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EDITORIAL



Editor-in-Chief
Prof. Fatma Ayca Gultekin, M.D. Zonguldak-Turkey

Promoting Collaboration, Quality, and Recognition in Scientific Publishing

Dear Colleagues,

The "III. International Colorectal Surgery Congress and XX. National Colon and Rectal Surgery Congress," held in Antalya from May 16 to 20, 2025, was an outstanding scientific gathering that brought together more than 1,400 participants. The event offered an extensive and dynamic program, featuring cutting-edge discussions led by leading experts in the field of colorectal surgery. The strong attendance and engagement reaffirm the commitment of our professional community to continuous learning and academic excellence.

I would like to express my sincere gratitude, on behalf of the Turkish Journal of Colorectal Disease (TJCD), to Congress President Prof. Dr. Emre Balık, Congress Secretary Prof. Dr. Cihangir Akyol, the organizing committee, President of the Turkish Society of Colon and Rectal Surgery Prof. Dr. Feza Yarbuğ Karakayalı, and the Society's Executive Board for their outstanding contributions.

This year, TJCD had the opportunity to expand its academic and educational mission at the congress. Building on the success of the previous "Editors Meet Reviewers" session, we launched an upgraded format in 2025 to include not only reviewers but also prospective authors. The "Mastering Scientific Writing and Peer Review" pre-congress course (Figure 1), held on May 16, was co-moderated by Dr. Alaa El-Hussuna and myself, with the active participation of 27 attendees. The pre-congress course covered essential topics such as manuscript structure, scientific integrity, adherence to reporting guidelines, the principles of constructive peer review, and methodological evaluation of different study designs. The interactive analysis of sample manuscripts enriched the educational content and enhanced its practical value.

I would like to extend my appreciation to our Editorial Board Members who contributed to the course and to our distinguished international speakers, Dr. Peter Christensen and Dr. Alaa El-Hussuna, for elevating the scientific content and global scope of the event.

Another highlight of the congress was the presentation of the TJCD Best Article Awards. These awards recognize outstanding original articles published in TJCD between January 2023 and December 2024. This initiative aims to encourage academic productivity and highlight high-quality research:

First Prize

Özben V, Okkabaz N, Group TCCDS. Partial Versus Total Mesorectal Excision for the Surgical Treatment of Mid-Rectal Cancer: An Assessment from the Turkish Society of Colon and Rectal Surgery's Colorectal Cancer Database. Turk J Colorectal Dis. 2024 Jun;34(2):41-49. doi:10.4274/tjcd.galenos.2024.2024-2-1.

Second Prize

Bişgin T, Canda AE, Manoğlu B, Ellidokuz H, Sökmen S. The Long-Term Effectiveness of Sacral Neuromodulation in Treating Low Anterior Resection Syndrome: A Single Center Experience. Turk J Colorectal Dis. 2023 Sep;33(3):72-79. doi:10.4274/tjcd.galenos.2023.2023-6-3.

Third Prize

Özata İH, Arslan Ç, Karahan SN, Tatar C, Aydın I, Kozan R, Yıldırım AC, Kulle CB, Kıvılcım T, Cakcak İE, Zenger S, Sevim Y, Zeren S, Kamer E. General Surgeons' Approach to Pilonidal Abscess in Turkey: Results of a Nationwide Survey. Turk J Colorectal Dis. 2024 Jun;34(2):54-61. doi:10.4274/tjcd.galenos.2024.2024-5-2.

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In parallel with this initiative, we also introduced a new award to recognize excellence in peer review—one of the cornerstones of scientific publishing. For the first time this year, and with the goal of establishing it as an annual tradition, we presented the TJCD Best Reviewers Award to three outstanding reviewers who provided the highest-quality and most consistent contributions to our journal over the past two years. I extend my deepest thanks to

Dr. Timuçin Erol,

Dr. Tayfun Bişgin,

and Dr. Özgen Işık

for their dedication, professionalism, and valuable support of TJCD's editorial process.



Figure 1. III. International Colorectal Surgery Congress and XX. National Colon and Rectal Surgery Congress; Pre-congress Course: Mastering Scientific Writing and Peer Review

On behalf of the editorial team, I would like to thank all authors, reviewers, and readers who contribute to the scientific excellence of TJCD. We remain committed to supporting academic development, promoting evidence-based research, and advancing the global visibility and quality of colorectal science.

Warm regards,

Dr. Fatma Ayca Gultekin

Editor-in-Chief

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In Memoriam: Dr. Neil Smart

On behalf of the Editorial Board of the Turkish Journal of Colorectal Disease (TJCD)

Dr. Fatma Ayca Gultekin – Editor-in-Chief

It is with great sorrow that we learned of the passing of Dr. Neil Smart, Editor-in-Chief of Colorectal Disease, a distinguished colorectal surgeon, and a highly respected academic who contributed significantly to the advancement of our field worldwide.

Dr. Smart was not only a leading figure in scientific publishing but also a generous mentor and a collaborative spirit who inspired countless colleagues through his editorial leadership and professional integrity. His participation in the Editors Meet Reviewers session at the II. International Colorectal Surgery Congress and XIX. National Colon and Rectal Surgery Congress, organized by TJCD, remains a vivid and meaningful memory. In that session, he shared his invaluable editorial experience and thoughtful reflections on the global peer-review ecosystem.

Beyond his editorial legacy, Dr. Smart's influence extended deeply into the academic and clinical life of the colorectal surgery community. His wisdom, clarity of thought, and commitment to scientific excellence helped shape the standards we uphold today in research and publication.

On behalf of the entire Editorial Board of the Turkish Journal of Colorectal Disease and the Turkish Society of Colon and Rectal Surgery we extend our heartfelt condolences to Dr. Smart's family, colleagues, and the international colorectal surgery community. We mourn the loss of a true leader, educator, and advocate for science. His contributions will be remembered with great respect and gratitude.

May he rest in peace.

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Turk J Colorectal Dis 2025;35(2):33-40

INVITED REVIEW

TAMIS: New Horizons in Modern Colorectal Surgery

Nurhilal Kızıltoprak[1], Jack Aaron[2], Camila Diez[3], Sam Atallah[4]

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ABSTRACT

Transanal minimally invasive surgery (TAMIS) has emerged as a major advancement in the management of rectal neoplasms. Building upon the principles of transanal endoscopic microsurgery (TEM), TAMIS provides a cost-effective and more accessible alternative that integrates standard laparoscopic instruments. To present a comprehensive review of the development, indications, technique, and clinical outcomes associated with TAMIS and to evaluate its current role and future potential in modern colorectal surgery. This narrative review was conducted through a comprehensive analysis of the literature on TAMIS, TEM, and transanal endoscopic surgery, focusing on the evolution of the technique, patient selection, operative strategy, oncological safety, and recent technological advancements such as robotic platforms. TAMIS is effective in the excision of benign rectal neoplasms and carefully selected early-stage rectal cancers, offering high R0 resection rates and low recurrence. It is less invasive than conventional surgery, preserves rectal function, and is associated with reduced morbidity. Although it requires a moderate learning curve, its technical feasibility and low setup cost have contributed to its widespread adoption. Comparative studies support its oncological adequacy, particularly in selected T1 cancers and ypT0 tumors following neoadjuvant therapy. TAMIS represents a transformative innovation in colorectal surgery. As technology and surgical expertise continue to evolve, TAMIS is expected to become integrated into standard oncological practice, expanding its indications and improving functional outcomes. Continued research and long-term follow-up are necessary to further define its role in the treatment of rectal cancer.

Keywords: Transanal minimally invasive surgery, transanal endoscopic microsurgery, rectal cancer, transanal surgery, local excision, minimally invasive surgery, colorectal surgery

Introduction

The first record of transanal excision of rectal tumors was reported by Dr. Jacques Lisfranc in the early 1800s.[1] In this report, a prolapsed and painful large rectal tumor was removed by amputating the tumor, including the anus. Anesthesia was not mentioned, and closure of the defect was not considered, rendering the patient with a perineal colostomy. Hemostasis was achieved with intrarectal packing at the end of the procedure.

In the 1960s, Sir Alan Parks popularized the modern transanal excision method. In this technique, steps such as anesthesia, use of metal ratcheting rectal retractors, epinephrine injection, creation of a submucosal resection plane, and primary closure of the defect with permanent sutures were defined.[2]

In the early 1980s, Professor Gerhard Buess developed a new technique and corresponding instrumentation for the removal of rectal tumors to address the limited field of view and access difficulties of conventional transanal excision. This innovation marked the beginning of transanal endoscopic surgery (TES).[3] The method and devices developed by Buess were named transanal endoscopic microsurgery (TEM) and include a cylindrical, reusable surgical rectoscope measuring 4 × 12 (or 20) cm, which is fixed to the operating table. TEM relies on insufflation of the rectum to expand and expose the surgical

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field and is similar in principle to single-port laparoscopic access channels (which did not evolve until decades later).

The impetus behind TEM at the time of its inception was to provide higher reach so that benign (only) rectal polyps and lesions could be removed transanally. Interestingly, Buess did not see it as a tool to remove cancers and did not know at the time that data would later reveal that TEM provided a better quality of local excision.

Compared with conventional transanal excision (Parks' transanal excision), TEM has been associated with better quality resection, a lower local recurrence rate, and better survival, especially in cases of histologically appropriate stage I (T1) rectal cancer.[4-8] In long-term follow-up studies, TEM excision of rectal tumors has been shown to have similar morbidity and mortality rates to conventional transanal excision.[9-13] Despite proven superior excision quality, TEM never became widely adopted. The main reasons for this are the difficulty of the learning process and the high cost of its specialized instruments.[14]

To overcome these limitations, in 2010, Atallah et al.[15] proposed the use of standard laparoscopic instruments and a single-port laparoscopic platform (recently introduced at the time) to perform transanal surgery. This technique was named transanal minimally invasive surgery (TAMIS). Subsequently, others validated the technique by reporting successful results with TAMIS.[16] Following these developments, many researchers have incorporated TAMIS into clinical practice and started to publish their data. Furthermore, TAMIS is likely a more economical alternative to TEM and is definitely more widespread in its use globally.[17-24] TEM and TAMIS show considerable differences in terms of cost, learning process, and technical applicability. The fact that TAMIS does not require costly specialized instrumentation, as in TEM, has enabled it to be performed by most colorectal specialists and minimally ınvasive surgery-trained surgeons. Due to the similarity in clinical outcomes, TEM, transanal endoscopic operation (TEO), and TAMIS are nowadays classified under the name TES, which is a general term covering all surgical methods that perform transanal excision using a minimally invasive approach.

TAMIS is a modification of TEM. Whereas TEM uses a reusable 4 cm diameter rigid surgical proctoscope, TAMIS replaces it with flexible and disposable single-port laparoscopic platforms. Vessel-sealing devices, laparoscopic aspiration, and standard laparoscopic imaging systems are also used. The evolution of TAMIS, including its historical milestones and future projections, is illustrated in Figure 1.

