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Original Article

The use of low level laser therapy in conjunction with diode laser-assisted and conventional vestibuloplasty: Comparison of wound healing and vestibular depth gain

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ABSTRACT

Background: The aim of this study is to compare wound healing and vestibular depth gain in individuals undergoing vestibule deepening surgery using diode laser and conventional technique and to further investigate the possible wound healing effect of low-level laser therapy (LLLT).
Material and Methods: 52 systemically healthy individuals with insufficient vestibular depth in the region of teeth 33−43 in the lower jaw were included. Following nonsurgical periodontal treatment, patients were divided into four groups as follows: a) diode laser (L); b) diode laser + LLLT; c) conventional surgery and d) conventional surgery + LLLT. Vestibular depth and horizontal wound size measurements of the individuals were recorded using digital calipers. Reepithelization was evaluated via an image analysis program.
Results: Vestibular depth measurements were found to be higher in the conventional surgery groups compared to that of diode laser groups after the operation, while the results were not statistically different between groups (p >0.05). Reepithelization area did not differ between groups in the evaluated time periods (p >0,05). On the other hand, horizontal wound shrinkage was significantly higher in the conventional surgery group than that of diode laser.
Conclusions: Within the limits of this study, both methods yielded in vestibule depth gain. On the other hand, LLLT did not have an additional positive effect on mucosal wound healing. As a clinical relevance, the results are valuable for clinicians in terms of showing that suturing of the mucosal flap formed following vestibule deepening should not be necessary in laser assisted surgery for attaining more vestibule depth.

1. Introduction

Keratinization plays an important role in protecting periodontium against frictional forces that occur during chewing. In addition, keratinization plays an active role in the development of resistance to the high tension created by muscle connections of mucosa at gingival margin. The frenulum and muscle attachments located close to the gingival margin stretch the gingival groove, facilitating plaque accumulation and increasing the rate of progression of gingival recession [1]. It is known that a narrow gingiva together with a shallow vestibule sulcus will increase the accumulation of food particles during chewing and prevent adequate oral hygiene [2]. Furthermore shallow vestibule sulcus which is also resulted following bone augmentation techniques is associated with mucosal recession and bone loss around dental implants [3] and therefore, is considered as risk factor for long-term success [4]. Vestibuloplasty, which is one of the most frequently performed mucogingival surgery aimed at eliminating these problems, is a procedure in which the vestibule sulcus is deepened by changing the positions of the soft tissue attachments. This procedure can be done with the gingival grafts to increase attach gingiva or via secondary epithelization. Among the indications of vestibuloplasty operations; correction of soft tissue anomalies such as fibrous hyperplasia that shallows vestibule sulcus and removal of high muscle attachments. Conventionally vestibuloplasty can be done with a scalpel but nowadays, as the fact that minimally invasive surgery is being of interest, lasers can also be used for these purposes [5]. Diode laser, which is a soft tissue laser, offers more clinical advantages upon conventional surgery as: ensuring sterilized working area, eliminating/reduction the need for anesthesia and sutures, excellent control of hemostasis due to its high absorption by hemoglobin [6].

The radiation of Indium-Gallium-Arsenide (InGaAs) laser, which is one of a diode laser type, in milliwatt (mW) ranges is called low level laser therapy (LLLT) [7]. It has been reported that LLLT treatment may increase the proliferation of gingival fibroblasts or periodontal ligament fibroblasts, and therefore it may contribute to periodontal wound healing [8]. In vitro studies have shown that LLLT had various biostimulator

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effects in wound healing, increases cell proliferation, collagen synthesis and mitochondrial activities [7], and may increase revascularization [9].

In the literature, there are several works that investigate the wound healing effect of diode laser or LLLT [10−12] and also compare with that of conventional surgery [13,14]. On the other hand, within our knowledge, there are no study that assess whether there is superiority against scalpel surgery in terms of vestibule depth gain and reducing scar contraction. Therefore, this randomized controlled parallel designed clinical study aims at comparing vestibule depth gain and dimensional changes of wound area in individuals, who underwent vestibule deepening surgery using diode laser and conventional technique. The second aim is to analyze the effect of LLLT on secondary wound healing.

