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Review article

Peri-Implantitis and Lasers - A Review

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A R T I C L E I N F O

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A B S T R A C T

The aim of this article was to review recent advances in dental implant care and to eliminate peri-implant infections and inflammation using dental lasers. Laser is acronym for light amplification by stimulated emission of radiation. Maiman invented first laser device in 1960 . Lasers have been investigated for applications in periodontal therapy including subgingival debridement and curettage, removal of granulation tissue during flap surgery, osseous recontouring as well as in implant surgery. In addition to undisturbed osseointegration and an adequate prosthetic design, implant maintenance is crucial for long term prognosis. Bacterial infection and inflammation of periimplant tissue induce bone loss and jeopardize clinical success. Various treatment modalities including mechanical debridement, antibiotics and antiseptics, laser treatment have been advocated. Lasers are an integral part of dental office out patient care and lasers have a definite part to play in maintenance of implants and management of periimplantitis. Conclusion- Nd:YAG and Ho:YAG lasers are not indicated for decontamination of implant surface . For Er:YAG and CO 2 lasers power output needs to be limited. GaAlAs lasers are safely used for decontamination of implant surface .

1.Introduction:

For more than a decade periimplant tissues have been treated with soft tissue lasers to prepare the osteotomy site and to uncover the submerged implants. The emergence profile of abutment and crown can be sculpted by soft tissue lasers which is of importance in esthetic zone where additional advantage includes preservation of interdental papilla. Innovative surgical practices have been made possible by the use of lasers which can reduce patients bleeding, edema, pain and post surgical scarring[1] . As more and more patients receive implant supported prosthesis, need for regular implant maintenance is required. When patients did not participate regularly in professional prophylaxis, periimplant inflammation was found around many implants[2]. Periimplantitis can be successfully treated with soft tissue lasers which provide more efficient decontamination and debridement of sites than using the traditional means[1]. Bacterial decontamination is accomplished by lasers, photodynamic disinfection or ozone gas. Implant surface decontamination by Er:YAG or CO2 laser has rendered superior results compared to other methods in several studies[2].

Laser is an acronym for light amplification by stimulated emission of radiation. The most common dental lasers used in implants are carbon dioxide and diodes[1]. Carbon dioxide lasers emit shallow penetrating energy no deeper than 0.1mm that is absorbed by watery tissues and vaporizes cells on tissue surface. In older generation (gated) CO2 lasers , char or carbon residue left formed a sterile dressing for the wound. New technologies such as Ultra speed CO2 technology increase surgical accuracy and accelerate healing process with excellent patient comfort. This is used in oral surgical soft tissue therapies like incisions, excisions, frenectomies, gingivectomies, biopsies, lesion removal. The invisible energy of CO2 laser can be directed onto tissues using red aiming beam from helium and neon elements. Laser type and strength must be chosen carefully for each dental procedure based on light wavelength and power, continuous or pulsed mode, and direct (contact) or indirect contact through some form of tip(non contact laser). Laser light can be absorbed, reflected, scattered, or transmitted inside the tissues, the later two conditions may lead to damage to tissues surrounding the target. Dentist must ensure safety of patient and staff during laser application.

