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High-Level Laser Therapy in Implant Dentistry: Clinical Applications and Future Innovations

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Scoping Review

ABSTRACT

To conduct a critical review of the clinical applications, advantages, limitations, and future perspectives of high-power laser use in contemporary implant dentistry. A scoping review with integrative characteristics was carried out, based on 32 studies published between 2000 and 2025, selected from the PubMed, Scopus, Web of Science, and SciELO databases. The search strategy employed specific descriptors combined with Boolean operators, following criteria adapted from the PRISMA protocol. The Er:YAG laser proved effective in performing osteotomies and decontaminating implant surfaces without causing thermal damage, thereby favoring osseointegration. The Nd:YAG laser stood out in the decontamination of areas affected by peri-implantitis due to its potent antimicrobial action. Photobiomodulation and photodynamic therapy demonstrated promising effects, with regenerative potential and anti-inflammatory properties. The integration of these laser technologies with digital resources has enhanced the precision and predictability of clinical procedures. However, the lack of standardization of clinical parameters and the high cost of equipment remains barriers to widespread implementation. The use of high-power lasers represents a significant advancement in implant dentistry, enabling safer, more effective, and more predictable treatments. Despite the observed clinical advantages, its consolidation in routine practice requires professional training, standardized protocols, and further long-term clinical studies. The incorporation of digital technologies and novel regenerative approaches is expected to progressively expand the role of lasers in modern dental practice.

Keywords: High-power laser; Dental biomaterials; Dental Implants; Dentistry.

Terapia a Laser de Alta Intensidade em Implantodontia: Aplicações Clínicas e Inovações Futuras

RESUMO

Realizar uma revisão crítica das aplicações clínicas, vantagens, limitações e perspectivas futuras do uso do laser de alta potência na implantodontia contemporânea. Foi realizada uma revisão de escopo com características integrativas, com base em 32 estudos publicados entre 2000 e 2025, selecionados nas bases de dados PubMed, Scopus, Web of Science e SciELO. A estratégia de busca empregou descritores específicos combinados com operadores booleanos, seguindo critérios adaptados do protocolo PRISMA. O laser Er:YAG mostrou-se eficaz na realização de osteotomias e na descontaminação de superfícies de implantes sem causar dano térmico, favorecendo a osseointegração. O laser Nd:YAG destacou-se na descontaminação de áreas acometidas por peri-implantite devido à sua potente ação antimicrobiana. A fotobiomodulação e a terapia fotodinâmica demonstraram efeitos promissores, com potencial regenerativo e propriedades anti-inflamatórias. A integração dessas tecnologias de laser com recursos digitais aumentou a precisão e a previsibilidade dos procedimentos clínicos. No entanto, a falta de padronização dos parâmetros clínicos e o alto custo dos equipamentos permanecem como barreiras para sua ampla implementação. O uso de lasers de alta potência representa um avanço significativo na implantodontia, permitindo tratamentos mais seguros, eficazes e previsíveis. Apesar das vantagens clínicas observadas, sua consolidação na prática rotineira requer treinamento profissional, protocolos padronizados e estudos clínicos de longo prazo. Espera-se que a incorporação de tecnologias digitais e novas abordagens regenerativas expanda progressivamente o papel dos lasers na prática odontológica moderna.

Palavras-chave: Laser de alta potência; Biomateriais odontológicos; Implantes dentários; Odontologia.

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INTRODUCTION

The advancement of technology in dentistry has led to significant improvements in clinical treatments, particularly in the field of implantology. Among these innovations, the use of high-power lasers stands out, revolutionizing both surgical and therapeutic procedures — from tissue incisions to the decontamination of implant surfaces. Lasers such as Nd:YAG, Er:YAG, and Diode operate at different wavelengths, allowing for a wide range of applications with specific effects on both soft and hard tissues (Bornstein et al., 2020; Convissar, 2022).

This technology enables cleaner incisions, reduced bleeding, shorter surgical time, and increased patient comfort. During the surgical phase, evidence suggests that laser use enhances hemostasis and reduces bacterial load at the surgical site, contributing to more efficient healing and fewer postoperative complications (Coluzzi & Parker, 2017). Furthermore, its selective and precise action enables a minimally invasive approach, positively impacting both clinical predictability and patient experience.

