Medical university - Varna
"Prof. Dr. Paraskev Stoyanov"
Faculty of Dental Medicine
Department of Oral Surgery

Dr. Velimira Hristova Georgieva

Use of dental lasers for the treatment of patients in oral surgery

Author's summary

of dissertation

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Prof. Tihomir Dobrinov Georgiev, MD, PhD, DSc

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The dissertation contains 176 pages, it is illustrated with 70 figures, and 67 tables. The bibliography consists of 158 sources, all of which are in Latin.

The number and the numbering of the figures in the author's summary do not correspond to those in the dissertation.

The public defense of the dissertation will take place on 05/07/2022, at 12:00 o'clock in Auditorium 103 "Assoc. Dr. Dimitar Klisarov" in the Faculty of Dental Medicine at the Medical University "Prof. Dr. Paraskev Stoyanov" - Varna, before the Scientific Jury:

Chairman:

Assoc. Prof. Georgi Yordanov Papanchev, MD, PhD – Internal member

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Assoc. Prof.Elitsa Georgieva Deliverska -Aleksandrova, MD, PhD

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Assoc. Prof. Asq Zaharieva Krasteva-Panova,MD,PhD

Contents:

Abbreviations used:

LLLT – Low Level Laser Therapy

VAS – Visual Analogue Scale

LA – Local Anesthesia

CGF – Concentrated Growth Factors

1. Introduction

Lasers have become increasingly used in medicine and dentistry in recent decades. In dentistry, lasers are used in all areas - oral surgery, orthodontics, periodontology, endodontics, cariesology, prosthetic dental medicine, pediatric dentistry. Main problem in the treatment of patients in need of surgical treatment in dentistry is the postoperative discomfort, which can last from 1-2 days to 10-14 days, depending on the surgical intervention and individual differences of the patients. Another problem is the patients' fear of the upcoming operation, often leading to delays in the procedure and worsening of the condition. Finding a solution to the issue of children in need of surgical treatment is also of particular interest. In many children cases, such treatment turns out to be impossible, traumatic, or requires treatment under general anesthesia, even for minimal amount and duration of surgery. In medicine, as well as in dentistry, new, modern, minimally invasive methods are constantly sought, offering maximum comfort to the patient, both intra- and postoperatively. Such a method is the laser treatment, which is a reliable alternative to standard surgical techniques used in oral surgery.

The main advantages and indications specified when using lasers in oral surgery are precisely the reduction of the strength and duration of the postoperative discomfort, a shorter healing period, and better perception by patients, especially children.

Lasers can be used in all areas of oral surgery, including soft and hard tissue surgeries, as well as with a biostimulating effect for faster wound healing and pain sensitivity reduction.

In oral surgery, laser treatment is a relatively new, contemporary method that is an alternative to standard surgical techniques. However, the use of dental lasers in oral surgery is still limited worldwide, especially in our country, due to its higher cost and contradictory evidence regarding the benefits it provides.

2. Objective and tasks

Objective of the research: Improving the effectiveness of treatment of patients using dental lasers.

In order to fulfill this goal, the following tasks were set:

1. To monitor the healing process in surgical treatment of frenulum with dental lasers.

2. To monitor the healing process of wound surfaces in the surgical treatment of chronic periapical processes with dental lasers.

3. To monitor the healing process of wound surfaces in surgical treatment of alveolitis with dental lasers.

3. Materials and methods

1. Materials and methods for task 1

1.1. Materials

To perform task 1, we conducted a prospective randomized clinical trial comparing intra- and postoperative clinical parameters and subjective complaints of patients with frenulotomy which was performed with diode or Er,Cr:YSGG laser. Patients were directed to the Department of Oral Surgery or the surgical sector of the University Medical and Dental Center by an orthodontist or from other departments at the Faculty of Dental Medicine to remove a short frenulum of the upper lip. Of the 153 patients examined for upper labial frenulum correction, 52 were included in the study who met the following criteria. The final patients were between 6 and 18 years old, divided into 2 groups - 1st group, including 28 patients operated with Er,Cr:YSGG laser and 2nd group, consisting of 24 patients treated with diode laser. The other 46 patients were not included in the study because they did not meet the requirements for undergoing frenulotomy surgery or due to the presence of contraindications of a general nature.

The following criteria have been identified as criteria for surgical treatment of short labial frenulum:

- orthodontic indications
- whitening of the mucosa vestibularly and of the papilla incisiva when the lip is stretched
- when the lip is stretched, the line that forms the frenulum should be straight and not with its characteristic arcuate curve
- papillary / papillopentrant type frenulum with diastema

- frenulum, restricting the movement of the lip
- patients should have central incisors that are erupted, preferably canines to prevent unnecessary intervention, in view of possible physiological self-regulation
- short frenulum, which impedes oral hygiene in the front and one that causes the papilla to peel off, which is a prerequisite for plaque accumulation and recessions
- hypertrophic type of frenulum

General and local conditions that slow down or hinder the healing process are defined as contraindications.

Before starting the manipulation, we reported the following parameters:

1. Type of frenulum

The type of frenulum was determined - according to the classification of Placek et al. 1974 - as mucosal, gingival, papillary and papillopenetrating.

2. Length of the frenulum

Prior to the manipulation, the length of the frenulum was measured in millimeters from its insertion to the lip to its mucosa/attached gingiva/papilla insertion using a UNC 15 periodontal probe. To monitor the preservation of the newly formed shape and length of the frenulum, as well as the presence of reinsertion near the place of initial attachment, we measured and compared the newly achieved length on the 14th day, after final soft tissue healing and again 1.5 months postoperatively.

1.2 Method for performing laser frenulotomy with Er,Cr:YSGG laser

The device we used in the study was Waterlase MDX Er,Cr:YSGG (Erbium, Chronium, Yttrium, Scandium, Galium, Garnet) with a wavelength of 2780 nm.

The frenulotomy was performed under contact anesthesia with Lidocaine spray 10% and infiltrative anesthesia with Ubistesin 4%. For frenulum excision, the laser was set to soft tissue cutting mode in contact mode with a power of 3.5 W, pulse mode with short pulses, frequency 25 Hz and water-air spray - water 10% and air 30%. MDX 300 handpiece and sapphire cylindrical type MT4, 6 mm long were used. After stretching the lip, the tip moves horizontally, perpendicular to the frenulum, on the surface of the soft tissues, applying light pressure, with slow sweeping movements, first cutting the integumentary mucosa, then cutting the fibrous drafts and muscle insertions, and their adhesion to the periosteum, until the release of the frenulum. The remnants of soft tissue ablation are then removed with sterile oxygen gauze swab. A gauze bandage with greasy ointment is placed on the wound surface.

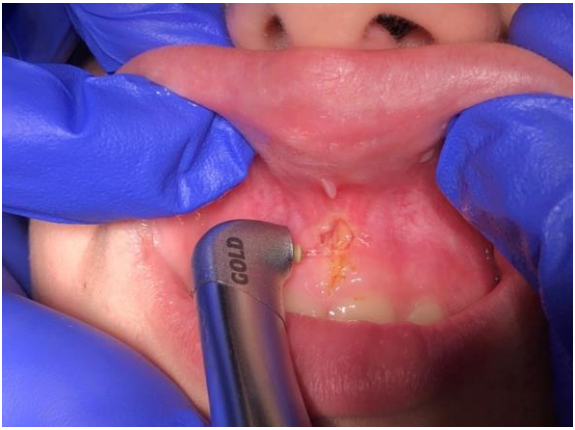


Figure 1. Intraoral image during frenulotomy with Waterlase laser

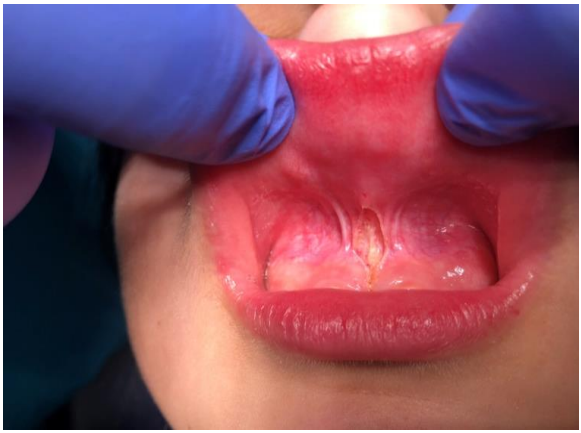


Figure 2. Intraoral image immediately after completion of the frenulotomy operation with the Waterlase laser

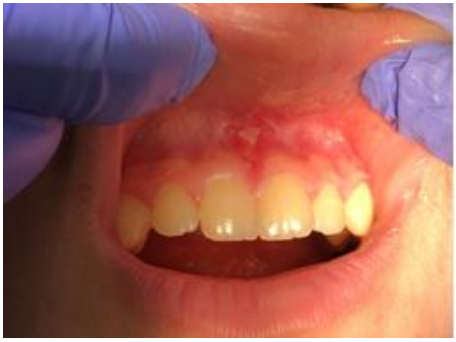


Figure 3. Intraoral image of a patient on day 7 after frenulotomy with Waterlase laser

1.3 Method for laser frenulotomy with diode laser

The device we used was Elexxion diode laser with a wavelength of 810 nm.

