Review Article

APPLICATION OF LASERS IN RESTORATIVE AND PROSTHODONTICS PROCEDURES: A SYSTEMATIC REVIEW

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ABSTRACT

Review paper for the decision of applications and clinical efficacy of laser in restorative and prosthodontic dental procedures based on recent developments and utility. Lasers have been used in dentistry starting from the 1960s; lasers in this field offer a less invasive approach compared to traditional ones. Laser offers many benefits, including accurate cutting, minimal pain sensation to the patient, and fast healing. Diode laser: popular and affordable, is categorized as a diode or Neodymium, abbreviated as ND laser. CO_2, Er, and Er, Cr, some of them appropriate for different kinds of tissues depending on the wavelength they emit. A PubMed, Cochrane, and Google Scholar search was conducted before aiming at the objective concerning the articles published between 2017 and 2022 on both soft and hard tissues. Studied work suggests that lasers facilitate better treatment outcomes in soft tissue surgeries, including cutting of gums and lip retraction, because they facilitate better blood control and decreased pain. Laser enables a conservative and specific approach in hard tissue treatments, including caries excavation and enamel etching. Still, some drawbacks are associated with the cotton fabric, such as high costs as well as the possibility of thermal damage. In general, lasers could significantly enhance patient care in restorative and prosthodontic dentistry; however, well-developed guidelines for using them are needed with further research to improve long-term results.

Key words: Dental lasers, Restorative, Prosthodontics, Diode, CO_2.

Introduction

Laser in dentistry has found its use in many procedures after its introduction in the early 1960s and has since become fundamental in many dental procedures, both for restoration and in prosthesis [1]. Laser characteristic like monochromatic coherent light sources, which can be focused to interact selectively with the required tissue type, makes them suitable. It makes it possible for clinicians to effect extremely accurate procedures whereby neighbouring tissues are rarely affected, hence less pain and quicker healing [2]. Lasers have become far more complex, with a great number of devices designed to work at particular wavelengths and interact with different types of tissues; the application of lasers in dentistry involves both the treatment of the soft tissues and the hard structure of the teeth [3].

In restorative and prosthodontic dentistry literature, lasers have received a lot of attention for use in caries, genial sculpting, enamel etching, and crown lengthening. Repairing these abnormalities is not facile with conventional techniques because of the challenges in attaining architectural accuracy and possible postoperative sequelae. While conventional procedures pose several of these complications, laser procedures present an advantage in that they allow the dentist to have precise control of the area to treat, the extent of which anesthesia is required, and the chances of bleeding [4]. These factors in combination, wherein patients undergo comfort, less invasiveness, and better clinical results, have boosted the practice of laser technology among dental clinics [5]. The types of lasers commonly used in dentistry include: diode laser, ND, CO_2, Er, and Er, Cr laser, which are unique in their operations, suitable for various dental procedures. For example, the diode laser is best suitable for soft tissue control because it is absorbed by melanin and hemoglobin, making it possible to use it for both cutting and coagulation [6].

On the other hand, Er and Er, Cr lasers work in wavelengths where water and hydroxyapatite absorbance is high, hence suitable for hard tissue cutting such as caries excavation and cavity conditioning [7]. Such flexibility in laser selection for a given procedure has made these devices essential in restorative and prosthodontic dentistry, where hard as well as soft tissue control is often an issue [3, 8]. The general use of Lasers in dental treatments has widely spread due to changes in Laser technology. For instance, Gingivectomy/frenectomy procedures have realized lesser bleeding incidences as well as lesser time required to recover incidence which is pivotal in complex prosthodontics cases [9]. Moreover, the application of lasers in hard tissue has been beneficial, especially when cutting healthy structures of teeth, where accuracy is important in delivering successful restoration and propelling long-lasting prosthodontic outcomes.