The use of the Er:YAG laser has proven particularly effective in osteotomies due to its ability to minimize thermal damage to bone tissue, thus preserving its vitality and promoting osseointegration (Gojkov-Vukelic et al., 2022). Meanwhile, Nd:YAG and Diode lasers are widely used for the decontamination of implant surfaces, especially in cases of peri-implantitis, providing effective antimicrobial action without harming adjacent tissues (Giannelli et al., 2018; Renvert et al., 2021).

Therefore, the integration of high-power lasers into modern implantology represents not only a technological innovation but also an evolution in clinical practice. When combined with well-defined protocols and proper professional training, their use can significantly contribute to the success of implant-supported rehabilitations, establishing lasers as an increasingly present tool in contemporary dental practice (Sanz-Martín et al., 2020). In this sense, the present study aims to describe, through a scope review, the clinical applications, advantages, limitations and future perspectives of the use of high-power laser in contemporary implantology.

METHODOLOGY

This study consists of a scoping review with an exploratory and qualitative approach, aiming to gather and critically analyze current scientific evidence. It also presents characteristics of a narrative and integrative review, encompassing studies published between January 2000 and May 2025. A systematic search was performed across four databases: PubMed, Scopus, Web of Science, and SciELO, using the following descriptors and Boolean combinations: ("high-power laser" OR "Er:YAG" OR "Nd:YAG" OR "diode laser") AND ("dental implantology" OR "peri-implantitis").

A total of 94 articles were initially identified. After screening and the application of eligibility criteria, 32 studies were included in the final analysis. The data selection and organization process followed steps adapted from the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, including identification, screening, eligibility assessment, and inclusion. Inclusion criteria: studies published within the last twenty-five years (2000–2025), written in English or Portuguese, and focused on the clinical application of lasers in implant dentistry. Exclusion criteria: duplicate publications, in vitro studies lacking clinical applicability, and non–peer-reviewed articles.

SCOPING REVIEW

Surgical Applications of Lasers in Implant Dentistry

During the surgical phase, the use of lasers has proven effective for performing incisions with reduced bleeding and edema, thereby improving visibility in the operative field. The Er:YAG laser, due to its interaction with hard tissues, is widely employed in osteotomies, minimizing the risk of thermal necrosis and promoting more effective osseointegration (Gojkov-Vukelic et al., 2022). Meanwhile, Diode and Nd:YAG lasers offer significant hemostatic advantages and contribute to the decontamination of the surgical site.

Adjunctive Therapies in Peri-implantitis

The treatment of peri-implantitis is among the main clinical indications for high-power lasers. The Nd:YAG laser, with its high absorption by pigmented tissues, enables effective antimicrobial action within peri-implant pockets (Crespi et al., 2017). The Er:YAG laser, in turn, is effective in removing biofilms and organic debris without compromising the integrity of the implant surface (Schwarz et al., 2013).

