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Review Article

Does Er,Cr:YSGG Laser would be the Gold Standard for Periodontal Treatment?. Review

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Abstract

Surgical treatment for the management of periodontal pockets associated with intrabony defects can be challenging. Due to access, these defects often require surgical intervention, employing regenerative surgical techniques including barrier membranes, osseous graft material or application of a biologically active material. There has been increasing interest in the use of Er,Cr:YSGG laser for managing periodontitis including non-surgical root surface debridement and a range of surgical therapies, with minimal clinical trials to demonstrate efficacy. In this regard there are few studies that have evaluated the use of the Er,Cr:YSGG. This article deals with laser basics generally with special reference to Er,Cr:YSGG, recent advances in nonsurgical use of it as adjunctive therapy for periodontal disease and will describe the effectiveness of the innovative radial firing tip (RFPT 5 - 14), advantages and disadvantages of this type of laser.

The conclusion was that Er,Cr:YSGG laser supported periodontal treatment could result in a significant reduction of periopathogenes. Using a different settings or water cooling system for the Er, Cr:YSGG laser with RFPT 5 - 14 tip may lead to a treatment plan that makes the hand instrumentation secondary or needless. Then, the treatment Er,Cr:YSGG laser with its special perio tip (RFPT 5 - 14) could be the gold standard for periodontal treatment in the near future.

Keywords: *Erbium; Chromium-Doped Yttrium Scandium Gallium Garnet (Er,Cr:YSGG) Laser; New Radial Firing Tip Radial Firing Tip (RFPT 5 - 14); Chronic Periodontitis; Intrabony Defects; Root Surface Debridement; Pocket Reduction; Laser Treatment; Ti Dental Implant; Implantitis*

Introduction

Chronic inflammation of the supporting periodontal tissues characterizes periodontal disease which is mediated by the host immune and inflammatory response to the microbial dental plaque flora [1]. The basic and long-term aspect of periodontal treatment, for preventing the progression of disease and maintaining the periodontal health, is by Elimination of supra- and subgingival bacterial deposits [2]. Nonsurgical periodontal treatment method using scaling and root planning proved its clinical efficacy and has been demonstrated in several clinical studies [3].

Mechanical therapy of periodontal diseases have been applied securely with high success rates for years [4]. Complete eradicating pathogenic bacteria, toxins within deep periodontal pockets and in complex root morphologies that are inaccessible by periodontal instruments by Mechanical periodontal treatment alone, is not all the time prognosticated and has some limitations [5,6]. Mechanical instrumentations alone have been shown to produce a smear layer that contains microbiota and its products. This leads to residual periodontal pocketing and bacterial recolonization affecting periodontal healing [6,7]. To overcome the limitations of the mechanical periodontal treatment there has been increasing interest in the use of lasers for managing periodontitis [8].

Based on its various characteristics, such as ablation or vaporization, hemostasis, and sterilization effect, laser treatment may serve as an adjunct or alternative to conventional, mechanical periodontal therapy. The Carbon dioxide (CO_2) and the Neodymium doped: Yttrium-Aluminum-Garnet (Nd:YAG) lasers were previously approved for soft tissue treatment in periodontics [9] because of their superior ability of soft tissue ablation, accompanied by strong hemostatic and bactericidal effects [10]. However, when these lasers are applied to dental hard tissues the result is major thermal damage, especially at a high-energy output, rendering them unsuitable for hard tissue treatment [11]. To avoid all drawbacks of the aforementioned treatment modalities for periodontal diseases, the Erbium-doped:Yttrium-Aluminum-Garnet (Er:YAG) laser is used [12]. As it is capable of ablation in both soft and hard tissues, the Er:YAG laser can be used for periodontal hard tissue treatment such as root surface debridement, as well as soft tissue management [13].