Indications and Contraindications

The indications for TAMIS are similar to those for TEM (and for all TES).[25] This method is especially preferred for the excision of benign rectal neoplasms and curative surgeries. It is also a suitable option for carefully selected T1-stage rectal cancer cases with a low risk of nodal metastasis and histologically favorable features.[26]

TAMIS can be used not only in early-stage cancers but, under special circumstances, also in locally advanced rectal cancers

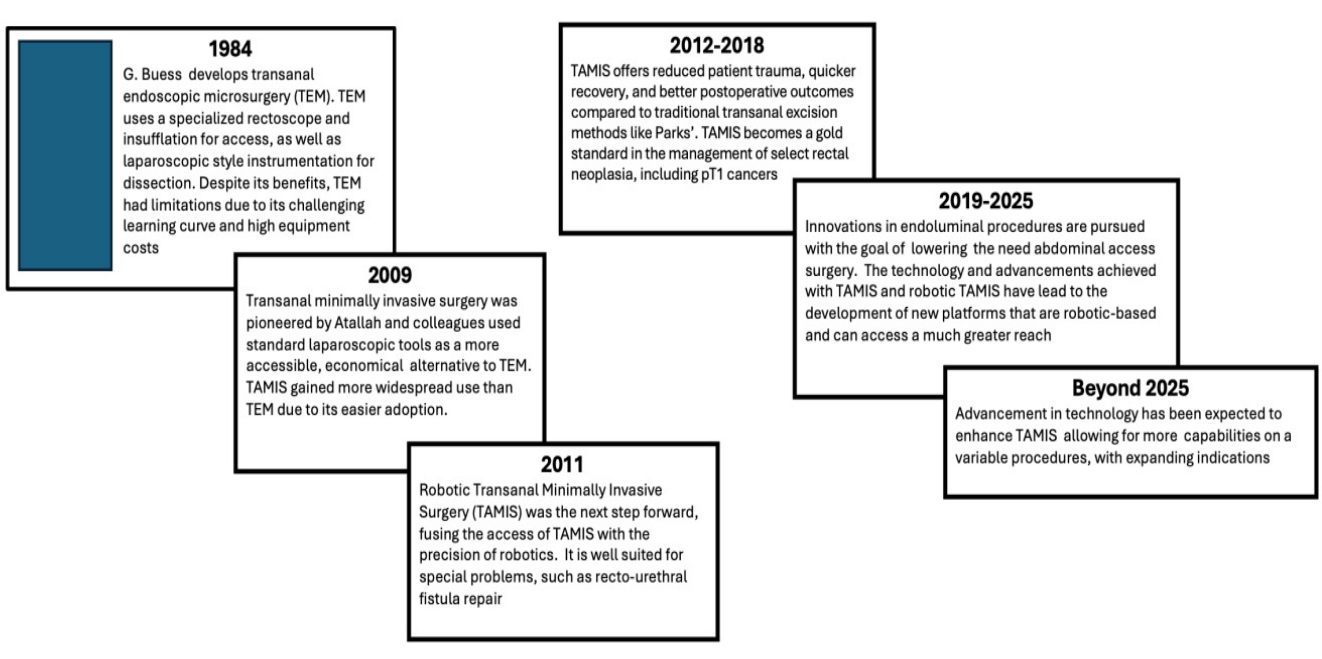


Figure 1. Timeline illustrating the evolution of transanal minimally invasive surgery and related technological advancements from its inception in 1984 to beyond 2025

after neoadjuvant treatment. To confirm the mural complete pathological response (ypT0), the indication for local excision of cT0 lesions after neoadjuvant treatment can be expanded.[27-29] In this context, TAMIS stands out as an effective method for the excision of benign lesions and early-stage rectal cancers, especially in the lower and middle regions of the rectum. Since the risk of occult nodal positivity in ypT0 lesions is reported to be as low as 3%-6%, this method is considered a valid option in appropriate cases.[30-32]

Since 1989, with the adoption of advanced transanal techniques in the United States, the local excision rate has approximately doubled for T1 rectal cancers and tripled for T2 lesions.[33] Studies have shown that local excision using advanced transanal platforms (TEM) in early-stage (T1) rectal cancer cases provides high survival rates and low recurrence rates in appropriately selected patients. In fact, these results have been shown to be comparable to radical resection.[34-36] Lezoche et al.[37] described similarly successful outcomes in T2 cancers treated with neoadjuvant chemoradiotherapy in addition to TEM-assisted volumetric or "pyramidal" excision.[38,39] It has also been reported that recurrence-free survival rates are higher in excisions performed with TEM than in standard Parks local excision. The main reason for this difference is thought to be the superior resection quality achieved with TEM/TAMIS-specifically, lower fragmentation rates and higher R0 excision rates.[40]

Polyps that are not amenable to endoscopic excision, carefully selected T1 cancers, low-risk rectal cancers, and patients requiring organ-sparing surgery are among the most preferred indications for TAMIS. However, T2-T3 rectal cancers with deep rectal wall invasion or a high risk of lymph node metastasis, large tumors that cannot be completely removed with TAMIS, and unsuitability for anesthesia due to severe systemic disease are among the conditions where this method cannot be applied with curative intent. Patients with advanced or bulky rectal tumors or evidence of distant metastatic disease are generally not considered suitable candidates for TAMIS due to the extent of the disease. Furthermore, patients with serious comorbidities or in poor general health may not be suitable for TAMIS, as the procedure still carries inherent surgical risks and requires general anesthesia. The feasibility of TAMIS is highly dependent on the expertise and experience of the surgical team. Therefore, careful patient selection is critical to achieving optimal results.

Surgical Technique

The success of TAMIS relies on a single-use access port as well as basic laparoscopic equipment. This system typically includes transanal access platforms that provide a stable working space while preserving the pneumorectum. For example, devices such as the GelPOINT® Path Transanal Access Platform allow effective surgical field control through a reliable seal.[41] Long, thin, and articulating instruments-such as standard laparoscopic insufflators, camera systems, laparoscopic graspers, scissors, and vessel-sealing devices-facilitate precise dissection and surgical maneuvers in the narrow rectal space.

In addition, advanced technologies such as endoscopic ultrasound and intraoperative fluorescence imaging allow better visualization of the surgical field and improved guidance of the surgical approach. In this way, even the excision of more complex lesions can be successfully performed with a minimally invasive approach.

The TAMIS procedure is usually performed in the lithotomy position, although in some cases, the lateral decubitus position may be preferred. Before starting the surgical procedure, the transanal access platform is carefully positioned, and a stable pneumorectum is created by carbon dioxide insufflation to allow better manipulation of the surgical field.

The TAMIS platform allows high-quality local excision using standard laparoscopic instruments. The technique has also been successfully applied in robotic surgery (Atallah et al.[15]).

The TAMIS procedure is performed using a systematic approach involving specific surgical steps. First, under general anesthesia, the patient is typically positioned in the lithotomy position, although the lateral decubitus position may be preferred in selected cases. Once positioned, access to the operative field is achieved by placing disposable transanal ports specific to the surgical procedure (e.g., GelPOINT Path or SILS Port). For enhanced visibility and maneuverability, carbon dioxide is insufflated to create a pneumorectum, thereby expanding the rectal lumen and stabilizing the surgical field. After achieving adequate exposure, lesion demarcation is performed using electrocautery or a marking instrument to

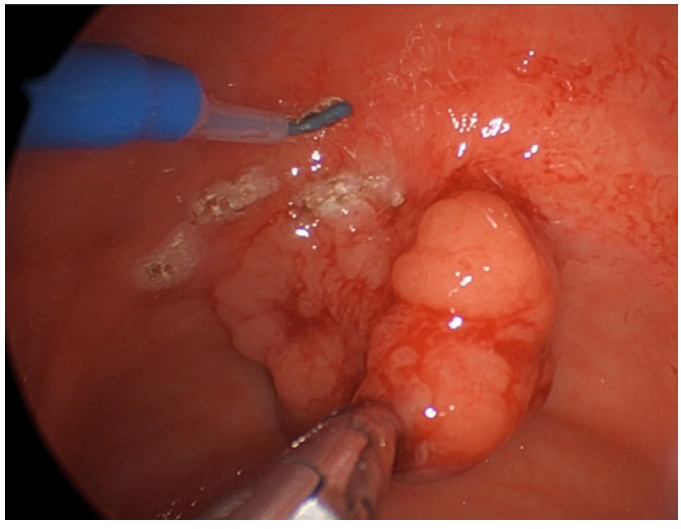


Figure 2. Lesion demarcation: Marking and delineation of the lesion in the transanal minimally invasive surgery procedure

define clear resection margins (Figure 2). During the excision stage, full-thickness or submucosal excision of the lesion is performed using electrocautery or a vessel sealer (Figure 3). Finally, the defect is closed with primary sutures or, in some cases, may be left open (Figure 4).

The TAMIS platform allows the surgeon to work more comfortably on the non-dependent (downward) wall of the rectum. This enables more cases to be performed in the lithotomy position, whereas TEM typically requires the patient to be positioned so that the lesion is in a downward position. The dissection stage is largely similar to the TEM technique. After completing the TAMIS procedure, the final appearance of the rectal mucosa demonstrates a well-healed and tension-free closure, with no signs of bleeding or residual tumor tissue (Figure 5).

During the procedure, different defect closure techniques may be employed. Among these, which vary between authors, closure can be performed using various laparoscopic suturing devices and barbed (self-locking) sutures, which obviate the need for intraluminal knot tying.

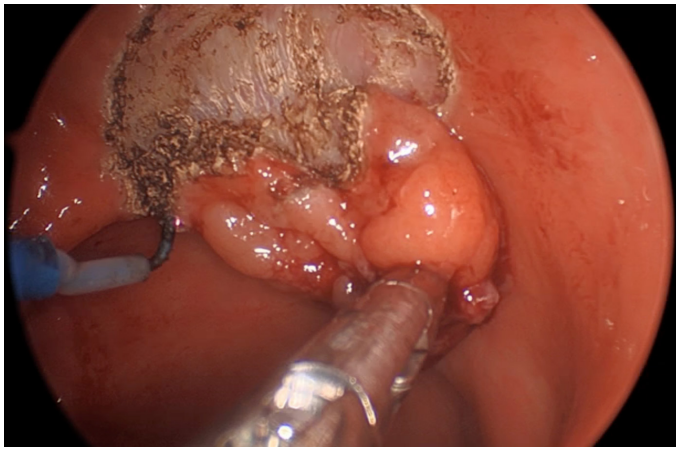


Figure 3. Dissection of the lesion using laparoscopic instruments in the transanal minimally invasive surgery technique

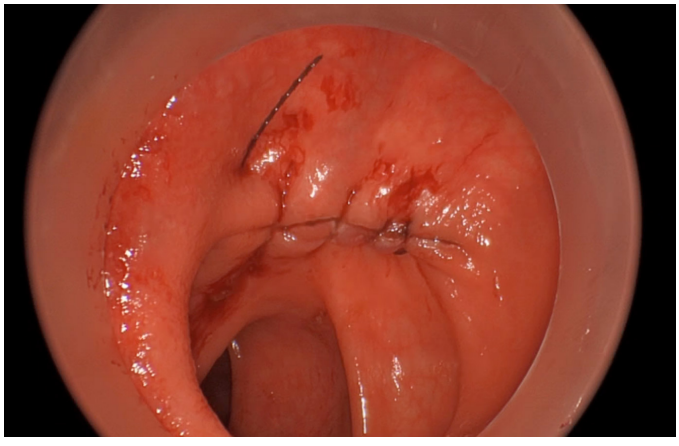


Figure 5. End result: The final surgical outcome after completion of the transanal minimally invasive surgery procedure

Rectal polyps located in the upper region of the sphincter complex may be partially concealed by the transanal device. In such cases, a hybrid TAMIS-transanal endoscopic (TAE) approach is required. In this method, the distal part of the lesion is first dissected under direct vision; then, the TAMIS device is placed, and the proximal part of the lesion is excised, with the closure of the defect completed using the traditional TAE technique. This allows the surgeon to benefit from both the minimally invasive advantages of TAMIS and the additional access provided by TAE. Invasive techniques such as the transcoccygeal (Kraske) and transsphincteric (York-Mason) approaches have been replaced by transanal techniques for local excision of rectal neoplasms and are now of historical interest only.

