ORIGINAL ARTICLE

Effect of Laser Patterned Microcoagulation on Keratinized Mucosa Width and Gingival Thickness Around Dental Implants

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ABSTRACT

Introduction: Although there is no consensus on the influence of sufficient keratinized mucosa width (KMW) on the success of dental implantation, the majority of practitioners recommend achieving at least 2 mm KMW in the peri-implant zone. Additional trauma and specific complications of tissue augmentation techniques require the development of less invasive methods of increasing KMW. Previous studies report on the possibility of using diode lasers for this purpose. Thus, this study aimed to evaluate the effect of laser patterned microcoagulation (LPM) on values of peri-implant KMW, gingival thickness (GTH), and microcirculation. **Materials and methods:** The study was conducted on 22 patients with a total of 48 sites of insufficient KMW. A total of four LPM sessions were performed on the DIOMAX® (KLS MartinGroup, Tuttlingen, Germany) 1550 nm diode laser. Microcirculation parameters were evaluated using laser doppler flowmetry (LDF). The values were obtained at the initial examination and two weeks after each LPM session. **Results:** Measurements demonstrated a gradual increase of KMW (2.21 ± 0.17 mm) and GTH (1.36 ± 0.21 mm) under the effect of LPM sessions ($p<0.05$). In addition, the manipulations had a positive influence on the local hemodynamics and resulted in improved blood supply. **Conclusion:** Within the study limitations, the data showed that LPM could be applied to achieve a sufficient KMW value without additional soft tissue augmentation. Also, the effect of gingiva thickening can expand the area of LPM application and be the basis for new clinical studies.
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INTRODUCTION

The value of sufficient keratinized mucosa width (KMW) around dental implants is still a subject of discussion. According to numerous clinical studies, inadequate KMW (< 2 mm) is associated with a higher risk of recession, peri-implantitis, mucositis, and a higher level of marginal bone loss (1–3). Other studies reported controversial results (4, 5). Although there is no consensus on this issue, a growing number of researchers recommend achieving at least a 2 mm zone of peri-implant keratinized tissue (1).

Gingival thickness is a significant factor in marginal bone and mucosal margin stability. A thin peri-implant mucosa is associated with higher marginal bone loss (6–10). Each keratinized tissue augmentation technique and grafting approach is related to additional traumatization and a particular risk of complications. The success of manipulation directly depends on the clinical experience of the surgeon (11–14). It requires the development of less invasive and more straightforward methods to achieve sufficient KMW and soft tissue phenotype.

Laser patterned microcoagulation (LPM) based on fractional photothermolysis (FP) is primarily used in periodontology to prevent recession and inflammation and for gingival depigmentation (15–17). The primary mechanism of tissue regeneration is associated with activating heat shock proteins and following neocollagenesis in response to thermal damage. The effect of LPM on the oral mucosa and the regeneration process has been studied in experimental animals (18–20).

However, few studies have been conducted in clinical cases related to inadequate peri-implant KMW (21). In addition, there is no published research on the effect of LPM on gingival thickness and local hemodynamics. Thus, all these facts determine the need for a more detailed study. The current research aimed to study the dynamics of peri-implant KMW, mucosal thickness, and indicators of blood supply after LPM sessions. The null hypothesis was that LPM would not increase KMW and GTH.

MATERIALS AND METHODS

Research design and patient selection

An open, prospective, non-randomized clinical trial was conducted at the Department of Maxillofacial Surgery of the Tashkent State Dental Institute clinic from February 2022 to March 2023. Ethical approval was obtained from the Ethical Committee of the Ministry of Health of the Republic of Uzbekistan (protocol No. 4/2-1487 from 27.12.2021). Each research team member had at least 5 years of continuous clinical experience. The study was conducted following the CONSORT guidelines for non-randomized clinical trials.

The inclusion criteria were as follows: 1) KMW less than 2 mm around dental implants; 2) presence of 1-3 implants installed 3 months earlier in the posterior maxilla/mandible; 3) signed informed consent.

The exclusion criteria were as follows: 1) age under 18 and over 70 years; 2) complete edentulousness; 3) scars and strands of peri-implant mucosa; 4) poor oral hygiene; 5) previous mucogingival flap surgery on the same site; 6) acute inflammation of the peri-implant zone. The exclusion criteria also included pregnancy, lactation, decompensated chronic diseases, cancer, hemostasis disorders, inflammatory and autoimmune diseases, viral hepatitis, AIDS, and tuberculosis.

