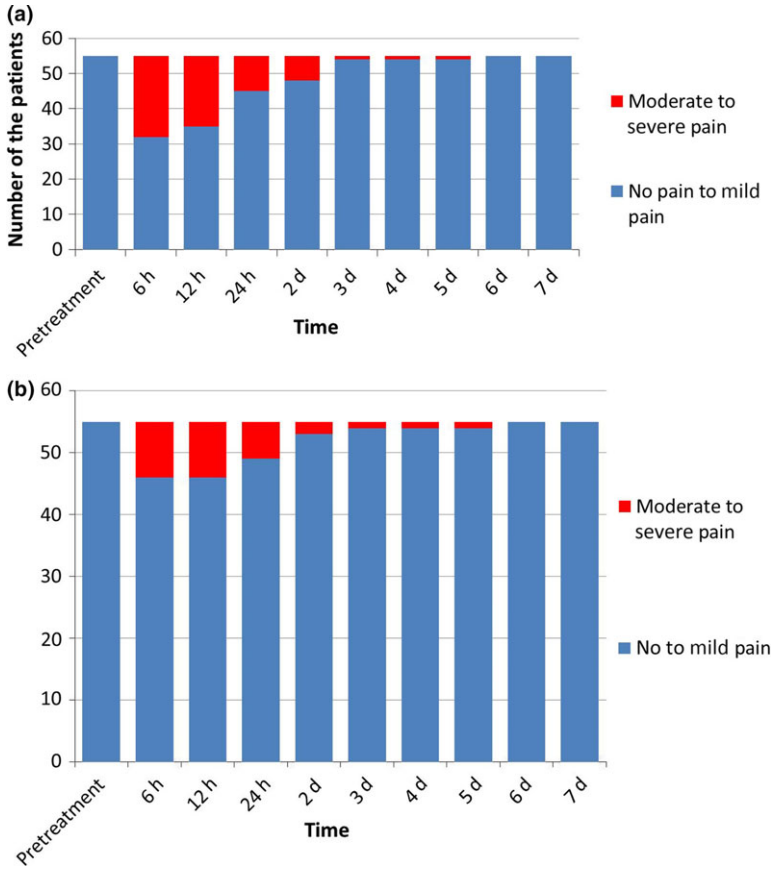

Figure 3 (a) Pain felt by the patients who received 2.5% NaOCl as irrigant when categorized in two different levels (no pain to mild pain and moderate pain to severe pain). (b) Pain felt by the patients who received 5.25% NaOCl as irrigant when categorized in two different levels (no pain to mild pain and moderate pain to severe pain).

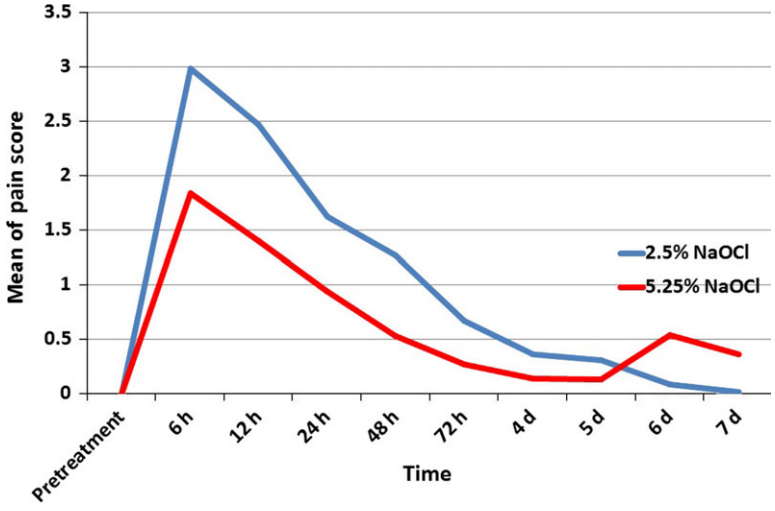

Figure 4 Mean level of pain on VAS felt by the patients in both groups during a 7-day period following root canal treatment.

