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Original Article

Comparison of the incidence of post-operative pain after low-level laser therapy between single- and multi-visit root canal treatments for chronic apical periodontitis: A prospective randomized clinical trial

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Abstract

Aim: The aim of this clinical study was to evaluate the effect of low-level laser therapy, used in conjunction with conventional canal disinfection techniques, on post-operative pain after single- and multi-visit root canal treatments for chronic apical periodontitis.

Methodology: 100 volunteers were randomly divided into 4 groups. The main inclusion criteria were radiographic evidence of apical periodontitis (minimum size of 2.0×2.0 mm) and a diagnosis of pulpal necrosis confirmed by a negative response to vitality tests. All the root canals were prepared using a standard shaping technique and irrigation procedure. In Groups I and III, the root canals were obturated during the first visit following chemo-mechanical preparation. In Groups II and IV, the root canals were medicated with calcium hydroxide and obturated during a second visit, 1 week later. In Groups III and IV, after the chemo-mechanical preparation, the root canals were additionally irradiated by an 810-nm diode laser at 1.5 W output for 20 seconds. A modified visual analogue scale was used to measure pain at 4, 8, 12, 24, and 48 hours and 7 days after the treatment.

Results: There was no statistically significant difference between the groups in terms of post-operative pain at any time during the observation period ($p>.05$). Post-operative pain occurred only at 8 and 12 hours and at 1, 2, and 3 days in all groups. There was no correlation between the results regarding age, gender, periapical index scores, or tooth type.

Conclusion: The use of low-level laser therapy had no significant effect on the incidence of post-operative pain, and single-visit root canal treatment may be a strong alternative to multi-visit treatment.

Keywords: Post-operative pain, apical periodontitis, lasers, endodontics

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Introduction

Endodontic treatment aims to remove vital or necrotic pulp tissue, microorganisms, and their by-products from the root canal system by instrumentation and irrigation (1). Since irrigation solutions are effective in direct contact with bacteria, they have limited effects on irregular and deep regions of root canals to completely eliminate bacteria from the deep layers of dentinal tubules (2).

The common view among clinicians is that using calcium hydroxide $Ca(OH)_2$ as an intra-canal medication can significantly affect the variety and amount of microorganisms that can be cultured in infected root canals (3).

However, the effects of $Ca(OH)_2$ on several microorganisms that cause persistent apical periodontitis are still questioned (4). Some studies have shown that the use of $Ca(OH)_2$ as an intra-canal medication improves healing (5), but some have reported that it has very little or no benefit (3). A systematic review and meta-analysis by Sathorn et al. (6) mentioned only a few in vivo studies that had the standards for the highest level of evidence (3,5,7), and declared that there was no statistically significant difference between single-and multi-visit root canal therapy in healing. Single-visit treatment, which has many advantages for both the clinician and the patient, has also been shown to be successful in several studies (8,9). It is less time consuming and is less traumatic than multi-visit treatment. Single-visit treatment also reduces the risk of inter-appointment recontamination of root canals and tooth fractures (10). In addition, some studies have shown that post-operative pain is lower in single-visit treatment (11).

Many researchers have tried to eliminate microorganisms from complex tubular root canals using various laser devices (12). Recently, diode lasers have been reported to have high antimicrobial activity and be effective in eliminating bacteria from root canals when used in addition to traditional disinfection procedures (12,13). Several published papers have indicated the effectiveness of disinfection using a diode laser in root canal treatment, demonstrating bactericidal activity against Enterococcus faecalis (12-14). A previous study indicated that high-power diode laser irradiation (830 nm, at a power of 3 W) and irrigation with 0.5% sodium hypochlorite (NaOCl) and 17% EDTA-T provided increased disinfection in the deep layers of dentin (14).

Post-operative pain is a common complication associated with root canal treatment and has an incidence rate between 3-58% (15). It is a considerable problem for both patients and dentists (15,16). The occurrence of post-operative pain after root canal treatment is generally the result of an acute inflammatory response in the periradicular tissues. Several factors, such as mechanical injury, chemical irritation, and the presence of microorganisms – particularly in infected cases, may be the reasons for the development of pain (11).

