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Laser Application for Diseases of the Anorectal Region

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Aim: to summarize the literature data of use of laser technologies in the treatment of anorectal diseases.
Key points. Lazer intervention technologies in the treatment of anorectal diseases such as haemorrhoids, anal fistula, anal fissure and pilonidal disease makes it possible to significantly reduce the intensity of pain syndrome, shorten the time of wound healing and also reduce the duration of the period of disability of the patient without worsening the quality of life. The main advantages of minimally invasive techniques are the absence of extensive wounds, minimal complications and reduction of the disease recurrence rate, minimally invasive methods are almost as effective as traditional ones. Besides, the use of laser allows to perform minimally invasive interventions under local anaesthesia in a day hospital.
Conclusion. It is necessary to further study and improve the use of laser technologies in the treatment of anorectal diseases, and to actively introduce techniques into practice to improve the results of treatment of patients with these nosologies.
Keywords: minimally invasive treatment, laser hemorrhoidoplasty, laser hemorrhoid procedure, laser hemorrhoidectomy, anal fissure, laser vaporization, SiLAC, FiLAC
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Области применения лазера при лечении заболеваний аноректальной области

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Цель: представить данные литературы о применении лазерных технологий в лечении заболеваний аноректальной области.
Основные положения. Применение лазера при лечении таких заболеваний аноректальной области, как геморрой, свищ прямой кишки, анальная трещина и хроническое воспаление эпителиального копчикового хода, дает возможность значительно уменьшить интенсивность болевого синдрома, сократить сроки заживления ран и также снизить продолжительность периода нетрудоспособности пациента без ухудшения качества жизни. Основными преимуществами малоинвазивных методик являются отсутствие обширных ран, минимальное количество осложнений и уменьшение частоты рецидива заболевания, а по эффективности малоинвазивные методы практически не уступают традиционным. Кроме того, использование лазерных технологий позволяет выполнять малоинвазивные вмешательства под местной анестезией в условиях дневного стационара.
Заключение. Необходимо дальнейшее изучение и усовершенствование применения лазерных технологий в лечении аноректальных заболеваний, активное внедрение методик в практику для улучшения результатов лечения пациентов с данными нозологиями.
Ключевые слова: малоинвазивное лечение, лазерная деструкция, лазерная дезартеризация, анальная трещина, лазерная вапоризация
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With the development of technology in the modern world, the use of laser in the treatment of diseases of the anorectal zone is becoming increasingly popular. Laser technologies are used for the treatment of coloproctological diseases with minimal impact on tissues, which contributes to the rapid recovery of patients in the postoperative period. Currently, lasers are used for the treatment of haemorrhoids, chronic anal fissure, anal fistula, pilonidal disease.

A laser is a technical device that emits electromagnetic radiation in the range from infrared to ultraviolet, which has high energy and biological effects. The term "laser" was introduced in 1957 by the American engineer Gordon Gould as an acronym for the English phrase "light amplification by the stimulated emission of radiation". Without a doubt, the creation of the laser is one of the outstanding achievements of the twentieth century, which influenced almost all areas of human activity. The physical operation of any laser was postulated by Albert Einstein in 1916, and in 1955 by a group of Soviet scientists N.G. Basov and A.M. Prokhorov, independently and simultaneously with the American scientist C.H. Townes, proposed the principle of creating a molecular generator — a laser, for which they were awarded the Nobel Prize in Physics in 1964 [1, 2]. In 1960, Albert Einstein's theory was improved by American physicist Theodor Maiman, resulting in the creation of the first ruby laser [3]. American physicists Ali Javan, William Ralph Bennett Jr. and Donald R. Herriott generated optical radiation in a gas discharge, thereby creating the first gas laser [4]. From 1961 to the present, laser manufacturing technologies have been improved, laser optics have been created and developed, and the use of laser technology in medicine and in surgery has been expanding, which is associated with a trend and an increase in the proportion of minimally invasive interventions, as a result of which the period of treatment is reduced. patient rehabilitation..

Various types of lasers have long been used successfully in surgery, ophthalmology, urology, dermatology, phlebology, dentistry, and cosmetology. In surgery, the American doctor Leon Goldman demonstrated the removal of skin melanoma using a ruby laser in in the early 60s of the 20th century. In 1963, Soviet engineer A.E. Nudelman created a laser ophthalmoscope-coagulator, with the help of which in 1964, for the first time in the USSR, surgery was performed in the retina using a ruby laser. Further our compatriots were ahead of their foreign colleagues actively using carbon dioxide laser as a scalpel. The most common medical use of laser radiation is low-intensity laser therapy (LILT) [5].

