



Evaluation of temperature rise on external root surface during laser endodontic therapy using 940nm diode laser: An *Invitro* study

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Abstract

As presently used in therapeutic medical and dental applications, lasers are, in essence, devices that produce a monochromatic and directional beam of light powerful enough to do biomedical work and with much less electrical energy converted into waste heat. The word Laser is an acronym for light amplification by stimulated emission of radiation.

Diode laser is a solid active medium laser manufactured from semiconductor crystals similar to that found in a light-emitting diode using some combinations of aluminum or indium, gallium and arsenic. Diode lasers emit light when an electric current passes through them. A 940 nm diode laser has been manufactured for clinical use. This machine has a fiber which is constant in diameter of 400 μm but with varying tips. Thus, only the tip needs to be changed according to the usage for a particular patient. The tip most commonly used for endodontic purpose is 200 μm in diameter and 14 mm in length. No studies are available which describe the use of this wavelength for endodontics and its effectiveness in bacterial decontamination. Thus, there is need for developing effective means of removing the smear layer from root canal walls following biomechanical instrumentation.

Keywords: Diode laser, temperature rise, laser irradiation, power modes

Introduction

In 1960, Theodore Maiman, a scientist with the Hughes Aircraft Corporation, developed the first working laser device which emitted a deep red colored beam from a ruby crystal [7]. During the next few years, dental researcher studied the possible applications of this visible laser energy. The word Laser is an acronym for light amplification by stimulated emission of radiation. All available dental laser devices have emission wavelength of approximately 500 to 10,600 nm. A laser consists of lasing medium contained within an optical cavity, with an external energy source to maintain a population inversion so that stimulated emission of a specific wavelength can occur, producing a monochromatic, collimated and coherent beam of light. One of the most commonly used lasers in dentistry is diode laser. Diode laser is a solid active medium laser manufactured from semiconductor crystals similar to that found in a light-emitting diode using some combinations of aluminum or indium, gallium and arsenic. Diode lasers emit light when an electric current passes through them. The available wavelengths for dental usage for diode laser range from about 800 nm for the active medium containing aluminum to 980 nm for the active medium composed of indium, placing them at the beginning of the near-infrared portion of the invisible nonionizing spectrum. The principle effect of laser energy is photothermal, i.e. conversion of light energy into heat energy. This thermal effect of laser energy on tissue depends on the degree of temperature rise and corresponding reaction of the interstitial and intracellular water. The rate of temperature rise plays an important role in this effect and is dependent on several factors, such as cooling of the surgical site and the surrounding tissue ability to dissipate the heat.

This rise in temperature due to thermal effect is commonly seen in laser-assisted root canal therapy. Use of diode laser as an adjunct during root canal therapy provides an additional advantage in reducing bacterial counts and thus improves the success of root canal therapy. Presence of bacteria in the dentinal tubules of infected teeth at approximately half the distance between the root canal walls and the cement dentinal junction was also reported [2, 3]. These findings justify the rationale and the need for developing effective means of removing the smear layer from root canal walls following biomechanical instrumentation. This would allow disinfectants and laser irradiation to reach and destroy microorganisms harbored in the dentinal tubules.

Benedicenti *et al* (2008) [4] did an *in vitro* study to investigate the bactericidal effects on root canals using an 810 nm diode laser and found that when used as an adjunct to conventional therapy, it results in increasing treatment efficiency and significantly better decontamination of the root canal [5]. However, it also concomitantly results in a rise in the external root surface temperature which can be hazardous to the surrounding periodontal tissues and the bone if temperature rises above 10°C. The threshold temperature level of 7°C is commonly considered as the highest temperature limit biologically accepted to avoid periodontal damage [22, 25].

Recently, a 940 nm diode laser has been manufactured for clinical use. This machine has a fiber which is constant in diameter of 400 μm but with varying tips. Thus, only the tip needs to be changed according to the usage for a particular patient. The tip most commonly used for endodontic purpose is 200 μm in diameter and 14 mm in length. No studies are available which describe the use of this wavelength for endodontics and its effectiveness in bacterial decontamination.