Laser patterned microcoagulation (LPM)

The procedure was performed using a DIOMAX® (KLS MartinGroup, Tuttlingen, Germany) 1550 nm diode laser with power parameters of 20 W, 1 Hz, 120 ms pulse. Under application anesthesia, microcoagulation columns were created along the mucogingival junction (MGJ) and further spread to the free gingiva with a filling factor of 30% (Figure 1). The treatment consisted of four LPM sessions with a two-week interval.

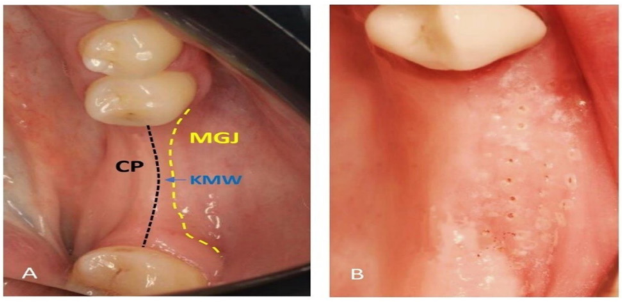

Figure 1: Clinical photos. Initial MGJ and KMW levels (A). Condition of gingiva after LPM session (B).

Outcome measurements

Pain intensity was controlled during LPM. Patients were instructed to report any undesirable effects after the LPM session. Local hyperemia, signs of inflammation, and edema were evaluated during examinations.

KMW was measured in millimeters from the central point (CP) in the implant projection to the MGJ using a calibrated periodontal probe. MGJ was identified using a roll-test (22).

GTH was assessed using transgingival probing with a K-file #10 fitted with a rubber stopper. Under application anesthesia, the #10 file was inserted into the attached gingiva perpendicularly until the alveolar bone. Then the stopper was moved and fixed on the gingiva. The interval between the stopper and the tip of the file was measured with a digital caliper (with a 0.01 mm sensitivity).

KMW and GTH were measured before each LPM session and two weeks after the last one.

Local microcirculation was studied using laser doppler flowmetry on LAKK-02® (Lazma, Moscow, Russia). Measurements were carried out before the treatment and two weeks after the last LPM. Data was also obtained from the symmetrical (healthy) side for comparison.

Statistical analysis

Statistics and data plotting were performed in OriginPro 8.6 using the Pair-Sample t-Test method of data analysis. Descriptive statistics for the considered parameters were presented as mean, standard deviation, maximum and minimum values. The normality test of the data and the homogeneity were evaluated using the Shapiro-Wilk test and the Levene test, respectively. The differences in KMW and GTH gain between maxillary and mandibular edentulous sites were analyzed by the paired Student's t-test and one-way ANOVA. A $p<0.05$ was considered statistically significant.

RESULTS

A total of 22 patients with 48 insufficient KMW sites were included in the study. Patients were 42-60 years old, with a mean age of 51.3 ± 4.7 years (Table I).

Table I: Patient data and initial parameters.

Parameters		Values
Age		51.3 ± 4.7
Sex	Male	14
	Female	8
Location	Maxilla	17
	Mandible	31
Baseline	KMW, mm	1,13 ± 0,25
	GTH, mm	0.99 ± 0.20

Most patients showed painless LPM and intervals between sessions. Only two patients felt mild pain during LPM. According to control examinations, treatment generally passed without any sign of inflammation or scar formation.

The effect of LPM on gingiva parameters

KMW and GTH increased gradually after each LPM session. A total gain was 1.08 ± 0.16 (95.6%) and 0.36 ± 0.06 mm (33.0%), respectively. It should be noted that KMW at 11 sites was >2 mm after the 3rd LPM session.

Finally, KMW was more than 2 mm at all studied sites, with an average value of 2.21 ± 0.17 mm. The lowest value of KMW was registered on two adjacent mandibular sites (4.4%) of the same patient – 2.01 and 2.03 mm, respectively. Adequate KMW (> 2 mm) became an indication for the healing abutment installation.