In this study, our aim was to investigate the effect of low-level laser therapy (LLLT) in addition to conventional canal disinfection techniques on post-operative pain after single- and multi-visit root canal treatments of chronic apical periodontitis.

Materials and Methods

A total of 100 anterior single-rooted teeth of 100 patients (62 women and 38 men) were selected. Every patient was well-informed about the objective, methodology, and purpose of the study. Post-operative care, follow-up examinations, and alternative treatment options were explained in detail before the patients' participation in the study. Informed consent was obtained from each patient included in the study. The study was conducted in the Istanbul University Faculty of Dentistry Department of Endodontics, and all procedures performed were in accordance with the ethical standards of the Istanbul University Ethical Committee of the Medical Faculty (no. 299-603) and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Sample selection

Medically immune-compromised patients, patients requiring antibiotic prophylaxis, and patients that had diabetes, hypertension, or drug allergies were excluded.

The main criteria for sample selection were single-rooted teeth with a healthy periodontium (pocket depth<3-4 mm) requiring root canal therapy due to asymptomatic chronic apical periodontitis and that had a periapical lesion with a minimum size of 2.0×2.0 mm, radiographically.

Teeth with negative responses to pulp tests, palpation, and percussion and without fistulas or acute swelling were included in the study. Teeth with an immature apex; acute dentoalveolar abscess or swelling; root cracks or fractures; internal or external resorption longer than 24 ± 2 mm; and on which a rubber dam could not be applied were excluded.

The patients were randomly allocated into 4 treatment groups. A detailed anamnesis, clinical examination, diagnosis, and treatment plan were conducted for each patient. The age, gender, obturation time, and working length of the root canals of the patients were recorded.

Root canal treatment protocol

Root canal treatment was performed by the same operator in all groups. The standard procedure during the first visit included the administration of local anesthesia, rubber dam isolation, and standard cavity preparation for all groups. After removing all caries, pre-endodontic restoration was performed using composite resin (3M ESPE, Seefeld, Germany) for the proper isolation of teeth with inadequate tooth structure to allow for rubber dam application as well as the prevention of leakage during and between

treatments. After preparing the endodontic access cavity, orifice openers (Endo-Access Bur, Dentsply Maillefer, Tulsa, OK, USA) were used to enlarge the coronal third of the root canals. The working length of each canal was determined using an electronic apex locator (RAYPEX 6, VDW, Munich, Germany), and by the paralleling digital radiographic method (Kodak RVG 5100, Rochester, NY, USA) with the use of a special film holder (Kerr Endo-Bite Senso, Orange, CA, USA). The root canals were prepared using a hybrid technique. Initially, a standard Revo-S (SC1, SC2, and SU files; #25 06 taper) NiTi rotary system (MicroMega, Besançon, France) and apical shaping files (AS30, AS35, and AS40) of the same system were used (#40 06 taper). Shaping of the root canals were continued using K-type hand files (Dentsply Maillefer, Ballaigues, Switzerland) and apical boxes were shaped up to #50 and #60, depending on the size of the initial apical file (11). Irrigation of the root canals was performed with a 30-gauge endodontic side-vented needle (Endo-Eze, Ultradent Products Inc., South Jordan, UT, USA), and 2 ml of 2.5% NaOCl solution between each file. After instrumentation, 5 ml of 17% EDTA, 2.5% NaOCl, and sterile water was used consecutively to remove the smear layer and 3 ml of 2% Chlorhexidine (CHX) was used for final irrigation.