Additionally, the bactericidal effects of lasers make them helpful in endodontic treatment as well as periodontal interventions within the prosthodontics and restorative

fields. Nonetheless, like any other process, it has several drawbacks, even though laser use can come with numerous advantages in dental practice. Consequently, the costs of equipment, the requirement for specialized courses, and possible thermal damage in the case of insufficient cooling have limited its availability in some points of care [10]. However, complication arises through the inadequacy of standard guidelines in the many applications of laser systems. Overcoming these concerns is critical for lasers to become more comprehensively incorporated into routine DM RPCs [11]. The goal of this review is to assess current data concerning the use and efficacy of lasers in restorative and prosthodontic dentistry. This review overviews the clinical findings, advantages, and perceived disadvantages of laser technology application in dentistry, systematically, to demonstrate how the integrated data or the lack thereof calls for more systematic investigation and guideline consensus regarding the utility of laser settings in dentistry.

Materials and Methods

Search strategy

Electronic databases with relevant keywords were searched principally to pinpoint studies comparing the use of lasers in restorations and prosthodontics. We utilized three primary databases: PubMed, Cochrane Library, and Google Scholar, as these databases readily offer vast numbers of medical and dental materials. Among these sources, the articles published from 2017 to 2022 were selected to enhance the relevance of the findings [12]. Search terms used were “laser in restorative dentistry”, “soft tissue laser in dentistry”, “hard tissue laser in dentistry”, “prosthodontics application of laser”, and “lasers in dentistry”. Keywords were interconnected by the Boolean operators to expand the range of results by using such terms as “AND” or “OR” [13]. The identified articles were initially screened for their relevance based on their titles and abstracts, and finally, only those articles that reported on laser uses in restorative and prosthodontic dentistry were included for detailed analysis.

Inclusion and exclusion criteria

Studies were included based on the following criteria: The inclusion criteria comprised the following: (1) peer-reviewed full-text original research articles of field interest in terms of laser applications in restorative or prosthodontics dentistry; (2) published in the last five years (from year 2017 to the current year 2022) to discover the more recently available literature; (3) Human subject-based studies and in vivo/in vitro experimental animal studies relevant to restorative and prosthodontics Studies were excluded if they met any of the following criteria: Excluded articles were those that consisted of: (1) only case reports, reviews or commentaries with no original data, (2) papers published in languages other than English, (3) papers that focused on the laser application in fields other than restorative or prosthodontics treatment and (4) papers where the full text was not available or if the information required to assess the methodological quality of the study was incomplete **(Figure 1)**.

Data extraction and synthesis

Data extraction was done by searching for information on laser application, the kind of laser used, the approaches used during the procedures, and the outcome from each of the selected studies. Information extracted from the studies consisted of sample and design, laser wavelength and type, patient sample used, major findings, and limitations. For comparison, each study was evaluated according to the application focus of the study: soft tissue, hard tissue, or the selected prosthodontics procedure. Each of the 13 studies was summarized to present its main findings, including main advantages, limitations, and potential clinical applications related to laser use in procedures of different types [13].