Most previous studies reported on the use of lasers in periodontal therapy have mainly investigated diode, Er:YAG and Nd:YAG lasers [14-17]. However, the Er,Cr:YSGG laser has had few studies in the field of periodontology, and on occasion has been grouped together with the Er:YAG laser due to having similar wavelengths and both having hard and soft tissue targets. The aim of review is to put Er,Cr:YSGG laser in focus as an innovative treatment modality of periodontal diseases taking into consideration laser basics, its new varieties, and previous work on this type of laser.

Production and characteristics of laser

Light amplification by stimulated emission of radiation are acronym of the term 'LASER'. Laser light is a man-made single photon wavelength and is not produced by nature sun) [18]. With the production of the American Dental Laser commercially using an active medium of Nd:YAG in1989 made laser use in dentistry possible [19]. In the mid-1990s various laser types (Diode laser (810 - 890 nm), Nd:YAG (1064 nm) Er,Cr:YSGG (2780 nm), Er:YAG (2940 nm) and CO_2 (10600 nm) became available and resulted in a great advance for dental lasers addressing dentists needs for hard and soft tissue procedures [20].

When an excited atom is stimulated to emit a photon before the process occurs spontaneously, the process of lasing occurs. Spontaneous emission of a photon by one atom stimulates the release of a subsequent photon and so on (Figure 1). This stimulated emission generates a laser light that have four characteristic properties (Figure 2A), when compared with normal light (Figure 2B), common to all laser types including Er,Cr:YSGG laser [21].

Laser-tissue interaction

Oral tissues will reflect, scatter, absorb or transmit any incident laser light e.g. in case of Er,Cr:YSGG (Figure 3). All laser lights are used in clinical dentistry to effect controlled and precise changes in target tissue, through the transfer of electromagnetic energy [22]. The interaction of laser light with oral tissues is one of four ways (Figure 3): a) Reflection: The beam redirects itself off the tissue surface without any effect on the target tissue, b) Transmission: Laser beam enters the medium and emerges distally without interacting with the medium i.e. no effect on the target tissue, c) Scatter: Result of light scattering is a weakening of laser energy producing no effect on target tissue and d) Absorption: The incident energy of the beam is absorbed by the medium and transferred into another form of energy. The most important interaction is absorption [23].

