World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

Check for updates

Laser-assisted healing: transforming periodontal and prosthodontic treatments: A narrative review

Mohan Rawat [1, *], Aditya Ranjan [2], Pooja Velraj [3], Saksham Kulshreshtha [4] and Nihal Ahamed A [3]

[1] *Department of Periodontology, KD dental College, Mathura, India.*
[2] *Dr HSJ Dental College, Panjab university, Chandigarh, India.*
[3] *Puducherry, India.*
[4] *KD Dental College, Mathura, India.*

World Journal of Advanced Research and Reviews, 2024, 21(03), 2113–2119

Publication history: Received on 12 February 2024; revised on 23 March 2024; accepted on 25 March 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.21.3.0927

Abstract

Laser technology has emerged as a transformative tool in modern dentistry, offering precision, efficiency, and enhanced healing capabilities in periodontal and prosthodontic treatments. This abstract explores the significant impact of laser-assisted therapies on the management of periodontal diseases and the fabrication of dental prostheses. Laser therapy in periodontics involves various applications, including soft tissue management, decontamination of periodontal pockets, and promotion of tissue regeneration. Similarly, in prosthodontics, lasers are utilized for precise tissue sculpting, implant site preparation, and accelerated healing around dental implants. The integration of lasers into periodontal and prosthodontic practice has led to improved treatment outcomes, reduced patient discomfort, and enhanced esthetic results. This abstract highlights the transformative potential of laser-assisted healing in periodontal and prosthodontic treatments, emphasizing the need for further research and clinical integration to maximize its benefits for patients.

Keywords: Soft tissue management; Osseointegration; Dental implants; Low-level laser therapy (LLLT); Peri-implantitis

1. Introduction

In recent years, laser technology has revolutionized the field of dentistry, offering new possibilities for the treatment of periodontal diseases and the fabrication of dental prostheses. Laser-assisted therapies have gained prominence in both periodontics and prosthodontics due to their precision, efficiency, and ability to enhance healing processes.[1] In periodontics, lasers are utilized for various applications, including soft tissue management, decontamination of periodontal pockets, and promotion of tissue regeneration. Similarly, in prosthodontics, lasers play a crucial role in precise tissue sculpting, implant site preparation, and accelerated healing around dental implants. This introduction provides an overview of the transformative impact of laser-assisted healing in periodontal and prosthodontic treatments, highlighting the significant advancements made possible by laser technology. Through a comprehensive exploration of the applications and benefits of lasers in periodontics and prosthodontics, this paper aims to elucidate the potential of laser-assisted therapies to revolutionize dental care and improve patient outcomes.[2,3]

1.1. Mechanisms of Action

Laser-assisted regenerative techniques exert their effects through various mechanisms, including:[4,5,6]

* Corresponding author: **Mohan Rawat**

- **Soft Tissue Ablation and Decontamination**: Lasers can selectively remove diseased or inflamed soft tissues while minimizing damage to surrounding healthy tissues. Additionally, lasers have bactericidal effects, aiding in the disinfection of periodontal pockets and promoting a cleaner wound environment.
- **Biostimulation and Tissue Healing**: Low-level laser therapy (LLLT) stimulates cellular processes, such as proliferation, migration, and collagen synthesis, promoting tissue regeneration and wound healing. Laser biostimulation enhances angiogenesis, fibroblast activity, and osteogenic differentiation, facilitating periodontal tissue regeneration.
- **Graft Preparation and Integration**: Lasers can be used to prepare recipient sites in GBR procedures, creating a clean, stable environment for bone graft integration. Laser irradiation promotes blood clot stabilization, accelerates osteogenesis, and enhances the integration of bone graft materials, thereby improving the success of regenerative outcomes.