For frenulum excision, the laser was set to pulse mode with a pulse rate of 12,000 Hz, a pulse length of 10 µs and an average power of 6

W. The procedure was performed similarly to that with the Waterlase laser.

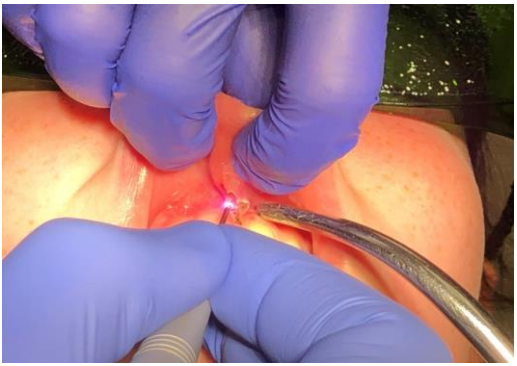


Figure 4. Intraoral image during laser frenulotomy with Elexxion diode laser, using aspiration to remove smoke produced by tissue ablation

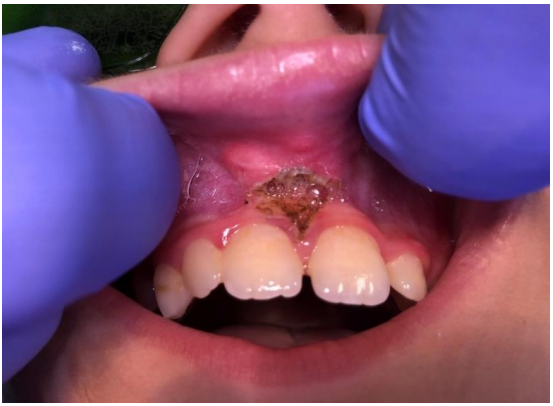


Figure 5. Intraoral image immediately after the completion of the frenulotomy with diode laser - there is charred soft tissue

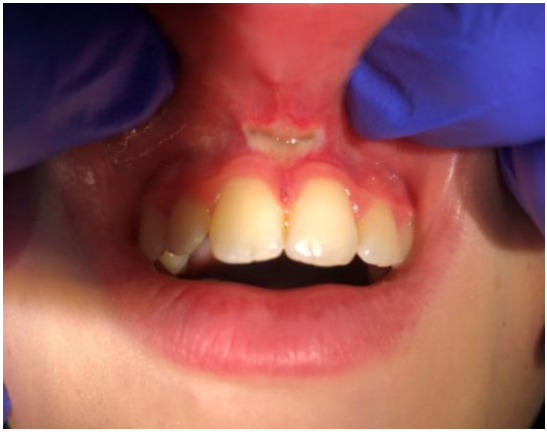


Figure 6. Intraoral image on the 7th day after diode laser frenulotomy surgery

We observed some intraoperative parameters and postoperative subjective complaints and objective clinical parameters when performing frenulotomy with Waterlase laser and diode laser.

The following parameters were considered during the intervention:

3. Surgical time - we recorded and compared the operational time in view of the differences in the nature of work between the two types of lasers, which could lead to its elongation or shortening. We also observed the average value of laser frenulotomy manipulation in all 52 patients examined, as their use should provide maximum shortening of the duration of the manipulation, due to the possibility of eliminating the need to suture the surgical wound and reduce bleeding, compared to standard surgical techniques using a scalpel and /or scissors.

We counted the surgical time in minutes - from the application of contact anesthesia to the application of the gauze bandage.

4. Bleeding - intraoperative bleeding is a significant factor, and its reduction makes it easier and more accurate to perform the

manipulation by the surgeon, which implies a shortening of the duration of the manipulation.

Bleeding during the procedure was assessed as absent, punctate or profuse.

5. The need for sutures is an important factor in pediatric patients, related to both the duration of the surgery and the level of cooperation and peace of mind of children during the procedure.

6. The degree of fear and anxiety during the manipulation was assessed in view of the level of perception of the procedure by pediatric patients, as the procedure is mainly indicated in children.

7. Taking painkillers - we asked patients about taking painkillers in the postoperative period - on what day, what type and how much.

Follow-up examinations were scheduled on the 1st, 3rd, 5th and 7th day after surgery to assess some of the patient's subjective complaints, in order to monitor the quality of the postoperative period and to assess soft tissue healing.

The following subjective parameters were reported postoperatively by questioning the patient:

8. The degree of pain on the 1st, 3rd, 5th and 7th day postoperatively - on VAS (Visual analog scale), horizontal line 10 cm, marked in centimeters, with the left with 0 reported no pain, and the right with 10 - unbearable pain. (Figure 7)

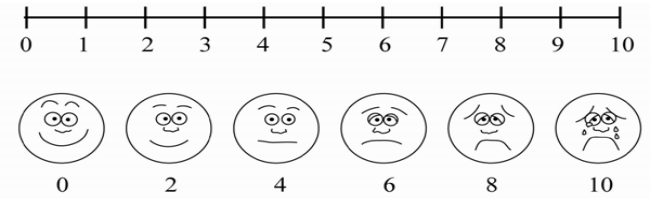


Figure 7. VAS scale for reporting the degree of pain

9. Eating function disorders on the 1st, 3rd, 5th and 7th day postoperatively, according to VAS, with 0 indicating no impairment of functions and 10 - severe discomfort with eating. Figure 5 shows the scale, as well as a legend to it about the meanings of numerical degrees.

10. Speech function disorders on the 1st, 3rd, 5th and 7th day postoperatively, according to the VAS, with 0 indicating a lack of dysfunction and with 10 - severe discomfort in speech.

VAS scales for measuring eating and speech function disorders were similar to that used to report the severity of pain.

Follow-up examinations were scheduled on the 7th and 14th postoperative day, as well as a month and a half after the surgery.

11. The degree of epithelization of the surgical wound on the 7th day after the manipulation was assessed as: lack of epithelization, partial epitheization and complete epithelization.

12. The formation of cicatrix was observed on the 14th day after surgery, after final epithelization of the wound.

2. Materials and methods for task 2

1.1 Materials

To perform task 2, we conducted a clinical study in which intra- and postoperative clinical parameters and subjective complaints of patients were monitored during apical osteotomy using Er,Cr:YSGG laser. The study included a total of 28 patients aged between 18 and 65 years.

Patients with chronic periodontitis, unsuitable for conservative treatment and odontogenic cysts of the upper jaw up to 1.5 cm in size, covering one tooth, with or without subjective complaints and without the presence of active inflammatory process and exacerbation at the moment of manipulation, were identified as criteria for inclusion in the study.

General and local conditions that slow down or hinder healing processes were identified as contraindications.

2.2 Methods for task 2

2.2.1 X-ray examinations

After getting acquainted with the general condition and local status of the patient, standard two-dimensional orthopantomography was prescribed. After acquainting the patient with the detections of orthopantomography and his informed consent, we conducted a three-dimensional CBCT X-ray examination using Planmeca ProMax 3D Max, giving us a more accurate and detailed assessment of the exact size, bone density, location and reliable data on the presence or absence of direct contact between the chronic periapical process and

the maxillary sinus, as well as the degree of coverage of the teeth by the formation.

2.2.2 Method for performing laser apical osteotomy with Er,Cr:YSGG laser

The device we used in the study was Waterlase MDX Er,Cr:YSGG (Erbium, Chronium, Yttrium, Scandium, Galium, Garnet) with a wavelength of 2780 nm.

Under local anesthesia with Ubistesin 4% and with the help of Er,Cr:YSGG laser a triangular or arcuate mucoperiosteal flap with a horizontal incision along the crest of the alveolar ridge was formed or intrasulcular flap in the presence of teeth with relief-vertical incision. The soft tissue incision was performed in contact mode, for soft tissue surgery, with a power of 2 W, long pulses, with a frequency of 30 Hz and water-air spray with 10% water and 30% air, using sapphire cylindrical type MT4. After isolating the flap with the help of a raspatorium, we proceed to remove the vestibular bone to access the cyst, again with the help of the laser. Handpiece Turbo was used for bone cutting, working in contactless mode for work on hard tissues, with a power of 6 W, short pulses with a frequency of 30 Hz and water-air spray with 30% water and 70% air. The tip was maintained at a distance of 3 to 5 mm from the bone, working with slow, circular or sweeping movements. After removing the required amount of bone to access the cyst/granuloma, resection of the tooth apex was performed. For resection of the apex, the laser was set in the mode of cutting hard dental tissues with a power of 3.5 W, short pulses with a frequency of 30 Hz and water-air spray with 20% water and 40% air. Granulation tissue in chronic periodontitis or cystic sac of the cyst was removed by laser ablation. The laser was used to

decontaminate the bone cavity in defocused mode with a power of 1W. The flap was repaired, adapted and sewn with 3/0 silk.

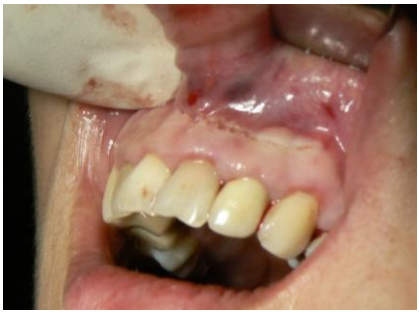


Figure 8. Intraoral image of the incision taken with Er:Cr:YSGG laser for isolation of the arcuate mucoperiosteal flap - uneven borders of the incision and no bleeding are observed

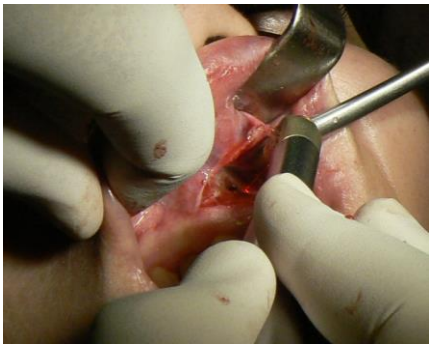


Figure 9. Intraoral image during vestibular bone removal to access the apical part of the root

During the manipulation it was reported:

1. The operative time was measured in minutes, from the anesthesia to the last suture. We monitored the duration of the manipulation to determine whether the use of lasers for bone removal

and resection of the apical part of the tooth helps to prolong the time for the manipulation.

2. The presence of discomfort during the surgery - by interrogation and reporting on VAS, as the leftmost with 0 - patients reporting no discomfort during the manipulation, and the right with 10 - severe discomfort during the manipulation.

The patient is instructed and prescribed drug therapy for 5 days, which includes: antibiotic - broad-spectrum penicillin, painkillers and chlorhexidine solution for mouthwash.

Follow-up examinations were performed on the 1st, 3rd and 7th day after the manipulation to assess:

3. The degree of pain - on VAS (Visual analog scale) horizontal line 10 cm, marked in centimeters, the leftmost with 0 patients reporting no pain, and the right with 10 - unbearable pain

4. Swelling in the nasolabial fold on days 3 and 7. We measured the swelling of the nasolabial fold by the distance from the point Al (Alare) to the commissure of the lip in millimeters. This distance was also measured preoperatively, to determine the anatomical size of the patient as a reference value and subsequent monitoring of the dynamics of postoperative swelling on the 3rd and 7th day.