There are two main TAMIS platforms approved by the U.S. Food and Drug Administration (FDA): the SILS Port and the GelPOINT Path.

The SILS Port (Covidien/Medtronic) was developed for single-port laparoscopic surgery and has been adapted for transanal use. This system is compatible with standard laparoscopic instruments, thanks to its 3-4 trocar ports, and offers flexible use. TAMIS was originally described using this port.

The GelPOINT Path (Applied Medical), another FDA approved platform, is designed specifically for TAMIS procedures. Thanks to its flexible structure and wide gel-based entry points, it better adapts to rectal anatomy. It offers improved maneuverability by facilitating surgical access. In addition, the integrated smoke evacuation system enhances visibility within the surgical field, making the operation process safer and more effective.

The safety, feasibility, and oncological effectiveness of TAMIS have been supported by several multicenter studies in recent years.[42-46] Investigations by Lee et al.,[42] Albert et al.,[43]

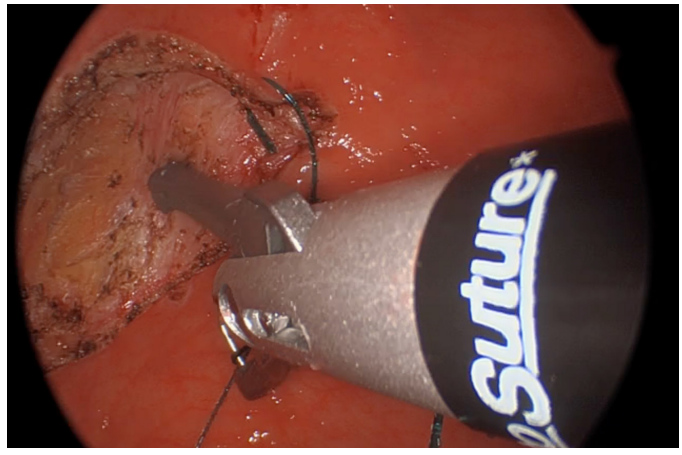


Figure 4. Closure: Primary suturing of the defect after resection

Castaño Llano et al.,[44] Kang et al.,[45] and Duggan et al.[46] have demonstrated that TAMIS is a reliable option for the treatment of benign rectal neoplasms and early-stage rectal cancers, with low complication rates, minimal local recurrence, and high R0 resection rates. These studies have reported positive margin rates ranging from 3.3% to 7% and local recurrence rates between 0% and 6%. These findings further support the role of TAMIS as an oncologically sound alternative to radical resection in appropriately selected patients.

A comparative overview of key TAMIS series is presented in Table 1, summarizing clinical data from five major studies. Patient cohorts ranged from 27 to 200 individuals, with average ages between 55 and 68 years. Average tumor sizes varied across studies (1.6-5.3 cm), and the distance from the anal verge ranged from 6 to 8.1 cm. Operative times differed substantially, reflecting variations in case complexity and surgical experience, with durations ranging from 52 to 115 minutes. Follow-up periods spanned from 14.4 to 53 months. Postoperative complication rates ranged from 6% to 22%, whereas local recurrence rates remained low (0%-6%). Positive margin rates were reported to be between 3.3% and 7%, and overall postoperative morbidity remained below 11% in most studies. These findings highlight the consistency of TAMIS in achieving favorable oncologic and perioperative outcomes, reinforcing its role as a safe and effective modality for both benign and selected malignant rectal neoplasms.

Advantages and Disadvantages of Transanal Minimally Invasive Surgery

Advantages

Minimally invasive technique: Compared with traditional transanal excision, TAMIS results in less postoperative pain, shorter hospital stays, and improved patient comfort.

Organ preservation: Enables rectal-sparing treatment in selected early-stage cancers and benign neoplasms, reducing the need for radical surgery and lowering the risk of low anterior resection syndrome.

Low morbidity: Associated with lower complication rates and better functional outcomes due to its less invasive nature.

Improved visualization and precision: Provides a wide field of view using laparoscopic optics and enables precise dissection with standard laparoscopic or robotic tools.

Lower cost and wider accessibility: Unlike TEM, TAMIS does not require expensive custom instruments, making it more feasible for general use.

Reduced inflammatory response and preserved immune function: The minimally invasive approach supports better postoperative recovery and systemic outcomes.

Robotic adaptation: Robotic-assisted TAMIS increases precision and dexterity, especially in challenging pelvic anatomy.

Feasibility in hybrid approaches: Can be combined with TAE for low-lying or partially concealed lesions.

Table 1. Summary of key clinical studies evaluating transanal minimally invasive surgery for rectal neoplasms

Study	Lee et al.[42]	Albert et al.[43]	Castaño Llano et al.[44]	Kang et al. [45]	Duggan et al.[46]
Year published	2009	2013	2019	2019	2023
Patient size, n	200	50	27	30	168
Gender (men/women)	112/88	37/17	17/10	19/11	101/67
Average age (years)	65	64	68	55	68
Average tumor size (cm)	2.9	2.8	5.3	1.6	4.8
Distance from anal verge (cm)	7.2	8.1	7.0	7.0	6.0
Operation time (min)	69.5	74.9	115	52	N/A
Follow-up (months)	14.4	20	32	53	17
Complication rate (%)	16	6	22	13.33	8.3
Local recurrence (%)	6	4	0	3.8	1.6
Positive margin (%)	7	6	4	3.3	4
Postoperative morbidity (%)	11	8	0	0	11
Cases	Adenoma, adenocarcinoma	Benign and malignant lesions, NETs	Low-/high-grade adenomas, NETs, fibrosis	NET, adenoma, rectal cancer, stenosis	Adenoma, ypT0-T2, carcinoid, maltoma

NET: Neuroendocrine tumor, N/A: Not available, R0: Complete (margin-negative) resection

Cost-effectiveness and accessibility: Compared with TEM, TAMIS eliminates the need for specialized and costly equipment, instead relying on standard laparoscopic tools. This makes it more affordable and scalable, particularly in lower-resource settings.

Effective training strategies: Simulation-based learning, cadaveric workshops, and mentorship models have been shown to substantially reduce the learning curve, ensuring safer and faster adoption of TAMIS among colorectal and minimally invasive surgeons.

Disadvantages

Learning curve: Although TAMIS is less technically complex than TEM, it still requires experience in laparoscopic techniques and familiarity with transanal platforms. The initial phase of skill acquisition may be challenging without dedicated training.

Equipment requirements: Requires dedicated transanal platforms (e.g., SILS, GelPOINT) and reliable insufflation and imaging systems.

Closure difficulties: Intrarectal suturing, particularly for large or awkwardly located defects, can be technically challenging.

Patient selection limitations: Not suitable for bulky tumors, advanced-stage cancers, or patients with severe comorbidities or contraindications to general anesthesia.

Limited access for some tumor locations: Lesions obscured by rectal folds or located too proximally may require conversion or hybrid techniques.

Comparison with Other Techniques

Compared with TEM and TEO, TAMIS offers a shorter setup time, broader accessibility due to lower costs, and greater instrument flexibility by utilizing conventional laparoscopic tools. Although all three techniques achieve comparable oncologic outcomes in well-selected patients, TAMIS stands out due to its ease of adoption and availability. By contrast, endoscopic submucosal dissection (ESD), although minimally invasive, is limited by technical complexity, longer procedure times, and difficulty in achieving full-thickness excision-particularly in lesions with submucosal fibrosis or deeper invasion. TAMIS presents a more controlled and reproducible option in such cases, especially when oncologic safety and full-thickness resection are critical.

Conclusion

TAMIS has achieved a high global adoption rate. Several studies have demonstrated that TAMIS is safe and effective in early-stage rectal cancers and large benign polyps. Careful patient selection, meticulous surgical planning, and continuous refinement of techniques and instrumentation are paramount to optimizing TAMIS outcomes and ensuring its safe and effective application.

In the future, TAMIS is expected to become applicable to a broader group of patients. As surgeons gain more experience with this emerging technique, its role beyond local excision will likely expand. The role of TAMIS in the treatment of colorectal diseases continues to evolve, with ongoing studies investigating its potential applications and long-term efficacy. With the growing body of available evidence, the clinical utility of TAMIS is expected to become even more widely adopted. Consequently, the integration of TAMIS into standard treatment algorithms is likely to accelerate. Advances in surgical technologies and the integration of robotic platforms may further enhance and optimize the TAMIS procedure. These developments could ultimately improve patient outcomes and expand the scope and reach of its clinical application.

In summary, TAMIS offers distinct advantages over traditional transanal excision (Parks) while also providing a more accessible and versatile alternative to other endoscopic techniques such as TEM, TEO, and ESD. These comparative insights reinforce TAMIS's emerging role as a key tool in minimally invasive rectal surgery.

Ethics

Informed Consent: Written informed consent was obtained from the patients for the use of clinical images and anonymized data in this publication.

Footnotes

Authorship Contributions

Surgical and Medical Practices: J.A., C.D., S.A., Concept: N.K., C.D., S.A., Design: N.K., J.A., S.A., Data Collection or Processing: N.K., Analysis or Interpretation: N.K., S.A., Literature Search: N.K., Writing: N.K., S.A.

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RESEARCH ARTICLE

Goodsall's Rule Revisited: An MRI-Based Assessment of its Accuracy in Perianal Fistulas

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ABSTRACT

Aim: The aim of this study is to evaluate the accuracy of Goodsall's rule in predicting the internal orifice of perianal fistulas based on magnetic resonance imaging (MRI) findings and to assess its relevance in contemporary imaging and surgical planning.

Method: In the retrospective analysis of 1,473 consecutive MRI scans performed for perianal fistulas, a total of 305 patients (men/women: 214/91) with a single fistula were included in the study. Fistulas were classified as anterior or posterior based on the external orifice position relative to the transverse anal line.

Results: Posteriorly located fistulas were more common (61.3% vs. 38.7%). The accuracy of Goodsall's rule was higher in anterior fistulas (64.4%) than in posterior fistulas (39.6%; p<0.001). There was no statistically significant difference in adherence to the rule between genders (p=0.416), different types of fistulas according to the Parks classification (p=0.588), or presence of abscess (p=0.464). Comorbidities significantly affected the accuracy of the rule (p=0.017). In the Bonferroni-adjusted analysis, no significant difference in adherence was found between the cryptoglandular and Crohn's disease groups (p>0.05). Among the 11 patients with malignancy, only 1 (9.1%) adhered to the rule, indicating reduced accuracy.

Conclusion: Goodsall's rule is more accurate for anterior fistulas; however, it does not apply to all perianal fistula cases, with greater exceptions observed in posterior fistulas. MRI should be considered for all perianal fistulas when possible to improve diagnosis and outcomes.