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2.BIOFILM

Dental plaque forms on surface of titanium implants and pocket formation similar to that in teeth involved with periodontitis is a common finding [3] . Lekholm and coworkers and Holt and assosciates have demonstrated that the supra and subgingival microflora cultured from titanium endosseous implants are similar to organisms cultured from natural tooth. It is important to examine the presence of periodontal pathogens after implantation and particularly after placement of prosthesis to avoid periimplantitis [4]. It is also necessary to inhibit bacterial biofilm formation on implant surface. The first phase of oral biofilm development consists of formation of salivary pellicle which has host proteins and glycoproteins serving as adhesion molecules for bacteria [5]. Streptococci, the first colonizers provide adhesion for Actinomyces and Fusobacterium. The cellular concentration of chemical signals secreted by colonizing bacteria reach a critical point at which cells start to express exopolysaccharides. These macromolecules make up biofilm matrix incorporating bacteria. Biofilms on penetration of implants through the gingiva are the main etiological factors for periimplantitis. 6Recent studies observed contamination of the inner parts of dental implants through bacterial penetration along the implant –abutment interface that may cause malodor and inflammation of periimplant tissue. 7 The similarity between teeth and implant microflora in partially edentulous patients has been confirmed. Bacteria colonizing implants in edentulous patients originate primarily from surface of oral mucous membranes ie microbiota present in oral cavity after implantation. Periimplantitis is referred to as an inflammatory process effecting the tissues around an osseointegrated implant in function resulting in loss of supporting bone (Albrektsson and Isidor1994). 8Periimplantitis can also be defined as a process in which progressive bone loss around an implant exceeded the limits of tolerable bone resorption after successful osseointegration. These can be classified as implant failures occuring for different reasons based on both chronological and etiological aspects as the pathogenic entities caused by bacterial process ,inappropriate biomechanical balance or a combination. The inflammation around implants can be located in marginal mucosa (perimucositis) or can spread periapically with resultant vertical and horizontal bone loss (periimplantitis). Perimucositis is considered a reversible process . Bacterial plaque is the main factor of this inflammatory response of soft tissue and periimplant bone. 9Implant failures are caused by advanced inflammatory changes in peri-implant tissues. Reversible inflammatory reactions in periimplant soft tissues (mucositis) and progressive periimplant bone loss after osseointegration are two different types of lesions in periimplant pathology. Bacterial accumulation starts in the soft tissues around implant neck , penetrates implant abutment connection and if untreated infection spreads apically resulting in vertical and horizontal bone loss with implant failure in later stages. 8Several in vitro and in vivo studies have shown bacterial colonization of periimplant socket similar to periodontal ones. Bacterial species such as Bacteroides gingivalis, Bacteroides intermedius and Actinobacillus actinomycetemcomitans are responsible for severe periodontitis and are also present in periimplantitis. 4Ellen et al and Kalykakis et al found that periodontal and periimplant microflora showed similar tendencies during progressive deterioration of tooth structures. Becker et al reported moderate levels of Aggregatibacter actinomycetemcomitans, Bacteriodes intermedius, and Porphyromonas gingivalis at failing implant sites. Jasenka Zivko-Babic et al have reported A. actinomycetemcomitans and F nucleatum as major periodontal pathogens in subgingival microflora of patients with implant supported restorations. However Prevotella intermedia, Prevotella oralis and Campylobacter rectus were found infrequently. In this study A actinomycetemcomitans , P. gingivalis , T. forsythensis and F. nucleatum were found . 10Retrograde periimplantitis assosciated with implant failure may be due to bone microfractures caused by premature implant loading, overloading , trauma or occlusal factors which may lead to loss of osseointegration around the neck of implant. Diagnosis can be made by soft tissue measurement by manual/automated probes, radiographs, clinical signs of suppuration, calculus, swelling, color changes and bleeding on probing and microbial monitoring.

11In percutaneous implants the evaluation of peri-implant abutment sebaceous crusting ,exudates, skin thickness, tissue reaction and implant mobility can be done. Peri-implant abutment tissue inflammation can be visually assessed around epithelial tissue of percutaneous implant abutments supporting maxillofacial prosthesis. Grade 0 denotes normal skin, grade 1 indicates mild inflammation (slight redness and or edema, nontender), grade 2 indicates moderate inflammation (redness, edema, mild tenderness) grade 3 indicates severe inflammation (marked redness, edema, ulceration, moderate to severe pain).

3.Treatment modalities

1 In 1995, the FDA cleared lasers for use in additional detailed soft tissue dental procedures and in 1997 followed with approval of hard tissue applications. 3In view of response of implants , which react as do natural teeth to oral ecosystem ,a schedule for implant maintenance should be a routine policy for every implant practice with due regards to lasers. 12Therapy of periimplantitis includes a nonsurgical phase which includes debridement by mechanical means with ultrasonic or laser devices either alone or combined with antiseptic or antibiotic agents and a surgical phase. 13The removal of bacteria and endotoxins by mechanical depuration is difficult especially between threads of implant when surfaces are rough. 3Fox and his colleagues noted unpredictable surface alterations occurring after debridement of titanium implants with metal instruments made of either stainless steel or titanium alloy. Dissimilar metal instruments could contaminate surface of implant , changing the oxide layer rendering it vulnerable to corrosion. Moreover disruption of epithelial seal during maintenance procedures could result in permanent detachment owing to enhanced plaque adherence to roughened surface due to disintegration of oxide layer of implant. 9Adequate removal of bacteria from implant surface is of utmost importance to achieve periimplant regeneration. Among mechanical methods, use of curettes or ultrasonic instruments have been criticized due to damage to implant surface. Air powder abrasive instruments have limitations in their applications due to assosciation with increased risk of emphysema when used in deep bony defects. They can negatively modify surface HA coated implants. Chemical adjuvants

involve gingival irrigation with antiseptics and local antibiotic therapy. Local antibiotic therapy with tetracycline fibres around failing implants have been reported without significant therapeutic effects. Systemic antibiotic therapy have limitations of bacterial resistance and ineffective dose of application. The bactericidal action of Lasers is well established and understanding the interaction between implant surface and lasers is mandatory. An in vitro study of irrigation of periimplant pockets with toludine blue and an irradiation with a 905 nm diode soft laser for one minute presented a significant reduction in periodontopathogenic bacteria in pockets.