5. The swelling in the area of the upper lip on the 3rd and 7th day was monitored by measuring the sum of the distances from the point Subnasale to the point Labrale superius and from the point Labrale superius to the border between the semi mucosa and the upper labial mucosa using UNC 15 periodontal probe. Similar to the previous studied parameter, this distance was measured before the operation, to take into account the constitutional size of the patient,

and on the 3rd and 7th day after the surgery, to monitor the presence of swelling.

6. Hyperemia around the operative wound - assessed as positive in the presence of 2 mm of the incision, and in less than 2 mm - as missing.

The sutures were removed on day 7, when following were clinically evaluated:

7. The degree of epitheization - as complete, partial and absent, as well as the presence/absence of gingival necrosis.

After the first month, patients were called for examination and control of soft tissue healing, and between the 3rd and 6th month, CBCT control tests were performed. The CBCT measured:

8. The volume of the bone cavity - in cubic centimeters, preoperatively and on the 3rd and 6th postoperative month. The volume assessment is done with a program that allows to choose the filling and calculation of the air cavity, which we select.

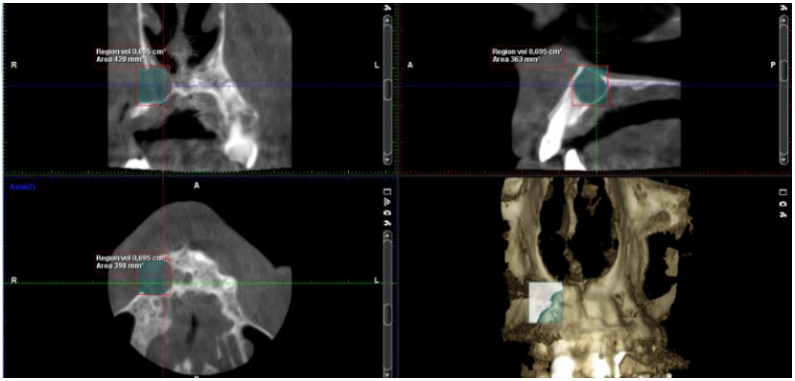


Figure 10. Measurement of the volume of the bone cavity - in this case it is 0.695 cm3

9. Bone density - we measured again preoperatively, on the 3rd and 6th postoperative month in HU (Hounsfield) units.

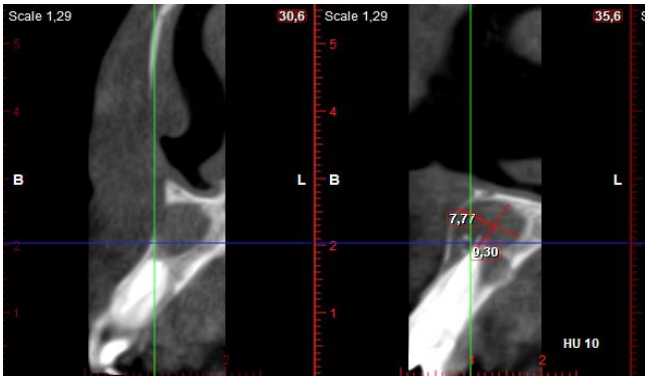


Figure 11. Measurement of bone density in a patient with a radicular cyst with size 7x9 mm in HU - in this case 10 HU

The analysis of the images was performed by two doctors in UMDC independently of each other, and if there was a difference in the research, the opinion was taken by a specialist - radiologist.

3. Materials and methods for task 3

3.1 Materials

To perform task 3, we conducted a clinical study that compared intra- and postoperative clinical parameters and subjective complaints of patients when treated for alveolitis with diode laser. The study included a total of 36 patients aged between 18 and 65 years.

Criteria for inclusion in the study were patients with alveolitis diagnosed by an oral surgeon, with acute, severe pain that appeared

2-3 days after the extraction, with empty alveolus, with exposed bone, without formed clot or granulation tissue.

General and local conditions that slow down or hinder the healing process were identified as contraindications.

3.2 Methodology for treatment of alveolitis with diode laser

The device we used was an Elexxion diode laser with GaAlAs semiconductor (Gallium Aluminum Arsenide), with a wavelength of 810 nm, class 4, as well as auxiliary, additional laser radiation for low level laser therapy (LLLT) with a wavelength of 635 nm, class 2.

Prior to the manipulation, the size of the alveolus was measured using a UNC 15 periodontal probe - in millimeters in the vestibulo-lingual and medio-distal directions, in order to monitor the degree of epithelization.

Using a 5 cc syringe with saline (NaCl 0.9%) and 3% oxygenated water in a 1:1 ratio, a thorough lavage of the alveolus was performed to remove debris and bacteria from the exposed bone. The alveolus was treated with the diode laser, in the therapeutic mode with low level laser therapy (LLLT) with a wavelength of 635 nm, in contactless, continuous mode. An Ergo T handpiece with a T8 glass tip for LLLT was used, and the alveolus was irradiated sequentially on three sides - buccal, lingually and occlusively, about 5-10 mm from the surface in non-contact mode, for 30 seconds on each side, with the average dose energy obtained on the surface - about 6 J. The same procedure was repeated every other day - after 48 hours.

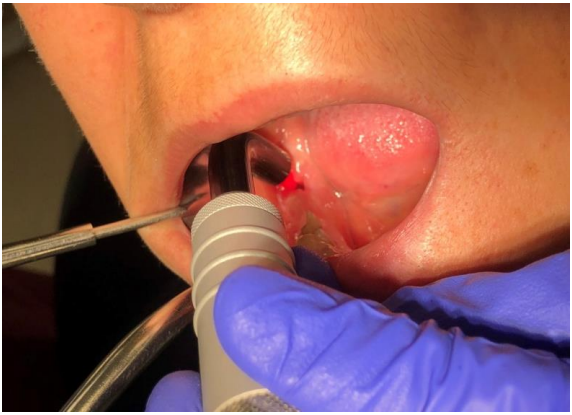


Figure 12. Intraoral image during diode laser treatment in LLLT mode - irradiation of the occlusal surface of the alveolus

Patients were instructed to adhere to strict oral hygiene. Hours were set for repeat manipulation and follow-up examinations on days 3, 5 and 7.

Patients were instructed to note:

1. The degree of pain on the 1st, 3rd, 5th and 7th day after diagnosis on VAS (Visual analog scale) - horizontal line 10 cm, marked in centimeters, the leftmost with 0 - patients reporting no pain, and on the right with 10 - unbearable pain.

Patients were followed on the 3rd, 5th and 7th day after diagnosis for assessment of objective clinical parameters - signs and symptoms typical of alveolitis. The following parameters were evaluated:

2. Presence of hyperemia around the alveolus, with 0 indicating no hyperemia, and 1 - the presence of such.

3. Presence of bare bone - 1 indicated the presence of bare bone, occupying up to 1/3 of the alveoli; with 2 - bare bone from 1/3 to 2/3 of the alveolus; with 3 - bare bone, occupying more than 2/3 of the alveolus.

4. Formation of new granulation tissue, with 1 indicating the presence of granulation tissue filling up to 1/3 of the alveolus; with 2 - granulation tissue from 1/3 to 2/3 of the alveolus; with 3 - granulation tissue filling more than 2/3 of the alveolus.

5. Presence of halitosis and unpleasant taste in the mouth - with 0 we reported the absence of halitosis, and with 1 - the presence of such.

6. The alveolar epithelization was monitored on days 3, 5, 7, and 14 and reported clinically, with 1 indicating epithelization up to 1/3 of the alveolar surface; with 2 - epithelization from 1/3 to 2/3 of the surface and with 3 - epithelization of more than 2/3 of the alveolar surface or complete epithelization.

4. RESULTS

Results of Task 1

From the preoperatively studied parameters we obtained the following results:

1. Frenulum type

The frenulum type was determined before the manipulation according to the classification of Placek et al. 1974 - as mucosal, gingival, papillary and papillopenetrating.

Graphical representation of the percentage ratio of frenulum types can be seen in the figure below (Fig.13)

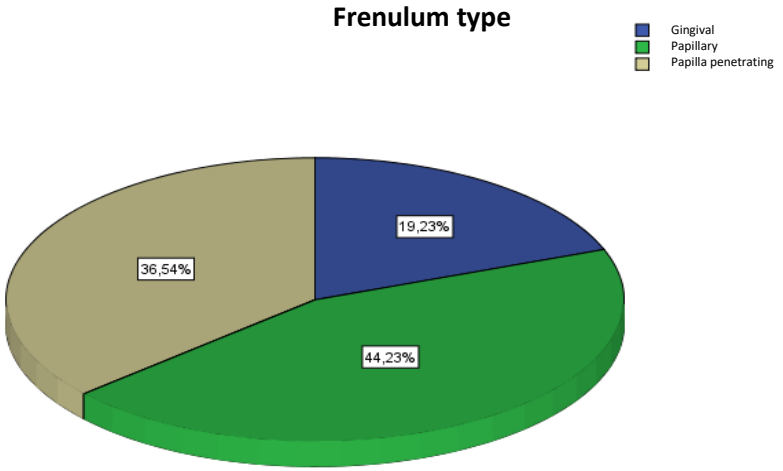


Figure 13. Graphical representation of the frequency distribution of frenulum types

2. Frenulum length

When measuring the newly achieved length of the frenulum on the 14th day after surgery, after final epithelization of the surgical wound, we observed a decrease of about 1/2 of the preoperatively measured length, with mean value of 5.7 mm. When measuring the length of the frenulum on the 6th week after surgery, we observed a slight increase in this length and coronary displacement of the frenulum insertion by mean value of 0.4 mm compared to the measurements of the 14th day frenulum.

The following parameters were examined during the manipulation:

3. Surgical time

We recorded an average time to perform the manipulation, for a total of 52 patients included in the study, in both laser groups of 6 minutes. The average duration of the procedure in patients operated with Waterlase laser was just under 6 minutes, and that in the diode laser group was just over 6 minutes.

