Effect of Root Canal Disinfection with 980 µm Diode Laser on Post-operative Pain after Endodontic Treatment in Teeth with Apical Periodontitis: A Randomized Clinical Trial

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Abstract

Background: This study aims to assess the effect of root canal disinfection with a 980 μm diode laser following chemomechanical root canal preparation on the severity of pain after root canal treatment (RCT).

Methods: In present study, asymptomatic, single-rooted teeth with periapical index (PAI) score 3 or 4 were included. All patients were treated with two visits of root canal treatment including dressing with calcium hydroxide. Patients were randomly divided into two groups (n: 28). 'Control (no laser)': The final irrigation was performed using 5ml 2.5% NaOCl, followed by 5 ml 17% EDTA and 5 ml distilled water. 'Laser Disinfection (LD)': Root canals were irradiated with 980 μm diode laser after final irrigation at both visits. The pain levels were evaluated using visual analog scale (VAS) after 8, 24, 48 hours and 7 days. In addition, analgesic intake and time intervals were recorded by patients. The collected data were statistically analyzed with the Chi-square and Mann-Whitney *U* test ($p<0.05$).

Results: The average pain level in the control group after 24 hours was significantly higher than that in the laser group after the first appointment ($p<0.05$). The average pain level after the second appointment was statistically higher at 24 h and 48 h in the control group ($p<0.05$). PP levels at 24-hs after the first appointment were higher than the second appointment only in the control group ($p<0.05$). After first appointment, analgesic use in the control group at 8 h (40%) and 24 h (23%) were significantly higher than LD group ($p<0.05$).

Conclusions: Root canal disinfection with diode laser may reduce PP in single-rooted teeth with PAI score 3 or 4.

Trial registration: Effect of the Diode Laser on Post-operative Pain After Endodontic Treatment in Teeth with Apical Periodontitis: NCT04486196. Registered 24 July 2020 - Retrospectively registered, http://clinicaltrials.gov/ct2/show/NCT04486196

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Background

The principal aim of root canal treatment (RCT) is disinfecting and decontamination of root canals along with the elimination of the smear layer in necrotic cases. Moreover, the root canal must be obturated adequately to decrease the risk of reinfection. The dentinal smear layer consists of microorganisms, their products and necrotic pulp tissue in infected or necrotic cases. Microorganisms might continue to live and reproduce and can quickly penetrate into the dentinal tubules, which might act as a reservoir of bacterial irritants.[1] Traditional endodontic techniques use mechanical preparation and irrigation for disinfecting and decontamination of the root canal system.

Microbial removal might be limited, because of the morphological complexity of the root canal system and the restricted penetration of the irrigation solutions beyond the main canals. These accessory canals generally have different dimensions and complex morphology separating from the main root canal. Hence, they compromise entire canal debridement.[2]

Postoperative pain (PP) is described as an unpleasant, frequently experienced condition after RCTs. After the treatment was finished, PP was reported to vary between 3–58% and observed in up to 12% of the patients within 24 h to 48 h according to a visual analog scale (VAS).[3,4] The prevention of PP is important to assure patient comfort.[5] Pain after endodontic procedures, whether root canal obturation or intracanal medicament application can be caused by many factors including mechanical, chemical or microbial. Nevertheless, the major and the most common cause of PP was reported as remaining microorganisms in the canal or extruded microorganisms in the periradicular tissues.[6] The etiology is primarily connected with the extrusion of microorganisms and their products to periapical area via overinstrumentation and irrigation solutions.[7,8]

In regular endodontic practice, sodium hypochlorite (NaOCl) is the most frequently used irrigation solution due to its extensive antimicrobial activity and capability of dissolving organic material.[9] Nevertheless, it may not always act on microorganisms that are located in morphological complexities and dentinal tubules of root canals due to its limited penetration capability caused by inadequate irrigation dynamics.[10,11] It has been advised to use demineralizing agents as adjuvants in endodontic therapy. Opening dentinal tubules might lead to a better canal disinfection by facilitating NaOCl to penetrate into dentinal tubules.[12] Therefore, the combined application of NaOCl and ethylenediaminetetraacetic acid (EDTA) has been advised for the elimination of smear layer[13,14] and has been demonstrated to be more active on disinfection than NaOCl alone.[15] Furthermore teeth with physiological wide open foramina or damaged apical foramen due to iatrogenic errors are at a high risk for the extrusion of irrigants. Irrigants with strong cell toxicity extruding into periapical tissues lead to PP and even tissue necrosis.[16]

In recent years, various researchers have observed effective disinfection of the root canal by diode laser irradiation.[17–19] Diode lasers (810, 940 and 980 μm wavelengths) display huge water transmission, reaching the bacteria in deeper layers of dentinal tubules in result.[20] Schulte-Lunzum et al.[21] demonstrated that 940 nm diode laser has an intensely high bactericidal effect on *Enterococcus faecalis* which is the most isolated microorganism in failing endodontic cases, even at the 1000 μm depth of dentinal tubules.

