Original Article

An Overview on the Impact of Diode Laser Therapy Upon Pre-Implantation, Stability and the Survival Rate of Dental Implants

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Abstract

Background: The effects of diode laser therapy on implant site preparation, primary and secondary stability of implants, and their survival rate have been subjects of growing interest in dentistry. Additionally, the impact of laser diodes on the height of the crestal bone is another critical factor influencing implant success. **Objectives:** The primary objective of this review is to determine the effects of diode laser therapy on implant site preparation, the stability of implants (both primary and secondary), and their survival rate. Another objective is to gain insights into the influence of diode lasers on crestal bone height. **Methods:** This study follows a descriptive narrative approach, systematically reviewing secondary information sourced from peer-reviewed articles, books, case reports, and clinical studies. The analysis is organized into themes that explore the role of diode lasers in implant stability and the factors affecting the survival rate of dental implants. **Results:** The review identified several themes, including the influence of diode lasers on both primary and secondary stability of implants and the factors impacting the survival rate of dental implants. A significant research gap was discovered, highlighting that no studies have specifically explored the use of diode lasers for implant site preparation. Additionally, the review found contradictory results regarding survival rates and other risk factors, suggesting a need for further investigation. **Conclusion:** This study is a pioneering effort in examining the effects of diode laser therapy on these specific aspects of dental implants. It emphasizes the need for future research to explore the use of diode lasers in implant site preparation and to address the inconsistencies in existing findings related to implant survival rates and associated risk factors.

Keywords: Laser Diode, Dental Implant, Periimplantitis, Primary and Secondary Stability, Crystal Bone Level, Osteointegration, Peri-implant Mucositis.

Introduction

Dental implants require two critical elements for normal function, namely osseointegration that occurs at the site of bone-implant interface followed by soft tissue integration in the transmucosal region. This must occur in a ubiquitous oral environment in the presence of pathogenic bacteria.[1] Dental implants have gained an essential position in oral rehabilitation procedures across the globe.[2] Implants can be differentiated according to the time of implantation, e.g., B. Immediate implantation, early implant placement, and delayed implant placement.[3] A few materials are generally used as dental implants such as titanium and the alloys of titanium, ceramic, zirconia, cast gold, resin, and cement (yttrium-stabilized tetragonal polycrystalline zirconia).[4] During the dental implantation process, the role played by the surface topography of the dental impact is crucial because it enhances contact with the bone and the implant.[5] For a dental implant to succeed, it is crucial to have a close contact between the implant's surface and

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the peri-implant bone.

Although long-term dental implants are well established in the literature, a significant number of patients suffer from implant failure and also peri-implant disease. The failure of dental implants segregated as early and late, can occur for different reasons[6] such as gender, age, smoking habit, systemic diseases, quantity and quality of implant bone, implant site in the upper jaw. Some of the factors that result in early failure include genetic and immunological, while excessive loading, inadequate prosthetic design, traumatic occlusion, nighttime teeth grinding, etc., are among the problems that lead to late failure.[7]

On the other hand, when the dental implants undergo periodical monitoring, the peri-implant diseases are diagnosed with the help of clinical and radiographic parameters.[7,8] The accumulation of bacterial plaque in the dental implants results in gingivitis, periodontitis, and peri-implantitis.[7,8] The formation of biofilms around the dental implants causes peri-implant mucositis that turns into peri-implantitis, if no treatment is provided. Being a reversible inflammatory disease, Peri-implant mucositis is induced by plaque and impacts the peri-implant soft tissues around the Osseointegrated dental implant.[9] On the other hand, developmental bone loss and inflammation of the connective tissue that surrounds the implant are commonly found in peri-implantitis. A consistent increase is found in peri-implant inflammation after dental implant therapy. Kochar *et al*.[7] mentioned that peri-implantitis can be managed through non-surgical and surgical methods. Though the disease is yet to have an established treatment procedure, appropriate oral hygiene and prophylaxis are crucial measures to prevent the condition.[5] Dental plaque helps bacteria to flourish in the form of biofilm, which in turn release different bioactive products into the gingival epithelium, thus causing gingivitis and, eventually, periodontitis.