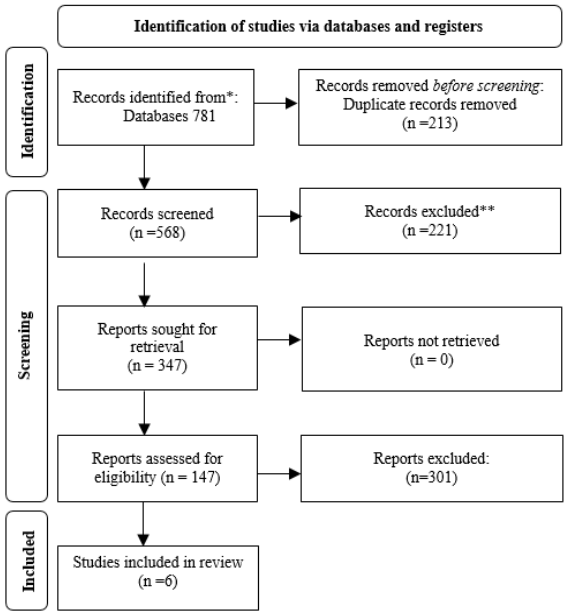

Figure 1. PRISMA flowchart explaining the screening process

Risk of bias assessment

To maintain the compatibility of the results, we evaluated the risk of bias using instruments that are appropriate for the kinds of papers included in this review. For in vivo studies, the bias in the study design, sample selection, and reporting of outcomes was assessed using the Science in Risk Assessment and Policy (SciRAP) tool as described by Sant’Anna *et al*. [14]. In vitro studies, the OHAT tool was used for factors such as the repeatability of the results and the level of their clarity [15]. For randomized controlled trials, the Scottish Intercollegiate Guidelines Network (SIGN) checklist was used to check general quality and>Any trials that meet the inclusion criteria and abstracts were reviewed according to the quality checklists that were set out in this study namely for randomized controlled trials SIGN checklist to check the overall quality and for

qualitative studies Tolman and Agar checklist for overall quality based on randomization, blinding and statistical analysis. To reduce intersubjective interference, two or more authors reviewed each of the studies independently, though discrepancies were discussed. Low risks of bias trials were given preference in the process of synthesizing knowledge regarding the therapeutic effects and uses of Lasers in Restorative and Prosthodontics dentistry.

Results and Discussion

The following table provides a brief tabulation of some of the findings from some of the studies that discuss the many uses of lasers in restorative and prosthodontic dentistry. The table separates the data with reference to the comparison, mechanical and antibacterial properties, clinical efficacies, methodologies, and main findings, to give a systematic and clear summarization of the laser technology and its impact on the enhancement of various dental treatments. The present snapshot is thus a convenient compendium that points to the benefits and clinical applicability of various forms of lasers in dental medicine **(Table 1)**.

Table 1. Summary of the included studies

Author (Year)	Comparison	Mechanical Properties	Clinical Outcomes	Methodologies	Main Results
Sant'Anna *et al*. (2017)	Laser-assisted orthodontics vs. traditional methods	Enhanced precision in tissue manipulation	Better patient outcomes in soft tissue management	In vivo study with orthodontic patients	Laser improved precision and reduced discomfort in soft tissue applications.
Meier *et al*. (2017)	Er: YAG laser for biofilm removal vs. other treatments	Effective biofilm removal on dentin surfaces	Improved long-term implant integration	In vitro study on dentin and titanium surfaces	Er: YAG laser demonstrated superior biofilm removal effectiveness.
Pereira *et al*. (2018)	Nd: YAG laser effect on dentin vs. fluoride application	Increased dentin strength after laser treatment	Enhanced stability of restorations	In vitro experiment on dentin erosion prevention	Nd: YAG laser showed enhanced dentin strength and antibacterial effects.
Zakrzewski *et al*. (2020)	Er: YAG laser on root canal filling removal vs. traditional methods	Efficient and safe for root canal debridement	Effective for long-term root canal success	In vitro and clinical study on root canals	Er: YAG laser is effective and safe in root canal treatments.
Hanke *et al*. (2021)	Diode laser use in soft tissue surgery vs. traditional scalpel	Controlled incision depth with minimal tissue damage	Reduced healing time and discomfort	Clinical evaluation in soft tissue procedures	Diode laser provided better control and reduced tissue damage.
Sun *et al*. (2017)	Diode laser for rapid enamel mineralization vs. traditional methods	Enhanced enamel microhardness	Stable enamel conditioning for restorative procedures	In vitro enamel mineralization study	Diode laser increased enamel hardness, aiding in mineralization.