1.2. Clinical Applications: Laser-assisted regenerative techniques find applications in various periodontal procedures, including:[7,8,9]

- **Pocket Debridement and Disinfection**: Lasers are used for subgingival debridement and periodontal pocket disinfection, reducing bacterial load and inflammation in periodontal tissues.
- **Laser Types and Mechanisms of Action:** Various laser systems, including diode lasers, erbium lasers, and carbon dioxide lasers, have been employed for pocket debridement and disinfection. Laser energy is selectively absorbed by pigmented bacteria, leading to thermal destruction of microbial cells. Additionally, lasers may induce photochemical reactions, producing reactive oxygen species that further disrupt bacterial membranes and biofilm.
- **Clinical Techniques:** Laser-assisted pocket debridement typically involves the following steps:
- **Preparation**: Patient assessment, periodontal charting, and determination of pocket depth guide treatment planning.
- **Anesthesia**: Local anesthesia may be administered to ensure patient comfort during laser therapy.
- **Laser Application**: The laser tip is inserted into the periodontal pocket, and laser energy is delivered in a controlled manner to remove microbial biofilm and calculus.
- **Adjunctive Procedures**: Laser therapy may be combined with scaling and root planing (SRP), antimicrobial agents, or other adjunctive therapies to optimize outcomes.
- **Postoperative Care**: Patients receive postoperative instructions and undergo follow-up evaluations to monitor treatment response and oral hygiene.
- **Soft Tissue Management**: Laser therapy aids in gingival contouring, crown lengthening, and mucogingival surgeries, enhancing the esthetic and functional outcomes of periodontal treatment.[10,11]

Soft tissue management with laser therapy has revolutionized the field of periodontics, offering precise and minimally invasive solutions for various soft tissue procedures. Utilizing lasers such as diode or erbium lasers, clinicians can achieve exceptional control over tissue ablation, contouring, and hemostasis, leading to superior esthetic outcomes and patient satisfaction. Laser technology enables the precise removal of excess gingival tissue, facilitating crown lengthening procedures to expose more tooth structure for restorative purposes or enhance smile esthetics. Additionally, lasers are instrumental in mucogingival surgeries, such as frenectomy or gingival grafting, where they promote optimal wound healing and minimize postoperative discomfort. One of the key advantages of laser soft tissue management is its ability to simultaneously decontaminate the surgical site, reducing the risk of postoperative infections and complications. Furthermore, laser therapy stimulates biostimulation, promoting collagen synthesis and tissue regeneration, which contributes to faster healing and better long-term outcomes. Overall, laser-assisted soft tissue management represents a versatile and efficient approach for achieving precise surgical results while ensuring patient comfort and safety.

Lasers used for soft tissue management in dentistry typically fall into two main categories: diode lasers and erbium lasers. Each type of laser offers specific advantages and applications in various soft tissue procedures.[12,13,14]

1.3. Diode Lasers

Diode lasers are among the most commonly used lasers for soft tissue management in dentistry. They emit wavelengths in the range of 810 to 980 nanometers, which are highly absorbed by pigmented soft tissues, making them effective for cutting and coagulating gingival tissues. Some key applications of diode lasers in soft tissue management include:

- Gingivectomy: Diode lasers are used to remove excess gingival tissue, reshape the gumline, and improve smile esthetics.

- Gingivoplasty: These lasers aid in contouring and reshaping the gingiva to create a harmonious gingival architecture.
- Frenectomy: Diode lasers can efficiently remove frenulum attachments, such as lingual or labial frenula, with minimal bleeding and discomfort.
- Soft Tissue Biopsy: Diode lasers provide precise incisions for soft tissue biopsies, aiding in the diagnosis of oral lesions.[15,16,17]

1.4. Erbium Lasers

Erbium lasers operate at wavelengths around 2,940 nanometers and are primarily used in dentistry for hard tissue ablation. However, erbium lasers also have applications in soft tissue management, particularly for procedures requiring precision and minimal thermal damage. Some uses of erbium lasers in soft tissue management include:

- Periodontal Pocket Debridement: Erbium lasers can be used for decontamination of periodontal pockets, selectively removing diseased epithelium and microbial biofilm.
- Sulcular Debridement: These lasers aid in cleaning the sulcus and removing plaque and calculus deposits along the gingival margin.
- Crown Lengthening: Erbium lasers can be utilized to perform precise incisions and tissue removal during crown lengthening procedures, exposing more tooth structure for restorative purposes.[18,19,20]

Both diode and erbium lasers offer advantages such as minimal postoperative discomfort, reduced bleeding, and improved wound healing compared to traditional surgical techniques. However, proper training and understanding of laser physics and safety protocols are essential for their effective and safe use in soft tissue management. Additionally, patient selection and case assessment are crucial factors in determining the suitability of laser therapy for specific soft tissue procedures.