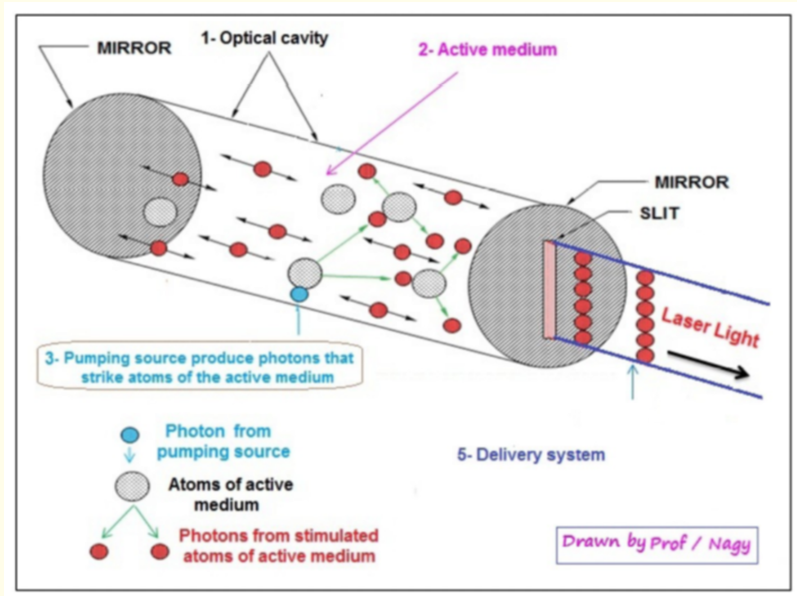

Figure 1: *Production of laser.*

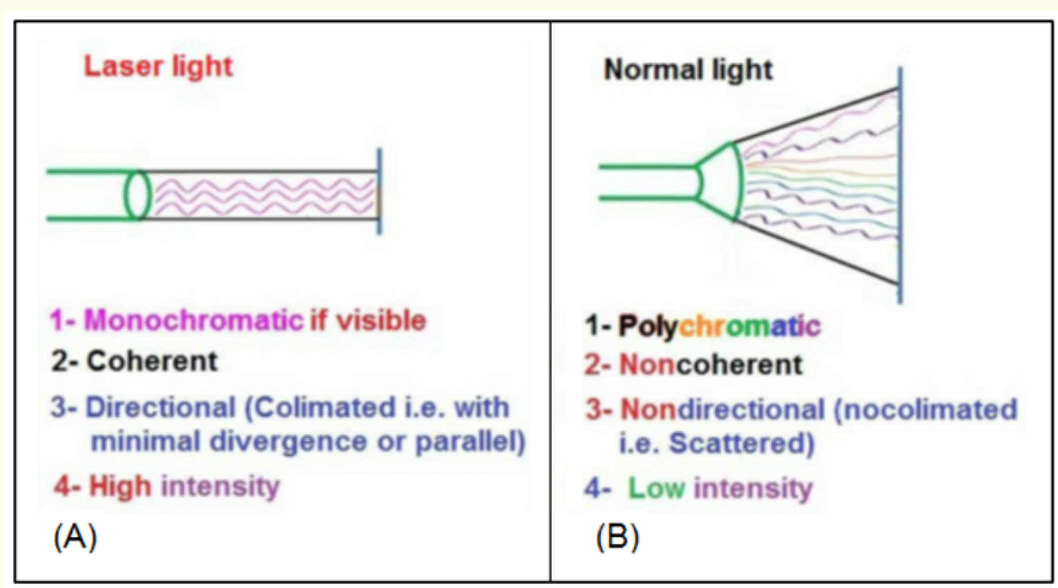

Figure 2: *Characteristic properties of laser light (A) and normal light (B).*

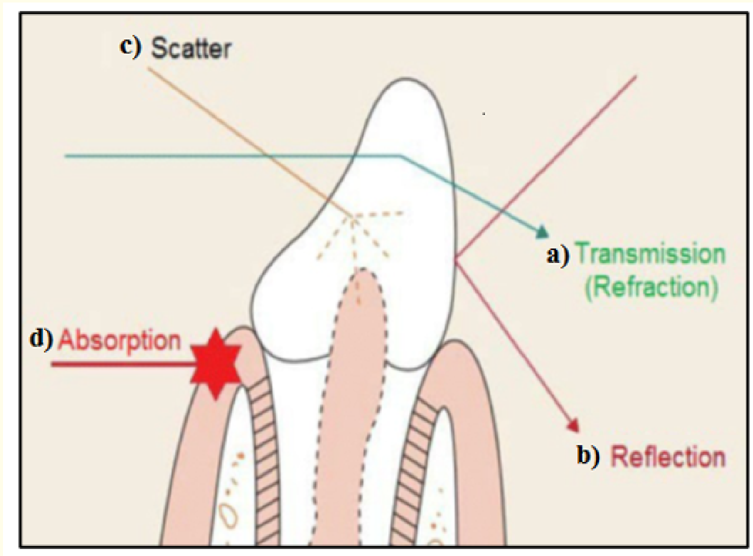

Figure 3: *Possible laser light-oral tissue interactions.*

The energy of each wavelength is absorbed by specific chromophores. To perform the work desired the absorbed energy is converted into thermal and and/or mechanical energy. Diodes and Nd:YAGs are near infrared lasers and mostly absorbed by pigments such as hemoglobin and melanin. Water absorbs erbium and CO_2 lasers but erbium wavelengths also exhibiting some hydroxyapatite absorption [24,25].