2. Methods

2.1. Study population

Systemically healthy patients aged between 18 and 53 years (10 males and 42 females) with inadequate vestibular depth and insufficient attached gingiva in the anterior mandible were included in this randomized parallel design study. The study protocol was approved by the Medical Faculty's Ethics Committee (acceptance number 2018/120) and also Ministry of Health Medical Drugs and Devices Institution with the document number 153829 (date 03/10/2019). (ClinicalTrials registration number NCT05252260).

All participants were informed about the study protocol including nonsurgical and surgical periodontal treatment, and their consent was obtained. The subjects were selected from October 2019 to June 2020 at the Department of Periodontology, Bolu Abant Izzet Baysal University according to the eligibility criteria described below:

2.2. Inclusion criteria

Patients were > 18 years old and of both genders, presenting inadequate vestibular depth and insufficient attached gingiva since high frenulum on incisors in the mandibular anterior region. Full mouth plaque index (PI) and gingival index (GI) scores < 1. The patients had to be systemically healthy and nonsmokers.

2.3. Exclusion criteria

Patients who had Miller class II and more advanced gingival recession in the region of the lower anterior incisors and interproximal attachment loss, patients taking medications that would interfere with the wound-healing process, pregnant or lactating women, patients having previously undergone periodontal surgery in the study area, patients having orthodontic therapy and using fixed/removable dentures involving lower anterior teeth were excluded from the study.

2.4. Study groups and randomization protocol

The study groups were constituted as follows:

Diode laser group (n = 13) (L); diode laser plus low-level laser therapy group (n = 13) (L-LLLT); conventional surgery group (n = 13) (C) and conventional surgery plus low-level laser therapy group (n = 13) (C-LLLT).

Randomization of the patients was generated through opaque, closed envelopes, which the group names were written. Conventional surgery was written in 26 of the sealed envelopes and diode laser surgery was written in 26 of them. Patients were asked to choose one of these envelopes, which were located in a glass box. After the selection, the groups, to which each individual belonged, were recorded by the researcher (MK). In addition, individuals were asked to select again from another box to determine the LLLT application groups and recorded by another researcher (ZK), who were not included the study protocol.

3. Surgical procedure

3.1. Clark's vestibuloplasty

Before the surgery, an acrylic stent was prepared for each patient to standardize the vestibule depth measurements and photogrammetric analysis. For this purpose, 1-mm thick and 5-mm-long full-round wire was placed on the prefabricated acrylic stent and located in the mandibular incisor area. Furthermore, three separate groves parallel to the long axis of the incisor teeth (one is located in the mandibular frenulum area) were created to locate the endodontic spreader along the same line to standardize the measurements.

An area of 20 mm in length was determined horizontally in the vestibule sulcus, with the frenulum as the midpoint. The depth of the wound was determined in each patient as 5 mm from the mucogingival line to the deepest point of the wound area [15].

A local anesthetic (Maxicaine Fort;80 mg/2 ml Ankara, Türkiye) was administered, a horizontal incision was then prepared at the mucogingival junction with a scalpel blade no. 15c. All the muscle fibers over the periosteum were resected carefully. Following, the mucosal flap was sutured to the depth of the vestibule sulcus with 4−0 polypropylene suture (Pegelak, Doğsan, Trabzon,Türkiye) material, once every 4 mm, from a total of 5 regions and no periodontal dressing was utilized to cover the area.

3.2. Laser assisted vestibuloplasty

Before the surgery, laser protective equipment consisting of laser safety glasses was worn by the clinician and patient and appropriate precautions were taken. Later, local anesthesia was achieved in the same manner as the C group. Laser irradiation was performed in continuous wave mode, using a 980 nm diode laser (Sirolaser Xtend, Dentsply Sirona) with an outpower of 1.5 W, 320 μm optical fiber.

After adequate local anesthesia, ablation was started from the mucogingival junction and performed via horizontal movements parallel to the bone. The muscle attachments were slowly released until the deepest point of the wound site was 5 mm. The fiber tip was kept in contact during the operation. The presence of residual muscle attachments was checked by retracting the patient's lip and if any residual muscle attachment remained, it was excised again by diode laser (MK). The surgical site was cleaned with saline irrigation following the surgery. The mucosal flap was not stabilized with sutures, and periodontal dressing was not used to cover the wound area.