Diode Laser Therapy – An Overview

"Light Amplification by the Stimulated Emission of Radiation" stands for the expansion of LASER, first deployed by Miaman in 1960 to treat both hard and soft tissues. Various domains of dentistry like oral surgery, periodontology, endodontics, conservative dentistry, implantology, and other such dental procedures, have gained tremendous benefits with the application of laser diode.[10] Atieh *et al*.[9] mentioned that diode laser can decontaminate (pathogenic bacteria) different types of implant surfaces like plasma-sprayed, hydroxyapatite-coated, acid-etched, and sandblasted titanium surfaces. The diode lasers improve aesthetics, controlling coagulation, preventing blood interference during implantation, and preventing issues regarding tissue shrinkage, etc.[11]

In the literature,[12-14] based on the expected outcomes such as dental implants or removal of biofilm, the wavelength of the lasers utilized in dentistry vary in visible light range between 400 and 700 nm (445 nm),[15] diodes 830-1,064 nm (with different wavelengths such as 445 nm, 810 nm, 940 nm, 970 nm, 980 nm),[16,17] Nd: YAG 1,064 nm,[18] Erbium 2,790-2,940 nm,[8,19] and CO_2 9.3-10.6 micrometers.[20]

When comparing the effect of different types of lasers (such as diode, CO2, Er: YAG and Er, Cr: YSGG) upon the dental implants' surface, the study,[21] found that the irradiation had Good results with diode lasers provided the lowest surface changes compared to the other laser types. This research investigation confirmed the superior outcomes achieved by the diode laser with regards to surface changes and mean profile area between the threats compared to its counterparts. The thermal effect of 445 nm diode lasers on five dental implant systems was analyzed by Deppe *et al*.[2] at different wattages, modes, and exposure times. The SEM analysis results revealed no changes at the surface level in the non-contact mode. In a Randomized Controlled Trial conducted earlier,[22] the authors assessed how far a 940 nm diode laser is effective in 2nd stage implant surgery than the conventional approach (Scalpel). The authors found that the 940 nm diode laser minimized post-operative pain, and reduced swelling with less inflammatory response, and was time-saving. The capability of the laser diode to reduce the number of microbes in the range of 30-67-100% based on the applied dose was confirmed by the earlier study.[23] There was an active reduction in the number of bacteria observed in a rat model study conducted by Jin *et al*.[24] using an 808 nm diode laser, which also ensured that the surface of the implant did not undergo any changes. On the other hand, a 635 nm diode laser was used supplementing the Photodynamic Therapy (PDT) in the earlier study[25] to treat non-surgical periodontitis. The study group exhibited a remarkable reduction in plaque index, bleeding on Probation, and clinical attachment loss compared to the control group. Dental lasers have been recommended to treat peri-implant infections since they are cost-effective, easy to handle, hemostatic, can reduce pain, swelling, and bleeding, and act effectively against periodontopathic pathogens. In the literature, laser diode-mediated dental implantation prevents the development of microbes that eventually result in Periimplantitis[23]—discussed the role played by diode lasers in soft tissue management. This study used a diode laser for to excise the soft tissue around the implants, after which gingival contouring was performed in the pontic region to attain the required zenith and contour of the gingival region. Applying soft tissue lasers such as CO_2, Nd: YAG, argon, holmium, and diode lasers started replacing the traditional soft tissue manipulation procedures.

It can be concluded that the laser diodes' role is extremely important in both pre-implantation of the dental implants as well as the associated postoperative procedures. With this in mind, the current research article is a unique attempt to provide insights into the effectiveness of diode laser therapy in implant site preparation and post-implant healing. There is a dearth of studies that focused on the effectiveness of diode laser therapy in terms of preparing the implant site since implant site preparation

remains one of the crucial factors that determine the success of the dental implants and its long-term stability. In order to achieve osseointegration, it is crucial to prepare the implant site and not overdo that may affect the surrounding tissues as well. In this background, the current review article aims at analyzing the impact of diode laser therapy on implantation site preparation and post-implantation healing. The primary research question of this study is to determine the effectiveness of diode laser therapy on stability and survival rate of the dental implants. In order to reach this goal, the following objectives were developed: (i) To assess the impact of diode laser therapy on primary and secondary stability of dental implant osteointegration, (ii) to assess the impact of diode laser therapy on crestal bone level and (iii) to determine the survival rate of dental implants using diode laser therapy.

The authors acknowledge that no such study has been conducted so far with the objectives set for the current study. Thus, the study intends to provide in-depth insights with substantial clinical information about the theme under study. The scope of the study is confined to low-level laser therapy and its application in dentistry, especially dental implant site preparation, stability and survival rate.

Methodology

The current study follows a descriptive narrative approach. This study provides a broad perspective on the comprehensive role of laser diode in dental implants. In order to gain knowledgeable insights, the authors have used secondary information from standard reference databases like PUBMED, EMBASE, Scopus etc., The keywords searched either as individual or in combination such as "diode laser therapy", " dental implant site preparation"," low-level laser therapy", "diode laser for dental implants", "dental implant survival rate", "primary stability of the implants" and so on. The inclusion criteria was those studies that dealt with diode laser therapy or low-level laser therapy in dentistry and the sources include peer-reviewed research articles, books, experimental studies, case reports, meta-analyses, systematic reviews, clinical studies, etc. The studies pertaining to lasers that are above or below the threshold are not included while studies related to other clinical domains were not considered. The themes have been discussed under separate sections in the results based on the collected information.