Absorber of light have a certain affinity for specific wavelengths to absorb and termed as chromophores. The primary chromophores in the intraoral soft tissue are a) Melanin, b) Hemoglobin, c) Water, 4) and in dental hard tissues (Water and Hydroxyapatite), and d) Photosensitive materials in visible light cured polymeric materials (Camphorquinone and α Diketone) [26]. The Er, Cr:YSGG at 2,780 nm and the Er:YAG at 2,940 nm are medium- infrared wavelengths, now called erbium family lase have specific affinity of water [27]. Therefore, they are currently the only two wavelengths capable of being greatly absorbed within the dental tissues, whether soft or hard, when used with safe and accepted clinical parameters (Figure 4) [28-31].

Mechanisms of laser tissue interaction

Despite the number of possible combinations for the experimental parameters is unlimited, today mainly five categories of interaction types are classified namely photoablation, plasma-induced ablation, and photodisruption (Figure 5). Terms use to describe the mechanism of laser tissue interaction are: a) Photochemical causing cell dissolution or destruction as laser energy initiates specific light-induced chemical reactions in the target tissue, b) Photoablative causing photodissociation or breaking of the molecular bonds in tissue by laser energy, c) Photothermal where laser light energy is converted into heat energy by absorption of the energy by the tissue target. This causes the tissue to heat up and vaporize, d) Plasma-induced ablation (Thermomechanical) as laser energy causes structural breakdown in tissue caused by shock wave plasma expansion, resulting in localized mechanical rupture and e) Thermal interactions playing significant role in soft and hard tissue ablasion due to absorption of water molecules to the Er,Cr:YSGG laser [32].

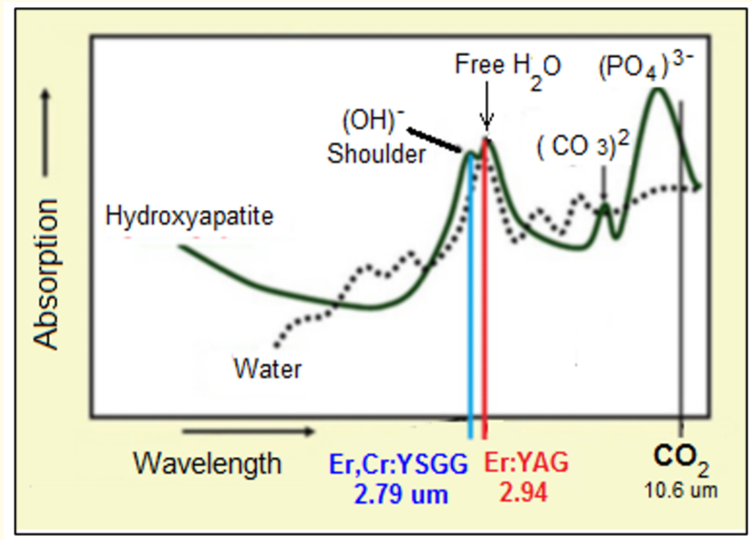

Figure 4: *Relative absorption of erbium wavelengths in oral tissue chromophore (water and hydroxyapatite).*