The purpose of this study was to evaluate the thermal effect of 940 nm diode laser on external root surface, during laser assisted root canal therapy, so that this particular laser can be used at appropriate laser settings safely and effectively without any collateral damage to the periodontal tissues.

Aim

The aim of the study was to investigate the rise in temperature on the external root surface during 940nm diode laser assisted root canal therapy.

Materials & Method

A total of 40 human single rooted teeth were included in the study (n = 10). The root canals were enlarged & laser irradiation were performed at four different stages (1W continuous mode, 1 W gated mode 10/10, 2 W continuous mode & 2 W gated mode 10/10). The rise in temperature were measured at apical, middle & cervical thirds. The temperature changes were evaluated by Thermocouple k type.

Results

The result of this study showed that 940nm diode laser can be considered safe for use for laser assisted root canal therapy.

Conclusion

Therefore, laser is safe to use for endodontic therapy. The temperature rise was maximum in apical third region followed by middle third region & least in the cervical third region when laser used.

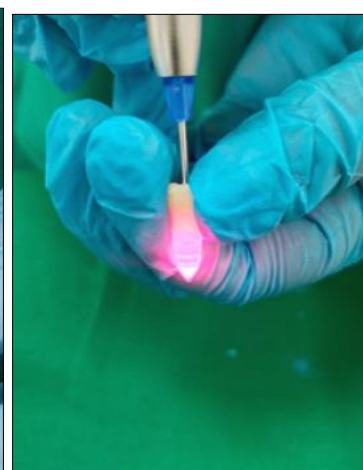
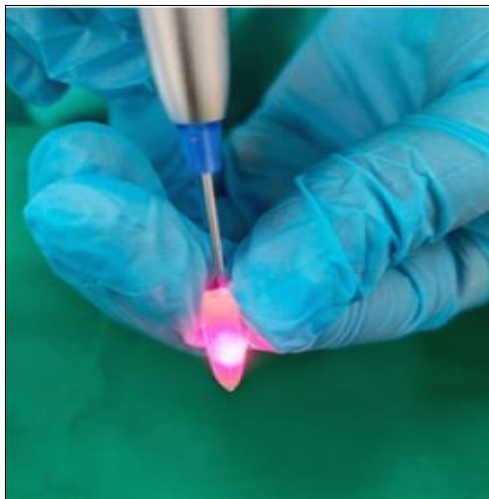
List of abbreviations

W- watt
CM – continuous mode

Materials & Methods

Materials to be used: Specimens: 45 single rooted teeth.
#2 and #4 Endo Access bur (Maillefer, Dentsply, Switzerland).
Safe-ended #0152 Endo-Z bur (Maillefer, Dentsply, Switzerland)
3.25% sodium hypochlorite solution
Endodontic explorer, DG-16 (Maillefer, Dentsply, Switzerland).
K-files #6, #8, #10, #15 (Mani, Japan)
Rotary files (Super Endo GOLD flex rotary files)
Endomotor (Eighteenth E- connect Pro Endomotor)
Ethylenediaminetetraacetic acid (EDTA) {PRIME DENTAL RC HELP, Prime Dental Products Pvt Ltd, Kalher}
Diode laser (Biolase)

Results: There was highly significant temperature rise at apical third area than middle third area at 1.5 watt & very highly significant temperature rise at apical third area at 2 watt.