The findings of this SR support the effectiveness of laser systems in the field of restorative and prosthodontic dentistry, especially for improving accuracy, comfort, and effectiveness of treatments. In soft tissue applications, which include the sulcular and gingival tissue, the diode and ND pose as less intrusive compared to conventional surgical implements, making them capable of removing tissue, causing little to no blood loss, and can heal much faster. Other surgeries like gingivectomy, frenectomy, and gingival contouring here also get advantage with laser by reducing the amount of tissue injury that subsequently enhances the level of patient comfort and early healing. These findings are in concordance with other studies where lasers have been shown to minimize the postoperative pain in soft tissue management [15]. In hard tissue applications, they use lasers to include Er and Er, Cr. They have also been proven to have efficacy in selective enamel and dentin caries removal and cavity preparation. This means more conservative approaches than conventional techniques because the laser can selectively cut out the decaying part while leaving the healthy part intact. Also, by laser conditioning of the enamel, the adhesion to the tissues is likely to provide better bond strength for restorations, which may in turn enhance the durability of the restoration. The antibacterial lasers are also very effective in preventing the formation of secondary caries by decreasing the bacterial content in treated areas [16] Lasers in prosthodontics practice suggest that lasers can improve the accuracy of procedures, including crown height reduction and gingival contouring, which the authors feel will improve prosthesis fit and esthetics. Also, the use of lasers in restoration removal, especially when using Er<tool_call>

Tags: Medical Technology, enhancements, lasers, Lasers, removal, Restoration, Restoration Removal, Technology, use, Use of Lasers, shows a technique that has less harm on the tooth than the traditional methods in terms of removing enamel and dentin. This aspect is of significant importance in the structure retention of teeth that are set aside for

further prosthetic studies. Altogether, the findings contribute to the further development of laser technology in dentistry and demonstrate both the flaws and the benefits of its application. However, more long-term research is needed to develop the guidelines for the laser application and assess its effectiveness over longer periods.

Soft tissue applications

Laser technology seems to have more value and utilization in different soft tissues in the dentistry field since it provides high accuracy, less bleeding, and quicker healing time than conventional procedures. Gingivectomy is relatively common among the commonly performed laser-assisted soft tissue surgeries, whereby excess or pathological gingival tissue is removed to aesthetically and therapeutically benefit the patient. Research has shown that Lasers, especially diode and ND lasers, provide higher precision options in tissue ablation, thus resulting in less bleeding after the surgery and less pain recurring for the patients. Another application that makes use of lasers is gingival contouring; laser offers an invaluable solution to re-contour or remodel the gum tissue without inflicting much trauma, or have a faster healing period for the improvement of the aesthetic appearance of patients who require such adjustments. In frenectomy surgical interventions, when the frenulum is to be cut for functional problems, such as tongue tie, lasers have a large number of benefits compared with traditional techniques. Solid state lasers are predominantly employed due to the efficiency of diode lasers in the bloodless operative field and the least suture requirement. Moreover, lasers minimize postoperative pain and inflammation that would affect children and adults [17]. Laser is also applied in treating oral pathology like aphthous ulcers, benign oral neoplasms, by applying the ablation method, which is less invasive and has less discomfort to the patient. Lasers have proved to be effective in the treatment of soft tissue pathologies such as melanin hyperpigmentation and are less painful with lasting outcomes implanted as compared to surgery. Concisely, LAS emerged as a more satisfactory treatment option with faster healing time, with some common clinical applications such as gingivectomy, contouring, and frenectomy [18, 19]. Reduced invasiveness, the precision of laser, and improved patient comfort, which are inevitably related to the use of laser in dental practice, make the use of laser on soft tissue more appropriate.