Keywords: Perianal fistula, magnetic resonance imaging, Goodsall's rule

INTRODUCTION

Perianal fistulas are pathological tracts connecting the anal canal to the perianal skin.[1] Their incidence varies across different populations. They most commonly affect individuals between the ages of 30 and 50 and are more frequently observed in men than in women.[2] These fistulas pose substantial challenges in both diagnosis and management. Magnetic resonance imaging (MRI) has emerged as the gold standard for preoperative assessment due to its superior ability to delineate fistulous tracts and associated abscesses, and surgery remains the primary modality for treatment.[3,4] Surgical success depends on factors such as the type and complexity of the fistula as well as the accurate identification of the internal orifice. Precise localization of the internal orifice is critical to achieving high healing rates and preventing recurrence.[5]

In 1900, the surgeon Goodsall introduced a rule to predict the internal orifice of perianal fistulas based on the location of the external orifice. According to Goodsall's rule, fistulas with an

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external orifice anterior to an imaginary transverse line across the anal canal tend to have a straight course to the internal orifice, whereas those with an external orifice posterior to the line are more likely to have a curved course, opening posteriorly at the midline.[6] Anterior fistulas located more than 2.5 cm from the anal verge are an exception to the rule, as they may follow a curvilinear course, similar to posterior fistulas, and open into the posterior midline of the anal canal.[7]

Although Goodsall's rule remains widely used in clinical practice, particularly in centers with limited access to MRI, its accuracy continues to be debated. Multiple studies have evaluated its reliability using intraoperative findings and endoanal ultrasonography (EAUS), with various results.[8-11] However, the application of advanced imaging modalities such as MRI to assess the rule's validity has been less extensively documented.[12] The purpose of this study is to evaluate the accuracy of Goodsall's rule based on MRI findings and to contribute to the understanding of its applicability in modern imaging and surgical planning.

Materials and Methods

Participants

This study was approved by the Ankara University Human Research Ethics Committee (approval number: I5-370-21, dated: 25.06.2021). All participants provided written informed consent prior to the examination. A retrospective analysis was conducted on 1,437 consecutive MRI examinations performed in the radiology department between August 2011 and May 2021 for patients over 18 years of age who were referred for suspected perianal fistula.

A total of 638 patients without perianal fistulas, 110 patients with repeated MRI examinations, 76 patients treated with setons, 50 patients with chronic fistulas, and 18 patients with external orifices located directly on the transverse line at the 3 or 9 o'clock anal positions (precluding the evaluation of Goodsall's rule) were excluded from the study. Additionally, 276 patients with multiple fistulas or fistulas complicated by secondary tracts were excluded, whereas fistulas complicated by abscesses were not. In total, 305 patients with a single active fistula were included in the study. The flowchart depicting the selection process is presented in Figure 1.

Imaging Technique

MRI scans were conducted using a 3-Tesla MR system (MAGNETOM Verio; Siemens Medical Solutions, Erlangen, Germany) with a standard body matrix coil. The coil was positioned to extend at least 10 cm below the symphysis pubis to ensure optimal signal acquisition from the anal canal.The imaging protocol included T2-weighted turbo spin-echo (TSE) sagittal and axial sequences, high-resolution (HR) T2-weighted TSE oblique axial sequences, and HR contrast-enhanced fat-

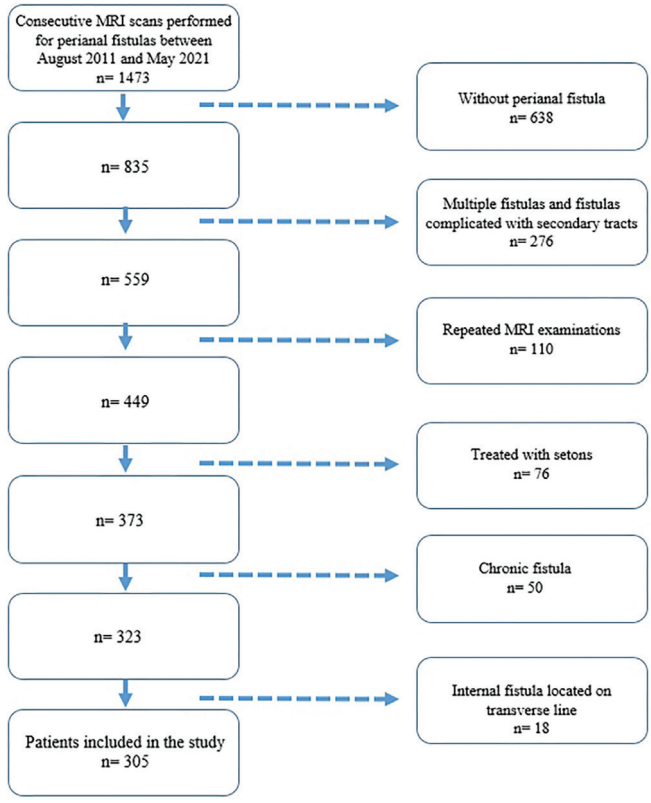


Figure 1. Flowchart summarizing patient accrual

suppressed T1-weighted TSE oblique axial and coronal sequences. Sagittal images were used to orient the oblique axial and coronal planes, aligning them perpendicularly and parallel to the long axis of the anal canal. Additional sequences included turbo inversion recovery magnitude oblique axial and coronal images, along with diffusion-weighted axial sequences. An endorectal coil was not used. The total scanning time was approximately 30-40 minutes.

Image Evaluation

Images were analyzed using a picture archiving and communication system workstation to identify the presence of perianal fistulas. Evaluated parameters included the position of the internal and external orifices according to the anal clock, the presence of associated abscesses, fistula type based on the Parks classification-categorized as intersphincteric, transsphincteric, suprasphincteric, or extrasphincteric -and the distance of the external orifice from the anal verge.[13]

All included MRI examinations were re-evaluated by consensus between two radiologists: an abdominal radiologist with 10 years of experience in proctology and a radiologist with 5 years of radiology experience.

To assess the validity of Goodsall's rule in the context of substantial comorbidities associated with perianal fistula development, patients were evaluated for comorbidities, including Crohn's disease, ulcerative colitis, hematological disorders, malignancy, and infections. This assessment was based on clinical data,

laboratory results, and histopathology results retrieved from the hospital's electronic medical record system.

Fistulas were categorized as anterior or posterior based on the location of the external orifice relative to the transverse anal line. The following were considered consistent with Goodsall's rule: anterior fistulas located within 2.5 cm of the anal verge with a radial course (Figure 2), anterior fistulas located more than 2.5 cm from the anus with a posterior midline internal orifice (Figure 3), and posterior fistulas with a curvilinear course terminating at the posterior midline (Figure 4). The accuracy of Goodsall's rule was assessed using MRI findings.

Statistical Analysis

Data analysis was performed using SPSS version 25.0 software. Categorical variables were reported as frequencies and percentages, whereas quantitative variables were presented as mean ± standard deviation. The accuracy of Goodsall's rule in identifying the internal fistula orifice was analyzed. Statistical significance was defined as a p-value less than 0.05.

Results

Among the 305 patients (mean age: 45.94±14.15 years), 214 (70.2%) were men and 91 (29.8%) were women, indicating a male predominance. According to the Parks classification, 162 fistulas (53.1%) were intersphincteric, 138 (45.2%) were transsphincteric, 3 (1.0%) were suprasphincteric, and 2 (0.7%) were extrasphincteric.

Underlying conditions included Crohn's disease in 29 patients, malignancy in 11, hematological disorders in 5, ulcerative colitis in 3, and perianal sepsis in 3. The remaining 254 patients had no associated underlying disease and were classified as cryptoglandular. Associated abscesses were observed in 54 patients (17.7%). The demographic data are presented in Table 1.

A total of 118 fistulas (38.7%) were located anteriorly, whereas 187 (61.3%) were posteriorly located. Overall, 49.2% of all fistulas were found to be consistent with Goodsall's rule. The rule was more accurate in anterior fistulas than in posterior fistulas ($p<0.001$).

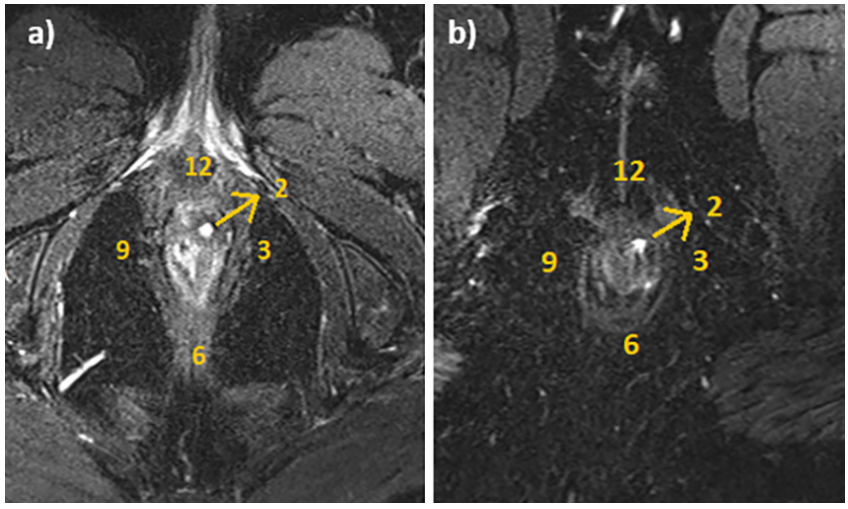


Figure 2. A 54-year-old woman with an internal orifice (a) at the 2 o'clock position at the anorectal junction. The fistula tract progresses caudally in the intersphincteric space and connects with the skin at the 2 o'clock position at the anal verge (b)

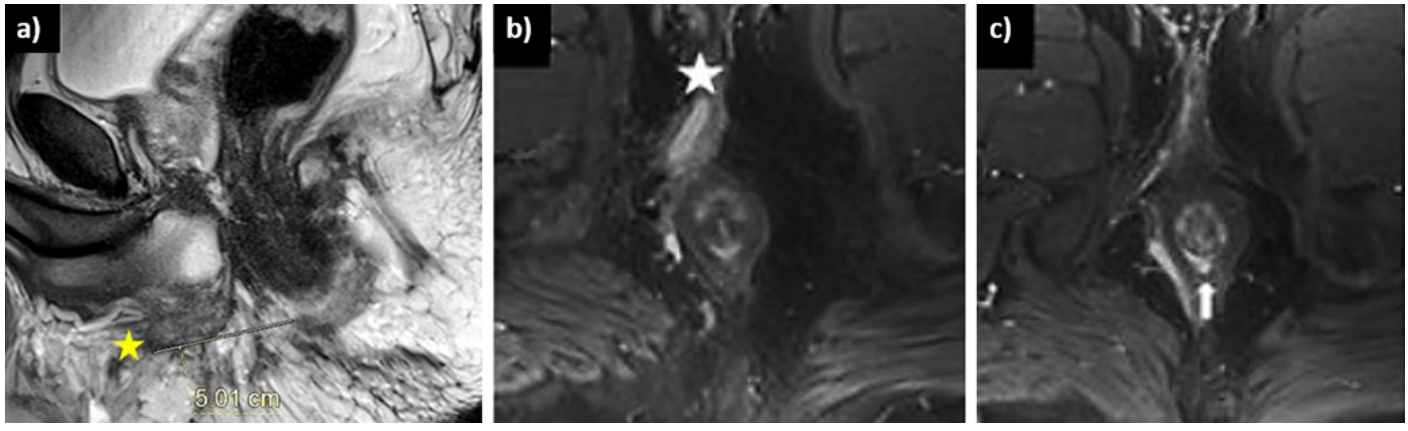


Figure 3. A 48-year-old man. The external orifice (star) is located anteriorly, 5 cm from the anal verge. The internal orifice is located at the posterior midline in the mid-portion of the anal canal (thick arrow), forming a fistula

