https://doi.org/10.22416/1382-4376-2025-35-1-53-63
UDC 616.147.17-007.64-085.849.19

First Experience of Laser Radiation Application in Wound Treatment After Open Hemorrhoidectomy

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Aim: to improve treatment outcomes for patients after open hemorrhoidectomy.
Materials and methods. The results of treatment of 62 patients after open hemorrhoidectomy by ultrasonic scalpel, who were randomized into the main and control groups, 31 persons in each group, were analyzed. The patients of the main group underwent dressing of postoperative wounds using water-soluble ointments in combination with laser irradiation daily from day 2 after the surgical intervention and further on days 14, 21 and 30. In the control group only dressing with the use of water-soluble ointments was performed. In the postoperative period the terms of wound healing were determined based on the data of visual inspection, anoscopy, planimetric and cytologic methods of examination. Microbiological (culture) examination, assessment of pain syndrome intensity using visual analog scale on days 1–7, 14, 21, and 30 after surgical treatment and quality of life using SF-36 questionnaire before hemorrhoidectomy and on day 30 after it were also performed.
Results. On day 30 wound healing occurred in 29/31 (94 %) patients of the main group and only in 5/31 (16 %) patients of the control group ($p < 0.001$). The growth of microorganisms in the main group was noted on day 2 in 31/31 (100 %) cases, on day 21 — in 20/28 (71 %) cases ($p = 0.001$); in the control group: on day 2 — in 27/31 (87 %), on day 21 — in 30/31 (97 %) cases, although the significance of differences was not achieved ($p = 0.4$). The level of pain syndrome was already lower from the second day after surgical treatment in patients of the main group and amounted to 5 (4; 6) points, in the control group — 6 (5; 7) ($p = 0.016$), and on day 30 — 0 (0; 0) points in the main group and 1 (0; 2) point in the control group ($p < 0.001$). Before treatment, the groups were comparable in quality of life; on day 30, statistically significant differences were noted in three indicators: physical functioning (PF) — 80 (75; 93) points in the main group vs. 80 (70; 80) points in the control group ($p = 0.041$); the criterion of role functioning due to emotional state (RE) — 100 (66; 100) points vs. 66 (17; 67) points ($p = 0.002$), and the criterion reflecting the intensity of pain and its impact on daily activities (BP) — 51 (37; 62) points vs. 41 (22; 51) points ($p = 0.023$).
Conclusion. Application of laser therapy after hemorrhoidectomy with ultrasonic scalpel promotes stimulation of reparation processes, shortening of postoperative wound healing time, reduction of bacterial contamination of wounds, reduction of pain syndrome intensity and improvement of quality-of-life indicators in patients of the main group in comparison with the control group.
Keywords: laser therapy, laser radiation, physiotherapeutic wound treatment, combined hemorrhoids, hemorrhoidectomy
Conflict of interest: the authors declare no conflict of interest.

For citation: Frolov S.A., Vyshegorodtsev D.V., Kuzminov A.M., Korolik V.Y., Melkumyan A.R., Ignatenko M.A., Vorobjeva I.V., Magomedova S.G. First Experience of Laser Radiation Application in Wound Treatment After Open Hemorrhoidectomy. Russian Journal of Gastroenterology, Hepatology, Coloproctology. 2025;35(1):53–63. https://doi.org/10.22416/1382-4376-2025-35-1-53-63

Первый опыт применения лазерного излучения в лечении ран после открытой геморроидэктомии

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Цель: улучшить результаты лечения больных после открытой геморроидэктомии.
Материалы и методы. Проанализированы результаты лечения 62 пациентов после открытой геморроидэктомии ультразвуковым скальпелем, которые были рандомизированы в основную и контрольную группы. Пациентам основной группы выполнена перевязка послеоперационных ран с использованием водорастворимых мазей в сочетании с воздействием лазерным излучением ежедневно со вторых суток после хирургического вмешательства и далее на 14, 21 и 30-е сутки. В контрольной группе выполнялась только перевязка с использованием водорастворимых мазей. В послеоперационном периоде были определены сроки заживления ран на основании данных визуального осмотра, аноскопии, планиметрического и цитологического методов исследования. Выполнено микробиологическое (культуральное) исследование, оценка интенсивности болевого синдрома с применением визуальной аналоговой шкалы на 1–7, 14, 21 и 30-е сутки после хирургического лечения и качества жизни с помощью опросника SF-36 до геморроидэктомии и на 30-е сутки после операции.
Результаты. На 30-е сутки заживление ран произошло у 29/31 (94 %) пациентов основной группы и лишь у 5/31 (16 %) пациентов контрольной ($p < 0,001$). Рост микроорганизмов в основной группе отмечен на 2-е сутки в 31/31 (100 %) случае, на 21-е сутки — в 20/28 (71 %) случаях ($p = 0,001$); в контрольной группе: на 2-е сутки — в 27/31 (87 %), на 21-е сутки — в 30/31 (97 %) случаях, хотя значимости различий не достигнуто ($p = 0,4$). Уровень болевого синдрома уже со вторых суток после хирургического лечения был ниже у пациентов основной группы и составлял 5 (4; 6) баллов, в контрольной — 6 (5; 7) ($p = 0,016$), а на 30-е сутки — 0 (0; 0) баллов в основной и 1 (0; 2) балл в контрольной группе ($p < 0,001$). До лечения группы были сопоставимы по качеству жизни. На 30-е сутки статистически значимые различия отмечались по трем показателям: физическому функционированию (PF) — 80 (75; 93) баллов в основной и 80 (70; 80) баллов в контрольной группе ($p = 0,041$); критерию ролевого функционирования, обусловленного эмоциональным состоянием (RE), — 100 (66; 100) баллов и 66 (17; 67) баллов ($p = 0,002$) соответственно, а также критерию, отражающему интенсивность боли и ее влияние на повседневную деятельность (BP), — 51 (37; 62) балл в основной и 41 (22; 51) балл в контрольной группе ($p = 0,023$).
Выводы. Применение лазерной терапии после геморроидэктомии ультразвуковым скальпелем способствует стимуляции процессов репарации, сокращению сроков заживления послеоперационных ран, снижению бактериальной обсемененности ран, уменьшению интенсивности болевого синдрома и улучшению показателей качества жизни у пациентов основной группы в сравнении с контрольной.
Ключевые слова: лазерная терапия, лазерное излучение, физиотерапевтическое лечение ран, комбинированный геморрой, геморроидэктомия
Конфликт интересов: авторы заявляют об отсутствии конфликта интересов.

