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The Application of Lasers in the Treatment of Peri-Implantitis

Abstract

The application of laser is one of the new methods offered in the treatment of peri-implantitis. Studies support the success of this method in the detoxification of the surface of implants, although there are limited studies in this regard and their results are controversial. Since the laser has a good capability of destroying microorganisms and also has high bactericidal and detoxification effects, it is considered one of the best techniques in the treatment of infection in tissues around the implant. The most important role of laser in the treatment of peri-implantitis is its bactericidal effect. Lasers with two photothermal and photochemical effects can destroy bacteria on the surface of the implant. In the photothermal method, high laser energy destroys bacteria, while in the photochemical method, the bacteria are not destroyed by increasing the temperature, but following the radiation of photosensitizer connected to the bacteria, it is activated, produces toxic substances for the bacteria, and destroys the bacteria. Since lack of change in the surface topography of the implant is considered an important indicator in choosing the material or method used to clean the implant surface, an ideal laser has the most antimicrobial effect while having the least effect on the topography of the implant surface and do not increase the temperature of the implant and the bone around it.

Keywords: *Implant, Pocket depth, Peri-implantitis, Laser*

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Introduction

Implantitis is an inflammatory reaction around the osseointegrated implant, which causes the loss of bone support, and if is not treated properly, it will result in the loss of the implant. Various treatments have been offered for the treatment of peri-implantitis, and the common feature of all of them is detoxification. Various treatments have been suggested for the treatment of peri-implantitis, the common aspect of all of them is detoxification, which is done with different methods. One of the new methods suggested in this regard is the use of lasers. Various studies support the success of this method in detoxifying the surface of implants, although there is still a need for further studies in this area. Park et al., (2005) reported that lasers can play a role in disinfecting the surface of implants in peri-implantitis and its treatment. They tried to determine the changes in implant surfaces after Nd: YAG and CO2 laser irradiation at different energy levels. NdYAG laser was used at powers of 5, 4, 3, 2, and 1 w, and the same powers were repeated for the CO2 laser. The study revealed that the CO2 laser performed better than Nd: YAG laser and the CO2 laser does not damage the titanium surface of the implant. In terms of power, 1 and 2 w lasers caused less damage than high-power lasers (1).

Stübinger et al., (2010) stated that although laser has nowadays become very popular in the treatment of peri-implantitis, their exact effect on the implant surface is not yet known. In their study, they tried to compare the effect of Er:YAG, CO2, and Diode lasers on the polished, sandblasted and the acid-etched surface of titanium implants. Finally, they concluded that CO2 and Diode lasers do not cause changes in the implant surface and are considered safe, but Er:YAG laser is considered safe only if its power is not more than 300 or 500 mJ/10 Hz (2). Chris Leja et al., (2013) reported that despite the extensive use of lasers in dentistry, our knowledge of the effect of lasers on the surface of implants is still incomplete. They investigated the effect of Er:YAG, 2 CO, and Diode lasers on increasing the temperature of implants inside the bones in vitro.

This study was conducted on an implant implanted in the rib bone of a cow. In this study, the time required for each laser to increase the temperature by 10 degrees was measured. The temperature increased up to 10 degrees with different lasers only within 0.9 to 60 seconds (depending on the type and frequency of the laser). Finally, they concluded that the temperature can exceed 10 degrees in only 18 seconds on average, which affects the life of bones (3). Listl et al., (2015) tried to evaluate the cost-effectiveness of different non-surgical methods in the treatment of peri-implantitis. In their study, they reviewed previous studies on pocket depth after various peri-implantitis treatments. After reviewing various studies, they stated that in most studies, using the debridement method is more cost-effective than the laser method, although the results lacked certainty. They stated that to obtain valid treatment recommendations for the treatment of peri-implantitis, there is a need for more comprehensive and patient-oriented studies on various non-surgical treatments, and previous studies in this area are insufficient (4). Given what was stated above, the aim of the present study is the use of lasers in the treatment of peri-implantitis.

