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Laser Destruction or Sclerotherapy in the Treatment of Grade 2–3 Hemorrhoids

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Aim: to improve treatment outcomes in patients with grade 2–3 hemorrhoids.

Materials and methods. Currently 91 patients with grade 2–3 hemorrhoids who met the inclusion criteria are enrolled in a single-center prospective randomized study. Of these, 48 patients underwent transdermal laser submucosal destruction of internal hemorrhoidal nodes using a water-absorbing laser with a wavelength of 1940 nm according to our proposed technique. Forty-three patients underwent sclerotherapy of internal hemorrhoidal nodes using the traditional method (injections of 3 % polidocanol (Aethoxysklerol®, Kreussler Pharma) into three internal hemorrhoidal nodes in a single session). Due to intraoperative bleeding, one patient was excluded from the laser group and underwent hemorrhoidectomy.

The primary endpoints of the study were the absence of cavernous tissue in internal hemorrhoidal nodes one month after surgery and the frequency of disease recurrence 6–12 months postoperatively. The effectiveness of the technique was assessed using anoscopy and rectal ultrasound with spectral Doppler imaging at 1, 3, 6, and 12 months after surgery. During the same periods, quality of life and severity of hemorrhoidal symptoms were evaluated using the SF-36 scale and a clinical symptom scoring system. In the first 7 days after surgery, pain intensity was assessed using the Visual Analog Scale (VAS). To evaluate the potential impact of these minimally invasive techniques on rectal sphincter function, sphincterometry was performed in all patients before and one month after surgery. Intra- and postoperative complications, as well as recurrence rates, were recorded over a 12-month follow-up period in both groups.

Results. In the group of transdermal laser submucosal destruction, the pain intensity on postoperative day 7 was 0 points on the VAS in 28 patients (59.6 %), while in the sclerotherapy group, this was observed in 31 (72.1 %) patients. Intraoperative complications occurred only in the main group: 1 (2.1 %) patient experienced bleeding, and 4 (8.5 %) patients developed submucosal hematomas. In the early postoperative period, thrombosis of external hemorrhoidal nodes occurred in 3 (6.4 %) patients in the main group and in 1 (2.3 %) patient in the control group. On days 5–7 after the procedure, mucosal ulceration at the site of the internal hemorrhoidal node was observed in one patient from each group; both cases were managed conservatively.

Internal hemorrhoidal nodes, which had been identified prior to the intervention, were no longer visualized one month after treatment in 45 (95.7 %) patients in the main group and 36 (83.7 %) patients in the control group, as confirmed by both anoscopy and transrectal ultrasonography. This effect persisted consistently at 3, 6, and 12 months postoperatively. Spectral wave Doppler imaging demonstrated a sustained reduction in blood flow through the terminal branches of the superior rectal artery by a factor of 4 in the main group and by a factor of 3 in the control group up to 12 months post-intervention.

Sphincterometric evaluation revealed no significant changes in anorectal sphincter function compared to preoperative values. At 6 months postoperatively, 1 (2.3 %) patient in the control group was diagnosed with recurrent hemorrhoidal disease. Analysis indicated that the recurrence was associated with an insufficient volume of the sclerosing agent administered.

Conclusion. The preliminary results of the study demonstrate higher efficacy of laser submucosal destruction compared to sclerotherapy in the treatment of grade 2–3 hemorrhoids. During the 12-month follow-up period, no cases of recurrence of hemorrhoidal symptoms were observed in the laser group, whereas 1 (2.3 %) case of recurrence occurred in the sclerotherapy group six months after the procedure. However, it should be noted that laser destruction is a more invasive technique compared to sclerotherapy, as evidenced by a higher incidence of intra- and postoperative complications and the requirement for anesthesia during the procedure.

Keywords: hemorrhoids, laser destruction, sclerotherapy treatment, minimally invasive methods of hemorrhoid treatment, laser hemorrhoidoplasty, laser, relapse

Conflict of interests: the authors declare no conflict of interest.

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Лазерная деструкция или склерозирование в лечении геморроя 2–3-й стадий

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Цель: улучшение результатов лечения пациентов с геморроем 2–3-й стадий.

