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Laser Dentistry: Revolutionizing Pain Management and Precision in Dental care

Rahmah Mansour Hattani, Samiah Jeres Alotibi, Wafaa Muteb Alshammari, Sara Ali Bidhy, Nawal Mohammed Alanzi, Ahlam Sayer Alotaibi, Anwar Aziz Alanzi, Amani Mohammed Fallatah

1. Dental Assistant, Specialized Dental Center in Riyadh, Riyadh

ABSTRACT

Laser dentistry has revolutionized pain management and precision in dental care by offering an innovative alternative to traditional anesthesia and surgical methods. This review explores the different types of lasers, including diode, carbon dioxide, neodymium, and erbium, and their mechanisms for pain relief and improved patient experience. Lasers work by modulating nerve activity, reducing inflammation, and promoting tissue healing, resulting in a more comfortable patient experience with fewer side effects. Although lasers are not a complete replacement for traditional methods, they offer distinct advantages such as reduced need for anesthesia, faster recovery, and improved precision. Advanced technologies in laser dentistry offer promising benefits in terms of reduced patient anxiety, reduced recovery time, and improved treatment outcomes. However, challenges remain such as cost, specialized training, and limitations in material compatibility.

KEYWORDS: Laser, pain management, dentistry, anesthesia, dental technology.

1. Introduction

Pain associated with dental treatment is one of the most worrying things for patients when they visit dentists, especially the pain resulting from local anesthesia injections during the injection and the accompanying pain when its effectiveness ends [1]. Therefore, it is considered one of the most important clinical challenges during dental treatment procedures. This requires searching for alternatives that overcome fears and anxiety about the pain associated with local anesthesia injections [2,3].

Dentistry is one of the specialties that has kept pace with advanced technology and employed modern digital technologies in dental functions that facilitated the process of diagnosis, treatment, evaluation and continuous follow-up [4]. In order for the dentist to be able to perform his tasks in diagnosing, treating and restoring teeth and treating gums efficiently and effectively, he must give the patient a local anesthetic to relieve the pain resulting from the treatment procedures followed, which are usually accompanied by severe pain that the patient cannot bear [5,6]. Despite the effectiveness of local anesthesia injections, they may not be suitable for all medical cases, especially for patients who are sensitive to the anesthetic substance used or patients who have a phobia and allergy to injections in general [7].

Laser stands out as the latest technology used in dentistry recently, which has received wide attention and acceptance from patients and dentists for its ability to manage and relieve pain quickly and efficiently and its suitability for many medical interventions in dentistry such as orthodontics, dental restoration, and others [8,9].

Laser is "intense light produced by stimulated emission of radiation", an innovative technology in dentistry, and works as heat-generating devices, converting electromagnetic energy into thermal energy. Lasers offer a unique combination of high power and beam quality, which distinguishes them from traditional light sources [10]. Laser energy modulates nerves and pain receptors through a set of mechanisms that include the photoacoustic effect, direct and indirect laser effects on nerves, in addition to modifying the biochemical system and neurons [11]. Although the analgesic effect resulting from laser may not be a complete substitute for traditional anesthesia, it provides an innovative means that enhances the patient's experience during dental treatment and overcomes the negative effects or phobia about traditional injections [12].

Accordingly, this review aims to explore the current landscape of using lasers in dentistry as a tool for pain relief in dentistry.

Laser Principle and Classification

The mechanism of operation of lasers used in dentistry depends on the amount of light and stimulated emission, as laser rays generate heat, and convert electromagnetic energy into thermal energy. The emitted laser rays are also characterized by being monochromatic, coherent and parallel. In dentistry, lasers are classified as an alternative to local anesthetic injections into several types [13,14]:

- Wavelength: visible (445–670 nm), diodes (810–980 nm), Nd:YAG (1064 nm), erbium family lasers (Er,Cr:YSGG 2780 nm and Er:YAG 2940 nm), and CO2 (10,600 nm).

- Tissues used: or the active medium used, which is divided into hard tissues and soft tissues

- Material used: Solid lasers (such as neodymium and erbium), liquids (such as dyes), or gases (such as argon and carbon dioxide)

Types of lasers used in dentistry for pain management:

- Diode lasers: Also known as low-level laser diode (LLLT) lasers, are the most common and widely used lasers in dentistry for pain management [15]. They emit wavelengths in the near-infrared spectrum, effectively penetrating soft tissues, making them suitable for procedures such as periodontal treatment, soft tissue surgeries, and oral lesion treatment [16]. These lasers provide precise ablation and tissue coagulation, facilitating pain relief and enhancing patient comfort during dental procedures.

- CO2 Laser: The first type of laser used in dentistry, the CO2 laser produces laser waves with a wavelength of 10,600 nanometers, which are well absorbed by water and are primarily used for soft tissue treatment. This type of laser is used for soft tissue removal and provides excellent coagulation and a very clean and clear

treatment area. It does not have the ability to penetrate deep into tissue and provides a largely painless recovery [17].

- Nd:YAG lasers: Nd:YAG lasers: Suitable for soft tissue and pain management, yttrium aluminum garnet and neodymium-doped garnet lasers provide deep tissue penetration, making them effective for pain relief in endodontic procedures, removal of dead tissue in periodontal treatment, oral surgery, and removal of early dental caries [18]. They emit wavelengths in the 1064 nm infrared spectrum, enabling targeted modulation of neural activity and pain perception. Clinical studies have demonstrated the efficacy of Nd:YAG lasers in reducing postoperative pain and inflammatio and improving patient outcomes in various dental interventions [19].