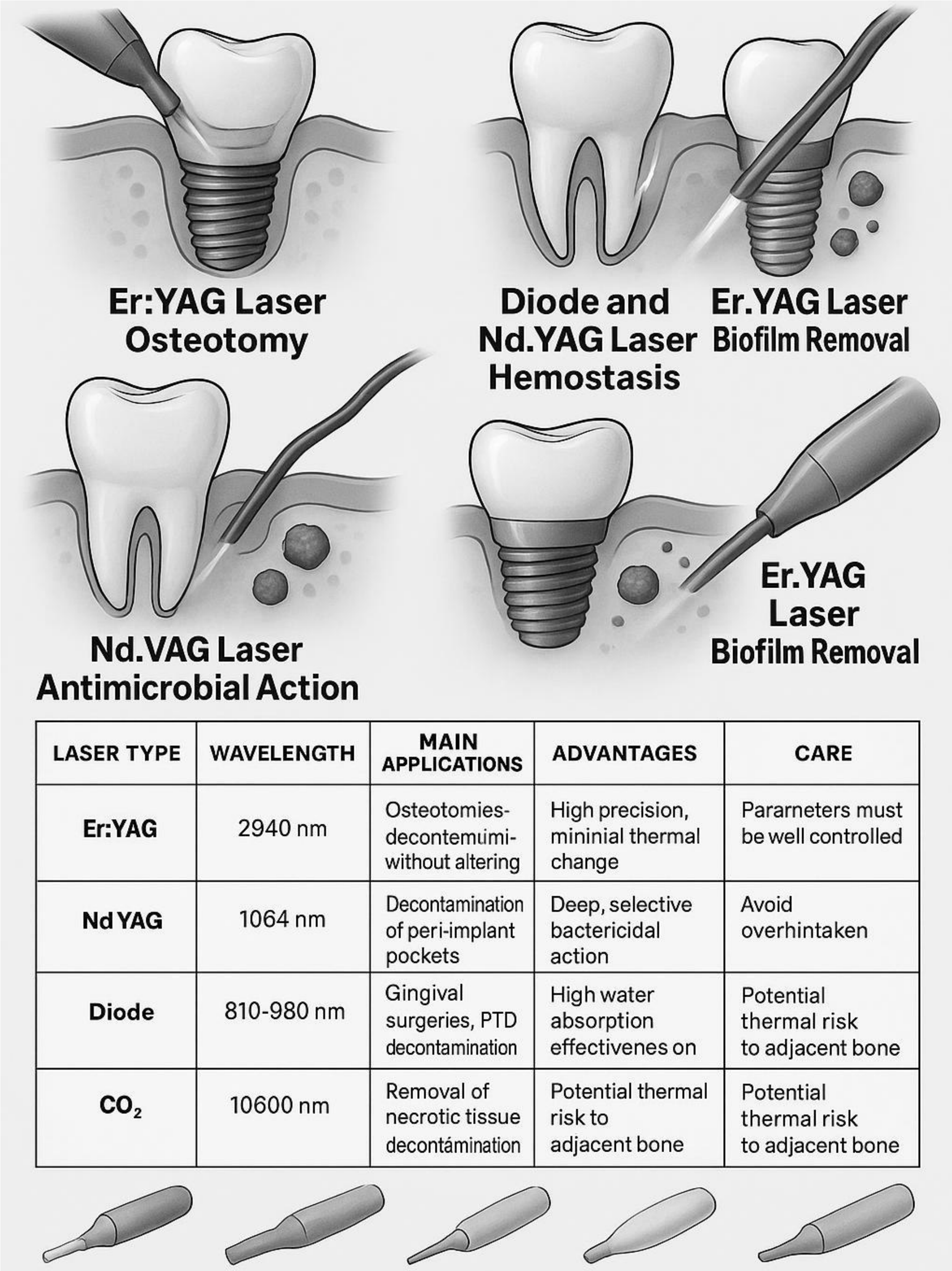
Photobiomodulation and Photodynamic Therapy

Clinical example: In a case study conducted by Andrade et al. (2022), a patient diagnosed with peri-implantitis underwent photodynamic therapy using a diode laser in combination with methylene blue. After four sessions, a significant reduction in probing depth and improvement in clinical inflammatory parameters were observed.

The combination of photobiomodulation and high-power laser therapy has shown positive outcomes in tissue regeneration and healing of peri-implant areas. Additionally, photodynamic therapy (PDT), using laser-activated dyes, supports the selective destruction of pathogens in inflamed tissues (de Almeida et al., 2019).

Integration with Digital Technologies

The integration of laser technology with digital tools such as intraoral scanners and CAD/CAM software has enhanced the precision and predictability of clinical procedures. This synergy facilitates digital impressions and guides immediate rehabilitations, reducing chair time and improving prosthetic fit and adaptation (Matys et al., 2021).



LASER TYPE	WAVELENGTH	MAIN APPLICATIONS	ADVANTAGES	CARE
Er:YAG	2940 nm	Osteotomies-decontemumi-without altering	High precision, mininial thermal change	Pararneters must be well controlled
Nd YAG	1064 nm	Decontamination of peri-implant pockets	Deep, selective bactericidal action	Avoid overhintaken
Diode	810-980 nm	Gingival surgeries, PTD decontamination	High water absorption effectivenes on	Potential thermal risk to adjacent bone
CO_2	10600 nm	Removal of necrotic tissue decontámination	Potential thermal risk to adjacent bone	Potential thermal risk to adjacent bone

Figure. 1 – Applications of lasers in implant dentistry.

Microbiological Aspects and Decontamination

One of the major challenges in implant dentistry is infection control in peri-implant areas. High-power lasers exhibit significant bactericidal activity, making them promising tools for the decontamination of implant surfaces. The Nd:YAG laser is effective against gram-negative bacteria commonly found in peri-implant infections, while the Er:YAG laser acts on biofilms present on rough surfaces without causing surface damage (Renvert et al., 2021; Schwarz et al., 2013).