For the first time in coloproctology the use of laser as an excisional technique of haemorrhoids treatment was started in the 1980s. In the treatment of haemorrhoids stage 4, CO_2 laser was used as an instrument of excisional haemorrhoidectomy.

One of the first to perform hemorrhoidectomy with a CO_2 laser in 1989 was described by H. Iwagaki et al. [6]. The prospective study included 1812 patients with stage 2–4 hemorrhoids. The intervention was performed using a CO_2 laser with a wavelength of 10,600 nm (MEDILASER-MIC 30, Mochida Co., Ltd., Japan). In this case, the vascular pedicle of the hemorrhoid was ligated by applying a latex ring. During follow-up periods of 3 to 6 months, no recurrence of hemorrhoids was noted [6].

In a randomized study described in 1991 by Japanese surgeons Wang J.Y. et al. [7], patients with stage 3 and 4 hemorrhoids underwent hemorrhoidectomy using a CO_2 laser and a neodymium laser (Nd:YAG laser). Patients (n = 88) were randomized into two groups: in group 1 (n = 44) patients underwent intervention in the scope of traditional closed hemorrhoidectomy; patients of group 2 (n = 44) were exposed to internal hemorrhoids using an Nd:YAG laser with a wavelength of 10,600 nm and a power of 25 W; external hemorrhoids were vaporized for the purpose of hemostasis using a CO2 laser with a wavelength 1060 nm. During the intervention, the vascular pedicle was sutured. In the postoperative period, there was a 45 % decrease in pain intensity in the laser hemorrhoidectomy group compared to the control group. According to the presence of postoperative complications in the main group, bleeding was detected in 1 (2.2 %) patient, anal stricture was detected in 2 (4.4 %) patients. In the closed hemorrhoidectomy group, bleeding was detected in 1 (2.2 %) patient, anal stricture in 1 (2.2 %) patient. During the one-year follow-up, the authors did not note any cases of relapse in either group [7].

In a randomized study by A. Senagore et al. (1993) analyzed the results of using the Nd:YAG laser in 86 patients with stages 3 and 4 hemorrhoids. Patients of the first group (n = 56) were operated on with laser hemorrhoidectomy using an Nd:YAG laser, and in the second group (n = 35)

patients underwent closed hemorrhoidectomy according to Ferguson. There were no significant differences between the groups in terms of healing time or number of complications [8].

Today, to perform excisional hemorrhoidectomy, it is possible to use modern laser systems with different wavelengths.

The study published by V.A. Privalov et al. (2015) presented the results of surgical treatment of 174 patients with stage 3 and 4 hemorrhoids using a fiber laser with a wavelength of 1940 nm. Patients were randomized into two groups: main (n = 92) and control (n = 82). Patients in the main group underwent laser hemorrhoidectomy without suturing the vascular pedicle, patients in the control group underwent hemorrhoidectomy according to Milligan — Morgan. With the data obtained as a result of the study, the authors confirm that the laser hemorrhoidectomy method reduces the operation time and reduces the intensity of pain in the postoperative period. The incidence of postoperative complications in the main group decreased by 10 % compared to the control group [9].

However, the possibilities of using lasers are not limited to excision methods. In the treatment of patients with stages 2 and 3 of hemorrhoids, minimally invasive methods are used — laser hemorrhoidoplasty, laser desarterization.

Laser hemorrhoidoplasty (LHP), one of the modern methods of treatment, which is used in the treatment of hemorrhoids of stages 2 and 3, is a minimally invasive procedure using laser energy that allows to achieve sclerosis of the cavernous tissue due to the denaturation of proteins, resulting in cavernous tissue being replaced by connective tissue, fixing it to the mucous membrane, which reduces the degree of prolapse. Laser energy also affects the terminal branches of the rectal artery. The prevalence of this technique is due to the minimally invasive nature of the intervention and low pain syndrome in the postoperative period [10, 11].

A.F. Karahalilo lu et al. (2007) described the first experience with LHP. The study included 106 patients with stage 1 and 2 hemorrhoids who underwent LHP with a 980 nm diode laser with a power of 15 W (Ceralas D15 ELVeS Laser, Biolitec, Germany). The intervention was performed transnodally, in a pulsed mode (at least 6 pulses for each node, depending on the size of the node). The effectiveness was 89 %, relapse of disease symptoms was observed in 11 % of patients [12, 13].