Theoretical foundations of research

Peri-implantitis

Peri-implantitis is defined as inflammatory reactions around an osseointegrated implant, leading to loss of bone support (5).

Peri-implant inflammation leads to serious diseases after implant treatment, which affects both soft tissue and hard tissue around it. The prevalence of peri-implantitis has been reported above 56%, which can result in loss of implant (5).

Peri-implantitis risk factors

In different studies, several risk factors such as a gingival index of more than 10% and having more than two implants were associated with the occurrence of peri-implantitis disease. Also, several other risk factors such as previous periodontal disease, poor plaque control, occlusal overload, rheumatoid arthritis, and excessive alcohol consumption have been identified (6). Although dental implants have become a predictable long-term treatment for patients, it should be noted that all implant treatments are not necessarily successful and peri-implant diseases are becoming common. Early diagnosis and removal of inflammatory processes around the implant will increase the long-term prognosis (7).

Smokers and people with a history of periodontal diseases are at a higher risk of developing peri-implantitis (8). There is also a statistically significant relationship between smoking and the keratinized width of the mucosa around the implant (less than 2 mm) and peri-implantitis disease. Other risk factors such as diabetes, genetics, and the roughness of the implant surface have also been proposed in this regard, but they still need more investigation (9, 10). Modifying the inflammatory conditions around the implant can reduce the infection rate. It can also be stated that the type of implant and its surface characteristics, methods, and materials used for bone augmentation and prosthetic processes can also be effective in the occurrence of peri-implantitis (11).

Diagnosis of peri-implantitis

Clinical diagnosis

Symptoms of this infection include frequent gingival bleeding. Also, increasing the depth of pocket around the implant is another symptom of this disease. There are a series of other symptoms that are common to many gingival diseases but may help to correctly diagnose the problem. These symptoms include gingivitis and discharge of infectious secretions from the gums. The main problem of dental implant infection is that this side effect can also affect the bone around the implant. By careful examination of the tissues around the implant, the dentist can diagnose the signs and symptoms of infection and thus make the right decision and choose the best method to treat the infection. Timely diagnosis of the problem is one of the issues that have a great impact on the treatment of implant infection. If it is diagnosed timely, it may be possible to maintain the dental implant and there is no need to replace the implant. One of the problems with peri-implantitis is that this disease usually does not cause any pain in the gums and teeth. The lack of pain causes the patient not to notice any problems in the mouth and tissues around the implant (12-13).

Radiographic diagnosis

When a dental implant infection is diagnosed, various measures are taken to solve the problem. One of the first steps the dentist takes for this purpose is to take a radiographic image of the infected dental implant. One of the ways to diagnose this disease is to identify the radiographic symptoms. In radiographic images, the presence and severity of the disease can be evaluated based on the degree of bone surface lowering from the edge of landmarks such as the shoulder of the implant or its distance from the helix screw.

Also, radiographic images help us to evaluate the improvement or progress of the disease over time. The significant point regarding radiography is that in many cases, bone loss occurs in the first weeks after implant placement and then stops. Thus, the radiographic image taken immediately after implant placement should not be used as evidence of peri-implantitis. Another symptom of this disease, which can be seen both in radiography and in the clinic, is an increase in the amount of excess dental cement in peri-implantitis disease. It has been shown that this symptom is seen in 81% of patients with peri-implantitis (14).

