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A Review on Lasers in Prosthodontics

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ABSTRACT

This review explores the applications and advantages of lasers in prosthodontics. Lasers, classified based on their medium, energy output, and oscillation mode, offer precision, efficiency, and minimal invasiveness in various procedures. In complete dentures, lasers aid in prototyping, CAD/CAM, and impression analysis. For fixed partial dentures, they facilitate tissue management and crown preparation. In removable partial dentures, laser welding enhances durability. In implantology, lasers assist in soft tissue surgeries, implant surface treatment, and peri-implantitis management. Maxillofacial prosthodontics benefits from laser-assisted sintering and rapid prototyping. While lasers offer numerous advantages, including reduced bleeding, faster healing, and improved patient comfort, challenges such as cost, training requirements, and limited research exist. Safety protocols are crucial to ensure safe and effective laser use. Future advancements in laser technology, including integration with digital dentistry, nanotechnology, and AI, hold promise for further enhancing clinical outcomes and patient experience in prosthodontics.

Keywords: Lasers, Prosthodontics, Dental Applications, Laser Technology, Dental Procedures, Soft Tissue, Hard Tissue, Implant Dentistry

INTRODUCTION

The term “LASER” stands for “Light Amplification by Stimulated Emission of Radiation.” It refers to a monochromatic and coherent light produced through the release of photons, which instigates a chain reaction. Lasers operate based on the principle of stimulated emission, a theory proposed by Albert Einstein in 1917, which builds on the concept of spontaneous stimulated emission postulated by Niels Bohr in the early 1900s. Traditionally, lasers are classified according to their physical construction (e.g., gas, liquid, solid-state, or semiconductor diode), the type of medium that undergoes lasing (e.g., Erbium: Yttrium Aluminium Garnet or Er), and their potential hazard level to the skin or eyes. Since their introduction in the 1960s, lasers have gradually replaced many conventional surgical and technical procedures, thereby improving treatment planning.[1] Their rapid adoption has made them integral to various applications within prosthodontics, resulting in enhanced efficiency and outcomes. Lasers contribute to better patient care by enabling precise tissue excision, facilitating quick healing, and improving tissue response. Commonly utilized laser types include carbon dioxide, argon, and YAG lasers, which are incorporated into diagnostic protocols, treatment strategies, and the fabrication of prosthetic restorations.[2, 3] The main components of a laser system include the active medium, pumping mechanism, optical resonators, cooling system, control panel, and delivery system. Lasers can also be categorized by wavelength: ultraviolet (below 400 nm), visible (400-700 nm), and infrared (700 nm to microwave). Medical practices typically utilize wavelengths ranging from 193 nm to 1060 nm. Lasers function by emitting a focused beam of light that can accurately target specific tissues, enabling minimally invasive procedures.[4] This makes them particularly effective for managing both hard and soft tissues in the oral cavity, with applications spanning from soft tissue procedures like gingivectomy and frenectomy to hard tissue applications such as tooth preparation and implant placement.

CLASSIFICATION OF LASERS AND DELIVERY SYSTEM IN PROSTHODONTICS

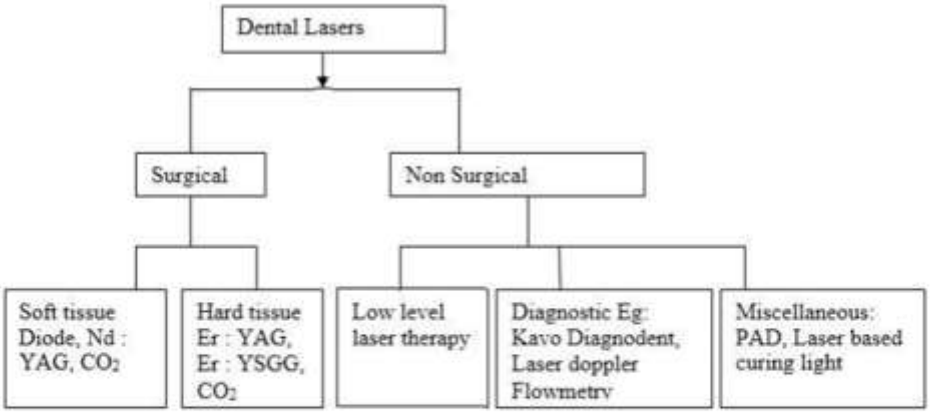

Fig 1 : Classification of lasers

APPLICATIONS OF LASERS IN PROSTHODONTICS

LASER TECHNOLOGY IN COMPLETE DENTURES

Rapid prototyping (RP) refers to a range of technologies that can automatically create physical models from Computer-Aided Design (CAD) data. This process involves using laser scanners and reverse engineering software to convert STL-formatted designs into numerical control codes, allowing the denture plate to be built layer by layer. Additionally, the accuracy of complete dentures can be analyzed using advanced laser scanner techniques and three-dimensional reconstruction, which examines occlusion and provides data on balanced occlusion parameters. Furthermore, laser scanners offer precise measurement of elastomeric impression materials without direct contact, employing three-dimensional digitizers to capture x, y, and z coordinates accurately. This capability minimizes subjective errors and enhances data collection by creating detailed 3D texture-mapped models, which can then be analyzed for dimensional accuracy.