L. Brusciano et al. (2020) assessed the effectiveness of LHP in patients with stage 2–3 hemorrhoids. The study included 50 patients who underwent intervention using a diode laser with a wavelength of 1470 nm. In the projection of the internal hemorrhoidal node, the intervention was carried out transdermally: at a distance of 1.5 cm from the edge of the anus, a microincision up to 3 mm in size was made, through which a laser instrument was inserted submucosally to the proximal edge of the internal hemorrhoidal node. Each node, depending on its size, was supplied with laser energy up to 24 J in a pulse-periodic mode of 10–12 pulses with a duration of 3 sec and a power of 8 W. As a result, the average value of postoperative pain on the VAS in the first three days was 2 points, on the next day it decreased to 0. The follow-up period was about 9 months, the authors did not note any cases of return of hemorrhoid symptoms [10].

Iranian researchers A. Jahanshahi et al. (2012) performed transdermal treatment on 341 patients with stages 2 and 4 hemorrhoids using laser radiation with a wavelength of 980 nm and a power of 30 W. Postoperative complications were noted in 12 (3.5%) patients: swelling of external hemorrhoids — in 8 (2.3 %), bleeding — in 2 (0.58 %), abscess — in 2 (0.58 %) people. Cases of bleeding and abscess required additional surgical intervention. No anesthesia was required. During the year of observation, the authors noted no relapse of the disease [14].

At the "National Medical Research Center of Coloproctology named after A.N. Ryzhikh" we have accumulated experience in treating 60 patients with stages 2–3 hemorrhoids using a transdermal method of intervention using a fiber laser with a wavelength of 1940 nm and a power of 8 W. According to our observations, bleeding from the internal hemorrhoid developed intraoperatively in 3 patients. In the postoperative period, 5 (8.3 %) patients developed thrombosis of external hemorrhoids, two of them developed acute urinary retention. A univariate analysis revealed an increase in the risk of developing postoperative complications with an increase in the amount of energy transferred to each hemorrhoid. According to anoscopy and transrectal ultrasound, 1 month after surgery, hemorrhoids were not visualized, which was also observed 6 months after surgery. During the entire observation period, no relapse of the disease was noted [15].

Laser desarterization (hemorrhoid laser procedure, HeLP) is an equally important minimally invasive method of treating hemorrhoids using laser technologies. Using a 20 MHz Doppler probe, the terminal branches of the superior rectal artery are identified and subsequently coagulated.

In 2009, R. Salfi et al. first published the results of treatment using HeLP in 200 patients with stages 2 and 3 hemorrhoids, followed up for 3 years. A special disposable proctoscope was inserted into the rectum, in the distal part of which

there was a small window with a Doppler sensor. Using a Doppler probe (probe with a frequency of 20 MHz, 3 mm in diameter), the location of 10–12 terminal branches of the superior rectal artery was determined 3 cm proximal to the dentate line. After identification, the Doppler probe was replaced with a laser instrument with a diameter of 1000 um, using a pulsed diode laser with a wavelength of 980 nm (each pulse 15–30 J, for a total of 60–120 J at a power of 10–25 W). The duration of the operation was about 15 minutes, the effectiveness was 91% [16].

N. Crea et al. in 2014 published immediate and long-term results of a prospective study on the use of the HeLP technique in 97 patients with stage 2–3 hemorrhoids, applying a 980 nm laser using the standard technique described above. The postoperative pain score 24 hours after surgery was 0–1 on the VAS. According to the study, in the long-term period after the intervention, 95 % of patients noted a persistent disappearance of hemorrhoid symptoms; the rate of return of symptoms was 5 % [17].

P. Giamundo et al. (2022) used a laser with a wavelength of 980 nm and a power of 13 W in their analysis of a two-year experience in the treatment of 276 patients with stages 1–4 hemorrhoids. The intervention technique did not differ. The advantages of the technique are its low invasiveness and selectivity of laser coagulation on the submucosal branches of the superior rectal artery under the control of a Doppler sensor. In 89.9 % of patients, the symptoms of the disease disappeared, and in the remaining 10.1 % cases symptoms of the disease returned. The study has showed that the effect of laser radiation should occur in a pulse-periodic mode, which ensures reliable occlusion of the terminal branches of the superior rectal artery, a lasting clinical effect, and a reduced risk of bleeding. In contrast to the continuous mode, in which a deep zone of carbonization occurs with the destruction of the walls of blood vessels and the absence of reliable hemostasis. The authors noted that the best treatment results and low relapse rates were observed in the initial stages of hemorrhoids. For severe prolapse of internal hemorrhoids, the technique was combined with mucopexy, which increased the effectiveness of laser disarterization (HeLPexx) [18, 19].

