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Applications of laser in the field of Endodontics : an update

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Abstract-

The scope of lasers in the field of Endodontic practices and research has increased rapidly in the past few years. Laser is light amplification by stimulated emission of radiation which provides blood loss field during treatment procedures. It is a non- invasive procedure with various applications in dentistry. However, lasers are slightly costlier than traditional treatment but are an effective tool to increase efficiency, specificity, ease and comfort of the dental treatment. This present article reviews the various applications of lasers in Endodontics.

Keywords: LASERS, Endodontic lasers, Nd:YAG, Er:YAG, CO_2.

INTRODUCTION

The field of dentistry has shown biggest boon in the use of modern technology to bring improvements in the treatment procedures. Among which is the use of LASER (Light Amplification by Stimulated Emission of Radiation) in the field of Endodontics. Laser light is a man-made single-photon wavelength. Through the process of optical amplification Laser emits light. Lasers was first introduced to the public in 1959, in an article by a Columbia University graduate student, Gordon Gould.[1] Theodore Maiman, at the Hughes Research Laboratories in Malibu, CA, built the first functioning laser,[2] by using a mixture of helium and neon. A laser From the crystals of yttrium-aluminum-garnet treated with 1-3% neodymium (Nd: YAG) was developed in the year 1961.[1] In 1962, the argon laser was developed, whereas, the ruby laser became the first medical laser to coagulate retinal lesions, when it was used in 1963.[1] Since then, the use of lases has progressed rapidly. In 1964, Patel at Bell Laboratories developed the CO_2 laser.[1] In 1990, the Food and Drug Administration (FDA) approved the use of laser therapy in intraoral gingival and mucosal tissue surgery as the therapy ensured a wound without suture, pain, and bleeding and increased the convenience for the dentist. On May 3, 1990 Myers introduced the first laser designed specifically for dentistry in the United States. Due to their many advantages, lasers are indicated for a wide variety of procedures. The laser amplified focused light energy which has the potential to interact with the biological dental tissues and structures in order to penetrate the surface of the tooth and access to the pulp cavity, clean, disinfect and shape the root canal system and finally help to fill it in three dimensions. The most comonly used lasers in endodontics are: Neodymium:YAG (Nd:YAG), Diode Laser, Erbium:YAG (Er:YAG), Erbium Chromium:YSGG (Er,Cr:YSGG) and He:Ne laser. A position paper from the American Association of Endodontists states that the application of lasers to disinfect the root canal is more promising than in

instrumentation and shaping of it.[3] Hence, the present paper focus on the various applications of lasers in dentistry.

Classification of lasers:[4]

1. According to their active medium lasers are divided into three groups.
   i) Solid-state laser:
   The medium which undergoes lasing, is in a solid form. Ruby laser is the prototype of all solid-state lasers: by forming crystalline materials, which are doped with rare earth elements, a wide range of solid state lasers can be produced. Eg: YAG(Yttrium Aluminium Garnet) crystal (HolmiumYAG, Thulium:YAG Neodymium:YAG and Erbium:YAG) and the YSGG (Yttrium Scandium Gallium Garnet) crystal (Er,Cr:YSGG).
   ii) Gas lasers:
   The lasing material ionized can be Argon gas, Carbon dioxide gas, Nitrogen gas or a Helium-Neon (He:Ne) gas mixture.
   iii) Diode lasers:
   Produces wavelengths in the visible spectrum.

2. According to the wavelength (nanometers)
   i) UV (ultraviolet) range – 140 to 400 nm
   ii) VS (visible spectrum) – 400 to 700 nm
   iii) IR (infrared) range – more than 700 nm

3. According to tissue applicability
   i) Hard tissue- eg: Er:YAG, Er:YSGG, CO_2
   ii) Soft tissue lasers- eg: Diode, Nd:YAG, CO_2

Applications of laser:

1. Prevention of dental caries
2. Management of post endodontic pain
3. Diagnosis of dental pulp vitality
4. Treatment of dentinal hypersensitivity
5. Pulp capping and pulpotomy (Vital pulp therapy)
6. Root canal irrigation
7. Obturation of root canal
8. Bleaching of root-treated discoloured teeth