Laboratory tests

The level of matrix metalloproteinase (MMP-8) in the sulcus fluid around the implant has been proposed as an important indicator in the diagnosis of peri-implantitis. The increase in the level of MMP-8 in the sulcus fluid around the implants affected by inflammation has been observed in both patients who had periodontitis and patients who did not have it. However, peri-implantitis patients with simultaneous periodontitis may show a higher level of MMP-8 in the sulcus fluid. MMP-8 found in the sulcus fluid of implants with peri-implantitis is pathologically high and the active form has changed. The conservative treatment of peri-implantitis causes a reduction in the level of MMP-8 in the sulcus fluid, especially in the group of patients who had simultaneous periodontitis. The assessment of MMP-8 is useful in the diagnosis and monitoring of peri-implantitis and is also used as an early sign of peri-implantitis (15). Moreover, the use of the PCR method is known as a diagnostic method to identify pathogenic periodontal bacteria in peri-implantitis, which Porphyromonas gingivalis, Treponema denticola, Tanerella forsythia have been identified in this method (16). The difference in the volumes of sulcus fluid between healthy and peri-implantitis sites is statistically significant. Also, there is a relationship between the probing depth of the PPD pocket, GCF, and (PISF, sulcus fluid around the implant). In the healthy site, there is a relationship between PISF and PPD, while this relationship does not exist during inflammation. Also, the rate of PISF increases when peri-implantitis occurs (17).

Treatment of peri-implantitis

The increasing use of dental implants has increased the incidence of peri-implantitis. With an increase in such cases, its treatment methods are also expanding every day, including the main etiological factors of peri-implantitis, bacterial infection, and biomechanical factors, and the choice of treatment type depends on the agents of the disease. When additional forces are the main etiological cause of bone loss around the implant, the treatment includes examining the good placement of the prosthesis, the appropriate number and position of the implants, and the evaluation of the occlusion. Changing the design of the prosthesis, improving the number and position of the implants, and establishing the occlusal balance can be effective in stopping the progress of tissue degradation around the implant, but when the cause of the bone loss around the dental implant is a microbial agent caused by the accumulation of bacterial plaque, removing the microbial agents with non-surgical non-therapeutic methods or reconstructive surgery, if necessary (18, 19).

After the correct diagnosis of peri-implantitis based on bacterial infection, the next step is to clean the implant surface. Cleaning the infected surface of the dental implant is one of the most important steps and aspects of the treatment of dental implant infection. However, it is not so simple task and depends on the type of surface coating of the implant. For this reason, it may be very difficult to clean the surface of the implant. At current, most implants have a rough surface, so the infected surface of these implants cannot be cleaned mechanically and with normal tools. After this step, the infected area is disinfected. Antibiotics are used for mild and common infections. Antibiotics are usually used when the bone around the dental implant is infected. If the dental implant infection is severe, surgery may be necessary. In addition to surgery, the implant is mechanically cleaned and antibiotics and other substances such as citric acid are used for detoxification (20). In general, it can be stated that the non-surgical treatment of bacterial infection around the implant includes local removal of plaque deposits by plastic devices and polishing all available surfaces with pumice powder along with sub-gingival washing of all pockets, systemic antimicrobial treatment for ten days and improving the patient's oral hygiene.

In the reconstructive method, to achieve new bone reconstruction and re-osseointegration, the lesion must first be cleaned and the infected surfaces of the implant must be prepared. For this purpose, many mechanical and chemical devices have been examined to prepare the implant surface, including Airpowder abrasive and supersaturated citric acid solution. One of the new methods presented in the treatment of peri-implantitis is the use of a laser. Studies support the success of this method in detoxification of the surface of implants, although there are still limited studies in this regard (21). Since the laser has a good capability to destroy microorganisms and also has high bactericidal and detoxification effects, it is considered one of the best techniques in the treatment of tissue infection around the implant. The most important role of laser in the treatment of peri-implantitis is its bactericidal effect.

In general, lasers with two photothermal and photochemical effects can destroy bacteria on the surface of the implant. In the photothermal method, high laser energy destroys bacteria, while in the photochemical method, the bacteria are not destroyed by increasing the temperature, but following the radiation of photosensitizer connected to the bacteria, it is activated, produces toxic substances for the bacteria, and destroys the bacteria. Since lack of change in the surface topography of the implant is considered an important indicator in choosing the material or method used to clean the implant surface, an ideal laser has the most antimicrobial effect while having the least effect on the topography of an implant surface and do not increase the temperature of the implant and the bone around it. There have been recent reports of the application of Er:YAG, Diode, CO2, and Er, Cr:YSGG lasers to prepare the implant surface and kill bacteria. Most of the limited basic, animal, and human studies carried out so far have confirmed the beneficial effects of laser use in the treatment of peri-implantitis, and some have reported negative effects such as reducing the mitochondrial activity of osteoblast cells (22).