3.3. Low level laser therapy

In this study, LLLT was applied in continuous wave mode for 1 min without contacting the tissue (power output, 0.1 W; total energy density (fluence) of 6 J/cm^2). During irradiation, the tip of the laser probe was positioned perpendicularly, and laser irradiation was applied within a wound area using back and forth action at a distance of 1−2 mm from the tissue. In the other group that would not be treated with LLLT, all procedures were repeated without active laser light. All these procedures were performed by another experienced clinician (ZU), who was not actively involved in the study, and were repeated immediately after the surgery, on the 1st, 3rd and 7th days.

4. Postoperative assessments

4.1. Vestibule depth measurement

Measurements were performed with the help of a plastic stopper placed on the endodontic canal instrument, with reference to the guides created on the acrylic stent, which was prepared before the surgery. The projection of the measurements obtained on the canal instrument was determined clearly with the help of digital caliper.

Vestibule depth measurements were repeated at 1 week, 2 weeks and 1 month immediately after the operation.

4.2. Re-epithelization

Areas, where there is little or no gingival epithelium were evaluated by applying a plaque staining agent (Mira-2-tone, GMBH & Co., Duisburg, Germany) to the surgical area [12]. Clinical photographs of the stained gingiva were taken immediately after the operation and on the 3rd, 7th, and 14th days after the operation, using pre-prepared acrylic stents. Images were taken at standard magnification and distance on a digital camera (four optical zooms, 20 cm), and the head of each patient was positioned to standardize the images. Incomplete epithelialized areas were measured using an image analysis software (Image J National Institutes of Health, Bethesda, MD, USA) by the investigator blinded to the groups (SG). The size of the 5 mm long metal round wire on the acrylic stent in the images was determined. Thus, the ratio between real (exact) and photographic dimensions was utilized to calibrate the images (See in Supplement Figure 1). Dark-stained areas were considered as ongoing wound healing without adequate epithelial layer. Measurements of the wound area were repeated three times in the computer-based program and the arithmetic mean of the obtained measurements were presented as the reepithelization which is given in mm^2.

4.3. Wound healing

The healing of the surgical area was scored using an index determined by Landry et al. [16]. The evaluation was repeated at the 1st, 7th, 14th and 28th days after the surgery.

4.4. Pain and loss of function

Patients were asked to rate their postoperative pain and functional changes (discomfort during eating and speaking) on visual analog scales (VAS). The left endpoint of the pain scale was marked as “no pain” (score 0) and the right endpoint as “worst pain imaginable” (score 10). Discomfort during eating and speaking was marked as “no discomfort” on the left and “worst discomfort” on the right. Thus, the degrees of pain and functional complications ranged from 0 to 10. The researcher recorded these scores on the first and seventh days after the operation.

4.5. Dimensions of wound area

During the weekly follow-ups (first, 2nd, and 4th weeks after the operation), the linear dimensions of the wound in the horizontal direction were measured with a digital caliper over the projection on the endodontic file and recorded on the patient form.

4.6. Statistical analysis

Before the study, power analysis was performed to determine the appropriate sample size. Accordingly, the vestibule depth gain was considered as the primary outcome variable. If a gain in vestibule depth difference between groups of 1.56 mms [17] is detected at α = 0.05 with an 80% power, 13 participants per group needed to be included.

All the data were entered into a Microsoft Excel sheet by a single person, who was masked to the groups, and imported into IBM SPSS Statistics Version 20.0 by the supervisor of the study (SG). Normality of the data was checked by the Shapiro−Wilk test. The categorical variable of gender was analyzed with the Chi-square test. Comparison between groups was analyzed with One Way Analysis of Variance-LSD test for normally distributed data. On the other hand, Kruskal Wallis-Mann Whitney U tests was utilized for data that did not show normal distribution. For intra group comparison, normally distributed data were analyzed by Repeated Measures Analysis of Variance and paired samples T test, non-normally distributed data were analyzed by Friedman-Wilcoxon signed rank test. A p value < 0.05 was considered significant.

5.1. Results

5.1. Vestibule depth measurements

The measurements of vestibule depth were compared between groups and it has been determined that the first week measurements in the conventional surgery group differed from the diode laser group. On the other hand, changes in the evaluated time periods between groups did not reach significance (p>0.05) (Table 1).

5.2. Re-epithelization

Measurements of the wound areas and also the alteration during the time periods did not differ between groups (p>0.05). In contrast, it was determined that the surgical wound area significantly decreased in the evaluated time periods in each group (p<0.05). (See Table 2).