- Erbium YAG: It is often used in removing caries because it is safe for the dental pulp as it works with a long wavelength of 2,940 nm and has less tissue penetration and is considered an anesthetic and provides comfort to the patient. It is also used in deepening the roots before applying permanent fillings [20].

- Erbium-Cr YSGG: It is one of the promising types in the field of dentistry and is often used for hard tissues and may be suitable for all types of tissues in the future [21].

Mechanisms of action of lasers in pain management in dentistry

The mechanism of action of laser in pain management depends on several mechanisms that include several different physiological processes within the oral tissues. The first of these mechanisms is neuromodulation, where the laser energy and the thermal and biochemical reactions it generates [22]. interact with the peripheral nerve endings of the teeth, affecting their excitability and the transmission of pain signals [23]. Moreover, the mechanism of action of the laser depends on the laser energy applied to the oral tissues, which can lead to desensitization of nerve endings and change the activity of pain receptors [24], which leads to effective anesthesia of the treatment area and reduction of pain sensitivity. In addition, the thermal effects of laser energy may enhance vasodilation, which increases blood flow to the affected tissues and facilitates the removal of inflammatory mediators, which further contributes to pain relief and tissue healing [13].

According to the classification of lasers used in dentistry according to wavelength, some types of lasers have anti-inflammatory properties such as Erbium YAG, - Diode lasers and CO2 Laser and thus act as an analgesic by treating inflamed tissues that cause the source of pain. By reducing tissue inflammation, lasers used in dentistry not only provide immediate pain relief, but also contribute to improved tissue healing and long-term treatment results in dental practice [25].

Advantages and Benefits of Laser Dentistry

Laser dentistry has emerged as a game changer in dental interventions. The use of lasers in dental interventions offers many advantages over traditional methods in dentistry. The most important of which is reducing the need for anesthesia. Laser dentistry provides the patient with comfort and a better experience without pain and discomfort during and after treatment. This eliminates the anxiety patients have

about needles and anesthetics [26].

Another major benefit of laser dentistry is the precision that lasers provide. Unlike traditional dental tools, lasers are incredibly precise and can target specific areas with precision. This results in less damage to surrounding tissues, resulting in faster healing times and fewer complications after surgery. In addition, lasers offer improved efficiency when it comes to certain procedures [27].

In addition, lasers have antimicrobial properties that help reduce the risk of infection during dental treatments. The intense heat generated by the laser destroys bacteria on contact, making it an excellent tool for treating gum disease and preventing further oral health problems. Many patients realize that laser dentistry often eliminates the need for stitches or sutures after the procedure. The lasers promote coagulation and clotting while simultaneously sealing nerve endings resulting in less trauma and faster recovery times [28].

Laser dentistry has truly revolutionized dental procedures. Its advanced technology and precision offer many advantages over traditional methods. Different types of lasers in dental procedures cater to specific treatments, allowing for personalized and effective care.

New Technologies and Applications

Diode Laser

It is considered one of the latest technologies in the world of cosmetic dentistry and treatment. It is usually used to treat and remove damaged tissues around the teeth before dental restorations, dental prostheses or dental implants, in addition to treating gum infections and sterilizing teeth from bacteria, as well as cleaning the roots during nerve treatment and filling and teeth whitening [29]. It is used to treat the jaw joint by reducing the swelling in it. It is also used to treat gum ulcers in the mouth, cut the gums, remove fibrosis in the mouth, remove gum pockets and stop bleeding after surgeries because it is considered an alternative to the surgical scalpel [9,29].

Iontophoresis Electrical anesthesia

The idea is based on using two local anesthetics, namely "Lidocaine" and "Prilocaine", then preparing them in the form of a gel to be fixed in the lining of the mouth, after which a slight electric current is passed, and experiments have proven that electrical charges contributed to accelerating the passage of anesthetic materials, and they were able to cross the lining of the mouth in larger quantities of up to 12 times the normal rate [30]. It has a longer pain-protective effect, iontophoresis may eliminate the need for painful anesthetic injections, especially since it is cheaper and reduces the chances of microbial infection and will encourage patients to visit the dentist to receive the necessary treatment [30,31].

Water Laser

Water laser technology is one of the latest dental technologies for painless treatment, as it is used in treating gums, removing cavities and pigmentation, sterilizing roots, and also beautifying the gums without the need for anesthesia during the session. It helps to perform surgeries without pain and without anesthesia in most cases without

bleeding and without post-operative complications in addition to speed and accuracy in work, which saves time for both the doctor and the patient. It is used in bone cutting operations that help in dental implants, gum cosmetic operations, removing cavities from teeth, and removing old porcelain veneers [32].

S.T.A – Single Tooth Anesthesia

A painless anesthesia device that uses the latest anesthesia methods as it anesthetizes the tooth to be worked on only without anesthetizing the tongue or lips. It helps a lot in pediatric dentistry because it makes the child feel absolutely no pain when it is necessary to anesthetize his teeth [33].

Challenges of Lasers

The biggest disadvantage is that lasers are very expensive and require special knowledge, skills, training and education to use them efficiently and effectively. In addition, lasers cannot be used with gold, amalgam and ceramic [3]. They also have no benefits for dental crowns or bridges, although there are some attempts to make this possible in the future. Many procedures performed with lasers also require the use of a drill [5].

2. Conclusion:

Lasers can be considered a very useful tool in all areas of dentistry, especially in pain management of dental procedures, improving patient experience and eliminating anxiety associated with injections and anesthesia. Technological developments are leading to a preference for the use of lasers in medical procedures over traditional methods. Laser therapy has a positive effect on the emotions of even the most fearful patient. The use of all types of lasers requires an appropriate learning curve in order to optimize positive therapeutic effects and avoid adverse effects.

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