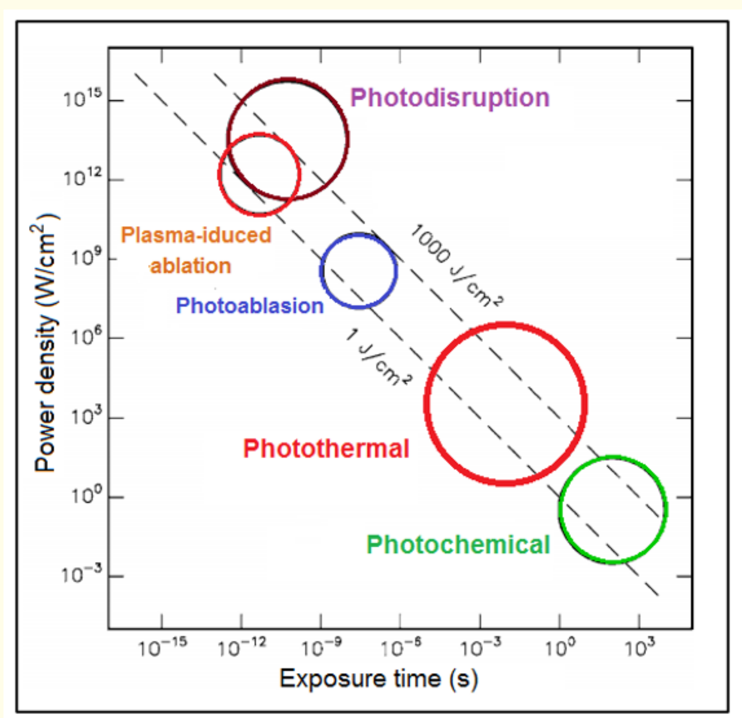

Figure 5: *Map of laser-tissue interactions. The circles give only a rough estimate of the associated laser parameters.*

Er,Cr:YSGG lasers with conventional tip in periodontal therapy

Better periodontal tissue regeneration is provided by Er,Cr:YSGG lasers than that of conventional non-surgical periodontal therapy since the last decade in dentistry [33]. In terms of attachment level restoration, a combination of Er,Cr:YSGG laser, conventional scaling and root plaining had better results compared to scaling root-plaining alone [34]. Other types of high intensity lasers such as Er:YAG and Nd:YAG lasers have been recently used in a way similar to Er,Cr:YSGG in the periodontal therapy [35,36]. Er:YAG lasers are securely used as an alternative to non-surgical periodontal therapy or as an adjunct for pocket treatment [37,38]. It is reported that the damage of the thermal side effects is prominently reduced in Er,Cr:YSGG laser and it can be safely and effectively used in non-surgical periodontal therapy [39].

A study evaluated the clinical use of Er,Cr:YSGG laser in the management of root furcation involvements and concluded that pocket debridement with Er,Cr:YSGG laser is a safe, comfortable, and clinically effective means of subgingival debridement in periodontal therapy [40]. The clinical effects of Er, Cr: YSGG laser treatment as a complementary to scaling and root planning (SRP) during the treatment of chronic periodontitis and gingival crevicular fluid (GCF) interleukin-1 beta (IL-1β), interleukin-35 (IL-35) levels were investigated. This showed that after periodontal treatment, CAL, PD, BOP, GI and PI, GCF volume, IL-1 β, IL-6 and IL-35 which are clinical parameters analyzed decreased. It was concluded that as GCF IL-1 β/IL-35 ratio changed significantly from disease to health, it can be suggested that IL-35 may be associated within the pathogenesis of periodontitis and that Er, Cr: YSGG laser can be used as an adjunct to SRP in periodontal treatment. For evaluating the exact role of host mediated cytokine network in the pathogenesis of periodontal disease further longitudinal clinical, microbiological and biochemical studies are required. Identifying patients having high susceptibility sites for periodontal disease activities by diagnostic biochemical markers will possibly provide patient site-specific treatment methods in the future [41].

As a retrospective analysis of an extended case series these results should be considered a low level of evidence for efficacy of adjunctive surgical laser treatment, but the outcomes are sufficient to warrant the need for proper randomised controlled studies of the Er,Cr:YSGG laser in the surgical and non-surgical management of periodontitis. This retrospective case series suggests that the use of the Er,Cr:YSGG laser for surgical treatment of periodontal pockets may be an effective adjunctive management for infra bony defects associated with chronic periodontitis. In future studies, there is a need to identify optimal protocols and parameters for use of Er,Cr:YSGG lasers in specific applications as these may profoundly influence therapeutic responses [27]. In particular, further well-designed RCTs are required to investigate these findings under more rigorous test conditions [42].