REMOVABLE DENTAL PROSTHETICS

Lasers have revolutionized various aspects of dental prosthetics, including removable applications. In removable prosthetics, lasers are employed for residual ridge modification by smoothing sharp bony projections, and for treating undercut alveolar ridges, which can result from factors like dilated tooth sockets. They are also effective in addressing enlarged tuberosities, with soft tissue lasers reducing tissue bulk to meet necessary clearance requirements for prosthetic rehabilitation. Surgical procedures involving tori and exostoses benefit from erbium lasers, providing precise removal with minimal overheating and enhancing healing.[11] Lasers effectively excise soft tissue lesions and manage epulis fissuratum, reducing postoperative pain and facilitating re-epithelialization. Vestibuloplasty procedures benefit from laser technology by shortening healing time and minimizing the need for sutures, while frenectomies using various lasers enhance denture stability. Additionally, lasers help in treating denture stomatitis, reducing inflammation and microbial infection. For accuracy in impression making, advanced laser scanners capture 3D coordinates with precision, aiding in the fabrication of dentures using selective laser sintering (SLS).

LASERS IN FIXED PROSTHETICS

Lasers have become increasingly integral to fixed prosthodontics, offering various applications that enhance both procedural efficiency and patient comfort. One significant application is crown lengthening, where Er lasers facilitate bone ablation, improving healing times and reducing postoperative discomfort. In soft tissue management around abutments, argon lasers provide excellent hemostasis and tissue vaporization, minimizing swelling and pain while enhancing healing. For crown preparation, while this remains a debated topic, Er, Cr: YSGG lasers using hydrokinetic technology have been advocated for their ability to prepare hard and soft tissues without local anesthesia in many cases. Lasers can create oval pontic sites for improved design through soft tissue and bone remodeling, utilizing various laser types for optimal outcomes. The removal of ceramic veneers with lasers improves patient comfort and expedites the procedure, while root canal etching using Er lasers enhances bonding by opening dentin tubules through thermomechanical ablation.

LASERS IN IMPLANTOLOGY

Key applications include implant recovery, where CO2 and Er lasers effectively assist in minimizing tissue trauma during flap reflection and suture placement, while Nd lasers are contraindicated due to the risk of overheating the implant surface.[17] For implant site preparation, lasers facilitate bloodless surgeries for mini implants, particularly beneficial for patients with bleeding disorders. Additionally, diode, CO2, and Er lasers can effectively sterilize the surface of implants and remove granulation tissue around osseointegrated implants, addressing inflammation. The treatment of peri-implantitis is simplified due to the bactericidal properties of these lasers, promoting healing. For failed implants, the Er, Cr: YSGG laser offers a minimally invasive technique for removal without damaging surrounding bone. Laser welding of titanium components is beneficial for fabricating frameworks for implant prostheses. Rapid prototyping technologies, including stereolithography (SLA), enable precise fabrication of surgical guides, enhancing the accuracy of implant placement.[18] During second-stage uncovering, lasers facilitate the removal of soft tissue overlying implants, allowing for immediate impressions due to reduced blood contamination and tissue shrinkage.

LASERS IN MAXILLOFACIAL PROSTHETICS

Maxillofacial prosthodontics has greatly benefited from advances in 3D printing technologies, which facilitate both bony and soft tissue reconstruction. This essential clinical tool constructs models layer by layer from computer-aided designs (CAD), employing various techniques such as stereolithography, multijet modeling, selective laser sintering (SLS), binder jetting, and fused deposition modeling. These rapid prototyping methods have proven advantageous, particularly SLS, which generates models directly from 3D data converted into STL files and sliced into thin layers, significantly reducing labor-intensive processes associated with traditional facial prosthesis fabrication. Additionally, laser holography imaging allows for accurate digitization of patient deformities without the radiation exposure or stress linked to conventional imaging methods like computed tomography and magnetic resonance imaging.

ADVANTAGES

Precision and a minimally invasive approach. Reduced postoperative discomfort and faster healing. Minimize bleeding, and decrease trauma to adjacent tissues. Possess hemostatic properties that promote blood clot formation during soft tissue procedures and aid in microbial decontamination, thereby enhancing treatment success rates.

DISADVANTAGES

High cost of laser equipment. Specialized training to effectively utilize laser technology, restricted access to certain anatomical areas, complicating procedures in hard-to-reach locations.[23] Improper use can result in thermal damage to surrounding tissues. The variable response of different tissues to laser energy can lead to unpredictable outcomes. A lack of robust evidence-based research for certain applications raises concerns about the long-term efficacy and safety of laser-assisted treatments.

SAFETY CONSIDERATIONS AND PROTOCOLS IN LASER USE INPROSTHODONTICS

Safety considerations for laser procedures are crucial, starting with adequate eye protection for both patients and dental teams, using eyewear that filters specific wavelengths. Careful control of laser parameters is essential to prevent excessive tissue heating and thermal damage, often achieved through water sprays or air cooling. .[26,27]

FUTURE ADVANCEMENTS

The potential integration of lasers with digital dentistry is an emerging trend that enhances clinical practice and research in prosthodontics. The intersection of laser technology with nanotechnology is leading to the development of novel biomaterials and innovative surface modification techniques aimed at improving the biocompatibility, bioavailability, and durability of dental implants and restorative materials. Low-level laser therapy (LLLT) is being explored for pain management and neuromodulation, potentially aiding in postoperative pain relief and inflammation reduction through nerve regeneration. Established protocols for using lasers in bone regeneration are still lacking, necessitating further investigation. The integration of artificial intelligence (AI) may also optimize treatment planning and personalize laser settings for enhanced precision in laser-assisted procedures. L

CONCLUSION

In conclusion, the incorporation of various lasers in prosthodontics has transformed the management of both soft and hard tissues surrounding dental and implant abutments, allowing practitioners to carry out multiple procedures with enhanced comfort and predictable outcomes. Although lasers offer numerous benefits in prosthodontics, some practitioners may still lean toward traditional techniques due to their familiarity and concerns about the limitations of laser technology. This ongoing discussion underscores the importance of continued research and training in laser applications to fully realize their potential in dental practice.

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