4. Hemorrhage

Hemorrhage *Type of laser Crosstabulation

			Type of laser		
			Waterlase	Diode	Total
Bleeding	Missing	Count	21	24	45
		% within Hemorrhage	46,7%	53,3%	100,0%
		% within Type of laser	75,0%	100,0%	86,5%
		% of Total	40,4%	46,2%	86,5%
	Punctate hemorrhage	Count	7	0	7
		% within Hemorrhage	100,0%	,0%	100,0%
		% within Type of laser	25,0%	,0%	13,5%
		% of Total	13,5%	,0%	13,5%
Total		Count	28	24	52
		% within Hemorrhage	53,8%	46,2%	100,0%
		% within Type of laser	100,0%	100,0%	100,0%
		% of Total	53,8%	46,2%	100,0%

Table 1. Crosstable showing the percentage of hemorrhage types to the type of laser used

Table 1 shows that all patients with punctate hemorrhage were from the Waterlase (Er,Cr:YSGG) laser group. This type of bleeding was observed in 7 of a total of 28 patients in this group or 25% of the patients in the group. No bleeding was observed in the remaining 21 patients, 75% of the Waterlase group. No bleeding was registered in 100% of the examined patients in the diode laser group.

5. Suture

Regarding the need for suturing of the operative wound, we did not find one in any of the 52 patients studied in both groups.

6. Fear/Anxiety

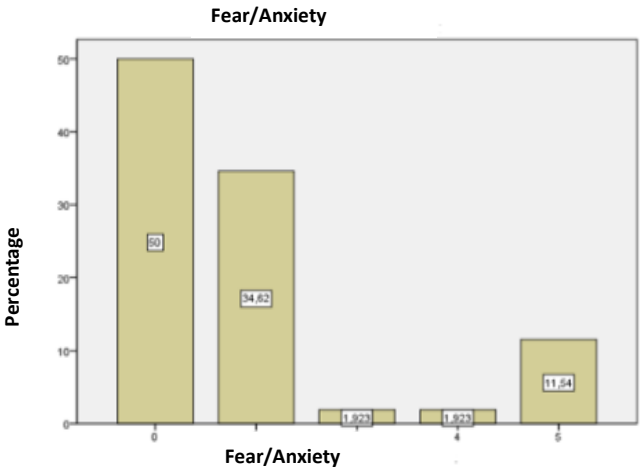


Figure 14. Histogram showing the percentage of fear and anxiety levels during the manipulation

Figure 14 shows that when assessing the levels of fear and anxiety during the operation, we reported a very good perception of children,

as 50% and 34.6% - for mild anxiety. The remaining patients reported mild to moderate anxiety with a maximum VAS score of 5. The mean measured value of this parameter was 1.4 on the VAS scale.

7. Taking analgesics

Regarding the need for analgesics, we received the following data: 86.54% or 45 of the 52 patients did not need painkillers, while only 13.46% or 7 patients received painkillers in the early postoperative period (Figure 15).

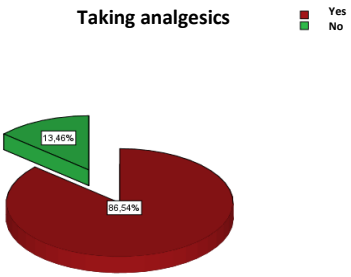


Figure 15. Graphical representation of the frequency distribution of the need for analgesics

4 of them are from the group operated with Waterlase (Er,Cr:YSGG) laser, and 3 - from the group operated with diode laser Elexxion. All of these 7 patients reported taking a single dose of Nurofen 200 mg on the day of surgery or on the first postoperative day.

8. Pain on the 1st, 3rd, 5th and 7th day

- Pain on the 1st day

When comparing pain on the 1st postoperative day between the two types of lasers, we found the following results: in patients treated

with Waterlase (Er,Cr:YSGG) laser, 21.4% or 6 of them were painless, 50% (14 of 28 children) with mild pain, 21.4% (6 of 28 children) with mild to moderate pain, 7.1% (2 of 28 children) with moderate pain that interferes with concentration and zero patients experiencing strong pain. In patients with diode laser use, the values of pain are as follows: without pain are 8.3% (2 of 24 children), with mild pain 37.5% (9 of 24 children), with 41.7% (10 of 24 children) mild to moderate pain, 4.2% (1 of 24 children) with moderate pain that interferes with concentration and 8.3% (2 of 24 children) with severe pain. These results are presented in the histogram below.

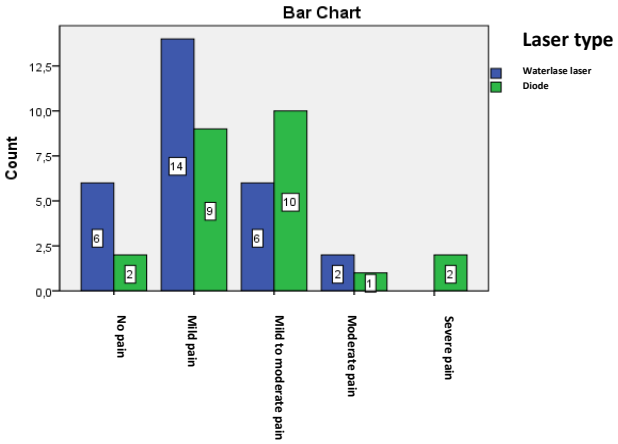
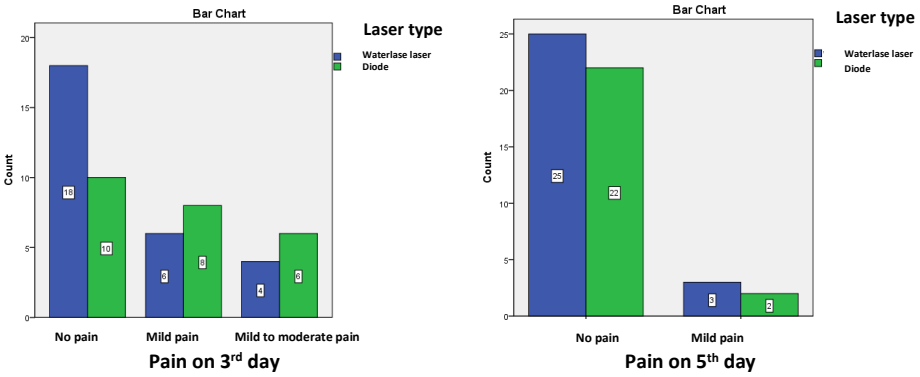


Figure 16. Histogram showing the differences in pain intensity between the two types of lasers - Waterlase and diode laser on the 1st day after surgery

- Pain on day 3 and 5



Figures 17 and 18. Histograms representing the strength of pain with both types of lasers - Waterlase and diode laser on the 3rd and 5th day after surgery

When comparing the pain on the 3rd postoperative day between the two types of lasers, we found the following results, which are presented in the histogram below: in patients treated with Waterlase (Er,Cr:YSGG), 64.3% of them (18 of 28 children) are without pain, 21.4% (6 of 28 children) - with mild pain, 14.3% (4 of 28 children) with mild to moderate pain. No patients with moderate or severe pain have been identified. In patients with diode laser use, the values of pain are as follows: without pain are 41.7% (10 of 24 children), with mild pain - 33.3% (8 of 24 children), and 25% (6 of 24 children) have mild to moderate pain. And there are no patients with moderate and severe pain on the 3rd day after surgery as well.(Figure 17)

Regarding the distribution of pain levels with the two lasers on the 5th day(Figure 18): there were pain-free patients predominantly, representing 89.3% (25 of 28 children) of the patients in the Waterlase laser group and 91.7% (22 out of 24 children) of those in the diode laser group. The remaining patients in both groups reported

mild pain - 10.7% (3 of 28 children) in the Waterlase laser group and 8.3% (2 of 24 children) in the diode laser group, respectively. Patients with higher levels of pain were not observed in either of the patients studied in both groups.

In patients from the Waterlase group, we observed lower levels of pain on all follow-up days and especially in the first days after the manipulation. However, there was no statistically significant difference between the two lasers in the degree of pain.

9. Eating discomfort on the 1st, 3rd, 5th and 7th day

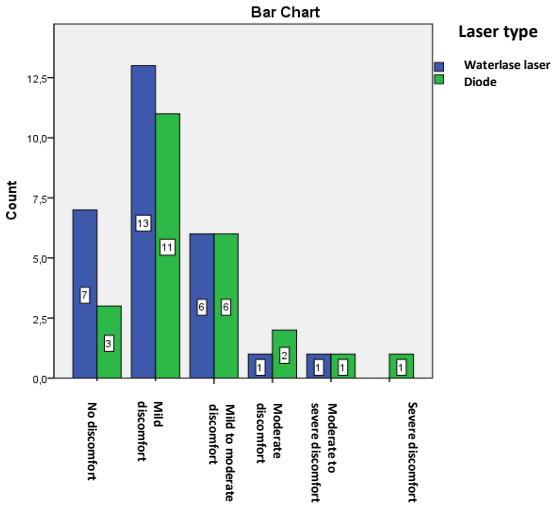
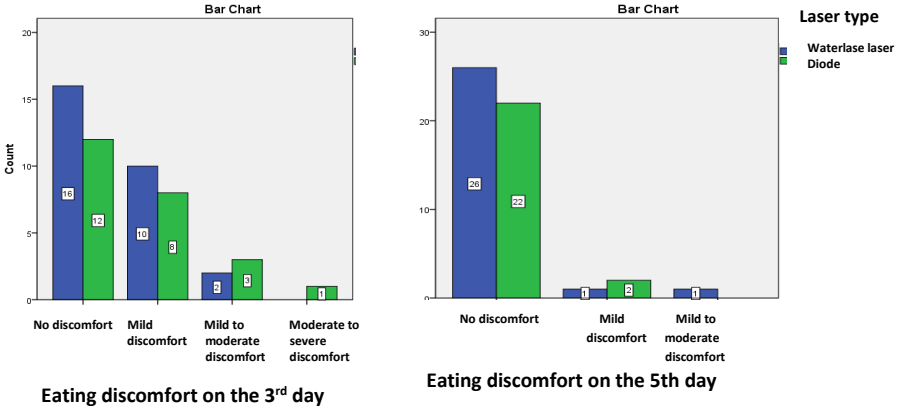


Figure 19. Histogram showing the distribution of degrees of eating discomfort on the 1st day after surgery for both types of lasers - Waterlase laser and diode laser

Figure 19 shows the differences in the levels of eating discomfort in patients from the two groups as follows: 25% (7 of 28 patients) in the Waterlase laser group reported no eating discomfort, compared to 12.5% (3 of 24 patients) from the diode laser group; mild eating discomfort was reported by 46.4% (13 of 28 patients) with Waterlase laser and 45.8% (11 of 24 patients) with diode laser, respectively;

mild to moderate discomfort was observed in 21.4% (6 of 28 patients) of the Waterlase laser group and 25% (6 of 24 patients); moderate discomfort was reported in 1.9% (1 of 28 patients) in the Waterlase laser group and 8.3% (2 in 24 patients) in the diode laser group; Moderate to severe discomfort was reported in 1 patient in both groups, and no severe eating discomfort was observed in any of the patients in the Waterlase laser group and in only 1 patient in the diode laser group.