Clinical photographs of the study groups showing the healing process in each evaluated time were given in Fig. 1.

Table 1
Clinical measurements of vestibule depth values with digital caliper in each groups (mm).

Vestibule Depth	Diode Laser (n = 13)	Diode Laser+LLLT (n = 13)	Conventional surgery (n = 13)	Conventional surgery+LLLT (n = 13)	P
Baseline (T0)	13,62 ± 1,59 (13,68)	14,14 ± 1,99 (13,37)	14,66 ± 1,39 (14,35)	14,43 ± 1,14 (14,28)	0,373#
1st week (T1)	16,44 ± 1,55 (16,46)^{a}	16,67 ± 2,24 (15,78)^{a}	18,13 ± 1,39 (17,69)$^{a \alpha \beta}$	17,83 ± 1,79 (18,22)$^{a \alpha \beta}$	**0,044#**
2nd week (T2)	15,39 ± 1,46 (15,49)^{ab}	15,70 ± 1,85 (14,98)^{ab}	16,94 ± 1,59 (17,35)^{ab}	16,74 ± 1,67 (16,63)^{ab}	0,051#
4th week (T3)	14,50 ± 1,69 (14,78)^{abc}	15,07 ± 1,93 (14,25)^{abc}	15,99 ± 1,43 (15,87)^{abc}	15,77 ± 1,64 (15,72)^{abc}	0,109#
ΔT0-T1	−2,82± 1,06 (−2,5)	−2,53±1.15 (−3,13)	−3,47±1,68 (−3,50)	−3,40±1,11 (−3,42)	0,412##
ΔT0-T2	−1,77±0,65 (−2,1)	−1,56±0,75 (−2,12)	−2,28±1,26 (−1,88)	−2,31±1,21 (−2,12)	0,899##
ΔT0-T3	−0,88±0,50 (−1,03)	−0,93±0,68 (−1,18)	−1,33±0,68 (−1,30)	−1,34±0,10 (−0,88)	0,782##
ΔT1-T2	1,05±1.05 (0,50)	0,97±0,67 (0,96)	1,19±0,91 (1,02)	1,09±0,82 (0,99)	0,304##
ΔT1-T3	1.94±1.00 (1,54)	1,60±0,85 (1,80)	2,14±1,40 (1,86)	2,06±0,84 (1,99)	0,593##
ΔT2-T3	0,89±0,61 (0,59)	0,63±0,45 (0,69)	0,95±0,83 (0,65)	0,97±0,45 (0,94)	0,690##

n: number of subjects. Values are given as mean ± standard deviation (median), p<0,05.
#: One-way ANOVA-LSD test.
α: Difference from Diode laser β: Difference from diode laser+LLLT.
##: Kruskal Wallis testi.
a: Difference from baseline b: Difference from 1st week c: Difference from 2nd week.
LLLT: Low Level Laser Therapy.

Table 2
Photogrammetric measurements of the re-epithelization area using computer based analysis program (mm^2).

Re-epithelization	Diode Laser (*n* = 13)	Diode Laser+LLLT (*n* = 13)	Conventional surgery (*n* = 13)	Conventional surgery+LLLT (*n* = 13)	p#
Post surgery (T0)	78,34 ± 13,40	71,80 ± 13,36	65,61 ± 19,11	78,94 ± 11,52	0,080
3rd day (T1)	68,41 ± 10,73 [a]	64,57 ± 11,23 [a]	58,37 ± 17,14 [a]	70,89 ± 15,52 [a]	0,128
7th day (T2)	49,57 ± 14,25 [ab]	43,52 ± 10,61 [ab]	44,53 ± 17,67 [ab]	52,11 ± 14,80 [ab]	0,388
14th day (T3)	22,42 ± 6,98 [abc]	21,03 ± 7,85 [abc]	21,03 ± 6,69[abc]	22,95 ± 9,32[abc]	0,892
ΔT0-T1	9,93 ± 6,30	7,23 ± 8,11	7,24 ± 4,43	8,05 ± 9,58	0,761
ΔT0-T2	28,77 ± 13,73	28,28 ± 12,96	21,08 ± 11,19	26,83 ± 13,29	0,408
ΔT0-T3	55,92 ± 10,91	50,77 ± 13,98	44,58 ± 16,19	55,99 ± 9,20	0,089
ΔT1-T2	18,84 ± 10,67	21,05 ± 12,25	13,84 ± 9,70	18,78 ± 10,85	0,394
ΔT1-T3	45,99 ± 7,87	43,54 ± 13,42	37,34 ± 13,99	47,94 ± 12,90	0,155
ΔT2-T3	27,15 ± 11,07	22,49 ± 7,30	23,50 ± 14,24	29,16 ± 13,63	0,449

n: number of subjects. Values are given as mean ± standard deviation, $p<0,05$.
#: One-way ANOVA test.
a: Difference from post-surgery b: Difference from 3rd day c: Difference from 1st week.
LLLT: Low Level Laser Therapy.

