Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.47750/jptcp.2023.30.06.015

Effect Of Root Planing With Er:Cr:YSGG In Comparison With Conventional Root Planing On Periodontitis Affected Teeth- An InVitro Histomorphometric And Scanning Electron Microscopic (SEM) Study

B.A.Deepika[1]*, Jaiganesh Ramamurthy[2], Chitra .S[3]

[1]Post graduate student, Department of Periodontics, Saveetha Dental college and Hospitals, Saveetha Institute of Medical and Technical Sciences , Saveetha University, Chennai, Tamilnadu , India

[2]Professor and Head, Department of Periodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical And Technical Sciences, Saveetha University, Chennai, Tamilnadu, India

[3]Assistant professor, Department of Biomaterials, Saveetha Dental College and Hospitals, Saveetha Institute of Medical And Technical Sciences, Saveetha University, Chennai, Tamilnadu, India

***Corresponding author:** B.A.Deepika, Post graduate student, Department of Periodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical And Technical Sciences, Saveetha University, Chennai, Tamilnadu, India, Email :deepikaba93@gmail.com

Submitted: 10 February 2023; Accepted: 25 March 2023; Published: 03 April 2023

ABSTRACT

Background: A laser is a device that produces light via an optical amplification process based on the stimulated emission of electromagnetic energy.Root planing is a procedure involving removal of dental plaque , calculus. It also produces smooth root surfaces . It also plains the exposed root surface . It also removes altered cementum.

Aim: The primary goal of this study is to compare the effects of Er:Cr:YSGG to traditional root planing in teeth which are extracted.

Materials And Method: A Total of 20extracted teeth was selected. In 10 extracted teeth, root planning was done with Er:Cr:YSGG with wavelength 2780nm and 10 other extracted teeth root planning was done with curette. Surface Irregularities were checked in stereomicroscope and then SEM analysis was done for the same .

Results: Root planing done with Conventional method shows better results when compared with Er:Cr:YSGG.However, the morphological data showed more irregularities were seen in laser when compared to hand instrumentation.

Conclusion: Root planing with Er:Cr:YSGG lasers as an adjuvant therapy can be effective in removing residual material from the root while having little or no detrimental thermal effect on the root surface, however the root surfaces showed increased surface imperfections. In addition, the Er:Cr:YSGG laser appears to be the best option for nonsurgical periodontal therapy. The study found that Er:Cr:YSGG lasers combined with root planing were successful in nonsurgical periodontal therapy.

Keywords: *Er:Cr:YSGG , NSPT, debridement - surface of root, Curettes ,Surface roughness, Stereomicroscope*

INTRODUCTION

Individual germs or groups of specialized microorganisms produce periodontitis, which is characterized as a gradual reduction in PDL (periodontal ligament)and loss of alveolar bone deterioration .It is accompanied by increasing probing pocket depth and also leads to gingival recession, or some times in results to both. The presence of clinically evident attachment loss as a clinical characteristic distinguishes periodontal disease from gingival diseases.Periodontal pocket formation and alterations in the density and height of the subjacent alveolar bone are usually associated with tooth loss. If just probing depth data is collected without clinical attachment levels being measured, recession of the marginal gingiva may occur, masking disease development. Inflammation is marked by changes in colour, shape, and consistency, as well as bleeding.

Every periodontal therapy requires scaling, and smooth root surfaces have long been regarded as the ultimate aim of the preliminary phase for all the periodontitis therapies. [1] The main aim of Phase I [Non-surgical periodontal treatments (NSPTs)] was to eliminate bacterial deposits and establish a relatively smooth root surface to speed cell adhesion and growth. Debridement of the root surface was traditionally done with a hand curette and ultrasonic instruments.[2]While scaling is uniquely sufficient to get rid of dental calculus and dental biofilm from the surface of tooth enamel. It results in a glossy smooth surface and shiny , polished ,cleansed surface of the tooth . It also removes calculus on the root surface and is typically entrenched in cementum irregularities. As a result, scaling alone isn't enough to get rid of it. [3]

SRP (Scaling and root planing) main aim is to promote attachment of new connective tissue all over the tooth i.e., by removing the lining of the periodontal pocket wall and junctional epithelium. [4] Despite the fact that SRP lowers periodontal inflammation to some extent, it is difficult to entirely eliminate periodontal disease. [5]

The following are some of the specific reasons for Phase I SRP (scaling and root planing)

Dental Plaque , Calculus removal (both an objective and a primary measure of the success of initial therapy). Endotoxin-infected root cementum should be removed with caution. To see how far nonsurgical therapy can help with healing and pocket reduction. In order to minimize inflammation in the days leading up to surgery. [6] Scaling and root planing eliminates plaque and calculus from beneath the gum line, breaks the dental biofilm, and cleans the root surface of microbial byproducts. Effective nonsurgical therapy, one of the most popular periodontal procedures, necessitates thorough instrumentation of periodontal pockets.