Материалы и методы. На данный момент в одноцентровое проспективное рандомизированное исследование включен 91 пациент с геморроем 2–3-й стадий, соответствующий критериям включения. Из них 48 пациентам выполнена трансдермальная лазерная подслизистая деструкция внутренних геморроидальных узлов при помощи водопоглощаемого лазера с длиной волны 1940 нм по предложенной нами методике, 43 пациентам — склерозирование внутренних геморроидальных узлов традиционным методом (инъекции 3%-го этоксисклерола в три внутренних геморроидальных узла в один этап). Один пациент исключен из основной группы исследования в связи с развившимся интраоперационным кровотечением — была выполнена геморроидэктомия. Первичными точками исследования являлись отсутствие кавернозной ткани внутренних геморроидальных узлов через месяц после операции и частота рецидивов заболевания через 6–12 месяцев после вмешательства. Оценка эффективности методики проводилась при помощи аноскопии, ультразвукового исследования ректальным датчиком со спектрально-волновой доплерографией через 1, 3, 6 и 12 месяцев после операции. В эти же сроки выполнялась оценка качества жизни и степени выраженности симптомов геморроидальной болезни по шкале SF-36 и балльной оценки клинических проявлений геморроя. В первые 7 дней после операции проводился анализ интенсивности болевого синдрома при помощи визуально-аналоговой шкалы (ВАШ). Для оценки возможного воздействия данных малоинвазивных методик на запирательный аппарат прямой кишки всем пациентам до и через 1 месяц после операции выполнялась сфинктерометрия. Также были зарегистрированы интра- и послеоперационные осложнения и рецидивы заболевания в течение 12 месяцев в обеих группах.

Результаты. В группе трансдермальной лазерной подслизистой деструкции уровень болевого синдрома к 7-му дню после операции соответствовал 0 баллов по ВАШ у 28 (59,6 %) пациентов, в группе склеротерапии — у 31 (72,1 %) пациента. Интраоперационные осложнения были зарегистрированы только у пациентов основной группы: у 1 (2,1 %) больного возникло кровотечение и у 4 (8,5 %) пациентов образовалась подслизистая гематома. В раннем послеоперационном периоде у 3 (6,4 %) пациентов основной группы и 1 (2,3 %) пациента контрольной группы развился тромбоз наружных геморроидальных узлов. На 5–7-е сутки после вмешательства у 1 больного после лазерной деструкции и у 1 больного после склерозирующего лечения возникла язва слизистой оболочки внутреннего геморроидального узла, пролеченная консервативно. Определяемые до операции внутренние геморроидальные узлы через месяц после вмешательства не визуализировались как при аноскопии, так и при выполнении ультразвукового исследования ректальным датчиком у 45 (95,7 %) пациентов основной и 36 (83,7 %) — контрольной группы. Данный эффект стойко сохранялся через 3, 6 и 12 месяцев после вмешательства. По результатам спектрально-волновой доплерографии отмечалось стойкое снижение показателей кровотока по конечным ветвям верхней прямокишечной артерии в 4 раза у пациентов основной и в 3 раза у пациентов контрольной группы в сроки до 12 месяцев после операции. По данным сфинктерометрии не отмечено изменения параметров функции анальных сфинктеров по сравнению с дооперационными показателями. Через 6 месяцев после операции у 1 (2,3 %) пациента диагностирован рецидив геморроидальной болезни. Проведенный анализ показал, что причиной возврата клинических проявлений заболевания явилось введение недостаточного количества склерозирующего препарата.

Заключение. Полученные предварительные результаты исследования демонстрируют более высокую эффективность лазерной подслизистой деструкции в сравнении со склеротерапией в лечении геморроя 2–3-й стадий. Так, за период наблюдения в течение 12 месяцев после операции не отмечено ни одного случая возврата клинических проявлений геморроидальной болезни в основной группе, тогда как среди пациентов контрольной группы зарегистрирован 1 (2,3 %) рецидив заболевания, возникший через 6 месяцев после вмешательства. Однако стоит отметить, что лазерная деструкция является более инвазивным методом в сравнении со склеротерапией, что подтверждается большим количеством интра- и послеоперационных осложнений, а также есть необходимость выполнения операции под одним из видов анестезии.

Ключевые слова: геморрой, лазерная деструкция, склерозирующее лечение, малоинвазивные методы лечения геморроя, лазерная геморроидопластика, лазер, рецидив

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Introduction

Hemorrhoids remain one of the most common proctological diseases in people of working age [1]. Currently, various minimally invasive techniques are widely used in the treatment of grade 2–3 hemorrhoidal disease when conservative therapy is ineffective. Compared with radical surgery, they allow patients to avoid intense postoperative pain syndrome and return to their normal activities as soon as possible. Along with such well-known methods as ligation with latex rings, sclerotherapy, infrared photocoagulation, techniques using various types of lasers are becoming increasingly widespread [2–4]. The most commonly used of these are laser dearterialization (Hemorrhoidal LASER Procedure, HeLP) and laser destruction of internal hemorrhoids (Laser Hemorrhoidoplasty, LHP) [5, 6]. LHP is a fairly promising method that does not require the use of additional equipment in the form of a Doppler sensor [6]. To date, this technique, according to available literature data, is performed in two ways: transnodally and transdermally using lasers with wavelengths of 980 and 1470 nm with an efficiency of up to 98 % [6, 7]. When performing the procedure in the first way, a laser instrument is used to directly puncture the mucous membrane of the internal hemorrhoid, after which the cavernous tissue is affected. With the transdermal method, laser energy is supplied to the internal hemorrhoid through a puncture with a laser instrument in the skin of the perianal region at a distance of 0.5–1 cm from the edge of the anus and its subcutaneous-submucous administration. In our opinion, this option is preferable, since the absence of wounds in the anal canal reduces the risk of developing purulent-inflammatory complications.