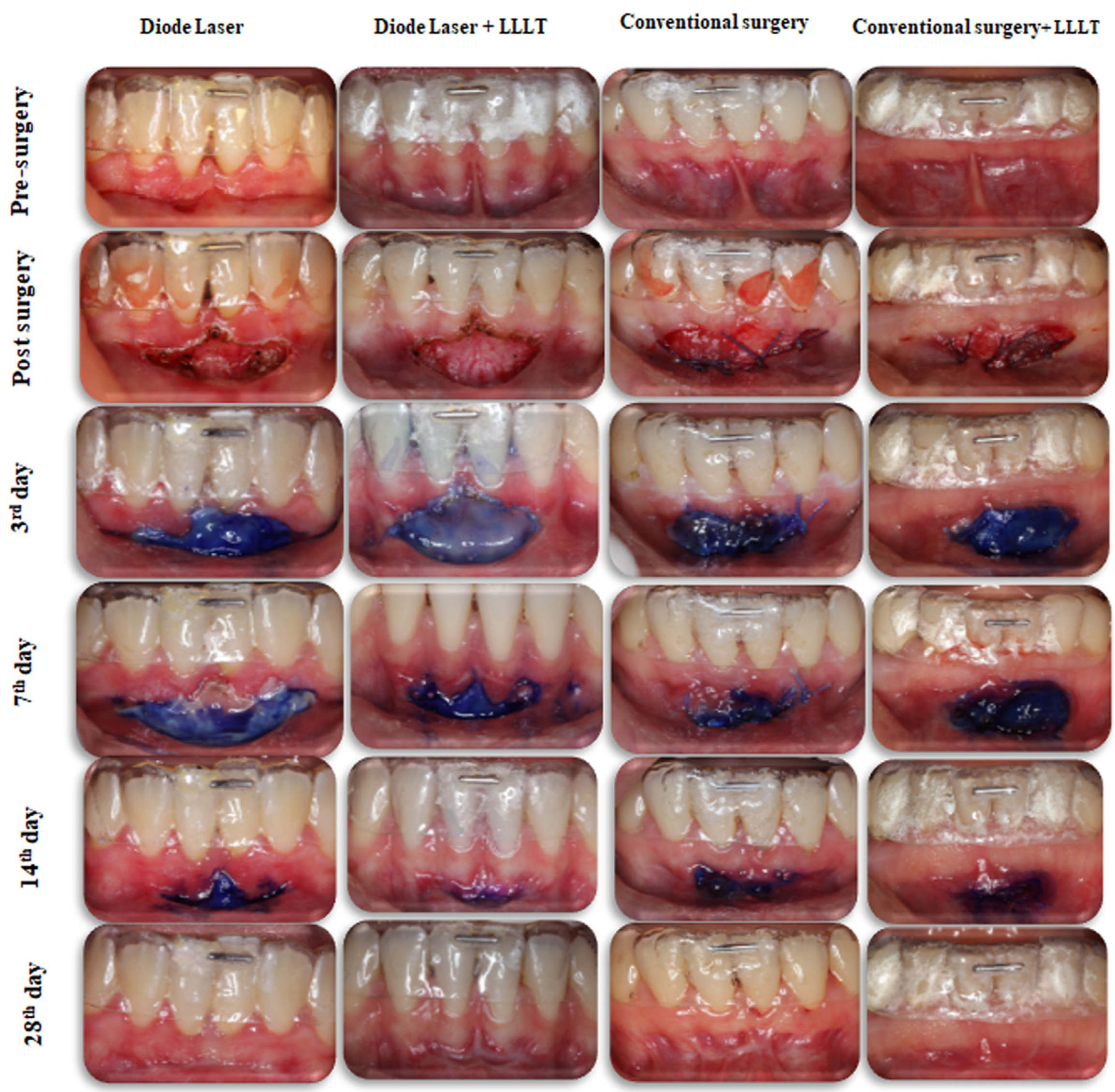

Fig. 1. Clinical photographs of the study groups in each evaluated time periods.