The removal of supra- and subgingival bacterial deposits can be accomplished using SRP(scaling and root planing). [7] Conventional instruments (Hand), ultrasonic and sonic scalers were compared, but there was no evident benefit for the machine-driven instruments. [8] When analyzing ultrasonic instrumentation, the employment of conventional instruments (i.e., traditional Area specific curettes) yielded even greater gains in several parameters.(e.g., bleeding on probing). [9] Traditional area specific curettes may result in more material damage besides considerably eliminating the calculus from the tooth surface while the sonic and ultrasonic devices result in less tooth material damage. [10,11,12] It also provides shiny smooth surfaces of the tooth root. [8,13,14]

The abbreviation "laser" stands for " Amplification of light by energizing with release of radiation." The Beam of the laser will be narrowed and tightly focused across a prolonged interval. It is discharged by an apparatus that releases spatially coherent and collimated light. When directed at tissues, several interactions occur. The reflection,transmission, scattering and absorption of laser light are all affected by the wavelength of the laser and the qualities of the tissue. [15] Laser therapy is used in periodontology for surgical therapy, nonsurgical treatment of periodontal beginning disease, and pathological changes in all periodontal diseases. [16]

Lasers are considered as an addition to standard SRP (scaling and root planing) in periodontal pockets. Some researchers recommended an increase in root surface harmony and ease for fibroblast cell adherence.[17] When a laser is used in periodontology, the following benefits can be incorporated into the treatment: greater patient comfort, less bleeding, [18,19] improved access to complicated anatomical areas, and biostimulation of the healing process. For nonsurgical periodontal therapy pockets of up to 8–10 mm,and Nd:YAG (erbium-doped yttrium/aluminum/garnet) Er:YAG (erbium-doped yttrium/aluminum/garnet) lasers have been utilized. [16]

Clinical use of an Er:YSGG laser resulted in a cleansed surface of root harmony even at higher energy settings, implying that dental calculus elimination could be done selectively. The Er:YSGG laser's efficiency on the root surface for scaling and root planing was tested on extracted teeth under optimum conditions. It includes water cooling, obvious control of laser tip and surface tilt. It also determines the control of dental calculus and dental plaque elimination.Many factors can interfere with Er:YSGG laser root debridement in periodontal deep pockets. It can be done with water irrigation, by interchanging the working tip of the laser. It also can be done by maintaining the correct angulation on the surface of roots, and acceleration of fiber during strokes of SRP. It also deals with the operator's potential to proceed with complete circumference into the periodontal deep pocket by using the tip of the laser.

Little pain,Little necessity for anesthetics which is a benefit for medically compromised patients. These are some of the benefits of employing lasers in periodontal therapy. Bacteremia is not a concern. There is no scar tissue formation as a result of the excellent wound healing. Control of bleeding depends on the power settings and wavelength of the laser. The need for Sutures are rarely required. There are fewer equipment and materials to use, and no autoclaving is required which is an economic advantage. Lasers can remove the hard as well as soft tissues. Scalpels and lasers can be used together. [20]

Our team has extensive knowledge and research experience that has translated into high quality publications1–10 . The primary goal of this research is to compare the effects of root planing with Er:Cr:YSGG Laser to traditional root planing (curettes) in removed teeth (extracted teeth).

MATERIALS AND METHODS

The Study Design is In Vitro study.The study takes place at the Department of periodontics, Saveetha Dental College And Hospitals. The Inclusion criteria are as follows: Teeth that have been extracted due to periodontal disease,Teeth with root surface calculus was selected. The Exclusion criteria are as follows: Teeth with caries, Teeth with restoration, Teeth with fracture lines on root surface, Teeth where endodontic treatment was done.

A total of 20 extracted teeth were included in the study with the above inclusion and exclusion criteria. The Study Group is divided in to two Groups 1&2.