Types of lasers used in dentistry

Erbium group: There are two distinct wavelengths used for erbium. Erbium and chromium lasers: (2780 nm) have an active interface of solid yttrium, scandium, and gallium garnet crystals, which are glazed with erbium and chromium. Erbium: YAG laser (2940 nm) has an active interface of solid crystal yttrium (Y), aluminum (A), and garnet (G), which is glazed with erbium.

Diode lasers: Lasers with a solid active interface are made of semiconductor crystals that use aluminum or a combination of indium, gallium, and arsenic. Wavelengths vary from about 800 nm for an aluminum-containing active interface to 980 nm for the active interface which is made of indium.

Argon lasers: This type of laser is an active interface of argon gas, which is ionized by a high current of electric discharge. It is transmitted by optical fiber in continuous and pulsed wave states, and it is the only surgical laser device in which its light can be observed in the visible spectrum. Two wavelengths are used in dentistry: 488 nm which has blue light and 514 nm which has the green light.

Helium-neon laser: It is a representative of the class of natural gas atomic lasers. Its advantages, including its significant optical characteristics, have made this laser commonly used as a tool to coordinate mechanical and optical systems in creating laser imaging and interferometry. It is also used in biology and

medicine. The output power of these lasers varies from less than 1 milliwatt to several tens of watts.

Nd:YAG laser: It is a solid active material made of the crystal combined with trace materials such as yttrium and aluminum, covered with neodymium ions. This active material is different from the types of semiconductors that were in the diode laser device. The energy source of those lamps is flashing. The models used in dentistry have a wavelength of 1064 nm, which is invisible and near the infrared spectrum.

CO2 laser: CO2 laser with a wavelength of 10600 nm is in the infrared spectrum. The energy of this laser is very quickly absorbed in large amounts by the water of tissues. It means that it is highly absorbed in the oral mucosa and there is almost no reflection and transmission on the mucosa. Tissue pigments are not involved in CO2 laser absorption, but it is limited in terms of penetration depth. When the CO2 laser is focused on a point, more complications are created (23).

Laser applications in dentistry

Root canal treatment: The main goal of root canal treatment is to clean the tooth canal. The laser can be used to sterilize the main canal set or the secondary canals of the tooth. The use of Diode, Nd:YAG, and Er:YAG lasers with different effectiveness is suggested for this purpose. However, the canal must be prepared in a standard way by the file for this purpose, so that the pathway for the entry of the fiber of at least 200 microns of the laser is restored.

Gum surgery: Erbium laser is used in gum surgery to remove granulation tissue or root surface stimulating factors. In the crown lengthening surgery, it is used to modify soft tissue and alveolar bone. However, this method is mainly used in the front of both jaws (maxillary and mandibular), where the interdental bone width is less. In the posterior areas of the jaws, bone removal requires the removal of the flap and lengthening of the crown classically.

Detection of caries and mass: One of the applications of laser in dentistry is the detection of caries and mass through the use of fluorescence laser. In this technique, laser light is irradiated to the biological tissue, and in the presence of bacterial metabolic activity; this laser returns a reflection to the device by inducing fluorescence effects.

Dentin hypersensitivity treatment: dentin hypersensitivity is one of the common reasons for patients to visit the dentist. There are different methods to treat this problem, such as using toothpaste containing anti-allergic substances, fluoride gels, and dental adhesives. Different types of lasers are also used to treat it. For example, irradiation of 810 nm diode laser to the surface of the tooth with a power of 1 watt and in a vertical and non-contact form for 30 to 60 seconds can significantly reduce the dentin hypersensitivity immediately. Also, studies have suggested repeating this procedure with an interval of 2 weeks significantly improves the results.