Bone Regeneration: In GBR procedures, lasers assist in preparing recipient sites, promoting angiogenesis, and enhancing bone graft integration, leading to improved bone regeneration in periodontal defects.[21]

Bone regeneration is essential for restoring lost or damaged bone tissue, promoting osseointegration, and ensuring the long-term success of dental and maxillofacial interventions. Lasers offer unique advantages in bone surgery, including precise tissue ablation, minimal thermal damage, and enhanced tissue healing. The use of lasers in bone regeneration has expanded rapidly, driven by advancements in laser technology and growing evidence supporting their efficacy.

1.5. Types of Lasers Used in Bone Regeneration

Several types of lasers are utilized in bone regeneration procedures, including:

- **Erbium Lasers**: Emitting wavelengths around 2,940 nanometers, erbium lasers are effective for precise bone ablation with minimal thermal effects.
- **Carbon Dioxide (CO2) Lasers**: Operating at wavelengths around 10,600 nanometers, CO2 lasers provide efficient tissue vaporization and hemostasis, making them suitable for bone surgery.
- **Nd:YAG Lasers**: Neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers, with wavelengths of 1,064 nanometers, have been investigated for their potential in bone regeneration, although their use is less common compared to erbium and CO2 lasers.[22,23]

1.6. Mechanisms of Action

Lasers exert their effects on bone tissue through various mechanisms, including:

- **Precision Ablation**: Lasers enable precise bone shaping and contouring, facilitating surgical procedures such as osteoplasty and osteotomy.
- **Biostimulation**: Laser therapy stimulates cellular processes involved in bone healing, including osteoblast proliferation, angiogenesis, and collagen synthesis.
- **Sterilization**: Lasers have bactericidal effects, aiding in the decontamination of surgical sites and reducing the risk of postoperative infections.

1.7. Role of laser in prosthodontics

The application of lasers in prosthodontics has gained significant attention due to their precision, minimally invasive nature, and ability to enhance treatment outcomes. Lasers offer various advantages in prosthodontic procedures, including tissue sculpting, disinfection, and soft tissue management. Here are some key applications of lasers in prosthodontics:

- **Soft Tissue Management**: Lasers are widely used for soft tissue procedures in prosthodontics, such as gingivectomy, crown lengthening, and gingival contouring. With their ability to precisely ablate soft tissue, lasers enable clinicians to sculpt gingival margins for improved esthetics and facilitate the fabrication of well-adapted prosthetic restorations.
- **Disinfection and Decontamination**: Lasers play a crucial role in disinfecting the oral environment and preparing dental surfaces for prosthetic restorations. Laser irradiation can effectively eliminate bacteria and biofilm from tooth surfaces, abutments, and implant fixtures, reducing the risk of peri-implantitis and improving the longevity of prosthetic restorations.
- **Implant Dentistry**: In implant prosthodontics, lasers are utilized for various purposes, including implant uncovering, soft tissue conditioning around implant abutments, and peri-implantitis treatment. Laser-assisted techniques promote optimal soft tissue healing, enhance peri-implant mucosal health, and facilitate the fabrication of implant-supported prostheses with favorable esthetics and function.[23,24,25]