Для цитирования: Фролов С.А., Вышегородцев Д.В., Кузьминов А.М., Королик В.Ю., Мелкумян А.Р., Игнатенко М.А., Воробьева И.В., Магомедова С.Г. Первый опыт применения лазерного излучения в лечении ран после открытой геморроидэктомии. Российский журнал гастроэнтерологии, гепатологии, колопроктологии. 2025;35(1):53–63. https://doi.org/10.22416/1382-4376-2025-35-1-53-63

Introduction

Hemorrhoids are still one of the most widespread human diseases, which is undoubtedly a socially significant problem, since among the patients young and middle-aged people of working age predominate [1–3]. In 25 % of cases, patients with hemorrhoidal disease seek medical help only at stage IV of the disease, when hemorrhoidectomy remains the only justified method of treatment [4]. Despite the radicality and effectiveness of surgical intervention, the postoperative period causes significant moral and physical suffering to patients due to the presence of wounds in the anal canal and perianal area, constant bacterial contamination, marked inflammatory response and intense pain syndrome. The healing time of postoperative wounds is quite long. All these facts determine the long-term disability of patients who have undergone hemorrhoidectomy.

Today, the arsenal of coloproctologists has a wide range of modern dressings, creams and ointments that help to improve tissue regeneration and have antibacterial action. However, the intensive use of antibiotics has led to the emergence of bacterial resistance, as a result of which antibacterial therapy becomes ineffective, and the healing time is still long [5]. In this regard, physical methods of treatment of postoperative wounds that would significantly reduce the above negative factors and shorten the healing time after hemorrhoidectomy are becoming increasingly important. One of such methods is laser treatment of postoperative wounds.

The aim of the study was to improve patient outcomes after open hemorrhoidectomy.

Materials and methods

In National Medical Research Center of Coloproctology named after A.N. Ryzhikh from September 2023

to December 2023, 62 patients with combined hemorrhoids stage IV were surgically treated. All patients signed a consent to participate in the study.

The study was single-center, prospective, randomized. Patients were randomized 1:1 using the Internet resource RandStuff.ru. The primary endpoint of the study was the frequency of epithelialization of postoperative wounds on day 30 after open hemorrhoidectomy.

Prior to surgery, patients underwent a standard complex of preoperative examination. All patients underwent open hemorrhoidectomy with ultrasound scalpel. After the operation the patients were randomized into the main (n = 31) and control (n = 31) groups.

Patients of the main group underwent daily dressing of postoperative wounds using water-soluble ointments in combination with laser therapy sessions daily from day 1 to day 7 after the surgery, then once a week — on days 14, 21, 30, and until complete wound healing. Laser therapy sessions were performed on a fiber laser with a wavelength of 970 nm produced by the company "IRE-Polus" (Russia). The device has an adjustable nozzle, which helps a change in the diameter of the laser beam.

The patient was in the lithotomy position during the procedure. The distance between nozzle and wound surface was 15 cm. A defocused laser beam with a diameter of 15 cm, 20 W power, in pulse-periodic mode with pulse duration of 50 ms and pause of 100 ms, power density of 0.038 W/cm^2 was applied to the wound without contact. The duration of one session was 4 min (Fig. 1).

Patients in the control group underwent only dressing of postoperative wounds using water-soluble ointments.

Figure 1. Laser device

Рисунок 1. Лазерный аппарат

The age of the patients was 51 (44; 57) years in the main group and 46 (43; 60) years in the control group (p = 0.8). There were 20 (65 %) men and 11 (35 %) women in the main group, 21 (68 %) men and 10 (32 %) women in the control group. According to anthropometric data, presence of comorbidities, duration of the disease, length of hospitalization, and duration of surgical intervention, the patients of the main and control groups did not differ statistically significantly (Table 1).

Pain intensity was assessed using visual analog scale (VAS) on days 1–7, 14, 21, and 30. The methods of determining the wound healing were visual inspection, finger examination of the rectum, anoscopy, planimetric method and cytologic examination of impression smears from the surface of postoperative wounds, the only method allowing to reliably judge the regeneration. The area of the postoperative wound was calculated using

Table 1. General characteristics of the patients in the main and control groups
Таблица 1. Общая характеристика пациентов основной и контрольной групп

