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# Dental LASER - An Innovative Tool in Endodontics

**Aditi Mittal[1], Deepinderjeet Kaur[2], Dr. Vaishali[3]**

[1] Intern, Department of Endodontics, Adesh Institute of Dental Sciences and Research

[2]Intern, Department of Endodontics, Adesh Institute of Dental Sciences and Research

[3] Senior Lecturer, Department of Endodontics, Adesh Institute of Dental Sciences and Research

**Abstract:** ***The Scope of Lasers in the field of dentistry is rapidly increasing due to ongoing studies and researches in the past few years. The study and experiments on lasers had started in the early 1960s, but its use has majorly increased in the past few years. Lasers are a better & an effective tool as compared to other traditional treatment methods. Lasers have improved the ease, specificity, efficacy, comfort and outcomes of the dental treatment. Our present study aims to review some applications of lasers in the field of Endodontics. According to the evidences stated in current study, lasers are used for pulp vitality testing methods, root canal shaping and cleaning, root canal irrigation and disinfection, obturation, sealing of dentinal tubules to treat dentinal hypersensitivity, whitening of teeth, pulp capping etc. Various endodontic surgical procedures are now carried out using lasers for its better outcomes. However, lasers are slightly costlier than conventional treatment methods. It has proved to be a boon in the field of endodontics. This article gives an insight on applications of lasers in endodontics along with an overview on laser safety.***

**Keywords:** $CO_2$, diode lasers, history of lasers, LASERS, laser safety, Nd: YAG, pulp diagnosis, root canal treatment, surgery

## 1. Introduction

In today's modern world, technology plays a great role in various fields of medicine and dentistry. In the field of dentistry, modern technology has upgraded the techniques and outcomes of various treatment procedures. **LASER** is widely used in dentistry which stands for "Light amplification by stimulated emission of radiation". Laser light is a man - made single - photon wavelength light with numerous applications [(1).] Patients comfort, care and wellbeing are being prioritized by its advancements in the field of dentistry. The intraoral use of lasers, when used efficaciously and ethically is an exceptional modality of treatment for many clinical conditions that dentists or dental specialists treat on a daily basis [(2).]

Various goals of endodontic treatment are to eliminate microorganisms from the root canal system, to remove pulp tissue that may support microbial growth, and to avoid forcing debris beyond the apical foramen which may sustain inflammation [(3).] In the past times, the infected tooth was extracted as treatment but today laser therapy has proven to be successful in eliminating bacterial contamination from the root canal system in endodontics. The cleaning ability with the use of light energy was improved with the introduction of laser technology as compared to traditional procedures.

There are two types of LASERS being used in dentistry –

1) **Hard Lasers**, such as, Carbon dioxide ($CO_2$), Nd: YAG, and Er: YAG lasers, which are used in both hard tissue and soft tissue applications. But, these Hard Lasers have some major limitations i. e. high costs and a potential for thermal injury to the pulp.
2) **Cold or Soft Lasers,** such as low - level laser therapy (LLLT), which are based on the semiconductor diode devices that give the advantage of compact and low - cost devices used predominantly for dental applications. They are based on the principle of '**biostimulation**' [(4).]

This article aims at focusing on the major and minor concepts involved in working of LASERS in endodontics. It covers both advantages and disadvantages of LASERS. It also covers and briefs on the various applications of LASERS in endodontics.

**HISTORY**

- **1917 - Alberte Einstein**

Theory of stimulated emission

- **1958 - Schawlow and Townes**

Invention of MASER

- **1960 - Maiman**

Invention of Ruby laser

- **1961 - Javan and Colleagues**

First actual continuously generating laser which used a mixture of helium and neon

- **1964 - Patel at bell**

Carbon dioxide laser

- **1965 - Goldman et al.**

First application of Ruby laser on the vital tooth in vivo

- **1971 - Weichman and Johnson**

First laser use in endodontics

- **1990 - FDA** approved the laser therapy for clinical oral soft tissue uses

- **1997 - FDA** approved Er: YAG laser as the first dental hard tissue laser

**Mechanism of Action of LASER**

The word LASER stands for ―Light Amplification by stimulated emission of Radiation. Lasers are characteristically monochromatic, unidirectional, coherent, and emitted from a stimulated active medium. This active media in dentistry can be in a solid state, gas, or

semiconductor [5]. It has three main parts: An energy source, an active lasing medium, and two or more mirrors which form an optical cavity [4].