The use of laser technology is not limited to the treatment of haemorrhoids: laser is also actively used in the treatment of chronic anal fissure. In 1990–2000, the CO_2 laser with a wavelength of 10,600 nm was used for excision of anal fissure.

In 2015 M.N. Esfahani et al. performed a pilot study in which a CO_2 laser with a wavelength of 10,600 nm and a power of 30 W was used to treat chronic anal fissure with sphincter spasm in 25 patients. After performing a lateral subcutaneous sphincterotomy, the area of the anoderm defect was exposed to a laser with an energy of 350–400 J to stimulate angiogenesis and wound healing. During the year of observation, the authors did not note the development of anal sphincter insufficiency or relapse of the disease [20].

In a randomized study conducted in 2018– 2020. at the Vitebsk Regional Clinical Specialized Center, 259 patients with chronic anal fissure were included. Patients of the main group (n = 149) underwent laser vaporization of the anal fissure with posterior dosed sphincterotomy. The intervention was performed using a diode laser with a power of 10 W and a wavelength of 1560 nm. In the control group, the results of treatment of patients with anal fissure excision (n = 110) were analyzed. In the postoperative period, there was no need to prescribe narcotic analgesics in the main group, unlike the control group. The average hospital stay in the main group was 4.1 ± 2 bed-days, in the control group — 9.3 ± 1.9 bed-days ($p < 0.05$). Assessment of the quality of life using the SF-36 questionnaire on day 1 and the first month after surgery showed that the main group had statistically significantly higher indicators of the physical and mental components of health ($p < 0.05$) [21].

In 2021, I. Giani et al. studied the efficacy of 10,600 nm CO_2 laser in the treatment of 29 patients with chronic anal fissure. All patients underwent precision vaporisation of the anoderm scar defect followed by wound treatment with a CO_2 laser (SmartXide2 C80 laser system, DEKA, Italy). The data on the presence of internal sphincter spasm and its elimination were not specified. After 1 month of follow-up, 85 % of patients had a decrease of pain syndrome intensity according to VAS scale up to 3 points. During the first week after the operation, 11 (37,9 %) patients out of 29 needed to take analgesics for 4 days. By the end of the first month, 5 (17.2 %) patients out of 29 were taking analgesics for a total of 8 days [22].

Treatment of rectal fistulas is the next effective point of laser use in coloproctology, along with hemorrhoidal disease and anal fissure. A. Wilhelm et al. (2011) described the first results of using laser thermoobliteration of rectal fistulas (fistula laser closure, FiLaC). The intervention was performed under epidural anesthesia in the lithotomy position. The fistula tract was treated with a curette and washed with saline. Next, a laser instrument was introduced through the external opening of the fistula along its entire length and the fistula tract was treated with laser energy with a power of 13 W, by uniform circular ablation of the fistula tract with a radial laser fiber at a

speed of 1 cm/3 s, using a wavelength of 1470 nm, after which the internal fistula opening was sutured or the rectal flap was retracted. The authors presented the results of treatment of 11 patients with cryptogenic rectal fistulas (transsphincteric, extrasphincteric fistulas). Patients with fistulas due to inflammatory bowel diseases were not included in the study. All patients had a history of previous repeated interventions for paraproctitis or fistula. The average follow-up period for operated patients was 7.4 months. Healing of the fistula was recorded in 9 (81.8%) of 11 patients [23]. Later in 2017, A. Wilhelm et al. presented the results of 5-year observation of 104 patients with transsphincteric and extrasphincteric rectal fistulas, the treatment was carried out using a diode laser with a wavelength of 1470 nm. The average follow-up period was 5 months. Healing of the fistula tract was noted in 66 (63.5 %) patients, 38 (35.5 %) patients required re-intervention [24].

P. Giamundo et al. (2015) described the results of treatment of rectal fistulas in 45 patients using the FiLaC method with a diode laser with a wavelength of 1470 nm and a power of 12 W; the speed of advancement of the laser instrument along the fistula tract was 1 mm/s. Closure of the internal fistula opening was not performed. The average follow-up period was 30 months. The healing time of the fistula, depending on the presence or absence of preliminary drainage with a ligature, did not differ ($p = 0.32$). The average healing time for the fistula was 5 weeks. The best treatment results were obtained in the presence of a fistula tract longer than 4 cm [25].

