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Lasers in Endodontics: A Literature Review

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Abstract: *The main goal of endodontic treatment is effective cleaning of the root-canal system. But there is limitation of endodontic therapy such as lateral canals with various morphologies and dimensions, anatomical complexity and difficulty of irrigants to penetrate into the lateral canals and the apical ramifications. Hence, there is need for new materials, techniques and technologies that can improve the cleaning and decontamination of these anatomical areas. Laser technology was introduced to endodontics with the goal of improving the results obtained with traditional procedures.*

Keywords: *Endodontics, Lasers, Pulp capping, Pulp vitality, Root canal treatment*

I. Introduction

The main goals of endodontic treatment are the effective cleaning of the root-canal system. Traditional endodontic techniques use mechanical instruments, as well as ultrasound and chemical irrigation to shape, clean and decontaminate the endodontic system. There is limitation of endodontic therapy such as lateral canals with various morphologies and dimensions [1], anatomical complexity and the difficulty of common irrigants to penetrate into the lateral canals and the apical ramifications. Hence, there is need for new materials, techniques and technologies that can improve the cleaning and decontamination of these anatomical areas.[2] Laser technology was introduced to endodontics with the goal of improving the results obtained with traditional procedures through the use of light energy by increasing cleaning ability and the removal of debris and the smear layer from the root canals and also improving the decontamination of the endodontic system. Built on the principles of quantum mechanics, Laser is a device which creates a beam of light where all of the photons are in a coherent state - usually with the same frequency and phase. this means that the light from a laser is often tightly focused and does not diverge much, resulting in the traditional laser beam.[3] The word "LASER" stands for Light amplification by stimulated emission of radiation. With the rapid development of laser technology, new lasers with a wide range of characteristics are now available and being used in various fields of dentistry.

II. History Of Lasers In Dentistry

The principle of the laser was based on the theory of stimulatedemission described by Albert Einstein in 1917.[4] In 1960, Theodore Maiman demonstrated the laser function and also developed a working laser device known as "ruby laser". Stern and Sognnaes reported in 1965 that a ruby laser could vaporize enamel.[5] The first laser that had truly both hard and soft tissue application was the CO2 laser which was invented by Patel in 1964(2). The Nd:YAG laser was also developed in 1964 by Geusic. In 1971, The first use of lasers in endodontics was reported by Weichman and Johnson, as they utilize high power infrared CO2 laser to seal the apical foramen *in vitro*.[6] In 1997 FDA gave clearance to the first true dental hard tissue Er: YAG laser and the Er, Cr: YSGG a year later. Semiconductor based diode lasers emerged in the late 1990s as well.[7] Clinical applications of the lasers are continue to increase rapidly. At present, lasers are indicated for a variety of dental procedures.

III. Mechanism Of Action

A laser beam is created from an active medium. This active medium when stimulated by light or electricity produces photons of a specific wavelength. Lasers have characteristic features like, they are monochromatic, unidirectional, coherent, and emitted from a stimulated active medium. In dentistry, the active media can be solid state, gas, or semiconductor. In solid state Er: YAG lasers the erbium is stimulated by light from a flash lamp with a process known as optical pumping. As an erbium atom absorbs a photon, its electrons are elevated to higher energy level. When the electrons return to a lower energy state, two identical photons are emitted which can further stimulate more atoms in a chain reaction, resulting in amplification of the light

produced. The resonators which are the mirrors surrounding the active medium further increase this light energy. Output coupler is one of the mirrors which is less than one hundred percent reflective. Light leaks from the output coupler and these are the photons that form the laser beam.[8] It is carried to the target tissue by various types of beam transfer hardware like mirrors in articulated arms and optical fibers.[9] The active medium is sealed in an air tight chamber in case of CO2 laser while the diode lasers have a semiconductor that when stimulated with electricity, laser light is emitted.[7]

IV. Classification Of Lasers [10,11]

IV.1 Based On Light Active Medium

Gas lasers:
• Argon
• Carbon-dioxide

Liquid:
• Dyes

Solid:
• **Nd:** YAG
• **Erbium:** yttrium aluminum garnet (Er: YAG)
• Diode

Semiconductor:
• Hybrid silicon laser

Excimers:
• Argon-fluoride
• Krypton-fluoride
• Xenon-fluoride

IV.2 Based On Light Spectrum [12]

UV Light	**100 nm - 400 nm**	**Not used in dentistry**
Visible light	400 nm to 750 nm	Most commonly used in dentistry (Argon & Diagnodent Lasers)
Infrared light	750 nm to 10000 nm	Most dental lasers are in this spectrum

V. Laser- Tissue Interaction[13,14]

Four type of interaction occur at tissue level.

