Lasers : a guiding light in Periodontics and implant dentistry

Dr. Ashok K.P
Department Of Periodontics
GSL Dental College & Hospital
Rajahmundry, India
drashokkp@gmail.com

ABSTRACT

Lasers have become ubiquitous. They have been used for different purposes based on their wavelength and other characteristics. A lot of innovative and new methods of use of lasers have been developed in the last 3 decades. Lasers have unlocked novel vistas and prospects that can augment periodontal and implantology treatment procedures. The current standard regulations of lasers allow them to be used for disinfection of periodontal pockets, elimination of calculus, enhancement of healing and also in the treatment of diseased implants.

Keywords: Laser, Photobiomodulation, Photodynamic therapy, LANAP, LLLT.

I. INTRODUCTION

Periodontitis is a chronic inflammation initiated by the biofilm upsetting the integrity of the periodontium and eventually resulting in its destruction.[1] Management of periodontal pathologies, notably periodontitis, consists mainly of the eradication of the prime etiology that is the biofilm. The aim of the non-surgical management of periodontitis is ultimately to eradicate the supragingival and subgingival biofilm, leading to a diminution of the inflammation.[2]

Numerous methods including surgical and nonsurgical therapies have been employed in the treatment of Periodontal and Peri-implant diseases. The principal aim of these therapies is to attain periodontal and peri-implant health and to minimize the threat of imminent disease relapse. A shared clinical goal in managing these situations is decreasing the pathogenic bacterial load and thus, the danger of further inflammation and disease relapse.[3]

The induction of Laser know-how has focused towards novel treatment plans and methods in the therapy of periodontal and peri-implant diseases. Laser beam is categorized by properties like Coherence, Collimation, Being of Single Color and Intensity. When the Laser comes into contact with a tissue, it can illustrate one of these properties – Reflection, Scattering, Absortion or transmission. The magnitude of energy absorption is dependent on the wavelength of light. Specific wavelength of Laser shows distinctive absorption features by certain proteins, Chromophores and water. Even bacterial chromophores absorb certain wavelength. So, the wavelength of Laser specifies the power of penetration and the structure of interaction. Diode and Nd: YAG are soft tissue lasers with larger depth of penetration compared to Co2, erbium-doped Yytrium aluminium garnet laser(Er: YAG)[4]

Lasers have been used in dentistry for multiple therapeutic options. The first laser was invented in 1960 by Theodore Maiman.[5] The use of Nd: YAG laser in oral surgical procedure was proposed by Myers and Myers in 1989.[6] LASERS are effective in eliminating periodontal pathogens. Laser use in the therapy of periodontal disease has offered an array of benefits. Laser treatment is advised for patients who have issues with bleeding during surgical treatment or with use of anesthesia.

Lasers bestow the capacity to supply enormous quantities of energy into comparatively tiny affected regions of hard or soft tissue. The appropriate choice of laser wavelength and considerations is essential in attaining a required alteration of tissues.[7]

II. CALCULUS DETECTION

A Commercially available device called DIAGNODENT uses a Laser wavelength of 655 nm marked for detection of calculus. It uses a separate tip for the uncovering of subgingival calculus which glows contrarily to healthy tissue. This is picked up by the device which is indicated in the numerical display.[8,9]

III. ASSESSMENT OF MOBILITY

Mobility of teeth can be assessed through Lasers. This technique is centered on the estimation of tooth mobility degree by way of the use of dynamic loads and the resultant dislodgement dimensional change by Laser Doppler Vibrometer(LDV)[10]

IV. LASERS IN REMOVAL OF SUBGINGIVAL CALCULUS

Scaling & Root planning is deemed as the yardstick of care in the non-surgical treatment of periodontitis. This can be done manually or by ultrasonic instruments with not much of a difference in terms of effectiveness between both methods.

Lasers are also used for scaling procedure. This will not only eradicate the calculus on the root surface, but also modifies the cemental surface to facilitate attachment of fibroblasts.

