

Current Applications of Er:YAG Lasers in Periodontal Therapy: A Review

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Abstract

Aim: To review the current evidence regarding the clinical applications, biological effects, and therapeutic value of the Er:YAG laser as an adjunct in periodontal therapy. **Background:** Periodontitis is a chronic inflammatory disorder characterized by progressive destruction of the tooth-supporting tissues. Although scaling and root planing remains the foundation of periodontal treatment, complete debridement is often difficult in deep pockets and anatomically complex sites. Because the Er:YAG laser is highly absorbed by water and hydroxyapatite, it enables precise removal of diseased tissues and deposits while minimizing thermal injury to adjacent structures. **Methods:** A narrative review of the literature was performed using PubMed, Scopus, and Google Scholar. Experimental studies, randomized clinical trials, systematic reviews, and relevant case reports evaluating the use of Er:YAG lasers in periodontal therapy were critically assessed. **Results:** The reviewed evidence indicates that Er:YAG laser therapy facilitates effective root surface debridement, microbial reduction, and removal of inflamed tissues. Clinical investigations have reported improvements in probing depth, clinical attachment level, postoperative healing, and patient comfort. Experimental findings also suggest favorable effects on cellular activities associated with periodontal regeneration. **Conclusion:** Current evidence supports the use of the Er:YAG laser as a useful adjunct to conventional periodontal therapy. While encouraging clinical and biological outcomes have been reported, further well-designed long-term studies are required before standardized treatment recommendations can be established.

Keywords: Er:YAG laser, periodontitis, periodontal therapy, scaling and root planing, periodontal regeneration.

I. INTRODUCTION

Periodontitis is a multifactorial inflammatory disease initiated by an imbalance between the host immune response and a dysbiotic subgingival biofilm, leading to progressive destruction of the periodontal ligament, alveolar bone, and other supporting structures of the teeth. If left untreated, continued tissue breakdown may ultimately result in tooth mobility and tooth loss, making effective disease control a primary objective of periodontal therapy.[1,2]

Conventional non-surgical periodontal treatment, particularly scaling and root planing (SRP), remains the cornerstone for managing periodontitis by disrupting the microbial biofilm and removing calculus deposits from root surfaces. Although SRP is highly effective, complete debridement may be difficult in deep periodontal pockets, furcation areas, root concavities, and other anatomically complex sites, where residual deposits and microorganisms can compromise treatment outcomes.[2]

To overcome these limitations, numerous adjunctive approaches have been investigated, including systemic and locally delivered antimicrobials, photodynamic therapy, ozone therapy, probiotics, and laser-assisted periodontal treatment. Each modality offers specific advantages; however, none has completely eliminated the challenges associated with conventional mechanical instrumentation.[3–5]

Laser technology has become an important adjunct in contemporary periodontal practice because it enables precise removal of diseased tissues while simultaneously providing antimicrobial effects and favorable wound healing conditions. Depending on the wavelength and tissue interaction, dental lasers may facilitate debridement, improve hemostasis, reduce postoperative discomfort, and influence cellular responses involved in tissue repair. These characteristics have expanded their use in both non-surgical and surgical periodontal procedures.[6]

Among the currently available laser systems, the erbium-doped yttrium aluminium garnet (Er:YAG)

laser has attracted considerable attention because its wavelength is highly absorbed by water and hydroxyapatite, allowing efficient treatment of both soft and hard periodontal tissues with limited collateral thermal injury. In addition to its debridement capabilities, growing evidence indicates that Er:YAG laser therapy may support biological processes associated with periodontal healing and regeneration. Accordingly, this review summarizes the mechanisms of action, biological effects, clinical applications, advantages, limitations, and current evidence regarding the use of Er:YAG lasers in periodontal therapy.

II. MATERIALS AND METHODS

A narrative review was undertaken to evaluate the current evidence regarding the use of erbium lasers in periodontal therapy. A comprehensive literature search was performed using PubMed, Scopus, and Google Scholar to identify relevant publications.

The search strategy incorporated combinations of the terms "Er:YAG laser," "Er,Cr:YSGG laser," "periodontitis," "periodontal therapy," "scaling and root planing," "periodontal regeneration," and "laser-assisted periodontal surgery." Reference lists of selected publications were also screened to identify additional relevant studies.