Group 1: Root planing done with curette - 10 Teeth (shown in figures 1-3)

FIGURE 1: The image shows the tooth - before root planing with curettes

FIGURE 2: The image shows the tooth - Root Planing with Curette

FIGURE 3: The image shows the tooth- after Root Planing done with Curette

Group 2: Root planing done with Laser (Er:Cr:YSGG) - 10 Teeth
(shown in figures4-6)

FIGURE 4: The image shows the tooth - before Root Planing with Er:Cr:YSGG Laser 2780nm

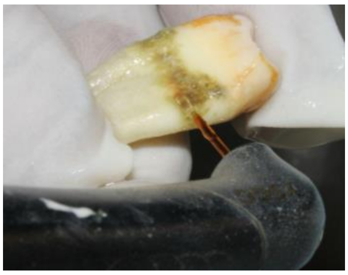

FIGURE 5: The image shows the tooth- Root Planing with Laser

FIGURE 6: The image shows the tooth-after Root Planing done with Er:Cr:YSGG Laser 2780nm

In Group 1 Root planing was done with Hand Instruments.Root planing was done with conventional method with curettes. Root planing was executed by 1 examiner using conventional curettes (Gracey curettes).Gracey curettes were used to eliminate dental calculus and unhealthy cementum. In group 1, the surface of the root is planned 4 times with Conventional curettes (Gracey curettes) .

In Group 2 - The Root Planing done with Er:Cr:YSGG Laser.Root planing was done with Er:Cr:YSGG .An Er:Cr:YSGG laser system wavelength 2780nm was used at 140 mJ/pulse energy level.Using a chisel-shaped fiber quartz tip and a handpiece in contact mode under water irrigation, the Er:Cr:YSGG laser beam was released into the deep periodontal pockets. The beam of laser was engrossed ahead of the 10 mm vertical axis of the quartz tip. The beam of the laser has a diameter of 400 m. Starting from root apex to the CEJ(cemento-enamel junction) horizontal movements were used to finalize the procedure. Surface irregularities were checked under stereomicroscope and evaluated (shown in figures 7,8)

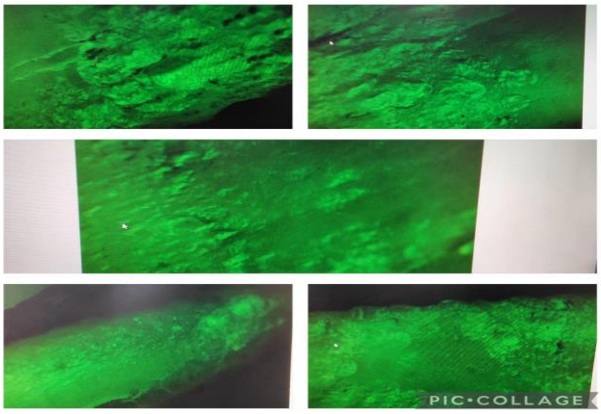

FIGURE 7: The image shows Root Planing done with Er:Cr:YSGG laser with 2780nm under stereomicroscope.

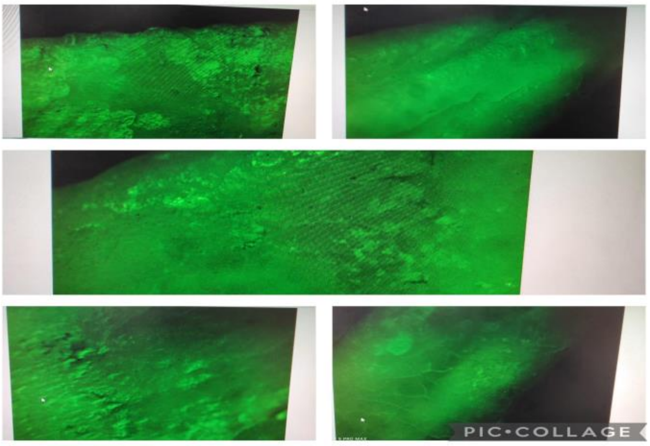

FIGURE 8: The image shows Root Planing done with Curette under stereomicroscope.

In Materials Characterization Section the Selected groups of specimens were processed to analyze the morphological variations via electron microscopy. JEOL JSM-IT 800 Field-Emission Scanning Electron Microscope (FESEM) was employed to explore the morphological changes. To induce the conductivity platinum was coated on the surface of the specimens for 30 sec. Further images were captured at 100 μm and 10 μm to comparatively analyze the impact in conventional curette and Er,Cr:YSGG laser treated specimens respectively (shown in figure 9)