In Group I, after instrumentation and final irrigation, the root canals were dried with paper points. If no exudate was observed, the root canals were obturated using gutta percha and AH Plus (Denstply Maillefer, Ballaigues, Switzerland) as the sealer and using the cold lateral compaction technique. After radiographic control, excess gutta-percha pieces were removed using a heated plugger, and the endodontic cavity was cleaned with alcohol until no gutta percha or sealer remained. Glass ionomer (Nova Glass, Imicryl Dental, Konya, Turkey) material was chosen as a base material, and the coronal restoration was completed using a composite resin (3M ESPE, Seefeld, Germany).

In Group II, after chemo-mechanical preparation and after the root canals were dried with paper points, a radiopaque $Ca(OH)_2$ paste (MM paste, MicroMega, Besançon, France) was applied as an intra-canal medication. $Ca(OH)_2$ paste was delivered through the root canal by means of a Lentulo spiral (Pastinject, MicroMega, Besançon, France). Confirmation of root filling was made radiographically. A cotton pellet was placed on the pulp chamber floor, and the access cavity was restored with glass ionomer and Cavit G (3M ESPE, Irvine, CA, USA) using the double-seal technique. At the second appointment 1 week later, minimal instrumentation was performed with the master apical file after irrigation with 5 ml of 2.5% NaOCl. The final irrigation, root canal obturation, and coronal restoration procedures were performed as in Group I.

In Group III, after all shaping and irrigation procedures, the root canals were irradiated with a solid diode laser (Cheese dental diode laser; Wuhan Gigaa Optronics Technology Co. Ltd., Wuhan, China) before obturation. The laser beam was delivered through a 200 µm flexible fiber optical plain tip and emitted at a wavelength of 810 nm. Based on a similar study (17), a power setting of 1.5 W using the continuous mode was selected. The laser tip was inserted 1 mm above the working length, activated, and removed using slow, helical movements in an apical-coronal direction for 20 seconds, applying total energy of 30 joules and ensuring all the canal walls were reached. After LLLT, the canals were obturated, and the teeth were restored as described in the previous groups.

In Group IV, after chemo-mechanical preparation, the root canals were dried with sterile paper points. Before the root canals were filled with $Ca(OH)_2$ paste, the LLLT was applied as in Group III. At the second appointment, the $Ca(OH)_2$ was removed and root canal obturation and coronal restoration were performed as described for Group II. The experiental groups are presented schematically in Table (1).

Table 1. Root canal disinfection protocol

Groups	Root canal disinfection protocol
Group 1	**Single visit (Only irrigation)**
Group 2	**Multi visits (Irrigation + $Ca(OH)_2$ paste between sessions)**
Group 3	**Single visit (Irrigation + laser irridation)**
Group 4	**Multi visits (Irrigation + laser irridation before placing $Ca(OH)_2$ paste between sessions**

Pain evaluation

Post-operative pain was assessed with a visual analog scale (VAS) at 4, 8, 12, and 24 hours and at 2, 3, 4, 5, 6, and 7 days after the treatments. The participants were called by telephone and asked to answer a questionnaire. The participants indicated the intensity of their pain using a numeric scale. The participants also expressed their level of discomfort by choosing numbers from 0 to 10 according to the following values: level 0: none; level 1-3: mild; level 4-7: moderate; or level 8-10: severe. The patients were instructed to use 100 mg flurbiprofen (Majezik, Sanovel, Istanbul, Turkey) twice a day if the pain was unbearable and were asked to record their analgesic intake. The participants were instructed to call the researcher in case of emergency or severe pain if the analgesics did not provide pain relief. In such cases, an intermediate emergency treatment appointment was scheduled (2 patients in Group II and 1 patient in Group IV) to relieve the patient's pain.

Statistical analysis

NCSS (Number Cruncher Statistical System) 2007 Statistical Software was used for the statistical analysis. For descriptive statistics (mean, standard deviation), the Friedman test for repeated measurements of multiple groups, the Kruskal-Wallis test for comparison between groups, the Dunn's test for subgroup comparisons, and the Chi-square test for quantitative data were used. Spearman's test was used to determine the relationship between the periapical index and VAS variables. The level of significance was set at $p<.05$.