1. Absorption is the phenomenon of the energy incident on tissue with affinity being absorbed and thereby exerting its biological effects.
2. Reflection is the phenomenon of a beam of laser light hitting a target and being reflected for lack of affinity.
3. Diffusion is the phenomenon of the incident light penetrating to a depth in a non-uniform manner with respect to the point of interaction, creating biological effects at a distance from the surface.
4. Transmission is the phenomenon of the laser beam being able to pass through tissue without affinity and having no effect.

VI. Applications Of Lasers In Dentistry [15]

1. Cutting Hard Tissue (Enamel and Dentin)
2. Root Canal- laser can be used for root canal, including tooth preparation to obtain access to the canal, root preparation, and canal enlargement and cleaning
3. Bone Surgery and Osseous Crown Lengthening
4. Apicoectomy& Endodontic Surgery
5. Periodontal Procedures
6. Soft Tissue- the YSGG laser demonstrated the capability to atraumatically treat soft tissue with little to no bleeding, little edema, and positive post-operative results

VII. Applications Of Lasers In Endodontics

Laser-supported treatments should be favored when treating patients that show one or several of the following symptoms [8]

1. Teeth with a purulent pulpitis or pulp necrosis
2. Teeth with lateral canals that lead to periodontal involvement

3. Teeth, of which the crown and root pulp show gangrenous changes
4. Teeth with peri-apical lesions (peri-apical gap from 1 mm, up to granulomas with a diameter of 5 mm and more)
5. Teeth with a peri-apical abscess
6. Absorption of the apex caused by inflammation or trauma
7. Teeth that have been treated for at least three months without success

VII. i lasers in analgesia

The pulsed Nd:YAG laser is widely used for analgesia in endodontics. Its wavelengths interferewith the sodium pump mechanism, change cell membrane permeability, alter temporarily the endings of sensory neurons, and block depolarization of C and A fibers of the nerves. [16]

VII.II For Diagnosis Of Pulp Vitality [17]

A Laser Doppler flowmetry was developed by Tenland in 1982 and later by Hollway in 1983. This method uses Helium-Neon and diode lasers at a lower power of 1 or 2 mW. Laser Doppler flowmetry is a noninvasive method of assessing and accurately measuring the rate of blood flow in a tissue. The blood flux level is much higher in vital than non- vital teeth. Currently, the vitality can be interpreted from a signal on the screen. Differential diagnosis of pulpitis can be made by laser stimulation.

VII.II.I Normal pulp and acute pulpitis

When normal pulp is stimulated by the pulsed Nd:YAG laser at 2W and 20 pulses per second (pps) at a distance approximately 10 mm from the tooth surface, pain is produced within 20 to 30 seconds and disappears a couple of seconds after the laser stimulation is stopped. While in acute pulpitis, the pain is induced immediately after laser application and continues for more than 30 seconds after stopping the laser stimulation.[8]

VII.II.II Acute serous pulpitis and acute suppurative pulpitis

If the electric current resistance is greater than 15.1 ohm and the patient experiences continuous pain for more than 30 seconds, the diagnosis is acute serous pulpitis. When the value of resistance is less than 15.0 ohm and there is continuous pain for more than 30 seconds, the diagnosis is acute suppurative pulpitis. No hard healthy dentin exists between the caries and the pulp chamber if Caries impedence is less than 15.0 ohm.[8,17]

Vii.Iii Lasers In Pulp Capping[17]

In accessory treatment by laser for Indirect Pulp capping, Pulsed Nd:YAG laser is used and black ink applied on the tooth surface. Air spray cooling is needed to prevent pulp damage. CO2 laser can also be used. In some cases, it is recommended that this laser be used with 38% silver ammonium solution.

VII.III.I Direct pulp capping by laser[17]

CO2 laser irradiation is performed at 1 or 2W after irrigating with 8% sodium hypoclorite and 3% hydrogen peroxide for more than 5 minutes. Calcium hydroxide paste must be used to dress the exposed pulp after laser treatment, after which the cavity should be tightly sealed with cement such as polycarboxylate cement. Pulsed Nd: YAG, argon, semiconductor diode, and Er:YAG can also be used. CO2 laser can also be used for Ablation and accessory treatment for vital pulp amputation. [8]

Vii.Iv In Root Canal Treatment [18]

The various uses of laser in root canal treatments are as follow:

1. Access cavity preparation and root canal orifice enlargement.
2. Root canal wall preparation.
3. Sweeping of Root canal and irrigation.
4. Removal of pulp remnants and debris at the apical foramen.
5. Sterilization or disinfection of infected canals.
6. Obturation with guttapercha or resin.
7. Removal of temporary cavity sealing materials, root canal sealing materials, and fractured instruments in root canals.