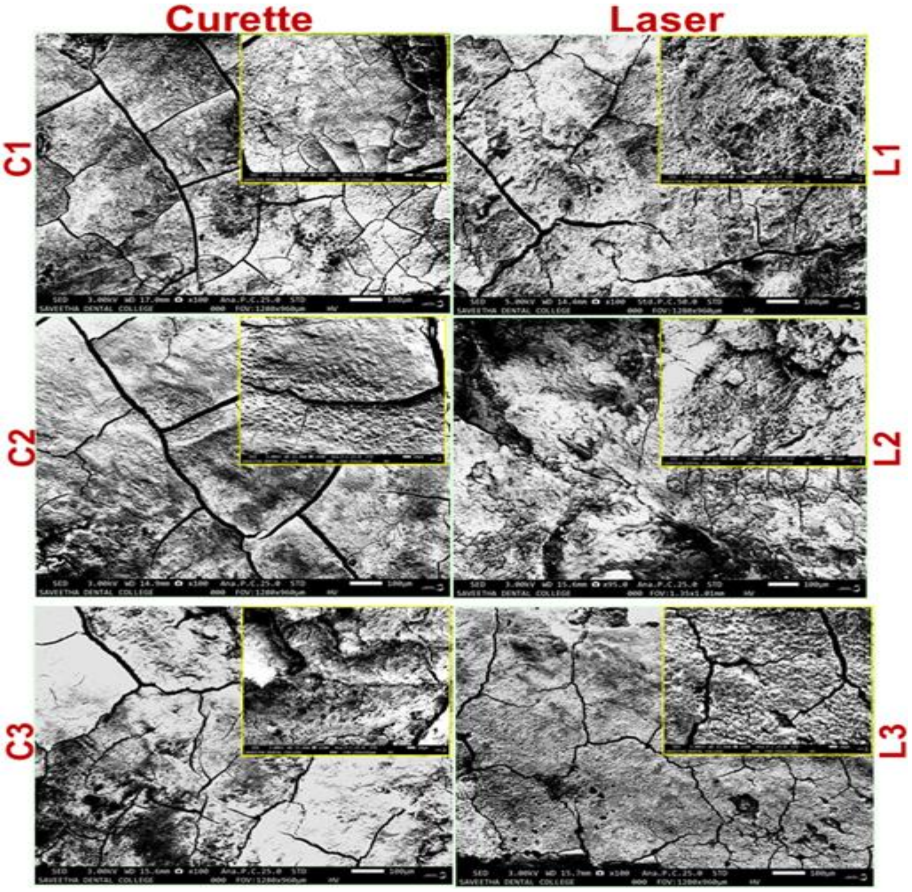

FIGURE 9: Field-Emission Scanning Electron Microscopic (FE-SEM) images explicates the morphological variations in conventional curette (curette) and Er,Cr:YSGG laser (laser) treated teeth samples to evaluate the root planning. Inserted with 10 µm images at the same site of interest.

RESULTS

On Root surface evaluation -The Root surface changes were estimated by stereomicroscope are shown in figure 7,8. On Evaluation by stereomicroscope the teeth were kept under stereomicroscopy and the images of the stereomicroscope (figure 7,8) illustrate that both treatments were well organized in eliminating dental calculus from the surfaces of the root. The root surface treated with conventional hand curettes groups showed a smoother surface when compared to groups that were treated with laser. Morphology of teeth was calculated manually and based on strikes present on the teeth it is described as +,++,+++ are shown in table 1 .

On Evaluation by SEM The Traditional hand curette and ultrasonic based equipment were also in trend for root exterior debridement. Some clinical practitioners trust that manual treatment leads meticulously to removal of surfaces; on the other hand, some people specified that ultrasonic technological devices may damage surfaces. In this direction, Er,Cr:YSGG laser essence remedy for dental plaque and dental calculus; this increases the mechanical damage (fig 9) that impacts in incredible trauma, decreases healing time and causes postoperative complications in patients compared to conventional treatments.

DISCUSSION

Periodontal disease is defined as multifactorial disease of supporting tissue of the teeth by particular microorganisms that leads to the progressive deterioration of the PDL (periodontal ligament) and alveolar bone. It leads to deep periodontal pocket development, and gingival recession. It also sometimes leads to periodontal pocket formation and gingival recession. Periodontitis is a bacterial disease that destroys the gingiva as well as the alveolar bone which supports the teeth. It is produced by germs found in the dental plaque that attaches to the tooth surface.

The existence of a periodontal pocket, which is defined as a pathologically deepened sulcus of the gingiva, which is predominant clinical indication of periodontal disease.It causes destruction to supporting tissues of the periodontium which leads the teeth to loosen and exfoliate. Periodontal pockets' root surface walls frequently experience considerable modifications, which can prolong the infection in the periodontium. It also leads to pain, and entangles periodontal therapy.

Cementitious changes can be classed as structural, chemical, or cytotoxic. Changes in structure: Pathologic granules are present, Mineralization hotspots include: Hypermineralization occurs when organic components and minerals are exchanged at site of cementum-saliva interface as a result of exposure to the mouth cavity.