In connection with the emergence of literary publications demonstrating much less thermal damage to surrounding tissues when exposed to long-wave lasers, National Medical Research Center of Coloproctology named after A.N. Ryzhikh uses a domestically produced water-absorbing laser with a wavelength of 1940 nm to perform laser destruction [8].

As a result of treating the internal hemorrhoidal node with laser radiation, the process of aseptic inflammation is launched, ending with the replacement of cavernous tissue with connective tissue. Among the long-known and widely used minimally invasive methods of treating hemorrhoids, the one that has a similar mechanism of action is sclerotherapy, where the same cascade of reactions is launched in response to the introduction of a chemical detergent into the tissue of the internal hemorrhoidal node. In this regard, the sclerosing treatment method was chosen as the control group for a randomized study devoted to assessing the effectiveness of transdermal laser submucosal destruction.

Patients and methods

Since September 2023, a single-center prospective randomized study has been conducted at the National Medical Research Center of Coloproctology named after A.N. Ryzhikh (Moscow, Russia), evaluating the use of transdermal laser submucosal destruction for the treatment of grade 2–3 hemorrhoids.

Study hypothesis: transdermal submucosal laser destruction of internal hemorrhoidal nodes using a 1940 nm wavelength laser is more effective than sclerotherapy.

Eligible participants included adult patients with grade 2–3 hemorrhoids scheduled for minimally invasive intervention, who provided written informed consent to participate. Exclusion criteria comprised acute hemorrhoids, grade 4 disease, prior anorectal surgery, inflammatory bowel disease, concurrent anorectal pathology, or severe decompensated systemic illnesses. Patients were also excluded if they withdrew consent at any point, failed to follow the treatment protocol, or required a change in the surgical procedure.

Primary endpoints included the absence of cavernous tissue in internal hemorrhoidal nodes one month after surgery and the rate of disease recurrence at 6–12 months. Secondary endpoints included assessment of postoperative pain intensity using the Visual Analog Scale (VAS), the incidence and types of postoperative complications, sphincter function abnormalities, and evaluation of hemorrhoidal symptoms and quality of life. Patients were randomized by computer-generated numbers and assigned to one of two groups: 1) transdermal laser submucosal destruction group; 2) sclerotherapy group. The calculated sample size for each group was 63 patients, based on 80 % study power and a 0.5 % confidence interval.

According to the study protocol, patients in both groups underwent identical preoperative

assessments and scheduled follow-up examinations. Preoperatively, all patients underwent colonoscopy to exclude concomitant colorectal pathology. At baseline, and at 1, 3, 6, and 12 months postoperatively, anoscopy was performed to visually assess the state and size of internal hemorrhoidal nodes. During the same follow-up intervals, transrectal ultrasonography combined with spectral Doppler imaging was performed using a high-frequency (10 MHz) rectal probe Arietta V 70a (Hitachi, Japan) to evaluate the area of cavernous tissue and flow velocity in the terminal branches of the superior rectal artery. To assess any impact of the interventions on anorectal sphincter function, all patients underwent anorectal manometry before and one month after surgery using the WPM Solar system (MMS, Netherlands). Parameters included resting tone of the anal sphincters and voluntary contraction strength of the external anal sphincter. Intraoperative and early postoperative complications were recorded, and VAS scores for pain (both during defecation and at rest) were assessed within the first 7 days postoperatively.

To quantify hemorrhoidal symptoms, we used the hemorrhoid symptom score developed at our center [9]. Quality of life was assessed with the standardized SF-36 questionnaire preoperatively and at 1, 3, 6, and 12 months after surgery.

As previously mentioned, laser submucosal destruction in our study was performed using a 1940 nm diode-pumped fiber laser (IRE-Polus LLC, Russia), approved for medical use (Registration certificate No. RZN 2019/9361). The laser probe was inserted subcutaneously/submucosally via a skin puncture in the perianal region. Laser energy was delivered in a fan-shaped motion in pulsed mode with the following settings: power — 7 W, pulse duration — 500 ms, pause — 750 ms (Patent of the Russian Federation No 2785255, dated 05.12.2022, "Method for treating hemorrhoids using a 1940 nm fiber laser"). To determine the amount of laser energy in joules (J) required to treat a specific hemorrhoid, after anesthesia is administered, the length of the internal nodes is measured using a caliper-type ruler. Thus, based on our previously conducted pilot study, we came to the conclusion that approximately 100 J of laser energy is required to provide an effective and safe effect on 1 cm of cavernous tissue. Summarizing the data of the patients included in our study, an average of 140 J of laser energy was required to treat a hemorrhoid at 3 o'clock (hereinafter referred to as the conventional clock face) with an average length of 18 (12–20) mm. 150 J of energy was transferred to the cavernous tissue of an internal hemorrhoid at 7 o'clock with an average size of 17 (11–22) mm, and 170 J to a hemorrhoid at 11 o'clock with a length of 19 (13–23) mm (Table 1).

