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A prospective randomized clinical study on the efficacy of CO₂ lasers on initial stage endodontics

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Abstract

The purpose of this study was to evaluate the clinical efficacy of the CO₂ laser in a prospective randomized trial. A total of 112 teeth in 112 patients, previously treated pulpectomy procedures were gathered and randomly divided into two groups composed of 56. Irradiation was performed on one group and non-irradiation forms of treatment were performed on the other group. On the first group of teeth, root canal enlargement was done and followed by exposure of the canal to a CO₂ laser light (5W, 200msec) using 3 cycles each at a rate of 15 seconds per cycle. The second group was not exposed to laser light following root canal enlargement. The laser was applied on the root canal for a controlled period of time.

On the day following pulpectomy, a statistically significant ($p < 0.05$) fewer number of patients observed pain in the irradiation group compared to the non-irradiation group. The treatment times and the total treatment days in the irradiation group are shorter than in the non-irradiation group ($p < 0.05$). Multivariate analysis showed that the laser treatment was significantly associated with treatment times.

This study shows that the degree of oral pain was greatly reduced in patients who underwent laser irradiation as compared to these who did not. Our study suggests that the use of laser treatment provide significant short-term improvement compared to conventional forms of treatment performed during pulpectomy.

Key words : randomized study, CO₂ laser, endodontics, pulpectomy.

Introduction

The success of endodontic treatment depends on the root canal system being thoroughly cleansed and disinfected, followed by the three-dimensional obturation of this space. Many methods have previously demonstrated that canal preparation techniques produce a considerable amount of smear, remaining pulp tissue, and inorganic dentin debris¹⁾. Conventional biomechanical preparation of the root canal system involves the use of hand and rotary instruments combined with chemical irrigation, which result in the formation of a smear layer on the dentin surface of the root canal. The removal of the smear layer which consists of dentinal shavings, organic tissue remnants, and micro-organisms is considered a major factor in root canal treatment since its presence may interfere with achieving an aseptic and hermetic seal of the obturated root canal space²⁾.

The laser has gained wide acceptance in the field of dental surgery because of its ability to cut without bleeding, vaporize, coagulate, decrease postoperative discomfort, and accelerate cicatrization³⁾. Dederich et al.⁴⁾ first reported on the melting and recrystallization of the root canal wall dentin following Nd:YAG laser exposure. Miserendino et al.⁵⁾, used a carbon dioxide laser to observe similar glazing of the dentin surface. Moshonov et al.⁶⁾ demonstrated that argon laser irradiation of the root canal system was efficient in removing intracanal debris. The laser is now technologically sophisticated so that it may be used to debride the canal more effectively than conventional methods⁷⁾. However, there are few reports in the literature on clinical statistical studies analyzing the effect of lasers in endodontics⁸⁾. Therefore, this randomized study was planned to evaluate the effect of laser exposure clinically. The above basic experiments suggested that the laser exposure results in shorter treatment times for root canal filling. We report here the results of laser treatment on the initial stage pulpectomy.

Material and methods

Healthy adults undergoing pulpectomy due to pulp exposure or acute pulpitis were considered as subject for this study. Patients' informed consent was granted by a thorough explanation of procedures both in written and oral form. It was also confirmed that these cases could no longer be treated using pulp capping procedures. The patients were divided into two groups: one undergoing irradiation and the other would not. Four randomized factors were considered: (1) gender, (2) age, (3) the type of teeth and (4) the condition of the teeth to be treated. We performed thermal pulp testing before pulpectomy in order to determine teeth condition⁹⁾. To evaluate thermal reaction, baseplate gutta-percha and ice was used to elicit response to heat and cold. These teeth were compared with the same type of teeth on results of thermal pulp testing.

After the pulpectomy under local anesthesia, all canals of the two groups were prepared using

hand instruments up to #50 on the first day of treatment. The working length was obtained by measuring the length of the initial instruments (#15) at the apical foramen minus 1mm for all canals. The root canal was flushed in each case with 3% H_2O_2 during enlargement of the root canal.