Peer-reviewed articles, including randomized controlled trials, clinical studies, systematic reviews, experimental investigations, and well-documented case reports, were considered for inclusion. Publications addressing laser-tissue interactions, biological effects, regenerative potential, clinical applications, treatment outcomes, and limitations of erbium lasers in periodontology were reviewed.

The collected evidence was critically evaluated and synthesized to summarize the mechanisms of action, therapeutic applications, reported clinical outcomes, advantages, and current limitations associated with Er:YAG laser therapy in periodontal practice.

III. RESULTS

Analysis of the selected literature indicates that erbium lasers have a wide range of periodontal applications. Their affinity for water-rich tissues and hydroxyapatite enables efficient management of soft tissue lesions, root surfaces, calculus deposits, bone defects, and implant-related conditions.

Experimental evidence suggests that laser irradiation may support cellular functions involved in healing and regeneration. In contrast, clinical studies have demonstrated improvements in periodontal parameters, including reductions in probing depth, attachment gain, and patient-reported comfort.[28-47]

In addition, Er:YAG lasers have been successfully incorporated into conventional surgical procedures, regenerative therapies, and minimally invasive

treatment approaches. Although the available findings are encouraging, additional long-term clinical investigations are required to strengthen the evidence base and establish standardized treatment recommendations.

IV. TISSUE INTERACTIONS

The clinical effects of dental lasers are determined by the way laser energy is absorbed by tissue components such as water, hydroxyapatite, and pigments. Differences in absorption characteristics influence the depth of penetration, extent of tissue removal, and biological response produced by each laser system.[7]

When laser energy is absorbed, a combination of thermal, mechanical, and biochemical effects may occur. In tissues with high water content, rapid energy absorption can generate localized vaporization and controlled tissue removal. Mechanical effects may result from pressure changes and micro cavitation within hydrated tissues, whereas biochemical responses can alter cellular activity and contribute to therapeutic outcomes.[7]

These interactions form the basis for the use of lasers in periodontal therapy, including tissue debridement, microbial reduction, wound healing, and regenerative procedures.

V. TYPES AND USES OF LASERS IN PERIODONTAL THERAPY

Dental lasers used in periodontology differ in wavelength, depth of tissue penetration, and affinity for biological chromophores, resulting in distinct clinical applications. Selection of an appropriate laser system depends on the target tissue, desired therapeutic effect, and clinical procedure. Among the various systems available, diode, Nd:YAG, Er:YAG, and Er,Cr:YSGG lasers are the most frequently used in periodontal practice.[8]

Diode Lasers

Diode lasers operate within the near-infrared wavelength range (approximately 810–1064 nm) and are absorbed predominantly by pigmented tissues containing melanin and hemoglobin. Because of these characteristics, they are primarily indicated for soft tissue procedures such as gingival contouring, sulcular debridement, and excision of inflamed periodontal tissues. Their ability to achieve effective coagulation provides excellent hemostasis, improves surgical visibility, and may contribute to reduced postoperative discomfort and faster soft tissue healing.[9-11]

Nd:YAG Lasers

The Nd:YAG laser emits light at a wavelength of 1064 nm and demonstrates deep penetration into soft tissues because of its affinity for pigmented structures. This property makes it useful for reducing bacterial load within periodontal pockets

and managing inflamed soft tissues. In addition to periodontal therapy, Nd:YAG lasers have been successfully employed for minor oral surgical procedures where effective bleeding control and antimicrobial action are advantageous.[12-14]

Erbium Family Lasers

The erbium family includes both Er:YAG and Er,Cr:YSGG laser systems, which share a high affinity for water and hydroxyapatite. Consequently, they are capable of treating both mineralized and soft tissues while producing minimal collateral thermal injury.[15]

Among these systems, the Er:YAG laser, operating at a wavelength of 2940 nm, demonstrates the greatest absorption by water, allowing precise removal of calculus, contaminated root surfaces, soft tissues, and alveolar bone. Beyond its ablative properties, evidence suggests that it may promote favorable healing responses and support periodontal regeneration, making it one of the most versatile laser systems in periodontal therapy.[6,16,17]