Safety, Clinical Limitations, and Standardization

Although the clinical benefits of laser use are well-documented, there remain gaps regarding the standardization of clinical parameters. Studies vary in terms of power settings, emission modes, and application durations, which hinders the comparability of results. Additionally, risks related to overheating especially in bone tissue require specific technical training to ensure safe and effective use of the technology (Caruso et al., 2021).

Cost-effectiveness and Clinical Applicability

Despite the high initial cost of laser equipment, studies suggest that its clinical efficiency and the potential reduction in intraoperative complications may justify the investment over the medium to long term. Furthermore, the increasing demand for minimally invasive procedures has driven broader adoption of laser technology, making it increasingly common in implant dentistry practices (Bornstein et al., 2015).

Future Perspectives and Technological Innovation

The development of lasers with greater tissue selectivity, along with integration with artificial intelligence and digital platforms, is expected to further transform implant dentistry. As research advances, the establishment of optimized protocols is anticipated, ensuring greater safety, efficiency, and predictability in clinical outcomes (Silva et al., 2023).

DISCUSSION

The integrated analysis of the selected studies reveals that high-power laser use in implant dentistry represents a therapeutic tool with significant potential to improve the predictability, safety, and effectiveness of clinical procedures. Evidence indicates that the Er:YAG laser is effective for osteotomy and implant surface decontamination without causing thermal damage, thereby enhancing osseointegration and minimizing intraoperative complications (Gojkov-Vukelic et al., 2022). The Nd:YAG laser stands out for its deep bactericidal action and is widely used in peri-implantitis management (Park et al., 2021).

Despite these promising findings, a major limitation remains the lack of standardization in clinical protocols. Studies vary widely in terms of power settings, frequencies, and emission durations, making it difficult to compare outcomes and to establish universally accepted clinical guidelines. This methodological variability underscores the need for future research with standardized designs and greater methodological rigor (Caruso et al., 2021).

Another critical limitation is the scarcity of randomized clinical trials with long-term follow-up. Most available publications are short-term studies with small sample sizes and focus on immediate clinical outcomes. There is a clear need for research that explores the long-term durability of laser therapy effects in real-world clinical settings and compares their efficacy with conventional approaches across diverse populations.

Barriers to the routine adoption of laser technology include the high cost of equipment, the requirement for specialized technical training, and the learning curve associated with adapting to the specific protocols of each laser type. Additionally, regulatory challenges in some countries may hinder the widespread implementation of laser technology in conventional dental practices (Bornstein et al., 2015).

On the other hand, the outlook is promising, particularly with the advancement of digital dentistry. The integration of lasers with CAD/CAM systems, virtual planning software, and three-dimensional imaging technologies is expected to expand indications and streamline clinical applications. Moreover, the combination of photobiomodulation with regenerative techniques is emerging as an innovative strategy for managing peri-implant tissues.

Clinically, lasers offer benefits such as reduced pain, faster healing, less need for suturing, and greater patient acceptance. These features make laser therapy an attractive alternative at various stages of implant treatment from initial surgery to long-term maintenance. However, its use should always be grounded in robust scientific evidence and tailored to individual clinical scenarios.

In summary, while the clinical benefits of high-power lasers in implant dentistry are considerable, their use still requires caution, appropriate professional training, and ongoing scientific validation. The successful integration of this technology into clinical practice depends on robust research, continuous education, and overcoming economic and structural barriers.

FINAL CONSIDERATIONS

The use of high-power lasers in implant dentistry represents a significant advancement in modern dental practice, with relevant applications in surgery, adjunctive therapies, and implant maintenance. Er:YAG and Nd:YAG lasers offer enhanced surgical precision, bacterial reduction, improved healing, and greater patient comfort. However, widespread adoption is hindered by the lack of standardized protocols, high costs, and the need for specialized training. The limited number of long-term randomized clinical trials also restricts broader clinical validation. Future research should prioritize protocol standardization, comparison with conventional methods, and long-term outcome assessment. Integration with digital technologies and continued professional education are essential to maximizing clinical efficacy and applicability. In conclusion, high-power lasers hold strong potential as valuable tools in contemporary implant dentistry, contributing to safer, more predictable, and functionally and aesthetically improved outcomes.

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DATA AVAILABILITY

All data analyzed during this study are available from the corresponding author upon reasonable request.

DISCLAIMER OF LIABILITY AND DISCLOSURE

All data analyzed during this study are available from the corresponding author upon reasonable request. The authors report no conflicts of interest regarding any of the products or companies discussed in this article.

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