Co2 laser has thermal properties which will cause carbonization and damage to the root. [11] According to Schwarz et al, the Diode lasers and Nd:YAG Lasers are generally ineffectual in removing calculus and may produce detrimental root surface changes like grooves and craters.[12]

Er:YAG and Er, Cr: YSGG lasers are used in SRP as they have a water absorption coefficient higher than Carbon dioxide and Nd:YAG laser. It is also absorbed in calcium and phosphorous which are the main constituents of subgingival calculus. The calculus heats up by absorbing the laser energy through the water molecules and bursts, thus making it easier to be detached.[13] A meta-analysis evaluating the accessible evidence regarding the clinical efficiency of Er:Cr: YSGG Laser in the non-surgical treatment of chronic periodontitis, concluded that the Laser , when employed as an adjunct to SRP, furnished significantly better clinical efficacy at a 3 month follow up. There was no significant difference at a 6 month follow up.[14]

According to the American Academy of Periodontology, The Er: YAG laser exhibited excellent usage of laser on hard tissue, causing minimum thermal injury and producing a biocompatible coating for the attachment of soft tissues.[15]

V. LASERS IN TREATMENT OF HYPERSENSITIVITY

Low -level laser therapy(LLLT) has been shown to bring about palliative, anti-inflammatory and cellular impacts in the management of hyperemia and dental pulp inflammation. A diode laser of 780 nm at a power of 3o mW or Nd: YAG Laser at low power can be used for the treatment of hypersensitivity. The laser treatment generates the ensuing effects on hypersensitive teeth:

Initially, it lessens the painful symptoms. Later, a powerful cellular metabolic activity, production of odontoblasts and dentin formation occurs. The treatment inhibits the nerve signal communication from periphery to the central nervous system. The dentinal tubules are sealed, blocking the communication, serving to sustain the analgesia. The seal is formed by the coagulation of the hydroxyapatite crystals and creation of reparative dentin.[16, 17]

VI. PHOTODYNAMIC THERAPY

The utilization of photoactive compounds to produce photodestruction of oral bacteria has been proven. The photodynamic method is built on the process of adapting light energy to chemical energy, aided by a supplementary vehicle to convert the light energy, the photosensitizer. This procedure is called photodynamic therapy or antimicrobial photo disinfection. In this, the dye is put on to the area to be treated. The dye (photosensitizer) after light absorption, generates highly reactive oxygen species, sensitizing the bacteria to visible light and causing damage. The free radicals produced are highly reactive with very short lifespans due to their unstable electronic alignment.[18]

Many photosensitizing compounds have been used in photodynamic therapy comprising of toluidine blue, methylene blue, tolonium chloride and phenothiazine chloride. The wavelength needed to excite these photosensitizer is 660 nm for toluidine blue and methylene blue . it is 805 or 810 nm for indocyanine green. When these molecules are dispensed in a periodontal pocket, they may interact with diverse cellular components depending on their affinities towards them.[19]

As periodontitis is caused by the plaque biofilm, the application of Photodynamic therapy may show favourable results. Some microbes like P.g and A.a can penetrate through the epithelial barrier and enter into the deeper connective tissues and reside there. So, conventional mechanical debridement will not be of much use in these cases. Thus, photodynamic therapy will be a useful adjunct in such cases as it will have a bactericidal effect on these pathogens. Lot of studies have shown that periodontal pathogens including Pg, Fn, Pi and Pm are susceptible to PDT treatment.[20, 21]

A recent study by Gandhi et al showed marked decrease in A.a and P G counts after Low level Laser treatment and APDT as an adjunct to SRP in periodontitis treatment.[22]

VII. PHOTOBIOMODULATION THERAPY

Photobiomodulation therapy (PBMT) is a type of treatment which uses light in the form of lasers to accelerate healing and tissue repair. This therapy can be employed to handle several ailments like inflammation, pain and wounds. Although the mechanism of action is not entirely comprehended, it is supposed to encompass the stimulation of cellular developments that encourage the healing and diminish the inflammation. PBMT has successfully been used in the management of chronic inflammation, oral mucositis, muscle recovery and pain management.