The Er,Cr:YSGG laser, with a wavelength of 2780 nm, exhibits similar clinical characteristics and is commonly utilized for soft tissue surgery, osseous contouring, and regenerative periodontal procedures. Its ability to combine efficient tissue ablation with reduced thermal effects has expanded its role in minimally invasive periodontal treatment.[18]

VI. CHARACTERISTICS AND BIOLOGICAL RESPONSES OF ER:YAG LASERS

Characteristics of Er: YAG Lasers

The clinical performance of the Er:YAG laser is primarily determined by its wavelength of 2940 nm, which corresponds to one of the highest absorption peaks for water. Because water is abundant in both soft and hard periodontal tissues, laser energy is absorbed superficially, permitting controlled tissue removal while minimizing heat transmission to adjacent structures.[19-21]

This characteristic enables precise ablation of gingival tissue, root surface deposits, and alveolar bone with minimal carbonization or charring. During irradiation, rapid vaporization of intracellular and extracellular water creates micro-explosive events that facilitate efficient tissue removal while preserving the surrounding tissues. Continuous water irrigation further limits thermal accumulation and improves procedural safety.[21-24]

Compared with other dental laser systems, the Er:YAG laser produces relatively shallow tissue penetration, thereby reducing the likelihood of unwanted thermal injury. These properties make it particularly suitable for periodontal procedures requiring precise hard- and soft-tissue management, including root surface debridement, osseous

contouring, and minimally invasive periodontal surgery.[25,26]

Biological Responses of Er:YAG Lasers

In addition to its mechanical debridement capability, Er:YAG laser irradiation has been reported to influence several biological processes involved in periodontal healing. Experimental investigations indicate that low-energy irradiation can enhance the activity of gingival fibroblasts, periodontal ligament fibroblasts, and osteoblast-like cells, suggesting a supportive role in tissue repair and regeneration.[27-33]

The observed biological responses are thought to result from modulation of multiple intracellular pathways rather than from a single mechanism. Studies have reported increased cellular metabolism, activation of signaling pathways associated with proliferation and differentiation, and enhanced expression of mediators involved in wound healing. Collectively, these effects may improve cellular migration, extracellular matrix production, and tissue remodeling during periodontal repair.[29,30,32,34,35]

Recent experimental evidence also suggests that laser-induced mechanical stimulation may influence genes associated with bone remodeling and regenerative processes. Although these laboratory findings are encouraging, further well-designed clinical studies are necessary to determine whether the observed cellular responses consistently translate into improved clinical outcomes for patients undergoing periodontal therapy.[36]

VII. APPLICATIONS OF ER:YAG LASERS IN PERIODONTAL SURGERY

Conventional Flap Surgery

The Er:YAG laser has been incorporated into conventional periodontal flap surgery to improve debridement of root surfaces and osseous defects while minimizing unnecessary trauma to adjacent tissues. Following flap reflection, the laser enables efficient removal of residual calculus, granulation tissue, and bacterial deposits, providing a clean surgical field that may support favorable wound healing.[37,38]

Clinical investigations have reported improvements in probing depth reduction, clinical attachment gain, and postoperative healing when Er:YAG laser therapy is used as an adjunct to conventional surgical procedures. Patients have also reported reduced postoperative discomfort and improved acceptance of treatment compared with conventional techniques alone. Although these findings are encouraging, treatment outcomes remain dependent on appropriate case selection and standardized laser parameters.[39-41]

Regenerative Periodontal Therapy

The regenerative potential of the Er:YAG laser has expanded its application in the management of intrabony periodontal defects and furcation involvement. Owing to its ability to remove contaminated tissues while preserving surrounding structures, the laser may create a biologically favorable environment for periodontal regeneration.[42]

Several clinical studies have demonstrated that combining Er:YAG laser therapy with regenerative materials, including enamel matrix derivatives and bone grafts, may enhance clinical attachment gain, reduce probing depth, and improve radiographic bone fill. Nevertheless, the magnitude of these benefits varies among studies because of differences in defect morphology, treatment protocols, and follow-up duration.[43-45]

Minimally Invasive and Flapless Procedures

The increasing emphasis on minimally invasive periodontal therapy has led to broader use of Er:YAG lasers in flapless and conservative surgical techniques. Precise tissue ablation with limited thermal injury allows selective removal of diseased tissues while preserving healthy periodontal structures, potentially reducing postoperative pain, swelling, and recovery time.[46]

