Uses of lasers in endodontics

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Abstract
LASER is light amplification by stimulated emission of radiation. Laser light is a man-made single-photon wavelength. The process occurs when an excited atom is stimulated to emit a photon. This is followed by subsequent release of another photon and so on. Stimulated emission generates, coherent (synchronous), monochromatic (single wavelength), and collimated form of light. LASER light when it reaches tissues gets reflected/absorbed/scattered/transmitted to surrounding tissues. This is due to the presence of water, proteins, and pigments in biological tissues. This absorption coefficient of biological tissue strongly depends on the wavelength of LASER.

Historical Perspective
In 1917, Einstein’s paper on Quantum theory contained conceptual ideas for stimulated emission of radiant energy. Niels Bohr’s Quantum mechanics concept that light has dual nature which gave the idea to fabricate optical resonators. In 1955, Gordon first demonstrated the stimulation of microwaves from the electromagnetic spectrum.

In 1958, Schawlow and Towne have showed that emission of radiant energy in the form of photons in infrared (IR) and visible spectra. In 1960, Maiman constructed the first working LASER by exciting a ruby rod with intense pulses of light using a flash lamp. In 1961, Javan et al. produced the first continuous working LASER using Helium and Neon.

Stern and Soagnes, Goldman et al. were pioneers to investigate potential uses of Ruby LASER in dentistry. Weichman and Johnson attempted to seal apical foramen in vitro by means of high powered IR CO_2 LASER.

Applications of LASER in Dentistry
1. Diagnosis of dental pulp vitality
2. Management of dentinal hypersensitivity
3. Pulp capping and pulpotomy (vital pulp therapy)
4. Modification of root canal walls
5. Sterilization of root canal system
6. Cleaning and shaping of root canal system
7. Obturation of root canal
8. Endodontic surgery

**Diagnosis of Dental Pulp Vitality**

LASER Doppler flowmetry is a non-invasive method of assessing and measuring the blood flow of pulp tissue. Advantages include the technique is more objective and reliable in assessing the health of pulp tissue. It has advantages of storing data, for measurements to be compared at later stages. Drawbacks include its technique sensitive, requires preparation of putty splint to hold probes and expensive.[4]

**LASERS in Vital Pulp Therapy**

Vital pulp therapy (pulpotomy) procedures using a LASER produce a bloodless field by vaporization and coagulation sealing smaller blood vessels and sterile wound. Melcer et al. used CO₂ LASER on beagle dogs and monkeys to achieve hemostasis after pulp tissue exposure.[2] Moritz et al. used CO₂ LASER for direct pulp capping compared with calcium hydroxide. Results showed, after 12 months, success rate of 89% with LASER and 68% with calcium hydroxide. Another study was conducted by Nair et al. using CO₂ LASER in 5 teeth. After 7 days, none of the teeth showed any pathologic changes at pulp-dentin complex 3 months post-operative 2 teeth showed subtle, yet, distinct apposition of tertiary dentin.[3]

One specimen showed mild inflammatory change with chronic inflammatory cells. This was attributed to antigens or micro-leakage rather than LASER therapy. Odabas et al. compared clinical, radiographic, and histopathologic effects of Nd:YAG LASER pulpotomy to formocresol pulpotomy for 12 months. Results showed that LASER group had a clinical success rate of 85.71%, and radiographic success rate of 71.42% formocresol group showed 90.47% success rate both clinically and radiographically.[6]

**LASERS in Disinfection of Root Canal System**

Elimination of microorganisms is commonly done to reduce the numbers of root canal micro-organisms, including the use of various instrumentation techniques, irrigation regimens, and intracanal medicaments. The bactericidal potential is developed through direct cell contact.[4] Regarding penetration of dentinal tubules, it has been demonstrated that NaOCl and Ca(OH)₂ have a limited ability (about 130 μm) to penetrate and disinfect.[5]

Chlorhexidine and IKI are a more effective in dentinal permeability. The intermediate energy level also increased dentine permeability, it also may harbor bacteria and debris on the wall of the root canal. Although this smear layer may be beneficial in that it provides an obstruction of tubules and decreases dentine permeability, it may also harbor bacteria and bacterial products.[3] Pashley et al. evaluated the effect of a CO₂ laser on the structure and permeability of smear layer covered human dentine in vitro.

