



POST-ENDODONTIC PAIN REDUCTION AFTER ONE AND TWO-VISITS ROOT CANAL TREATMENT IN TEETH WITH NECROTIC PULPS AND APICAL PERIODONTITIS WITH 3 PROTOCOLS OF IRRIGATION

*Dr. Jorge Paredes Vieyra, D.D.S., MSc, Ph.D. and Julieta Acosta Guardado, D.D.S., MSc

Universidad Autónoma de Baja California, Campus Tijuana, BC México CP 22000.

*Corresponding Author: Dr. Jorge Paredes Vieyra

Universidad Autónoma de Baja California, Campus Tijuana, BC México CP 22000.

Article Received on 03/10/2018

Article Revised on 23/10/2018

Article Accepted on 13/11/2018

ABSTRACT

Objective: The aim of this clinical trial was to assess whether controlled irrigation with three cryotherapy protocols with different temperature would result in a reduced of post-endodontic pain after one-visit and two visits root canal treatment in teeth with necrotic pulps. The null hypothesis was that there would be no difference between the control group and cryotherapy groups in terms of post-endodontic pain. **Materials and Methods:** Two hundred and forty patients aged 18-65 years were treated with three cryotherapy protocols with different temperature after one-visit and two visits root canal treatment detected with only necrotic pulps. All canals were clean and shaped with Reciproc instruments. Final irrigation with cold (6°C, 2.5°C, and room temperature) 17% EDTA and 10 mL cold saline solution. **Results:** No statistically relevant modification ($p > .05$) between the control group and group A were encountered concerning level or period of pain. There was no statistically relevant difference ($p > .05$) among Group A and CG compared with Group B. Group B showed less pain than the rest of the groups. Cryotherapy protocols used in the two experimental groups can help dentists to manage pain in root canal treatments with vital pulps. **Conclusion:** The methodology in both selecting the participants in the study and analyzing the data in this randomized clinical trial permitted us to conclude that cryotherapy aids clinical procedures to clean and shape the canals in order to reduce the occurrence of post-endodontic pain and the need for a prescription in patients with a diagnosis of vital pulp.

KEYWORDS: Cryotherapy, post-operative pain, post-endodontic pain, pain.

INTRODUCTION

Post-endodontic pain can be distressing to both the patient and the dental professional. It is an unwanted but common sensation regardless of the pre-operative periapical condition of the tooth treated. Therefore, pain prevention and management during and after root therapy is essential with regard to endodontic practice.^[1] Debris, organic tissue, microbes, and irrigant solutions extruded outside the apical foramen during root canal procedures initiate inflammation and post-operative problems.^[2-4]

The composition and the degree of bacterial contamination of the debris and the reactions of the patient's immune system will play an important role in post-endodontic pain. Meticulous determination and maintenance of working length may reduce the amount of debris extruded through the main foramen, but may not avoid this entirely.^[5,6] Accumulation of tissue remnants and dentin in the apical constriction is usual and can produce obstruction of the root canal.^[7] This

condition can be prevented if working length and patency of the apical foramen is maintained.^[8,9]

Several strategies have been developed to mitigate post-endodontic pain, which includes prescribing prophylactic analgesics and corticosteroids, administering long-lasting anesthesia, root canal preparation using the crown down technique, and utilizing glide path applications and occlusal reduction.^[10,11]

Some authors indicated that maintaining apical patency would not produce more post-endodontic complications.^[12] A newly issued *in vitro* study exhibited that intracanal carriage of cold irrigant at 2.5°C with Endo-Vac irrigation decreased the exterior side temperature by about 10°C, preserving such a temperature for five minutes^[13], which, according to the abovementioned scenario, would be adequate to create a confined anti-inflammatory beneficial consequence in periradicular tissues. Cryotherapy is derived from the Greek term *cryos*, which means "very cold".^[14] Hence, cryotherapy uses low temperatures to treat harms and

inflammation. Cryotherapy aims at removing heat and thus gaining an advantage by reducing inflammation.^[15]

Cryotherapy is a long-standing method that has been regularly applied in sports injuries and medical procedures for pain management and post-operative care. Cryotherapy, by itself, suggests that applying cold through several methods may reduce the transmission speed of nerve motions, hemorrhage, edema, and local inflammation. It is therefore effective in the reduction of musculoskeletal pain, muscular spasm, and connective tissue distension.^[13]

Hence the goal of this clinical study was to evaluate the post-endodontic pain reduction after one and two-visits root canal treatment in teeth with necrotic pulps and apical periodontitis with 3 protocols of irrigation. The null hypothesis was that there would be no difference between the control group and experimental groups in terms of post-endodontic pain.

