



LASERS IN ENDODONTICS

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ABSTRACT

The search for new devices and technologies for endodontic procedures always has been challenging. In the past 2 decades, much experience and knowledge has been gained. The purpose of this article is to provide the current and possible future clinical applications of lasers in endodontics. Endodontic procedures for which conventional treatments cannot provide comparable results or are less effective are emphasized.

KEYWORDS: endodontic.

INTRODUCTION

The first laser was introduced into the fields of medicine and dentistry during the 1960s (Goldman *et al.*, 1964). Since then, this technology has progressed rapidly. Lasers are indicated for a wide variety of procedures (Frentzen and Koort, 1990; Aoki *et al.*, 1994; Pelagalli *et al.*, 1997; Walsh 2003). Conventional methods of cavity preparation with low- and high-speed handpieces involve noise, uncomfortable vibrations and stress for patients. Although pain may be reduced by local anaesthesia, fear of the needle and of noise and vibration of mechanical preparation remains causes of discomfort. These disadvantages have led to a search for new techniques as potential alternatives for dental hard tissue removal.^[1]

Therefore, the use of laser in Endodontics plays a important role and its different uses are as follows;

DENTINAL HYPERSENSITIVITY

Dentinal hypersensitivity is characterized as a short, sharp pain from exposed dentin that occurs in response to provoking stimuli such as cold, heat, evaporation, tactileity, osmosis, or chemicals.^[2] Such pain cannot be ascribed to any other form of dental defect or pathology.^[3]

Brannstrom *et al.*^[4,5] proposed that nerve endings in the dentin-pulp border area are activated by hydrodynamic fluid flow in response to dentinal stimulation (the hydrodynamic mechanism). According to the

hydrodynamic theory, rapid dentinal fluid flow serves as the final stimulus in activating intradental nociceptors for many different types of stimuli. Studies have confirmed that the patency of the dentinal tubules is a prerequisite for the sensitivity of exposed dentin.^[6,7,8] It also was shown using scanning electron microscopy (SEM) that teeth with dentinal hypersensitivity have a significantly higher number of patent dentinal tubules per millimetre^[3] and a significantly greater mean diameter per tubule than control teeth.^[8]

The management of dentinal hypersensitivity involves the application of therapies that reduce the flow of dentinal fluid or lower the activity of dentinal neurons.^[9] Seventy years ago, Grossman^[10] outlined the requirements for the treatment of this condition: therapy should be nonirritating to the pulp, be relatively painless on application, be performed easily, act rapidly, be effective for a long period of time, be devoid of staining effects, and be consistently effective.

A different treatment modality for reducing dentinal hypersensitivity involves the use of laser technology. The rationale for laser-induced reduction in dentinal hypersensitivity is based on two possible mechanisms that differ greatly from each other. The first mechanism implies the direct effect of laser irradiation on the electric activity of nerve fibers within the dental pulp, whereas the second involves modification of the tubular structure of the dentin by melting and fusing of the hard tissue or

smear layer and subsequent sealing of the dentinal tubules. The lasers used for the treatment of dentinal hypersensitivity may be divided into two groups: low output power lasers (helium-neon and gallium/aluminum/arsenide [diode]) and middle output power lasers (Nd:YAG and carbon dioxide [CO]).^[3]

Three gallium/aluminum/arsenide (diode) laser wavelengths (780, 830, and 900 nm) were used for the treatment of dentinal hypersensitivity³ Matsumoto *et al*^[11] and it was reported the use of a diode laser for this purpose. They applied an output power of 30 mW in a continuous wave irradiation mode for 0.5 to 3 min and reported treatment effectiveness ranging from 85% to 100%. The investigators considered that the analgesic effect was related to depressed nerve transmission caused by the diode laser irradiation blocking the depolarization of C-fiber afferents.^[12]

Dederich *et al*^[13] were the first to describe the melting and re-crystallization of root canal wall dentin following Nd:YAG laser exposure. Based on the nonporous appearance of the root canal wall under SEM, they speculated that the exposed dentin exhibited reduced permeability to fluids. Decreased permeability of laser-treated dentin caused by fusion of the smear layer into the dentinal tubules also was reported.^[14] In this study, the investigators evaluated the effect of irradiation of dentin with the Nd:YAG laser, using SEM and dye penetration. Reduction in dentin permeability and melting of the apical dentin surfaces in teeth following apicoectomy also has been reported by Stabholz *et al*^[15,16], who used Nd:YAG laser energy (3 W) to irradiate the teeth.