1. Prevention of dental caries

Dental hard tissues when irradiated with laser shows modification in the calcium-to-phosphate ratio, reduces the carbonate-to-phosphorous ratio, and leads to the formation of more stable and less acid soluble compounds, reducing susceptibility to acid attack and caries. Laboratory studies have indicated that enamel surfaces when exposed to laser irradiation are more acid resistant than non-laser treated surfaces.[5] The one-time initial laser treatment provides degree of protection against caries progression comparable to daily fluoride treatment by a fluoride dentifrice. The threshold pH of dissolution of enamel was reduced from 5.5 to 4.8, and for hard tooth structure was 4 times more resistant. However, it is still unclear how the laser irradiation causes mechanism of acid resistance, and particularly in vivo studies are required to test those claims.

2. Management of post endodontic pain

Sometimes patient experiences pain the day after endodontic treatment. This is especially more common after the treatment of chronic complaints. This can be managed by LLLT(Low level laser therapy). It includes light-emitting diodes and other light sources. It is effective for reducing pain and inflammation after endodontic treatment and can be used as a diagnostic tool for pulp hyperemia. In a study, LLLT was used to decrease the pain after one session treatment. A study states that LLLT is an effective and non-pharmacological tool for the reduction of post-endodontic treatment pain.[6]
A wavelength between 600 and 1000 nm power from 5 to 500 Mw with red-beam or near-infrared lasers is used in LLLT. In contrast, lasers used in surgery typically are of 300 W. These lasers are nonthermal. Although the exact mechanism is unknown, it is theorized that, the laser light can penetrate deeply into the tissues due to the low absorption by human skin where it has a photobiostimulation effect. The therapy performed with such lasers is often called LLLT, and the lasers are called "therapeutic lasers." Light in infrared spectrum at specific wavelength penetrates the tissue and is absorbed where the light energy is converted into biochemical energy, restoring normal cell function.[6]
LLLT reduces pain due to inflammation in a dose-dependent manner and reduces levels of prostaglandin E2, prostaglandinendoperoxide synthase 2, interleukin 1-beta, tumor necrosis factor-alpha, the cellular influx of neutrophil granulocytes, oxidative stress, edema, and bleeding. 0.3 and 19 J/cm2 appears to be the appropriate dose of laser to reduce pain due to inflammation . Other theory proposed is the "Neural inhibition as a mechanism of pain relief," which is widely accepted.[7]

3. Diagnosis of dental pulp vitality

The most accurate marker of pulp vitality is Vascular supply. A possible test For detecting pulp vitality is assessing vascular supply which relies on the passage of light through a tooth. Laser Doppler flowmetry (LDF) was adapted by Gazelius and Olgaret in 1986 for use on human teeth in order to measure pulpal blood flow.[8] It is a noninvasive, objective, painless and semiquantitative method which is reliable for measuring pulpal blood flow. In this technique the moving blood cells scatters the laser light and undergoes a shift in frequency according to the Doppler principle. The light is detected and processed to produce a signal that shows the function of the red cell flux (volume of cells X cell velocity).[9] It is useful in detecting episodes of transient ischemia and identifying teeth at risk of developing adverse sequelae. IKawa et al in 2003 stated that age related changes in human pulpal blood flow could be measured by LDF as their findings indicated that the hemodynamic of the human pulp is reduced with age.[10] LDF has some limitations, as it is expensive, not readily available and requires skill in its application in teeth with large restorations, and laser light may not reach pulp and measure the true blood flow. A major portion of the signal from LDF comes from tissues other than the pulp. The results may be inconsistent in pulp blood flow measurements without taking precautions (such as dental-dam application).[11]

4. Treatment of dentinal hypersensitivity

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. The study showed that the combination of Nd:YAG laser with 5% sodium fluoride varnish showed an impressive efficacy in treating dentine hypersensitivity. [12] Aranha et al. evaluated the effects of Nd: YAG and Er:YAG lasers on reducing dentine permeability by sealing opened tubules and it was shown that Er:YAG laser at 60 mJ, 2 Hz, and the Nd:YAG laser at 1.5 W, 15 Hz decreases dentine permeability.[13] The effectiveness of lasers for treating dentin hypersensitivity 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.[14]