MATERIALS AND METHODS

This clinical study was carried out at the Autonomous University of Baja California, School of Dentistry, Tijuana, Mexico. The protocol was accepted by the Ethics Commission of the University (number: 93/2018) and managed in agreement with the ethical principles of the last update of the Declaration of Helsinki.^[16]

Three specialized endodontists with an average clinical practice of 18 years and qualified in the techniques, strategies, and methods studied were incorporated in the study. They performed 80 root canal treatments each ($n=240$) in maxillary/mandibular anterior or posterior teeth, having necrotic pulps established by pulp sensitivity testing with heat and cold. Pulpal response was assessed with previous root canal treatment (RCT) using EndoIce (Hygenic Co, Ak, OH), and proper palpation and percussion examinations were conducted.

Another condition taken into account was the nonexistence of roentgenographic signs of apical pathology. The above-mentioned analysis was established on a sample size calculation that expected, at least, 40 subjects per clinician were essential in order to identify changes among the two experimental and control groups for an effect size of 0.85 with an alpha error of 0.05.^[17] All root canal treatments were performed over one and two visits. Root canal treatments and written agreement of all individuals participating in the study were obtained.

Pulpal sensibility tests were performed by the principal author, and the digital radiographic diagnosis was recognized by two certified clinicians. Further clinical requirements for patients' inclusion were as follows: 1) Requirements of the clinical trial were understood and freely accepted. 2) Patients in adequate physical and mental health were included. 3) Teeth with sufficient coronal structure and diagnosed with necrotic pulps. 4)

No previous root canal treatment. 5) No intake of analgesics or antibiotics seven days prior to the root canal treatment.

Exclusion criteria: Previously root canal treated teeth, pregnancy, failure to obtain patient's authorization, patients with a record of treatment for long-lasting pain, patients less than 18 years of age and more than 65 years of age. Vital teeth and teeth with apical radiolucency, internal or external resorption, open apex, severe curvatures ($>36^\circ$), or a radiographically canal calcifications were all rejected from the study. Mishaps or difficulties during RCT (impossibility to achieve working length) also resulted in the exclusion of patients from the study.

The diagnosis of necrotic pulp was confirmed by the non-existence of bleeding after gaining access to the pulp chamber. If the sensibility test was affirmative and there was bleeding following pulp exposure, the tooth was recognized as vital and eliminated of the study. Presence or absence of pain seven days previous to the event (yes/no) was observed.

Patient selection and distribution: A total of 240 of 254 patients (129 females and 111 male) aged between 18–65 years were integrated into this clinical trial, while 14 were rejected as not completing the requirements needed. Any patient who declined to agree with the study rejected one-visit RCT, and consumed analgesics or NSAIDs were eliminated also. Each qualifying patient was informed about the intentions, hazards, and plan of the trial, and written informed consent authorizations were obtained prior to their enrollment. A clinician who did not participate in the study carried out the randomization procedure using a processor random table generator (www.random.org 2018).

Each patient received a consecutive number. Two-hundred and forty patients met the inclusion criteria and were integrated into the study. Of the complete sample, 80 were randomly allocated to one and two-visits root canal treatment with different irrigating regimes and different temperatures (Fig. 1).

Clinical methodology: The root canal treatments were planned to be completed over one or two visits. Topical anesthetic (Anesthesia Topica, Astra Mexico) was applied before infiltration. Patients received 1 carpule of articaine 2% with epinephrine 1:200,000 (Septodont, Saint-Maur des-Fosses, France). In circumstances in which additional anesthesia was necessary, intra-ligamental anesthesia (2 mL articaine 2%) was administered. For the maxillary teeth, the solution was injected by gentle and gradual local infiltration. For the mandibular teeth, one of the carpules was used for an inferior alveolar nerve block and the other for a gentle labial infiltration near the tooth to be treated.