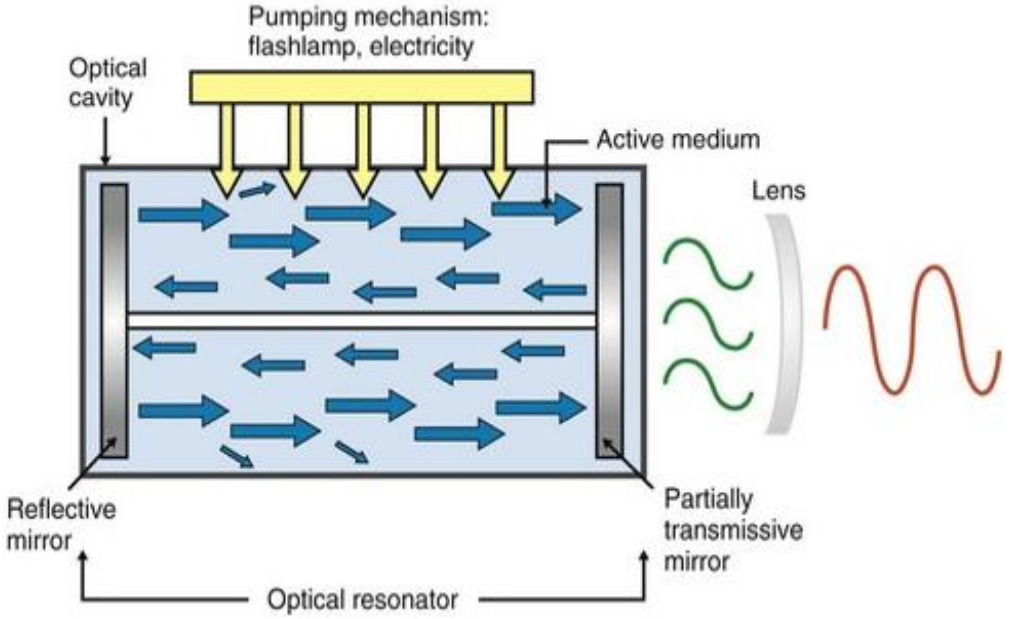


**Figure 1:** Laser components, eg., $CO_2$ or Nd: YAG

Laser is created when the electrons in atoms absorb energy from an electrical current or another laser and become "excited". The excited electrons move from a lower energy orbit to a higher - energy orbit around the atom's nucleus. When they return to their normal or "ground" state, the electrons emit photons (particles of light) [3]. (Fig 1)

The laser beam, on the other hand, implies **stimulated emission** of radiation. During laser production, the excited electron is stimulated to emit a photon before the process occurs by itself.

The light energy which is produced by a laser interacts with the target tissue in four different ways: Reflection, Transmission, Scattering, and Absorption [4]. The absorbers of light in the target tissues are called Chromophores. They have particular previously specified affinity for absorption of specific wavelengths of light. In the intraoral soft tissue, primary chromophores are Melanin, Hemoglobin, and Water. Similarly in dental hard tissues the majorly acting chromophores are Water and Hydroxyapatite. Hence, the laser selection procedure is made dependent because of different absorption coefficients of different laser wavelengths with respect to the target tissue components.