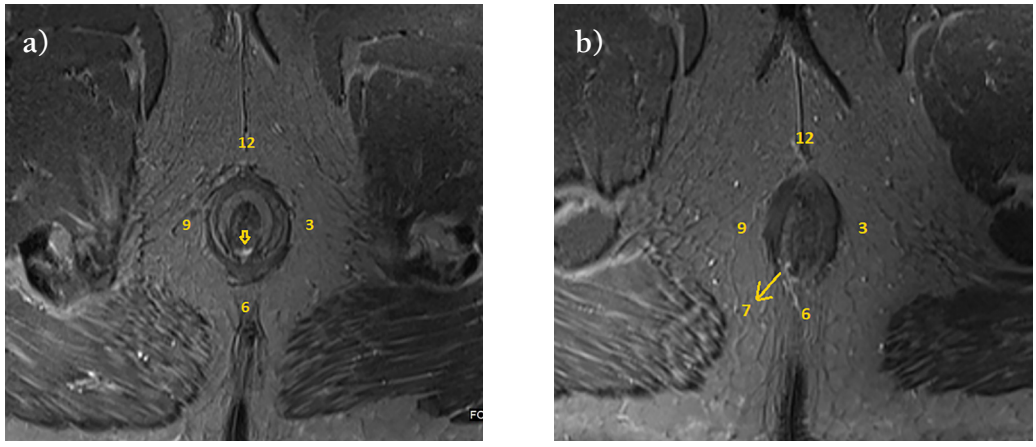


Figure 4. A 54-year-old man. The internal orifice (short thick arrow) is located at the 6 o'clock position. The fistula extends caudally and posteriorly through the transsphincteric space, with the external orifice located at the 7 o'clock position (long thick arrow), forming a transsphincteric fistula

Among patients with a posterior external orifice, 175 (93.6%) had a posterior internal orifice, 7 (3.7%) had an anterior internal orifice, and 5 (2.7%) had an internal orifice on the transverse line (at the 3 or 9 o'clock positions). Of the 187 patients with posterior fistulas, 74 had an internal orifice at the posterior midline consistent with Goodsall's rule, yielding an accuracy rate of 39.6% (Figure 5).

Of the 118 patients with an anterior external orifice, 100 had fistulas located within 2.5 cm of the anal verge, of which 71 exhibited radial tracts consistent with Goodsall's rule. Among the 18 anterior fistulas located more than 2.5 cm from the anal verge, 5 had internal orifices at the posterior midline, also consistent with the rule. In total, 76 anterior fistulas were found to align with Goodsall's rule, resulting in an accuracy rate of 64.4% (Figure 5). Adherence to Goodsall's rule in anterior and posterior fistulas is summarized in Table 2.

Fistulas with a radial course were more common than those with curvilinear tracts (57.7% vs. 42.3%, respectively).

The accuracy of Goodsall's rule was observed in 52.7% of women and 47.7% of men, with no statistically significant difference between genders (p=0.416). No significant difference in adherence to the rule was observed between patients with and without associated abscesses (p=0.464). Similarly, there was no significant difference in adherence among different fistula types based on the Parks classification (p=0.588).

However, comorbid diseases significantly affected the accuracy of the rule (p=0.017). In the Bonferroni-adjusted subgroup analysis, no significant difference was observed between the cryptoglandular group and patients with Crohn's disease (p>0.05). Among the 11 patients with malignancy, only 1 (9.1%) adhered to the rule, distinguishing this group in terms of reduced accuracy.

Discussion

Perianal fistulas are a major cause of morbidity, and their complex anatomy and close relationship with the anal sphincters highlight the importance of precise preoperative diagnosis to prevent recurrence and preserve continence.[1] Identifying the correct location of the internal orifice is critical for successful intervention, as it is the primary source of sepsis. Accurate localization minimizes the risk of incomplete excision, reduces recurrence rates, and improves patient

Table 1. Demographic data of the study population

Demographic data	**Mean ± SD**
Age (year)	45.94±14.15
	n (%)
Gender	
Men	214 (70.2%)
Women	91 (29.8%)
Fistula type (Parks Classification)	
Intersphincteric	162 (53.1%)
Transsphincteric	138 (45.2%)
Suprasphincteric	3 (1.0%)
Extrasphincteric	2 (0.7%)
Etiology	
Idiopathic	254 (83.3%)
Crohn's disease	29 (9.5%)
Malignancy	11 (3.6%)
Hematological disorders	5 (1.6%)
Ulcerative colitis	3 (1.0%)
Perianal sepsis	3 (1.0%)

SD: Standart deviation

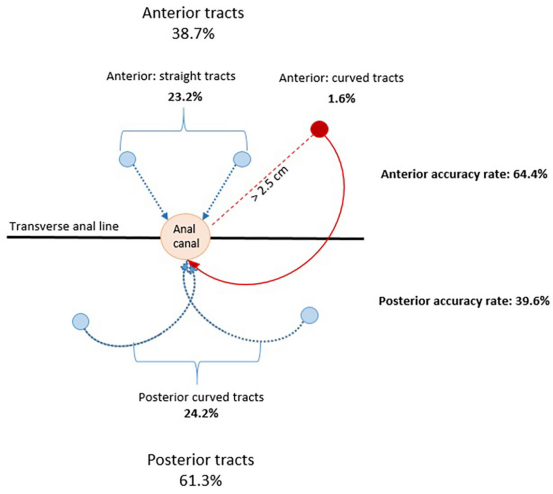


Figure 5. Schematic representation of fistula distribution

outcomes. In this study, we evaluated the validity of Goodsall's rule in predicting the internal orifice of perianal fistulas based on MRI findings. Our results revealed an overall accuracy of 49.2%, with the rule being more applicable to anterior fistulas, showing an accuracy of 64.4% compared with 39.6% for posterior fistulas.

The lower accuracy of Goodsall's rule in posterior fistulas may be attributed to several factors. First, the posterior perianal region presents more complex anatomical spaces, containing intricate fascial planes and potential spaces such as the deep postanal space and ischiorectal fossa, which are less prominent anteriorly. This anatomical complexity increases the likelihood of fistula tracts following atypical paths. Second, lateral posterior external openings are typically farther from the posterior midline than anterior external openings are from their usual internal counterparts, allowing more anatomical structures to potentially influence tract development. Third, studies indicate a higher prevalence of complex fistulas posteriorly, with branching or high transsphincteric fistulas occurring more frequently in the posterior quadrants, inherently limiting the predictive value of simplified anatomical rules. Finally, the influence of previous anorectal disease, including hemorrhoids, fissures, and prior surgical interventions, may distort normal anatomy, particularly in the posterior region, thereby affecting the development and course of fistula tracts.

In addition to Goodsall's rule, attempts to identify the internal orifice include preoperative MRI, clinical examination with palpation and gentle probing at the expected site, EAUS, and injection of hydrogen peroxide or methylene blue into the external orifice.[14,15] Several studies comparing the sensitivity of these modalities in detecting the internal orifice have reported comparable results.[16,17] In one such study by Buchanan et al.[18], EAUS was nearly as accurate as MRI, identifying the internal opening in 91% of cases compared with 97% with MRI. In another study comparing hydrogen peroxide-enhanced EAUS and MRI, both modalities demonstrated equal sensitivity, identifying the internal orifice in 86% of cases.[19] A meta-analysis by Li et al.[20] demonstrated that EAUS may have a sensitivity as high as 97% for detecting the internal opening. These findings support the use of all these methods as reliable tools for the preoperative assessment of fistulous disease and the safe and accurate localization of the internal orifice.

In perianal fistulas, surgical findings and MRI results show a high degree of correlation, further highlighting the role of MRI in preoperative planning by providing superior anatomical detail and enabling the precise localization of fistulous tracts and associated complications.[21,22] As stated in the European Society of Coloproctology's anal fistula guideline, early imaging (MRI or EAUS) should be used to differentiate simple fistulas from complex fistulas. In suspected complex cases or when EAUS is insufficient, preoperative MRI is recommended as moderate-level evidence.[17]

Goodsall's rule, although widely used, demonstrates varying accuracy depending on the clinical context and the modality used for evaluation. In our study, the rule was more accurate for anterior fistulas (64.4%) than for posterior ones (39.6%). These findings are consistent with several previous studies. For example, using hydrogen peroxide injection as a reference, Gunawardhana et al.[23] reported an accuracy of 72% for anterior fistulas and 41% for posterior fistulas; Devi et al.[24] also demonstrated lower adherence in posterior fistulas (69.1% vs. 84.6%). Similarly, Alexander et al.[7] reported adherence rates of 66% for anterior fistulas and 29% for posterior ones,

Table 2. Adherence to Goodsall's rule in anterior and posterior fistulas

	Consistent with the rule n (%)	Inconsistent with the rule n (%)	Total (n)
Anterior fistulas	76 (64.4%)	42 (35.6%)	118
Distance from anal verge ≤2.5cm	71 (71%)	29 (%29)	100
Distance from anal verge >2.5cm	5 (27.8%)	13 (72.2%)	18
Posterior fistulas	74 (39.6%)	113 (60.4%)	187
Total	150 (49.2%)	155 (50.8%)	305

reinforcing the limitations of the rule in posterior cases. A recent study by Kumar et al.[12] found that Goodsall's rule was more accurate for anterior fistulas than for posterior ones based on MRI fistulogram findings (80% vs. 57.2%, respectively).

However, some studies have reported higher accuracy of Goodsall's rule in posterior fistulas, in contrast to our findings. For instance, Barwood et al.[25], using intraoperative data, reported 91% accuracy for posterior fistulas and 69% for anterior ones. Bakir et al.[26], in a study incorporating MRI, EAUS, and surgical findings, reported accuracy rates of 73% for posterior fistulas and 52.4% for anterior fistulas, which conflicts with our results. Likewise, Cirocco and Reilly[27] reported 90% accuracy for posterior fistulas and noted that the rule was particularly unreliable for identifying anterior internal orifices, especially in women (31%). The study by Coremans et al.[28] supported these findings, demonstrating lower consistency with the rule in women and anterior fistulas. That study also reported no significant difference in adherence to Goodsall's rule between patients with Crohn's disease and those without.

In our study, although patients with Crohn's disease did not significantly differ from the cryptoglandular group, patients with malignancy-a smaller subgroup-exhibited notable inconsistency with the rule. This finding highlights the need for caution when applying Goodsall's rule in malignancy-related fistulas.

The variability in results across studies likely stems from differences in the inclusion criteria for complex fistulas and different methods employed to assess adherence to the rule, such as imaging modalities, hydrogen peroxide injection, or intraoperative observations. This discrepancy in the literature suggests that although Goodsall's rule remains a useful guideline, its accuracy may be substantially affected by underlying conditions and the anatomical complexity of the fistula. Its limitations in complex cases underscore the importance of incorporating advanced imaging techniques to complement traditional anatomical rules.

Study Limitations

The main limitation of our study is that adherence to the rule was investigated in relatively simple fistulas due to the exclusion of multiple fistulas and those complicated by secondary tracts. It is challenging to assess the validity of the rule using a fistula-based approach in cases involving a single internal orifice with secondary branches leading to different external orifices. Therefore, applying the rule to relatively simple fistulas appears to be a more reasonable approach in preoperative evaluation.

Another limitation is the small sample size in subgroups with underlying conditions. Additionally, because of the retrospective design, the results could not be correlated with intraoperative observations.

Nevertheless, our findings emphasize the need for greater caution when applying Goodsall's rule in the preoperative assessment of fistulas and highlight the importance of employing additional imaging modalities for the detection of the internal orifice, particularly in posterior fistulas, to ensure precise surgical planning and achieve better surgical outcomes.