A rubber dam was placed and the tooth was disinfected with sterile gauze embedded with 2.5% NaOCl. The access cavity was accomplished using sterile # 331 bur (Dentsply Int, York, PA), with high-speed and refrigeration. 2.5% NaOCl was employed to disinfect the coronal access. The canals were cautiously explored with #10 K-type file (Flex-R files, Moyco/Union Broach, York PA, USA). The working length was established with a #15 k-file and the Root ZX electronic apex locator (J Morita, Irvine CA, USA) and confirmed radiographically (Schick Technologies, NY, USA). 1.5 mL of liquid 17% EDTA (Roth International, Chicago, IL) was administered at the entrance of the canals.

Cervical and middle thirds of the canal were flared with a K3XF 25/10 rotary instrument (Kerr Endo, Orange County, CA) at 500 rpm. The root canal was flushed with 3 mL 5.25% sodium hypochlorite (NaOCl). A glide path to the WL was then established. Preparations of the canals were completed with an electric motor (VDW Silver Motor, VDW, Munich Germany) in reciprocating mode.

Dentinal remains were removed from the instrument with a sterile gauze embedded with 2.5% NaOCl, immediately post the instrument change and after two-three pull in-and-pull out (pecking) movements (Reciproc) following the manufacturers' recommendations.

Each root canal was flushed with 2.5mL 2.5% NaOCl. Irrigation was achieved using a 24-gauge needle (Max-I-Probe; Tulsa Dental, York, PA) and a 31-G NaviTip needle (Ultradent Products Inc, South Jordan, UT) when getting the WL after each instrument insertion. A size #10 K file was used to maintain WL after each Reciproc instrument. The established WL was checked repeatedly throughout the clinical procedures. After instrumentation, the root canals were flushed with 3 mL 2.5% NaOCl and activated ultrasonically. It was carried out by means of an Irrisafe ultrasonic 20.00 tip (Satelec, Merignac, France) at 50% power of the Mini-Endo ultrasonic device (Kerr Endo), with the tip placed three mm from the WL for thirty seconds per root canal.

Irrigating Protocols

Group A. This group was divided into two sub-groups, GA1: 40 patients to be treated in one visit, and GA2: 40 patients to be treated in two visits.

The R25 (size 25/ .08) instrument was used in narrow and curved canals, and R40 files (40/ .06) were used in broad root canals. Three in/out pecking cycles were employed with a fullness of not more than 3 mm until obtaining the established WL. Patients belonging to this groups received a final irrigation with 5 mL cold (6°C) 17% EDTA followed with 10 mL cold (6°C) sterile saline solution dispensed to the WL using a cold (6°C) metallic micro-cannula included in the Endo Vac System (Kerr Endo) and maintained intracanal for one minute.

Group B. This group was divided into two sub-groups, GB1: 40 patients to be treated in one visit, and GB2: 40 patients to be treated in two visits.

Canals were prepared as in group A. Patients belonging to this groups received a final irrigation with 5 mL cold (2.5°C) 17% EDTA followed with 10 mL cold (2.5°C) sterile saline solution dispensed to the WL using a cold (2.5°C) metallic micro-cannula included in the Endo Vac System for one minute.

Control Group (CG). This group was divided into two sub-groups, CG1: 40 patients to be treated in one-visit, and CG2: 40 patients to be treated in two-visits.

Patients belonging to this groups were treated in a manner identical to the experimental groups (A and B), except that they received a final flush with 5 mL (room temperature) 17% EDTA followed with 10 mL (room temperature) sterile saline solution delivered to the WL using a metallic micro-cannula included in the Endo Vac System for one minute.

Each experimental and control group was flushed with the irrigant described above. Care was taken to confirm that the metallic cannula would aspirate properly by noticing the system's translucent evacuation duct. In case there was some obstacle, the metallic device was promptly replaced.

The working length was performed again by using an apex locator, as described, before using #35 and #40 files.

For the *single-visit groups*, the root canals were desiccated with sterile paper cones and filled at the same appointment. Gutta-percha points (Dentsply Maillefer) were laterally condensed with #25 nickel-titanium spreaders (Dentsply Maillefer) and AH-plus as the sealer (Dentsply Maillefer). The access cavities were etched and fixed with Fuji IX (GC Corp, Tokyo, Japan).

For the *two-visit groups*, the root canals were dried and medicated with calcium hydroxide powder (Roth, International) with distilled water in a creamy consistency. The paste was prepared by using equal volumes of Ca (OH)₂ powder and distilled water and applied meticulously into the root canal using endodontic hand files.