Er,Cr:YSGG (2780nm) and Er:YAG (2940nm) can be used for access cavity preparation, root canal shaping and cleaning. Nd:YAG(1064 nm) are used for root canal wall preperation.[19] If pulsed Nd:YAG laser is applied at 15 Hz / 1.5 W, smear layer can be removed completely and most part of dentinal tubuli can get closed. 5.25% Sodium hypochlorite or 14% EDTA must be used along laser irradiation.[20] Nd:YAG are also used for removal of pulp remnants and debris at the apical foramen, control of hemorrhage, and stimulation of

cells surrounding the root apex as well as debridement on the surface. In Photoactivated disinfection, tolonium dye is applied to the infected area and light is transmitted into the root canals at the tip of a small flexible optical fiber that is attached to a disposable hand piece. Laser emits 100mW and does not generate sufficient heat to harm the adjacent tissues.[20,21] Obturation of canals can be done with Lasers using vertical condensation. Anic and Matsumoto studied whether it is possible to perform the root canal filling using sectioned gutta-percha segments and a pulsed Nd:YAG laser. Thus with the lasers, removal of temporary cavity sealing materials, root canal sealing materials, and fractured instruments in root canals became possible.[22]

VII.V Laser Treatment Of Periapical Lesions Of Sinus Tract

Pulsed Nd:YAG and CO 2 lasers are recommended in cases for which apicoectomy or periapical curettage cannot be performed It accelerates wound healing. [23]This treatment generally is performed three or four times during one visit. When using the CO laser, the exit of drainage must be ablated as deeply as possible at 1 or 2 W and under air cooling or local anesthesia. These laser treatments are performed once or twice a week until the sinus tract disappears. For the pulsed Nd:YAG laser, 2 W and 20pps are the recommended parameters and the fiber tip must be inserted into the tract and drawn slowly from the root apex to the exit through the sinus tract.[24]

VII.Vi Laser In Periapical Curettage, Apicoectomy And Retrograde Cavity Preparation

Lasers proved to be effective because of relatively bloodless and post surgical course, coagulation, minimal cutting, sterile surgical area, swelling and scarring, vaporization and minimal or no suturing and much less or no post surgical pain. [25] The use of lasers resulted in smoother surfaces and more homogenous dentin fusion and recrystallization, which occluded tubules and decreased permeability, for example; Nd:YAG laser, Er:YAG laser.[26,27]

VIII. Indication And Contraindication Of Lasers In Endodontics [13,28,29]

VIII.I Indications:

a. Teeth with lateral canal leading to periodontal involvement.
b. Teeth with pulp necrosis and purulent pulpitis.
c. Teeth with gangrenous changes.
d. Teeth with periapical lesions upto 5mm or more.
e. Teeth that have been treated atleast 3 months with no success.

VIII.II Contraindications:

a. In advanced periodontitis cases.
b. A deep crown and root fracture.
c. Obliterated root canals in endodontic treated teeth.

IX. Advantage and limitation of lasers in endodontics

IX. IAdvantages of Lasers [8,21]

a. Ability to selectively and precisely interact with diseased tissues
b. Allows the surgeon to reduce the amount of bacteria and other oral pathogens in the surgical field and incase of soft-tissue procedures
c. While using YSSG laser dramatic reduction of pain in most cases reduces the need for injected anesthesia
d. Achieve good hemostasis with reduced need for sutures
e. Osseous tissue removal and contouring proceed easily with the Erbium family of laser instruments

IX.II Limitations of Lasers [8,21]

a. High cost
b. It requires additional training and education for various clinical applications and types of lasers
c. Accessibility to the surgical area
d. Overheating the tissue and air embolisms that could be produced by excessive air and water used during the procedure
e. Erbium lasers cannot remove metallic restorations
f. No single wavelength will treat all dental disease

X. Protection from lasers [13]

The surgical environment must have a warning sign and limited access. The operator should be well trained to use a laser device. The operator, patient and the surgical team should wear protective eyewear so that

any reflected energy does no damage. Infection protocol should be followed. To evacuate the plume formed by tissue ablation , high volume suction must be used.[30,31]

XI. Conclusion

When used efficaciously and ethically, lasers have been an essential tool in many dental treatments. With the development of thinner, more flexible and durable laser fibres, laser applications in endodontics will increase . With the advent of Lasers in dentistry, the complex procedures have become easier and time saving. Thus the ability to care for patients has improved.

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