4.LASERS

The neodymium : yttrium- aluminium -garnet (Nd:YAG), carbondioxide (CO2), erbium :YAG (Er:YAG) ,erbium, chromium: yttrium (Er,Cr:YSGG) are the lasers most often used in dentistry. 14The use of lasers have been investigated for periodontal therapy as subgingival debridement, and curettage, removal of granulation tissue during flap surgery, osseous recontouring in implant surgery, their maintenance and management of periimplantitis.

5.Nd:YAG Lasers

Using dental Nd:YAG laser in contact as well as noncontact mode ,the effects on surface of titanium implants , hydroxyapatite and nonhydroxyapatite TPS types were evaluated including effects of laser after contamination of implant with spores of Bacillus subtilis. Use of Nd:YAG laser at energy settings of o.3, 2.0,3.o w resulted in surface melting, loss of porosity and other alterations including physical changes in crystalline structure of hydroxyapatite coating. Moreover total sterilization of surface was not achieved. 8 Nd-YAG lasers though effective in decontaminating implant surface have been known to alter them severly.9Sufficient decontamination in terms of sterilization of implant however leads to surface being completely damaged with melting and crater like formation depending on type of implant surface .Due to significant rise of temperature, application of contact Nd:YAG laser for treatment of periimplantitis , hyperplastic mucositis and second stage surgery in submerged endosseous implants is contraindicated. 15Melting , cracks, loss of porosity, dissolution and damage of sand blasted, plasma sprayed, HA coated implant surface have been found after the application of pulsed Nd:YAG laser with low or high power settings(2.0-6.0W) The damage to HA coated implants was extensive manifest as dissolution and cracks . Crater like alterations and lava like layers on all irradiated implant surfaces were found. The significant absorption of Nd:YAG laser by metal surface suggests a considerable risk of damage to periimplant soft tissue. 3 Nd:YAG lasers have properties suitable for welding Titanium and laser welding produces superior results as compared with plasma welding or soldering. It thus has important role to play in laser welding of implant supported superstructures. Bone necrosis is common when Nd:YAG laser is applied to osseous tissues.

6.Diode Lasers

Diode lasers of both 810, 980 nm do not damage root shaped implant retentive surface in presence of good coolant[8]. This study does not recommend the use of CO_2 or Nd:YAG lasers in periimplantitis. GaAlAs diode laser therapy of 810 nm(Diolaser) at 1 to 1.5W for 20s maximum in continuous wave mode and under air / water spray seems to efficiently reduce bacterial contamination and inflammation followed by guided bone regeneration treatment. High power diode lasers have excellent coagulation properties similar to Nd:YAG lasers characterized by superficial tissue absorption without damaging underlying tissues[9]. Studies show significant reduction of pathogenic bacteria in pockets especially of Actinobacillus actinomycetemcomitans , Prevotella intermedia, Porphyromonas gingivalis. Diode lasers with wavelength of 980 nm do not damage titanium disc surfaces with different disc patterns in invitro studies. Thus such lasers should be effective in decontaminating implant surface after flap elevation in treatment of periimplant bone defects.

7.Er:YAG Lasers

Some studies show the negative effect of frequency doubled Alexandrite laser irradiation on implant surface and modification of implant surface after Er:YAG irradiation although the later has been shown to possess bactericidal effect in treating periimplantitis [8]. Investigation of Er:YAG laser with 540um periimplantitis application tip used at a distance of 0.5mm from implant surface with pulse energy variation between 60 and 120 mj at 10pps with bone block placed in 37c waterbath simulating in vivo thermal conductivity and diffusivity of heat revealed it to be suitable for decontaminating various implant surfaces without adverse effect to implant and periimplant bone [16]. During test irradiation was performed with and without cooling, temperature of cooling agent used being 23.5c. However temperature elevation was significantly higher at the hydroxyapatite-coated implants than in two titanium surface groups. It seems that application of lasers might be an adequate treatment alternative for ailing implants.[12]According to Schwarz et al (2005) Er:YAG laser and the combination of mechanical debridement /chlorhexidine are equally efficacious at six months after therapy in improving probing pocket depth(PPD) and clinical attachment level(CAL), but the use of Er:YAG laser provides a significantly higher reduction of bleeding on probing. However in a subsequent study (Schwarz et al.2006) the efficacy of Er:YAG laser appeared limited to six month period particularly for advanced periimplantitis lesions. It was further suggested that a single course of treatment with laser may not be adequate for achieving stable therapy and additional therapeutic measures such as supplemental use of laser or osseous regenerative procedures, might be required. However this study reported surface alterations and somewhat ineffective cleaning by Key laser 3(2940nm) [2].