Three different energy levels were used (11, 113, and 566 J/cm²). The lowest exposure to the laser energy increased dentine permeability. The intermediate energy level also increased...
Uses of LASERS in endodontics

Swetha, et al.

Lasers can play a role in several endodontic procedures, notably in the shaping of root canals, obturation, and treatment of dentinal hypersensitivity. The use of lasers in endodontics involves a variety of laser types, each with its own characteristics and applications.

**LASERS in Root Canal Shaping**

Root canal shaping aims at removal of organic tissues and facilitates irrigation and canal obturation. The laser beams can be delivered through an optical fiber that allows for better accessibility to the root canals. The technique requires widening of the root canal by conventional methods before the laser probes can be placed in the canal.[4]

The fibers diameter, used inside the canal space, range from 200 to 400 um, equivalent to a No. 20-40 file. Levy found that clean and regular root canal walls could be achieved using Nd:YAG laser irradiation from apical to coronal surface in a continuous, circling fashion.[5]

Sousa-Neto et al. evaluated the adhesion of an epoxy-based sealer to human dentine with Er:YAG or Nd:YAG laser. Increase in frequency of the lasers, independent of power settings, increased adhesion of an epoxy-based root canal sealer. Varella and Pileggi evaluated the number of canals and isthmuses obturated after Cr, Er:YSGG laser treatment.[6] They found that Cr, Er:YSGG treatment resulted in a statistically significant greater number of canals/isthmuses obturated. de Moura-Netto et al. assessed the influence of Nd:YAG and diode laser irradiation on apical sealing when applied before root canal filling with two different resin-based cements (AH-Plus and EndoREZ). The SEM analysis as well as leakage results revealed better filling adaptation for the AH-Plus and Nd:YAG laser group.[7]

**Limitations of Lasers in Root Canal Shaping**

Optic fibers do not touch all canal walls meaning that areas with clean surfaces are interspersed with those covered by residual debris; this is compounded by severely curved canals.[5]

**LASERS in Root Canal Obturation**

Three-dimensional cleaning, disinfecting, and shaping of the root canal system is the major aim of modern root canal treatment along with sealing without leakage from the apical foramen to the crown. Maden et al. compared the apical leakage of lateral condensation, Nd:YAG laser-softened gutta-percha and System-B techniques and found no significant difference between the groups. “The lateral condensation group and the group treated with System-B showed less leakage than the group of laser-softened gutta-percha.”[8]

Anic and Matsumoto found that Argon and Partial CO₂ lasers are more suitable for softening the gutta-percha fragments in the apical third of the root canal. Anjo et al. studied usefulness of a pulsed Nd:YAG laser in removing two types of endodontic obturation material from the root canal. Concluded that Nd: YAG laser irradiation was an effective tool for the removal of root canal obturation materials, and may offer advantages over the conventional method.[4]

**LASERS in Treatment of Dentinal Hypersensitivity**

Lasers used for treatment are divided into two groups:

1. Low output power lasers (He-Ne and gallium/aluminum/arsenide [Ga/Al/As] lasers),
2. Middle output power lasers (Nd: YAG and CO₂ lasers).

Kumar and Mehta evaluated clinically and under SEM the efficacy of Nd:YAG laser irradiation alone and in combination with 5% sodium fluoride varnish in the management of dentine hypersensitivity.[5] They found that the combination of Nd:YAG laser and 5% sodium fluoride varnish seemed to show an...
impressive efficacy, when compared to either treatment alone, in treating dentine hypersensitivity. Aranha et al. evaluated the effects of Nd: YAG and Er:YAG lasers on reducing dentine permeability by sealing opened tubules.\(^3\)

Results showed that the Er:YAG laser at 60 mJ, 2 Hz, and the Nd:YAG laser at 1.5 W, 15 Hz are useful for decreasing dentine permeability. The effectiveness of lasers for treating DH varies from 5% to 100%, depending on the type of laser and the treatment parameters. Studies have reported that the Nd: YAG laser, the Er:YAG laser and Ga-Al-As low-level laser reduced Dentin Hypersensitivity.\(^3\)