Parameter ***Показатель***	**Main group** ***Основная группа*** n = 31	**Control group** ***Контрольная группа*** n = 31	p
Gender / *Пол* male / *мужской* female / *женский*	 20 (65 %) 11 (35 %)	 21 (68 %) 10 (32 %)	0.8
Age, years / *Возраст, лет*	51 (44; 57)	46 (43; 60)	0.8
Body mass index, kg/m^2 *Индекс массы тела, кг/м^2*	27.7 (24.3; 30.9)	25.5 (24.1; 28.9)	0.3
Bed days / *Койко-дни*	7 (7; 7)	7 (6; 7)	0.2
Operation duration, min *Длительность операции, мин*	20 (15; 30)	25 (15; 30)	0.4
Duration of the disease, years *Длительность заболевания, годы*	7 (4; 10)	5 (5; 10)	0.7
Number of patients with comorbidities *Количество пациентов с сопутствующими заболеваниями*	13 (42 %)	8 (26 %)	0.2

the lp_square 5.0 program. To determine the effect of laser radiation on the microbial spectrum of postoperative wounds, all patients underwent microbiologic (culture) examination. Material collection was performed after wound treatment with physiologic solution (0.9 % NaCl) once in patients of the control group and twice in patients of the main group: before and after laser radiation treatment. Quality of life was determined using the SF-36 questionnaire before surgery and on day 30 after the surgery.

Statistical analysis

Information on the analyzed indicators was entered into a relational database in Microsoft Access (Microsoft Corp., USA). Statistical data processing was performed in RStudio (R v. 4.4.1; R Core Team, Austria)) using RODBC, dplyr, and gtsummary libraries. All quantitative values were presented as median, lower and upper quartiles (*Me* (Q1; Q3)); qualitative values were presented as absolute and relative frequencies (*n* (%) or *n*/*N* (%)). Groups were compared by Wilcoxon rank sum criterion for quantitative and qualitative ordinal values; binary qualitative — by Pearson's χ^2 at expected values > 10, at lower values — by two-sided Fisher's exact test. Differences were considered statistically significant at $p < 0.05$.

Results

The laser therapy procedure was well tolerated by all patients and did not cause adverse reactions or complications.

When analyzing the distribution of pain intensity, it was noted that the level of pain in patients of the main group was statistically significantly lower than in the control group: on day 2 — 5 (4; 6) points in the main group and 6 (5; 7) points in the control group ($p = 0.016$), on day 30 — 0 (0; 0) points in the main group and 1 (0; 2) points in the control group ($p < 0.001$) (Table 2).

When comparing the planimetric indices between the groups, the area of postoperative wounds from day 2 to day 7 did not differ significantly ($p = 0.4$). However, already from day 14 the wound area in the patients of the main group was statistically significantly smaller than in the control group: 107 (97; 124) mm^2 vs. 128 (107; 142) mm^2 ($p = 0.014$), and on day 30 — 0 (0; 0) mm^2 vs. 64 (23; 87) mm^2 ($p < 0.001$), which allows to judge about the ability of laser radiation to stimulate reparative processes (Table 3).

The cytomorphologic picture in the main and control groups on day 2 did not differ significantly and was represented by inflammatory elements of predominantly neutrophilic character with blood elements and mixed flora (Fig. 2).

On day 7 the morphologic picture in the patients of the main and control groups corresponded to the cytogram of inflammation. However, histiocytes (in 17 (54.8 %) patients) and fibroblasts (in 7 (22.6 %) patients) were detected more often in the main group, which indicates active cleansing processes and initial signs of wound repair. In patients of the control group histiocytes were found in 15 (48.4 %) cases, fibroblasts were found three times less frequently compared to the main group — 2 (6.5 %) cases (Fig. 3).

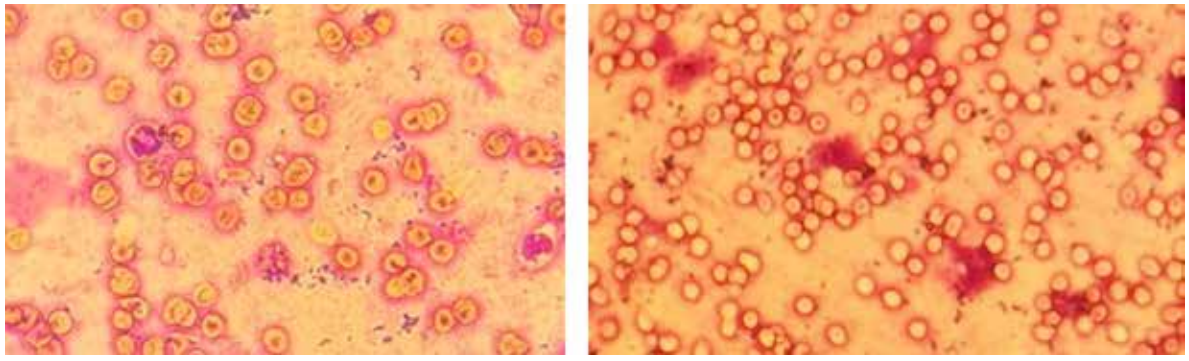
On day 14 after the surgery, the morphologic picture in the patients of the main group predominantly corresponded to the cytogram of proliferative type, as evidenced by the detection of histiocytes and fibroblasts in large numbers in impression smears — in 21 (67.7 %) patients. At the

Table 2. Pain intensity by VAS on days 1–7, 14, 21 and 30 after the surgery
Таблица 2. Интенсивность болевого синдрома по ВАШ на 1–7, 14, 21 и 30-е сутки после операции