The access cavities (occlusal/palatal surface) were sealed with Cavit (3M ESPE, Seefeld, Germany) and the quality of the calcium hydroxide powder filling was checked radiographically.

Patients of the *two-visit group* were scheduled for a second appointment to complete root canal therapy at least 1 week after the initial appointment. At the second appointment, the calcium hydroxide paste was removed with hand instruments and copious irrigation with

distilled water followed by 2.5 mL 17% EDTA and a final rinse with 5.0 mL 5.25% NaOCl using the EndoVac irrigation system.

Following removal of the calcium hydroxide, the root canals were dried with sterile paper points, and obturation was performed with the same technique described for the single-visit group: Post-treatment radiographs were taken and all teeth were restored with a Fuji IX buildup.

The patients were warned of the possible occurrence of pain for hours following RCT and provided an evaluation form (VAS questionnaire) to be completed and returned 72 hours later. The forms confirmed the presence/absence of pain. The pain level was measured using a validated pain scale known as VAS.^[18] The VAS scale is a continuous measure comprised of a straight line, which is 10 cm in length. For pain intensity, the VAS is anchored by “no pain” (score of 0) and “pain as bad as it could be” (score of 10). The cut points on the pain VAS are no pain (0–0.5 cm), mild pain (0.6–4.0 cm), moderate pain (4.05–7.4 cm), and severe pain (7.5–10 cm).^[23] The pain VAS was completed by the patients. The patients were asked to put a mark perpendicular to the pain VAS line at the point that indicated their pain severity during the three days after the endodontic treatment.

Statistical Analysis: The associated issues pre-operatively recorded were incorporated into the analysis as follows: age, sex, the presence of occlusal contacts, and maxillary or mandibular teeth. Differences in the general intensity of pain between groups were analyzed using the ordinal (linear) Chi-square test. Dissimilarities in VAS recorded values after 24, 48 and 72 hours and in the amount of analgesic intake between the two groups tested.

The results were statistically evaluated with the ordinal Chi-Square test for the existence of post-endodontic pain with a level of significance of $p = 0.05$.

RESULTS

The study results showed statistically significant dissimilarities among the control group and group B throughout all time periods for post-operative pain. Table 1 shows the distribution of clinical variables; a total of 240 patients took part in this study: 129 (53.75%) were women and 111 (46.25%) were men. Their ages ranged between 18 and 65 years; 118 (49.16%) of the treated teeth were in the maxilla and 122 (52.83%) were in the mandible.

The clinical organization of the participants is presented in Table 1. No statistically relevant modification ($p > .05$) between the control group and group A were encountered concerning level or period of pain. According to the VAS examination, marks were seen 24–72 hours later in the three groups with an important decline subsequently (Table 2).

No statistically relevant distinction was appreciated among the three groups assessed in the trial in terms of level and quantity of analgesic intake ($p > .05$, Table 3). Analgesic intake was regulated in the 24 hours subsequent to the RCT in all the groups assessed. Two of the 240 patients indicated pain through the phase of the investigation corresponding to 1 and 1 for Group A and control group respectively.

There was no statistically relevant difference ($p > .05$) among Group A and CG compared with Group B. Group B showed less pain than the rest of the groups in relation to the existence of pain at any of the three-time points measured (Table 2).

Patients in the CG had a significantly higher occurrence of a post-endodontic pain than the rest (Table 2). Participants in groups A and B suffered significantly less pain after 24, 48 and 72 hours and needed fewer analgesics post-treatment ($p < .05$). Participants in the control group exhibited a significantly higher frequency of pain in general and lengthier period ($p < .05$).

Table 1: Distribution by group of teeth and location.

Variables	Irrigant Protocols		
	Control Group (n= 80)	Group A (n= 80)	Group B (n= 80)
Sex:			
Male	35	36	40
Female	41	45	43
Age Group:			
18-30	23	23	29
31-43	41	42	41
44-56	13	11	7
57-65	4	3	39
Arch		38	39
Maxilla	41	41	40
Mandible	41		
Occlusal contact:		5	4
Yes	5	75	76
No	75		

Table 2: Occurrence of post-endodontic pain.