Results

Table 2 shows the distribution of the treated teeth according to age and gender in the groups (N = 100). There were no statistically significant differences between the groups in the distribution of gender (p = .133) and age (p = .128).

Table 3 shows the distribution of teeth according to tooth type. There was no significant different between the groups in the terms of tooth type distribution.

In all groups, post-operative pain was observed after 8, 12, and 24 hours and after 1, 2, and 3 days. However, at 4 hours, and at 4, 5, 6, and 7 days, no pain was reported in all groups (Figure 1).

The overall incidence of post-operative pain after root canal treatment during the follow-up period was not significantly different between the groups (Table 4).

Laser disinfection and single- or multi-visit sessions with $Ca(OH)_2$ had no effect on post-operative pain.

In Groups II and IV, post-operative pain scores differed significantly between the time intervals (p = .004 and p = .032, respectively; Table 4).

Table 2. Distribution of teeth according to age and gender

		Group 1		Group 2		Group 3		Group 4		p
Age		36,2±11,65		31,56±12,21		40,36±12,69		35,96±14,79		0,128
Gender	Male	10	40,00%	7	28,00%	14	56,00%	7	28,00%	0,133
	Female	15	60,00%	18	72,00%	11	44,00%	18	72,00%	

Table 3. Distribution of teeth according to tooth type

Tooth no	Group 1		Group 2		Group 3		Group 4	
11	8	32,00%	3	12,00%	4	16,00%	6	24,00%
12	4	16,00%	5	20,00%	4	16,00%	6	24,00%
13	1	4,00%	0	0,00%	0	0,00%	0	0,00%
21	4	16,00%	15	60,00%	5	20,00%	10	40,00%
22	7	28,00%	2	8,00%	12	48,00%	3	12,00%
23	1	4,00%	0	0,00%	0	0,00%	0	0,00%

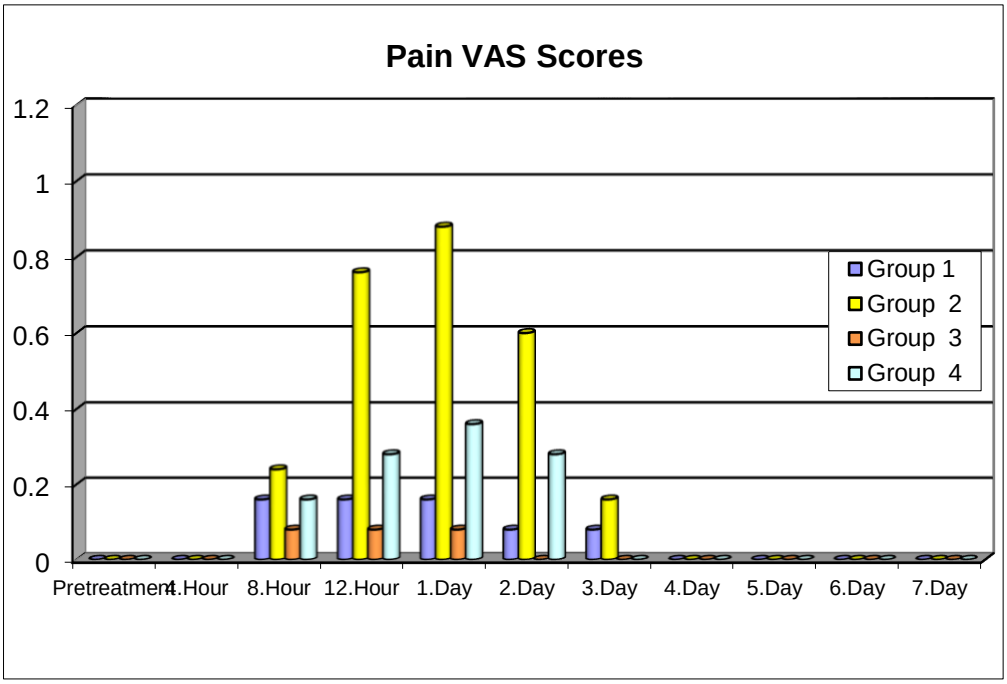

Figure 1. The overall incidence of post-operative pain after root canal treatment during the follow-up period