Days after the surgery *Сутки после операции*	Pain intensity (points) *Интенсивность болевого синдрома (баллы)*		*p*
	Main group *Основная группа* *n* = 31	Control group *Контрольная группа* *n* = 31	
1	6 (4; 7)	6 (6; 8)	0.075
2	5 (4; 6)	6 (5; 7)	0.016
3	4 (3; 6)	6 (5; 7)	< 0.001
4	3 (3; 5)	6 (5; 6)	< 0.001
5	3 (3; 4)	5 (5; 6)	< 0.001
6	3 (2; 4)	5 (5; 6)	< 0.001
7	3 (2; 4)	5 (4; 5)	< 0.001
14	2 (1; 2)	4 (2; 4)	< 0.001
21	1 (0; 1)	2 (2; 3)	< 0.001

Table 3. Area of postoperative wounds on days 2, 7, 14, 21, and 30 after the surgery
Таблица 3. Площадь послеоперационных ран на 2, 7, 14, 21 и 30-е сутки после операции

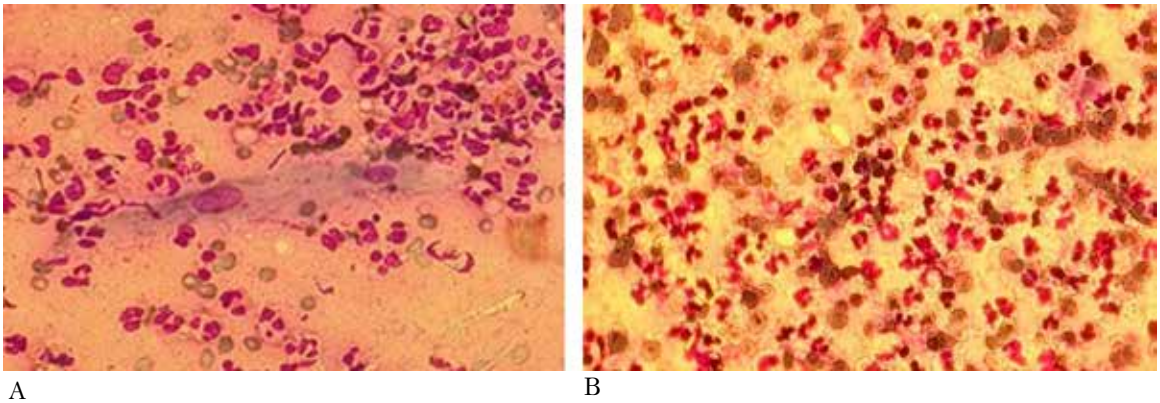
Days after the surgery *Сутки после операции*	Wound area, mm² *Площадь ран, мм²*		*p*
	Main group *Основная группа* *n* = 31	Control group *Контрольная группа* *n* = 31	
2	159 (145; 175)	157 (137; 168)	0.4
7	149 (135; 173)	151 (130; 162)	0.4
14	107 (97; 124)	128 (107; 142)	0.014
21	54 (27; 75)	101 (83; 114)	< 0.001
30	0 (0; 0)	64 (23; 87)	< 0.001



A B

Figure 2. Cytologic picture on day 2 after the surgery: A — the main group (patient K., 43 years old; cytogram is represented by blood cell elements, single leukocytes; Pappenheim staining, ×400); B — the control group (patient T., 49 years old; cytogram is represented by blood cellular elements, single leukocytes; Pappenheim staining, ×400)

Рисунок 2. Цитологическая картина на 2-е сутки после операции: А — основная группа (пациент К., 43 года; цитограмма представлена клеточными элементами крови, единичными лейкоцитами; окрашивание по Паппенгейму, ×400); В — контрольная группа (пациент Т., 49 лет; цитограмма представлена клеточными элементами крови, единичными лейкоцитами; окрашивание по Паппенгейму, ×400)



A B

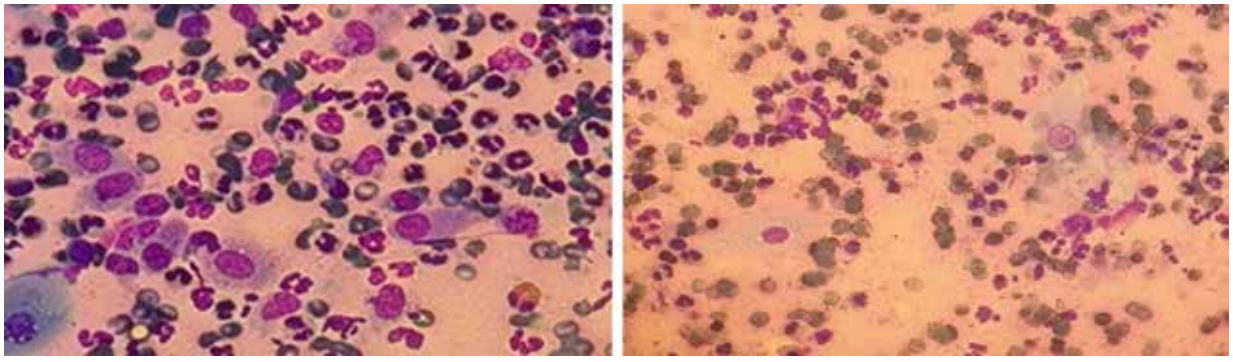
Figure 3. Cytologic picture on day 7 after the surgery: A — the main group (patient K., 43 years old; cytogram is represented by neutrophilic inflammatory elements and histiocytes; Pappenheim staining, ×400); B — the control group (patient T., 49 years old; cytogram is represented by neutrophilic inflammatory elements and blood elements; Pappenheim staining, ×400)

Рисунок 3. Цитологическая картина на 7-е сутки после операции: А — основная группа (пациент К., 43 года; цитограмма представлена элементами воспаления нейтрофильного характера, гистиоцитами; окрашивание по Паппенгейму, ×400); В — контрольная группа (пациент Т., 49 лет; цитограмма представлена элементами воспаления нейтрофильного характера, элементами крови; окрашивание по Паппенгейму, ×400)

same time in the control group the indicated type of cytogram was determined only in 9 (29.0 %) cases (Fig. 4).