Figures 20 and 21. Histograms showing the distribution of levels in eating discomfort on the 3rd and 5th day after surgery with both types of lasers – Waterlase laser and diode lase

Figure 20 shows a similar distribution of the levels of eating discomfort on the 3rd day after surgery in the two laser groups: 57.1% (16 of 28 patients) in the Waterlase laser group reported no discomfort and 50% (12 of 24 patients) from the diode laser group, respectively; mild discomfort was observed in 35.7% (10 of 28 patients) with Waterlase laser and 33.3% (8 of 24 patients) with diode laser; mild to moderate discomfort was observed in only 7.1% (2 of 28 patients) with Waterlase laser and 12.5% (3 of 24 patients) with diode laser; moderate to severe discomfort was not observed in the Waterlase group and in only 1 patient in the diode laser group.

Figure 21 shows the distribution in the levels of eating discomfort in the two laser groups. It is noteworthy that on the 5th day after the manipulation there was no discomfort in the majority of patients in both groups, respectively in 92.9% (26 of 28 patients) with Waterlase and 91.7% (22 of 24 patients) from the diode laser group; only 1 patient with Waterlase laser and 2 patients with diode laser reported mild discomfort, and 1 patient from the Waterlase group and 0 patients from the diode laser group reported mild to moderate discomfort.

On day 7, no eating discomfort was observed in any of the examined patients, both in the Waterlase laser group and in the diode laser group.

10. Speech disorder - 1st, 3rd, 5th and 7th day

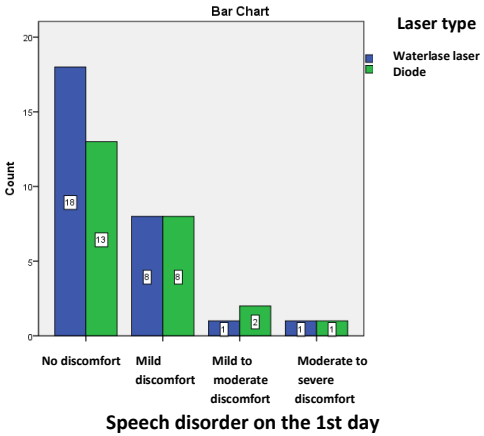
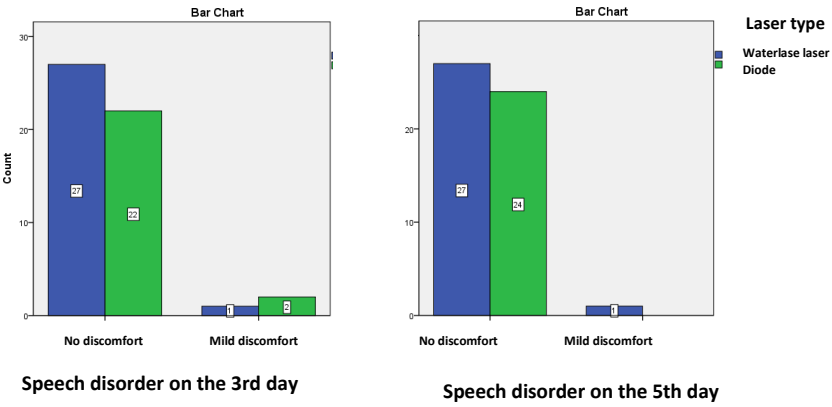


Figure 22. Histogram showing the degree of speech discomfort on the 1st day after the surgery in the two laser groups - Waterlase laser and diode laser

Figure 22 shows the distribution of grade speech disorders on the 1st day after surgery in both types of lasers: 64.3% (18 of 28 patients) in the Waterlase group and 54.2% (13 of 24 patients) from the diode laser group reported no speech difficulties; 8 patients from each group reported mild difficulties; for mild to moderate - only 1 patient (3.6%) from the Waterlase laser group and 2 (8.3%) from the diode laser group, and for moderate difficulties only 1 patient from each group.



Figures 23 and 24. Histograms showing the degree of speech disorders on the 3rd and 5th day after surgery in the two laser groups – Waterlase laser and diode laser

On the 3rd day after the manipulation, there were almost no speech difficulties - 96.4% (27 of 28 patients) from the Waterlase laser group and 91.7% (22 from 24 patients) from the diode laser group reported absence of such. Only 1 patient (3.6%) in the Waterlase group and 2 (8.3%) in the diode laser group still had mild speech difficulties (Figure 23).

On the 5th (Figure 24) and 7th day after surgery, patients did not report speech difficulties, except for 1 patient in the Waterlase group, who reported mild difficulty.

No statistically significant differences in eating and speech disorders were found between the two types of lasers used during either of the observed days.

10. Epithelization

Table 35 shows that when monitoring the rate of epithelization on the 7th postoperative day, we observed significantly better epithelization in patients from the Waterlase laser (Er,Cr:YSGG) group. We can point out here that the use of Waterlase laser did not show any epithelization, 7.1% of patients (2 patients) were with partial and 92.9% (26 patients) with complete epithelization. When using a diode laser, the values are as follows: 8.3% (2 patients) have no epithelization, 83.3% (20 patients) have partial epithelization, and 8.3% (2 patients) have complete epithelization. The histogram below (Figure 25) shows the differences in the rate of epithelization between the two lasers.

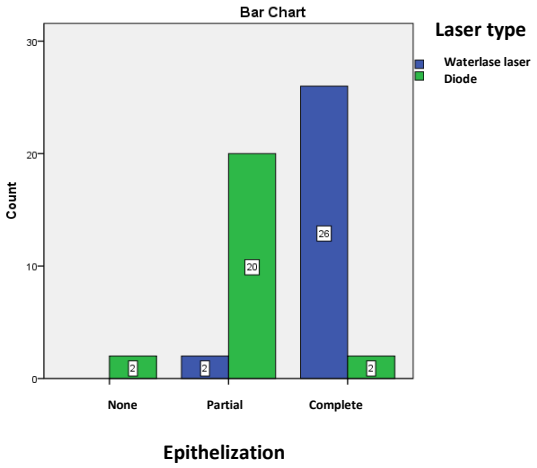


Figure 25. Graphical representation of the epithelization rate in both types of lasers - Waterlase and diode laser on the 7th day after surgery

The differences in rate epithelization between the two types of lasers were statistically significant, as we found that the Waterlase laser significantly accelerates epithelization..

11. Cicatrix

In a follow-up examination on the 14th postoperative day after tracking and forming of cicatrix after laser frequencies, we reported only 1 case of cicatrix from the total study of 52 patients, this case was from the Waterlase (Er,Cr:YSGG) laser group.

Results of Task 2

1.Surgical time

We observed a mean value for the manipulation of 41 minutes, with the duration of the surgery varying from 27 minutes to 54 minutes .

2. Discomfort intraoperatively

In the study of the "intraoperative discomfort" parameter we registered the following data: 46.4% or 13 of the patients reported that they did not feel discomfort, 39.3% or 11 that they experienced mild discomfort, and mild to moderate discomfort was registered only at 14.3 % of all patients or 4 out of 28 . A graphical representation of these results can be seen in Figure 26.

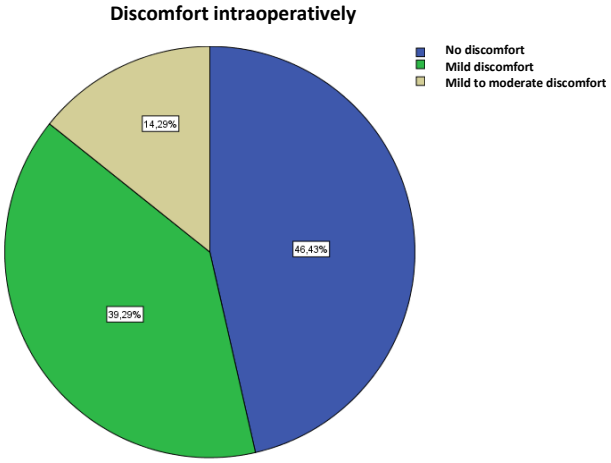


Figure 26. Graphical representation of the frequency distribution of the level of discomfort intraoperatively

3. Pain on the 1st, 3rd, 7th day postoperatively

When monitoring the intensity of pain on the 1st day after surgery, we reported the following data: the majority of patients reported mild to moderate pain - 64.3% or 18 of the 28 examined patients. No pain was reported in 17.9% (5 patients), and the same number of patients - 17.9% reported mild to moderate pain. It is noteworthy that none of the patients of the study group reported moderate, severe or excruciating pain. These results are also presented graphically below (Figure 27).