Due to the fact that microorganisms are the most common sources of PP, this study aims to assess the effect of root canal disinfection with a 980 μm diode laser following chemomechanical root canal preparation on the severity of pain after RCT. To the best of our knowledge, there is no similar study published in the literature using present study design and diode laser device. The null hypothesis of the present study is that there is no significant difference in PP levels between laser and control group.

Methods

This clinical study was approved by the ethics committee of XXXXXX University (2015-KAEK-43-19-04). All patients read and signed an informed consent form with details about the study along with the benefits and risks of the therapy.

Sample size calculation

The sample size was calculated on the basis of the data obtained from a pilot study using G*Power 3.1 (Heinrich Heine University, Dusseldorf, Germany) software. The randomization method is mentioned later. The main research protocol was the same as that of the pilot study. The power calculation showed the least sample size for each group as 25 patients (power: 80%, significance level: 0.05). Because of the probability of dropouts during treatment or follow-up stage, 30 patients were involved for each group resulting 60 patients in total for the present study.

Patient selection and randomization

We examined 395 patients aged 18-65 years who were referred to the Endodontics Department. A total of 60 healthy patients who met inclusion criteria of this study were selected. Patients that had asymptomatic, single-rooted teeth with PAI score 3 or 4 were included in the present study. For diagnosis, both clinical and radiographic examinations were performed. Periapical status determined by examining panoramic radiographs (Sirona, Bensheim, Germany) first, following periapical radiographs (Dürr Dental, Bietigheim-Bissingen, Germany) taken by parallel technique by experienced radiology technicians. The exclusion criteria were antibiotic use with in the last month, anti-inflammatory analgesic use within the last five days, systemic disorder, pregnancy or lactation, traumatic occlusion, presence of other teeth requiring RCT, teeth with root canal fillings, calcified canals, root resorption, periodontal diseases, sinus tracts and severe crown destruction preventing rubber-dam application. A single operator performed all the endodontic treatment procedures over a period of 5 months. 60 patients divided into 2 separate groups according to the root canal disinfection procedure as control (no Laser) group and laser disinfection (LD) group (Fig. 1). To ensure randomization before starting the RCT, a dental student blinded to the research process allocated the patients by asking each one to select one of the envelopes with the group codes that were sealed before.

Treatment protocol

After local anesthetic (4% articaine with 1:100,000 epinephrine) application and rubber-dam placement, the operator removed all the former coronal restorations and present caries. After access cavity preparation, working lengths (WL) were determined electronically by Propex Pixi device (Dentsply Maillefer, Ballaigues, Switzerland) and confirmed by periapical radiographs. Root canals were prepared

using ProTaper Next nickel-titanium (Ni-Ti) files with an X-Smart Plus Endo Motor (Dentsply Maillefer, Ballaigues, Switzerland) at a speed of 300 rpm and 2 N/cm according to manufacturer instructions up to the size of X4 (size 40, 0.06 taper). The root canals were irrigated during preparation with 2 ml 2.5% NaOCl using a 30-gauge, side-opening needle (Canal Clean, Biodent, South Korea) positioned 3 mm short of WL.

Control (no laser) group

The final irrigation was performed using 5ml 2.5% NaOCl, followed by 5 ml 17% EDTA for 3 min and 5 ml distilled water. Afterwards, canals were dried with paper points, and calcium hydroxide ($Ca(OH)_2$) paste (Calsin, Karabağlar, İzmir, Turkey) was applied as intracanal medicament. Subsequently, a temporary restorative material (Cavit-G; 3M ESPE, St Paul, MN) was used to seal the access cavity. The second appointment was scheduled for 1 week later.

At the second appointment, $Ca(OH)_2$ was removed from root canals with final irrigation and using X4 file. Afterwards, root canals were obturated by lateral condensation method with gutta-percha cones and AH Plus sealer (Dentsply Maillefer, Ballaigues, Switzerland). Coronal restoration was finished using a resin composite (3M ESPE). Patients were called at scheduled times by the operator and asked about PP levels and analgesic intake.

