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LASERS IN ENDODONTICS

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Abstract:

Background: *Laser technology is an evolving field. New lasers that have a diverse range of characteristics are now available and are being used in various fields of dentistry. Over the past 20 years, many technological advances have been made, and we now have new and improved lasers for our use. Laser technology was introduced to endodontics first by Weichman in 1971 with the goal of improving the results obtained with traditional procedures.*

The aim of Work: *The aim of this review article is to provide an overview of the present and possible future clinical applications of lasers in endodontics including their use in pulp diagnosis, dentinal hypersensitivity, vital pulp therapy, sterilization of root canals, root canal cleaning, shaping and obturation, and endodontic surgery.*

Materials and methods*: This review is a comprehensive search of PUBMED, MEDLINE, EMBASE up to November 2018. The following search items were used: lasers in endodontics, lasers in dentistry, endodontic treatment, advances in endodontic treatment*

Conclusion: *According to the literature reviewed for this article, when used efficaciously and properly, lasers can be a very useful tool for dentists. With the development of thinner, more flexible and durable laser fibers, laser applications in endodontics will increase. Its better disinfection efficacy, more effective root canal cleaning, reduction of permeability, reduction of micro-leakage, and elimination of the need to use toxic solvents represent the main advantages to dentists, enabling them to provide better treatment for their patients.*

Keywords: *lasers in endodontics, lasers in dentistry, classification of dental lasers, laser wavelengths, endodontic treatment, successful endodontic treatment.*

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INTRODUCTION:

A conventional endodontic treatment (RCT) involves complete debridement of the root canal system from inflamed or necrotic pulp tissues and microorganisms. [1] Traditional endodontic treatment uses mechanical instruments, chemical irrigants as well as ultrasonic activation to shape, clean and disinfect the root canal system. [2] There are however various limitations to a successful root canal treatment including anatomic complexities, lateral canals, apical ramifications and the failure of the current protocols to properly disinfect these. A recent study found intricate anatomical structures in 75% of the teeth analyzed. The study also found residual pulp after biomechanical preparation both in the lateral canals and in the apical areas in vital and necrotic teeth. [6] Hence, there is a need for new materials, techniques, and technologies that can improve the cleaning and decontamination of these anatomical areas. [3]

METHODOLOGY:

- **Data Sources and Search terms**

We conducted this review using a comprehensive search of MEDLINE, PubMed, and EMBASE, January 1985, through February 2017. The following search terms were used: lasers in endodontics, lasers in dentistry, endodontic treatment, advances in endodontic treatment

- **Data Extraction**

Two reviewers have independently reviewed the studies, abstracted data, and disagreements were resolved by consensus. Studies were evaluated for quality and a review protocol was followed throughout.

The study was approved by the ethical board of King Abdulaziz University Hospital

HISTORY OF LASERS IN ENDODONTICS:

The need for new materials and techniques for treatment led to the development of dental lasers for use in endodontics. It was introduced to endodontics with the purpose of obtaining better results than those obtained with traditional techniques via the use of light energy. Maiman in 1960 developed the ruby laser, and since then Dental researchers began investigating the potential uses of lasers in dentistry. It was Stern and Sognnaes in 1965 that reported that a ruby laser could vaporize enamel. [4]

"LASER" stands for Light amplification by stimulated emission of radiation.

Built on the principles of quantum mechanics, this device creates a beam of light where all of the photons are in a coherent state - usually with the same frequency and phase. This causes the light from a laser to be tightly focused, not diverging much, resulting in the traditional laser beam. [5]

CLASSIFICATION OF LASERS [7,8]:

A. 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

B. Based On Light Spectrum [9]

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

Table 1: classificartion based on spectrum

LASER WAVELENGTH CONSIDERATIONS:

Different lasers considered for endodontic applications are the

- Near infrared laser—diode (810, 940, 980 and 1,064 nm) and Nd:YAG(1,064 nm)
- The medium infrared lasers—Erbium,Chromium: YSGG (Er, Cr:YSGG; 2,780 nm)
- The Erbium:YAG (2,940 nm). [10]

Near-infrared lasers such as Nd: YAG (from 803 nm to 1,340 nm) are not absorbed by hard dentinal tissues and have no ablative effect on dentinal surfaces. It has a disinfecting effect on the deeper dentin layer due to its thermal effect.

The **medium infrared lasers**, such as the Erbium (2,780 nm and 2,940 nm) laser family, have flexible, fine tips. They are well absorbed by the water content of the dentinal walls and therefore have a superficial ablative and disinfecting effect on the root canal surface.