Occurrence of pain	Pre-operative pain		Post-endodontic pain					
	Asymptomatic.	Symptomatic	Asymptomatic 24 h 48 h 72h			Symptomatic 24 h 48 h 72h		
Control Group								
One-visit treatment	36	4	37	38	40	3	2	0
Two-visit treatment	37	3	39	40	40	1	0	0
Group A								
One-visit treatment	36	4	38	39	40	2	1	0
Two-visit treatment	36	4	39	40	40	1	0	0
Group B								
One-visit treatment	37	3	39	40	40	1	0	0
Two-visit treatment	38	2	40	40	40	0	0	0

Table 3: Quantity of analgesics intake.

	Control Group	Group A	Group B
24 hrs. after	(n = 80) (%)	(n = 80) (%)	(n = 80) (%)
Quantity			
None	76 (95)	77 (70.83)	78 (97.5)
One tablet	03 (3.75)	3 (3.75)	2 (2.5)
Two tablets	01 (1.25)	1 (1.25)	1 (1.25)
Three tablets	0	0	0

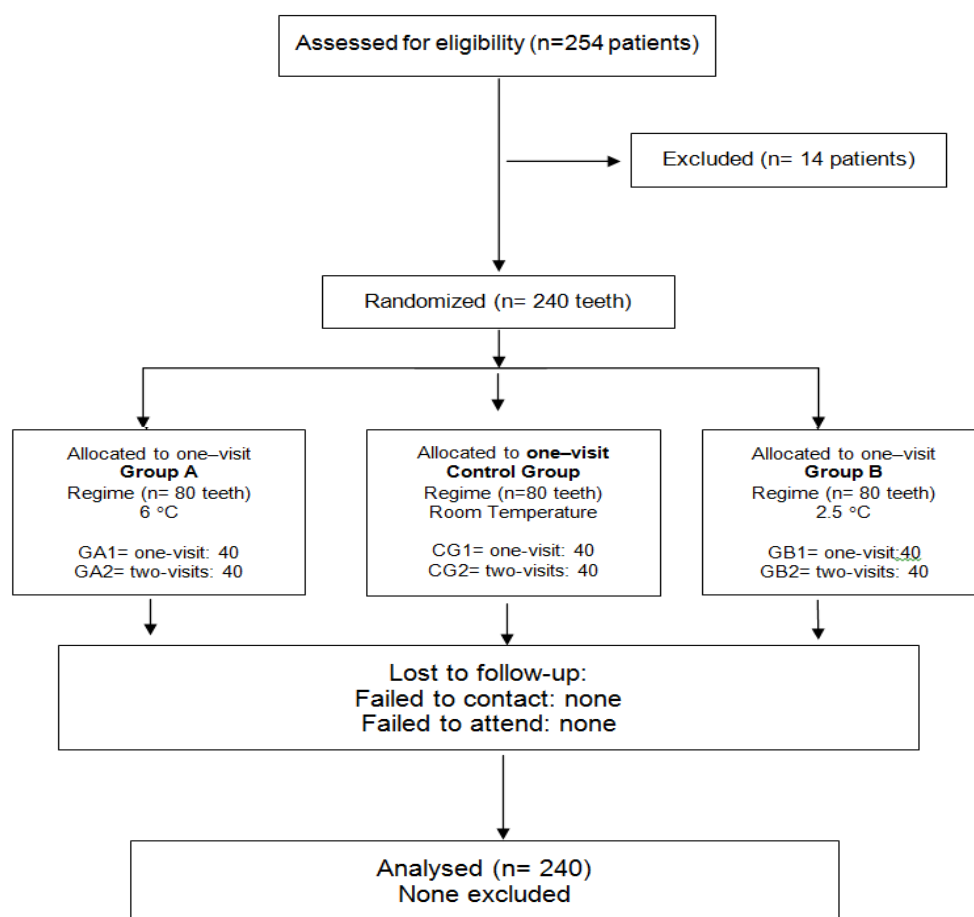


Figure 1: Flow diagram of the progress of phases of the study.

DISCUSSION

Pain by itself is difficult to understand and measure, especially when it happens suddenly in patients. The principal difficulty in learning aching and discomfort is the participant's idiosyncratic assessment and dimension. For this purpose, planning the evaluation form has to be completely comprehended by the participants.