By day 21 after the surgery, in addition to histiocytes and fibroblasts, squamous epithelial cells of different maturity stages were detected in 15 (48.4 %) patients of the main group and 8 (25.8 %) patients of the control group. At the same time, complete wound healing occurred in three patients of the main group, which was confirmed by the detection of mature squamous epithelium cells in smears (Fig. 5).

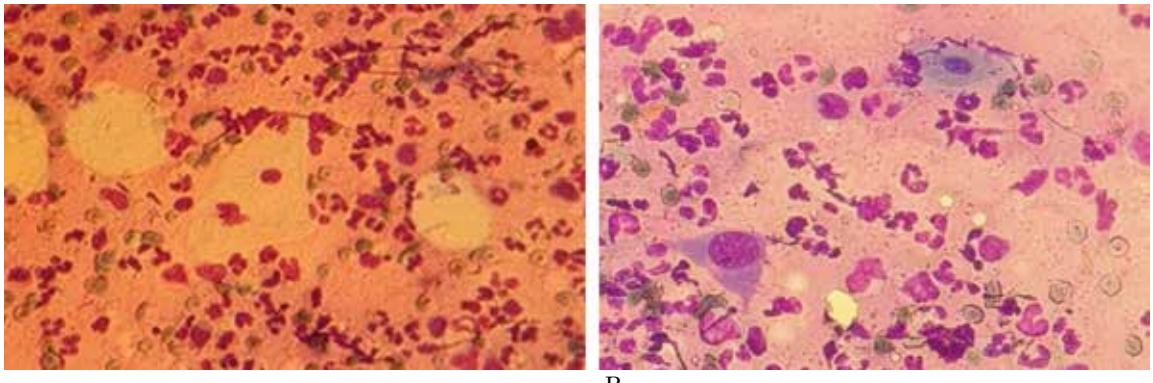
On day 30 after the operation, the type of cytogram, where there were no signs of inflammation and mature squamous epithelium cells were detected, which corresponds to the stage of repair, was determined in 29 (93.6 %) patients of the main group and only in 5 (16.1 %) patients of the



A B

Figure 4. Cytologic picture on day 14 after the surgery: A — the main group (patient K., 43 years old; cytogram is represented by neutrophilic inflammatory elements, histiocytes and fibroblasts in large numbers; Pappenheim staining, ×400); B — the control group (patient T., 49 years old; cytogram is represented by neutrophilic inflammatory elements, single histiocytes; Pappenheim staining, ×400)

Рисунок 4. Цитологическая картина на 14-е сутки после операции: А — основная группа (пациент К., 43 года; цитограмма представлена элементами воспаления нейтрофильного характера, гистиоцитами и фибробластами в большом количестве; окрашивание по Паппенгейму, ×400); В — контрольная группа (пациент Т., 49 лет; цитограмма представлена элементами воспаления нейтрофильного характера, единичными гистиоцитами; окрашивание по Паппенгейму, ×400)



A B

Figure 5. Cytologic picture on day 21 after the surgery: A — the main group (patient K., 43 years old; cytogram is represented by single fibroblasts and histiocytes, squamous epithelial cells; Pappenheim staining, ×400); B — the control group (patient T., 49 years old; cytogram is represented by inflammatory elements in large amount, histiocytes and single fibroblasts; Pappenheim staining, ×400)

Рисунок 5. Цитологическая картина на 21-е сутки после операции: А — основная группа (пациент К., 43 года; цитограмма представлена единичными фибробластами и гистиоцитами, клетками плоского эпителия; окрашивание по Паппенгейму, ×400); В — контрольная группа (пациент Т., 49 лет; цитограмма представлена элементами воспаления в большом количестве, гистиоцитами и единичными фибробластами; окрашивание по Паппенгейму, ×400)

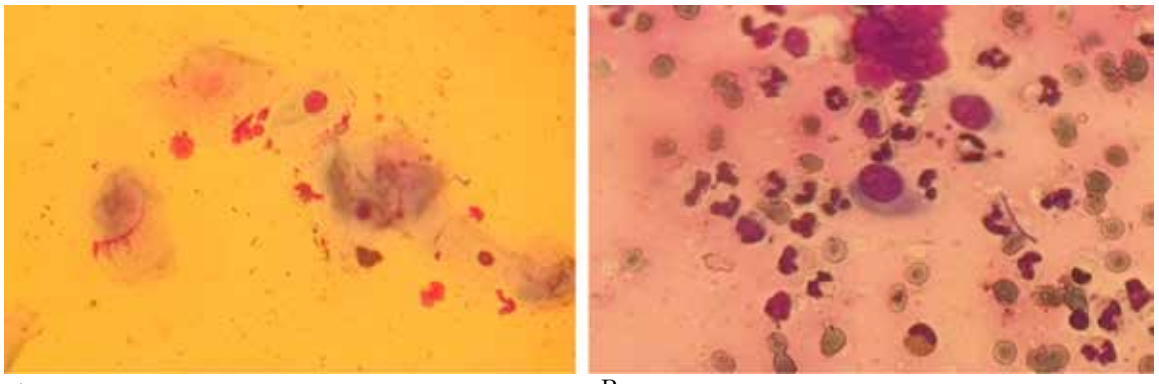


Figure 6. Cytologic picture on day 30 after the surgery: A — the main group (patient K., 43 years old; cytogram is represented by single fibroblasts and histiocytes, squamous epithelial cells; Pappenheim staining, ×400); B — the control group (patient T., 49 years old; cytogram is represented by inflammatory elements in large amount, histiocytes and single fibroblasts; Pappenheim staining, ×400)

Рисунок 6. Цитологическая картина на 30-е сутки после операции: А — основная группа (пациент К., 43 года; цитограмма представлена единичными фибробластами и гистиоцитами, клетками плоского эпителия; окрашивание по Паппенгейму, ×400); В — контрольная группа (пациент Т., 49 лет; цитограмма представлена элементами воспаления в большом количестве, гистиоцитами и единичными фибробластами; окрашивание по Паппенгейму, ×400)

control group (Fig. 6). The data obtained indicate a positive effect of laser radiation on the rate of wound healing.