Table 1 Average number and standard error (SE) of analgesic consumption during different times following the treatment

Group	Time										
	6 h	12 h	24 h	48 h	72 h	4 days	5 days	6 days	7 days	Total average	*P*
2.5% NaOCl	2.91 (0.3)	2.47 (0.32)	1.61 (0.25)	1.27 (0.26)	0.66 (0.17)	0.36 (0.12)	0.3 (0.09)	0.09 (0.03)	0.01 (0.01)	2.27 (0.25)	0.001
5.25% NaOCl	1.83 (0.26)	1.40 (0.23)	0.94 (0.21)	0.52 (0.15)	0.27 (0.10)	0.14 (0.08)	0.12 (0.08)	0.005 (0.04)	0.003 (0.02)	1.64 (0.16)	

higher concentration of NaOCl was used is unclear. However, it is possibly related to the inclusion criteria where only patients with inflamed pulps without periapical pathosis were included. No periapical radiolucency and the presence of normal periapical structures may prevent extrusion of the irrigant as well as debris despite the higher dissolution capacity of 5.25% NaOCl. Also the higher dissolution capacity of 5.25% NaOCl may dissolve the remaining apical pulp tissues more effectively and therefore not let them to release signalling molecules that may upregulate inflammation in the periapical tissues.

One of the important aspects of clinical trials is to include patients with similar preoperative conditions. It has been shown that preoperative pain had significant impact on postoperative pain (Gondim *et al.* 2010, Ali *et al.* 2012, Applebaum *et al.* 2015, Law *et al.* 2015). Therefore, in this study, to prevent bias due to the presence of preoperative pain, only patients with no spontaneous pain were included.

All patients were asked about the medication they used during the 2 days prior to the treatment. As these patients had no spontaneous pain, they had not used analgesic medication just prior to the treatment visit, and for that reason, the effect of an important possible bias was eliminated (i.e. pre-treatment analgesic consumption on postoperative pain following root canal treatment).

In the present study, single-visit root canal treatment was undertaken because systematic reviews and meta-analyses have found either no significant difference or significantly lower postoperative pain following single-visit root canal treatment compared to multivisit treatment even in teeth with necrotic pulps (Su *et al.* 2011, Wong *et al.* 2014).

The patients were asked to take a capsule of Gelofen immediately after treatment because two previous studies have shown that the use of an NSAID after treatment had a significant influence on reducing postoperative pain (Morse *et al.* 1990, Mehrvarzfar *et al.* 2012). The patients were also instructed to take Gelofen in case of pain after treatment because another study has reported no significant difference in pain felt by the patients with either regular or on-demand use of ibuprofen following treatment of mandibular molars with irreversible pulpitis (Parirokh *et al.* 2014a).

The number of analgesics taken by patients who had 5.25% NaOCl was significantly lower than that taken by those who had 2.5% NaOCl ($P = 0.001$). The lower analgesic consumption confirms lower pain reported by the patients in the 5.25% NaOCl group.

The results of a systematic review and meta-analysis showed that during the first 48 h after root canal treatment, pain felt by the patients significantly decreased (Pak & White 2011). Therefore, some investigations limited their research to the first 48–72 h after treatment (Gondim *et al.* 2010, Parirokh *et al.* 2012b, Silva *et al.* 2013, Kara Tuncer & Gerek 2014, Parirokh *et al.* 2014a, Kandemir Demirci & Çalışkan 2016). The results of the present study revealed that higher levels of pain were reported by the patients in both groups during the first 3 postoperative days compared to later time intervals.

In the present study, an epoxy resin root canal cement (AH26) was used for root canal filling. There are some reports that have shown that NaOCl may influence the bond strength of epoxy root canal cements to dentine when used as the final rinse (Neelakantan *et al.* 2011, 2015). Therefore, 5 mL normal saline was used as the final irrigant.

Researchers have used various methods for comparing the effect of their interventions on postoperative endodontic pain. They have either categorized pain at different levels or have just compared the pain based on the numerical VAS (Torabinejad *et al.* 2005, Attar *et al.* 2008, Parirokh *et al.* 2012b, 2013, Silva *et al.* 2013, Parirokh *et al.* 2014a, Kara Tuncer & Gerek 2014, Nekoofar *et al.* 2015, Kandemir Demirci & Çalışkan 2016). In the present study, both two- and four-level pain categorization systems were used to compare the effect of two different NaOCl concentrations on postoperative pain. The results showed that changing the pain categorization system had no influence on the results at different time intervals after treatment, which is in accordance with Attar *et al.* (2008) who reported a high correlation between different questionnaires and categorization used for recording postoperative endodontic pain.

Conclusion

Up to 3 days following root canal treatment, the use of 5.25% NaOCl as an irrigant was associated with significantly less pain than the use of 2.5% of NaOCl.

Acknowledgement

The protocol of this study was approved by the Ethics Committee of Kerman University of Medical Sciences (Ir.kmu.rec.1394.293 and Iranian Registry of Clinical Trials ID No. IRCT201601202016N6). Authors wish to thank Ms. Jafarzadeh and Ms. Haghighi for their help.

Conflict of interest

The authors have stated explicitly that there are no conflict of interests in connection with this article.

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