Another study evaluated the efficacy of Er,Cr:YSGG laser assisted periodontal therapy on the reduction of oral malodor and periodontal disease and concluded that Er,Cr:YSGG laser assisted conventional periodontal therapy is more effective in reducing oral malodor and improving periodontal healing compared to conventional periodontal therapy alone [43].

Er,Cr:YSGG use in treatment of periimplantitis

Due to better removal of biofilm and the bacteria within it, in combination with other advantages the use of lasers has been more effective than conventional approaches [44]. During clinical dental surgery Er,Cr:YSGG lasers are used on hard tissue [45] and in general practice, it is used on soft tissue lesions, tooth structure, and bone because it is well-absorbed by collagen, hydroxyapatite, and water components. The Er,Cr:YSGG laser, due to its properties, has been applied than have conventional approaches in patients with peri-implant mucositis and peri-implantitis and has produced good soft tissue benefits and less postoperative pain and swelling [36].

To treat peri-implantitis, many techniques have been used including conventional methods such as mechanical debridement, chemical surface treatment, and laser therapy [47]. In an *invitro* study the Er,Cr:YSGG laser used was highly efficient and effective in removing contaminants from the implant material with minimal changes to the titanium surface roughness and the lack of an organic smear layer. A standard for detoxification of implant surfaces laser irradiation at 100 mJ/pulse and 10 Hz for 1 minute is suggested [48].

High efficiency in removing plaque biofilm in an energy-dependent manner using the same Er,Cr:YSGG laser machine with settings of 1.5W and 20 Hz with an air/water ratio of 50/50 has been demonstrated, but they did not reestablish the biocompatibility of contaminated titanium surfaces [50]. These findings agree with those of Gheith., *et al*. [51], who concluded that Er,Cr:YSGG laser, after cell viability testing and SEM analysis, could safely improve the biocompatibility of dental implants made of titanium alloy (Ti-6Al-4V); no undesirable changes were observed with the use of 2W. Other researches used higher settings than those used showed surface alterations such as melting and flattening with settings of 2W, 20 Hz, 4 mm and 45s and with settings of 3 W, 25 Hz, 2 mm, 45s on Ti discs [52].

Because the wavelength of the Er,Cr:YSGG laser is highly specific to water and is sensitive to gingival fluid, saliva, and blood [53], which makes the process of clinical implant surface decontamination different from that in *in-vitro* situations. Er,Cr:YSGG laser treatment for peri-implantitis, showed increased radiographic bone density of dental implant stability 13 months after laser irradiation [54].

Er,Cr:YSGG laser proved to be more advantageous than mechanical therapy, such as that with titanium curettes or citric acid, in the treatment of peri-implantitis [55,56]. To achieve safer guidelines for clinicians in decontamination, promoting biofilm removal, reducing bacterial adhesion, and improving cell attachment, while the dental implant surface characteristics are preserved after laser irradiation, it is important to determine the best laser settings, such as the power and the distance between the tip and titanium surface [52].

Er,Cr:YSGG laser treatment made Ti disc surfaces slightly smoother, reduction of *P. gingivalis* adhesion, improved the biological responses to the treated surfaces and increasing of fibroblast viability and osteoblast differentiation were observed in a recent study about laser effect upon Ti disc surfaces. For these reasons, Er,Cr:YSGG laser treatment can be considered for laser-assisted therapy settings and in guidelines for the treatment of peri-implantitis [57].

ER,Cr:YSGG laser with an innovative RFT 5-14 tip

The Waterlase MD Er,Cr:YSGG laser (Biolase, Irvine, California, USA), introduced standard handpiece with the new RFPT 5 - 14 tip. To allow irradiation laterally as well as straight at the same time, this tip has a new and special shape allowing firing 360∘. It is 14 mm length, 580 μm diameter, produces primarily radial emission (80%) of laser energy with a portion of straight emission (20%) as seen in figure 6 [58]. The effectiveness of a radial firing tip of an Er,Cr:YSGG laser as an adjunct to a nonsurgical periodontal treatment for chronic or aggressive periodontitis was evaluated and concluded that laser supported periodontal treatment leads to a significant reduction of periopathogenes and thereby helps the maintenance of periodontal health [12].