Multidisciplinary prospective studies with larger populations, focusing on the comparative accuracy of the rule across simple and complex fistulas and incorporating both MRI and intraoperative findings, are needed to clarify conflicting results.

Conclusion

In conclusion, the traditional Goodsall principle, while demonstrating relative strength in predicting anterior fistula pathways, exhibits substantial limitations when applied to posterior fistulas. The inconsistent reliability observed across our patient cohort indicates that this historical rule should not serve as the sole basis for surgical planning.

Instead, our findings support the integration of advanced radiological assessment, particularly MRI, into standard preoperative protocols. We recommend that clinicians incorporate MRI evaluation whenever institutional resources allow to maximize diagnostic precision and guide appropriate surgical strategies, potentially reducing recurrence rates and associated morbidity.

Ethics

Ethics Committee Approval: This study was approved by the Ankara University Human Research Ethics Committee (approval number: I5-370-21, dated: 25.06.2021).

Informed Consent: All participants provided written informed consent prior to the examination.

Footnotes

Authorship Contributions

Surgical and Medical Practices: C.A., İ.E.G., Concept: D.K.Ö., A.E., Design: D.K.Ö., A.E., Data Collection or Processing: D.K.Ö., S.N.Y.Z., Z.E., Analysis or Interpretation: S.N.Y.Z., Z.E., F.S.Ö.A., Literature Search: D.K.Ö., S.N.Y.Z., Z.E., Writing: D.K.Ö., S.N.Y.Z., Z.E.

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RESEARCH ARTICLE

Balancing Risk in Rectal Cancer Surgery: A Retrospective Cohort Study Examining the Consequences of Anastomotic Leaks and Diversion

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ABSTRACT

Aim: This study aimed to aid decision-making concerning selective diversion in rectal cancer surgery by examining the complications and management of anastomotic leaks in diverted and undiverted patients, as well as ileostomy complications and permanence.

Method: A review of all anterior resections performed at our United Kingdom tertiary referral center between 2012 and 2018 was conducted to assess anastomotic leaks and their management and ileostomy-related complications and closure rate.

Results: Of 578 total anterior resections, 223 (38.5%) were diverted. Leaks occurred in 40 (6.9%), of which 25 (62.5%) were diverted and 15 (37.5%) were undiverted; 89% of diverted patients did not leak. There was one death, which was not leak-related. Of the 40 leaks, 24 (60%) were managed transanally and percutaneously with antibiotics or were incidental; these were mostly in the diverted patients. Undiverted patients underwent operative management more frequently, mostly with laparoscopic washout and ileostomy formation (47%). Ileostomy morbidity was common at both creation (27%) and closure (25%), with a leak rate of 3%. Diversion permanence occurred in 16% overall and 10% in ileostomies created at rescue, the most common reason being disease progression (38%) as opposed to leakage (11%).

Conclusion: The anastomotic leak rate is low, with one-third of all patients being "overprotected" and thus unlikely to derive any benefit from index diversion. Although diverted patients are more likely to have non-operative management of a leak, significant ileostomy complication rates and permanence should be taken into account when deciding which patients to divert.

Keywords: Rectal cancer, anterior resection, anastomotic leak, ileostomy, complications

Introduction

Surgical resection, with or without neoadjuvant chemoradiotherapy (CRT), is the established gold standard treatment for localized rectal cancer. Reported leak rates from rectal anastomoses vary in the literature between 1% and 24%.[1] Distance from anal verge <7 cm, number of linear staple firings >2, neoadjuvant CRT, steroid use, and male gender are negative prognostic indicators for anastomotic leaks.[2,3] Anastomotic leaks correlate with an increased risk of postoperative death, return to theatre, prolonged hospital stay, and postponement of adjuvant chemotherapy. Moreover, anastomotic leaks are associated with a higher rate of local recurrence and poorer long-term survival.[4,5]

Temporary diversion with a loop ileostomy, in combination with bowel preparation, has been shown to reduce morbidity associated with anastomotic leaks.[6] However, diversion also carries a risk of significant morbidity, including dehydration and acute kidney injury related to high output, parastomal

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hernia, and contact dermatitis.[7] One recent series found that ileostomy-related complications accounted for 13% of index procedure morbidity and 15% of readmissions,[8] with an associated impact on long-term quality of life.[9] Furthermore, diversion commits the patient to further surgery should they wish to restore gastrointestinal continuity.[1,10] The reported leak rate for reversal of loop ileostomy is 2%-3%, potentially leading to return to theatre, permanent stoma, or-rarely-post-operative death.[11,12]

Anastomotic leaks are unpredictable, even after consideration of individual patient risk factors. This leads to many patients being "overprotected" (i.e., diversion, no leak) and, less commonly, some patients being "underprotected" (no diversion, leak).

The concept of "rescue" in anastomotic leaks is well recognized.[8,13] When anastomotic leaks occur, early recognition facilitates a timely return to theatre for washout, drainage, and diverting ileostomy or transanal repair, thereby potentially salvaging the anastomosis. This approach has the advantage of avoiding stomas and their inherent complications in patients where no leak occurs, thereby reducing the number of "overprotected" patients. In light of this, some practitioners argue that proximal diversion is being overused and that the morbidity associated with diverting ileostomies needs to factor more heavily into the decision-making.[14]

In this study, we describe a large cohort of patients undergoing anterior resection in a tertiary referral center to explore the data regarding leak rates and consequences and ileostomy complication rates. The authors declare no conflicts of interest.

Materials and Methods

This was a retrospective cohort study comprising all patients aged >18 years who underwent anterior resection for primary colorectal cancer at a single tertiary referral unit within the United Kingdom, Oxford University Health Trust, between October 1, 2012, and December 31, 2018, identified from a prospectively maintained database. Patients were excluded if they did not have histologically proven rectal cancer, if there was no primary colorectal/coloanal anastomosis, or if they underwent formation of a loop ileostomy without resection of the primary tumor. Patients with metastatic disease undergoing resection of the primary tumor were included.

High anterior resection (HAR) was defined as laparoscopic or open anterior resection with the anastomosis above or at the level of the peritoneal reflection. Low anterior resection (LAR) was defined as laparoscopic or open total or partial mesorectal resection with an anastomosis below the peritoneal reflection. Patient demographics, operative details, pathological tumor–node–metastasis staging, and 90-day complications (using the Clavien-Dindo classification) were extracted and recorded. An anastomotic leak was defined per the International Study Group of Rectal Cancer as "a defect of the intestinal wall at the anastomotic site (including suture and staple lines of neorectal reservoirs) leading to a communication between the intra- and extraluminal compartments".[15] Leaks were diagnosed radiologically, surgically, and/or endoscopically.

Outcomes of interest were the rate of diversion at the index procedure, anastomotic leak rate, management of anastomotic leak, ileostomy-related complications, time to ileostomy closure, and complications at closure.

Patients were divided into 4 cohorts: undiverted and no leak-"no danger"; diverted and leak-"protected"; diverted and no leak-"overprotected"; and undiverted and leak-"underprotected."

Generic consent was gained from patients prospectively at the time of their operation. As this study was conducted as a retrospective database audit on patients already consented, approval was given by the institution's clinical governance team, which stipulated that it did not require formal ethics approval, in line with the institution's guidelines for de-identified data analysis. Data confidentiality and ethical standards were strictly maintained throughout the research process.

Statistical Analysis

Outcomes with a p-value of <0.05 were considered significant. All analyses were performed using the Statistical Package for the Social Sciences (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY, USA). Chi-squared tests were employed to compare categorical variables using crosstab analysis, and two-sided t-tests were utilized to compare categorical variables with quantitative variables.

Results

A total of 2,267 patients undergoing colorectal resection were identified between October 2012 and December 2018, of whom 1,568 were being treated for colorectal cancer. A total of 578 patients underwent rectosigmoid resections with or without diversion and were included in the study (Figure 1).

Table 1 shows the characteristics of diverted and undiverted patients. A total of 297 (51.4%) patients underwent LAR, and 281 (48.6%) underwent HAR. One (0.3%) postoperative death was observed within 30 days; the cause of death was myocardial infarction, not thought to be directly related to the procedure.

Categorization of Risk

Table 2 shows the categorization of risk: 58.8% of patients were in "no danger" (undiverted/no leak), 4.3% "protected" (diverted/leak), 34.26% "overprotected" (diverted/no leak), and 2.6% "underprotected" (undiverted/leak).

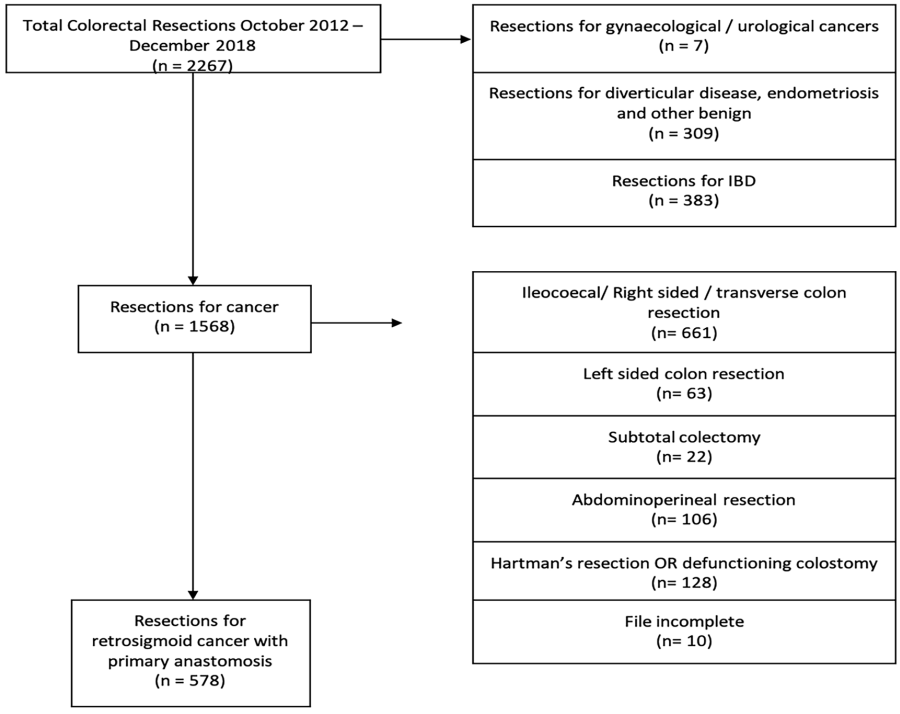


Figure 1. Flowchart of inclusions

Table 1. Characteristics of diverted and undiverted patients

		Diverted (n=223)	Undiverted (n=355)	p-value
Age; median (range)		66 (32-90)	66 (21-90)	
Gender	Male Female	150 (67%) 73 (33%)	200 (56%) 155 (44%)	**p=0.008**
American Society of Anesthesiologists classification	I II III	117 92 14	162 175 18	p=0.165
Resection height	Low anterior resection High anterior resection	209 14	88 267	**p<0.00001**
Stage	T1-2 T3+	79 144	123 232	p=0.848
Neoadjuvant chemoradiotherapy	No Yes	152 71	312 43	**p<0.00001**
Anastomotic leak	No Yes	198 25 (11.2%)	340 15 (4.2%)	**p=0.0012**

Ileostomy Formation Rates

A total of 223 (39%) patients had a diverting ileostomy formed at or before the index procedure (the diverted group), and 355 (61%) had no ileostomy (the undiverted group). The rate of diversion was significantly higher in patients receiving a LAR than in those receiving a HAR (70% vs. 5%, p<0.00001). Diversion rates were also significantly higher in those receiving neoadjuvant CRT (62% vs. 33%, p<0.00001) and male gender (67% vs. 33%, p=0.008). Patient comorbidity, defined using the American Society of Anesthesiologists classification system, and the T-stage did not significantly affect the rate of diversion (p=0.165 and p=0.848, respectively) (Table 1).