Despite the availability of various sclerotherapy methods, our study employed the most commonly used and equipment-free technique: injection of liquid 3 % polidocanol (lauromacrogol 400) into the cavernous tissue. We performed sclerotherapy on all three hemorrhoidal nodes in a single session. The volume of sclerosant was adjusted according to the size of the node [9]. For a node up to 1,5 cm in length, 1 mL of sclerosant was administered.

All collected data were entered into a relational database using Microsoft Access (Microsoft Corp., USA). Statistical analysis was performed using RStudio (R v. 4.4.1; R Core Team, Austria) with the support of R packages: RODBC, dplyr, and gtsummary. Quantitative variables are presented as median with interquartile range (Me [Q1; Q3]); qualitative variables are presented as absolute and relative frequencies (n (%) or n/N (%)). Group comparisons were conducted using the Wilcoxon rank-sum test for quantitative and ordinal categorical variables. Binary categorical variables were compared using Pearson's χ^2 test when the expected frequency was > 10; otherwise, the two-sided Fisher's exact test was applied. Statistical significance was established at $p < 0,05$.

Results

At the time of analysis, 91 patients were enrolled in the study. Among them, 48 (52.7 %) patients underwent transdermal laser submucosal destruction of internal hemorrhoidal nodes, while 43 (47.3 %) patients received traditional sclerotherapy. One patient (2.1 %) in the laser group was excluded due to intraoperative bleeding, which necessitated conversion to open hemorrhoidectomy. Fifteen patients (16.7 %) have completed the 12-month follow-up period to date, including 8 (8.9 %) patients from the laser group and 7 (7.8 %) patients from the sclerotherapy group. Six-month follow-up examinations were completed by 16 (34 %)

patients in the laser group and 14 (32.6 %) patients in the control group; 3-month follow-up data were available for 32 (68.1 %) patients in the laser group and 28 (65.1 %) patients in the sclerotherapy group.

Comparison of baseline demographic and clinical characteristics revealed no statistically significant differences between groups with respect to sex, age, disease duration, or mean body mass index (Table 1). However, it is noteworthy that a greater proportion of patients in the laser group had grade 3 hemorrhoids (31 patients, 66 %), while grade 2 predominated in the sclerotherapy group (30 patients, 69.8 %) (Table 1).

An important observation is that all patients in the laser group underwent the procedure under anesthesia. Based on patient preference, 31 (64.6 %) patients received local anesthesia and 17 (35.4 %) patients underwent spinal anesthesia. In contrast, all 43 patients in the sclerotherapy group were treated without anesthesia (Table 1).

An important aspect during the performance of these interventions is the presence of intraoperative visual changes in the internal hemorrhoidal nodes. Due to the relatively low penetration depth (0,7 mm) of the 1940 nm wavelength laser, there were no changes in the size or mucosal surface over the internal hemorrhoidal nodes during the procedure. Immediately after sclerosant injection, tissue pallor and induration of the internal hemorrhoidal node were observed.

We analyzed intra- and postoperative complications in both groups. In the laser group, intraoperative bleeding occurred in 1 (2.1 %) patient due to trauma to the internal hemorrhoidal node at the 3 o'clock position, which necessitated conversion to hemorrhoidectomy and subsequent exclusion from the study. Hemorrhoidectomy was performed to control bleeding at the 3 o'clock site. Additionally, 4 (8.5 %) patients in the laser group developed submucosal hematomas intraoperatively. All these patients underwent intraoperative and postoperative (day 3) transrectal ultrasound examinations, which revealed differing pathogenetic mechanisms underlying these nodal changes. Analysis showed that in all cases, the laser fiber contacted the venous plexus (venous sinusoids), but in 1 (2.1 %) patient, a small amount of laser energy was applied, resulting in a true hematoma that persisted for several days and was managed conservatively. In the other cases, exposure of the venous plexus to high laser energy caused a rapid cavitation ("bubble burst") effect with formation of a "false" hematoma, which was not detectable on ultrasound by the next day.

No intraoperative complications were recorded in patients undergoing sclerotherapy of internal hemorrhoidal nodes.