5. Pulp capping and pulpotomy (Vital pulp therapy)

A bloodless field is provided in Vital pulp therapy procedures when a laser is used. It causes vaporization and coagulation sealing of smaller blood vessels and sterile wound. Between 1985 and 1987 Melcer et al. suggested that the CO_2 laser could be used for direct pulp capping.[15] Moritz et al. used CO_2 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 CO_2 laser in 5 teeth. After 7 days, none of 5 teeth showed any pathologic changes at pulp-dentin complex 3 months post-operative 2 teeth showed subtle, yet, distinct apposition of tertiary dentin.[16] Suzuki et al. showed that CO_2 laser is effective for pulp capping procedures; however a longer observation time would be required to determine the presence of dentine bridge formation.[17] Er:YAG and Nd:YAG lasers have been successful in pulp capping procedures in several different studies, demonstrating good healing capacity with the formation of a dentine bridge and reparative dentine.[18,19] Among lasers CO_2 laser is an effective tool for direct pulp capping and also for pulpotomy of primary teeth. CO_2 laser has a success rate of 91 to 98% in pulpotomy of primary teeth by Pescheck and Moritz in 2002.[20]

6. Root canal irrigation

Presently, Er:YAG, Nd:YAG, CO_2 laser and diode laser have been shown to be efficient and effective for the purpose of root canal disinfection and smear layer removal.[21]

Nd: YAG laser irradiation was compared with that of NaOCl in disinfecting the root canal system by Moshonov et al. Results showed that Nd:YAG laser irradiation significantly reduced the number of bacteria while NaOCl irrigation effectively disinfected the canals.[13] the antimicrobial effect of Er:YAG laser irradiation with 1% sodium hypochlorite irrigation by Perin et al. evaluated for root canal disinfection. It was found that the NaOCl solutions and the Er:YAG laser irradiation to working length were effective against all microorganisms.[14] The NaOCl treatment was statistically superior to the CO2 laser treatment.[13] In a study it was found that bacterial recovery decreased when laser irradiation duration or power increased. A greater degree of disinfection was achieved with a 120 s application of laser than with sodium hypochlorite treatment.[12] In another study it was found that bacterial recovery decreased when laser irradiation duration or power increased. A greater degree of disinfection was achieved with a 120 seconds application of laser than with sodium hypochlorite treatment.[14]

7. Obturation of root canal

Major aim of modern root canal treatment is three-dimensional cleaning, disinfecting, and shaping of the root canal system along with sealing without leakage from the apical foramen to the crown. apical leakage of lateral condensation, Nd:YAG laser-softened gutta-percha and System-B techniques was compared by Maden et al. and found no significant difference between the groups. In the study less leakage was observed in the lateral condensation group and in System-B goup than the group of laser-softened gutta-percha.[22]

The pulsed Nd:YAG laser was used removing two types of endodontic obturation material from the root canal by Anjo et al and it was found 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.[23]

8. Bleaching of root-treated discoloured teeth

After root canal treatment, tooth discoloration is a common, aesthetic problem particularly in anterior teeth.[24] According to Nicholls, the main causes of intrinsic tooth discoloration related to endodontic treatment are decomposition of necrotic pulp tissue, hemorrhage into the pulp chamber, intracanal drugs and filling materials.[25] After obturaion when Gutta-percha and different types of sealers if not removed

from the pulp chamber may cause mild to severe discoloration of the tooth. Laser-assisted bleaching technique has been shown to be an efficient method to treat resistant discolorations in less than one hour.[26]

Conclusion

In the past few years the scope of use of lasers has increased significantly in the field of Endodontics. This present article summarizes the various uses of lasers in endodontics which provides rapid, painless, and atraumatic treatment which is a trend in modern dentistry. But More studies are required to accept the use of lasers in future for complete eradication of microbes in root canal system in regular endodontic practices.

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