When examining SEM photographs of dentin irradiated by lasers such as CO₂, Nd:YAG, and excimer, melting and resolidification of dentin usually is observed. A closer look frequently reveals that the melted material resembles glazed interconnected droplets. Thus, resolidification and recrystallization of the melted areas appears to be incomplete and discontinuous. A solid, uninterrupted melted and resolidified area would likely be less permeable and could more effectively block external stimuli associated with dentinal hypersensitivity and the penetration of microorganisms into the dentinal tubules. Recent experiments on the application of 9.6-lmCO₂ laser irradiation to enamel and dentin show promising results regarding its ability to melt hard tissues of the tooth.^[17] Complete familiarity with a safe and recommended protocol is essential at all times when irradiating vital teeth with lasers to alleviate the pain associated with hypersensitive dentin.

PULP DIAGNOSIS

Laser Doppler flowmetry, which was developed to assess blood flow in microvascular systems^[18], also can be used for diagnosis of blood flow in the dental pulp.^[19] This technique uses helium-neon and diode lasers at a low power of 1 or 2 mW²⁰. The laser beam is directed

through the crown of the tooth to the blood vessels within the pulp. Moving red blood cells causes the frequency of the laser beam to be Doppler shifted and some of the light to be backscattered out of the tooth.^[19] The reflected light is detected by a photocell on the tooth surface and its output is proportional to the number and velocity of the blood cells.^[21,22] The main advantage of this technique, in comparison with electric pulp testing or other vitality tests, is that it does not rely on the occurrence of a painful sensation to determine the vitality of a tooth. Moreover, teeth that have experienced recent trauma or are located in part of the jaw that may be affected following orthognathic surgery, can lose sensibility while intact blood supply and pulp vitality are maintained.^[19] Laser Doppler flowmetry assures objective measurement of pulpal vitality. When equipment costs decrease and clinical application improves, this technology could be used for patients who have difficulties in communicating or for young children whose responses may not be reliable.^[19]

PULP CAPPING AND PULPOTOMY

Pulp capping, as defined by the American Association of Endodontists, is a procedure in which “a dental material is placed over an exposed or nearly exposed pulp to encourage the formation of irritation dentin at the site of injury.” Pulpotomy entails surgical removal of a small portion of vital pulp as a means of preserving the remaining coronal and radicular pulp tissues. Pulp capping is recommended when the exposure is very small, 1.0 mm or less^[23,24], and the patients are young; pulpotomy is recommended when the young pulp already is exposed to caries and the roots are not yet fully formed (open apices).