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

Parameter ***Показатель***	**Main group** ***Основная группа*** ***n* = 47**	**Control group** ***Контрольная группа*** ***n* = 43**
Gender / *Пол*		
male / *мужской*	28 (58.3 %)	24 (55.8 %)
female / *женский*	20 (41.7 %)	19 (44.2 %)
Age, years / *Возраст, лет*	41 (19; 78)	38 (21; 75)
Body mass index, kg/cm^2 *Индекс массы тела, кг/м^2*	24.8 (17.7; 38.9)	23.2 (18; 31.3)
Medical history, months *Анамнез заболевания, мес.*	5 (0.2–21.0)	4 (0.3–17)
Grades of hemorrhoids / *Стадия геморроя*		
Grade 2 / *Вторая*	17 (35.4 %)	30 (69.8 %)
Grade 3 / *Третья*	31 (64.6 %)	13 (30.2 %)
Type of anesthesia / *Вид анестезии*		
local / *местная*	31 (64.6 %)	–
spinal / *спинальная*	17 (35.4 %)	–
Size of internal hemorrhoids, mm *Размер внутренних геморроидальных узлов, мм*		
at 3 o'clock / *на 3 часах*	18 (13; 28)	16 (10; 22)
at 7 o'clock / *на 7 часах*	16 (11; 26)	15 (11; 23)
at 11 o'clock / *на 11 часах*	15 (10; 27)	14 (9; 21)

In the early postoperative period, thrombosis of external hemorrhoidal nodes developed in 3 (6.4 %) patients from the laser group and in 1 (2.3 %) patient from the control group. In patients treated with transdermal laser submucosal destruction, this complication was attributed to the effect of laser energy on the cavernous tissue of external hemorrhoids. Notably, thrombosis of external nodes occurred only in cases performed under spinal anesthesia, which caused complete relaxation of the anal sphincter and maximal prolapse of internal hemorrhoidal nodes, complicating accurate laser fiber positioning and targeting solely of internal hemorrhoidal tissue.

In the sclerotherapy group, thrombosis of an external hemorrhoidal node occurred in 1 (2.3 %) patient. All patients with thrombosis were managed conservatively with favorable outcomes.

Ulceration of the mucosa of internal hemorrhoidal nodes developed on postoperative days 5–7 in 1 (2.1 %) patient in the laser group and 1 (2.3 %) patient in the control group. Transrectal ultrasound revealed these ulcers as hypoechoic defects with hyperechoic inclusions. In the laser group, the complication was linked to very close proximity of the laser fiber to the mucosal surface during the procedure. Due to the low penetration depth of the laser, no intraoperative visual changes were noted, but mucosal necrosis and ulcer formation developed by day 7. In the sclerotherapy patient, submucosal injection of the sclerosant led to partial tissue necrosis and ulcer formation. Both patients received conservative treatment with topical antibacterial ointments with positive effect. Follow-up anoscopy and ultrasound on day 14 showed no residual ulcerative defects.

Pain intensity was assessed using a visual analog scale (VAS, 0–10 points) during the first 7 postoperative days. On day 2, pain intensity did not exceed 3 points in 30 (63.8 %) patients from the laser group and 33 (76.7 %) patients in the sclerotherapy group. By day 7, pain was absent in 28 (59.6 %) patients in the laser group and 31 (72.1 %) patients in the control group (Table 2). Similar trends were observed when evaluating pain during defecation.

To assess the primary endpoint of our study, all patients underwent anoscopy and transrectal ultrasound with Doppler imaging at 1, 3, 6, and 12 months postoperatively. Visual assessment during anoscopy demonstrated that in the transdermal laser submucosal destruction group, internal hemorrhoidal nodes identified preoperatively were no longer visualized in 45 (95.7 %) patients at 1 month after surgery. This finding persisted at 3, 6, and 12 months after intervention. In the sclerotherapy group, absence of internal hemorrhoidal nodes was recorded in 35 (81.4 %) patients at 1 month, with sustained absence confirmed in all 28 patients examined at 3 months and in 13 (92.9 %) patients assessed at 6 months.

Instrumental evaluation of the effectiveness of these minimally invasive techniques using transrectal ultrasound showed strong correlation with the anoscopic findings. At this stage of the study, only one patient in the sclerotherapy group demonstrated residual islands of cavernous tissue at 6 months post-procedure (Table 3).

As mentioned above, spectral Doppler wave analysis was used to assess changes in blood flow velocity in the terminal branches of the superior rectal artery. This was performed using a high-frequency 10 MHz transrectal probe (Arietta V70a, Hitachi, Japan). The measured velocity parameters included peak systolic velocity, end-diastolic velocity, mean velocity, resistive index, and pulsation index. One month after the procedure, a fourfold reduction in blood flow velocity was observed in 44 (93.6 %)

Table 2. Pain intensity according to VAS on days 1–7 after surgery, points
Таблица 2. Интенсивность болевого синдрома по ВАШ на 1–7-е сутки после операции, баллы