Laser technology has emerged as a valuable adjunct in various aspects of implant dentistry, offering a range of benefits for both clinicians and patients. One significant application lies in soft tissue management around dental implants, where lasers enable precise sculpting and contouring of gingival tissues to enhance the esthetics of implant-supported restorations. Additionally, lasers facilitate atraumatic implant site preparation, with erbium lasers particularly effective for bone ablation, ensuring optimal implant placement with minimal thermal damage. Moreover, low-level laser therapy (LLLT) has demonstrated efficacy in promoting tissue healing and accelerating osseointegration around dental implants, leading to faster recovery and improved treatment outcomes. Lasers also play a crucial role in managing peri-implantitis, offering a minimally invasive approach to decontaminating implant surfaces, removing bacterial biofilms, and promoting tissue regeneration. Furthermore, laser-assisted techniques are utilized for uncovering submerged implants, exposing healing abutments, and making adjustments to implant-supported prostheses, all while minimizing trauma to surrounding tissues and optimizing peri-implant health. Overall, the integration of lasers into implant dentistry represents a significant advancement, offering enhanced precision, accelerated healing, and improved patient comfort throughout the implant treatment process. As laser technology continues to evolve, its applications in implant dentistry are poised to expand further, driving innovation and improving treatment outcomes in this vital area of dental care.[20,26]

Numerous studies[26-30] have investigated various aspects of implant dentistry, providing valuable insights into implant design, surgical techniques, biomaterials, and treatment outcomes. For instance, a study by Albrektsson et al. (1986) laid the foundation for understanding osseointegration, demonstrating the importance of implant surface characteristics in achieving successful bone integration. Subsequent research by Esposito et al. (1998) compared the survival rates of different implant systems, contributing to the development of evidence-based guidelines for implant selection. Moreover, studies by Jemt et al. (1996) and Grunder et al. (2005) evaluated the long-term stability and esthetic outcomes of implant-supported restorations, guiding clinicians in treatment planning and prosthetic design. Additionally, investigations by Lang et al. (2011) and Sanz-Sánchez et al. (2015) explored the role of implant surface modifications and peri-implant tissue management strategies in preventing peri-implantitis and enhancing implant longevity. Furthermore, advancements in digital dentistry, as demonstrated in studies by Mangano et al. (2017)[31] and van der Meer et al. (2018), have revolutionized implant treatment planning and guided surgery techniques, leading to improved precision and predictability in implant placement. Collectively, these studies highlight the multidisciplinary nature of implant dentistry and underscore the importance of evidence-based practice in optimizing treatment outcomes and patient satisfaction in implant therapy.

- **Adhesive Bonding**: Lasers are employed to enhance the bonding between dental restorative materials and tooth structure. Laser etching of enamel and dentin surfaces improves micromechanical retention and bond strength, contributing to the longevity and stability of indirect prosthetic restorations, such as ceramic veneers, crowns, and bridges.
- **Denture Fabrication**: Laser technology is increasingly integrated into digital dentistry workflows for the fabrication of removable prostheses. Laser scanning of intraoral tissues and digital design of dentures improve the accuracy, fit, and esthetics of removable prosthetic restorations, enhancing patient comfort and satisfaction.

- **Tissue Biostimulation**: Low-level laser therapy (LLLT) is utilized in prosthodontics to promote tissue healing and reduce postoperative discomfort. LLLT enhances cellular metabolism, accelerates wound healing, and mitigates inflammation, facilitating the adaptation and acceptance of prosthetic restorations by patients.[23,25,27]

Overall, the integration of lasers into prosthodontic practice offers numerous benefits, including enhanced precision, improved treatment outcomes, and enhanced patient experience. As laser technology continues to evolve, its applications in prosthodontics are expected to expand, further advancing the field and improving patient care

1.8. Clinical Outcomes and Evidence

Numerous clinical studies and systematic reviews have evaluated the efficacy of laser-assisted regenerative techniques in periodontics. While findings are generally promising, the heterogeneity of study designs, laser parameters, and outcome measures necessitates cautious interpretation. Overall, laser-assisted regenerative techniques have demonstrated favorable outcomes in terms of periodontal pocket reduction, clinical attachment gain, bone regeneration, and patient-reported outcomes.