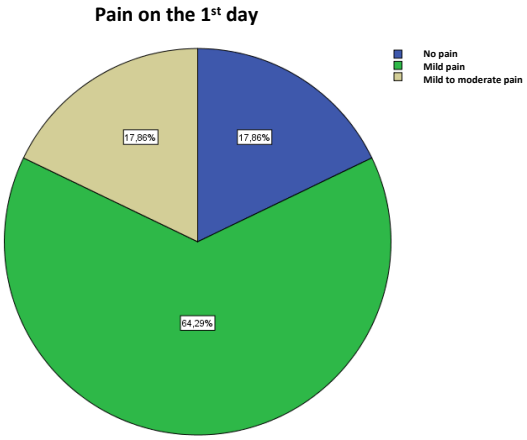


Figure 27. Graphical representation of the frequency distribution of pain intensity on the 1st day after surgery

In contrast to day 1, on day 3 we observed that the majority of examined patients did not report pain. They are about 64.3% (18 patients) of all, and the remaining 35.7% (10 patients) have mild pain . Again, for better illustration, we have presented these results in the form of a pie chart - Figure 62.

While maintaining the downward trend between the first and third day, we similarly note that on the seventh day 7% of patients (2 patients) experience mild pain, while the remaining 93% (26 patients) no longer experience pain .

At the control examinations on the 3rd and 7th day we evaluated the following objective parameters:

3. Swelling on the 3rd and 7th day nasolabial fold

When monitoring the swelling on the 3rd and 7th day, we noted a minimal presence of postoperative edema with a mean value of about 3 mm more - 38.32 mm on the 3rd day, compared to the preoperatively measured - 35.82 mm . On the 7th day, there were

insignificant differences compared to the initially measured sizes - preoperatively (from 35.82 mm before surgery to 35.89 mm on the 7th day), i.e. almost no swelling was observed .

4. Swelling on the 3rd and 7th day upper lip

Similar to the previous parameter, we followed the swelling in the area of the upper lip on the control examinations on the 3rd and 7th day, comparing with the preoperatively measured distance in mm.

In the area of the upper lip, we also observed the development of minimal swelling - from a mean measured value of 22.89 mm before surgery to 25.29 mm mean value on the 3rd day postoperatively . On day 7, the results showed no or insignificant swelling within about 0.2 mm (from a mean of 22.89 mm before surgery to 23.11 mm on day 7) .

5. Hyperemia on the 3rd day after surgery. Hyperemia around the operative wound was observed in all 28 patients, and on the 7th day such was not observed in any of the patients.

We monitored the soft tissue healing on the 7th day after the operation, assessing the rate of epithelization of the surgical wound:

6. Epithelization

We observed complete epithelization in the majority of the studied patients - 89.3% or 25 of 28 patients. Partial epithelization was reported in only 3 of the patients or 10.7% of all. The results are presented graphically in Figure 28.

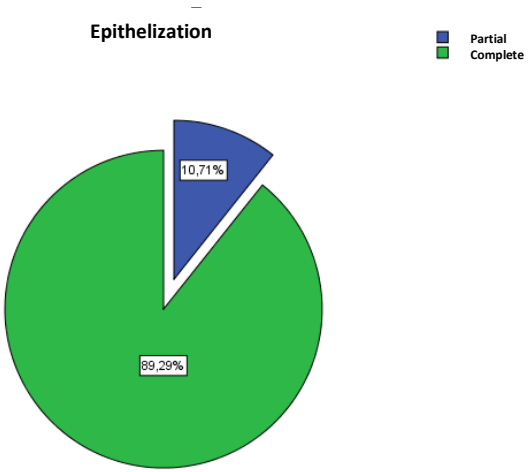


Figure 28. Graphical representation of the frequency distribution of the rate of epithelization on the 7th day after surgery

The volume of the bone cavity and the bone density were examined by CBCT, taking into account their dynamics at the 3rd and 6th month, compared to the preoperatively reported data.

7. Volume of the bone cavity preoperatively, in the 3rd and 6th month

We observe a decrease in the volume of the bone cavity from the mean reported value in patients - 0.2 cm3 before surgery to 0.15 cm3 in the 3rd and 0.08 cm3 in the 6th postoperative month, reported on CBCT.

8. Bone density preoperatively, at 3rd and 6th month Bone density was recorded in Hounsfield (HU) units, on CBCT, before surgery and again in the 3rd and 6th month postoperatively.

We reported the following data: before the surgery we observed a mean measured value of bone density of 23.9 HU (D5), recording a

significant increase in bone density to 300 ± 35.86 HU (D4) in the 3rd month after surgery and 636 ± 68 , 64 HU (D3).

Results of Task 3

After the diagnosis of alveolitis, we undertook treatment of the alveolus with LLLT, using an Elexxion diode laser with a wavelength of 635 nm. We performed the procedure immediately after the diagnosis of alveolitis, as well as every 48 hours, on the 3rd and 5th day after the initial examination.

We studied the dynamics in the intensity of pain, as well as the signs typical for alveolitis - hyperemia around the alveolus, halitosis, exposed bone, the formation of new granulation tissue on the 3rd, 5th and 7th day. We also observed the degree of epithelization on the days of the manipulations, as well as on the 7th day after the diagnosis.

1. **Pain on the 1st, 3rd, 5th and 7th day**

When monitoring the strength of the pain, we reported a gradual decrease in its intensity, and after the first laser irradiation we observed a decrease in pain from mean value on the 1st day - 8.53 (severe pain) to 3.25 (mild to moderate pain) on the 3rd day. After the second laser treatment, patients reported very mild pain with an average of 1.19 on day 5. On day 7, after completion of treatment, 33 of the 36 examined patients reported no pain, and only 3 patients reported a very mild degree of pain with grade 1. These results are presented in Table 2.

Statistics

		Pain on the 1st day	Pain on the 3rd day	Pain on the 5th day	Pain on the 7th day
N	Valid	36	36	36	36
	Missing	0	0	0	0
Mean		8,53	3,25	1,19	,11
Std. Error of Mean		,157	,134	,153	,053
Median		8,50	3,00	2,00	,00
Mode		8	3	2	0
Std. Deviation		,941	,806	,920	,319
Variance		,885	,650	,847	,102
Skewness		,024	,195	-,410	2,584
Std. Error of Skewness		,393	,393	,393	,393
Kurtosis		-,805	-,309	-1,741	4,948
Std. Error of Kurtosis		,768	,768	,768	,768
Range		3	3	2	1
Minimum		7	2	0	0
Maximum		10	5	2	1

Table 2. Mean pain values on days 1, 3, 5 and 7

2. Hyperemia around the alveolus

Regarding the parameter hyperemia around the alveolus, we registered the following data: on the 3rd day after diagnosis, 17 of the patients had it , and 19 had no such; on the 5th day, after the second irradiation with the diode laser with LLLT, the presence of hyperemia was almost not observed - such was reported in only 1 of the patients, out of a total of 36 examined . Respectively, on day 7, none of the patients had hyperemia around the alveolus .

3. Exposed bone on the 3rd, 5th and 7th day

When monitoring the degree of exposed bone after treatment with LLLT, on the 3rd, 5th and 7th day we reported the following results:

On the 3rd day, after a laser procedure, we observed the following data: in 25% or 9 of the 36 examined patients, we registered the presence of exposed bone, occupying more than 2/3 of the alveolar

surface; most patients were with exposed bone occupying between 1/3 and 2/3 of the alveolar surface - 69.4% or 25 patients, and those with exposed bone up to 1/3 of the alveolar surface were only 2 - 5.6% (Figure 29).

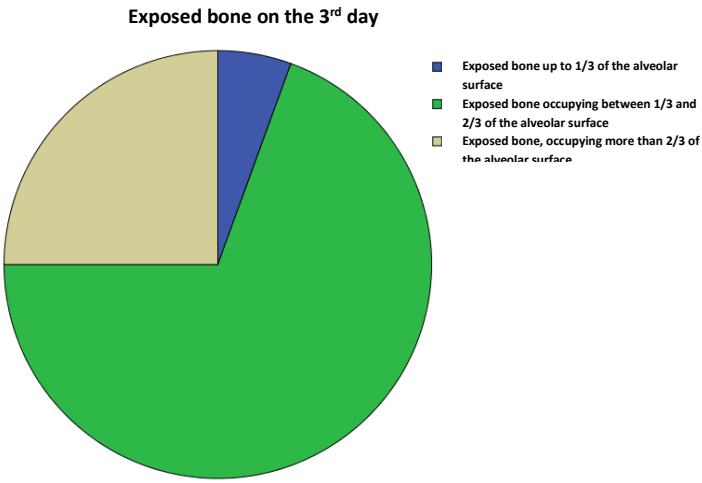


Figure 29. Graphical representation of the frequency distribution of the degree of bone exposure on the 3rd day after the diagnosis of alveolitis

On the 5th day, after the second laser procedure, we observed a positive effect in the majority of patients, with a decrease in the volume of exposed bone compared to previous days - we no longer observed patients with exposed bones, occupying more than 2/3 of the surface of the alveolus, those with 1/3 to 2/3 are still the predominant cases - 83.3% or 30 patients, and in 6 patients or 16.7% there is almost complete absence of exposed bone or up to 1/3 of the surface .

On the 7th day, after the third laser procedure, we observed a significant improvement in the majority of patients, with a clear

decrease in the volume of exposed bone, compared to the previous days - no more patients with exposed bone occupying more than 2/3 from the surface of the alveolus, those with 1/3 to 2/3 are only 2 patients out of the total of 36 examined, and massively in patients - 94.4% or 34 people, there is almost complete healing, with epithelization of exposed bone occupying not more than 1/3 of the surface of the alveolus .

3. Newly formed granulation tissue

The formation of new granulation tissue was reported again on the 3rd, 5th and 7th day after diagnosis, observing the correlation between this and the previous studied parameter, and the data was interpreted analogically.

