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Evaluation of Diode Laser Treatment on Implant Stability, Healing Edema and Implant Survival in a Sample of Iraqi Patients Seeking Dental Implants: Single Center Study

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Abstract

Objective: To investigate the impact of diode laser therapy on pre-implant site preparation and post-implant healing, primary and secondary stability of the dental implant osteointegration, to measure crestal bone level, and the survival rate of the dental implants.

Methods: This prospective clinical study was organized from November 2022 to August 2024 at the Dentistry College Teaching Hospital, Department of Oral and Maxillofacial Surgery/Dental Implant Unit/University of Kut. Patients were randomly allocated into two groups: study group receiving diode laser and control group receiving no laser treatment. Outcome variables included mainly healing edema score, implant stability, and survival of implant.

Results: Regarding primary stability, there was no significant difference in its mean level between study group and control group, 67.12 ±5.44 ISQ versus 68.54 ±5.77 ISQ, respectively ($p = 0.208$). Regarding secondary stability following 7 days, 4 weeks, 8 weeks, and 12 weeks, there was no significant difference in its mean level between study group and control group ($p > 0.05$). Higher scores of healing edema were found in the control group when compared to study groups at 3 days, 7 days and 14 days intervals ($p < 0.001$).

Conclusion: Laser therapy resulted in improved healing edema score, but it had no significant impact on dental stability or implant survival.

Keywords: diode laser, dental implant, stability, healing edema.

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Introduction

The utilization of laser technology in contemporary dental procedures encompasses a broad spectrum of sub-disciplines, including conservative dentistry, oral surgery, endodontics, periodontology, implantology, aesthetic dentistry, among other dental interventions [1]. The historical application of laser technology within the field of dentistry spans five decades, having undergone continuous development since its introduction in the 1960s by Miaman, with significant implications for both hard tissue applications, such as restorative removal and curing, caries prevention, cavity preparation, growth modulation, and dentinal hypersensitivity, as well as soft tissue applications, including wound healing and the excision of hyperplastic tissue to facilitate the exposure of edentulous teeth, alongside

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various other therapeutic uses [2]. Lasers can be classified into distinct categories based on criteria such as the active material, energy emission levels, wavelength ranges, and laser movement methodologies [3]. Nevertheless, lasers are generally classified into two overarching categories—hard lasers and cold or soft lasers—based on parameters such as intensity, mode, and power utilized. Among the diverse array of lasers employed in dental applications, the diode laser has garnered significant attention both pre- and post-dental implant procedures, attributable to its efficacy in facilitating rapid tissue healing, minimizing inflammation, enhancing patient satisfaction, and improving overall recovery rates [4]. Particularly noteworthy is Low Level Laser Treatment (LLLT), a well-established concept recognized for its photobiostimulatory and photobiomodulatory properties, which are known to enhance cellular regeneration, elevate cellular metabolic rates, and promote cell proliferation [5]. Furthermore, diode lasers are characterized by ease of use in proximity, reduced thermal output, cost-effectiveness, and non-conductivity of electricity [6].

Teeth replacement, with the help of dental implants, is one of the ancient medical practices used since ancient civilizations. Various materials are used in implantology such as shells, bamboo, porcelain, iridioplatinum, gold, silver and at times, the teeth of other human beings. The loss of a teeth has two primary concerns, difficulty in chewing food and aesthetic issue. Some of the solutions include bridges, ligatures or external teeth, and dental implants. Until the development of modern dentistry, these dental implants remained a painful procedure that often posed a nightmare to the patients. However, with the development of modern dentistry, endosseeous implant or dental implant, the surgical element which creates a bond between bone and the surrounding prothesis (such as crown, bridge or denture), is well accepted [7]. The present study intended to investigate the application of diode laser therapy in dental implants. In the presence of various types of lasers, diode laser has been chosen for the study since it is widely used in dentistry, specifically for soft tissue applications. Before the placement and in the aftermath of fixation, various complex processes play a critical role in defining the success of the dental implants.

