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Current Status and Analysis of Research on the Application of Laser in Dental Clinics

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Abstract

Along with the overall improvement of the dental medical level, the development of laser technology and the promotion of the concept of comfortable and minimally invasive treatment, the application of laser in dental treatment is becoming more and more extensive; and the design and updating of dental laser equipment also make the dental clinicians more convenient and efficient in the treatment and operation. Different lasers have different absorption characteristics and different effects on oral soft and hard tissues, so that they have their own advantages in the treatment of oral diseases. Therefore, when choosing laser treatment, the appropriate laser should be selected according to the type and degree of lesions in order to achieve the treatment purpose and avoid or reduce the side effects of laser. This paper presents a review on the application of laser in the field of oral cavity, introducing the application, advantages and development prospects of laser in oral mucosal disease, periodontal, endodontic and maxillofacial surgery.

Keywords

Oral Mucosal Disease; Periodontal; Caries; Maxillofacial Surgery; Laser; Clinical Application.

1. Introduction

In China, the basic research and clinical application of laser in stomatology began in the early 1970s; the marginal discipline of laser medicine, which combined laser technology and medicine, emerged in the 1980s; since the 1990s, the innovation of lasers and the development of laser medical technology have made the laser equipment and technology applied to the oral field more and more widely. The attention and research of dental scholars, the general mastery and use of dentists have made the laser better promoted and developed, which has shown good therapeutic effects in oral soft and hard tissue diseases. For oral mucosal diseases limited to drug treatment, patients discomfort in the basic treatment of periodontal disease, poor effect of repeated treatment of severe periodontitis, heavy bleeding in soft tissue surgery trauma and other clinical problems, laser treatment has become an alternative means of traditional oral disease diagnosis and treatment. Now, we mainly review the laser application for common oral diseases.

2. The Advantages and Principle Characteristics of Laser Diagnosis and Treatment

Laser refers to the energy released in the form of photons when the electrons in the atom absorb energy, migrate from the low energy level to the high energy level, and then fall back to the low energy level. The laser equipment is equipped with a resonant cavity, one end is a full reflector, the other end is a half-reflector, when the laser is emitted, it must be reflected back and forth in the

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resonant cavity, when the energy accumulates to more than half-reflector reflection limit, the truly practical laser is transmitted through the optical fiber to the handle and launched to the site to be irradiated. The laser has a number of properties that distinguish it from ordinary light and make it more advantageous in clinical work. First of all, the laser is monochromatic and consistent, with a single and stable wave spectrum that is less likely to produce other side effects. Secondly, when interacting with tissues, there are usually absorption, reflection and transmission effects, When the tissue absorbs laser light,it can achieve changes of coagulation, carbonization and vaporization to achieve treatment purposes such as disinfection, hemostasis and cutting. In addition, laser can also cause thermal effect, electromagnetic effect, pressure effect and biostimulation effect on the tissue. Due to the complex structure of the oral structure, the rich blood circulation in the maxillofacial area, and the fear of dental preparation during the treatment of dental diseases, the operation performed by the physician in the oral cavity and the maxillofacial region needs to be extraordinarily precise, and more emphasis on painless, minimally invasive and comfortable. The laser transmitted by fiber optics in oral treatment can not only be precisely positioned by safe light guidance, but also can enter any treatment site such as the bottom of periodontal pockets and oral cavity, which is convenient and fast; the handle of the oral laser treatment instrument is similar to a high-speed cell phone, with compact structure and high integration, which is simple to operate and easy to master; the energy of the laser can be adjusted within a certain range, which makes the treatment safe and achieves low thermal damage and short healing period. At the same time, it can also achieve the effect of low pain, minimally invasive and sterilization.

3. Application of Laser in Dental Clinical Treatment

The laser emitted by different material media and the laser emitted by the same material media with different power also have different biological effect performance. According to the different laser media, it can be divided into CO2 laser, Nd:YAG laser, erbium laser, semiconductor laser, etc.; according to the different laser energy, it can be divided into low, medium, and high energy laser. Physicians should choose the appropriate treatment laser according to different oral diseases in order to achieve the optimal treatment effect.

3.1 Oral Mucosal Disease

3.1.1 Oral Mucosal Leukoplakia

In 2019, Dorina Lauritano[1]et al. conducted a clinical study on semiconductor laser-assisted surgical excision of leukoplakia and hyperkeratosis with a wavelength of 940 nm and a peak laser power setting of 1.8 W in pulsed mode and an average power of 0.9 W during emission. The discomfort, pain, and tactile perception before, during, and after treatment by semiconductor laser cutting were analyzed. It was found that the pulsed state effectively avoids thermal damage to the tissue, and this power setting does not require the use of preoperative anesthesia, and patients experience mild pain and no postoperative suture treatment. This study demonstrates the cutting advantages of the semiconductor laser, which can effectively reduce intraoperative bleeding and edema. In 2021, K. Naga Venkata Sai Praveen[2]et al. compared the effect of the semiconductor laser with cryotherapy in the treatment of leukoplakia and found that the use of the 810 nm semiconductor laser has stronger biostimulation ability, including activation of blood cell immunologically active substances and promotion of blood circulation; stimulating the central nervous system and initiating the neurohumoral regulation mechanism, thus playing the role of analgesia, regulating biological metabolism and immune activity; regulating the immune function of the body by stimulating lymphocytes, preventing infection and eliminating inflammation. In the treatment of leukoplakia, laser has the advantages of selective removal of diseased tissues and less damage to surrounding healthy tissues, it also has significant advantages in reducing postoperative edema, pain, inflammation and scars.