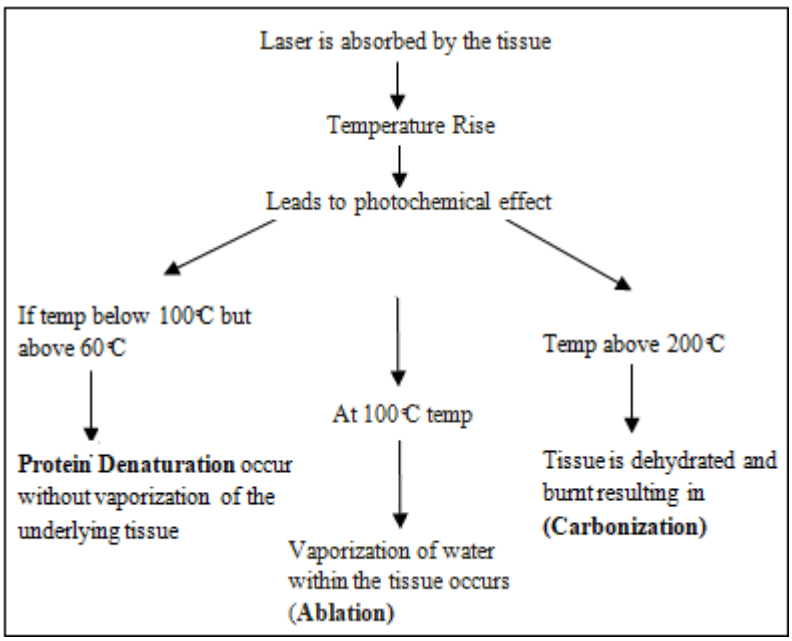


**Figure 2:** Effects of laser light on vital tissue

**Applications of Laser**

1) Pulp vitality
   - Laser Doppler Flowmetry
   - Pulp Oximetry
2) Treatment of dentinal hypersensitivity
3) Tooth bleaching
   - Vital tooth
   - Non - vital Bleaching
4) Pulp Capping and pulpotomy
5) Root canal treatment
   - Access cavity preparation
   - Cleaning and shaping of root canal system
   - Irrigation and disinfection of root canal
   - Sterilization of root canal
   - Obturation
   - Removal of gutta percha obturation material
   - Management of post endodontic pain
6) Periradicular surgery
   - Apicectomy
   - Cavity preparation
   - Retrograde filling
7) Vertical root fracture diagnosis and treatment
8) Lasers as analgesia

**Pulp vitality**

Vitality testing forms an integral part of oral diagnosis, as a means of distinguishing or identifying diseases ([6]). Pulp vitality is most accurately measured using vascular supply of the pulp. Vascular supply which relies on the passage of light through a tooth is usually considered a feasible test for detecting pulp vitality [(1).]

**Laser Doppler Flowmetry** (LDF) was developed as a non invasive method which is useful in assessing blood flow in micro - vascular systems. The use of this method in teeth was first described by GAZELIUS [(7).] It monitors the dynamic changes in pulpal blood flow. The laser light is transmitted through a fiber optic source placed on the tooth surface. The light enters the tooth and gets absorbed by the red blood cells which lead to a shift in the frequency of the scattered light, this occurs due to Doppler principle. The proportion of doppler shifted light is detected with the help of a photo - detector [(8).]

Its advantages are non - invasive, painless, reproducible, gold standard for pulpal blood flow determination. Limitations are - time consuming, requires a special device. Therefore, it is not conducted as a routine procedure in clinical practice [(5).]

**Pulse Oximetry**

It is the technique most commonly used for the measurement of oxygen concentration in the blood because of its ease and availability. Pulse oximetry is a non invasive oxygen saturation monitoring device widely used in medical and dental practices for recording blood oxygen saturation levels. It was invented by Takuo Aoyqagi,, in early 1970s [(9).]

Pulp oximetry uses red and infrared wavelengths to trans - illuminate a tissue bed, detecting absorbance peaks due to pulsatile blood circulation and uses this information to calculate oxygen saturation and pulse rate. The sensor consist of two lights emitted diodes: - red light (660nm), infrared light (940nm) and a photodetector on the opposite side of vascular bed. LED transmits red and infrared light through a vascular bed. Oxygenated haemoglobin and deoxygenated haemoglobin absorbs different amounts of red and infrared light. The pulsatile change in the blood volume causes periodic changes in the red - infrared light absorbed by vascular bed before reaching the photodetector.

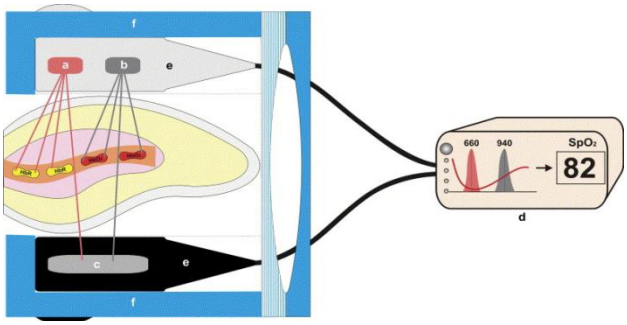


**Figure 3:** Pulse Oximetry

**Treatment of dentinal hypersensitivity**

In clinical dental practice, the most common complaint of the patients is dentinal hypersensitivity. This condition arises through the incorrect tooth brushing, gingival recession, inappropriate diet and some other factors. The sensation of pain is usually due to patent dentinal tubules not covered by smear layer or enamel.