Bleaching: Bleaching in the clinic is considered one of the common uses of lasers in dentistry. However, the laser in the bleaching treatment is only used to activate the bleaching gel, and no laser has bleaching properties independently. The laser can raise the temperature and increase the activation speed of the gel in a shorter time. In this method, bleaching products containing pigments are usually used to increase laser energy absorption.

Caries removal and cavity preparation: One of the interesting applications of laser for dental patients is the use of ER:YAG laser as an alternative to cavity cutting and caries removal. In this method, the erbium laser, which has the highest absorption in water molecules, causes instant evaporation of water and expansion of hydroxyapatite crystals by water molecules present in dental or bone hard tissue. This process causes layer ablation of biological hard tissue. This method makes dental treatments more pleasant and tolerable by eliminating dental drills and their unpleasant sound.

Soft tissue surgery: almost all common lasers used in dentistry have the capability of cutting soft tissue with different mechanisms. In diode and Nd: YAG lasers, it is done by energy absorption by pigment and hemoglobin in the tissue, while it is done by energy absorption by tissue water in working with CO2 or Er:YAG laser. Removal of soft tissue lesions or modification of the soft tissue shape can be done with these lasers (24).

Laser applications in implant and peri-implantitis treatment

The use of surgical lasers has been recommended to help implant placement and uncover the second stage of dental implants along with soft tissue shaping. In implant surgery, like other oral surgeries, the speed of recovery and the anti-inflammatory and pain-relieving properties of the laser helps significantly with post-implant problems. Most of the patients who perform implant surgery with laser are no longer willing to undergo surgery with conventional methods. Moreover, the use of a laser is recommended to help disinfect implant surfaces in peri-implantitis cases. Laser is one of the new treatment techniques in implant dentistry that reduces time, pain, and bleeding. Various lasers have been examined for surface detoxification, including CO2, Nd:YAG, Er, Cr:YSGG, Er:YAG, and Diode lasers, and the efforts to find the most suitable laser in this area are continuing.

Conclusion

Nowadays, lasers are the focus of attention as a new treatment in dental science. One of the applications of lasers is their use in implant dentistry treatments. Since the laser light is reflected and scattered from the target tissues, it can have unfavorable effects on other tissues. Even low-power lasers with only a few milliwatts of output power, directly or after reflection from a shiny surface, can be harmful to the human eye, if it hits the

eye. Lasers are usually labeled with a safety number for each category, which indicates the degree of danger of the laser. Laser has made available a wide range of applications in periodontal treatments (ranging from eliminating the need for flaps to cleaning infected dental roots). Also, the laser has been tested as a bactericidal agent for titanium implant surfaces to treat peri-implantitis. Lasers can provide a more complete understanding of mechanical methods, especially on rough surfaces used commonly to improve implant osseointegration. However, there is limited and controversial information about how laser application affects the biological properties of titanium, cell attachment, cell growth, and differentiation. Laser irradiation on titanium can increase the surface temperature and induce morphological changes when it reaches a high degree of energy.

Stübinger et al., (2010) stated that although laser has nowadays become very popular in the treatment of peri-implantitis, their exact effect on the implant surface is not yet known. In their study, they tried to compare the effect of Er:YAG, CO2, and Diode lasers on the polished, sandblasted and the acid-etched surface of titanium implants. Finally, they concluded that CO2 and Diode lasers do not cause changes in the implant surface and are considered safe, but Er:YAG laser is considered safe only if its power is not more than 300 or 500 mJ/10 Hz (2). The ideal laser for implant surface application in peri-implantitis cases should have a minimum temperature increase. It has been reported that Er:YAG laser causes fewer temperature changes than Nd:YAG or CO2 laser. It has also been proven that Er:YAG laser is effective in removing microbial infection and has various effects on cell attachment and growth. Published evidence on the biological behavior of cells after laser application on the implant surface is still unknown.

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Conflict of interest

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Ethics statement

None

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