Laser endodontic therapy using 940 nm diode laser

Temperature rise on external root surface—Part I

Authors_Dr Pradhan Suchetan & Dr Karnik Rohit, India

_Introduction

Nearly 50 years after the first dental laser was created, lasers have finally found their way onto the shelves of dental clinics. A perceived mysterious technology, whose most dramatic use is in the art of warfare, is now an integral part of the medical and dental armamentarium.

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.

Fig. 1_The 940 nm diode laser that was used for this study: Ezlase 940, Biolase®.

Fig. 1

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 (Coluzzi 2004)[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 devises have emission wavelength of approximately 500 nm 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 a 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. Laser light is generated in a beam that is directional and monochromatic which enables laser light to be focused to a very small spot diameters needed for medical and dental applications.

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.

Successful endodontic therapy mainly depends on the elimination of micro-organism from the root canal system which is traditionally accomplished by the means of biomechanical instrumentation of the root canal. Studies have shown however, that the complete removal of microorgansims from the root canal system is virtually impossible (Bystrom and Sundquist 1981[5], Sjogren et al 1990[26]) and a smear layer covering the instrumented walls of the root canal is formed (McComb and Smith 1975[20], Moodnik et al 1976[21], Mader et al 1984[18]).

Peters et al (2001)[23] clearly demonstrated that more than 35 % of the canals surface area remained unchanged following instrumentation of the root canal using four Ni-Ti preparation techniques.

The presence of bacteria in the dentinal tubules of infected teeth at approximately half the distance between the root canal walls and the cemento-dentinal junction was also reported (Ando and Hoshino 1990[2], Armitage et al 1983[3]). These finding 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 micro-organisms harbored in the dentinal tubules.

Gutknecht et al (2004)[10] in his research using a 980 nm diode laser showed that the 980 nm diode laser can eliminate bacteria that have immigrated deep into the dentin, thus being able to increase the success rate in endodontic therapy. 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. 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 (Ericson et al 1983[8]).

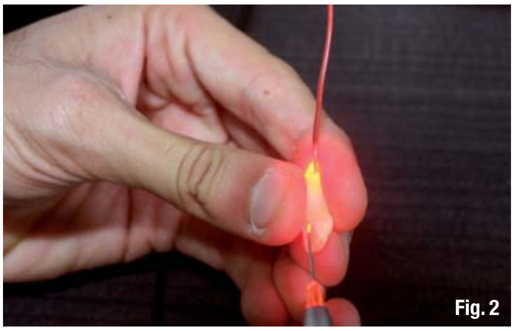

Fig. 2

Fig. 2_Tooth being held between the fingers and thermocouple while in contact with the tooth surface to measure temperature changes with the laser in activated mode.

The threshold temperature level of 7 °C is commonly considered as the highest temperature limit biologically accepted to avoid periodontal damage (Saunders 1990[25], Nammour et al 2004[22]).

Studies have been done with 810 nm and 980 nm diode laser which show rise in temperature on external root surface of teeth following diode laser assisted root canal therapy (Gutknecht et al 2005[11], Alfredo et al 2008[1]). Gutknecht et al 2005[11] found that there was temperature rise of not more than 7 °C when irradiated upto 1.5 W and thus can be considered safe for use in laser assisted endodontic therapy.

Heysselaer et al 2007[12] using a 980 nm laser used 3 W, 2 W and 1 W in continuous mode and found average rise in temperature at 20.7 ± 0.3 °C, 9.3 ± 0.4 °C and 5.8 ± 0.8 °C for 3 W, 2 W and 1 W of laser irradiation on external root surface. Results showed that the use of diode laser in root canal treatments may be harmful for periodontal tissues if the irradiation conditions are not strictly respected.

Manos and Gutknecht 2007[19] did a study using 980 nm diode laser with the same power settings of 2.5 W at continuous mode and chopped mode and found that the temperature rising never exceeds the threshold point of thermal bone necrosis of 47 °C and thus can be considered safe for periodontal tissues during laser assisted root canal treatment.

Laser Treatment	N	Mean	Standard Deviation	Standard Error	Maximum	Minimum
1 W, Continuous	30	4.17	1.262	0.230	7	2
1 W, Gated	30	1.80	0.664	0.121	3	1
2 W, Continuous	30	6.47	1.756	0.321	11	3
2 W, Gated	30	2.43	0.774	0.141	4	1
Total	120	3.72	2.166	0.198	11	1

Table 1_Descriptive statistics for four treatments on apical third.

Pairs compared	Mean difference	Standard error	P-value
1 W, continuous vs 1 W, gated	2.367*	0.260	0.0005
1 W, continuous vs 2 W, continuous	2.300*	0.395	0.0005
1 W, continuous vs 2 W, gated	1.733*	0.270	0.0005
1 W, gated vs 2 W, continuous	4.667*	0.343	0.0005
1 W, gated vs 2 W, gated	0.633*	0.186	0.007
2 W, continuous vs 2 W, gated	4.033*	0.350	0.005

Table 2_Multiple comparisons (for apical third).
*The mean difference is significant at the 0.05 level (Tamhane Test).

Fig. 3

Fig. 3_The power meter measuring the power at the distal end of the tip.

Alfredo et al. 2008[1] in his study assessed the temperature variation at 1.5 W, 3 W and 5 W and found that at 1.5 W in all operating modes, and 3.0 W, in the pulsed mode, for 20 sec, can safely be used in endodontic treatment, irrespective of the presence of humidity. The 810 nm and 980 nm diode lasers are available in varying fiber diameters ranging from 200 µm to 600 µm. The end cutting property of the fiber along with a variation in diameter results in varying energy density at the tip.

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. Consequently safety parameters for 940 nm wavelength are not available. 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. _

_contact laser

Dr Suchetan Pradhan
MDS (Prosthodontics), MSc Laser Dentistry (Aachen Univ., Germany), EMDOLA (European Union), Co-worker, Aachen University, Germany
Founder President, Indian Academy of Laser Dentistry, Director, Department of Laser Dentistry, Manipal Faculty, Implant Department, Manipal
Professor, Department of Implantology, SS Dental College, Hyderabad, India
E-mail: suchetanpradhan@gmail.com

Dr Rohit Karnik
MDS (Periodontics), FAGE
Ex-Faculty, Nair Hospital Dental College, Mumbai, India
Currently in private practice at Pradhan Dental Center
E-mail: drrohitkarnik@gmail.com

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