The lasers which are used in treatment of dentinal hypersensitivity are divided into two groups – low output power lasers (He - Ne and GaAlAs) and middle output power lasers (Nd: YAG and $CO_2$ lasers). In Low output power lasers, a fraction of the laser energy reaches to pulp tissue when it is transmitted through enamel or dentine where they act on A - Delta and C fibers. In case of middle output lasers they have thermal medicated effect causing pulpal analgesia.

Aranha et al. studied the effects of Nd: YAG and Er: YAG lasers on decreasing dentine permeability by occluding opened dentinal tubules and stated that the dentine permeability is significantly reduced by Er. YAG laser and Nd. YAG laser [(1).] Kumar and Mehta have seen the efficacy of Nd: YAG laser along with 5% sodium fluoride varnish in management of dentinal hypersensitivity. They stated that, the combination showed the higher efficacy in treating dentinal hypersensitivity. Depending upon the type of laser used and extremity of dentinal hypersenstivity, the usefulness of lasers varies from 5% to 100 %. [(10).]

**Tooth bleaching**

**Vital tooth bleaching**

Now days, patient desire to have whiter teeth and are aware of various options available such as the bleaching techniques. Lasers can act as a boon in bleaching of vital teeth, when used in combination with conventional bleaching gels containing $H_2O_2$ or carbamide peroxide.

Lasers used for bleaching are infrared $CO_2$ laser, the cool blue argon laser and diode laser. Laser irradiation of dental hard tissue can cause morphological and chemical changes.

When laser light strike the bleaching gel it results in the rise in temperature which might cause the damage to adjacent tissues. So the compositional changes are made to increase and decrease the solubility of irradiated enamel and dentine. These temperature changes due to use of laser light along with bleaching gel affects the tooth structure from inside and outside. The major disadvantage of $CO_2$ laser light used earlier was that it caused rise in temperature. Similarly with use of diode lasers the rise in temperature was significantly high; this was critical for the pulpal health. However, according to some studies, the LED and KTP lasers induce a safer pulpal temperature increase when assisted with Hi - Lite bleaching gel [(6).]

**Non - Vital tooth bleaching**

After root canal treatment usually the tooth discolouration is mostly seen in anterior teeth. According to Nicholls, intrinsic tooth discolorations which are related to endodontic treatment are because of necrotic pulp tissue, hemorrhage into the pulp chamber, intracanal drugs and filling materials [(1).] Some mild and severe discolourations of the root canal treated tooth are due to unremoved gutta percha and different type of sealers from the pulp chamber after obturation. Now, Laser - assisted bleaching technique is considered as an efficient method in treating resistant discolorations in less than one hour [(1).]

**Lasers in Pulp Capping and Pulpotomy**

Use of laser for vital pulp therapy gives bloodless field by vaporization, coagulation and sealing smaller blood vessels with no complications [(11).] The traditionally used material for pulp capping is Ca (OH) $_2$, which creates an area of necrosis below the dentin bridge. This necrotic zone may allow bacterial growth in case of micro leakage. On the other hand, the newer material MTA, takes longer to set completely. These disadvantages of our conventional materials has been overcomed by introduction of lasers.

Melcer et al showed that new mineralized dentin was produced by $CO_2$ laser without any cellular modification of pulpal tissue [(12).] Moreover a comparative study between $CO_2$ laser and calcium hydroxide for pulp capping procedures have shown the success rates of 89% and 68% respectively over a 12 month follow up period [(13).] In direct pulp capping and pulpotomy of primary teeth, $CO_2$ lasers are observed as an effective tool. Pescheck and Moritz in 2002 claimed that 91% to 98% of success rate was found with $CO_2$ lasers in pulpotomy of primary teeth [(14).]

Er: YAG and Nd: YAG lasers in several different studies, demonstrated good healing capacity with the formation of a dentine bridge and reparative dentine.