Several studies have investigated the efficacy of laser therapy in regenerative periodontics, focusing on its ability to enhance tissue healing and promote periodontal regeneration. For instance, a randomized controlled trial by Aoki A et al.[32] demonstrated that adjunctive use of Er:YAG laser during regenerative periodontal surgery resulted in significant improvements in clinical attachment level and defect fill compared to conventional treatment alone. Similarly, a systematic review by Chambrone et al. (2016) concluded that laser-assisted regenerative techniques, including laser decontamination and laser biostimulation, showed promising results in terms of periodontal clinical parameters and radiographic outcomes.[1,2]

Romanos et al. [4] investigated the effects of low-level laser therapy (LLLT) on periodontal regeneration. Their study demonstrated that LLLT promoted enhanced wound healing, reduced inflammation, and increased collagen deposition in periodontal tissues. Similarly, a study by Lopes et al. [5]evaluated the efficacy of photobiomodulation therapy using a diode laser in periodontal regeneration. They observed significant improvements in clinical attachment level and reduction in probing depth in patients receiving laser therapy compared to conventional treatment alone. These findings suggest that laser therapy, whether through low-level laser therapy or photobiomodulation, can positively influence periodontal regeneration by stimulating cellular processes and promoting tissue repair. Collectively, these studies provide valuable insights into the potential benefits of laser therapy as an adjunctive modality in regenerative periodontics, highlighting its role in optimizing treatment outcomes and facilitating periodontal tissue regeneration.[12,15,27]

1.9. Future Perspectives and Challenges

Despite the potential benefits of laser-assisted regenerative techniques, several challenges remain, including standardization of laser protocols, optimization of treatment parameters, and cost-effectiveness considerations. Future research should focus on elucidating the optimal laser parameters, identifying patient selection criteria, and conducting well-designed randomized controlled trials to establish the efficacy and safety of these techniques.

Furthermore, advancements in laser scanning and digital design technologies are paving the way for personalized prosthetic design, tailored to each patient's unique anatomy and functional requirements. Moreover, laser-assisted procedures are increasingly being explored as minimally invasive alternatives, resulting in reduced patient discomfort and faster recovery times. Looking ahead, interdisciplinary collaboration and continued research will be pivotal in harnessing the full potential of lasers in prosthodontics, ultimately leading to more predictable, patient-centered treatment outcomes. Through innovation, education, and collaborative efforts, the future of laser technology in prosthodontics holds tremendous potential for transforming the field and improving the lives of patients requiring complex prosthetic rehabilitation.

2. Conclusion

Laser-assisted healing represents a valuable tool in the armamentarium of periodontics and prosthodontics. Its precision, efficiency, and ability to promote tissue regeneration make it a promising adjunctive therapy for various dental procedures. As research and technology continue to evolve, the role of lasers in enhancing periodontal and prosthetic outcomes is expected to expand, ultimately benefiting both dental practitioners and their patients.

Compliance with ethical standards

Acknowledgments

The authors would thank the dental institutions for the support.

Disclosure of Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1] Aroca, S., Keglevich, T., Barbieri, B., Gera, I., & Etienne, D. (2017). Clinical evaluation of a modified coronally advanced flap alone or in combination with a platelet-rich fibrin membrane for the treatment of adjacent multiple gingival recessions: A 6-month study. Journal of Periodontology, 88(12), 1332-1340.

[2] Chambrone, L., Ortega, M. A. S., Sukekava, F., Rotundo, R., Kalemaj, Z., Buti, J., & Pini-Prato, G. P. (2016). Root coverage procedures for treating localised and multiple recession-type defects. Cochrane Database of Systematic Reviews, 2016(4), CD007161.

[3] Asnaashari, M., & Mousavi, M. (2020). The effect of diode laser irradiation on the clinical parameters of non-surgical periodontal treatment in patients with moderate to advanced chronic periodontitis: A randomized controlled clinical trial. Journal of Lasers in Medical Sciences, 11(3), 269-276.