Before the insertion of the dental implant, it is imperative to prepare the implant bed and thoroughly assess the clinical condition of the patient. Following the placement of the implant, it is critical to ensure its primary stability initially. To achieve this, the implant must be scrutinized for osseointegration, which is the biological process that facilitates the integration of living bone with

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the implant surface. The various challenges encountered throughout this procedure, including microbial contamination, plaque accumulation, complications arising from the physical and chemical properties of the implant, as well as the biological and cellular responses that determine the acceptance or rejection of the dental implant, inflammation, primary stability, failures in osseointegration, and aesthetic considerations, must be meticulously analyzed to provide a comprehensive understanding of the significance of dental implants and the contribution of diode laser technology in this context. Additionally, it is essential to elaborate on the modifications that occur within the crestal bone, as these alterations play a pivotal role in the long-term success and stability of the implant. Considering these, the present study represents a pioneering effort to investigate the impact of diode laser therapy on patient healing outcomes, with the objective of enhancing the success rate of dental implants.

Material and Methods

This prospective clinical study was organized from November 2022 to August 2024 in Dentistry College Teaching Hospital, Department of Oral and Maxillofacial Surgery/Dental Implant Unit/University of Kut. The study sample was derived from the population of patients who was treated at the department of oral and maxillofacial surgery/college of dentistry, who were seeking dental implant prosthodontic rehabilitation to replace a single, multiple or unrestorable maxillary and mandibular teeth by dental implants. The protocol of this study was approved by the scientific committee of the department. All patients signed informed consent forms.

A total of 100 Iraqi adult patients aged 22 to 72 years, 50 males and50 females were enrolled in the study. They received 266 dental implants. Partially or completely edentulous patients aged over 18 years of either gender with D1, D2, D3 and D4 bone density having sufficient bone volumes were included in the study. Patients having chronic medical illness or contraindications for oral surgery, those with residual infection at implant sites, or having severe alveolar bone destruction, smokers and pregnant women were excluded from study.

All patients were subjected preoperatively to detailed clinical examination and radiographic evaluation utilizing cone beam computed tomographic scans (CBCT) and panoramic and periapical radiographs to scan the jaws and implants sites. All implants were placed by one surgeon according to a strict surgical protocol following the manufacture's information. Sequential osteotomy was carried out using osteotomy drill at 600 to 800 rpm speed with external irrigation with normal saline fluid.

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Peak seating torque was measured for each dental implant using calibrated manual torque ratchet and dental implant engine. For all 266 implants, after they were inserted, the operator measured RFA values (implant stability quotients ISQ) using RF analyzer (ostell) to obtain the primary and secondary stability for each dental implant.

Crestal bone level was measured around all dental implant fixtures using CBCT scans immediately after surgery. All the patients were recalled 3, 7, and 14 days after surgery to measure the healing edema according to a visual analogue scale (VAS) protocol. Secondary stability was measured 7 days, (4,8, and 12 weeks after dental implant insertion for all participants. All patients were recalled for follow up until one year after dental implant insertion for survival rate checking, and also to measure the crestal bone level around fixture using cone beam computed tomography scans. For the study group, diode laser Doctor smile diode laser device (ITALY) was irradiated by a clinician in an isolated room. For each dental implant fixture, survival rate was measured for one year follow up. Some of materials used in this study are shown in Figures 1 and 2.

Figure 1. Manual calibrated torque ratchet with torque scale (10-70N/cm) (Medentika Co., Germany).

Figure 2. Doctor smile™ diode laser device (ITALY).

Statistical analysis

Data were analyzed using SPSS (version 26). Numeric data were expressed as mean, minimum value, maximum value, standard deviation, interquartile range and median. Independent samples t-test was used to compare means between study and control groups; Mann Whitney U test was used to compare mean rank values between study and control groups, and chi-square was used to compare proportions between study and control groups. The level of significance was based on p-value of ≤ 0.05.

Results

In this study, the general characteristics of patients are shown in Table 1. With respect to age, there was no significant variation in the mean between study and control groups (p = 0.743), and the mean age with corresponding standard deviation were 47.02 ±14.25 years versus 46.10 ±13.77 years, respectively. In addition, in either group, the age ranged between 22 and 72 years. With respect to proportions of males and females, the researchers intentionally enrolled equal

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number of males and females in both study and control groups to ensure statistical matching. The range of implants (1 to 6), as well as the median(2), and the inter-quartile range (1) were the same for both groups. The researchers intentionally enrolled equal numbers of maxillary and mandibular implants in each group.