Table 4. Incidence of postoperative pain in groups during different time intervals

	Group 1	Group 2	Group 3	Group 4	p+
Pretreatment	0±0	0±0	0±0	0±0	-
4.Hour	0±0	0±0	0±0	0±0	-
8.Hour	0,16±0,55	0,24±0,66	0,08±0,4	0,16±0,55	0,788
12.Hour	0,16±0,55	0,76±2,33	0,08±0,4	0,28±1,06	0,273
1.Day	0,16±0,55	0,88±2,77	0,08±0,4	0,36±1,44	0,291
2.Day	0,08±0,4	0,60±1,83	0±0	0,28±1,06	0,207
3.Day	0,08±0,4	0,16±0,8	0±0	0±0	0,535
4.Day	0±0	0±0	0±0	0±0	-
5.Day	0±0	0±0	0±0	0±0	-
6.Day	0±0	0±0	0±0	0±0	-
7.Day	0±0	0±0	0±0	0±0	-
p*	0,082	0,004	0,440	0,032	

Discussion

The purpose of this study was to evaluate the effect of LLLT on post-operative pain between single- and multi-visit root canal treatments. Our results showed that LLLT or single- and multi-visit treatments had no effect on post-operative pain and in some cases, the interval pain level may differ within the groups.

One of the considerable handicaps in clinical post-operative pain studies is the difficulty in measuring pain because of its subjective nature. Therefore, designing an appropriate questionnaire is a critical step in such studies. The questionnaire must be properly understood by patients and easily interpreted by researchers. Despite the concerns, the VAS has been in use for the measurement of intangible quantities, such as pain and anxiety, for many years. The results of a PubMed search using the search terms “pain” and “visual analogue scale” or “visual analog scale” between the years 1975 to 2014 yielded more than 2000

results (18). Thus, in the current study, the VAS scale was selected because of its confirmed reliability for pain assessment.

Previous studies reported that age, gender, tooth type, pulpal and periapical status, and pre-operative pain play a fundamental role in post-operative pain (19). In our study, there were no significant differences in the distribution of gender, age, and tooth type between the groups (Tables 2 and 3). Patients with pre-treatment pain and swelling have been reported to experience more pain than patients without any complaint (20); therefore, only asymptomatic teeth were included in the current study. Another factor that may affect post-operative pain is the difficulty of instrumentation of the root canals of molar teeth due to their anatomical complexity and canal curvatures. To eliminate this factor, straight-rooted maxillary incisor teeth with a single canal were used.

In a recent systematic review, the prevalence of post-operative pain at 24 hours was 40%, and pain gradually decreased by the second day following treatment, dropping to 10% or less after 7 days (21). In our study, similar to these finding, we found that post-operative pain decreased by the third day in all groups. In addition, post-operative pain was observed after 8 and 12 hours and at 1, 2, and 3 days in all groups. However, after 4 hours and at 4, 5,6, and 7 days, no pain was reported (Figure 1).

One important factor leading to post-operative pain is apical extrusion of the infected material during chemo-mechanical instrumentation. All of the preparation techniques and instruments that are currently available cause some degree of extrusion of debris. However, rotary NiTi systems were reported to lead to less apical extrusion because of their general crown-down working principle (22). In this study, the Revo-S Ni-Ti rotary system (taper: 6%, working length: 25 mm, tip size: 0.40) and K-type hand files were preferred for shaping the root canals to minimize the effects of extruded debris on post-operative pain.