Anastomotic Leak Rates

A total of 40 anastomotic leaks were reported, with an overall leak rate of 6.9%. Leak rates were significantly higher in patients receiving neoadjuvant treatment (12.3% vs. 5.2%, p=0.01).

Of the 40 leaks, 25 (11.2%) occurred in the "protected" (diverted) group (3 after HAR and 25 after LAR) and 15 (4.2%) in the "underprotected" (undiverted) group (5 after HAR and 10 after LAR, p=0.0012). There was no leak-related mortality.

Management of Anastomotic Leaks

Table 3 shows the treatment of anastomotic leaks in both groups. Of the 40 leaks, 3 were subclinical radiological leaks identified on rectal contrast studies performed in preparation for ileostomy closure. These were managed conservatively. The remaining 37 leaks were identified within the post-operative period and managed with antibiotics, radiologically, or surgically. The anastomosis was taken down and an end colostomy was formed in 5 patients (13%), of whom 1 was already diverted. All end colostomies were permanent.

The majority of leaks (15/25, 60%) in the diverted group were managed conservatively; 3 (12%) were subclinical and required no treatment, 11 (44%) were successfully managed with antibiotics only, and 1 (4%) patient had a radiologically placed drain. Six (15%) patients received transanal repair of the anastomotic defect, and 3 (13%) patients required a laparoscopic washout with preservation of the anastomosis. In total, 24/25 (96%) leaks were successfully managed with preservation of the anastomosis, with 1 (4%) patient requiring resection of the anastomosis and end colostomy formation.

Most leaks in the undiverted group were treated surgically (13/15, 87%). In 4 (27%) of these patients, the clinical presentation necessitated resection of the anastomosis and formation of an end colostomy. In 7 (47%) patients, a washout with formation of a "rescue" ileostomy was performed, with preservation of the anastomosis, 1 (7%) had a transanal repair, and 1 (7%) laparoscopic washout without ileostomy formation. The remaining 2 (13%) patients were managed conservatively: 1 with antibiotics and 1 with a radiologically placed drain, without stoma formation.Strict post-operative monitoring of all patients took place with daily senior review and blood tests, including C-reactive protein. All patients with clinical suspicion of an anastomotic leak underwent an urgent computed tomography scan with intravenous (IV) and rectal contrast performed on the day of request. The median time between the index procedure and return to theatre was 4 days. All surgical reinterventions were carried out by a colorectal specialist surgeon within 24 hours of the initial clinical suspicion.

Table 2. Categorization of risk

Total patients =578	Diverted	Undiverted
No leak	198 (34.26%) **"Overprotected"**	340 (58.8%) **"No danger"**
Leak	25 (4.3%) **"Protected"**	15 (2.6%) **"Underprotected"**

Ileostomy-Related Complications

Table 4 depicts ileostomy-related complications. A total of 63 (27%) patients were either readmitted or had a prolonged hospital stay following the index operation. Eleven (5%) patients had a prolonged post-operative ileus, 12 (5%) patients developed stomal obstruction due to parastomal hernia or retraction, with 2/12 requiring ileostomy closure within 7 days of the index operation; neither procedure resulted in an anastomotic leak. A total of 36 (16%) patients required readmission and IV fluids for high output, and 4 (2%) patients developed other ileostomy-related complications.

Time to Ileostomy Closure and Closure-Related Complications

In total, 195 (84%) ileostomies were closed during the follow-up period (≥24 months), with a median time between index operation and ileostomy closure of 19 months (0-106). Of the patients with an ileostomy formed as part of the "rescue" procedure (n=10), 9/10 (90%) had their ileostomy closed within the follow-up period.

Table 5 shows closure-related morbidity and reasons for non-closure. There were no ileostomy closure-related mortalities. The anastomotic leak rate at ileostomy closure was 3%

Table 3. Treatment of anastomotic leak

		Diverted (n=223)	Undiverted (n=355)	Total (n=578)
GRADE A None (incidental finding)		3	0	3
GRADE B Antibiotics		11	1	12
Radiologically placed drain		1	1	2
GRADE C	Transanal repair	6	1	7
Reoperation	Laparoscopic washout	3	1	4
	Laparoscopic loop ileostomy	-	7	7
	Resection anastomosis + end colostomy	1	4	5
Total		25 (11.2%)	15 (4.2%)	40 (6.9%)

(6/195 patients); 5 underwent urgent re-operation with new ileostomy formation, and 1 patient was successfully treated with antibiotics and percutaneous drainage. Of the 5 patients who had a second ileostomy formed, 2 patients ended up with a permanent end ileostomy, 2 patients had ileostomy closure at a later date without further complications, and 1 patient was lost to follow-up. Further common complications following ileostomy closure were ileus (12, 6%), surgical site infection (8.4%), hematoma (5.3%), and incisional hernia (5, 3%). No statistically significant relationship was found between patient comorbidity and the occurrence of ileostomy closure complications.

A total of 38 ileostomies were not closed during the followup period. The most common reason was progression to metastatic disease (n=15, 38%), followed by patient comorbidity (n=4, 11%), patient choice (n=4, 11%), anastomotic issues (stricture, persistent leak) (n=4, 11%), death (n=3, 8%) and other/unknown (n=8, 21%).

Table 4. Ileostomy-related morbidity

	Frequency (n=233)†
None	170 (72%)
Prolonged post-operative ileus	11 (4.7%)
Obstructing parastomal hernia	12 (5.2%)
High output requiring readmission for rehydration	36 (15.5%)
Other	4 (1.7%)
Total morbidity	**63 (27%)**

†223 "index" +10 "rescue"

Discussion

In this study, we compared anastomotic leak rates and consequences in diverted and undiverted patients receiving anterior resection for rectal cancer and examined ileostomy complication and permanence rates. Whether to perform a diversion at the index procedure is a decision made by the operating surgeon based on a range of factors including patient characteristics, tumor factors (such as height and prior CRT), institutional factors (access to theatres, availability of senior staff to review post-operatively, "culture" of diversion), and intangible "human factors" related to risk perception.

Diversion was unsurprisingly significantly higher in LAR (68.0%) than in HAR (4.6%), in male patients and in patients who had neoadjuvant CRT. The anastomotic leak rate was significantly higher in diverted patients (4.3% vs 2.6%, p=0.0012). A 2010 Cochrane review and a more recent meta-analysis in 2014 found lower anastomotic leaks and re-operation rates in the presence of diversion.[16,17] Our current data contradict this, likely reflecting appropriate patient selection; surgeons chose to divert higher-risk patients. Additionally, three subclinical leaks were found via rectal contrast study prior to ileostomy closure. These delayed leaks can be difficult to treat, often more so than recognising and dealing with acute leaks.[14,18]

Further suggesting appropriate selection of diversion was a low number of "underprotected" (leak with no diversion) patients, at 2.6%. Advocates of routine diversion would argue that although diversion does not prevent anastomotic leak, it protects against overwhelming pelvic sepsis and possibly preserves more anastomoses.[19] It is important to note that no mortalities occurred within this group, nor was there any

Table 5. Ileostomy closure-related complications and reasons for non-closure

Ileostomy closed		**Yes, 195 (84%)**	**No, 38 (16%)**
Median time to closure in months: (range)		19 (0-106)	-
Complications	None	146 (75%)	-
	Ileus	12 (6%)	-
	Anastomotic leak	6 (3%)	-
	Haematoma	5 (2%)	-
	Surgical site infection	8 (4%)	-
	Incisional hernia	5 (3%)	-
	Other	13 (7%)	-
Ileostomy not closed			
Reason	Progressive disease	-	15 (38%)
	Comorbidity	-	4 (11%)
	Patient choice	-	4(11%)
	Anastomotic problems (stricture, persistent leak)	-	4 (11%)
	Death	-	3 (8%)
	Other		8 (21%)

overwhelming sepsis. The main difference between diverted and undiverted leaks is that the former were much more likely to receive non-operative management, such as antibiotics alone (56% vs. 4%) or a less invasive surgical intervention, such as transanal repair or laparoscopic washout. Although there was an increase in anastomotic loss in the undiverted group, the numbers were small (4 vs. 1) and not statistically significant. This suggests that close monitoring and early rescue can be done safely.

Although a majority (58.8%) of patients were appropriately in "no danger" (undiverted and did not leak), 34.3% of patients were "overprotected" (diverted and did not leak), meaning one-third of patients were exposed to the risks of an ileostomy, with no benefit gained from diversion. Diversion-related complications occurred in 27%, meaning a large proportion of these patients experience unnecessary complications. Although many of these complications were relatively minor, they may delay the time to adjuvant treatment, if this is required. Complications at ileostomy closure were also common, occurring in 25% of cases. Notably, patient-reported outcomes were not measured, which may be an area of future research.

Evidence on the optimal timing for ileostomy reversal is mixed. Although several studies, including a recent meta-analysis, advocate for early closure to reduce morbidity, a recent study was stopped early due to high complication rates at 2 versus 12 weeks.[20-22] In our study, patients waited a median of 19 months, exceeding the potential benefits of early closure and increasing the risk of ileostomy-associated complications. Despite the support for early reversal, our findings highlight the challenges in implementing this in overburdened public health systems.

In this study, 16% of ileostomies were not closed during the follow-up period (≥24 months). This figure is in line with other studies, which quote 17-18% ileostomy permanence.[23,24] In the United Kingdom, the National Bowel Cancer Audit 2025 shows a persistent ileostomy rate of 38%. Despite the target being a 35% reversal rate by 18 months, this has increased from 35% last year and 29% in 2020, which is thought to be due to persistent long surgical waiting times since the COVID-19 pandemic.[25,26] This increasing wait time should be taken into consideration when choosing to divert and effectively mandating a repeat procedure.

Surprisingly, despite diversion occurring to prevent complications of a leak, anastomotic complications accounted for only 11% of stoma permanence. The major reason for non-closure was progressive disease (38%). The presence of an ileostomy may complicate adjuvant therapy, particularly in the context of high output, and may deleteriously impact palliation. Also worth noting is that 10% in the rescue group versus 16% overall did not have their ileostomies reversed within the following period, suggesting that an ileostomy formed as part of rescue is no more likely to be permanent than if formed at index.

The evidence regarding routine diversion is mixed. A recent meta-analysis of 2,366 patients from 14 studies found a reduced anastomotic leak rate in diverted patients (6% vs. 9%) but a higher overall complication rate, likely reflecting ileostomy-related complications.[27] A 2017 cohort from Sweden showed a decrease in all-cause mortality in diverted patients and no differences in long-term oncological outcomes, leading the authors to recommend routine diversion for LAR.[23]

Contrarily, a growing body of evidence has questioned the premise of routine diversion. A recent Dutch study assessed long-term outcomes in 99 patients undergoing LAR where highly selective diversion was practiced.[28] Stoma permanence was reduced by 9% compared with studies advocating routine diversion. Thirty-day mortality was also reduced, which the authors attributed to strict surveillance and a protocol dictating early intervention in anastomotic leak, thereby avoiding uncontrolled sepsis and failure to rescue.

Multiple papers have since suggested the overuse of diversion and called for a paradigm shift from routine diversion to omitting diversion as a principle.[14,29] Our institution has largely adopted the practice of highly selective diversion, and the data presented support this practice.