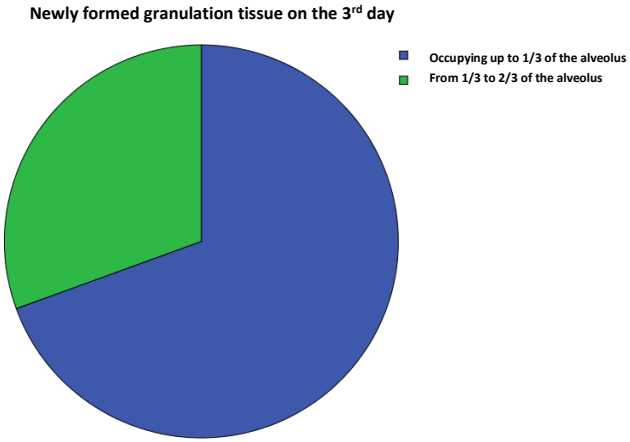


Figure 30. Graphical representation of the frequency distribution of the level of formation of new granulation tissue on the 3rd day after the diagnosis of alveolitis

On the 3rd day after diagnosis, after a single treatment with LLLT, we observed the presence of newly formed granulation tissue,

occupying up to 1/3 of the alveolar volume in 69.4% or 25 of the 36 examined patients; a smaller proportion of patients had more newly formed granulation tissue - 1/3 to 2/3 of the alveolar surface - 30.6% or 11 of the patients. These results are graphically represented in Figure 30.

On the 5th day, after two treatments with the diode laser in LLLT mode, we observed an increase in the formation of granulation tissue, respectively - in the majority of patients the presence of newly formed granulation tissue, occupying between 1/3 and 2/3 of the volume of the alveolus - 94.4% or 34 patients, and those with less than 1/3 or more than 2/3 of the granulation tissue of the alveolus were observed in 1 patient, respectively .

When monitoring the patients on the 7th day after the diagnosis of alveolitis, we reported a significant improvement in the condition of the majority of patients - in 86.1% or 31 of the 36 examined patients, the newly formed granulation tissue occupies the entire alveolar volume or not less than 2/3 of its surface; in 13.9% or 5 of the patients, the newly formed granulation tissue was still between 1/3 and 2/3 of the surface.

5. Halitosis

During the follow-up examinations on the 3rd, 5th and 7th day we also reported anamnestic presence or absence of halitosis in the patients, recording the following data: on the 3rd day we reported the presence of halitosis in 15 of the 36 examined patients, on the 5th day - in only 2 patients, and on the 7th day none of the patients reported the presence of halitosis.

6. Epithelization

Epithelization of the extraction wound was followed again at the scheduled follow-up examinations on the 3rd, 5th and 7th day. On day 3, we observed a lack or minimal presence of epithelization in 61.1% or 22 of the 36 examined patients, and a partial presence in 38.9% or 14 of the patients ; on day 5, all patients had partial epithelization occupying between 1/3 and 2/3 of the surface , and on day 7, the majority of patients had complete or occupying more than 2/3 of the surface. Epithelization - 86.1% or 31 patients. In only 13.9% or 5 patients, epithelization was still partial .

5. DISCUSSION

Discussion on task 1

There are various data in the literature regarding the level of efficiency of different types of dental lasers used for soft tissue surgery. From the studied sources it was found that the most commonly used lasers for this purpose are diode lasers, Nd:YAG, CO2 and erbium lasers - Er:YAG and Er,Cr:YSGG. In our study the used lasers were - diode laser Elexxion, with a wavelength of 810 nm and Er,Cr:YSGG Waterlase laser, with a wavelength of 2780 nm.

The reduction of intraoperative hemorrhage is an indisputable advantage of lasers over conventional methods, as the degree of efficiency in terms of coagulation ability varies between different types of lasers. Erbium lasers show reduced coagulation capacity according to the reviewed publications (10,76,120,147), which according to most authors is due to the water-air spray and pulse regime with which they work. In our study, we confirmed the reduced hemostatic ability of Er,Cr:YSGG lasers compared to diode

lasers. However, we noted that the presence of minimal bleeding in Er,Cr:YSGG lasers does not complicate the manipulation - there is no need for suturing, prolongation of the operative time or limited visibility of the operative field. Diode lasers, in turn, provide perfect control of bleeding, as their thermal effects cause melting, coagulation and sealing of blood vessels. The excellent hemostatic ability of diode lasers has also been proven experimentally - even when taking anticoagulants, no bleeding has been reported (26).

The reduction of the surgical time in laser frenulotomies, compared to standard surgical methods, is due to the reduced levels of hemorrhage during the manipulation, the associated better visibility of the operative field, and the fact that the need for sutures is eliminated (95,122). In our study, we recorded a significantly short time to perform the manipulation - an average of about 6 minutes, without statistical differences between patients in the two groups.

Good perception of the procedure, with low levels of fear and anxiety is of particular importance in the surgery of pediatric patients, in view of better cooperation and accuracy of the operation and the ability to perform the manipulation under local anesthesia. This is facilitated by the fact that laser treatment provides decreased intraoperative pain, reduces or eliminates the need for infiltrative anesthesia, there is a significant reduction in the duration of the procedure, and it eliminates the need for the so scary to children suturing the surgical wound. In our study, we reported very good levels of perception of the manipulation, as the average value of fear and anxiety during surgery indicated by pediatric patients was 1.4 (VAS scale from 0 to 10). The statements in more than one study that lasers are an excellent alternative to conventional frenulotomy techniques, providing maximum comfort, peace of mind and good, cooperative behavior on the part of children have been confirmed (25,64,149,151). We registered a significantly better perception of

the manipulation by children when working with the Waterlase laser, with statistically significant differences and an advantage in this case over the diode laser. This fact can be explained by the lack of heating, unpleasant smell of charcoal and smoke present in the diode laser.

Improving the quality of the postoperative period, with reduced pain levels and difficulties in eating and speech functions is another often mentioned advantage in working with lasers, compared to conventional methods (25,37,67,122). In our study, like other authors, we reported low levels of pain postoperatively, with predominant cases without or with mild pain in the first days after the procedure, and after the 5th day we registered over 90% of patients who reported no pain. No advantages were found for either type of laser, although patients in the Er,Cr:YSGG laser group had lower pain levels on all days followed, but no statistically significant differences. This can be explained by the lower thermal damage to the tissues by the Er,Cr:YSGG laser and the lack of charring observed with the diode laser.

The healing of the surgical wound is directly dependent on the degree of affection of the surrounding tissues, the thermal effects of laser beams and the charring of the tissues. The most effective in this case, according to most publications, are erbium lasers, providing accelerated soft tissue healing, both for other types of lasers and for standard surgical procedures with a scalpel (96,120,140,147). In our study, the results of the studied literature were confirmed, as in patients from the Er,Cr:YSGG laser group, significantly shortened terms for epithelization were observed compared to the diode laser group.

The risk of recurrence after frenulotomy and reinsertion at the place of initial attachment is a problem that has been the subject of several

of the publications reviewed (108,109,113,120). In the present study, we also considered this parameter by measuring the length of the frenulum preoperatively, on day 14 and 1.5 months postoperatively. Recurrence was not reported in any of the examined patients, as the increase in frenulum length at 6 weeks compared to that measured on day 14 was within 0.4 mm, which can be explained by soft tissue reorganization and regeneration. Similar results were obtained in their research by other authors who studied the risk of recurrence - Sanchez et al. (120) and Olivi et al. (109), who also reported no recurrence in 100% of the examined patients, and Ozener et al. (113) - at 91.4%. These results confirm that lasers are an effective means for frenulotomy, as there is no increase in the risk of reinsertion.

According to data from various authors, laser radiation has a sterilizing, decontaminating and bactericidal effect on irradiated tissues (1,54,73,80,141). This helps to minimize the possibility of postoperative infection. Similar to the studied data, in our study we did not report a case of infection of the surgical wound in any of the examined patients.

Based on the studied data, as well as the results of our own research, we can say that sufficient evidence has been found that laser frenulotomy is an effective method that provides many benefits to both the patient and the oral surgeon, namely reduction of intraoperative bleeding, reduced operative time, ensuring a smooth postoperative period with low levels of pain and functional disorders in eating and speech, a short period of healing of the operative wound, without the development of complications. That gives us reason to define this method as a reliable alternative method for performing frenulotomy with both types of used lasers, with clear advantages in operating on pediatric patients.

Discussion on task 2

In oral surgery, dental lasers are widely used for soft tissue surgery, while their application to bone is still limited. However, in recent years, efforts to prove their effectiveness in this area have been steadily increasing in order to provide a reliable alternative to standard surgical techniques related to bone removal and bone cutting.

This gave us a reason to include in the study a manipulation requiring bone removal, in order to assess the capabilities of the Er, Cr: YSGG laser for osteotomies. In our study, we included 28 patients who underwent cystectomy performed with Waterlase (Er:Cr:YSGG) laser. We were interested in following the postoperative period - early and late; the development of complications and the success of the method.

In the studied literature we found a lot of data on the various applications of dental lasers on bone tissue, including: lengthening of the clinical crown, extraction of retinal wisdom teeth, apical osteotomy, cystectomy, autogenous bone grafting, placement and detection of dental implants, recontouring of the alveolar ridge, removal of benign bone formations, etc. In most of the publications reviewed, the main problem mentioned is the extended operating time compared to conventional techniques (35,63,117,129,144). In confirmation of the data presented in the literature, we observed slower bone removal compared to our experience with a surgical motor and mechanical steel bone cutter.

The limited application of lasers on bone in oral surgery could be explained by concerns about the presence of thermal effects on the underlying bone, leading to alteration and bone necrosis. Numerous pieces of evidence have been found in the literature for the lack of thermal bone damage when using erbium lasers, as they have a shallower depth of laser beam penetration than other types of lasers,

which helps to localize their effects in target tissues and minimal affection of the surrounding bone (30,53,116,142). This is facilitated by the fact that they work with water-air cooling, which prevents the rise in bone temperature and charring. In the present study, we did not find abnormalities in bone regeneration, as well as in bone density, when monitoring with CBCT at 3 and 6 months after surgery. Normal time of bone recovery was observed, without prolonged and delayed bone reparation. According to some of the studied data, laser osteotomy provides acceleration of bone healing processes, as clean, smooth cuts are observed, without the presence of debris and microcracks, which are present in the mechanical steel bone cutter (63,91,116,128).