PBMT has been demonstrated to mainly activate an enzyme called cytochrome c oxidase(CCO) , which translates energy into electrons. This enzyme activation intensifies the mitochondrial activity, ATP Production and cellular activities. Besides, PBMT modulate the reactive oxygen species hindering the respiratory chain of stressed cells.[23, 24]

VIII. SURGICAL PERIODONTAL THERAPY

In addition to root surface decontamination and detoxification, as considered earlier, certain lasers and laser protocols are thought to contribute to more effective subgingival curettage, targeted and/or overall reduction in subgingival bacteria, reductions in inflammation, and rapid wound healing.

Flap surgery along with accompanying laser treatment have been tried with Diode, Carbon dioxide, Nd: YAG, Er: YAG and ER: Cr: YSGG Lasers. In an access flap surgery of 5 mm or deeper pockets, Er: YAG and Diode lasers have been used along with mechanical debridement and were compared to mechanical debridement alone. The Lasers showed similar or greater enhancements in clinical findings after 3 or 6 months.[25, 26] One study showed good improvements after 3 years also.[27]

One controlled clinical study with a coronally advanced flap along with Carbon dioxide laser and modified Widman flap as control showed remarkable results after 15-year follow-up. Over a 15-year period, Substantial decrease in probing depth and increase in clinical attachment level were maintained in sites with initial probing depth of 5 mm or greater. [28]

In a study done with Er: Cr: YSGG laser to evaluate the reduction of oral malodor and periodontal disease, the authors concluded that there was a significant reduction in volatile sulphur compound values in the laser group at 3rd and 6th month post treatment. Pocket depth values at 1 month post-treatment and BOP values at 3rd and 6th month post treatment were significantly decreased in laser group[29]

A systematic review was done by Triantafyllia Vadgouti et al on the long term clinical outcomes of Er: YAG or ER, Cr: YSGG lasers utilized as monotherapy or as adjuncts to mechanical therapy in the treatment of chronic periodontitis. They concluded that Er: YAG and Er, Cr: YSGG lasers as monotherapy or as adjunct to SRP appear to function better in terms of CAL and PPD reduction particularly in deep pockets ≥7 mm.[30]

IX. LANAP (LASER ASSISTED NEW ATTACHMENT PROCEDURE)

The epithelial lining of gingival sulcus and Junctional epithelium are removed in this procedure. It has been denoted that the retardation of epithelial down growth is seen, allowing further time for connective tissue attachment on the root surface after application of the laser. The inventors, Gregg and McCarthy framed a set of norms for LANAP. This was approved by FDA in 2004. Patients requiring distinctive periodontal therapy with pocket depth of ≥4 mm are specified for LANAP. A 1064 nm free running pulsed Nd: YAG is used for this(6W Periolase MVP)[31]

The procedure is as follows:

1. To begin with, the patient is anesthetized with a local anesthetic
2. A 0.3 to 0.4 μ diameter optic fiber tip is positioned parallel to the root surface, and is moved in a coronal to apical motion to carry away the epithelial lining of the pocket. The first pass laser scatters the energy at 4 w, free running 100 milliseconds pulse, driving out the unhealthy pocket lining.
3. Removal of calcified plaque attached to root surface is accomplished.
4. The diseased, infected epithelium of the pocket is removed sparing the connective tissue through selective photothermolysis
5. The second pass is done with energy dissipation at 4 w 650 milliseconds pulse. This creates an adhesive fibrin blood clot and continues healing from inside out.
6. Closure of the pocket is done by packing the gingival tissues against the root surface to create a firm fibrin clot.

Post-operative instructions are given. Patient recall is at 1 week, one month and subsequently every 3 months for maintenance.[32]

Histologic verification of the cases done under LANAP has clearly shown evidences of periodontal regeneration including new Cementum, new bone and periodontal ligament.[33] A case series for the management of Periodontitis using LANAP with A Nd: YAG Laser showed good histologic verification of periodontal regeneration on teeth considered to have a hopeless prognosis. A mean probing depth reduction of 5.4 ± 2.64 mm and mean clinical attachment level gain of 3.8 ± 2.38 mm was observed after follow-up of 9 months.[34] Harris et al in 2014 conducted a split mouth randomized multi centre study. He promoted that LANAP could yield a systemic effect on the wound healing subgingivally.[35]