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3.1.2 Oral Lichen Planus

In 2019, Zhendong Gong[3]et al. supplemented the treatment of oral lichen planus with 970 nm semiconductor laser low power(0.7W)irradiation based on the treatment of total peony capsule and found that low power semiconductor laser could significantly enhance the treatment effect. In 2020, Rui Wang[4] and others combined compound betamethasone injection and thymopentin injection with Nd:YAG laser local irradiation, which could enhance the immune function, reduce damage to adjacent tissues, increase the absorption of local drugs, and promote healing, thereby improving clinical efficacy. Er:YAG is a good alternative to the traditional scalpel due to its less complications and good wound healing[5,6]. In 2021, Svetlana Tarasenko[7] et al.compared Er:YAG with a wavelength of 2940 nm and an output power of 2W, Nd:YAG with a wavelength of 1064 nm and a power of 1.5W and conventional scalpel cutting in the treatment of oral lichen planus and found that Er:YAG was more effective than Nd:YAG laser in the treatment of lichen planus ineffective in conservative treatment.

3.1.3 Recurrent Aphthous Ulcers

The Nd:YAG laser with a wavelength of 1064 nm and a power of 1.5W was used to irradiate recurrent aphthous ulcers, and it was found that the Nd:YAG laser can not only promote ulcer healing and shorten the course of the disease, but also had obvious analgesic effect. And the effect of Nd:YAG laser and CO2 laser on the treatment of recurrent aphthous ulcer was studied in comparison, and it was found that both of them had certain therapeutic effect on the disease, but Nd:YAG laser was better than CO2 laser in terms of total effective rate, analgesic effect and promotion of healing. In 2019, Jia Ma [8]et al. conducted a comparative study on low-energy semiconductor laser irradiation treatment and general drug treatment. The results showed that low-energy semiconductor laser can promote anti- inflammatory effects and wound healing by stimulating mast cells, lymphocytes, etc., resulting in immediate pain relief.

3.1.4 Other Mucosal Diseases

In 2020, Wei Dang[9]et al. analyzed the effect of Nd:YAG laser combined with triamcinolone acetonide in the treatment of oral submucosal fibrosis, showed that the combined laser treatment resulted in significantly better facial tenderness and mouth opening than the single drug group and reduced the area of intraoral mucosal lesions. Ana Liz Pereira de Matos[10]et al. performed a detailed review of laser application in the treatment of burning mouth syndrome, it was noted that low-energy laser therapy would be an effective treatment for pain and burning sensation in the oral mucosa and tongue of patients with burning mouth syndrome.

3.2 Periodontal and Pupl Diseases

3.2.1 Periodontitis

The study found that the short-term therapeutic effect of pulsed CO2 oral laser-assisted treatment of chronic periodontitis was better than periodontal treatment alone. In 2021, Bing Han[11]et al. pointed out that both periodontal basic treatment and semiconductor laser-assisted periodontal basic treatment for moderate and severe chronic periodontitis have better debridement effects. The effect of semiconductor laser in removing calculus is not as good as expected[12]. However, it could reduce bleeding, promote inflammation absorption and improve local microcirculation in assisted periodontal treatment and root surface debridement[13,14].

There is controversy about the therapeutic effect of Nd:YAG-assisted subgingival scraping and root planing. Some scholars believe that Nd:YAG laser-assisted treatment of periodontitis has not shown

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more obvious advantages[15,16]; while others believe that Nd:YAG laser-assisted periodontal basic therapy is better than periodontal basic therapy alone[17,18,19]. In 2021, Weihang Si[20]et al. found that the Nd:YAG laser was significantly effective in improving gingival probe bleeding and deep periodontal pockets, but not better in improving attachment loss. Zhou et al[21] did a controlled trial using left and right half of the mouth and showed that periodontal base treatment combined with Er:YAG laser treatment significantly improved periodontal probe depth (PD) and clinical attachment loss (CAL) compared to periodontal base treatment alone. This has also been confirmed by several studies[22,23,24]. Due to its good bactericidal effect, the Er:YAG laser can effectively remove the bacterial biofilm formed by peri-implantitis-causing bacteria and provide a clean surface for cell reattachment in the surrounding tissues[25]. It has also been suggested that the photobiologically active response generated by the Er:YAG laser at low power levels can further stimulate the proliferation and differentiation of osteoblasts[26], thus accelerating the formation of early new bone[27].