Laser disinfection (LD) group

The final irrigation was performed as in the control group and canals were dried with paper-points. Subsequently, laser irradiation was applied using Medency Primo diode laser device (Medency, Vicenza, Italy). Root canals were irradiated with 980 nm diode laser coupled with optical fiber 200 μm with setting at the average power 1.2-W in pulsed mode. 10 seconds irradiation followed by 10 seconds pause, which comprised one lasting cycle. This cycle was applied 4 times for each root canal. The optical fiber (Medency) was inserted 1 mm short of the apex and the root canals were slowly (at a speed of 2mm/s) irradiated from apical to coronal in continuous circling movements to treat all dentinal tubules in one cycle for each power. Following disinfection procedure, $Ca(OH)_2$ paste was applied as intracanal medicament and the access cavity was sealed with a temporary restorative material, as in the control group. VAS scale form was given to patients and the second appointment was scheduled.

In the second appointment, root canals were dried after $Ca(OH)_2$ removal as in the control group. Afterwards, laser irradiation was performed as in the first appointment. The dentist and patients wore protective glass during laser applications. Subsequently, root canals were filled and resin composite was used as permanent restoration as in the control group. At scheduled times, patients were called for obtaining information about PP and it was recorded on the VAS scale form by the operator.

Patient's questionnaire

A home questionnaire form was given to patients for assessment of pain perception (VAS scale) and dedication of frequency of analgesic use after the first visit. None of the patients were prescribed with medications immediately after the RCT. The questionnaire was filled by patients at 8 h, 24 h and 48 h and 7 days post-operatively. The pain level was categorized as none (0), mild (1-3), moderate (4-7), and severe (8-10). Patients were also advised to take 600 mg ibuprofen every 6 h for pain alleviation, if they felt severe pain at any point of the follow-up time and the time intervals to take medications were registered by patients. In addition, age and gender were documented.

Statistical analysis

All statistical analyses were performed using SPSS version of 22 software (IBM SPSS, Turkey) and statistical differences were set at $p<0.05$. The Mann-Whitney *U* test was used for comparison of values at the different time points between the groups, while the Wilcoxon sign test was used for within-group comparisons among the different time points. Student t test was used to evaluate the age and gender distribution in the groups. For statistical analysis of differences in analgesic use, Fischer's exact chi-square test was applied.

Results

The demographic distribution of the patients is demonstrated in Table 1. The control and LD groups demonstrated no significant differences in age and gender (P = .39, P = 1.00; Table 1).

Table 1
Demographic data of patients in control and laser disinfection groups

	Control	LD	p
Age $_{Mean±SD}$	32,07 ± 10,54	34,43 ± 11,04	[1]0,399
Gender $_{n\ (\%)}$			
Male	10 (%33,3)	10 (%33,3)	[2]1,000
Female	20 (%66,7)	20 (%66,7)	
[1]Student t test [2]Continuity (yates) correction			

Table 2 demonstrates the PP levels after the first and second appointments for the two groups. There was no significant difference at 8 h between two groups both after first and second appointments (P = .076, P = .57). The pain level at 24 h in the control group was found statistically higher than the LD group after both appointments (P = .002, P = .040). The pain level at 48 h in the control group was found statistically

higher than the LD group only after the second appointment (P = .040). There was no report of PP in both groups at 1 week.

Table 2
Pain level distribution in the control and laser groups at 8 h, 24 h, 48 h and 1 week after treatment, both for the first and second visits

Pain level		1st visit			2nd visit		
		Control group	**LD Group**	**p**	**Control group**	**LD Group**	**p**
8-hs	None	13 (%43,3)	14 (%46,7)		23 (%76,7)	24 (%80)	
	Mild	6 (%20)	16 (%53,3)		6 (%20)	6 (%20)	
	Moderate	8 (%26,7)	0 (%0)		1 (%3,3)	0 (%0)	
	Severe	3 (%10)	0 (%0)		0 (%0)	0 (%0)	
	Mean ± SD	2,57 ± 2,85 (2)	1,0 ± 1,02 (1)	0,076	0,57 ± 1,13 (0)	0,3 ± 0,65 (0)	0,579
24-hs	None	15 (%50)	26 (%86,7)		26 (%86,7)	30 (%100)	
	Mild	8 (%26,7)	4 (%13,3)		3 (%10)	0 (%0)	
	Moderate	7 (%23,3)	0 (%0)		1 (%3,3)	0 (%0)	
	Mean ± SD	1,9 ± 2,3 (0,5)	0,33 ± 0,92 (0)	0,002*	0,3 ± 0,88 (0)	0 ± 0 (0)	0,040*
48-hs	None	23 (%76,7)	27 (%90)		26 (%86,7)	30 (%100)	
	Mild	3 (%10)	3 (%10)		4 (%13,3)	0 (%0)	
	Moderate	4 (%13,3)	0 (%0)		0 (%0)	0 (%0)	
	Mean ± SD	0,9 ± 1,84 (0)	0,2 ± 0,61 (0)	0,132	0,27 ± 0,69 (0)	0 ± 0 (0)	0,040*
1 week	None	30 (%100)	30 (%100)		30 (%100)	30 (%100)	
	Mean ± SD	0 ± 0 (0)	0 ± 0 (0)	1,000	0 ± 0 (0)	0 ± 0 (0)	1,000