Emerging evidence indicates that Er:YAG laser-assisted minimally invasive procedures can achieve clinical outcomes comparable with conventional surgical approaches in selected cases. However, current evidence remains limited, and further randomized controlled trials with long-term follow-up are needed to establish standardized clinical protocols and determine the most appropriate indications for these techniques.[47]

VIII. LIMITATIONS AND POTENTIAL DRAWBACKS

Despite the promising clinical outcomes associated with Er:YAG lasers, the available evidence remains limited. As most of the studies consist of experimental investigations, case reports, or short-term clinical trials, the requirement of large-scale randomized controlled studies is essential to establish standardized treatment protocols and long-term efficacy.[27]

The success of Er:YAG laser therapy is highly dependent on appropriate irradiation parameters and operator skill. Excessive energy delivery or improper technique may result in undesirable thermal effects, root surface alterations, or delayed wound healing.[48] Therefore, adequate training and adherence to recommended clinical protocols are essential for safe and predictable outcomes.

In addition, although experimental studies have demonstrated favorable effects on tissue

regeneration and bone healing, further in vivo investigations are needed to validate these biological mechanisms under clinical conditions.[38]

IX. DISCUSSION

The management of periodontitis has progressively evolved from conventional mechanical instrumentation alone to the incorporation of adjunctive technologies that aim to improve clinical outcomes while preserving healthy tissues. Among these technologies, the Er:YAG laser has attracted considerable interest because its physical properties permit precise removal of both soft and mineralized tissues with minimal thermal alteration. These characteristics distinguish it from several other dental laser systems that are primarily limited to soft tissue applications.[19-21]

The literature reviewed in this study indicates that Er:YAG laser therapy provides multiple clinical benefits when used alongside conventional periodontal treatment. Efficient removal of calculus, bacterial biofilm, and inflamed granulation tissue may contribute to improvements in probing depth reduction, clinical attachment gain, and postoperative healing. In addition, patients frequently report reduced discomfort and improved acceptance of treatment following laser-assisted procedures.[37-47]

Experimental studies have also demonstrated that Er:YAG laser irradiation may influence cellular activities associated with periodontal repair. Enhanced proliferation of fibroblasts, stimulation of osteoblast-like cells, and modulation of signaling pathways involved in wound healing suggest that the laser may contribute not only to debridement but also to biological events supporting tissue regeneration.[28-36] Although these findings are promising, most evidence originates from laboratory investigations, and additional clinical validation is required before definitive conclusions regarding regenerative potential can be drawn.

Despite encouraging outcomes, several limitations continue to influence the interpretation of available evidence. Considerable variation exists among published studies with respect to laser settings, treatment protocols, patient selection, outcome measures, and follow-up periods. Such heterogeneity limits direct comparison between studies and makes it difficult to establish standardized clinical recommendations. Consequently, Er:YAG laser therapy should currently be regarded as an adjunct to evidence-based periodontal treatment rather than a replacement for conventional mechanical therapy.

Future research should focus on large multicenter randomized controlled trials with standardized irradiation parameters and long-term follow-up. Further investigation into the biological mechanisms underlying laser-assisted periodontal regeneration

may also help optimize treatment protocols and expand the clinical applications of Er:YAG lasers.

X. CONCLUSION

The Er:YAG laser has become an important adjunctive modality in contemporary periodontal therapy because it enables effective management of both hard and soft periodontal tissues while minimizing collateral thermal damage. Current evidence supports its usefulness in nonsurgical periodontal treatment, periodontal flap surgery, regenerative procedures, and minimally invasive therapeutic approaches.

Available experimental and clinical studies suggest favorable effects on debridement, wound healing, patient comfort, and periodontal regeneration when the laser is appropriately integrated with conventional treatment. Nevertheless, variability among published studies and the absence of universally accepted treatment protocols indicate that additional high-quality clinical research remains necessary.

With continuing advances in laser technology and growing clinical experience, Er:YAG lasers are expected to play an increasingly significant role in periodontal practice. Future investigations should aim to establish evidence-based treatment guidelines that maximize clinical benefits while ensuring predictable long-term outcomes.

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