Results

This The current section discusses the information obtained from the literature review relevant to the three objectives. The following sections briefly discuss the use of laser diode therapy in dental implant site preparation, followed by its effects on primary and secondary stability. In addition, the section also contains information on determining the crystal bone level with this therapy. In addition, the survival rate of dental implants was also discussed.

Diode Laser Therapy and the Preparation of Dental Implant Site

Diode lasers have been established as a decontaminant for the infected implant surfaces. Further, it also plays a remarkable role in the vaporization of soft tissues.[26] In implant bed preparation suggested by Ingenegeren[27], the laser tip should be longer compared to the implants, while the shape of the implant and the bone in which it is going to be implanted must align. Finally, the bone must be cooled sufficiently enough. Despite the advantages of laser diode, it consumes 20 minutes in case of highly dense bone.

Diode laser is best utilized for uncovering dental implants, whereas Er: YAG laser has the potential to be applied in the preparation of the implant bed before the implantation process.[28] In literature,[29] the impact of Er: YAG laser upon dental implant preparation (in terms of both soft and hard tissues) was investigated through histological evidence. The study results confirmed the absence of any blood cells or debris in laser samples than the all-bur samples. This feature enables faster healing and also facilitates the osseointegration process.

In literature, various studies have established the importance of using Er, Cr:YSGG,[30,31] Er:YAG[29,32,33] and short-pulsed CO_2 lasers[34] for implant site preparation. Though studies have established the role played by these two lasers in implant bed preparation, there is a lack of studies that determine the role played by diode lasers on implant bed preparation. This might be attributed to both these lasers exhibiting minimal optical penetration depth in bone, removal of bone through vaporization, precision in cutting the bone, and low thermal damage to the tissues.

Impact of Diode Laser Therapy on Primary as Well as Secondary Stability of the Dental Implant

Implant stability is a mandatory factor that ensures an undisturbed healing process in a patient who underwent a dental implantation procedure.[35] This characteristic is influenced by various parameters of clinical and mechanical significance such as the jaw with varying bone densities, implant anchoring in the surrounding bone, implanted component's stiffness and the bone in which the implant is placed, and the bone-implant interface.[36] The primary stability of an implant has a vital role in achieving osseointegration and acts as a base for secondary stability. Surgical site issues or the implant/surgical method used during implantation, local factors like quality and volume of bone, and the implant's factors such as shape, length, diameter, and surface texture are the three primary reasons that tend to influence the outcome of dental implant's primary stability. In a clinical trial[37] conducted earlier to determine the impact of 808 nm diode laser upon the implant's mechanical stability (primary), the Implant Stability Quotient (ISQ) measurements were found to be well-balanced in the experimental group than the control group. Further, the implant's stability (ISQ)

increased after 8 weeks of implantation. In addition, the mucosal inflammation and healing time were reduced among the laser-treated patients.

On the other hand, secondary stability corresponds to implant integration as a result of bone formation that occur due to its remodeling. This stability is highly influenced by the activities of the bone, load, etc.[4] In the literature, the authors[38] determined the stability (both primary as well as secondary) of the dental implants and bone density in the peri-implant zone after low-level laser therapy using a 635-diode laser. The study found that a 635 nm diode laser increased the secondary stability of the implants as well as bone density compared to the irradiated subject. The reduction of the implant's stability was much slower in the laser group compared to the control group. Further, various studies[39] established the crucial role played by diode laser in enhancing the secondary stability of the implants. In the aftermath of Low-level laser therapy, the osteoporosis group achieved phenomenal stability than the control group.[40] The secondary implant stability was higher in the study group[3] when using the Resonance Frequency Analysis technique than the control group. This investigation concluded that a low-level diode laser 980 nm stimulates bone formation during, before, and after the immediate placement of the implant.