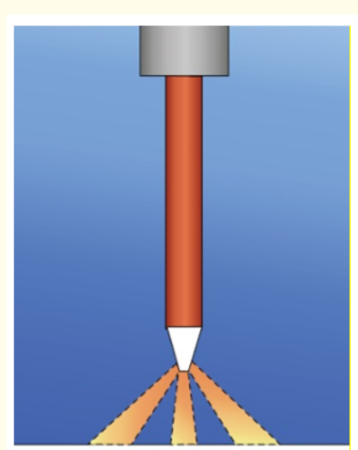

Figure 6: *The new RFPT 5 - 14 tip.*

Advantages of this radiation pattern are: a) accentuates the better access to the narrow part of the periodontal pocket since the tip has no side edges and is rather flexible, b) the significantly reduced power directly in front of the tip end eliminating a potential risk of damaging periodontal ligament within the pocket and c) the efficiency of laser power emitted radially away from the end of the tip is increased for more efficient radiation of the root surface and soft tissue of the gum. This tip should to be renewed after every use especially when deformed (Figure 7) [12].

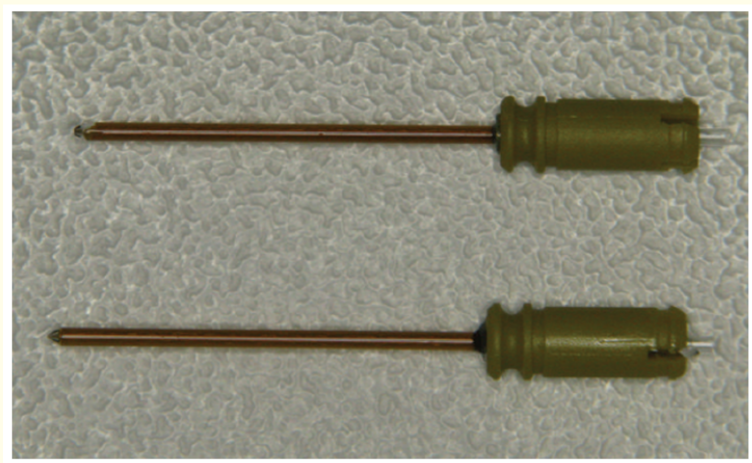

Figure 7: *RFPT 5 - 14 tip (upper one deformed apex).*

Traditionally diode lasers and Nd:YAG lasers were preferred by clinicians because of their flexible fiber delivery system, which is suitable for all hidden areas inside the oral cavity [37]. Currently with the new flexible 14mm long tip (RFPT 5 - 14 tip) and Er,Cr:YSGG laser all teeth could have been treated appropriately because no danger of breaking the tip inside the pocket appeared during treatment [12].

To determine the long-term role of the microbiological results an interesting investigation about the Effects of Er:YAG laser compared to ultrasonic scaler in periodontal treatment for a long-term control after one year or even after three years was performed. The lased pockets succumb to less recolonization or are recolonized by only less harmful germs were shown. Two years follow-up in another case found that a significant difference in the probing depth to favor Er:YAG treatment over conservative treatment with ultrasonic devices [59].

No hurting or bleeding by contact with this type of fiber tip were observed in a recent study [12], perhaps this was too much energy for periodontal treatment with this tip or at least for the soft tissue side of the periodontal pocket. This tip decreased amount of straight energy emission, an explicit advantage, thereby reducing the potential damage to the periodontal ligament when the tip is used vertically [58]. A discrete reduction in the bacterial load inside a significant number of examined periodontal pockets as well as a considerable reduction of each examined bacterium itself were the results of this study. The Er,Cr:YSGG laser with the new RFPT 5 - 14 tip supported periodontal treatment leading to a significant reduction of perio-pathogenes and thereby helps the maintenance of periodontal health was the conclusion of this study [58].