## Root Canal Treatment

**Access cavity preparation**

Root canal treatment is the treatment which widely uses lasers from access cavity preparation to obturation. Use of lasers have made the RCT procedure uncomplicated and easy to perform. Initial Root canal treatment steps can be done using Er, Cr: YSGG (2, 780 nm) and Er: YAG (2, 940 nm) lasers. Nd: YAG (1, 064 nm) are used to remove pulp remnants and debris at the apical foramen as well as for control of hemorrhage. Pulsed Nd: YAG laser used at 15 Hz/1.5 W, can be used to eradicate smear layer completely with dentinal tubules sealing [(3).] Root canal orifices were prepared using Er: YAG lasers after which surfaces of the root canals appear smooth in light microscope

**Cleaning & Shaping Of Root Canal System**

For successful root canal treatment, proper cleaning and shaping of root canals is important. This can be obtained using conventional methods along with lasers as an adjunct. Nd: YAG laser irradiation produces clean and regular walls. Laser irradiation provides potential bactericidal effect on various microorganisms in root canals along with additional cleaning using biomechanical instrumentation [(15).]

**Root canal irrigation and disinfection**

Presently, lasers which are effective and efficient for root canal irrigation and smear layer removal are Er: YAD, Nd: YAG, $CO_2$, and diode lasers. NaOCl irrigation used for elimination of microorganisms along with the intracanal medicaments have shown limited ability to penetration and disinfection [(16).] Hence, the reoccurrence of microorganisms after the treatment is seen. But now, with laser light, the disinfection of deep area within the dentine can be achieved. No reoccurrence of microorganisms colony was witnessed after laser light irradiation [(17).] In a study, it was found that when laser irradiation duration or power is increased, the bacterial recovery is decreased. A 120seconds of application of laser light causes much disinfection than with sodium hypochlorite treatment. [(1)]

**Sterilization of root canals**

Numerous studies into the sterilization of root canals have been performed using $CO_2$, Nd: YAG lasers and diode lasers. All lasers have a bactericidal effect at high power, intensity of which may vary with each laser. The smoke which is produced by the laser can be responsible for spread of bacterial infections from root canal system to the patient and the dental team, which can cause bacterial dissemination (Hardee et al.1994) [(2).] Thus, when using lasers in the root canal treatment, some precautions must be taken such as strong vacuum pump to protect against spreading bacterial infections. (McKinley & Ludlow 1994) [(18).] However, thermal injury to periodontal tissues can be possible when sterilizing root canals in some cases. [(2)]

**Obturation**

Laser irradiation can be used as a heat source for softening of gutta percha. An Ar laser emitting light at 477 and 488 nm can be possibly used for obturation with the photo - polymerization of camphorquinone - activated resins. [(2)] Anic & Matsumoto in 1995 [(18)] stated that the Ar, CO2, and Nd: YAG lasers can be used for softening gutta percha and results indicates that Ar laser can be used to produce a good apical seal. Previous studies have determined that heat energy from laser light cannot be safe for surrounding structures of the tooth. Hence, lasers are not a preferable medium for obturation.

**Removal of Gutta Percha Obturation Material**

Lasers are effective in non - surgical retreatment and removing gutta percha and sealers from the root canal space. The Nd: YAG laser working at 3 output powers (1 W, 2 W,

3 W), enables the removal of filling material in more than 70% of cases, and broken instruments in 55% of cases [3]. Pulsed Nd: YAG laser has been used in successful removal of different types of obturating materials. It took shorter time for removal of debris from root canal then conventional methods hence it has been concluded that Nd: YAG laser irradiation is effective for removing the root canal obturating material, and is more advantageous over the conventional methods.

**Management of post endodontic pain**

After conventionally treated root canals, flare ups or post - operative pain may develop. Using Low - Level Laser Therapy (LLLT) in such cases reduces postoperative pain. It is a practical and non - pharmacologic technique for reducing pain [3]. Pain due to inflammation is believed to be reduced with the dose of 0.3 and 19 J/cm$^2$. Other theory proposed is the "Neural inhibition as a mechanism of pain relief, " which stated that the spinal cord contains a neurological gate that either blocks pain signals or allows them to continue on to the brain and this theory is widely accepted [1].

**Periradicular surgery**

Application of laser have been reported for endodontic surgery with the help of soft tissue laser such as Nd: YAG, diode or $CO_2$. These can be used to provide clean incision for direct access to periradicular areas. Moreover studies have demonstrated that the use of lasers provide bloodless operating area and sound incision with no secondary complications after the procedure. Lasers decrease the risk of blood - borne contamination compared to aerosol producing materials used for periapical procedure. These have ability to vapourise the tissue, lower the rates of inflammation and edema and easily coagulate and seal the small blood vessels.