Pre-operative pain is one of the highest predictors of post-endodontic pain.^[18] Thus, only teeth with necrotic pulps indicated for root canal treatment were treated. All treatments were performed over one and two visits, the involucrate teeth in the three groups were released of any early occlusal points after endodontic procedures so that unsuitable traumatic occlusion would not disturb the outcomes. WL was estimated with an EAL and confirmed with a radiograph. Root ZX EAL was employed because its exactitude has been established in two clinical environments.^[19-22] As suggested by Herrera *et al.*^[23], electronic WL measurement was repetitive after cervical and middle thirds shaping.

This study is in agreement with that of Yaylali *et al.*^[24], who described that the incidence of postoperative pain was significantly lower when apical patency was maintained but in non-vital teeth. In our study, clean and shape procedures were performed on root thirds using reciprocating movements, respectively, followed by a final irrigation with cold (6°C and 2.5°C) 17% EDTA gently delivered to the WL using a cold (6 and 2.5°C) sterile metallic micro cannula attached to the Endovac, which was supported in early scientific reports.^[25-30] The standardized and controlled procedures used in this study may also have contributed to the reduction of post-endodontic pain. We used cold saline solution in the two experimental groups as the final irrigant that decreases the external root surface temperature may be sufficient to generate a local anti-inflammatory result in the periradicular tissues. Bleakley *et al.*^[31,32] evaluated the efficiency of cryotherapy applications in soft tissue injuries. These effects can explain the reduced pain levels of the cryotherapy groups in the present study.

The study results showed statistically significant differences between the control group and one cryotherapy group (2.5°C) throughout all time periods for post-endodontic pain. Therefore, the null hypothesis of the study was rejected. Intracanal cryotherapy can be simply and safely included in the non-surgical root canal treatment.

CONCLUSION

The methodology in both selecting the participants in the study and analyzing the data in this clinical research permitted us to conclude that cryotherapy aids clinical procedures to clean and shape the canals in order to reduce the occurrence of post-endodontic pain and the need for a prescription in patients with a diagnosis of teeth with necrotic pulp.

REFERENCES

1. Ince B, Ercan E, Dalli M, Dulgergil CT, Zorba YO Colak H. Incidence of postoperative pain after single-and multi-visit endodontic treatment in teeth with vital and non-vital pulp. *Eur J Dent.*, 2009; 3(4): 273–9.
2. Tanalp J, Güngör T. Apical extrusion of debris: a literature review of an inherent occurrence during root canal treatment. *Int Endod J.*, 2014; 47(3): 211–221.
3. Ferraz CC, Gomes NV, Gomes BP, Zaia AA, Teixeira FB, Souza-Filho FJ. Apical extrusion of debris and irrigants using two hands and three engine-driven instrumentation techniques. *Int Endod J.*, 2001; 34(5): 354–8.
4. Bürklein S, Schäfer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. *J Endod.*, 2012; 38(6): 850–2.
5. Torabinejad M, Kettering JD, McGraw JC, Cummings RR, Dwyer TG, Tobias TS. Factors associated with endodontic interappointment emergencies of teeth with necrotic pulps. *J Endod.*, 1988; 14(5): 261–6.
6. Hülsmann, M., Peters, O., Dummer P. Mechanical preparation of root canals: shaping goals, techniques and means. *Endod Top.*, 2005; 10: 30–76.
7. Hülsmann M. Extrusion von Debris und Spülflüssigkeiten während der Wurzelkanalbehandlung. *Endodontie*, 2008; 17: 353–354.
8. Souza RA. The importance of apical patency and cleaning of the apical foramen on root canal preparation. *Braz Dent J.*, 2006; 17(1): 6–9.
9. Hülsmann M, Schäfer E. Apical patency: fact and fiction - a myth or a must? A contribution to the discussion. *Endo-Endod Prac T.*, 2009; 3(4): 285–208.
10. Pochapski MT, Santos FA, de Andrade ED, Sydney GB. Effect of pretreatment dexamethasone on postendodontic pain. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.*, 2009; 108(5): 790–5.
11. Attar S, Bowles WR, Baisden MK, Hodges JS, McClanahan SB. Evaluation of pretreatment analgesia and endodontic treatment for postoperative endodontic pain. *J Endod.*, 2008; 34(6): 652–5.
12. Arias A, Azabal M, Hidalgo JJ, de la Macorra JC. Relationship between post endodontic pain, tooth diagnostic factors, and apical patency. *J Endod.*, 2009; 35(2): 189–192.
13. Vera J, Ochoa-Rivera J, Vazquez-Carcano M, Romero M, Arias A, Sleiman P. Effect of intracanal cryotherapy on reducing root surface temperature. *J Endod.*, 2015; 41(11): 1884–7.
14. Braddom RL. *Handbook of Physical Medicine and Rehabilitation*, 2004; 2nd ed. Philadelphia: Saunders.
15. Belitsky RB, Odam SJ, Hubley-Kozey C. Evaluation of the usefulness of ice (wet and dry), and cryogenic packets in decreasing skin temperature. *Phys Ther.*, 1987; 67(7): 1080–4.