On the basis of macroscopic (visual inspection, finger examination, anoscopy), planimetric and cytologic characteristics, the terms of wound healing were determined. On day 30 wound healing occurred in 29 (94 %) patients of the main group and only in 5 (16 %) patients of the control group ($p < 0.001$). By day 40 epithelization of wounds was observed in all patients of the main group and only in 10 (32 %) patients of the control group ($p < 0.001$). In the control group, wound healing in all patients occurred only on day 45 (Table 4).

The bacterial culture of wound discharge was performed to consider the growth of microorganisms in aerobic and anaerobic conditions. The study revealed growth of culturable aerobic bacteria, obligate anaerobic bacteria and fungi colonizing the wound surface and being an etiological factor for the development of wound infection. The wound microbiota of this area was formed from representatives of both the intestinal microbiota and the skin microbiota. The study monitored changes in the composition of the wound microbiota at various stages of treatment and healing. When assessing the microbial spectrum of postoperative wounds before treatment, the groups were comparable by the presence of growth and species composition of microorganisms. *Escherichia coli, Staphylococcus epidermidis, Staphylococcus aureus, Enterococcus faecalis, Staphylococcus haemolyticus* were the most common.

If on day 2 after the operation the growth of microorganisms was noted in 100 % of the cases, then by day 21 after the laser exposure microorganisms were detected in only 71.4 % ($p = 0.001$) cases. At the same time, both the quantitative and species composition of microorganisms changed: the number of isolated microorganisms on day 2

Table 4. The frequency of wound healing on days 14, 21, 30, 40, and 45 after the surgery
Таблица 4. Частота заживления ран на 14, 21, 30, 40 и 45-е сутки после операции

Days after the surgery *Сутки после операции*	The frequency of wound healing *Частота заживления ран*		*p*
	Main group *Основная группа* *n* = 31	Control group *Контрольная группа* *n* = 31	
14	0	0	–
21	3 (10 %)	0	0.2
30	29 (94 %)	5 (16 %)	< 0.001
40	31 (100 %)	17 (55 %)	< 0.001
45	31 (100 %)	31 (100 %)	–

was 60, on day 21 — 32, the number of microorganism species decreased from 22 on day 2 to 12 on day 21. In the control group, no significant changes were noted (Table 5).

Thus, a comparative analysis of the microbial spectrum between the groups showed a statistically significant decrease in the number of microorganisms cultured during laser therapy of postoperative wounds, which indicates a decrease in wound colonization by microbial associations and, in turn, reduces the risk of developing wound infection [14].

Analysis of patients' quality of life according to SF-36 questionnaire before treatment showed comparability of groups, however, in the postoperative period (day 30) statistically significant differences were revealed in three indicators: physical functioning (PF) — 80 (75; 93) points in the main group, 80 (70; 80) points in the control group ($p = 0.041$); pain intensity (BP) — 51 (37; 62) points in the main group, 41 (22; 51) points in the control group ($p = 0.023$), and role functioning due to emotional state (RE) — 100 (66; 100) points and 66 (17; 67) respectively ($p = 0.002$) (Table 6).

Discussion

Laser therapy is widely used as a treatment method to achieve a reduction in pain and

Table 5. Comparative assessment of the microbial spectrum of postoperative wounds on days 2 and 21 in the main (before laser treatment) and control groups

Таблица 5. Сравнительная оценка микробного спектра послеоперационных ран на 2-е и 21-е сутки в основной (до обработки лазерным излучением) и контрольной группе

Parameter *Показатель*	Main group *Основная группа*			Control group *Контрольная группа*		
	Day 2 *2-е сутки* *n* = 31	Day 21 *21-е сутк* *n* = 28	*p*	Day 2 *2-е сутки* *n* = 31	Day 21 *21-е сутк* *n* = 31	*p*
Presence of microbial growth *Наличие роста микроорганизмов*	31 (100 %)	20 (71.4 %)	0,001	27 (87 %)	30 (97 %)	0.4
Number of microorganism strains *Количество штаммов микроорганизмов*	60	32	–	65	58	–
Number of microbial species (microbial diversity) *Количество видов микроорганизмов (микробное разнообразие)*	22	12	–	23	18	–

Table 6. Assessment of the quality of life of patients according to the SF-36 questionnaire before and 30 days after the surgery

Таблица 6. Оценка качества жизни пациентов по опроснику SF-36 до операции и через 30 суток после нее