Table 3
Visual assessment of postoperative wound healing.

Wound healing scores	Diode Laser (*n* = 13)	Diode Laser+LLLT (*n* = 13)	Conventional surgery (*n* = 13)	Conventional surgery+LLLT (*n* = 13)	P#
3rd day (T1)	2,00 ± 0,00 (2)	2,00 ± 0,00 (2)	2,00 ± 0,00 (2)	2,00 ± 0,00 (2)	**1**
7th day (T2)	2,00 ± 0,00 (2)	2,00 ± 0,00 (2)	2,00 ± 0,00 (2)	2,00 ± 0,00 (2)	**1**
14th day (T3)	3,00 ± 0,70 (3) ab	3,3 ± 0,63 (3)ab	3,61 ± 0,50 (4)abα	3,61 ± 0,50 (4)abα	**0.05**
28th day (T3)	5,00 ± 0,00 (5)abc	5,00 ± 0,00 (5)abc	5,00 ± 0,00 (5)abc	5,00± 0,00 (5)abc	**1**
P##	**0,000**	**0,000**	**0,000**	**0,000**	

n: number of subjects Values are given as mean ± standard deviation (median), p<0,05.
#: Kruskal Wallis-Mann Whitney U test.
α: Difference from diode laser group.
Friedman-Wilcoxon signed rank test.
a: Difference from 3rd day b: Difference from 1st week c: Difference from 2nd week.
LLLT: Low Level Laser Therapy.

5.3. Wound healing

Healing scores of values of the conventional surgery group were found to be significantly higher than the diode laser group on 14th day (p<0.05), despite complete healing was determined in each group on the 28th day. On the other hand, the results did not differ between the LLLT applied groups (p>0.05). When we compare the results in the evaluated time periods for each group, wound healing scores on the 14th and 28th days in all groups were found to be significantly higher than the values on the 3rd and 7th days (p<0.001). (See Table 3)

5.4. Pain and loss of function

Pain scores in the conventional surgery group were found to be significantly higher on the first postoperative day compared to diode laser group (p<0.001). On the other hand, although the postoperative first day values, which indicates the functional ability in the diode laser group were lower than that of conventional surgery group, the results did not reach significance (p>0.05) (Table 4).

5.5. Dimensions of wound area

It was observed that the changes in the second and fourth weeks in the conventional surgery group were significantly higher than in the diode laser group (p<0.05). On the other hand, LLLT did not affect the dimensional changes significantly (p>0.05) (Table 5).

6. Discussion

In this randomized parallel designed clinical study, wound healing and vestibule depth gain were compared in individuals who underwent vestibule deepening surgery either via diode laser assisted or conventional technique. Furthermore, the possible effect of low-level laser treatment (0.1 W, 6 J/cm ^{2}) on secondary wound healing was investigated. To the best of our knowledge, this clinical study is the first one, which compared the diode laser assisted surgery and conventional surgery in terms of vestibule depth gain.

The main purpose of vestibuloplasty operations is to provide adequate vestibule depth and to enable individuals to perform oral hygiene easily. In the literature, there are studies evaluating the vestibule depth acquisition of different procedures [18]. However, it has been reported in various studies and case reports that there was a significant increase in vestibule depth as a result of vestibuloplasty procedures using lasers [5,13,19].

Kalakonda et al. [13] compared the healing of patterns of diode laser assisted vestibuloplasty and scalpel surgery on the 1st, 3rd, 7th and 21st days after the operation. The researchers reported that they achieved better results in the diode laser group than the scalpel surgery group in terms of vestibule depth due to the less reattachment of scar tissue in their study. However, they did not report numerical data about the measurements of the vestibule depth in the evaluated periods. In our study, although the acquisition of the vestibule sulcus depth is greater in the scalpel surgery (conventional surgery) group in the early period, the results were not statistically and also clinically

Table 4
Pain and Loss of Function scores of the groups after the operation.