Hard tissue applications

Lasers have been effective within hard tissue applications such as caries removal, enamel conditioning, and cavity preparation. For caries removal, Er laser is particularly preferred because of its highly selective interaction with dental tissue, allowing the removal of only the carious tissue and leaving the enamel and dentin intact. According to the research, laser caries excavations cause low levels of heat generation affecting the tissues surrounding it, thus being an alternative to the mechanical burs common in traditional dentistry that may sometimes lead to micro cracks within the teeth [15, 20]. Also, the patients note that they are less anxious during laser caries removal than with conventional techniques because the process is less noisy and involves less tissue penetration. Lasers also have potential in enamel conditioning, especially while etching teeth for adhesive processes. The ND and Er laser is applied to roughen the surface of the enamel to increase the micro-retention of the bonding agents to the restorative material. Studies have shown that through laser conditioning, they have enhanced bonding characteristics and therefore increased resistance towards failure of the restoration. Laser conditioning does not use acidic agents while acid etching does; therefore, it is ideal for patients with sensitive teeth. Regarding cavity preparation, lasers such as the Er, Cr, and Er those studies have been demonstrated to be effective in preparing the tooth surface with accuracy. Laser-assisted cavity preparation enables the use of minimally invasive procedures since lasers are used to remove the required amount of tooth structure without necessarily requiring the removal of sound tooth structure. The antibacterial properties also contribute to the process of disinfection of the prepared cavity, and would probably lessen secondary decay [14, 21]. Therefore, lasers provide not only efficient working with hard dental tissues but also enhanced clinical efficacy due to the promotion of less invasive solutions and increased bond strength, being valuable in the area of conservative Dentistry.

Prosthodontics applications

Lasers are used in many different applications in the field of prosthodontics; perhaps the most common is crown elongation, followed by the procedure referred to as gingival troughing, and finally in the removal of restorations, where the precision that the laser provides is beneficial to the patient. Procedures such as crown lengthening, which may be done to expose more of the tooth for restoration, do very well with lasers. Others have pointed out that lasers, specifically diode and Er, Cr lasers, decrease inflammation and provide selective tissue coagulation, enabling the clinician to accomplish selective gingival sculpting without raising surgical flaps [8, 22]. With laser crown lengthening, post-operative discomfort is minimal, and healing time is rather short, making the patient more compliant and happy. While taking the impressions for crown placement, it may be needed to perform the procedure known as gingival troughing; the same can be done with the help of lasers instead of retraction cords.

Diode lasers are typically utilized for this procedure because the sulcular epithelium is removed, as when preparing a flap, and makes for a clean gingival margin without using mechanical retraction to do so, which can be uncomfortable for the patient. This technique enables a dry operative field, which helps in gaining an accurate wax bite and minimizes the chances of damage to the gums, leading to a better marginal fit of the prosthesis. Laser technology also assists in the planning of ceramic or composite restoration removal. Er and Er, Cr lasers have been found especially useful in removing such materials while leaving

the natural tooth fibers intact. In restoration removal, lasers are applied to decrease the time of the procedure and the microfractures that appear when using a bur [23, 24]. It also enhances patient satisfaction since it takes less time, and the patients have little time to get irritated by vibration and mechanical sounds from instruments [18, 25] In general, the accuracy, tissue-sparing effects, and time-saving capability of lasers qualify them as important assets in prosthodontics in improving the quality and longevity of prosthetic solutions [26-30].

Challenges and limitations

Challenges

It therefore comes as no surprise that laser technology in dentistry has several drawbacks that hamper its use. Laser equipment is expensive, both for purchasing and for maintaining, and is thus considered to be a somewhat limiting factor in the present day. This also makes laser technology less affordable to restricted dental practices and pushes up the cost of treatments to patients. Further, appropriate usage of lasers necessitates proper training; this is because different lasers produce different effects on different types of tissues, and care must be taken to use each laser type appropriately to avoid tissue injury [31-35].

Another problem is the absence of a validated technique that will be used in laser applications, depending on the specific procedure, which causes variability in results. Scarcity of data on the longevity of the priming laser treatment, together with the performance of the restorative material, also poses a great challenge to the adoption of laser treatment in normal practice. Others include the actual threat of harming the target tissues in terms of thermal damage. These challenges could be overcome with more cost-efficient laser options, wider implementation of training programs to educate and integrate laser usage, as well as advancing research in the topic.