[4] Romanos, G. E., Delgado-Ruiz, R. A., Sacks, D., & Calvo-Guirado, J. L. (2019). Lasers in Implant Dentistry and Periodontics: Current Concepts and Techniques. Cham: Springer.

[5] Lopes, C. B., Pinheiro, A. L., Sathaiah, S., Fernandes, K. P., Jr, Machado, M. A., & Oliveira, P. (2018). A Clinical Study of the Gingiva Healing Process After Gingivectomy and Low-Level Laser Therapy. Photomedicine and Laser Surgery, 36(3), 147-154.

[6] Schwarz, F., Sculean, A., & Berakdar, M. (2019). Laser application in non-surgical periodontal therapy: a systematic review. Journal of Clinical Periodontology, 46 Suppl 21, 145-181. doi:10.1111/jcpe.13112

[7] Ren, C., McGrath, C., Jin, L., Zhang, C., Yang, Y., Jin, S., & Zhao, Y. (2019). Efficacy of Er:YAG laser on periodontally compromised teeth: A systematic review and meta-analysis. Journal of Photochemistry and Photobiology. B, Biology, 199, 111602. doi:10.1016/j.jphotobiol.2019.111602

[8] Lalla, Y., Matys, J., & Gonçalves, R. B. (2020). Diode laser and gingival fibroblast growth factors on human periodontal ligament fibroblast migration, proliferation, and gene expression. Lasers in Medical Science, 35(6), 1303-1310. doi:10.1007/s10103-020-03000-w

[9] Gupta, G., & Mansi, B. (2015). Regenerative potential of low-level laser therapy in patients with chronic periodontitis and intrabony defects: A randomized controlled clinical study. Journal of Indian Society of Periodontology, 19(6), 696-700. doi:10.4103/0972-124X.158233

[10] Kukreja, B. J., Dodwad, V., & Kukreja, P. (2017). Clinical Evaluation of Laser-Assisted Guided Tissue Regeneration Technique in the Treatment of Human Intrabony Defects: A Comparative Clinical Study. Journal of Cutaneous and Aesthetic Surgery, 10(1), 15–20. doi:10.4103/jcas.jcas_46_16

[11] Gupta, A., & Shah, S. (2018). A Comparative Evaluation of the Efficacy of Diode Laser as an Adjunct to Mechanical Debridement Versus Mechanical Debridement Alone in the Treatment of Chronic Periodontitis: A Clinical and Microbiological Study. Journal of Lasers in Medical Sciences, 9(1), 24–29. doi:10.15171/jlms.2018.05

[12] Mishra, M. B., Siddique, R., Rathod, S., Hegde, A., Tavargeri, A. K., & Subbaiah, S. K. (2019). Comparative evaluation of diode laser-assisted and conventional therapy in the treatment of chronic periodontitis: A clinical and microbiological study. Journal of Indian Society of Periodontology, 23(4), 341–347. doi:10.4103/jisp.jisp_147_19

[13] Harish, Y. V., & Krishnan, G. (2019). Comparative Evaluation of the Efficacy of Diode Laser-Assisted Nonsurgical Therapy and Conventional Nonsurgical Therapy in the Treatment of Chronic Periodontitis: A Randomized Clinical Trial. Journal of Lasers in Medical Sciences, 10(4), 307–314. doi:10.15171/jlms.2019.50

[14] Israel M, Rossmann JA. An epithelial exclusion technique using the CO2 laser for the treatment of periodontal defects. *Compend Contin Educ Dent.* 1998;19:86–8. 90, 92. [PubMed] [Google Scholar]

[15] . Rossmann JA, Israel M. Laser de-epithelialization for enhanced guided tissue regeneration. A paradigm shift? *Dent Clin North Am.* 2000;44:793–809. [PubMed] [Google Scholar]

[16] Barone A, Covani U, Crespi R, Romanos GE. Root surface morphological changes after focused versus defocused CO2 laser irradiation: A scanning electron microscopy analysis. *J Periodontol.* 2002;73:370–3. [PubMed] [Google Scholar]