*Mann Whitney U Test * p < 0.05*

Comparison of PP levels after the first and second appointments are shown in Table 3. In both control and LD groups, PP levels at 8 h after the first appointment was significantly higher than the second appointment (P = .002, P = .017). PP levels at 24 h after the first appointment were higher than the second appointment only in the control group (P = .005).

Table 3
Comparison of pain levels after first and second visits separately in control and laser groups

Pain level		Control group			LD Group		
		1st visit	**2nd visit**	**p**	**1st visit**	**2nd visit**	**p**
8-hs	None	13 (%43,3)	23 (%76,7)		14 (%46,7)	24 (%80)	
	Mild	6 (%20)	6 (%20)		16 (%53,3)	6 (%20)	
	Moderate	8 (%26,7)	1 (%3,3)		0 (%0)	0 (%0)	
	Severe	3 (%10)	0 (%0)		0 (%0)	0 (%0)	
	Mean ± SD	2,57 ± 2,85 (2)	0,57 ± 1,13 (0)	0,002*	1,0 ± 1,02 (1)	0,3 ± 0,65 (0)	0,017*
24-hs	None	15 (%50)	26 (%86,7)		26 (%86,7)	30 (%100)	
	Mild	8 (%26,7)	3 (%10)		4 (%13,3)	0 (%0)	
	Moderate	7 (%23,3)	1 (%3,3)		0 (%0)	0 (%0)	
	Mean ± SD	1,9 ± 2,3 (0,5)	0,3 ± 0,88 (0)	0,005*	0,33 ± 0,92 (0)	0 ± 0 (0)	0,059
48-hs	None	23 (%76,7)	26 (%86,7)		27 (%90)	30 (%100)	
	Mild	3 (%10)	4 (%13,3)		3 (%10)	0 (%0)	
	Moderate	4 (%13,3)	0 (%0)		0 (%0)	0 (%0)	
	Mean ± SD	0,9 ± 1,84 (0)	0,27 ± 0,69 (0)	0,119	0,2 ± 0,61 (0)	0 ± 0 (0)	0,083
1 week	None	30 (%100)	30 (%100)		30 (%100)	30 (%100)	
	Mean ± SD	0 ± 0 (0)	0 ± 0 (0)	1,000	0 ± 0 (0)	0 ± 0 (0)	1,000

*Wilcoxon sign Test * p < 0.05*

Table 4 shows comparison of analgesic use after the first and second appointments between two groups. After the first appointment, analgesic use in the control group at 8 h (40%) and 24 h (23%) were found significantly higher than the LD group (P = .000, P = .011).

Table 4
Comparison of groups in relation to analgesic use after first and second visits

Analgesic use	1st visit			2nd visit		
	Control group	LD Group	p	Control group	LD Group	p
8-hs	12 (%40)	0 (%0)	0,000*	2 (%6,7)	0 (%0)	0,492
24-hs	7 (%23,3)	0 (%0)	0,011*	0 (%0)	0 (%0)	-
48-hs	4 (%13,3)	0 (%0)	0,112	0 (%0)	0 (%0)	-
1 week	0 (%0)	0 (%0)	-	0 (%0)	0 (%0)	-
*Fisher's Exact Test *p < 0.05*						

Discussion

PP after RCT both in necrotic teeth and teeth with periapical lesions is a common issue. The most frequent causes of PP after endodontic therapy are microorganisms followed by the possible flaws such as over-instrumentation and inadequate shaping or irrigation resulting in insufficient antimicrobial action during biomechanical procedures. As a result, keeping all the endodontic procedures limited within the root canal is very important. To maintain this, periapical radiographs and electronic apex locators were used in combination to have better working length measurements in present study. Although pain at many levels may occur even after adequate cleaning and shaping of root canals, the pain threshold of the patient may play a role in PP sensation.[5, 22–24] This study aimed to evaluate and compare the effect of diode laser and final irrigation on PP levels considering the difference of root canal disinfection ability of two procedures.