Impact of Diode Laser Therapy Upon Crestal Bone Level

Crestal Bone Loss (CBL) has a multi-factorial etiology that affects the dental implant either in the early stages (within a year of implantation) or later. Factors such as mechanical overloading, pathogenic, immunological, environmental, and patient-related (such as smoking, bruxism, motivation, and infection) cumulatively influence the occurrence of CBL. It can be determined using different sorts of imaging techniques, such as standardized intraoral radiographs (SIR), panoramic radiographs, CT scans, and "Cone Beam Computerized Tomography" (CBCT) scans.[41]

The resorption of the initial bone that occurs at the surface of the implant has an influence on the implant's success rate. Various initiatives have been taken to ensure that the peri-implant crestal bone loss can be reduced. In this scenario, the role played by diode laser therapy has been documented sufficiently in the literature.[42-44]

In a comparative analysis[43] conducted between traditional and diode lasers upon the crystal bone levels around the dental implants, the authors found no significant difference between the groups regarding CBL values. This result was also supported by the study conducted by Mohamed *et al*.[44]. In Gulati *et al*.[45], the study group, i.e., LLLT irradiated group, achieved significantly less crystal bone loss than the non-irradiated group. Further, when the 980 nm diode laser was verified for its role in preserving the socket, the authors,[42] in the preliminary split mouth RCT, found the positive impact created by the laser group than its counterpart. In the earlier study,[44] the authors determined the impact caused by diode and ER, Cr: YSGG lasers upon the CBL levels over dental implants. The study found that the implants without laser application suffered from huge crestal bone loss during the first follow-up period while no such difference was found between the groups after making a follow-up for a period of one year.

Survival Rate of Dental Implants

The dental implants have survival rate in the range of 95.2% to 96.8% for a period of five years and between 86.7% and 92.8% for a decade.[46] However, this survival rate gets heavily influenced by different factors such as the biological complications, history of periodontal diseases, plaque-induced peri-implantitis, poor oral hygiene, diabetes mellitus, smoking etc.[47] With regards to success and survival rate of the implants, the peri-implant marginal bone and the changes that it undergoes are crucial. The successful implant incurs a marginal bone loss not more than 1.5 mm in the first year of implantation.[48] The survival rates of the dental implants are high in case of immediate implants with either immediate or else early loading in comparison with the placement of implant at the healed site.[49]

In the retrospective study conducted earlier,[46] the authors analysed different factors that tend to influence the survival rate of dental implants and found that gender, length as well as diameter of the implant, quality of the bone and region of implantation heavily influence the survival rate of the dental implants. In a case report, the authors conducted immediate implant placement using diode laser which has multiple advantages such as reduced resorption of soft- and hard-tissues, crestal bone preservation, time-savvy, low complex surgical procedure, less trauma and better patient satisfaction. Comparatively, the clinicians found crown troughing using a diode laser was more accessible, and after one year, it proved to have less bleeding, minimal bone loss, improved aesthetics, etc.[50] Yang *et al*.[50] conducted a retrospective study that focused on the factors that influence the early failure and survival rates among Chinese implants, the study recommended that implant placement should be cautiously handled to increase the survival rate of the implants.

French *et al*.[51] found that the patients with multiple implants are likely to have higher chances for implant failure. Further, immediate implantation was found to have a remarkable contribution towards implant failure. In the case of a stabilized implant, this risk factor can be nullified. However, this conclusion was refuted by the researchers,[52,53] who found no remarkable difference between the immediate and delayed implant placement. The study also found that an immediate implant has a high survival rate. In an interesting study conducted earlier,[52,53] the survival rate and the risk factors associated with dental implant failure placed by postgraduate students were assessed. This study found that 90.5% of the dental implants survived for 52 months, whereas, in contradiction with the previous studies, this study found no significant association between implant loss and the rest of the factors

like gender, DM, smoking, type, and position of an implant, type of prosthetic material and the existing bone graft. On the other hand, bone type density, pre-implant sinus lift surgery, smoking, infection at the site of surgery, and rheumatoid arthritis are the risk factors found by Thiebot *et al.*[54] for the failure of dental implants.

Conclusion

The current review provided an overview of the dental implants along with the factors that risk the survival of the dental implants over a certain period of time. The authors further detailed about the types of lasers used in dentistry while a special focus was made upon diode laser or low-level laser therapy. Its applications upon the dental implants' primary and secondary stability were measured. Further, the study also delved into the influence of diode laser upon the crestal bone level. The study found that no studies has been conducted so far regarding the impact of diode laser upon the preparation of the implant site. So, the future studies may take an initiative to fulfil this research gap with the advanced technologies. On the other hand, different types of conclusions have been arrived in literature regarding the association between implant loss and the commonly-cited factors. So, the researchers may also validate these results in other geographical settings and different clinical conditions. The current study is a first-of-its-kind review to provide insights about the objectives undertaken and has an immense contribution to the research community.

Author Contributions

Conceptualization, Bakir Ghanem Murrade; validation, Bakir Ghanem Murrad, Jed Bouguila , Thair A. Hasan and Reyadh R. Al-Rashidi;.; writing—original draft preparation, Bakir Ghanem Murrade.; writing—review and editing, Bakir Ghanem Murrade.

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Conflicts of Interest

The authors declare no conflicts of interest.

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