Parameter *Показатель*	Before the surgery *До операции*			Day 30 after the surgery *30-е сутки после операции*		
	Main group *Основная группа* *n* = 31	Control group *Контрольная группа* *n* = 31	*p*	Main group *Основная группа* *n* = 31	Control group *Контрольная группа* *n* = 31	*p*
PF	90 (63; 100)	90 (78; 95)	0.9	80 (75; 93)	80 (70; 80)	0.041
RP	100 (13; 100)	100 (43; 100)	0.3	50 (0; 88)	25 (0; 75)	0.2
BP	64 (52; 100)	94 (47; 100)	0.7	51 (37; 62)	41 (22; 51)	0.023
GH	62 (44; 75)	77 (47; 77)	0.2	57 (52; 77)	72 (51; 77)	0.4
VT	55 (48; 85)	60 (43; 85)	0.4	65 (50; 75)	65 (50; 75)	0.7
SF	87 (56; 88)	87 (53; 87)	0.2	75 (50; 88)	62 (37; 88)	0.2
RE	100 (33; 100)	100 (50; 100)	0.3	100 (66; 100)	66 (17; 67)	0.002
MH	60 (54; 86)	64 (48; 88)	0.8	76 (60; 82)	64 (56; 88)	0.5

Note: *PF — physical functioning; RP — physical role functioning; BP — bodily pain; GH — general health; VT — vitality; SF — social functioning; RE — emotional role functioning; MH — mental health.*

Примечание: *PF — физическое функционирование; RP — ролевое функционирование. обусловленное физическим состоянием; BP — интенсивность боли; GH — общее состояние здоровья; VT — жизненная активность; SF — социальное функционирование; RE — ролевое функционирование. обусловленное эмоциональным состоянием; MH — психическое здоровье.*

inflammation, helping to stimulate tissue healing processes [6].

The possibilities of laser technology application in the therapeutic treatment of long non-healing wounds are known. There are a number of studies proving the effect of laser radiation on wound healing. V.V. Stupak and E.N. Rodyukova in a randomized study applied laser radiation for treatment of patients with trophic ulcers and bedsores. According to the results of the study, the rate and percentage of epithelization of superficial bedsores in the main group were higher than in the control group by 2.1–8.0 and 2.6–6.5 times, respectively. In deep pressure sores the picture was similar: the epithelization rate was 4.1–7.4 times higher, and the percentage of epithelization was 2.7–4.7 times higher compared to the control group [7]. The obtained results indicate the stimulating effect of laser radiation on the process of tissue epithelization, which is also confirmed by our study, where wound healing in 94 % of patients in the main group occurred on day 30, while in the control group only on day 45.

A number of mechanisms explaining the effects of laser radiation on biological tissues have been described in the literature.

According to one theory, laser radiation triggers photochemical reactions in target cells containing chromophores. The main chromophore in mitochondria that absorbs light photons is the enzyme cytochrome C oxidase, which is located in the fourth block of the mitochondrial respiratory chain. The interaction of infrared radiation with cytochrome C oxidase leads to an increase in the proton gradient, resulting in increased production of calcium ions (Ca^{2+}), reactive oxygen species and adenosine triphosphate. Radiation in the near infrared range (810–1064 nm) activates light-sensitive ion channels, and the interaction of reactive oxygen species and cyclic adenosine monophosphate with calcium ions occurs. These photochemical reactions result in activation of cell differentiation, proliferation and migration [8, 9].

There are studies proving the effect of laser radiation on the proliferative activity of fibroblasts. For example, in one of the studies, histological examination of skin samples exposed to laser treatment showed an increase in the number of dermal fibroblasts, mitochondria, intermediate filament vimentin, and collagen and elastin content [10].

Another positive property of laser radiation is stimulation of angiogenesis and microcirculation. In the study by T.V. Konchugova et al., patients with trophic ulcers of the lower extremities underwent a course of laser therapy. The data of subsequent computer capillaroscopy showed that the therapeutic efficacy of laser treatment is based on its positive effect on all links of microcirculation [11].

Thus, the study of the cytological characteristics of the wounds obtained by us confirms the above and indicates the positive effect of laser radiation on all stages of the wound process.

There are many studies describing the effect of laser radiation on the microbiota of wounds. According to the results of one of them, laser radiation stimulates the immune response to the presence of microorganisms by improving the bactericidal activity of neutrophils, monocytes, and macrophages. The mechanism of action is explained by an increase in the production of hydrogen peroxide, which is then converted into chemicals with high reactivity under the influence of the enzyme myeloperoxidase [12].

Another mechanism explaining the bactericidal effect of laser radiation is the activation of endogenous photosensitizers (e.g., porphyrins and flavoproteins), which can increase the production of free radicals that have a cytotoxic effect on bacterial cells [13]. This is confirmed by a 21.8 % decrease in microorganism seeding from day 2 to day 21 after laser therapy, as well as by the change in the quantitative and species composition of microorganisms of postoperative wounds demonstrated in our study.

Arising out of the lack of data on the physiotherapeutic effect of laser radiation on wounds after open hemorrhoidectomy, we have developed a safe, effective, non-invasive technique that can be actively used in the postoperative period in coloproctology patients.

Conclusions

Thus, the obtained preliminary results prove that the use of laser irradiation in the postoperative period allows to reduce bacterial contamination of wounds, which contributes to the reduction of inflammatory reaction in tissues and pain syndrome. In addition, the effect of laser study on all phases of the wound process allows to achieve a reduction in the wound healing time and thus improve the quality of life of operated patients.