Day after surgery ***Сутки после операции***	**Main group** ***Основная группа*** ***n* = 47**	**Control group** ***Контрольная группа*** ***n* = 43**
1	6 (5; 6)	5 (3;5)
2	5 (3; 5)	4 (2; 2)
3	4 (2; 5)	3 (2; 3)
4	3 (2; 3)	2 (2; 3)
5	3 (3; 2)	2 (1; 2)
6	2 (1; 3)	1 (1; 2)
7	1 (2; 3)	1 (1; 2)

Table 3. Results of transrectal ultrasound examination at 1, 3, 6, and 12 months after surgery
Таблица 3. Результаты трансректального ультразвукового исследования через 1, 3, 6 и 12 месяцев после операции

Months after surgery ***Месяцы после операции***	**Main group** ***Основная группа*** ***n* = 47**		**Control group** ***Контрольная группа*** ***n* = 43**	
In 1 month *Через 1 месяц*	Examined: / *Обследованы:* cavernous tissue is not detected *кавернозная ткань не определяется*	*n* = 47 *n* = 45 (95.7 %)	Examined: / *Обследованы:* cavernous tissue is not detected *кавернозная ткань не определяется*	*n* = 43 *n* = 36 (83.7 %)
In 3 months *Через 3 месяца*	Examined: / *Обследованы:* cavernous tissue is not detected *кавернозная ткань не определяется*	*n* = 32 *n* = 30 (93.8 %)	Examined: / *Обследованы:* cavernous tissue is not detected *кавернозная ткань не определяется*	*n* = 28 *n* = 21 (75 %)
In 6 months *Через 6 месяцев*	Examined: / *Обследованы:* cavernous tissue is not detected *кавернозная ткань не определяется*	*n* = 16 *n* = 15 (93.8 %)	Examined: / *Обследованы:* cavernous tissue is not detected *кавернозная ткань не определяется*	*n* = 14 *n* = 10 (71.4 %)
In 12 months *Через 12 месяцев*	Examined: / *Обследованы:* cavernous tissue is not detected *кавернозная ткань не определяется*	*n* = 8 *n* = 7 (87.5 %)	Examined: / *Обследованы:* cavernous tissue is not detected *кавернозная ткань не определяется*	*n* = 7 *n* = 4 (57.1 %)

Table 4. Results of spectral wave Doppler ultrasonography at 1, 3, 6, and 12 months after surgery
Таблица 4. Результаты спектрально-волновой доплерографии через 1, 3, 6 и 12 месяцев после операции

Months after surgery ***Месяцы после операции***	**Main group** ***Основная группа*** ***n* = 47**		**Control group** ***Контрольная группа*** ***n* = 43**	
In 1 month *Через 1 месяц*	Examined: / *Обследованы:* a 4-fold decrease in blood flow velocity indicators *снижение скоростных показателей кровотока в 4 раза*	*n* = 47 *n* = 44 (93.6 %)	Examined: / *Обследованы:* a 3-fold decrease in blood flow velocity indicators *снижение скоростных показателей кровотока в 3 раза*	*n* = 43 *n* = 34 (79.1 %)
In 3 months *Через 3 месяца*	Examined: / *Обследованы:* a 4-fold decrease in blood flow velocity indicators *снижение скоростных показателей кровотока в 4 раз*а	*n* = 32 *n* = 29 (90.6 %)	Examined: / *Обследованы:* a 3-fold decrease in blood flow velocity indicators *снижение скоростных показателей кровотока в 3 раза*	*n* = 28 *n* = 21 (75 %)
In 6 months *Через 6 месяцев*	Examined: / *Обследованы:* a 4-fold decrease in blood flow velocity indicators *снижение скоростных показателей кровотока в 4 раза*	*n* = 16 *n* = 14 (97.5 %)	Examined: / *Обследованы:* *a 3-fold decrease in blood flow* velocity indicators *снижение скоростных показателей кровотока в 3 раза*	*n* = 14 *n* = 10 (71.4 %)
In 12 months *Через 12 месяцев*	Examined: / *Обследованы:* a 4-fold decrease in blood flow velocity indicators *снижение скоростных показателей кровотока в 4 раза*	*n* = 8 *n* = 7 (87.5 %)	Examined: / *Обследованы:* a 3-fold decrease in blood flow velocity indicators *снижение скоростных показателей кровотока в 3 раза*	*n* = 7 *n* = 4 (57.1 %)

patients after laser submucosal destruction, whereas in the sclerotherapy group, velocity parameters decreased threefold in 34 (79.1 %) patients. This effect persisted in all patients of the laser group who underwent follow-up examinations at 3, 6, and 12 months post-intervention. In contrast, the therapeutic effect in the sclerotherapy group was maintained only up to 3 months post-procedure. At the 6-month follow-up, one patient showed an increase in velocity parameters (Table 4).