	Diode Laser (*n* = 13)	Diode Laser+LLLT (*n* = 13)	Conventional surgery (*n* = 13)	Conventional surgery+LLLT (*n* = 13)	P#
Pain					
1st day	3,61 ± 2,5 (3)	2,38 ± 1,26 (3)	5,84 ± 1,28 (5)αβ	3,76 ± 2,68 (4)	**0,001**
7th day	0,92 ± 1,03 (1)a	0,76 ± 0,72 (1)a	1,15 ± 0,55 (1)a	1,07 ± 1,38 (1)a	0,555
P##	**0,002**	**0,001**	**0,000**	**0,002**	
Loss of Function					
1st day	4,84 ± 2,64 (5)	3,38 ± 1,32 (3)	6,38 ± 1,80 (6) αβΩ	3,84 ± 2,37 (4)	**0,006**
7th day	1,07 ± 1,18 (1)a	0,92 ± 0,95 (1)a	1,30 ± 1,18 (1)a	1,00 ± 1,08 (1)a	0,843
P##	**0,001**	**0,000**	**0,000**	**0,002**	

n: number of subjects Values are given as mean ± standard deviation (median), p<0,05.
#: Kruskal Wallis-Mann Whitney U test.
α: Difference from diode laser group β: Difference from diode laser+LLLT Ω: Difference from conventional surgery +LLLT.
Friedman-Wilcoxon signed rank test.
a: Difference from 1st day.
LLLT: Low Level Laser Therapy.

Table 5
Alteration of horizontal wound dimensions in each evaluated time periods (mm).

Horizontal wound dimensions	Diode Laser (n = 13)	Diode Laser+LLLT (n = 13)	Conventional surgery (n = 13)	Conventional surgery+LLLT (n = 13)	p#
Baseline (T0)	20,00 ± 0,00	20,00 ± 0,00	20,00 ± 0,00	20,00 ± 0,00	–
1st week (T1)	17,68 ± 1,00^{a}	17,50 ± 1,43^{a}	16,91 ± 1,85^{a}	17,05 ± 1,72^{a}	0,540
2nd week (T2)	15,08 ± 1,63^{ab}	14,88 ± 1,82^{ab}	13,49 ± 2,26^{ab}	13,09 ± 1,62 ^{ab}	**0,017**
4th week (T3)	13,01 ± 1,52^{abc}	13,24 ± 2,35^{abc}	11,60 ± 1,97^{abc}	11,39 ± 1,55^{abc}	**0,009**
ΔT0-T1	2,32 ± 1,00	2,50 ± 1,43	3,09 ± 1,85	2,95 ± 1,71	0,540
ΔT0-T2	4,92 ± 1,63	5,12 ± 1,82	6,51 ± 2,27$^{\alpha\ \beta}$	6,91 ± 1,61$^{\alpha\beta}$	**0,017**
ΔT0-T3	6,99 ± 1,52	6,76 ± 2,35	8,40 ± 1,97 $^{\alpha\ \beta}$	8,61 ± 1,55$^{\alpha\beta}$	**0,009**
ΔT1-T2	2,60 ± 1,34	2,62 ± 1,58	3,42 ± 1,92	3,96 ± 1,77	0,119
ΔT1-T3	4,67 ± 1,44	4,26 ± 1,90	5,31 ± 1,76	5,66 ± 2,43$^{\beta}$	0,077
ΔT2-T3	2,07 ± 1,28	1,64 ± 0,10	1,89 ± 1,04	1,70 ± 1,69	0,773

n: number of subjects. Values are given as mean ± standard deviation, p<0,05.
One-way ANOVA-LSD test.
α: Difference from diode laser group β: Difference from diode laser+LLLT Δ: alteration LLLT: Low Level Laser Therapy.
a: Difference from baseline b: Difference from 1st week c: Difference from 2nd week.

important. This result can be explained by the fact that in the conventional surgery group, the mucosal flap was fixed to the floor of the vestibule sulcus via resorbable sutures, and therefore, preventing vestibule depth reversal in the early recovery period. On the other hand, the absence of difference between the groups is a precious result for clinical applications which shows that there may not be need for suturing the mucosal flap to the periosteum when diode laser-assisted vestibule deepening is considered.

The role of lasers in wound healing mechanisms on soft tissues is controversial. It has been reported that thermal denaturation of the laser-irradiated surface may cause delayed wound healing by affecting the adhesion of the epithelial surfaces for primary wound healing [20]. However, many factors play an important role in the tissue's response to laser irradiation, including laser power, density, focal length, and the characteristics of tissue [20]. While there are studies reporting that laser wound healing is faster [21] than the conventional surgery, there are also studies reporting that wound healing is similar in both methods [13].