The **far infrared laser CO2 (10,600 nm)** was the first to be used in endodontics for disinfection and in retrograde prepration. It is no longer used expect for in vital pulp therapy. (pulpotomy and pulp coagulation). [10]

APPLICATION IN ENDODONTICS[3]:

1. Diagnostic Tool for Endodontics
2. Analgesia
3. Dentinal Hypersensitivity
4. Vital Pulp Therapy (Pulpotomy, Direct pulp capping, and Indirect Pulp capping)
5. Root canal treatment
   - Access cavity preparation
   - Orifice location and enlargement
   - Preparation of the canal walls
   - Irrigation and disinfection of infected canals.
   - Obturation of canal
   - Removal of Gutter Percha obturation material;
   - Retrieval of temporary cavity sealing materials, root canal sealing materials, and fractured instruments in root canals
6. Vertical root fracture diagnosis and treatment
7. Endodontic surgery-

- Flap preparation – incision of soft tissue to prepare a flap and expose the bone.
- Cutting bone to prepare window access to the apex (apices) of the roots
- Apicectomy – amputation of the root end
- Root end preparation for retrograde preparation
- Removal of pathological tissues (i.e., cysts, neoplasm or abscess) and hyperplastic tissues (i.e., granulation tissue) from around the apex. [3]

DIAGNOSTIC TOOL IN ENDODONTIC:

Laser Doppler flowery was developed to assess blood flow in microvascular systems but is now also being used for diagnosis of blood flow in the dental pulp. Helium-neon and diode lasers at low powers of 1-2mW are used. [11]. When the laser beam is directed through the crown of the tooth, it passes through the blood vessels within the pulp. The moving red blood cells cause Doppler shifts in the frequency of the laser beam and backscattering of some of the light out of the tooth. Use of lasers for pulp sensibility testing offers the advantage of not relying on a painful sensation for diagnosis. [12]

LASERS IN ANALGESIA:

The pulsed â Nd: YAG laser is widely used as an analgesic in endodontics. Its wavelengths interfere with 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, causing analgesia.[3]

LASERS AND DENTINAL HYPERSENSITIVITY:

Dentinal hypersensitivity is usually defined as a short, sharp pain from exposed dentinal tubules that occurs in due to stimuli such as cold, heat, tactility, osmosis, evaporation, or chemicals. This pain cannot be attributed to any other dental defect or pathology. [13]

Current clinical interventions aim to reduce dentinal hypersensitivity by blocking dentinal fluid flow[22]. These methods including the use of resins, oxalate salts, isobutyl cyanoacrylate, and fluoride-releasing resins or varnishes, and the use of devices that burnish exposed dentin have been successful in reducing the problem. The use of desensitizing agents has also been investigated extensively. They work by reducing the neural responsiveness.[23]

The mechanism of lasers for treatment of dentin hypersensitivity is not well understood. Pashley suggested that it may be due to coagulation and precipitation of plasma in dentinal fluid or by alteration of nerve fiber activity. [24]

Kimura et al. recommended laser therapy for treatment of dentin hypersensitivity. It showed varying effectiveness depending on the type of lasers and parameters, ranging from 5.2% to 100. According to the authors, lasers are more effective than other treatments, except in cases with severe dentin hypersensitivity. [11]

VITAL PULP THERAPY:

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 secondary dentin at the site of injury." Pulpotomy involves surgical removal of a small portion of vital pulp, usually in young patients.

There have been several studies showing the effect of different lasers on the dentin-pulp complex. Ruby lasers were shown to cause pulpal damage but Melcer et al. showed that the CO2 laser, when used at 2w for 2s in beagles and primates, was able to produce newly mineralized dentin without cellular modification of pulpal tissue [14]

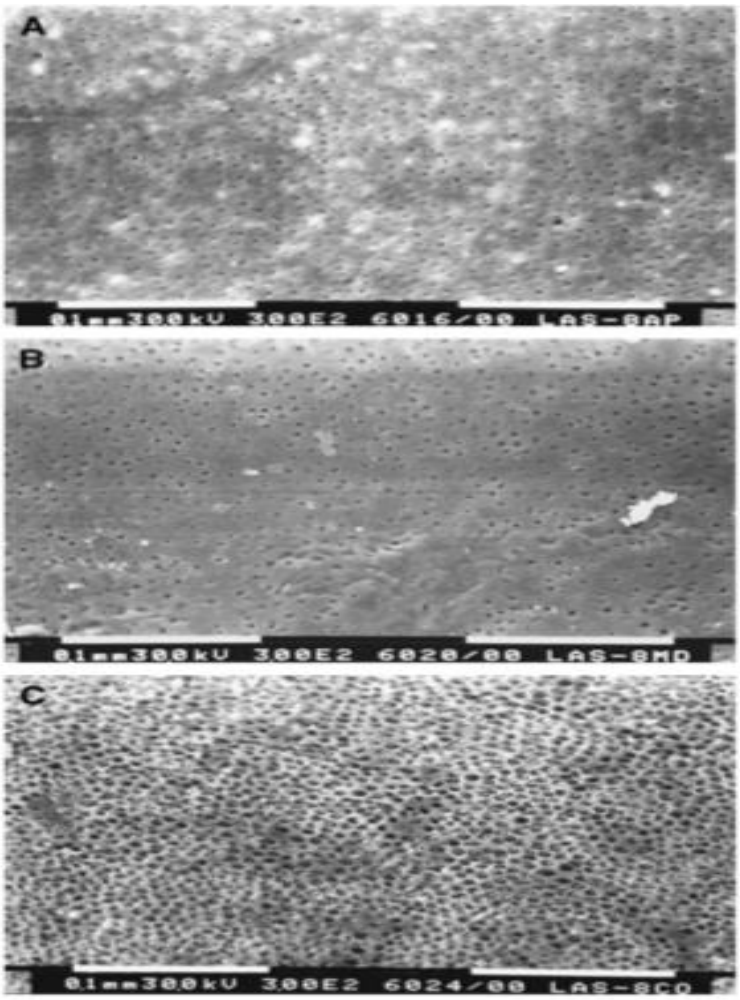

Fig 1: Lased wall of root canal
A. apical, B. middle, C. coronal part [14]