The median level of bone density in the study group was lower than that reported in the control group, 619 HU versus 698 HU, respectively. However, this difference was insignificant (*p* = 0.153). Moreover, the proportions of patients with D1, D2, D3 and D4 bone intensities in both groups were almost the same, 4% versus 2 %, 20 % versus 32 %, 76 % versus 62 %, and 0 % versus 4 %, respectively. There was no significant difference in mean insertion torque between both groups, 40.10 ±4.57 versus 38.74 ±5.27 N/CM, respectively (*p* = 0.171), Table 2.

Comparison of stability level between study group and control group is shown in Table 3. Regarding primary stability, there was no significant difference in its mean level between study group and control group, 67.12 ±5.44 ISQ versus 68.54 ±5.77 ISQ, respectively (*p* = 0.208). Regarding secondary stability following 7 days, 4 weeks, 8 weeks, and 12 weeks, there was no significant difference in its mean level between study group and control group (*p*> 0.05). Comparison of healing edema score between study group and control group is shown in Table 4. Higher scores of healing edema were associated significantly with control group when compared to study groups at 3 days, 7 days, and 14 days (*p*< 0.001).

Figures 3 to 5 illustrate some of the procedures in the present study.

Table 1. Demographic characteristics of patients enrolled in this study contrasted between study group and control group.

Characteristic	Study group *n* = 50	Control group *n* = 50	*P*
Age (years)			
Mean ±SD	47.02 ±14.25	46.10 ±13.77	0.743 I NS
Range	22 -72	22 -72	
Sex			
Male, *n* (%)	25 (50.0 %)	25 (50.0 %)	1.000 C NS
Female, *n* (%)	25 (50.0 %)	25 (50.0 %)	
Implant number			
Median (IQR)	2 (1)	2 (1)	0.898 M NS
Range	1 -6	1 -6	
Jaw bone			
Maxilla, *n* (%)	25 (50.0)	25 (50.0)	1.000 C NS
Mandible, *n* (%)	25 (50.0)	25 (50.0)	

n: number of cases; **SD**: standard deviation; **I**: independent samples student *t*-test; **C**: chi-square test; **NS**: not significant; **IQR**: inter-quartile range; **M**: Mann Whitney U test

Table 2. Comparison of bone density level between study group and control group.

Characteristic	Study group	Control group	*P*
Bone Density			
Median (IQR)	619 (341)	698 (352.25)	0.153 M NS
Range	345 -1308	296 -1290	
D1	2 (4.0 %)	1 (2.0 %)	
D2	10 (20.0 %)	16 (32.0 %)	
D3	38 (76.0 %)	31 (62.0 %)	
D4	0 (0.0 %)	2 (4.0 %)	
Insertion torque N/CM			
Mean ±SD	40.10 ±4.57	38.74 ±5.27	0.171 I NS
Range	30 -45	25 -50	

n: number of cases; **IQR**: inter-quartile range; **M**: Mann Whitney U test; **NS**: not significant; ***n***: number of cases; **SD**: standard deviation; **I**: independent samples student *t*-test; **NS**: not significant; **N**: Newton; **M**: meter

Table 3. Comparison of stability level between study group and control group.

Characteristic	Study group *n* = 50	Control group *n* = 50	*P*
Primary stability (ISQ)			
Mean ±SD	67.12 ±5.44	68.54 ±5.77	0.208 I NS
Range	54 -77	55 -81	
Secondary stability (ISQ)			
7 days			
Mean ±SD	66.70 ±5.27	67.78 ±5.31	0.310 I NS
Range	56 -76	55 -79	
4 weeks			
Mean ±SD	65.84 ±5.10	64.88 ±5.31	0.359 I NS
Range	54 -76	51 -76	
8 weeks			
Mean ±SD	66.30 ±5.10	64.66 ±5.33	0.119 I NS
Range	55 -77	51 -77	
12 weeks			
Mean ±SD	71.72 ±4.66	71.44 ±5.08	0.775 I NS
Range	63 -80	62 -82	

n: number of cases; **SD**: standard deviation; **I**: independent samples student *t*-test; **NS**: not significant; **ISQ**: Implant Stability Quotient

Table 4. Comparison of healing edema score between study group and control group.