3.2.2 Pulp and Periapical Diseases

Yves Saydjari[28]et al. have done a detailed review of the effect of Nd:YAG laser and two wavelengths of semiconductor laser to kill bacteria in the root canal, stating that all three lasers can achieve root canal disinfection, but the Nd:YAG laser can remove bacteria in deeper dentin. Chen Cai[29]et al. described in detail the activating and irrigating of Er:YAG laser, which includes the photothermal effect of activating the detergent, generating heat to increase dentin permeability and killing bacteria in the root canal[30]; the vacuolation effect; the action of the laser can make the irrigating solution vibrate violently in the root canal; and the Moses effect[31]. Wang et al.[32] compared the in vitro effects of Er:YAG laser with ultrasonic irrigation and found that the Er:YAG laser had a better cleaning effect on bacterial biofilm than ultrasonic non-cutting irrigation. In the treatment of sinus type chronic apical periodontitis, Lin Shen[33]et al. used a semiconductor laser to penetrate deep into the apical part of the root canal for light treatment, and the results showed that it could effectively reduce the endodontic interappointment pain and accelerate the healing of the sinus tract at the same time.

3.3 Caries and Dentin Hypersensitivity

Er:YAG laser irradiation before fluoride application can enhance the acid resistance of enamel to prevent caries in cooperation with fluoride gel; the use of Er:YAG laser irradiation before cavity sealing can increase the roughness of enamel surface and thus enhance the adhesive effect of cavity sealant. The wavelength of Er:YAG laser is similar to the infrared absorption peak of water and hydroxyapatite, which can effectively ablate the diseased dental hard tissue for cavity preparation[34], and the thermal effect produced by Er:YAG laser under different energy parameters[35] can perform tissue cutting and tissue treatment to achieve selective remove caries and sterilization effect[36]. Qingqing Lu[37]et al. studied the resin bonding effect of Er:YAG laser cavity preparation in vitro and showed that the microleakage of resin filling with Er:YAG laser preparation and etching was smaller. However, no clear view on whether Er:YAG laser can replace acid etchers and its effect on bonding is not clearly seen in the study by Qing Du[38]et al.

Er:YAG laser has a good antibacterial and bactericidal effect, but its curative effect is not stable, and the irradiation time needs to be strictly controlled. In 2019, Kaixin Xiong[39]et al. summarized the commonly used laser treatment characteristics, among which Nd:YAG laser is recommended as the first choice for the treatment of dentin sensitivity. CO2 laser has little damage to the pulp and obvious immediate efficacy, but its efficacy depends on the location of the tooth, lesion site and the beam direction.It is not effective on tooth surfaces where the beam cannot be irradiated vertically.

3.4 Surgical Cutting

Laser cutting can be simply understood as the denaturation through thermal effects, further heating to carbonize and thus vaporization. Shuiting Fu[40]et al. conducted a clinical study on the treatment of oral mucosal venous malformations with semiconductor laser. The results showed that the 980nm

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semiconductor laser has better hemoglobin absorption rate, and the high power makes it more stable for inter-tissue laser coagulation and hemostasis.

4. Conclusion

Laser has been wildly used in various disciplines of dental treatment activities, the output and function of laser are closely related to the energy. When performing different operations, a laser with an appropriate wavelength and energy should be selected. Various inflammation in the oral cavity, such as early pulpitis, apical periodontitis, pulp congestion, soft tissue infection, pericoronitis, some mucosal diseases, dentin hypersensitivity, etc. can be treated by low energy laser such as semiconductor, Nd:YAG laser. Because the irradiation can achieve pain relief and desensitization effect. When applied to the sterilization of cavities, root canals, periodontal pockets and extraction sockets, medium-energy lasers up to 1w can be selected, such as Nd:YAG laser, semiconductor laser, carbon dioxide laser, etc. It should be noted that when Er:YAG laser is used for cavity preparation, there is still a problem that the removal range is not easy to control, and it is worth further research. For surgical procedures that do not require suture, such as gingival-buccal sulcus extension, frenum extension, gingivectomy or plasty, and small tumor removal, high-energy lasers with an output power of 5W or more, such as Er:YAG lasers and diode lasers, can be used. In addition to the above-mentioned diseases, there are also relevant literature reports that lasers can be applied in the treatment of tooth bleaching, removal of nickel-titanium instruments fractured in root canals, gingival retraction during crown restoration, and scarring after dry socket and tow-stage repair for cleft lip [41,42,43,44,45]. At the 2021 National Conference on Oral Laser Medicine, the reports of preoperative laser irradiation to determine the extent of surgery, more precise preservation of active tissue shown by high fluorescence response and postoperative application of laser combined with antibiotics for drug-related osteonecrosis of the jaw; and the application of green light to improve bone defects showed that there is still much room for research on laser in the field of oral treatment.

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