A clinical study used the new RFPT 5 - 14 laser tip used with Er,Cr:YSGG in periodontal treatment. Supra-gingival calculus was removed using ultrasonic scaler (Cavitron™ Plus™, Dentsply, Swiss) at the time of the first visit, During the second visit, the laser was irradiated with RFPT 5 - 14 with a specification as shown in figure 8 and Settings of laser devices at 1.5W power, 38 Hz pulse rate, 11% air, 20% water and H mode. The laser irradiation was approached at 15 to 30 degrees and without direct contact with the root surface. 30 seconds for buccal was the total time of irradiation and lingual sides about fifteen seconds. At three months post-treatment calculus ablation was self-evident and could be easily observed on plain radiograph. When probing depth was measured reduced bleeding was appreciated. At three months post-treatment the clinical attachment level was noted to be improved. Laser therapy can be effective in improvement of chronic periodontitis and reduction of periodontal pocket depth was the conclusion of this study [60].

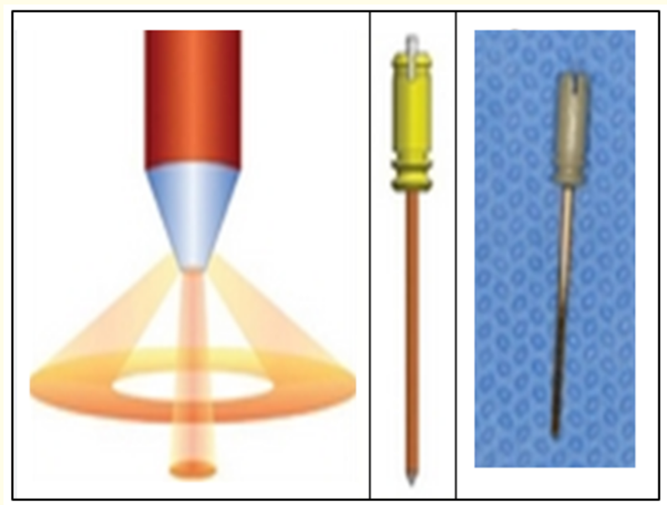

Figure 8: *Specification of Radial firing tip (RFPT) 5 - 14 tip. The features are 580 μm diameter, 14 mm length, 4.0 W power and a 0.80 calibration factor. The laser is emitted to the long axis and side of the tip.*

Conclusion

1. The Er,Cr:YSGG laser for surgical treatment of periodontal pockets may be an effective adjunctive management for infrabony defects associated with chronic periodontitis. In future studies, there is a need to identify optimal protocols and parameters for use of Er,Cr:YSGG lasers in specific applications as these may profoundly influence therapeutic responses. In particular, further well-designed Randomized clinical trials (RCTs) are required to investigate these findings under more rigorous test conditions.
2. A significant reduction of periopathogenes and thereby helping the maintenance of periodontal health.is gained by using Er,Cr:YSGG laser supported periodontal treatment.
3. Since we have modern tools, now, like Er,Cr:YSGG laser with 360∘ firing tips (RFPT 5 - 14 tip) that has a large impact on the microflora inside a periodontal pocket, the research with those instruments should progress. RFPT 5 - 14 tip could lead to a treatment plan which may be makes the hand instrumentation secondary or needless if used with different settings or an advanced water-cooling system for this. Then, the treatment with laser with its special perio tip (RFPT 5 - 14) could be the gold standard for periodontal treatment in the near future.

Recommendation

The special perio tip (RFPT 5 - 14 tip) needs further studies to clear this matter.

Conflict of Interests

The authors declare that there is no conflict of interests.

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Volume 19 Issue 9 September 2020