8.Carbon dioxide Lasers

CO_2 Lasers have bactericidal effects without significantly increasing implant body temperature. No significant changes were detected by scanning electron microscopy [9]. In this study focused noncontact beam of CO_2 laser with 4W setting was used for excising hyperplastic tissue around the neck of subperiosteal implant, the tissue subsequently carbonized with defocused beam. In case of perimplantitis, after raising mucoperiosteal flap, removing granulation tissue with plastic curettes and irrigation, decontamination of implant surface was performed with defocused beam of CO_2 laser using 4w power setting for 1 minute followed by immediate filling of bone defect by BioOss and placement of resorbable membrane. A study using cw(continuous wave) CO_2 laser at low power output of 2W for sixty seconds from a distance of 20mm on sand blasted titanium implants found statistically significant low count of bacteria Porphyromonas gingivalis [13]. With this laser, on titanium implant surface, the undesirable by products of heating hydroxyapatite are not generated. Another study demonstrated[15] that cw CO_2 laser irradiation at upto 6w does not alter sandblasted, plasma sprayed or HA coated implant surface. Deppe et al did not find any surface alteration on TPS coated implants and an excellent sterilization effect was demonstrated when the power setting was 2.5w. CO_2 laser in noncontact mode at distance of 5 mm in continuous and both pulsed mode (1, 2pulses per second –pulse duration 5msec and mode 9,2 pulses per second –pulse duration of 100 msec) at power setting of 2.0, 4.0, 6.0 w showed no alteration or melting of sand blasted , plasma spray or HA coated titanium implants. Ganz used a standardized protocol and suggested CO_2 laser is safe to apply around both HA coated and titanium screws with power setting not exceeding 2-4W in a continuous mode or 5-6 W in a pulsed mode. Ganz also believed that pulsed laser beam was more appropriate for reducing the time the laser energy is actually in contact with implant surface. One could begin with continuous mode and switch to pulsed mode. Because of the high absorption of the carbondioxide laser by the water content of mucosa and the decreased penetration depth, tissue necrosis is very limited(100-200um). In addition, the specular reflection of CO_2 irradiation is high meaning the metallic implant surface can not absorb laser radiation and cannot increase temperature to critical levels. CO_2 lasers can be used in periimplant pathology without limitations. The carbondioxide laser can be used in gingival tissue contouring near implants and exposure of implant during second stage surgery, control of mucosal abnormalities and treatment of implant soft tissue complications. The authors did not recommend use of coaxial laser carbondioxide –Nd:YAG in preference to conventional means in the treatment of periodontal disease[3].

Laser technology has been explored for use in determining vascular perfusion of mucoperiosteal flaps used in guided tissue regeneration and in treatment of oral diseases which have an effect on implant success placed in the oral cavity. Low intensity laser therapy is an effective treatment for recurrent herpes simplex infection. Reports have been presented of a possible prosthetic solution after combined laser and chemotherapy in a maxillary onlay bone graft with single step implant therapy that would have

9.Summary

Implants with peri-implantitis reveal complex microbiota encompassing conventional periodontal pathogens[7]. Most implants feature a rough surface or modifications to increase area of bone contact and firm anchorage . Surface roughness makes elimination of bacteria from implants difficult and hence sterilization and cleaning of implant surface with laser has been advocated[16].

Nd;YAG and Ho:YAG lasers are not suitable for use in decontamination of implant surface irrespective of power output. When using Er:YAG and CO_2 laser, the power output must be limited to avoid damage [18].

The Er: YAG laser operated at pulse energy of 60-120mj guarantees significant bacterial reduction on Ti plasma sprayed, acid etched and hydroxyapatite coated implant surface [16].

With Er: YAG laser alterations were detected at 8.9Jcm^{-2} on TPS surface, 11.2Jcm^{-2} on SA surface , 17.8Jcm^{-2} on HA coated surface, 28.OJcm-2 on smooth surface. With CO2 laser ,HA coating was effected at fluence of 15.2Jcm^{-2} and at fluence above 30Jcm^{-2} surface of TPS and SA specimens appeared glazed[18].

GaAlAs laser seems to be safe as far as possible surface alterations are concerned even when energy fluence was increasd to 26.6Jcm^{-2} at 50pps and at maximum power setting .

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