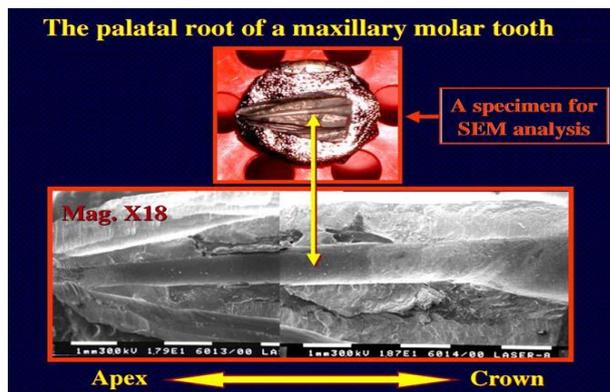
Since the introduction of lasers to dentistry, several studies have shown the effect of different laser devices on dentin and pulpal tissue. Although ruby lasers caused pulpal damage, Melcer *et al*²⁵ showed that the CO₂ laser produced new mineralized dentin formation without cellular modification of pulpal tissue when tooth cavities were irradiated in beagles and primates. Shoji *et al*^[26] applied CO₂ laser energy to the exposed pulps of dogs using a focused and defocused laser mode and a wide range of energy levels (3, 10, 30, and 60 W). Charring, coagulation necrosis, and degeneration of the odontoblastic layer occurred, although no damage was detected in the radicular portion of the pulp. Jukic *et al*^[27] used CO₂ and Nd:YAG lasers with energy densities of 4 J/cm and 6.3 J/cm respectively, on exposed pulp tissue. In both experimental groups, carbonization, necrosis, an inflammatory response, edema, and hemorrhage were observed in the pulp tissue. In some specimens, a dentinal bridge was formed. The effect of Nd:YAG laser energy on intrapulpal temperature was investigated by White *et al*. They found that the use of a pulsed Nd:YAG laser with an energy level of below 1 W, a 10-Hz repetition rate, and an overall 10-second exposure time did not significantly elevate the intrapulpal temperature. According to their results, these parameters

may be considered safety parameters because the remaining dentinal thickness in cavity preparations cannot be measured *in vivo*. It is therefore recommended that clinicians choose laser parameters lower than these safety limits.

CLEANING AND SHAPING THE ROOT CANAL SYSTEM

Successful endodontic therapy, which mainly depends on the elimination of microorganisms from the root canal system, is accomplished by means of biomechanical instrumentation of the root canal.

A recently completed pilot study^[28] examined the efficacy of the endodontic side-firing spiral tip in removing debris and smear layer from distal and palatal root canals of freshly extracted human molars that were instrumented using nickel-titanium (ProTaper; Dentsply, Tulsa Dental, Tulsa Oklahoma) files to size F3. Following root canal preparation, the pulp chamber and the root canals of the prepared teeth were filled with 17% EDTA and irradiated with Er:YAG laser (Opus 20, Lumenis, Opus Dent, Israel), using 500 mJ per pulse at a frequency of 12 Hz for four cycles of 15 seconds each. The RCLase Side-Firing Spiral Tip was used for the irradiation. The lased roots were removed, split longitudinally, and submitted for SEM evaluation.



Longitudinally split palatal root of a maxillary molar, sputter coated by gold and ready for SEM evaluation. The vertical arrow indicated the root canal as shown on the SEM photograph.

ENDODONTIC SURGERY

The goal of all endodontic surgery is to eliminate the disease and to prevent it from recurring²⁹ Miserendino³⁰ applied CO₂ laser energy to the apices of freshly extracted human teeth and demonstrated recrystallization of apical root dentin. The recrystallized structure was smooth and suitable for placement of retrograde filling material. He suggested that the rationale for laser use in endodontic periapical surgery should include the following: improved hemostasis and concurrent visualization of the operative field, potential sterilization of the contaminated root apex, potential reduction of the permeability of the root surface dentin, a reduction in postoperative pain, and a reduced risk of surgical site

contamination by eliminating the use of aerosol producing air turbine handpieces for apicoectomy. Despite its potential to lower dentin permeability, the conclusions of an *in vivo* study were that the use of CO₂ laser in apical surgery on dogs did not improve the success rate following surgery.

The main contribution of laser technology to surgical endodontics (apicoectomy and so forth) is to convert the apical dentin and cementum structure into a uniformly glazed area that does not allow egress of microorganisms through dentinal tubules and other openings in the apex of the tooth. Hemostasis and sterilization of the contaminated root apex also have a significant input.

CONCLUSION

Dental laser research & application has grown steadily from its modest & unheralded beginnings in 1963 to a state of development that pretends dramatic implication for the nature of clinical dental practice in the 2000 & beyond. Dental laser research has emerged to maturity & presages a substantial contribution to the future of clinical dental practice.

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