At the National Medical Research Center of Coloproctology named after A.N. Ryzhikh our colleagues performed a comparative analysis of the results of laser thermoobliteration ($n = 29$) and monopolar coagulation ($n = 23$) of the fistula tract in patients with trans- and extrasphincteric rectal fistulas. The wavelength of the diode laser was 1470 nm, a radial light guide was used in continuous mode with a power of 12 W. Internal fistula openings up to 0.3 cm in size were sutured; for larger sizes, a rectal mucomuscular flap was removed. The healing rate in the group with laser exposure was statistically significantly higher — 19 (65.5 %) patients (10 — transsphincteric fistulas, 9 — extrasphincteric fistulas) compared to 7 (30.4 %) patients in the monopolar coagulation group (5 — transsphincteric fistulas, 2 — extrasphincteric fistulas), ($p = 0.012$). In the laser thermoobliteration group, a complication in the form of acute paraproctitis was noted in the postoperative period in only 2 patients, and therefore the purulent cavity was opened. Subsequently, due to non-healing of the fistula tract in both cases, one of the patients underwent excision of the fistula with suturing of the sphincter; in the second patient, the fistula was eliminated using the ligature method. There were no complications observed in the monopolar coagulation group [26].

Sinus laser coagulation (SiLaC) is one of the most popular minimally invasive methods for treating chronic inflammation of the epithelial coccygeal tract (ECC). The use of this technology in a retrospective study was first described by M. Dessily et al. (2017). In their work, the authors described the use of a diode laser with a wavelength of 1470 nm and a power of 10 W in the treatment of 40 patients operated on in the period 2014–2015. The intervention technique consisted of coagulation of the walls of the fistula tract with a diode laser with preliminary curettage, removal of hair and inflammatory detritus. In treatment of ECC, the healing rate was 87.5 % ($n = 35$), relapse was noted in 1 (2.9 %) patient. Later, in 2019, the authors described the results of treatment for 200 patients, where the healing rate was 94 % of cases [27, 28].

In their randomized study M. Abdelnaby et al. (2021) compared the results of treatment of 139 patients with the SiLaC method and with ECC excision without suturing the wound. The intervention technique of the main group coincided with the technique first proposed by M. Dessily et al., while the power of the diode laser with a wavelength of 1470 nm was 13 W. The follow-up period was 1 year after surgery. Wound healing in 62 patients of the main group occurred significantly faster than in 77 patients in the control group — 10.1 ± 2.7 days vs. 34.1 ± 15.1 days ($p < 0.0001$) [29].

The retrospective study by C. Arslan et al. (2023) presents the analysis of the results of treatment of 121 patients randomized into two groups: in group 1 ($n = 80$), patients underwent the pit-picking technique, in group 2 ($n = 41$) a combination of pit-picking with laser processing of ECC was used. In the main group, a laser with a wavelength of 1470 nm and a power of 10 W was used in continuous mode: during the gradual removal of the laser instrument, energy was supplied, the total amount of which was 100 J/cm. In group 1 ("pit-picking" group), the rate of complications in the postoperative period was 11.6 %: seroma — 12.5 %, bleeding — 7.5 %, secondary wound infection — 2.5 % of patients. In group 2 ("pit-picking + laser"), no postoperative complications were noted. The severity of postoperative pain according to VAS on day 7 in the main group was 1.3 ± 0.9 points, in the control group — 0.9 ± 0.7 points ($p = 0.040$). The period of disability in the "pit-picking + laser" group was shorter than in group 1 — 3.2 ± 2.2 days

vs. 6.7 ± 2.3 days ($p < 0.0001$). Also, the rate of complete wound healing in group 2 was statistically significantly higher: 10.1 ± 2.3 days vs. 14.1 ± 3.8 days ($p < 0.001$). The follow-up period for patients was 43–65 months, 13 (10.7 %) patients had a relapse, of which 4 (9.8 %) were in the "pit-picking + laser" group with an average time to symptom return of 10.8 ± 4.3 months. The authors claim that the use of laser in the treatment of ECC is safe and significantly speeds up the postoperative rehabilitation of patients [30].

Conclusion

Analysis of publications by various authors, including our own data, allows us to say that the use of laser technologies in the treatment of hemorrhoids, rectal fistulas, anal fissures, and epithelial coccygeal tract allows to reduce the severity of pain after surgery, significantly reduce the healing time of postoperative wounds, and shorten the period of disability without reducing the quality of life of patients. Minimally invasive interventions are not accompanied by the formation of extensive wounds, but are associated with a low intensity of pain, a minimal number of complications, a short period of postoperative rehabilitation and a reduced risk of disease relapse. In terms of effectiveness, these interventions are practically not inferior to traditional methods, and are mainly performed under local anesthesia, which allows them to be carried out in a day hospital.

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