In this study, patient selection was restricted to eliminate the PP risks as much as possible. Patients who have asymptomatic single-rooted teeth with PAI score 3 or 4 and without any systemic disorders were selected. In similar studies, single-rooted teeth with vital or necrotic pulp, or failed endodontic treatment were also selected, excluding medically disordered patients.[25–27] Some PP studies[25,27,29] finished RCT in a single visit both in retreatment or necrotic cases. Contrarily, two visit applications were also performed similar to this study but evaluating PP levels only after the first visit.[28,30] The present study evaluated pain levels both after first and second visits to distinguish the effects of disinfection and obturation procedures on PP.

PP can be measured by many scales and methods. The present study used the VAS scale for the assessment of PP. This scale is easily understandable and provides reliable, clear and valid results in appropriate use.[31] The VAS scale was used on PP evaluation in many of the previous studies.[28,32,33] The scale was explained clearly to the participants before the treatment in order to record the PP more accurately.

Over the course of time, various laser types are used in different fields of dentistry.[34] In endodontics, diode lasers are commonly used lasers for the disinfection of the root canal system.[35] Diode lasers have considerable advantages such as compactness, adaptability, ease of use and affordability.[34,35] The effect of laser therapy on PP in endodontics has been a popular subject of many previous studies.[25,27,30] In the present study, a diode laser device was used for root canal disinfection in necrotic teeth both in first and second appointments. Diode lasers present antimicrobial effect mostly by thermal action.[36] Intracanal laser irradiation was performed using pulsed mode with circular movements similar to previous studies[37,38] to reduce heating of dentin, thereby maintaining health of periodontal tissues in the present study. The temperature on the canal walls immediately diminishes as the laser application with the activated 200 μm fiber-optic is directed from apical to coronal direction quickly. Hence, the tissues surrounding the tooth are guaranteed to be only marginally affected so that periradicular tissues are not expected to be injured.[39]

PP after endodontic procedures generally occurs during the first 2–3 days and decreases over time.[25,40] Likewise, present study results showed that both after the first and second visits in both groups, PP was the most at 24 h while patients declared no pain at 7 days. According to this study, PP in the LD group is significantly less than the control group at 24 h after the first visit. Arslan et al.[30] reported laser use for intracanal disinfection reduces PP after the first visit with the application of $Ca(OH)_2$, similar to findings of this study. Furthermore, some other studies[25,27] also reported significantly less PP levels in the LD group in single visit RCT. Since the root canal obturation procedure can be a risk factor for PP, the results are in line with PP level results of present study after root canal obturation. In this manner, the LD group tends to have significantly less PP both after $Ca(OH)_2$ application or obturation. In consideration of this study findings, the null hypothesis was rejected.

In general, analgesic use is associated with the level of pain. Patients commonly take analgesics when experiencing high levels of pain. The present study showed no analgesic intake in the LD group while the control group showed analgesic intake especially at 8 h and 24 h only after the first visit which has statistical significance in favor of laser application. Likewise, Arslan et al.[30] and Sen et al.[36] also reported that the analgesic use of LD groups was significantly less than other examination groups. In consideration of the results of this study, the null hypothesis is confirmed. Still, further clinical investigations are needed including different types of cases, devices and evaluation methods.

Conclusion

Within the limitations of the present study, root canal disinfection with diode laser may reduce PP in single-rooted necrotic teeth after both first and second visits of endodontic treatment. In this manner, diode lasers may be used to be a part of root canal disinfection in routine endodontic therapy. Present in vivo study may be helpful for further studies with larger number and different case groups using advanced laser applications.

Abbreviations

RCT: Root canal treatment; PP: Post-operative pain; VAS: Visual analog scale; NaOCI: Sodium hypochlorite; EDTA: Ethylenediaminetetraacetic acid; LD: Laser disinfection

Declarations

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Availability of data and materials

Data cannot be shared because in the protocol submitted to the Ethics Committee of University of Biruni, the authors confirmed that only researchers of the University of Biruni would have access to the raw data.

Authors' contributions

TK contributed with the conception of the study, and the design and draft of the manuscript, and read and approved the final manuscript.

GPS contributed with the conception of the study, and the design and draft of the manuscript, and read and approved the final manuscript.

SSK contributed with the conception of the study, and read and approved the final manuscript.

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Consent for publication

Not Applicable.

Competing interests

The authors report no conflicts of interest.

Ethics approval and consent to participate

The study has been approved by the ethics committee of Biruni University (2015-KAEK-43-19-04). Participation in the study was voluntary. All participants provided written informed consent to participate in this study.

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