In our study, time-dependent variation in re-epithelization of the surgical area did not differ between the conventional surgery and diode laser-assisted vestibuloplasty groups which were analyzed via photogrammetric measurements. On the other hand, visual analysis of wound healing on the 14th day, the healing scores of the conventional surgery group were significantly higher than the diode laser group, while all participants showed complete healing on the 28th day after surgery. Moreover, LLLT did not accelerate the mucosal healing in both conventional surgery and laser assisted surgery. This result might be due to the relatively low energy density applied in the surgery field, because in a recently published in vitro study [22], researchers reported that application of a total energy dosage of 12 j/cm^2 provides more growth factor expression in gingival fibroblasts than 6 J/cm ^{2} during seven days and they suggested energy dosage of 12 j/cm^2 for the enhancement of the wound healing. The range of values required for stimulation of fibroblasts is wide (0.45–60 J/cm^2). However, it has known that the stimulation range of fibroblast cells in the oral mucosa, gingiva and periodontal ligament is narrower (0.45–7.9 J/cm^2) [23,24]. In relation to that, Damante et al. [25] reported that a total energy density of 4 J/cm^2 may not be sufficient to have an additional wound healing effect following gingivoplasty operation. Furthermore, energy density of 6 J/cm^2 [11] and 10 J/cm^2 [26] LLLT did not accelerate the re-epithelization of the free gingival graft healing.

Another effective factor in laser biomodulation is the frequency and distance of laser application. Demir et al. [27] applied LLLT four times in seven days in mice and observed that the recovery results were positively affected. In another study [28], it was reported that LLLT performed at a distance of 1 cm immediately after the operation, on the 3rd, 7th and 9th days, accelerated the wound healing process. In our study, LLLT was applied immediately after the operation, and repeated on the 1st, 3rd and 7th days, in non-contact mode, 1–2 mm away from the tissue.

Researchers have reported that myofibroblasts are formed three times more in the wound healing period after the conventional surgery, compared to the laser applications. Therefore, more tissue contraction occurs following conventional surgery [29]. In our study, horizontal wound size measurement was performed on the postoperative 1st, 2nd and 4th weeks. As a result of the measurement, it was determined that the alteration in the 2nd and 4th weeks compared to baseline in the conventional surgery groups were higher than those of diode laser assisted surgery groups. This difference can be explained by the formation of more myofibroblasts in the scalpel incisions and thus resulting in more contraction.

The primary goal of surgical treatment is to have minimal or no complications during and after the operation and to obtain satisfactory postoperative results with optimum patient comfort. Many researchers have reported minimal postoperative pain after laser procedures, including diode laser [14,21]. On the other hand, Grover et al. [30] reported in a split mouth study that there was no significant superiority for postoperative pain management in laser applied depigmentation procedures on conventional scalpel surgery. In our study, it was determined that the patients in the conventional surgery group had more pain complaints at the first postoperative day, however, this difference disappeared on the seventh day and also the scores of the loss of function on chewing and speaking was found to be similar in both groups. The fact that there was less post-operative pain in the diode laser group is thought to be due to the protein coagulation acting as a biological barrier on the wound and covering the nerve endings or due to the individual differences in pain management.

The limitations of this study may be considered as the short-term follow-up of the individuals and not recording the duration of the operation. In addition, in order to compare both techniques in terms of aesthetics, digital analysis of the scar formation rather than the assessment by utilizing visual scale, can yield more objective results.

Conclusion

Within the limits of this randomized clinical trial, both conventional surgery and diode laser-assisted vestibule deepening methods yielded in vestibule depth gain without significant clinical difference. On the other hand, the early results are valuable for clinicians in terms of showing that the suturing of the mucosal flap formed following vestibule deepening may not be necessary in laser assisted surgery for attaining more vestibule depth. In addition, LLLT did not accelerate the re-epithelization process during mucosal wound healing in both vestibule deepening techniques.

Authors' contributions

M.K. performed the surgical procedures and transferred all the patient data to the Microsoft excel. S.G. designed the study protocol, supervised all the clinical procedures, interpreted the results and wrote the final manuscript. All authors read and approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no conflict of interest related to this study.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jormas.2023.101476.

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