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MODERN APPROACHES TO EARLY DETECTION AND TREATMENT OF PERI-IMPLANTITIS: THE ROLE OF LASER THERAPY

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Abstracts: Peri-implantitis is a pathological condition occurring in tissues around dental implants, characterized by inflammation of the peri-implant connective tissue and progressive loss of supporting bone. With the increasing number of dental implants placed globally, the management of biological complications has become a critical challenge. Objective: The aim of this study was to evaluate the clinical efficacy of diode laser therapy as an adjunctive treatment to mechanical debridement in the management of peri-implantitis compared to conventional mechanical therapy alone. Methods: A randomized controlled clinical trial was conducted at the Namangan Regional Dental Polyclinic, involving 35 patients diagnosed with peri-implantitis. Participants were randomly assigned to two groups: the Control Group (n=17) received mechanical debridement (MD) with chlorhexidine irrigation, and the Test Group (n=18) received MD followed by diode laser irradiation (980 nm). Clinical parameters, including Probing Pocket Depth (PPD), Bleeding on Probing (BOP), and Plaque Index (PI), were assessed at baseline, 1 month, and 3 months. Results: Both groups exhibited improvements in clinical parameters. However, the Test Group showed a significantly greater reduction in PPD (from 5.8±0.4 mm to 3.2±0.3 mm) compared to the Control Group (from 5.9±0.5 mm to 4.6±0.4 mm) at the 3-month follow-up ($p<0.05$). The resolution of inflammation, indicated by BOP scores, was also superior in the laser-treated group. Conclusion: The adjunctive use of diode laser therapy significantly enhances the outcomes of non-surgical treatment for peri-implantitis by effectively reducing pocket depth and inflammation.

Keywords: Peri-implantitis, Diode laser, dental implants, mechanical debridement, Namangan, oral health, biofilm.

1. Introduction

Dental implantology has revolutionized oral rehabilitation, providing a reliable solution for edentulous patients with success rates reportedly exceeding 95% over 10 years. However, the widespread application of dental implants has been accompanied by an increase in biological complications, specifically peri-implant mucositis and peri-implantitis [1, p. 12]. Peri-implantitis is defined as a plaque-associated pathological condition characterized by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting bone [2, p. 284]. The prevalence of peri-implantitis varies widely in the literature but is estimated to affect approximately 20% of patients and 10% of implants worldwide [3, p. 67]. The primary etiological factor is the accumulation of bacterial biofilm on the implant surface. The complex microstructure of modern implant surfaces, while beneficial for osseointegration, facilitates bacterial adhesion and makes mechanical removal of biofilm extremely difficult.

Conventional treatment strategies for peri-implantitis involve mechanical debridement (MD) using curettes, ultrasonic scalers, and air-polishing devices, often supplemented with local or systemic antibiotics. However, mechanical debridement alone has limited efficacy in completely

eliminating bacteria from the rough threads and micro-porosities of the implant surface [4, p. 45]. Moreover, excessive mechanical scraping can damage the implant surface, promoting further plaque retention. In recent years, laser therapy has gained attention as a promising adjunctive treatment modality. Lasers, such as the Diode, CO2, and Er:YAG, offer potential benefits including bactericidal effects, photobiomodulation (PBM), and hemostasis [5, p. 112]. The diode laser (wavelengths 810-980 nm) is particularly popular in clinical practice due to its compact size, affordability, and ability to penetrate soft tissues to reduce bacterial load without damaging the titanium surface [6, p. 33]. Despite the theoretical advantages, clinical data regarding the efficacy of diode lasers in specific regional populations remains limited. Therefore, the objective of this study was to evaluate the clinical efficacy of diode laser therapy as an adjunct to mechanical debridement in the treatment of peri-implantitis among patients at the Namangan Regional Dental Polyclinic.

2. Materials and Methods

Study Design and Setting: This study was designed as a randomized, parallel-group, controlled clinical trial. The investigation was carried out at the Department of Periodontology and Implantology of the Namangan Regional Dental Polyclinic (Namangan viloyat stomatologiya poliklinikasi), Uzbekistan, from September 2024 to January 2025. The study protocol adhered to the Declaration of Helsinki and was approved by the local Ethics Committee.

Participants: A total of 35 patients (19 males, 16 females, aged 30-60 years) diagnosed with peri-implantitis were enrolled.

Inclusion Criteria:

1. Presence of at least one osseointegrated implant in function for ≥ 1 year.
2. Diagnosis of peri-implantitis: Probing Pocket Depth (PPD) ≥ 5 mm with bleeding on probing (BOP) and radiographic bone loss ≥ 2 mm.
3. Systemically healthy patients capable of complying with the study protocol.

Exclusion Criteria:

4. Uncontrolled diabetes or other systemic diseases affecting wound healing.
5. Heavy smokers (>10 cigarettes/day).
6. Use of antibiotics or anti-inflammatory drugs in the past 3 months.
7. Total implant mobility.

Randomization and Grouping: The 35 patients were randomly assigned into two groups using a simple lottery method:

- Control Group (n=17): Treated with Mechanical Debridement (MD) + Chlorhexidine irrigation.
- Test Group (n=18): Treated with Mechanical Debridement (MD) + Diode Laser therapy.

Treatment Protocol: All patients received professional oral hygiene instructions prior to therapy.