The final average GTH was 1.36 ± 0.21 mm. The lowest value was registered on two maxillary sites – 0.88 and 0.96 mm, respectively. The GTH of the other sites was more than 1 mm (Figure 2).

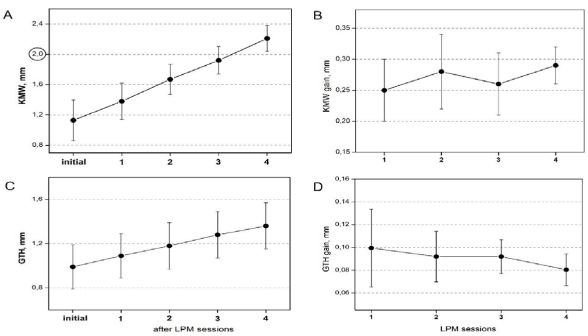

Figure 2: Gradual increase of KMW and GTH parameters. KMW at 11 sites already was more than 2 mm after 3rd LPM session. Finally, there was no any site with inadequate KMW after all LPM sessions (A). Amount of KMW gain fluctuated. The average KMW gain was 0.27 ± 0.02 mm after each LPM session (B). Final values of GTH was more than 1 mm at all sites (C). The average GTH gain was 0.09 ± 0.01 mm after each LPM session (D).

There were no statistically significant differences in KMW and GTH gain between maxillary and mandibular edentulous sites (p>0.05) after LPM sessions.

Effect of LPM on microcirculation parameters

Initial values indicated a reduction of blood supply due to the lack of masticatory load [23, 24]. The initial parameters of LDF showed vasoconstriction: the vascular tonus was higher than normal values by 18%. Compared to the symmetrical side, blood flow (M) decreased by 31%. A low intensity of blood flow (σ) indicated a reduced level of tissue nutrition. Low values of high frequency and pulse fluctuations pointed to complicated venous outflow.

The microcirculation parameters were re-measured two weeks after the last LPM. The indicators pointed to positive changes in blood supply. The blood flow level and intensity increased by 30% in response to microcoagulation. The vascular tonus decreased to close to normal values, reducing blood flow resistance. The increased amplitude of myogenic oscillations also reflected reduced peripheral resistance and improved venous outflow (Figure 3).

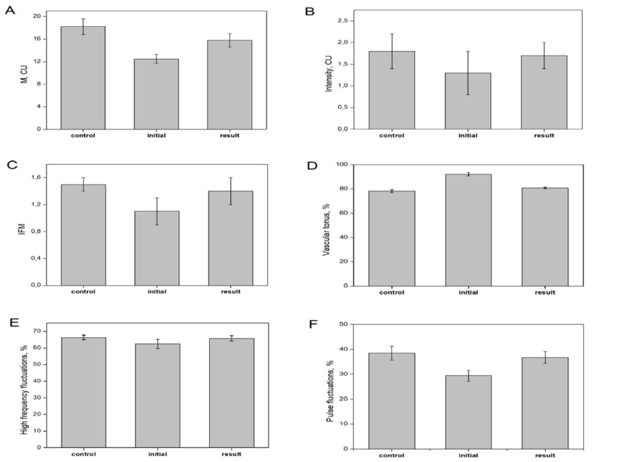

Figure 3: Dynamics of microcirculation parameters after LPM sessions. Most of LDF parameters changed close to normal values. Microcoagulation caused increasing of blood flow level (M) and its intensity (A, B). Index of flaxmotions (IFM) indicated normalization of local microcirculation regulation (C). Decrease of vascular tonus reflected reducing of blood flow resistance (D). Increased value of high frequency fluctuations indicated the enhancement of compensatory and adaptive mechanisms as a reaction to microcoagulation (E). LPM led to the improvement of venous outflow (F).

DISCUSSION

In this study, we evaluated the effect of laser patterned microcoagulation (LPM) or fractional laser photothermolysis on peri-implant mucosa parameters: keratinized mucosa width (KMW), gingival thickness (GTH), and local hemodynamics. We demonstrated that microcoagulation columns created by a 1550 nm diode laser heal without inflammatory complications orscar formation. In addition, LPM sessions resulted in achieving the optimal value of KMW (> 2 mm) and the thickening of gingiva around installed dental implants. Previous clinical studies aimed to estimate the effect of LPM sessions only on KMW (21, 30). In the current study, we found a positive influence of fractional laser photothermolysis on microcirculation parameters. Results of LDF demonstrated a significant enhancement of local blood supply and compensatory and adaptive mechanisms.