References / Литература

1. *Шелыгин Ю.А., Благодарный Л.А.* Справочник колопроктолога. М.: Литтера, 2014:64–89. [*Shelygin Yu.A., Blagodarny L.A.* Coloproctologist's Guide. Moscow: Littera Publ., 2014:64–89. (In Russ.)].
2. *Ассоциация колопроктологов России.* Клинические рекомендации: Геморрой. 2024. [*Association of Proctologists of Russia.* Clinical guidelines: Hemorrhoids. 2024. (In Russ.)].
3. *Шелыгин Ю.А.* Клинические рекомендации: Колопроктология. М.: «ГЭОТАР-Медиа», 2015. [*Shelygin Yu.A.* Clinical guidelines: Coloproctology. Moscow: GEOTAR Media Publ., 2015. (In Russ.)].
4. *Костенко Н.В., Шомиров С.С., Есин В.И., Халов В.Ю., Титова Ю.П.* Динамика раневого процесса после геморроидэктомии. *Кубанский научный медицинский вестник.* 2014;5:60–6. [*Kostenko N.V., Shomirov S.S., Esin V.I., Khalov V.Y., Titova Y.P.* Wound healing dynamics after hemorrhoidectomy. *Kuban Scientific Medical Bulletin.* 2014;5:60–6. (In Russ.)].
5. *Абдулкадырова А.Т., Юсуппаева П.П., Аджиева Ф.С.* Антибиотикорезистентность: исследование механизмов антибиотикорезистентности и поиск новых подходов к лечению. Пенза: Наука и Просвещение, 2023:134–6. [*Abdulkadyrova A.T., Yusuppayeva P.P., Adzhieva F.S.* Antibiotic resistance: Investigation of the mechanisms of antibiotic resistance and the search for new approaches to treatment. Penza: "Nauka i Prosveshchenie" Publ., 2023:134–6. (In Russ.)].
6. *Traverzim M., Makabe S., Silva D.F.T., Pavani C., Bussadori S.K., Fernandes K.S.P., et al.* Effect of led photobiomodulation on analgesia during labor: Study protocol for a randomized clinical trial. *Medicine (Baltimore).* 2018;97(25):e11120. DOI: 10.1097/MD.0000000000011120
7. *Ступак В.В., Родюкова Е.Н.* Местное низкоинтенсивное лазерное облучение в лечении трофических осложнений у больных с позвоночно-спинномозговой травмой. *Хирургия позвоночника.* 2005;(2):34–40. [*Stupak V.V., Rodyukova E.N.* Local low intensive laser irradiation for treatment of trophic complications in patients with spinal cord injuries. *Russian Journal of Spine Surgery.* 2005;2:34–40. (In Russ.)]. DOI: 10.14531/ss2005.2.34-40
8. *Hamblin M.R.* Photobiomodulation for traumatic brain injury and stroke. *J Neurosci Res.* 2018;96(4):731–43. DOI: 10.1002/jnr.24190
9. *Zamani A.R.N., Saberianpour S., Geranmayeh M.H., Bani F., Haghighi L., Rahbarghazi R.* Modulatory effect of photobiomodulation on stem cell epigenetic memory: A highlight on differentiation capacity. *Lasers Med Sci.* 2020;35(2):299–306. DOI: 10.1007/s10103-019-02873-7
10. *Гребень А.И., Еремин П.С., Костромина Е.Ю., Марков П.А., Гребень Т.Н., Гильмутдинова И.Р. и др.* Низкоинтенсивная лазерная терапия: молекулярные механизмы противовоспалительного и регенеративного эффектов. *Вопросы курортологии, физиотерапии и лечебной физкультуры.* 2023;100(2):61–8. [*Greben A.I., Eremin P.S., Kostromina E.Yu., Markov P.A., Greben T.N., Gilmutdinova I.R., et al.* Low level laser therapy: Molecular mechanisms of anti-inflammatory and regenerative effects. *Problems of Balneology, Physiotherapy and Exercise Therapy.* 2023;100(2):61–8. (In Russ.)]. DOI: 10.17116/kurort202310002161
11. *Кончугова Т.В., Асхадулин Е.В., Кульчицкая Д.Б., Фесюн А.Д., Мельникова Е.А., Никитин М.В.* Эффективность комбинированной лазерной терапии у пациентов с трофическими язвами нижних конечностей и хронической венозной недостаточностью. *Вопросы курортологии, физиотерапии и лечебной физической культуры.* 2020;97(5):45–51. [*Konchugova T.V., Askhadulin E.V., Kulchitskaya D.B., Fesyun A.D., Melnikova E.A., Nikitin M.V.* The effectiveness of combined laser therapy in patients with trophic leg ulcer and chronic venous insufficiency. *Problems of Balneology, Physiotherapy and Exercise Therapy.* 2020;97(5):45–51. (In Russ.)]. DOI: 10.17116/kurort20209705145
12. *Silva I.H., de Andrade S.C., de Faria A.B., Fonsêca D.D., Gueiros L.A., Carvalho A.A., et al.* Increase in the nitric oxide release without changes in cell viability of macrophages after laser therapy with 660 and 808 nm lasers. *Lasers Med Sci.* 2016;31(9):1855–62. DOI: 10.1007/s10103-016-2061-1
13. *de Souza da Fonseca A., da Silva Sergio L.P., Mencalha A.L., de Paoli F.* Low-power lasers on bacteria: Stimulation, inhibition, or effectless? *Lasers Med Sci.* 2021;36(9):1791–805. DOI: 10.1007/s10103-021-03258-5
14. *Bolton L.L., Girolami S., Corbett L., van Rijswijk L.* The Association for the Advancement of Wound Care (AAWC) venous and pressure ulcer guidelines. *Ostomy Wound Manage.* 2014;60(11):24–66.

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Submitted: 30.10.2024 Accepted: 29.11.2024 Published: 28.02.2025
Поступила: 30.10.2024 Принята: 29.11.2024 Опубликована: 28.02.2025

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