X. LAPIP PROTOCOL

McCarthy introduced the model of LAPIP" Laser-assisted Peri-implantitis procedure" which can be used in ailing implants. The Laser used eliminates inflamed pockets, disturbing the biofilms and disinfects the implant surface. LAPIP procedure is executed on the implant without any detrimental effects to the implant. A Single appointment may be adequate to achieve the results.[36]

XI. LASER ASSISTED REGENERATION(LAR)

The application of Nd:YAG laser for the treatment of Periodontitis has been shown to enhance regeneration of bone and an overall betterment of clinical periodontal factors. Later, some studies were done giving rise to the concept acknowledged as "laser -assisted periodontal regeneration" (LAR)[37]

Yukna et al conducted a histological study on teeth which were treated with a laser-assisted regeneration (LAR) method. They showed that new attachment creation and regeneration of periodontal ligament and cementum was attainable after follow up of 12 weeks.[33]

Nammour et al did a clinical and bacterial study using a 980 nm diode laser along with 3% Hydrogen peroxide. There was a significant improvement in the CAL, and a reduction in the pocket depth.[38]

Laser assisted periodontal regeneration has a lot of potential as it involves usable surgical resources and minimally invasive character.

XII. PERI-IMPLANTITIS

A. NONSURGICAL TREATMENT OUTCOMES FOR PERI-IMPLANTITIS

Laser usage for the decontamination of implants has been deemed to enhance the nonsurgical outcomes compared to the mechanical debridement. Chambrone et al used antimicrobial photodynamic therapy (aPDT) in the treatment of periimplantis. aPDT presented comparable results to nonsurgical treatment.[39]

B. SURGICAL TREATMENT OUTCOMES FOR PERI-IMPLANTITIS

Laser is an efficient treatment for peri-implantis. Clem D and Gunsolley JC did a study using an Er: YaG laser for implant surface and defect debridement.1 year following the treatment, probing depths of 6 mm reduced to 3.5 mm and showed radiographic defect fill[40].

XIII. CONCLUSION

Lasers have the capability to invigorate cell activity, decrease the inflammation and enhance wound healing. Lasers offer an efficient and reliable option to the regular treatment methods for disruption of biofilm and removal of calculus. Surgical treatment with lasers is correlated with less pain than standard therapy. Laser therapy has shown increases in clinical attachment level and probing depth similar or slightly better than conventional therapy. As lasers tend to have a variety of tissue reactions, newer modalities of delivery and use of lasers is the need of the hour.