Demineralization zones include: Hypomineralization is frequently associated with root caries. The mineral composition of the exposed cementum increases as a result of chemical reactions. Calcium, magnesium, phosphorus, and fluoride, for example. Microhardness, on the other hand, does not vary. Bacterial endotoxins have been found in the cementum of periodontally affected teeth that have not been treated. Resorption in Areas of cellular cementum and dentin are common in roots that are not impacted by periodontal disease.

Surface morphology of the tooth wall : Cementum coated with calculus,Plaque affixed Zone of plaque adhesion to the tooth, Zone of plaque attachment to the tooth, Zone of plaque attachment to the tooth, Zone of plaque attachment to the tooth, Zone of plaque attachment to the tooth, Zone of plaque attachment to the tooth, Zone of plaque attachment to the tooth A zone of connective tissue fibers that have been partially damaged. The exchange of organic components and minerals at the site of cementum-saliva interface occurs as a result of exposure to the mouth cavity.

The chemical and physical properties of periodontal pathogen-affected root surfaces showed significant alterations. Clinical fresh connective tissue attachment, on the other hand, can be used to reduce pocket depth and remove ecological niches. [20] In nonsurgical periodontal therapies, the entire technique must generate a biocompatible root surface and a preferred base for gingival fibroblast reattachment. [21]

During NSPTs, a variety of equipment and therapeutic protocols are used to remove bacterial deposits and necrotic cementum. In clinics, the traditional method of utilizing hand curettes and ultrasonic instruments has been widely used. Adjunctive usage of various lasers are employed such as ; Nd:YAG, Er:YAG, Er,Cr:YSGG, and diode lasers have been reported by some writers to have some extra benefits on clinical outcomes. [22] Besides some lasers , insist that laser-assisted NSPTs showed no substantial improvement .[23]

Several laser technologies have been proposed as possible replacements for traditional hand tools. The Er: YAG and Er,Cr:YSGG lasers seem to be capable of eliminating subgingival calculus at levels comparable to ultrasonic scalers and hand instruments without causing thermal side effects . [24-27]

In comparison to conventional instrumentation or chemically managed tooth surfaces, Crespi et.al, and Pant et.al, showed greater fibroblast adhesion to CO2 laser–treated surfaces.They discovered that root surfaces which are affected by periodontal disease managed with the Er:Cr:YSGG laser or by direct conventional maneuver are biocompatible for the adherence of human PDL fibroblasts. The diseased root surfaces which are not treated obstruct biocompatibility of the cell. They studied the outcomes of surface alterations caused by the Er:Cr:YSGG laser at different settings and conventional instrumentation on the behaviour of Periodontal ligament cells (PDL)cells. This in vitro study implies that RP using a Gracey curette could be replaced by utilizing an Er:

Cr:YSGG laser in H mode that is in short-pulse length.This Er:Cr:YSGG laser setting is never good for cell adhesion and cell migration. It also boosts the amount of cells that can develop into periodontal regeneration cells. [28,29]

Even at higher energy set up, Schwarz et al illustrated that using an Er:YAG laser proceeds into a smoother surface.[30] Folwaczny et al. established that roughness of surface is independent of radiation energy and working tip angulation. [31]

Ting et al. evaluated the structural modifications of root surfaces. The efficacy of dental calculus elimination by using Er:Cr:YSGG lasers . Er:Cr:YSGG laser with varying power outcomes (0.5 W, 1 W, 1.5 W, and 2 W). They found that a 1 W power outcome was adequate for SRP (scaling and root planing). They also found that the 2 W power outcome was significantly more effective in removing dental calculus but caused considerable structural changes to the surface of the root.They demonstrated that the Er:Cr:YSGG laser might be used to scale roots without causing morphologic changes and to eliminate calculus. [32]

Feist et al demonstrated adhesion and growth of cultured human gingival fibroblasts on root surfaces treated with Er:YAG laser irradiation or hand instruments . They were compared to determine the biocompatibility of Er:YAG laser-treated root surfaces. Positive results were obtained on surfaces managed with 60 mJ/pulse. Surfaces treated with conventional root planing or 100 mJ/pulse laser irradiation stimulated faster adhesion and growth than Er:YAG laser irradiated surfaces. Irradiation done by using Er:YAG laser. [33] When compared to traditional SRP with curettes, Romanos et al. found that conventional instrumentation of periodontal tissues in accordance with diode laser treatment resulted in full eradication of pocket epithelium. [34]