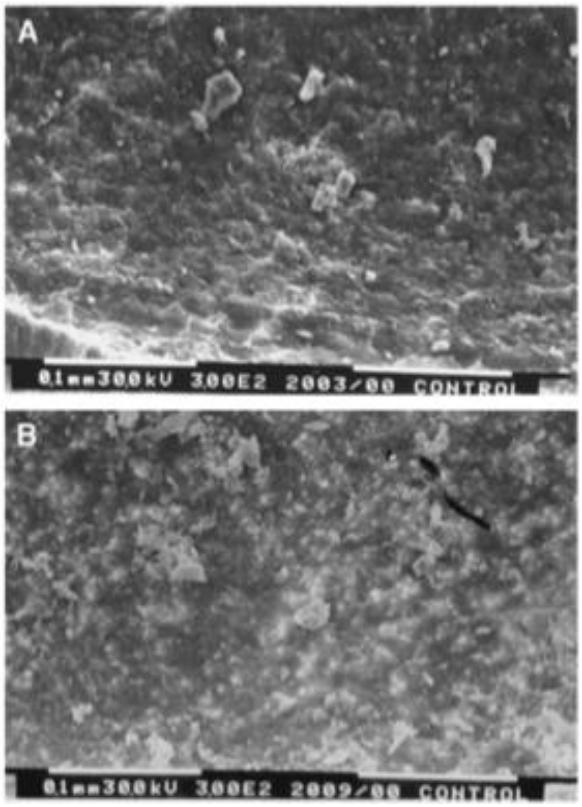

Fig 2: nonlased wall of root canal
A. apical, B. middle part [14]

ROOT CANAL TREATMENT:

Er, Cr: YSGG (2780nm) and Er: YAG (2940nm) are commonly used for access cavity preparation and for the cleaning and shaping of the root canal Er: YSGG (2780nm), Er: YAG (2940nm) and Nd: YAG(1064 nm) lasers are used for canal wall preparation. [15]

In various laser systems used in dentistry, the emitted energy can be delivered into the root canal system by a thin optical fiber (Nd: YAG, erbium, chromium:yttrium-scandium-gallium-garnet [Er, Cr: YSGG], argon, and diode) or by a hollow tube (CO2 and Er: YAG). Thus, the bactericidal effect of laser irradiation can be used for additional disinfecting the root canal system following instrumentation with the traditional methods. It also has been proven in various studies that CO2, Nd: YAG argon, Er, Cr: YSGG and Er: YAG laser irradiation can remove debris and the smear layer from the root canal walls following biomechanical instrumentation. [16,17,18]

Obturation of canals can be done with Lasers using vertical condensation. Anic and Matsumoto studied the possibilty of performing obturation with sectioned gutta percha segments and 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. [20]

There are several limitations that may be associated with the intracanal use of lasers that cannot be overlooked The emission of laser energy from the tip of the laser is directed apically along the root canal and not towards root canal walls laterally. Therefore its impossible to obtain uniform disinfectin of the canal walls unless a side firing spiral tip is used.

There are also chances of damage to the periradicular tissue because of the heat produced. [19].

DIAGNOSIS OF VERTICAL ROOT FRACTURE:

There have been very few studies on the use of lasers for diagnosing vertical root fractures. In a study by Kimura et al. (2009) they used diagnodent for the detection of vertical root fractures in vivoBut clinically this technique appers to be impractical.Vertical fractures should be treated tradionally first using a surgical approach on the fracture site, cleaning the fracture line and repairing it with composite resin or bioactive materials. [11]

LASER IN ENDODONTIC SURGERY:

The main contribution of laser technology to endodontic surgery is that it causes conversion of apical dentin and cementum to a uniformly glazed area . This dosent allow the mircoorganisms to penetrate through the dentinal tubules and other structures at the apical area.[21]

Apart from that laser application in endodontic surgeries offers advantages similar to those it offers for other surgical procedures. Soft tissue lasers like the Nd: YAG; Diode or CO2 provide clean incisions with little bleeding for accessing the periradicular area. The use of lasers instead of the available hand pieces for periapical surgries greatly reduces aerosol production, reducing contamination of the surgical enviornment and spread of infections.The Er: YAG or the Er, Cr: YSGG can be used for cutting the bone, sectioning of the apical part of the root and also for the retrograde prepraion fo the root end. Laser when used for endodontic surgeries have been shown to reduce post operative pain and edema and reduce scarring. [3]

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