It is noteworthy that in some cases following sclerotherapy, an increase in end-diastolic velocity was observed. This effect was recorded in 9 (20.9 %) patients of the control group one month after the procedure, with persistence throughout the follow-up at 3, 6, and 12 months.

Analysis of the patients' subjective assessment of symptom relief showed that the median score on the clinical manifestations scale of hemorrhoidal disease decreased from 18 to 0 in both groups one month after the intervention (Table 5).

Assessment of the potential impact of these minimally invasive interventions on the anal sphincter muscles, based on sphincterometry performed on all patients one month after surgery, revealed no significant differences between pre- and postoperative measurements, confirming the safety of the aforementioned minimally invasive techniques (Table 6).

Additionally, quality of life was assessed using the SF-36 questionnaire in all patients enrolled in the study. Statistically significant improvements were observed in both groups in the domains of Physical Functioning (PF) and Mental Health (MH) after surgery (Table 7).

At this stage of the study, recurrence of hemorrhoidal disease symptoms was observed in 1 (2.3 %) patient from the sclerotherapy

Table 5. Median scores for assessing clinical manifestations of hemorrhoids before and 1, 3, 6, and 12 months after surgery

Таблица 5. Медиана баллов по оценке клинических проявлений геморроя до и через 1, 3, 6 и 12 месяцев после операции

Months after surgery ***Месяцы после операции***	**Main group** ***Основная группа*** ***n* = 47**	**Control group** ***Контрольная группа*** ***n* = 43**
Before surgery / *До операции*	18 (2–30)	17 (2–29)
In 1 month / *Через 1 месяц*	0 (0–5)	0 (0–4)
In 3 months / *Через 3 месяца*	0 (0–4)	0 (0–4)
In 6 months / *Через 6 месяцев*	0 (0–4)	0 (0–12)
In 12 months / *Через 12 месяцев*	0 (0–4)	0 (0–5)

Table 6. Sphincterometry parameters before and after surgery

Таблица 6. Показатели сфинктерометрии до и после операции

Parameter ***Показатель***	**Main group** ***Основная группа*** ***n* = 47**			**Control group** ***Контрольная группа*** ***n* = 43**		
	Before surgery ***До операции***	**Day 30 after surgery** ***30-й день после операции***	***p***	**Before surgery** ***До операции***	**Day 30 after surgery** ***30-й день после операции***	***p***
Average pressure in the anal canal at rest, mmHg (normal: 41–63) *Среднее давление в анальном канале в покое, мм рт. ст. (норма: 41–63)*	38 (36; 43)	38 (37; 41)	0.6	40 (33; 47)	41 (34; 46)	0.6
Maximum pressure in the anal canal during voluntary contraction, mmHg (normal: 110–227) *Максимальное давление в анальном канале при волевом сокращении, мм рт. ст. (норма: 110–227)*	177.5 (136; 207)	171.5 (138; 188)	0.09	182 (141; 223)	180 (139; 221)	0.08

Table 7. Assessment of quality of life according to the SF-36 scale before and after surgery
Таблица 7. Оценка качества жизни по шкале SF-36 до и после операции

Parameter *Показатель*	Main group *Основная группа* *n* = 47		Control group *Контрольная группа* *n* = 43	
	Before surgery *До операции*	Day 30 after surgery *30-й день после операции*	Before surgery *До операции*	Day 30 after surgery *30-й день после операции*
Physical functioning (PF) *Физическое функционирование (PF)*	85.1 (15; 100)	91.8 (38; 100)	86.3 (16; 47)	92.1 (39; 100)
Mental health (MH) *Психологическое здоровье (MH)*	61.8 (40; 100)	77.3 (39; 100)	60.4 (39; 100)	76.8 (40; 100)

group. The patient initially presented with complaints of rectal bleeding and prolapse of internal hemorrhoidal nodes during defecation, which required manual reduction. The disease was classified as grade 3, and the clinical symptom score totaled 17 points. Anoscopy revealed enlarged internal hemorrhoidal nodes located at 3, 7, and 11 o'clock positions, measuring 18 mm, 20 and 16 mm, respectively. Transrectal ultrasonography showed the area of cavernous tissue to be 0.9, 1.4 and 0.64 cm^2, respectively. Spectral Doppler ultrasonography registered preoperative flow velocity parameters in the terminal branches of the superior rectal artery. The patient underwent conventional sclerotherapy of internal hemorrhoids at the 3, 7, and 11 o'clock positions using 0.5, 1.0 and 0.5 mL of 3 % polidocanol (ethoxysclerol), respectively. One month after treatment, the patient reported complete resolution of symptoms (clinical score — 0). Anoscopy and transrectal ultrasonography revealed no cavernous tissue in the treated hemorrhoidal sites, and spectral Doppler sonography demonstrated a threefold reduction in blood flow velocity in the terminal branches of the superior rectal artery compared to preoperative values. These results remained stable over the first three months postoperatively. However, six months after the procedure, the patient reported recurrence of symptoms, including prolapse of a hemorrhoidal node during defecation (which reduced spontaneously) and the presence of blood on toilet paper. The clinical score at that point was 12, corresponding to grade 2 hemorrhoids. Anoscopy and transrectal ultrasonography revealed a residual island of cavernous tissue (0.56 cm^2) at the 3 o'clock position. Additionally, spectral Doppler parameters showed increased blood flow compared to the previous follow-up examination. Specifically, 3 months postoperatively, the peak systolic velocity (PSV) was 7.2 cm/s, end-diastolic velocity (EDV) — 0.6 cm/s, and mean velocity (MnV) — 3.9 cm/s. At 6 months, these values increased to 13.3, 1.4 and 7.35 cm/s, respectively. After discussion with the patient, a repeat sclerotherapy session targeting the internal hemorrhoid at the 3 o'clock position was performed, yielding a positive clinical response. Based on our analysis of the recurrence, we concluded that the initial procedure likely involved an insufficient volume of sclerosant administered to the specific hemorrhoidal node.