References:
1. Hajishengallis, G.; Chavakis, T.; Lambris, J.D. Current understanding of periodontal disease pathogenesis and targets for host-modulation therapy. Periodontol. 2000 2020, 84, 14–34
2. Sanz, M.; Herrera, D.; Kebschull, M.; Chapple, I.; Jepsen, S.; Berglundh, T.; Sculean, A.; Tonetti, M.S. Treatment of stage I–III periodontitis—The EFP S3 level clinical practice guideline. J. Clin. Periodontol. 2020, 47, 4–60.
3. Zander HA, Polson AM, Heijl LC. Goals of periodontal therapy. J Periodontol. 1976;47:261
4. Peng Q, Juzeniene A, Chen J, Svaasand LO, Warloe T, Giercksky K-E, Moan J. Lasers in medicine. Rep Prog Phys. 2008;71:056701
5. Maiman TH. Stimulated optical radiation in ruby masers. Nature 1960;187:493-494
6. Myers TD, Myers WD, Stone RM. First soft tissue study utilizing a pulsed Nd: YAG dental laser. Northwest Dent 1989 Mar-Apr; 68(2):14-7
7. Peng Q, Juzeniene A, Chen J, Svaasand LO, Warloe T, Giercksky K-E, Moan J. Lasers in medicine. Rep Prog Phys. 2008;71:056701
8. Gimbel CB. Hard tissue laser procedures. Dent Clin North Am. 2000;44(4):931-53
9. Kurihara E, Koseki T, Gohara K, Nishihara T, Ansai T, Takehara T. Detection of subgingival calculus and dentine caries by laser fluorescence. J Periodontal Res 2004;39: 59-65
10. Castellini p and Scalise L. tooth mobility measurement by laser doppler vibrometer. . Rev Sci Instrum. Vol 70. No 6 june 1999. 2850-2855
11. Aoki A, Sasaki KM, Watanabe H, Ishikawa I. Lasers in nonsurgical periodontal therapy. Periodontol. 2004;2000(36):59–97
12. Schwarz F, Sculean A, Berakdar M, Szathmari L, Georg T, Becker J. In vivo and in vitro effects of an Er:YAG laser, a GaAlAs diode laser, and scaling and root planing on periodontally diseased root surfaces: a comparative histologic study. Lasers Surg Med. 2003;32:359–66.
13. Eberhard J, Ehlers H, Falk W, Acil Y, Albers HK, Jepsen S. Efficacy of subgingival calculus removal with Er:YAG laser compared to mechanical debridement: an in situ study. J Clin Periodontol. 2003;30:511–8.
14. Li, M.M.; Jia, J.H.; Wu, M.X.; Zhao, C.Y.; Jia, L.Y.; Shi, H.; Zhang, X.L. Clinical effectiveness of Er, Cr: YSGG lasers in non-surgical treatment of chronic periodontitis: A meta-analysis of randomized controlled trials. Lasers Med. Sci. 2021, 36, 889–901
15. Mills, M.P.; Rosen, P.S.; Chambrone, L.; Greenwell, H.; Kao, R.T.; Klokkevold, P.R.; McAllister, B.S.; Reynolds, M.A.; Romanos, G.E.; Wang, H.-L. American Academy of Periodontology best evidence consensus statement on the efficacy of laser therapy used alone or as an adjunct to non-surgical and surgical treatment of periodontitis and peri-implant diseases. J. Periodontol. 2018, 89, 737–742.
16. Matsumoto K, Funai H, Shirasuka T & Wakabayashi H. Effects of Nd: YAG laser in the treatment of hypersensitive dentine. Japanese J Conserv Dent 1985;28:760-765.
17. Irvine JH. Root surface sensitivity: a review of aetiology and management. J NZ Soc Periodontol 1988; 66:15-18
18. Alves E, Faustino MA, Neves MG, Cunha A, Tome J, Almeida A. An insight on bacterial cellular targets of photodynamic inactivation. Future Med Chem. 2014;6:141–64
19. Akram Z, Al-Shareef SA, Daood U, Asiri FY, Shah AH, Alqahtani MA, Vohra F, Javed F. Bactericidal efficacy of photodynamic therapy against periodontal pathogens in periodontal disease: a systematic review. Photomed Laser Surg. 2016;34:137–49.
20. Fekrazad, R.; Khoei, F.; Bahador, A.; Hakimiha, N. Comparison of different modes of photo-activated disinfection against Porphyromonas gingivalis: An in vitro study. Photodiagn. Photodyn. Ther. 2020, 32, 101951.
21. Pourhajibagher, M.; Bahador, A. Exploring Photoactivated Disinfection-Induced Bystander Effects on Microbial Biofilms of Aggregatibacter actinomycetemcomitans. Infect. Disord. Drug Targets 2021, 21, 170721187710
22. Gandhi KK, Pavaskar R, Cappetta EG, Drew HJ. Effectiveness of adjunctive use of low-level laser therapy and photodynamic therapy after scaling and root planing in patients with chronic periodontitis. Int J Periodontics Restorative Dent. 2019;39:837–43
23. Zecha, J.AEM.; Raber-Durlacher, JE.; Nair RG.; Epstein,JB.; Sonis, ST.; Elad, S.; Hamblin MR.; Barasch, A.; Migliorati, CA.; Milstein, DM.J.; et al. Low level laser therapy/photobiomodulation in the management of side effects of chemoradiation therapy in head and neck cancer: Part 1: Mechanisms of action, dosimetric, and safety considerations. Support. Care Cancer 2016, 24, 2781–2792.
24. Zecha, J.A.E.M.; Raber-Durlacher, JE.; Nair, RG.; Epstein, JB.; Elad, S.; Hamblin, MR.; Barasch, A.; Migliorati, CA.; Milstein, DM.J.; Genot, MT.; et al. Low-Level laser therapy/photobiomodulation in the management of side effects of chemoradiation therapy in head and neck cancer: Part 2: Proposed applications and treatment protocols. Support. Care Cancer 2016, 24, 2793–2805.
25. Gokhale SR, Padhye AM, Byakod G, Jain SA, Padbidri V, Shivaswamy S. A comparative evaluation of the efficacy of diode laser as an adjunct to mechanical debridement versus conventional mechanical debridement in periodontal flap surgery: a clinical and microbiological study. Photomed Laser Surg. 2012;30:598–603.
26. Sculean A, Schwarz F, Berakdar M, Romanos GE, Arweiler NB, Becker J. Periodontal treatment with an Er:YAG laser compared to ultrasonic instrumentation: a pilot study. J Periodontol. 2004;75:966–7
27. Gaspirc B, Skaleric U. Clinical evaluation of periodontal surgical treatment with an Er:YAG laser: 5-year results. J Periodontol. 2007;78:1864–71.
28. Crespi R, Cappare P, Gherlone E, Romanos GE. Comparison of modified widman and coronally advanced flap surgery combined with CO2 laser root irradiation in periodontal therapy: a 15-year follow-up. Int J Periodontics Restorative Dent.