Limitations

The applicability of lasers in restorative and prosthodontic dentistry has been labeled as having several limitations despite its valuable characteristics. One of the flaws still present when using lasers in restorative dentistry is the insufficient evidence about the longevity and efficacy of restorative laser-treated closures. Many evaluate the outcomes of laser treatments over a short period of time, which leads to a lack of knowledge of the long-term advantages and rare adverse effects. This lack of certainty means that dentists are somewhat in the dark as to the best way of incorporating lasers into their everyday practice. Another shortcoming is the instability of lasers in terms of the emitted wavelength, power configuration, and operational modes, which can greatly affect treatments' efficacy. On this basis, due to differences in protocols, findings from different studies often show disparities, and it is hard to generalize the results. Furthermore, not all specific types of lasers apply to all dental operations, and the problem of heat effects on surrounding tissues is evident; these disadvantages are especially critical if the surgeon is not very experienced [19, 31, 36-43]. Accessibility is an issue due to expensive equipment and training being required to use such technology, particularly when practiced in small or limited access settings, such as general rural dental practices. These limitations are a little beyond the scope of current, non-standardized research methods, and the current state of laser development and application may specify lasers more safely and consistently for broader use in dentistry.

Future research direction

Melzi has provided some insights on the relative lack of well-controlled studies on the clinical use of lasers; future studies should aim to fill this gap by providing parameters that must, however, be clarified to improve the predictability of laser application in restorative and prosthodontic dentistry. Research works that look into the best laser parameters that include the laser wavelength, power, and irradiation time for particular dental operations may help develop a versatile clinical protocol that can guide practitioners. Further long-term randomized clinical trials are required to compare the effectiveness of laser-assisted treatments for suitable long-term restorations and more mechanical prosthodontic implants. Expanding upon the fine work of engineers who have developed cheaper, versatile lasers that could be applied to numerous dental applications would also introduce this technology into more general practices. Additional studies utilizing the guidance offered by the present work might extend the safety level of applying lasers for RTT to laser equipment. Last, investigations regarding utilizing lasers together with other modern technologies, like photodynamic treatment, will show potential for elevating bactericidal properties as well as stimulating tissue regeneration in dentistry.

Conclusion

Therefore, laser technology has been introduced as one of the most useful tools in restorative and prosthodontic dentistry, with many clinical benefits in comparison with the conventional concepts. This analysis of the current literature finds that lasers contribute to increased accuracy, speed, and satisfaction in both soft and hard tissue treatment. In versatile applications, laser-like diodes and ND have been used in soft tissue applications. Have also proven the possibility of solving the problems of decreased bleeding, post-operative pain, and injury healing periods. Non-surgical applications such as: gingivectomy, gingival contouring, frenectomy, gain from laser surgery due to the advantages in complication rates and patient anxiety that are associated with the conventional surgical instruments. In hard tissue applications, Er: YAG laser is preferred because of its value in several medical fields and its capability of cutting through bones and dental prostheses. And, Er, Cr, their use has proved appropriate in caries excision, enamel and dentin conditioning, as well as cavity preparation. The feature of these lasers is that they can

profoundly eliminate irregularity of the tooth, while at the same time leaving sound tooth structure, which is in the end restrictive and conservative; this is very advantageous to the overall dental wellness. In addition, it is stated that the antibacterial effects of lasers prevent bacteria from colonizing treated areas and may reduce the incidence of new cavities and aid in the long-term success of restorations. In prosthodontic practice, lasers are frequently used for crown lengthening, gingival troughing, and precise removal of restorations. The studies highlighted above show that lasers optimize the clinical care delivery process and also contribute positively to the characteristics of final prostheses. Giving the patients and tissue management and restoration removal other choices than surgical intervention, lasers are improving the predictability and comfort of prosthodontic procedures. The versatility of laser technology is apparent, but further investigation is required to implement it; it could become the gold standard in many applications and assess the lasting effectiveness of treatments. Concerns related to training, costs, and the overall technical availability of training to as many potential participants as possible should also be discussed. In general, lasers can be regarded as one of the developments that can be beneficial for the progress in the field of dentistry as well as for the achievement of the goal — to provide patients with the highest quality and personalized treatment in the contemporary world.

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