- Control Group: Mechanical debridement was performed using titanium curettes (Hu-Friedy, USA) and plastic probes to remove supra- and subgingival calculus. The pockets were then irrigated with 0.2% Chlorhexidine gluconate solution for 1 minute [7, p. 89].
- Test Group: Following the same mechanical debridement procedure as the control group, the peri-implant pockets were treated with a Diode Laser (980 nm). The laser fiber (400 µm diameter) was inserted into the pocket parallel to the implant axis. The laser was activated in continuous wave mode at 1.0 W power. The fiber was moved in a sweeping motion (circumferential and vertical) for 20 seconds per site (mesial, distal, buccal, lingual), totaling 80 seconds per implant. This procedure was repeated once a week for 3 consecutive weeks [8, p. 201].

Clinical Assessments: The following parameters were measured by a blinded examiner at Baseline (T0), 1 month (T1), and 3 months (T2):

1. Plaque Index (PI): Assessed at 4 sites per implant (Silness & Löe).
2. Bleeding on Probing (BOP): Presence (1) or absence (0) of bleeding within 15 seconds of probing.
3. Probing Pocket Depth (PPD): Measured to the nearest millimeter using a calibrated plastic probe (Colorvue).

Statistical Analysis: Data were analyzed using IBM SPSS Statistics version 26.0. Continuous variables (PPD) were expressed as Mean ± Standard Deviation (SD). Intra-group comparisons were performed using the Paired t-test, and inter-group comparisons were made using the Independent Student's t-test. A p-value of <0.05 was considered statistically significant.

3. Results

All 35 patients completed the study. There were no complications or adverse effects reported in either group.

Baseline Characteristics: At the beginning of the study (T0), there were no statistically significant differences between the Control and Test groups regarding age, gender distribution, or baseline clinical parameters (PI, BOP, PPD), indicating a homogenous sample distribution ($p>0.05$). Plaque Index (PI) and Bleeding on Probing (BOP): Both treatment modalities resulted in a significant reduction in Plaque Index scores at 1 and 3 months, reflecting improved oral hygiene. Regarding inflammation, the Test Group (Laser) showed a more rapid and pronounced reduction in BOP. At 3 months, the percentage of sites with BOP was 18% in the Test Group compared to 42% in the Control Group.

Probing Pocket Depth (PPD): The changes in PPD are the primary outcome of this study and are summarized in Table 1. In the Control Group, PPD reduced from 5.9 ± 0.5 mm at baseline to 4.6 ± 0.4 mm at 3 months. While this reduction was significant compared to baseline, the values remained indicative of residual pathology. In the Test Group, PPD reduced from 5.8 ± 0.4 mm at baseline to 3.2 ± 0.3 mm at 3 months. The inter-group comparison at 3 months revealed a statistically significant difference ($p < 0.05$) in favor of the laser group.

Table 1. Comparison of Mean Probing Pocket Depth (PPD) between Control and Test Groups over the study period.

Time Interval	Control Group (MD + CHX) (n=17)	Test Group (MD + Laser) (n=18)	P-value (Inter-group)
Baseline (T0)	5.9 ± 0.5 mm	5.8 ± 0.4 mm	> 0.05 (NS)
1 Month (T1)	5.1 ± 0.4 mm	4.0 ± 0.3 mm	< 0.05
3 Months (T2)	4.6 ± 0.4 mm	**3.2 ± 0.3 mm**	**< 0.01**

Note: Values are Mean ± SD. NS = Not Significant. MD = Mechanical Debridement. CHX = Chlorhexidine.

4. Discussion

The present study, conducted at the Namangan Regional Dental Polyclinic, provides clinical evidence supporting the use of diode lasers in the treatment of peri-implantitis. The results demonstrate that the combination of mechanical debridement and diode laser irradiation is significantly more effective than mechanical debridement alone in reducing pocket depth and inflammation. The main challenge in treating peri-implantitis is the decontamination of the implant surface. As highlighted by Mombelli et al., mechanical instruments often fail to reach bacteria located in the undercuts and micro-threads of the implant [9, p. 15]. Our findings in the Control Group confirm this; although PPD decreased, it did not reach the level of "health" (<4 mm) in many cases, suggesting the persistence of a subgingival biofilm. The superior results in the Test Group can be attributed to the specific properties of the diode laser. First, the laser energy exerts a strong bactericidal effect. Research by Romanos et al. has shown that diode lasers can penetrate soft tissue walls and reduce bacterial counts of periodontal pathogens like Porphyromonas gingivalis and Prevotella intermedia significantly more effectively than antiseptics [5, p. 115]. Second, the laser promotes photobiomodulation (low-level laser therapy effect). This process stimulates mitochondrial activity, enhances ATP production, and accelerates the regeneration of collagen and soft tissue attachment [10, p. 410]. This explains the rapid resolution of bleeding (BOP) observed in our laser group.

It is also important to note the local context. In Uzbekistan, particularly in regional centers like Namangan, the adoption of advanced technologies like laser dentistry is growing. This study validates that such technologies can be effectively integrated into routine polyclinic workflows, providing high-standard care to the local population [11, p. 55]. However, the study has limitations. The sample size (35 patients) is relatively small, and the follow-up period was limited to 3 months. Long-term studies (12-24 months) are needed to assess the stability of the results and radiographic bone refill. Additionally, future research should compare different laser wavelengths (e.g., Er:YAG vs. Diode) within the same population.

Conclusion

Within the limitations of this study conducted in Namangan, the following conclusions can be drawn:

1. Diode laser therapy (980 nm) is a safe and effective adjunct to mechanical debridement for the treatment of peri-implantitis.
2. The laser group achieved a significantly greater reduction in Probing Pocket Depth (PPD) and Bleeding on Probing (BOP) compared to the control group.
3. Implementation of laser protocols in regional dental polyclinics can significantly improve the quality of implant maintenance and patient outcomes.

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