The procedure of LPM is based on creating isolated columns of micro-thermal wounds surrounded by normal tissue. Viable tissue around necrotic zones induces faster re-epithelialization of injured tissue by stimulating neocollagenesis and elastic tissue formation. According to cross-polarization optic coherence tomography, increased collagen synthesis and the formation of new collagen fibers occur in the period between the 5th and the 12th days after LPM (18). The process of collagen remodeling and synthesis leads to tissue thickening. Keratinocytes migrate from the surrounding viable tissue and replace thermally destroyed tissue within the first 24 hours after LPM (25, 26).

LPM has already been effectively used in clinical periodontology to prevent recessions and control periodontal infection. According to previous clinical trials, fractional laser photothermolysis contributes to eliminating Stillman's cleft. In addition, a mucogingival triangular-shaped defect was no longer observed in 82.6% of patients 3-6 months after treatment. Moreover, laser exposure has a positive effect on the scarring of the oral mucosa – the reduction of the scar area varies from 18% to 100% (16, 20).

Peri-implant keratinized mucosa width and mucosal thickness are critical factors affecting peri-implant health. Therefore, assessment of the KMW and GTH at the edentulous site before implant placement is crucial during treatment planning for clinicians to predict the success of dental implantation. Soft tissue augmentation is associated with additional trauma and an appropriate risk of failure (10, 27). In this study, painless LPM sessions positively affected KMW and GTH and induced increased values on impacted sites. Sufficient KMW values were achieved after four LPM sessions in six weeks without additional augmentation.

Histologically, the process of tissue healing occurs without signs of dyskeratosis and spongiosis in the epithelium, as well as signs of scarring in the connective tissue. In the healing process, new tissue is characterized by increased blood supply and fibroblasts concentration without signs of fibrosis. The precise mechanism of healing still needs to be studied (28). In our study, the process passed without signs of inflammation or scar formation. Therefore, LPM can provide an excellent esthetic result without additional trauma and complications related to tissue augmentation surgery.

Absence of masticatory load on the edentulous site indicates functionally inactive bone. Therefore, the effectiveness of its microcirculation is reduced due to a decrease in the intensity of blood flow, deterioration of vascular elasticity, and the involution of functionally inactive micro-vessels (23, 24). Laser exposure increases vascularization and blood supply due to the formation of new vessels related to active fibroblasts proliferation. Young connective tissue contains newly formed, thin-walled blood vessels (16, 29). In our study, the initial LDF parameters indicated vasoconstriction, a decrease in the intensity of blood flow, and obstructed venous outflow. LPM sessions led to the enhancement of local hemodynamics and venous outflow parameters. Normalization of IFM and the blood flow level (M) indicated that laser exposure stimulated angiogenesis and the growth of connective tissue with a rich capillary network. Consequently, improved blood supply had a positive effect on tissue nutrition and regeneration.

One of the limitations of this study was the lack of previous clinical studies on this topic. Furthermore, these articles provide only short-term results of laser exposure to gingiva. According to a previous clinical trial, fractional laser photothermolysis contributes to an increase of KMW in 60% of the total 60 cases, with an average gain of 0.9 mm. The authors of the trial suppose that LPM is effective in patients with minor mucogingival defects (30). In our study, the final KMW was more than 2 mm at all impacted sites, with an average gain of 1.08 ± 0.16 mm. The minimal initial value of KMW to assign LPM sessions is still not indicated. Further prospective studies with a larger sample size should be carried out to determine this value.

CONCLUSION

n conclusion, fractional laser microcoagulation provides an increase in KMW and GTH and improves the local blood supply. Consequently, the use of LPM has a positive effect on peri-implant health and long-term treatment results. The method can be used before healing abutment installation in cases of two-stage implant placement. Further prospective studies with a larger sample size should be conducted to determine the minimal initial value of KMW at which LPM sessions result in sufficient width of attached mucosa. The effect of gingiva thickening can expand the scope of LPM application in dentistry. The promising results of this research can be the basis for new studies on using LPM to correct different conditions of the oral mucosa.

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