According to Nivetha G, Jaiganesh R, et al., The employment of the laser showed to be an essential instrument for increasing the effectiveness, specificity,attentiveness, ease, value, and consolation for treatment in dentistry. Hard tissue lasers, when used in conjunction with a microscope and its magnification, made the process simple for restorative operative treatment and microsurgical procedures. Laser flexibility showed a wide range of implementation in restorative operative dentistry and miniature oral surgical procedures. [35]

Intention of this investigation was to study the detailed morphological aspects of the tooth after treatment with laser and conventionally assisted parameters via field-emission scanning electron microscopy. Initially stereomicroscopic images show that laser treated specimens showed higher surface eruptions than the conventionally treated groups, to reconfirm that electron microscopic images were captured and analyzed. Laser treated groups showed lesser splits in 100 µm scale; on the contrary, micro-structural irregularities were noted in 10 µm, which indicates minute damage on the surface. All the three laser-treated micrographs enumerated deep crest and trough-like structural patterns that indicated rapid damage on the surface. Alternatively, conventionally treated groups exhibited more split-ups in lower magnification (100 µm); however, narrowing down into the higher magnification (10 µm) the surface was not evidently damaged and this eruption is very minimal compared to laser treated teeth groups.

It is reported that the Erbium group of laser sources have the potentiality to remove hard bacterial deposits. Clinicians use high energy lasers for the removal of calculus and this high energy may induce heating as a result of which pits, fissures and cracks may produce. Er,Cr:YSGG laser works by emitting high energy light at the wavelength of 2790 nm, it is difficult to withstand this high energy by both soft and hard tissue, this may create lesions on the exposed area . High energy laser sources typically damage the micro structural surface of the tooth and may end up with severe lesions. The core damage in tubular structure is evidently visible from the obtained electron micrographs. Hence, based on the literary knowledge and the current results it can be concluded that conventionally treatment is a better choice of methodology for root planing than the Er:Cr:YSGG laser therapy owing to the severe damage in micro structure of tooth.

CONCLUSION

Our research found that root planing with conventional hand equipment produced superior clinical results than SRP(root planing)using the Er:Cr:YSGG laser. As a result, root surface roughness can be reduced using an Er:Cr:YSGG laser with a wavelength of 2780nm as an adjuvant therapy to standard root planing. However, when compared to hand instrumentation, the morphological data revealed more abnormalities. As an additional therapy, root planing (SRP) with Er:Cr:YSGG lasers can be efficient in eliminating residual debris from the surface of the roots while having small or no detrimental thermal effect on the root surface. In addition, the Er:Cr:YSGG laser is the best option for NSPT (nonsurgical periodontal therapy). The study found that Er:Cr:YSGG lasers combined with root planing were successful in nonsurgical periodontal therapy.