2011;31:641–51.
29. Dereci O, Hatipoglu M, Sindel A, Tozoglu S and Ustun K. The Efficacy of Er: Cr: YSGG laser supported periodontal therapy on the reduction of periodontal disease related malodor: a randomized clinical study. Head Face Med 2016;12:20
30. Vagdouti t, Theodoridis C, Tseleki G et al. Long-term clinical outcomes of Er: YAG or Er, Cr: YSGG lasers utilized as monotherapy or as adjuncts to mechanical theray in the treatment of chronic periodontitis: a systematic review. Laser Dent Sci 2023 ;7: 1-16
31. Nevins ML, Camelo M, Schupbach P, Kim SW, Kim DM, Nevins M. Human clinical and histologic evaluation of laser-assisted new attachment procedure. Int J Periodontics Restorative Dent. 2012;32:497–507
32. Gregg RH, McCarthy D. Laser periodontal therapy for bone regeneration. Dent today 2002;21(5):54-59
33. Yukna RA, Carr RL, Evans GH. Histologic evaluation of an Nd:YAG laser-assisted new attachment procedure in humans. Int J Periodontics Restorative Dent. 2007;27:577–87
34. Nevins ML, Camelo M, Schupbach P, Kim SW, Kim DM, Nevins M. Human clinical and histologic evaluation of laser-assisted new attachment procedure. Int J Periodontics Restorative Dent. 2012;32:497–507
35. Harris DM, Nicholson DM, Mccarthy D et al. Change in Clinical Indices following laser or scalpel treatment for Periodontitis: A split-mouth, Randomized, Multi-center trial. Proc SPIE Int Soc Opt Eng2014;8929: 89290G-I
36. Jha A, Gupta V, Adinarayan R. LANAP< Periodontics and Beyond: A review. J Lasers Med sci 2018;9(2): 76-81
37. Harris, DM.; Ii, RHG.; McCarthy, D.K.; Colby, LE.; Tilt, L.V. Sulcular debridement with pulsed Nd: YAG. In Lasers in Dentistry VIII; SPIE: San Francisco, CA, USA, 2002; Volume 4610, pp. 49–59
38. Nammour, S.; El Mobadder, M.; Maalouf, E.; Namour, M.; Namour, A.; Rey, G.; Matamba, P.; Matys, J.; Zeinoun, T.; GrzechLe´sniak, K. Clinical Evaluation of Diode (980 nm) Laser-Assisted Nonsurgical Periodontal Pocket Therapy: A Randomized Comparative Clinical Trial and Bacteriological Study. Photobiomodul. Photomed. Laser Surg. 2021, 39, 10–22.
39. Chambrone L, Wang HL, Romanos GE. Antimicrobial photodynamic therapy for the treatment of periodontitis and peri-Implantitis: an American Academy of Periodontology best evidence review. J Periodontol. 2018 b;89:783–803
40. Clem D, Gunsolley JC. Peri-implantitis treatment using Er:Yag laser and bone grafting. A prospective consecutive case series evaluation: 1 year posttherapy. Int J Periodontics Restorative Dent. 2019;39:479–89