A 10.6nm wavelength CO_2 laser (Luxar, output power: 5W, pulse: 200msec) was used for irradiation in the first group of patients. We enlarged the root canal orifice to 3mm below the floor of pulp chamber in order to accommodate the extension tip (Luxar LXT-010SS, length: 10mm, spot:0.4mm) of the laser. The extension tip was fixed at the root canal orifice and the laser was applied in a stationary position for a total of 15 seconds per cycle, the canal was exposed repeatedly for one second followed by a 2-second break, for a total of five times. A total of 3 cycles were performed with short breaks of 10 second in between each cycle. The teeth of the second group of patients were not exposed to the laser. The root canal was finally rinsed 3 times with 1mL of 5.25% NaOCl and 1mL of 3% H_2O_2 to remove the smear layer and dried with paper points. The patients had dental appointments at interval of once a week.

Root canals were obturated with gutta-percha points and canals using the lateral condensation method. Root canal filling was performed when there was (1) exudation or bleeding in the root canal, and/or (2) when pain (Pain levels we categorized as: slight spontaneous pain, percussive pain, pain upon insertion of a hand instrument) was absent. However, first day after the pulpectomy in this study, we did not perform root canal filling for the diagnosis. The aforementioned conditions were strictly followed prior to root canal filling by the other doctors since failure may have resulted if any of the conditions were not met. Any pain experienced the day following pulpectomy was noted. Averages of root canal treatment duration of the two groups were compared in evaluating the effect of laser exposure in the initial stage. We defined that "treatment times" is the number of appointments in order to complete root canal therapy. "Total treatment days", in our study, is defined as the total number of days needed, from the pulpectomy to the last, to complete the endodontic treatment. On post-operative radiographs, the conditions of periapical area and the technical quality of root canal fillings were assessed¹⁰⁾.

The Chi-square test with Yates correction was used to analyze differences between the two groups. Average treatment times and total treatment days were compared statistically by using the student-t test. Multivariate analysis of the treatment time factors was carried out using linear multiple regression analysis. A partial correlation coefficient was calculated from the treatment times as an independent variable while important factors (age, gender, jaw, number of root canals, spontaneous pain, thermal pulpitis test, laser irradiation) were calculated as explanatory variables. A step-wise discrimination analysis of the variables was used. A p-value of <0.05 was considered as significant. All statistical calculations were done using SPSS ver.6.1 software for the Macintosh computer.

Results

One hundred nineteen patients were listed and randomly chosen from May 2000 to January 2001. Seven patients were randomized but did not receive treatment after pulpectomy. There were 62 males and 50 females. Patient ages were from 16 to 72 (average 39.8 years, median 38 years) Half of the 112 teeth in 112 patients were exposed to laser light. Table 1 lists the characteristics of patients and the conditions of the teeth before treatment. The conditions and the characteristics were statistically equivalent between the two treatment groups.

The first day after the pulpectomy, a few (5/112,4.3%) patients had experienced bleeding (Table 2). Incidence of pain were lower (10.7%) in the group who received laser treatment compared to these who did not. On post-operative radiographs, there was not periapical radiolucency in all of cases. The difference in the presence of pain between the two groups was statistically significant ($p < 0.05$). The total treatment days and treatment times of the irradiation group were fewer than for the non-irradiation group, and males showed fewer total treatment days and reduced treatment times than the females (Table 3).

Table 1. Characteristics of patients and teeth before treatment

character	non-irradiation	irradiation
total patients	56	56
gender		
male	31	31
female	25	25
age		
average	39.5	40.1
range	16-72	20-72
teeth		
jaw		
upper	33	29
lower	23	27
type of teeth		
incisor	8	8
premolar	14	17
molar	34	31
number of root canals		
one	17	23
two	10	6
three	22	23
four	7	4
pain		
spontaneous pain		
none	25	28
mild	20	19
moderate	11	9
percussion pain		
none	39	48
mild	17	8
moderate	0	0
thermal test		
warm reaction		
none	1	3
mild	42	38
moderate	13	15
cold reaction		
none	1	2
mild	42	42
moderate	13	12

Table 2. Symptoms on the first day after pulpectomy

	non-irradiation	irradiation
pain	13(23.2%)*	6(10.7%)*
exudate or bleeding in root canal	3(2.3%)	2(3.8%)
	p value* < 0.05	