**Apicectomy**

It is a surgical procedure in which the root apex is removed and the adjacent periapical tissues are curetted to remove granulation tissue. Resection is mainly indicated when the root canal treatment fails. Er: YAG laser have enough potential to cut hard dental tissue without significant thermal and structural damage to the tooth.

**Cavity preparation**

Cavity preparation is done using lasers, as Nd: YAG laser enhances the amount of melting and recrystallisation of dentine and the radiation and initiator increases the leakage. Oliveira et al. evaluated the dentinal and marginal permeability of the cut surface after apicectomy, treatment and retro - cavity preparation with Er: YAG and Nd: YAG lasers [6].

**Retrograde Filling**

Various studies compared the sealing effectiveness of ER: YAG laser to the ultra sonic device when using different retrograde filling materials. The results showed that the micro - leakage was lower in cavities prepared with Er: YAG laser.

**Vertical root fracture diagnosis and treatment**

Use of lasers in vertical root fracture diagnosis cases is quite limited. Although Kimura et al. (2009) used diagnodent for vertical root fracture detection in vivo. But this technique appears to be impractical for clinical use [5]. Moreover vertical fracture cases are treated using surgical techniques on fracture side which involves cleaning of fracture line and filling with bioactive materials. Thereafter, low power lasers can be used for accelerated soft tissue repair.

**Lasers in Analgesia**

The pulsed Nd: YAG laser is widely used as a analgesia in endodontics. Its wavelength interferes with the sodium pump mechanism, change in cell membrane permeability, temporary alterations in the endings of sensory neurons, and blocking depolarization of C and A fibers of the nerves [5].

**Indication and Contraindication of Lasers**

**Indications**

**Used in treatment of - -**

- Teeth with lateral canals leading to periodontal involvement.
- Teeth with pulp necrosis and purulent pulpitis.
- Teeth with gangrenous changes.
- Teeth with periapical lesions upto 5mm or more.
- Teeth that have been treated atleast for 3 months with no success.
- Sterilization of dental instruments.

**Contraindications**

- In advanced periodontitis cases.
- A deep crown and root fracture
- Obliterated root canals requiring root canal treatment.
- Patients with Pacemaker

**Advantages of Lasers**

- controlled bleeding
- Less pain
- No noise
- Faster healing
- Less chances of infection
- Reduced anxiety in patient

**Disadvantages of Lasers**

- High cost
- Lack of knowledge, use and safety
- Requires specialized training for the clinician
- Harmful to eye and skin of both clinician and patients if exposed adversely

**Laser safety**

Usually most of the lasers used in dental practices are simple to use but some precautions should be taken to ensure its safe operation.

- First and foremost protection is **eye protection**. Protective eyewear should be worn depending upon the laser system being used. Anyone working in vicinity of the lasers including doctor, assistants; patient should definitely wear eye protection.

- Laser warning signs should be posted outside the clinic along with limited access to the surgical environment and minimizing the use of reflective surfaces.
- High volume suction should be used to evacuate the plume from tissue ablation.
- The lasers should be checked for their good working conditions and should be used and stored as per manufacturer's instruction.
- It is important to make sure that the equipment is serviced and checked regularly [19].
- The operatory must be kept dry and electrical power unit should be protected from any kind of splashing.
- Treating dentist should take adequate care and precautions to prevent injury or damage to adjacent soft and hard tissue or to the pulp and periodontal apparatus.
- The temperature should be kept below 5 ℃ which does not damage the periodontal tissues. A threshold temperature increase of 7°C is commonly considered as the highest thermal change which is biologically acceptable to avoid periodontal damage [19].
- Laser safety officer should be appointed to supervise the proper use of laser, oversee the use of protective eyewear and be familiar with the regulations and guidelines.

## 2. Conclusion

This article signifies the need to increase the use of lasers in the field of endodontics. Lasers in endodontics provide an option for painless, atraumatic treatment. The complex procedures have become rapid and easier which is a trend in the modern dentistry. Hence, patient compliance and care has improved. They tend to influence the available treatment options for dental patients & improve the treatment outcomes with an increased success rate. Many advantages are been reported in this article which promotes the use of lasers in endodontic surgical procedures i. e. sterilization, low rate of complications, clean and well sealed surgical wounds, decreased requirement for surgical sutures and reduced bleeding. However this article might have missed on to various other aspects and advancements occurring, due to a limit in sources. Hence, further studies and investigations must be conducted to make this tool a regular method to adopt in regular dental treatment.

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