According to our results, despite our antimicrobial strategy and the care taken during treatment, flare-ups occurred in several patients (8%). Higher pain levels were scored in Groups II and IV (multi-visit groups). This result emphasizes that post-operative pain cannot be completely prevented and may be related to certain host factors. The low prevalence of pain experienced after root canal obturation among our patients was consistent with some studies (23,24), but it was found to be much less than pain levels reported in other studies (25). In our study, no significant difference was observed between single- and multi-visit root canal treatment, similar to the reports by Walton and Fouad (26), and Di Renzo et al. (27). However, the single-visit groups (Groups I and III) showed slightly less pain than the multi-visit groups. This is similar to the findings of Roane et al. (28), Eleazer and Eleazer (29), and Albashaireh et al. (30), which reported less flare-ups for the single-visit group compared to the multi-visit group. Yoldas et al have reported less pain in multi-visit groups (31), which is in contrast to our findings. These discrepancies could be attributed to treatment protocol, differences in the pre-operative status of the teeth, extrusion of canal filling and tooth type.

As laser devices have developed, the diode laser has become popular because of its cheapness and compactness (12,14). Many studies showed that diode lasers provide satisfactory bactericidal effects (12-14), but fewer studies have been performed about post-operative pain. Up to now, studies related to the effect of lasers on post-operative pain have usually been directed to external (out of root surface) application of lasers. In such studies, Arslan et al. (32) and Asnaashari et al. (33) investigated the effect of LLLT on post-operative pain after root canal re-treatment and Arslan et al. found laser application has a significant effect in reducing post-operative pain, while Asnaashari et al. claimed that laser application has a limited effect in reducing post-operative pain. Similarly, Lopes et al. (34) investigated the effect of photobiomodulation therapy on post-operative pain after endodontic treatment of teeth with irreversible pulpitis and claimed that lasers have a significant effect in reducing post-operative pain after 6 and 24 hours.

The studies examining the effect of intra-canal application of various lasers on post-operative pain are quite few. LLLT is claimed to possess anti-inflammatory properties and decrease prostaglandin levels, edema, and pain (35).

Doğanay Yıldız and Arslan (36) investigated the effect of LLLT on post-operative pain in molars with symptomatic apical periodontitis and stated that LLLT resulted in lower pain levels than those observed in the control and placebo groups on days 1 and 3. The authors explained the reason for decreased pain levels may be due to the ability of lasers to reduce inflammatory processes, fire nociceptors, and increase lymphatic drainage and histamine release.

In a study by Coelho et al. (37) about the effects of photodynamic therapy on post-operative pain in teeth with necrotic pulps, it was found that photodynamic therapy had a significant effect in decreasing post-operative pain at 24 and 72 hour intervals. Nunes et al. (38) compared the effect of photobiomodulation therapy and Ibuprofen on post-operative pain and concluded that the use of lasers was effective in reducing pain within the first 24 hours when compared with the administration of 600 mg of Ibuprofen.

Although the results of our study were similar to these studies, the differences between the results in our study were not significant. In our clinic trial, LLLT had a limited effect on reducing post-operative pain.

Similar to our study, Koba et. al (39) found that Nd: YAG laser irradiation in root canals immediately after pulpectomy and shaping has a limited advantage in reducing post-operative pain for the single-visit treatment of root canals.

Our results have shown that the use of LLLT in combination with traditional disinfection techniques can be safely used without causing additional discomfort to the patient. Single-visit root canal treatment was found to be successful in terms of post-operative pain regardless of whether a diode laser was applied. Today, there is no consensus on the most

effective root canal treatment procedure. The treatment procedure must involve the maximum elimination of bacteria in the root canal system, while minimizing post-operative pain and damage to the tooth tissue. Thus, single-visit treatment seems to be a good alternative to multi-visit treatments that are accompanied by risks such as fractures, contamination between sessions, and unnecessary time requirements. Our study evaluated only post-operative pain, which is a parameter for short-term success. Long-term follow-up and clinical and radiographic evaluation of teeth are important for evaluating the long-term success of the treatment.

Conclusions

Under the conditions of the present study, it can be concluded that LLLT may be used safely with the combination of traditional disinfection techniques without causing additional discomfort to the patient, and single-visit treatment seems to be a good alternative to multi-visit treatments.

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