Apart from the extended operative time, another frequently discussed problem when working with lasers on bone tissues is the lack of tactile sensation due to the fact that the work is done in contactless mode with a distance of 0.5-1 cm from the bone surface (81,144,145). In our study we did not find any difficulties of this nature, as we worked mainly in the frontal area of the upper jaw, which provided good visibility and accessibility to the operative field.

On the other hand, the non-contact mode of surgery prevents unpleasant for the patient feelings of pressure, noise and vibration produced by the mechanical steel bone cutter (53,143,144). For this reason, we investigated the degree of intraoperative discomfort by questioning patients immediately after the end of the manipulation and VAS reporting from 0 to 10. We confirmed the available data in the studied literature that laser bone removal contributes to a very good perception of the manipulation by patients, providing peace of mind and comfort during surgery. We registered the absence or presence of minimal discomfort during the manipulation in the

majority of the examined patients - in 85% of them. The others reported moderate discomfort.

Regarding the postoperative discomfort - pain, swelling and hyperemia, the discovered data of the studies show lower levels in patients operated with laser compared to control groups using a surgical motor and a steel bone cutter to remove bone (59,83,86,117,129). In our study, we examined the levels of pain, swelling and redness in the first week after surgery, finding mild to moderate pain, decreasing to mild pain on day 3, to complete absence of pain in 92.9% of patients on the 7th postoperative day. We observed minimal levels of swelling on the 3rd day after surgery, with an average measured value of about 3-4 mm more than originally measured and no swelling on the 7th postoperative day. Some authors believe that the reduced levels of postoperative swelling are due to the fact that lasers provide minimal mechanical trauma and have the ability to seal the lymph and blood vessels when irradiated (51).

Our results, as well as the data studied in the literature, have shown that the use of dental lasers for cystectomy or other manipulations related to bone cutting is a possible but not yet well-studied and well-established method. More research is needed to find a solution to the problem of significantly extended surgical time and the difficulties associated with the lack of tactile sensation. However, the methodology seems promising, given its undeniable advantages in sensitive and scared patients, due to the elimination of pressure, vibration and noise produced by mechanical steel bone cutters.

Discussion on task 3

Alveolitis is one of the most unpleasant complications after extraction, as this condition can significantly impair the quality of life and working ability of the patient due to the high intensity of pain

that accompanies it. According to various authors, currently the most commonly used agents for the treatment of alveolitis include: zinc oxide eugenol; Alvozhil; platelet-rich plasma; aloe vera gel-based inserts; chlorhexidine gel; topical gels containing anesthetic and LLLT (33,55,58,71,103,137,155). Treatment of alveolitis is mainly symptomatic, aimed at reducing the strength of pain sensitivity, as well as to provide conditions for faster epithelization. According to some of the studied data, LLLT is an effective method for the treatment of alveolitis, showing advantages over other standard means used in practice, because in addition to pain control, it helps the acceleration of healing processes through its biomodulatory effects (31,71,72,75,107,137). Some authors suggest the use of LLLT immediately after extraction to prevent the development of alveolitis (103).

To investigate the effectiveness and reliability of LLLT with a diode laser for the treatment of alveolitis, we conducted a clinical study involving 36 patients. We monitored pain levels, the degree of epithelization, and some symptoms characteristic of alveolitis, such as hyperemia around the alveoli, exposed bone, halitosis, and granulation tissue formation.

Regarding the dynamics of pain levels, we reported a good response to the use of the laser after the first procedure, with a significant increase in the effect over time, and on the first day, at diagnosis, patients report severe pain, on the 3rd day the majority of patients have mild to moderate pain, and after day 5, most patients report no or very mild pain. Eshghpour et al. (42) explain the better efficacy of LLLT than the Alvogyl insert by the fact that, despite the rapid action of Alvogyl, due to the filling of the empty alveoli, which provides mechanical and chemical protection of the exposed bone and the anesthetics contained in the insert, in the long run the epithelization of the wound is delayed, which prolongs the pain symptomatology.

Chow et al. (33), after a thorough review of the literature on modern methods of treatment of alveolitis, form recommendations in clinical practice not to use drug inserts such as Alvogyl and Salicept patch (insert based on aloe vera), as they may initiate unlocking of a foreign body type reaction. Kamal et al. (71) and Kaya et al (75) also reported lower levels of pain when treated with LLLT, compared to the methods of drug insertion (Alvogyl and Salicept). On the other hand, in another study by Kamal et al. (72), the authors find the use of CGF – concentrated growth factors, for a more effective methodology, compared to LLLT, providing better clinical results.

Epithelization of the alveoli and the accompanying reduction in the volume of exposed bone and the formation of complete granulation tissue are signs that determine the good development of the healing process in alveolitis. For this reason, in our study, we monitored these parameters for the first 7 days after diagnosis. We registered a normal healing process, without complications or significant prolongation in the time of epithelization in any of the patients, and on the 7th day we reported the presence of epithelization, occupying more than 2/3 of the alveolar surface, in 86% of the examined patients. In most of the studies reviewed, the authors reported a significant acceleration of healing processes and epithelization due to the application of LLLT (72,75,84,125). Eshghpour et al. (42) explain this by the fact that drug inserts act as a mechanical barrier to epithelization, as well as by the biomodulatory effect of the laser, which stimulates fibroblasts and improves the organization of collagen fibers. Kamal et al. (71) believe that the better results in LLLT are due to increased vascularization, induction of fibroblast activity and reduction of inflammatory factors due to laser irradiation. Cirac et al. (34) observed greater bone density and faster trabecular bone organization after LLLT irradiation, and Nica et al. (104) reported increased osteoblast formation and earlier immature bone tissue formation during LLLT treatment after extraction.

Our results, as well as the studied data, gave us a reason to define LLLT as an effective, alternative methodology of standard medication inserts, helping to reduce pain and accelerate the healing process. The procedure is easy to apply and has a place in the daily clinical practice of the oral surgeon.

6. CONCLUSIONS

1. The high efficiency of dental lasers has been identified as an irreplaceable tool for performing frenulotomy in children, as they provide quick, easy manipulation and provide ample opportunities to work under local anesthesia.

2. Diode and Er,Cr:YSGG lasers provide excellent bleeding control, which completely eliminates the need for sutures. While in diode lasers there is a complete absence of bleeding during frenulotomy, in some patients operated with Er,Cr:YSGG laser, which require ablation of soft tissues in greater volume and density – papilla penetrating or hypertrophic frenulum, minimal bleeding is observed.

3. Er,Cr:YSGG laser provides significant acceleration of soft tissue healing processes, compared to diode lasers, due to the lack of thermal impact and charring of soft tissues.

4. The use of diode and Er,Cr:YSGG lasers for soft tissue surgical procedures completely eliminates the risk of postoperative infection and inflammation of the surgical wound due to the sterilizing and bactericidal effect of laser radiation.

5. Diode and Er,Cr:YSGG lasers provide a smooth postoperative period after frenulotomy, with minimal levels of pain and functional difficulties in eating and speaking.

6. The use of diode and Er,Cr:YSGG for frenulotomy guarantees high levels of comfort, calmness and very good cooperation with pediatric patients, which allows maximum reduction of the time of manipulation and eliminates the need for general anesthesia.

7. Er,Cr:YSGG laser, used to remove bone tissue in cystectomy and apical osteotomy, is an irreplaceable tool in surgery of scared, sensitive and non-cooperative patients, as in contactless mode there

are no unpleasant sensations of vibration, pressure and noise. This provides greater opportunities to work under local anesthesia with this type of patients.

8. The use of Er,Cr:YSGG laser for interventions requiring bone removal helps for the acceleration of bone regeneration.

9. Prolongation of surgical time was observed with Er,Cr:YSGG laser for cystectomy and apical osteotomy.

10. Treatment of alveolitis with LLLT with diode laser provides very good control and significant reduction in the intensity of the considerable pain in this condition.

11. LLLT with diode laser provides acceleration of epithelization of the postextractional alveolus in the alveolitis condition, due to its biomodulatory effect and the lack of mechanical obstacles from placed drugs in the alveolus.

7. CONTRIBUTIONS

Confirmatory contributions:

1. The role of dental lasers as the first tool of choice for soft tissue surgery when working with children is confirmed.

2. The advantages of using dental lasers for frenulotomy have been proven - decrease of bleeding, reduction of the surgical time and elimination of the need for sutures.

3. The multifunctionality and efficiency of Er,Cr:YSGG lasers in various surgical interventions in oral surgery, both on soft and hard tissues, is confirmed.

4. The effectiveness of Er,Cr:YSGG lasers is confirmed as minimally invasive, providing shorter soft tissue recovery time compared to other types of lasers.

5. The role of LLLT in influencing postoperative pain and inducing soft tissue healing is confirmed.

Contributions of original nature to the country:

1. For the first time in the country a comparative study was conducted to prove the advantages and disadvantages of diode and Er,Cr:YSGG lasers for frenulotomy.

2. For the first time in the country a study was conducted to determine the effectiveness of Er,Cr:YSGG laser for apical osteotomy.

3. For the first time in the country a study was conducted to establish the effectiveness of LLLT as a tool for treating alveolitis.

Contributions of original nature:

1. For the first time, a study with such a scope was conducted, aimed at proving the application of dental lasers in various fields of oral surgery.

Publications related to the dissertation:

1. GEORGIEVA, Velimira; DZHONGOVA, Elitsa; PETROVA, Izabella. Main advantages and drawbacks of different types of dental lasers in soft-tissue oral surgery. **Scripta Scientifica Medicinae Dentalis**, [S.l.], v. 7, n. 1, p. 12-17, Sep.2021

2. GEORGIEVA, Velimira; DZHONGOVA, Elitsa; PETROVA, Izabella. A comparative study of maxillary labial frenectomy performed with diode and Er,Cr:YSGG lasers. **Scripta Scientifica Medicinae Dentalis**, [S.l.], Apr. 2022.

3. GEORGIEVA, Velimira; DZHONGOVA, Elitsa; PETROVA, Izabella. APPLICATION OF DENTAL LASERS IN BONE SURGERY. **Scripta Scientifica Medicinae Dentalis**, [S.l.], Apr.2022.