Discussion

In recent years, laser destruction of internal hemorrhoidal nodes has been increasingly used in the treatment of hemorrhoidal disease. Along with all the advantages of minimally invasive techniques, it demonstrates a high level of effectiveness in the treatment of grade 2–3 hemorrhoids.

Back in the early stages of implementing this technique using a 980 nm wavelength laser, A. Jahanshahi et al. published the results of a study involving 341 patients with grade 2–3 hemorrhoids. The authors demonstrated high efficacy of the method, with no disease recurrence observed during the one-year follow-up period. Postoperative complications were reported in 12 (3.51 %) patients, including external hemorrhoidal edema in 8 (2.34 %) patients, bleeding in 2 (0.58 %), and perianal abscess in 2 (0.58 %) [10].

Similar results were obtained by L. Brusciano et al., who evaluated 50 patients with grade 2–3 hemorrhoids treated using diode laser destruction

at a wavelength of 1470 nm. During a mean follow-up of 8.6 months, no recurrences were reported. The authors also noted the absence of significant intraoperative complications, which they attributed to the reduced tissue penetration depth (up to 2 mm) associated with the increased wavelength of this laser system [11].

Several researchers have compared laser destruction with more radical surgical interventions. P.L. Cheng et al. conducted a meta-analysis including 17 studies with a total of 1,196 patients, among whom 596 (49.8 %) underwent laser hemorrhoidoplasty (LHP) and 600 (50.2 %) underwent Milligan — Morgan or Ferguson hemorrhoidectomy. The results showed that LHP was equivalent to hemorrhoidectomy in terms of recurrence rates. However, LHP was associated with a lower risk of postoperative bleeding and a higher incidence of external hemorrhoidal thrombosis. When comparing laser systems with wavelengths of 980 and 1470 nm, fewer cases of acute urinary retention were reported with the 1470 nm laser (3 vs. 5 cases) [12].

In our study, we utilized a water-absorbing laser with a wavelength of 1940 nm. As previously noted, a major advantage of this wavelength is its shallow penetration depth of approximately 0.7 mm [8], which allows effective ablation of hemorrhoidal tissue while minimizing the risk of intra- and postoperative complications [13].

Equally important is the specific technique used in our patented approach. By advancing the laser fiber to the proximal border of the internal hemorrhoidal node, we are able to target both the cavernous tissue and the terminal branches of the superior rectal artery, thereby achieving an additional dearterialization effect. This outcome is clearly reflected in the results of spectral Doppler ultrasound.

Our findings also emphasize the sustained effectiveness of laser destruction, with no recurrences observed during the six-month follow-up period.

When comparing this method with the well-known minimally invasive technique of internal hemorrhoidal sclerotherapy, we note that, despite a similar pathophysiological mechanism of action, the clinical outcomes differ somewhat. Notably, there are measurable changes in blood flow velocity in the terminal branches of the superior rectal artery on Doppler ultrasonography. However, unlike laser treatment, these changes are not related to dearterialization, but rather to altered perfusion of partially or completely fibrotic hemorrhoidal tissue. In some cases, sclerotherapy was associated with an increase in end-diastolic velocity, which may be explained by intensified pulse wave reflection from the fibrotic tissue [9].

Conclusion

The preliminary results of our study demonstrate higher efficacy of submucosal laser destruction compared to sclerotherapy in the treatment of grade 2–3 hemorrhoidal disease. During the 12-month postoperative follow-up, no recurrences of clinical symptoms were observed in the laser group, whereas one case (2.3 %) of recurrence was documented in the sclerotherapy group at 6 months post-treatment. However, it is important to note that laser destruction is a more invasive technique compared to sclerotherapy. This is evidenced by the higher incidence of intra- and postoperative complications and the requirement for anesthesia.

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