REFERENCES

1. Lopes BM, Theodoro LH, Melo RF, Thompson GM, Marcantonio RA. Clinical and microbiologic follow-up evaluations after non-surgical periodontal treatment with erbium: YAG laser and scaling and root planing. J Periodontol 2010;81:682-91.
2. Herrero A, García-Kass AI, Gómez C, Sanz M, García-Nuñez JA. Effect of two kinds of Er: YAG laser systems on root surface in comparison to ultrasonic scaling: an in vitro study. Photomed Laser Surg 2010;28:497-504.
3. Crespi R, Covani U, Margarone JE, Andreana S. Periodontal tissue regeneration in beagle dogs after laser therapy. Lasers Surg Med 1997;21:395-402.
4. American Academy of Periodontology. The American Academy of Periodontology statement regarding gingival curettage. J Periodontol 2002;73:1229-30.
5. Worthington HV, Clarkson JE, Bryan G, Beirne PV. Routine scale and polish for periodontal health in adults. Cochrane Database Syst Rev 2013
6. EDEN BD. Prevention strategies for periodontal diseases. Prevention in Clin Oral Health Care. 2008;1:213-29.
7. Apatzidou DA, Kinane DF. Nonsurgical mechanical treatment strategies for periodontal disease. Dent Clin North Am 2010;54:1-2.
8. Tunkel J, Heinecke A, Flemmig TF. A systematic review of efficacy of machine-driven and manual subgingival debridement in the treatment of chronic periodontitis. J Clin Periodontol 2002;29:72-81.
9. Christgau M, Männer T, Beuer S, Hiller KA, Schmalz G. Periodontal healing after non-surgical therapy with a new ultrasonic device: a randomized controlled clinical trial.J Clin Periodontol 2007;34:137-47.
10. Schmidlin PR, Beuchat M, Busslinger A, Lehmann B, Lutz F. Tooth substance loss resulting from mechanical, sonic and ultrasonic root instrumentation assessed by liquid scintillation. J Clin Periodontol 2001;28:1058-66.
11. Kocher T, Langenbeck M, Rühling A, Plagmann HC. Subgingival polishing with a teflon-coated sonic scaler insert in comparison to conventional instruments as assessed on extracted teeth: (I) Residual deposits. J Clin Periodontol 2000;27:243-9.
12. Braun A, Krause F, Frentzen M, Jepsen S. Efficiency of subgingival calculus removal with the Vector™-system compared to ultrasonic scaling and hand instrumentation in vitro. J Periodontal Res 2005;40:48-52.
13. Kishida M, Sato S, Ito K. Comparison of the effects of various periodontal rotary instruments on surface characteristics of root surface. J Oral Sci 2004;46:1-8.
14. Sisera M, Hofer DJ, Sener B, Attin T, Schmidlin PR (2009) In vitro evaluation of three curettes with edge retention technology after extended use. Schweiz Monatsschr Zahnmed 119:1200–1208
15. Gross AJ, Herrmann TR. History of lasers. World J Urol 2007;25:217-20.
16. Agoob Alfergany M, Nasher R, Gutknecht N. Calculus removal and root surface roughness when using the Er: YAG or Er, Cr: YSGG laser compared with conventional instrumentation method: a literature review. Photobiomodul Photomed Laser Surg. 2019;37:197-226.
17. Maruyama H, Aoki A, Sasaki KM, Takasaki AA, Iwasaki K, Ichinose S, Oda S, Ishikawa I, Izumi Y. The effect of chemical and/or mechanical conditioning on the Er: YAG laser-treated root cementum: Analysis of surface morphology and periodontal ligament fibroblast attachment. Lasers Surg Med. 2008;40:211-22.
18. Romanos GE. Clinical applications of the Nd: YAG laser in oral soft tissue surgery and periodontology. J Clin Laser Med Surg 1994;12:103-8.