16. World Medical Association. Declaration of Helsinki: ethical principles for medical research involving human subjects. *J Am Med Assoc.*, 2000; 284(23): 3043–5.
17. Schumm, W. R., Pratt, K. K. Hartenstein, J. L., Jenkins, B. A., Johnson, G. A. Determining statistical significance (alpha) and reporting statistical trends: controversies, issues, and facts. *Comp Psych.*, 2013; 2(10): 1-10.
18. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arth Care Res (Hoboken)*, 2011; 63(Suppl 11): S240–52.
19. Jensen MP, Chen C, Brugger AM. Interpretation of visual analog scale ratings and change scores: a reanalysis of two clinical trials of postoperative pain. *J Pain*, 2003; 4(7): 407–14.
20. Luiz F, Santana D, Correia L. The ability of two apex locators to locate the apical foramen: an in vitro study. *J Endod*, 2006; 32(6): 560–2.
21. Tselnik M, Baumgartner J, Gordon Marshall J. An evaluation of Root ZX and Elements diagnostic apex locators. *J Endod*, 2006; 31(7): 507–9.
22. Welk A, Baumgartner J, Gordon Marshall J. An in vivo comparison of two frequency- based electronic apex locators. *J Endod*, 2003; 29(8): 497–500.
23. Dunlap CA, Remeikis NA, BeGole EA, Rauschenberger CR. An in vivo evaluation of an electronic apex locator that uses the ratio method in vital and necrotic canals. *J Endod*, 1998; 24(1): 48–50.
24. Herrera MC, Abalos A, Planas J, Llamas R. Influence of apical constriction diameter on Root ZX apex locator precision. *J Endod*, 2007; 33(8): 995–8.
25. Yaylali IE, Kurnaz S, Tunca YM. Maintaining Apical Patency Does Not Increase Postoperative Pain in Molars with Necrotic Pulp and Apical Periodontitis: A Randomized Controlled Trial. *J Endod*, 2018; 44(3): 335–340.
26. Modabber A, Rana M, Ghassemi A, et al. Three-dimensional evaluation of postoperative swelling in treatment of zygomatic bone fractures using two different cooling therapy methods: a randomized, observer-blind, prospective study. *Trials.*, 2013; 14: 1–10.
27. Al-Nahlawi T, Abo Hatab T, Abd Alrazak M, Al-Abdullah A. Effect of intracanal cryotherapy and negative irrigation technique on post endodontic pain. *Journal of Contemp Dent Pract.*, 2016; 17(2): 990–6.
28. Vera RJ, Ochoa J, Romero M, et al. Intracanal Cryotherapy Reduces Postoperative Pain in Teeth with Symptomatic Apical Periodontitis: A Randomized Multicenter Clinical Trial. *J Endod.*, 2018; 44(1): 4–8.
29. Keskin C, Özdemir Ö, Uzun İ, Güler B. Effect of intracanal cryotherapy on pain after single-visit root canal treatment. *Aust Endod J.*, 2017; 43(2): 83–88.
30. Candas GE, Arslan H. Effects of Various Cryotherapy Applications on Postoperative Pain in Molar Teeth with Symptomatic Apical Periodontitis: A Preliminary Randomized Prospective Clinical Trial. *J Endod.*, 2018; 44(3): 349– 354.
31. Bleakley C, McDonough S, MacAuley D. The use of ice in the treatment of acute soft tissue injury: a systematic review of randomized controlled trials. *Am J Sports Med.*, 2004; 32(1): 251–61.
32. Bleakley CM, McDonough SM, MacAuley DC, Bjordal J. Cryotherapy for acute ankle sprains: a randomized controlled study of two different icing protocols. *Brit J Sport Med.*, 2006; 40(8): 700–5.