**LASERS in Periradicular Surgery**

Apicectomy is a surgical procedure in which the root apex is removed; the adjacent periapical tissues are removed and curedt at the same time. LASER used for the surgery provides a bloodless surgical field by vaporizing tissue and coagulating and sealing small blood vessels. If the cut surface is irradiated, the surface is sterilized and sealed.\(^3\)

Er:YAG laser can cut hard dental tissues without significant thermal or structural damage. Misrendonzo using the CO\(_2\) laser, in an apicectomy, for the treatment of a secondary apical abscess was able to seal the dentinal tubules in the apical portion of the root and to sterilize the affected area Gouw-Soares investigated the use of Er:YAG, Nd:YAG, and Ga-Al-As lasers in periradicular surgery clinically.\(^5\)

About 3 years follow-up showed radiographically significant decrease of the radiolucent periapical area and no clinical signs and symptoms Oliveira et al. and Arisu et al. evaluated the morphological changes and apical dye penetration at apical dentine surfaces. The groups irradiated with a laser showed to have lower infiltration indices.\(^1\)

**LASERS in Tooth Bleaching**

Power bleaching or in-office bleaching produces the whitening results quickly, without the long-term commitment of wearing trays. Abbots used high-intensity light to raise the temperature of hydrogen peroxide, accelerating the chemical process of bleaching.

The energy source can be derived from:
1. Blue-colored halogen curing lamps
2. IR CO\(_2\) lasers
3. Blue-colored plasma arc lamps
4. Cool blue argon laser
5. 980 nm Ga-Al-As laser.

Luk et al. compared the whitening effects and tooth temperature changes induced by various combinations of peroxide bleaches and light sources. A placebo gel (control), a 35% hydrogen peroxide or a 10% carbamide peroxide bleach was placed on the tooth surface and was irradiated with no light (control), a halogen curing light, an IR light, an argon laser, or a CO\(_2\) laser.\(^3\)

Their findings demonstrated that color and temperature changes were significantly affected by an interaction of the bleach and light variables. The application of lights significantly improved the whitening efficacy of some bleaching materials but it caused significant temperature increases in the outer and inner tooth surfaces. The IR and CO\(_2\) laser lights caused the highest tooth temperature increases.\(^3\) Eldeniz et al. measured intrapulpal temperature rise induced by two kinds of bleaching gels when the tooth was exposed to a variety of light curing units and a diode laser in vitro.

Light activation of bleaching materials with diode laser caused higher temperature changes as compared to other curing units and the temperature rise detected was viewed as critical for pulp health. Zhang et al. examined the whitening efficacy of a light-emitting diode (LED), a diode laser, and KTP laser irradiation in dental bleaching by analyzing the change in color achieved from the treatment, the temperature increase induced in the pulp cavity, as well as enamel microhardness measurement after treatment.\(^3\) The results showed that the KTP laser was effective at providing brighter teeth. According to the conditions used in this study, the LED and KTP laser induced a safer pulpal temperature increase when assisted with Hi-Lite bleaching gel.\(^8\)

**Side Effects of LASERS**

During laser usage for intracanal applications, thermal injury to periodontal tissues is of concern. Eriksson and Albrektsson found that the threshold level for bone survival was 47°C for 1 min. Bahcall et al., for the 1st time, reported the effect of the Nd:YAG laser on periodontal tissues in dogs.\(^3\)

They found that the laser-treated teeth exhibited ankylosis, cemental lysis, and major bone remodeling. Kimura et al. found that laser systems operate in various modes, such as continuous wave, pulsed, chopped-wave, and Q-switched.\(^3\) To minimize the rise in tissue temperature within the target and surrounding areas, use of the Q-switched nanosecond pulsed mode was beneficial. Cohen et al., Gutknecht et al., Nammour et al. suggested use of a LASER in a pulsed mode to avoid thermal increase and potential tissue damage.\(^7\)

**Conclusions**

“In the presence of good research and corresponding systematic review, a complete knowledge of the optimal LASER parameters for each treatment modality is acceptable. Therefore, the clinical use of the lasers in endodontics is promisable.”

**References**

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