Characteristic	Study group n = 50	Control group n = 50	*P*
Healing Edema			
3 days			
1	24 (48.0 %)	0 (0.0 %)	<0.001 C ***
2	22 (44.0 %)	25 (50.0 %)	
3	4 (8.0 %)	25 (50.0 %)	
7 days			
0	28 (56.0 %)	1 (2.0 %)	<0.001 C ***
1	19 (38.0 %)	26 (52.0 %)	
2	3 (6.0 %)	23 (46.0 %)	
14 days			
0	50 (100.0 %)	25 (50.0 %)	<0.001 C ***
1	0 (0.0 %)	25 (50.0 %)	

n: number of cases; **C**: chi-square test; *****: significant at $p \leq 0.001$

Figure 3. Application of diode laser at the implant sites **(A)** activating surgical tip **(B** cutting soft tissue.

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Figure 4. Recording primary stability using Osstell ISQ device. **(A)** Bucco-palata direction. **(B)** Mesio-distal direction.

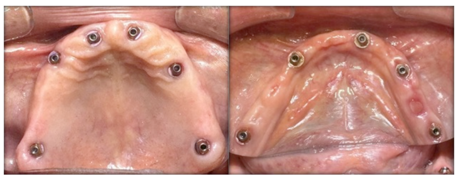

Figure 5. Complete healing after 3 months of the maxilla (left) and mandible (right).

Discussion

Comparison of stability level between study group and control group in this study revealed no significant difference. Kinalski et al., in 2021 performed a study, on patients who were randomly allocated to LLLT or control groups. LLLT consisted in the application of 808-nm GaAlA laser applied before the preparation of the implant bed and after suturing (80 seconds; 11J/cm^2); implant stability quotient (ISQ) was evaluated and the results showed that LLLT did not influence the implant stability in implants placed in healed sites compared to a control group [8]. Indeed, these results are supportive to current study findings.

Implant stability is categorized into primary stability, which occurs at the time of implant placement, and secondary stability, which is attained after the process of osseointegration [9]. In the context of implants that are situated within native bone, assessments of implant stability quotient (ISQ) indicate a discernible upward trend throughout the healing phase, a phenomenon that can be attributed to the biological remodeling processes occurring at the implant-bone interface, which are indicative of osseointegration [8]. From this standpoint, our investigation did not reveal a significant advantage of low-level laser therapy (LLLT) in comparison to the control group, as the intervention groups exhibited analogous values for implant stability, with no statistically significant differences detected when implant stability was evaluated against the control group. Consequently, the null hypothesis posited in our study, which asserted that there would be no discernible difference in implant stability when LLLT was juxtaposed with a control group in the context of implant placement in healed sites, was upheld.

Comparison of healing edema score between study group and control group is shown in this study during 14 days of follow up revealed significant variation which was in favor of study group. Based on the observation of Pouremadi et al., in 2019 [10], to evaluate the impact of 650 nm LLL irradiation on the decline in problems following advanced implant operations, they found that adjuvant laser therapy could considerably enhance wound healing and lessen the intensity and length of pain and edema about the biological consequences of sophisticated implant operations and associated problems.

The efficacy of an implant is predominantly influenced by the process of osseointegration. Various applications of Low-Level Laser (LLL) therapy in addressing peri-implant tissue complications enhance the population of viable osteoclasts and stimulate metabolic activity within the bone by facilitating local circulatory improvements, augmenting the surface area of bone in contact with the implant, and expediting the maturation of bone tissue. This intervention modifies the bone-implant contact surface area to facilitate a more rapid osseointegration process [11].

In the investigation conducted on a cohort comprising sixty participants (27 male and 33 female, with a mean age of 47.13 ± 8.05 years) was incorporated and subsequently allocated at

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random to three distinct groups: the experimental group (which underwent implant surgery accompanied by photobiostimulation), the placebo group (which received implant surgery alongside simulated photobiostimulation), and the control group (which underwent implant surgery exclusively). The findings indicated that edema was nearly negligible in the experimental group (with a maximum value of 1), in stark contrast to both the control (with a maximum value of 6) and placebo groups (also with a maximum value of 6) [12]. The later findings are consistent with current study observation with respect to edema score.

Conclusion

Laser therapy resulted in improved healing edema score, but it had no significant impact on dental stability or implant survival.

Conflicts of interest

The authors declare no competing interest.

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