19. White JM, Goodis HE, Rose CL. Use of the pulsed Nd: YAG laser for intraoral soft tissue surgery. Lasers Surg Med 1991;11:455-61.
20. Romanos G. Current concepts in the use of lasers in periodontal and implant dentistry. J Indian Soc Periodontol 2015;19:490.
21. Vadivel JK, Govindarajan M, Somasundaram E, Muthukrishnan A. Mast cell expression in oral lichen planus: A systematic review. J Investig Clin Dent. 2019 Nov;10(4):e12457.
22. Panda S, Jayakumar ND, Sankari M, Varghese SS, Kumar DS. Platelet rich fibrin and xenograft in treatment of intrabony defect. Contemp Clin Dent. 2014 Oct;5(4):550–4.
23. Mehta M, Dhanjal DS, Paudel KR, Singh B, Gupta G, Rajeshkumar S, et al. Cellular signalling pathways mediating the pathogenesis of chronic inflammatory respiratory diseases: an update. Inflammopharmacology. 2020 Aug;28(4):795–817.
24. Venkatesan J, Singh SK, Anil S, Kim SK, Shim MS. Preparation, Characterization and Biological Applications of Biosynthesized Silver Nanoparticles with Chitosan-Fucoidan Coating. Molecules [Internet]. 2018 Jun 12;23(6). Available from: http://dx.doi.org/10.3390/molecules23061429
25. Bhansali KJ, Balinge KR, Raut SU, Deshmukh SA, Senthil Kumar M, Ramesh Kumar C, et al. Visible light assisted sulfonic acid-functionalized porphyrin comprising benzimidazolium moiety for photocatalytic transesterification of castor oil. Fuel. 2021 Nov 15;304:121490.
26. Deepanraj B, Senthilkumar N, Mala D, Sathiamourthy A. Cashew nut shell liquid as alternate fuel for CI engine—optimization approach for performance improvement. Biomass Conversion and Biorefinery. 2022 May 1;12(5):1715–28.
27. Kamath M, Rao SK, Jaison, Sridhar, Kasthuri, Gopinath, et al. Melatonin delivery from PCL scaffold enhances glycosaminoglycans deposition in human chondrocytes – Bioactive scaffold model for cartilage regeneration. Process Biochem. 2020 Dec;99:36–47.
28. Paramasivam A, Priyadharsini JV. Novel insights into m6A modification in circular RNA and implications for immunity [Internet]. Vol. 17, Cellular & Molecular Immunology. 2020. p. 668–9. Available from: http://dx.doi.org/10.1038/s41423-020-0387-x
29. Li Z, Veeraraghavan VP, Mohan SK, Bolla SR, Lakshmanan H, Kumaran S, et al. Apoptotic induction and anti-metastatic activity of eugenol encapsulated chitosan nanopolymer on rat glioma C6 cells via alleviating the MMP signaling pathway [Internet]. Vol. 203, Journal of Photochemistry and Photobiology B: Biology. 2020. p. 111773. Available from: http://dx.doi.org/10.1016/j.jphotobiol.2019.111773
30. Nambi G, Kamal W, Es S, Joshi S, Trivedi P. Spinal manipulation plus laser therapy versus laser therapy alone in the treatment of chronic non-specific low back pain: a randomized controlled study. Eur J Phys Rehabil Med. 2018 Dec;54(6):880–9.
31. Hakki SS, Korkusuz P, Berk G, Dundar N, Saglam M, Bozkurt B, Purali N. Comparison of Er, Cr: YSGG laser and hand instrumentation on the attachment of periodontal ligament fibroblasts to periodontally diseased root surfaces: an in vitro study. J Periodontol 2010;81:1216-25.
32. Ishikawa I, Aoki A, Takasaki AA. Clinical application of erbium: YAG laser in periodontology. J Int Acad Periodontol 2008;10:22-30.
33. Rotundo R, Nieri M, Cairo F, Franceschi D, Mervelt J, Bonaccini D, Esposito M, Pini-Prato G. Lack of adjunctive benefit of Er: YAG laser in non-surgical periodontal treatment: a randomized split-mouth clinical trial. J Clin Periodontol 2010;37:526-33.
34. Crespi R, Barone A, Covani U. Er: YAG laser scaling of diseased root surfaces: a histologic study. J Periodontol 2006;77:218-22.
35. Maruyama H, Aoki A, Sasaki KM, Takasaki AA, Iwasaki K, Ichinose S, Oda S, Ishikawa I, Izumi Y. The effect of chemical and/or mechanical conditioning on the Er: YAG laser-treated root cementum: Analysis of surface morphology and periodontal ligament fibroblast attachment. Lasers Surg Med. 2008;40:211-22.
36. Crespi R, Barone A, Covani U. Effect of Er: YAG laser on diseased root surfaces: An in vivo study. J Periodontol 2005;76:1386-90.
37. Noori ZT, Fekrazad R, Eslami B, Etemadi A, Khosravi S, Mir M. Comparing the effects of root surface scaling with ultrasonic instruments and Er, Cr: YSGG laser. Lasers Med Sci 2008;23:283-7.
38. Crespi R, Barone A, Covani U, Ciaglia RN, Romanos GE. Effects of CO2 laser treatment on fibroblast attachment to root surfaces. A scanning electron microscopy analysis. J Periodontol 2002;73:1308-12.
39. Pant V, Dixit J, Agrawal AK, Seth PK, Pant AB. Behavior of human periodontal ligament cells on CO2 laser irradiated dentinal root surfaces: An in vitro study. J Periodontal Res 2004;39:373-9.

40. Schwarz F, Pütz N, Georg T, Reich E. Effect of an Er: YAG laser on periodontally involved root surfaces: an in vivo and in vitro SEM comparison. Lasers Surg Med 2001;29:328-35.
41. Folwaczny M, George G, Thiele L, Mehl A, Hickel R. Root surface roughness following Er: YAG laser irradiation at different radiation energies and working tip angulations. J Clin Periodontol 2002;29:598-603.
42. Ting CC, Fukuda M, Watanabe T, Aoki T, Sanaoka A, Noguchi T. Effects of Er, Cr: YSGG laser irradiation on the root surface: morphologic analysis and efficiency of calculus removal. J Periodontol 2007;78:2156-64.
43. Feist IS, De Micheli G, Carneiro SR, Eduardo CP, Miyagi SP, Marques MM. Adhesion and growth of cultured human gingival fibroblasts on periodontally involved root surfaces treated by Er: YAG laser. J Periodontol 2003;74:1368-75.
44. Romanos GE, Henze M, Banihashemi S, Parsanejad HR, Winckler J, Nentwig GH. Removal of epithelium in periodontal pockets following diode (980 nm) laser application in the animal model: an in vitro study. Photomed Laser Surg 2004;22:177-83.
45. Nivetha G, Ramamurthy J. Hard tissue laser applications in dentistry-A review. Drug Invention Today. 2019;1;11.

TABLE 1: The table depicts the surface irregularities under stereomicroscope done by curettes and by Er:Cr: YSGG laser

Curette	Er:Cr:YSGG laser
++	+++
+	+++
++	++
++	+
+	++
++	+++
+	+++
++	++
++	+
+	++