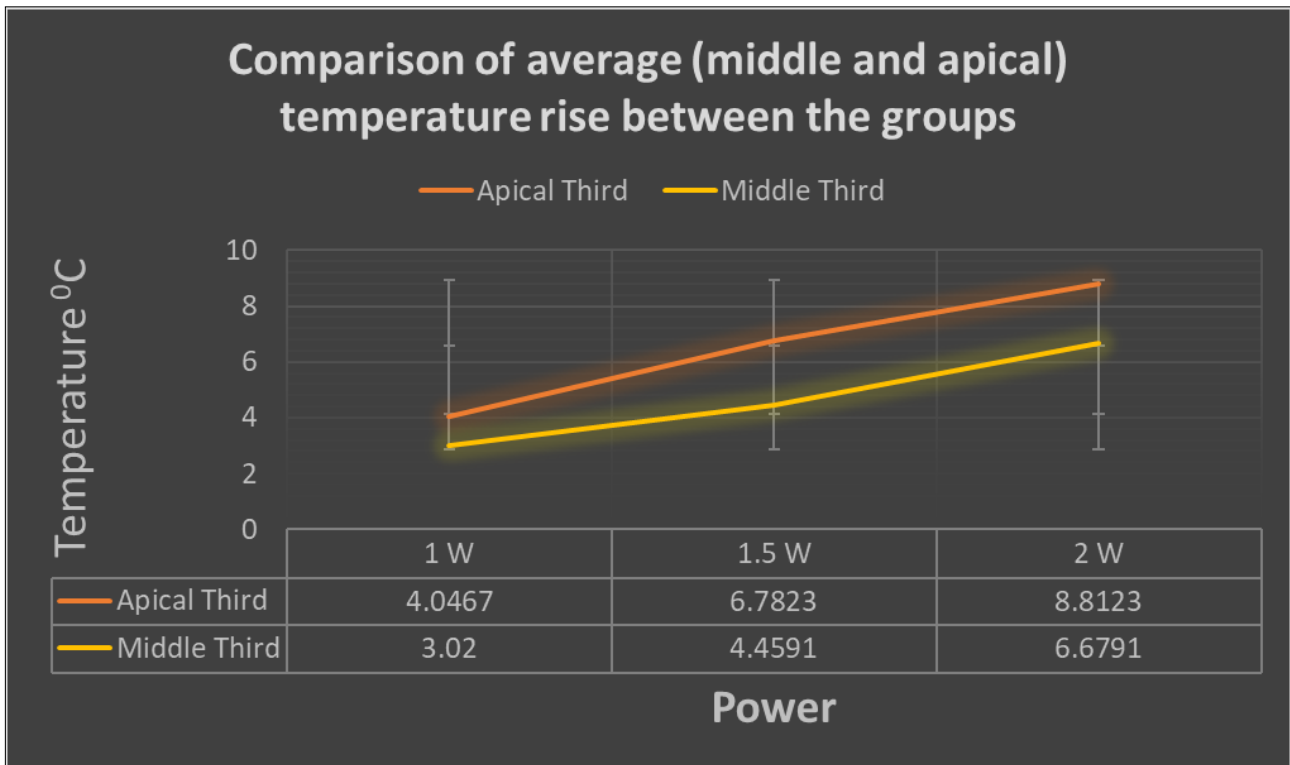


Table 1: Different Laser power levels showing temperature rise at Apical third and Middle third of external root surface after laser irradiation.

Power	Apical third Mean value + Standard Deviation	Middle third Mean value + Standard Deviation	t value (unpaired t test)	P value (Probability value)
1 Watt	4.0467 ± 1.034	3.0200 ± 1.016	1.1621	0.1103
1.5 Watt	6.7823 ± 1.324	4.4591 ± 1.093	2.4136	0.0001
2 Watt	8.8123 ± 1.881	6.6791 ± 1.334	2.4410	0.0001

Discussion

In the field of endodontics, lasers are serving as an important tool, and over a short period, it has gained significant interest of researchers. Temperature rising over the root surface beyond a particular threshold can be detrimental for surrounding periodontium. A temperature rise of 47°C for 1 min is considered to be tolerable threshold for bone. That means approximately 10°C increase in temperature for 1 min can be well tolerated. However, temperature rise of 11°C for 5 min or 13°C for 1 min is the critical threshold for periodontium. Currently, lasers are being used widely in endodontics because it presents the capacity for microbial reduction in the root canals at depths of up to 1 mm in the dentinal canaliculi.

Conclusion

The results of this study showed that 940 nm diode laser 1 W CM, 1.5 W CM, 2 W CM can be considered safe for use for laser assisted root canal therapy when used in a circular motion & withdrawn at 2mm every second. The temperature rise was maximum in apical third region followed by middle third region following laser use. Hence, lasers can be a better treatment option when used within safe yet effective power levels.

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