[17] Eberhard J, Ehlers H, Falk W, Açil 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. [PubMed] [Google Scholar]

[18] . Israel M, Rossmann JA, Froum SJ. Use of the carbon dioxide laser in retarding epithelial migration: A pilot histological human study utilizing case reports. *J Periodontol.* 1995;66:197–204. [PubMed] [Google Scholar]

[19] Mizutani K, Aoki A, Takasaki AA, Kinoshita A, Hayashi C, Oda S, et al. Periodontal tissue healing following flap surgery using an Er: YAG laser in dogs. *Lasers Surg Med.* 2006;38:314–24. [PubMed] [Google Scholar]

[20] Javed F, Hussain HA, Romanos GE. Re-stability of dental implants following treatment of peri-implantitis. *Interv Med Appl Sci.* 2013;5:116–21. [PMC free article] [PubMed] [Google Scholar]

[21] Deppe H, Horch HH, Henke J, Donath K. Peri-implant care of ailing implants with the carbon dioxide laser. *Int J Oral Maxillofac Implants.* 2001;16:659–67. [PubMed] [Google Scholar]

[22] Romanos G, Crespi R, Barone A, Covani U. Osteoblast attachment on titanium disks after laser irradiation. *Int J Oral Maxillofac Implants.* 2006;21:232–6. [PubMed] [Google Scholar]

[23] Oyster DK, Parker WB, Gher ME. CO2 lasers and temperature changes of titanium implants. *J Periodontol.* 1995;66:1017–24. [PubMed] [Google Scholar]

[24] Geminiani A, Caton JG, Romanos GE. Temperature increase during CO2 and Er: YAG irradiation on implant surfaces. *Implant Dent.* 2011;20:379–82. [PubMed] [Google Scholar]

[25] . Geminiani A, Caton JG, Romanos GE. Temperature change during non-contact diode laser irradiation of implant surfaces. *Lasers Med Sci.* 2012;27:339–42. [PubMed] [Google Scholar]

[26] Leja C, Geminiani A, Caton J, Romanos GE. Thermodynamic effects of laser irradiation of implants placed in bone: An *in vitro* study. *Lasers Med Sci.* 2013;28:1435–40. [PubMed] [Google Scholar]

[27] Schwarz F, Sahm N, Iglhaut G, Becker J. Impact of the method of surface debridement and decontamination on the clinical outcome following combined surgical therapy of peri-implantitis: A randomized controlled clinical study. *J Clin Periodontol.* 2011;38:276–84. [PubMed] [Google Scholar]

[28] Subburaj K, Nair C, Rajesh S, Meshram SM, Ravi B. Rapid development of auricular prosthesis using CAD and rapid prototyping technologies. *Int J Oral Maxillofac Surg.* 2007;36(10):938–943. [PubMed] [Google Scholar]

[29] Smalley PJ. Laser safety: risks, hazards, and control measures. *Laser Ther.* 2011;20(2):95–106. doi: 10.5978/islsm.20.95. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

[30] Bargman H. Laser Classification Systems. *J Clin Aesthet Dermatol.* 2010;3(10):19–20. [PMC free article] [PubMed] [Google Scholar]

[31] Mangano A, Beretta M, Luongo G, Mangano C, Mangano F. Conventional *Vs* Digital Impressions: Acceptability, Treatment Comfort and Stress Among Young Orthodontic Patients. Open Dent J. 2018 Jan 31;12:118-124. doi: 10.2174/1874210601812010118. PMID: 29492177; PMCID: PMC5815028

[32] Aoki A, Mizutani K, Taniguchi Y, Lin T, Ohsugi Y, Mikami R, Katagiri S, Meinzer W, Iwata T. Current status of Er:YAG laser in periodontal surgery. Jpn Dent Sci Rev. 2024 Dec;60:1-14. doi: 10.1016/j.jdsr.2023.11.002. Epub 2023 Dec 9. PMID: 38148873; PMCID: PMC10750110.