Table 3. Average treatment time

	treatment times	total treatment days
irradiation(n=56)	2.14 (SD:0.39)*	16.2(SD:3.8)**
non-irradiation(n=56)	2.43 (SD:0.43)*	18.8(SD:5.3)**
male (n=62)	2.17(SD:0.40)***	16.3(SD:3.7)****
female(n=50)	2.42(SD:0.45)***	19.7(SD:5.8)****
	p value* < 0.05	
	p value** < 0.05	
	p value*** < 0.05	
	p value**** < 0.05	

Table 4. Results of multivariate analysis

factor	coefficient	P value
age	-0.021	0.853
gender	0.198	0.044*
jaw	0.157	0.146
number of root canals	-0.041	0.707
spontaneous pain	0.103	0.396
percussion pain	-0.099	0.363
warm reaction	0.032	0.789
cold reaction	-0.099	0.363
laser radiation	0.206	0.038*
	p value* < 0.05	

There was a good correlation between the number of roots and the type of teeth ($r=0.89$) in the univariate correlation analysis, and the type of teeth was not included as an explanatory variable in the multivariate analysis. Multivariate analysis revealed that treatment times in all cases were significantly related to gender and laser irradiation (Table 4). The calculated p-value of the other factors (age, jaw, number of root canals, spontaneous pain, thermal pulpitis test) on linear multiple regression analysis was over 0.05.

Discussion

In this study, the incidence of pain were lower in the group who received laser treatment the first day after the pulpectomy and this result induced the shorter treatment duration of root canal treatments. Univariate analysis indicates that the total number of treatment days and treatment times using laser irradiation is significantly shorter than without laser irradiation. Multivariate analysis shows that the laser irradiation factor contributes most to the treatment time difference because of the low p-value shown on linear multiple regression analysis. The results suggest that laser light irradiation effectively reduces the time needed in order to complete treatment.

A previous study has shown that endodontic instruments produce organic and mineral debris and are unable to remove all of this¹¹⁾. When viewed by scanning electron microscopy, root canal preparation by both laser and hand instrumentation showed a general absence of a smear layer, and no remaining tissue remnants¹²⁾. Arrasria-Jitosho et al.²⁾ reported that a pulsed laser was effective in removing soft tissue and the smear layer on the surface of dentinal walls. In the study reported here, the presence of pain reported by the irradiated group was lower than that of the non-irradiated group on the first day after pulpectomy. This suggests that there was less pulpitis in the laser irradiated group after elimination of the smear layer and pulp tissue, and the results suggest that, the treatment times for the laser irradiated group are significantly shorter than for the non-irradiated group. Sunders et al.¹³⁾ showed that lasing cleaned the root canal almost completely of pulp tissue.

The presence of overlying pulp tissue, tissue remnants, and the smear layer are factors that influence the effect of the laser on dentinal structures. In the presence of substantial pulp tissue, debris, and the smear layer, the dentin walls remained unaltered even after long exposure times¹⁴⁾. In this study, all canals of the two groups were first prepared with hand instruments up to #50 before laser irradiation and the laser light irradiation was effective to reduce the remaining pulpitis. The analysis indicated that treatment duration for males was significantly shorter than for females. A reason for this may be that males are busy with their work, however, the reasons remain unclear.

The thermal effect of the laser has been investigated by some authors¹⁵⁻¹⁸⁾. These studies have measured temperature increases and evaluated periodontal tissue damage. This issue of tissue damage induced by laser has not been settled, but the present study suggests that there

was no periodontal damage due to thermal effects. In fact, the presence of pain was more noticeable in the patients who did not undergo irradiation and there was not periapical radiolucency in the laser irradiated group on the post-operative radiographs.

These results suggest that laser treatment provided significant short-term improvement compared to conventional modes of treatment. However, if the thermal effects induce periodontal tissue damage, the laser treatment may give rise to a rather poor future prognosis. In this case, continuous follow-up consultations are needed after the initial treatment period.

Conclusions

This study shows that the degree of oral pain was greatly reduced in patients who underwent laser irradiation as compared to those who did not. It is concluded that the use of laser treatment provide significant short-term improvement compared to conventional forms of treatment performed during pulpectomy.

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