This analysis is limited by its retrospective, observational format. The more minor post-operative complications may be underreported in the medical notes, and some patients may have re-presented to other centers. However, in our cohort of 578 anterior resections, we have shown a low overall anastomotic leak rate and no leak-related mortality. Appropriately, leaks were more common in diverted patients. Although diverted patients were more likely to have non-operative management of their leak, anastomotic takedown was marginally higher in the undiverted group, and almost half were managed with rescue ileostomy alone. Ileostomy in this context was no more likely to be permanent than if made at the index procedure. One-third of all patients were "overprotected" and thus unlikely to have derived any benefit from index diversion. These factors, a 27% ileostomy-related complication rate and 16% permanence rate, should be taken into account when deciding which patients to divert, and suggest there is safety in very selective diversion.

Ethics

Ethics Committee Approval: As this study was conducted as a retrospective database audit on patients already consented, approval was given by the institution's clinical governance team, which stipulated that it did not require formal ethics approval, in line with the institution's guidelines for de-identified data analysis.

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.M., C.V., J.F.M., S.A.H., C.D.M.W., I.L.F., Concept: C.V., J.F.M., S.A.H., C.D.M.W., I.L.F., Design: C.V., J.F.M., S.A.H., C.D.M.W., I.L.F., Data Collection or Processing: M.M., C.V., J.F.M., S.A.H., C.D.M.W., I.L.F., Analysis or Interpretation: M.M., C.V., J.F.M., S.A.H., C.D.M.W., I.L.F., Literature Search: M.M., C.V., J.F.M., S.A.H., C.D.M.W., Writing: M.M., C.V., J.F.M., S.A.H., C.D.M.W., I.L.F..

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RESEARCH ARTICLE

The Relationship Between Sweat Response, BMI, and Physical Activity: Implications for Pilonidal Sinus Disease

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ABSTRACT

Aim: Obesity has been suspected of influencing sweating and constituting a risk factor for pilonidal sinus disease (PSD), given the parallel rise in both obesity and PSD incidence in developed countries. This study, therefore, examined the relationship between sweating and body mass index (BMI).

Methods: A total of 322 individuals from a large northern German cohort, all without PSD, were assessed. A questionnaire was designed to evaluate BMI and engagement in sports activities. Standardized pilocarpine iontophoresis sweat testing was performed in the glabella sacralis region, 5-10 cm cephalad to the intergluteal fold.

Results: The normal BMI group had significantly higher sweat production (20.74±2.5 µl) than the high BMI group (17.10±2.8 µl) ($p<0.001$). Individuals who regularly participated in sports more than twice a week exhibited significantly higher sweat production than those who did not exercise (27.2±2.9 µl vs. 24.4±1.6 µl, $p<0.001$).

Conclusion: Increased BMI was not associated with increased pilocarpine iontophoresis-induced glabella sacralis sweat output. Engagement in sports increased sweat production in both normal and high BMI individuals. Increased sweating may play a protective role, potentially contributing to weight reduction and, consequently, a lower incidence of PSD through mechanisms yet to be elucidated.

Keywords: BMI, obesity, inactivity, sports, sweat, intergluteal, moisture, hair, pilonidal sinus, hair strength, hair force, incidence

Introduction

Pilonidal sinus disease (PSD) is an acute or chronic infection of the subcutaneous tissue caused by the penetration of sharply cut hair fragments into the upper intergluteal fold. This condition necessitates more than 30,000 surgical interventions annually in Germany, predominantly affecting young men and women. Its incidence has been rising in both military and civilian populations.[1]

An increasing prevalence of PSD has long been suspected. Karydakis documented a rise in the proportion of Greek army recruits affected by PSD, from 4.9% in 1960 to 25.8% in 1974, with further increases to 30%-33% by 1992.[2] Hair penetration into the skin generally occurs during a "vulnerable time window" around puberty,[3,4] with symptom onset thought to be facilitated by sweating and repetitive mechanical stress.[5,6] The reasons for the worldwide increase in PSD remain unclear. Although poor hygiene was previously, but incorrectly, implicated,[7] the substantial presence of sharp hair fragments in the lumbar region immediately following haircuts may be a contributing factor,[8] particularly in military environments where short haircuts are mandatory.[1,6,9,10]

Over the past three decades, increased sweating due to obesity has been considered a potential risk factor for PSD. However, studies have paradoxically shown decreased sweat production

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in patients with PSD.[11]Nevertheless, obesity remains high on the list of suspected contributing factors. Given the global rise in obesity, PSD has been increasingly observed in so-called developed (well-nourished) countries. Despite the widespread assumption of an association, only one study has provided robust epidemiological evidence linking obesity to PSD. At the University of Minnesota, Cowan (as cited by Dwight in 1953) assessed 30,480 men, demonstrating that those without PSD had an average weight of 103% of normal, whereas the 355 students diagnosed with PSD had an average weight of 109% of normal ($p<0.001$).[12]

The objective of this study was to investigate whether obesity is associated with decreased sweat production, which, if confirmed, might suggest a link between obesity and PSD. The study hypothesis ($H\alpha$) posited that obesity leads to a reduction in sweat production, independent of sports activity.

Materials and Method

All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study did not include any interventions that could cause harm to human participants. Informed consent was obtained from all participants prior to sweat testing. Ethical approval was granted in advance through formal application to and approval by the Institutional Review Board of the Ärztekammer Hannover (approval number:BO/33/2016, dated 08.122016).

Sweat testing was conducted in a cohort of healthy individuals from northern Germany, aged 5 to 79 years, including 332 participants aged 16 years or older. Individuals were excluded from the study if they had thyroid disease, muscular disorders, were underweight or had cachexia, pain exceeding 3 on the Visual Analogue Scale,[13, 14] or any conditions associated with known or suspected disturbances in temperature regulation or fluid balance, such as fever, renal disease, ileus, dehydration, or endocrine disorders. Additionally, individuals receiving diuretic therapy were deemed ineligible.

Participants were classified according to the World Health Organization (WHO) criteria for body weight as follows:

- Category 0: Underweight, with a body mass index (BMI) below 18.5 kg/m^2.
- Category 1: Normal weight, with a BMI between 18.5 kg/m^2 and <25 kg/m^2.
- Category 2: Overweight, with a BMI of 25 kg/m^2 and above.[15]

In Category 2, BMI ranges of WHO-defined pre-obese individuals and those with class I–III obesity were combined. Although waist circumference is recognized as a reliable indicator of intra-abdominal fat deposits and cardiovascular risk,[16] it was not utilized in this study due to its limited accuracy in assessing body weight-related exertion, as it does not account for height and associated weight.[16]

Sweat Test

Sweat testing was performed as previously described.[11,17] In summary, the procedure was conducted as follows:

The Macroduct Sweat Collection System (Webster Sweat Inducer, iontophoresis electrodes, SS-032G pilocarpine gel discs, and sweat-collecting device; Kreienbaum Neoscience GmbH, Langenfeld, Germany) was used, ensuring standardized sweat collection across all participants. The test area was restricted to the lumbar region, with the red electrode positioned midway between the fossae sacrales (Figure 2). To avoid alterations in skin perfusion, alcohol swabs were not used for skin preparation.

Sweat production was induced via pilocarpine iontophoresis, with the red electrode placed on the glabella sacralis and the black electrode positioned approximately one fingerbreadth above. A Webster sweat inducer (model 3700) delivered a constant iontophoretic current of 1.5 mA for five minutes. Pilocarpine was administered through reagent-impregnated (0.5% pilocarpine) solid agar gel discs (Pilogel® discs). This method is recognized as a reliable and standardized approach for inducing sweat production and is widely used for sweat stimulation and collection, including in neonates for the diagnosis of cystic fibrosis.[18-20]

Sweat was collected for 15 minutes following standardized iontophoretic stimulation using a Macroduct sweat collector. The volume of sweat collected was determined by measuring the length of the fixed-diameter plastic tube filled with sweat using the standardized Macroduct scale. Immediately after removal of the Macroduct sweat collection system from the pilocarpine-stimulated skin area, any residual fluid at the contact site was absorbed using a pre-weighed dry swab. The swab was then weighed using a wind-shielded Sartorius scale (model 1201 MP2, Sartorius). The weight of the swab plus the absorbed fluid was added to the volume collected via the Macroduct system, and all measurements were documented in Excel (Microsoft Office Package 2003, Microsoft Corp., Richmond, USA).

Statistical Analysis

To assess differences in sweat response between BMI groups and levels of sports activity, statistical analyses were performed using an independent t-test. This test was applied to compare the mean sweat response between normal-weight and overweight individuals across varying activity levels. A p-value of <0.05 was considered statistically significant.

Results

There were 148 participants in BMI Group 1 and 184 participants in BMI Group 2. Across all individuals, the total average sweat response was 18.5±2.6 µl. The normal-weight group exhibited a higher overall sweat response, with a mean of 20.74±2.5 µl, compared with 17.10±2.8 µl in the overweight group (p<0.001) (Table 1).

In the absence of sports participation, the sweat response was similar between normal-weight (16.84±1.3 µl) and overweight individuals (15.95±1.4 µl) (p=0.238). Among those engaging in sports once a week, the sweat response increased to 17.69±1.2 µl in the normal-weight group and 18.74±1.6 µl in the overweight group (p=0.825). For individuals participating in sports more than twice a week, the difference was significant, with normal-weight individuals showing a sweat response of 27.70±2.9 µl compared with 24.47±1.6 µl in the overweight group (p<0.001) (Table 1).

Discussion

This analysis demonstrates that sweat response is substantially influenced by both BMI and physical activity levels. Although overweight individuals exhibit greater sweat production at rest and during low-intensity activity, normal-weight individuals demonstrate a more pronounced increase in sweat response with higher levels of physical exertion. This suggests that thermoregulatory efficiency is optimized in normal-weight individuals, whereas overweight individuals may experience physiological constraints in sweat gland activation and heat dissipation during intense exercise. Further research is warranted to evaluate the impact of hydration status, environmental factors, and long-term training adaptations on sweat response across different BMI categories.

Although the data suggest that normal-weight individuals tend to exhibit a slightly higher sweat response, particularly with increased physical activity, statistical analysis confirms that this difference is not sufficiently robust to be deemed substantial. Conversely, overweight individuals display consistently high sweat responses across all levels of activity; however, their peak sweat output does not surpass that of the normal-weight group in a meaningful manner. These findings imply that BMI alone is not a major determinant of sweat response.

The data presented in the table highlight a clear correlation between sports participation and sweat response, with a general trend of increased sweat production as the frequency of sports activity rises. Individuals engaging in sports more than twice per week demonstrate the highest sweat response within both normal-weight and overweight groups. This suggests that regular physical activity enhances the body's ability to produce sweat, likely as a thermoregulatory adaptation to exercise.

Regarding sweat response and sports frequency, a higher sweat response is observed with increased sports participation: both normal-weight and overweight individuals who engage in sports more than twice per week exhibit the highest sweat output (27.70 µl for normal-weight individuals and 24.47 µl for overweight individuals). Those participating once or twice per week show a moderate increase in sweat response compared with non-athletes.

There is a consistently high sweat response in overweight individuals: sweat production in this group remains relatively elevated across all levels of sports participation, suggesting that higher body mass contributes to greater baseline sweating, potentially due to increased heat production. However, their capacity to further increase sweat response with higher physical activity is less pronounced than in normal-weight individuals, indicating potential limitations in thermoregulatory efficiency.

A dynamic sweat response is observed in normal-weight individuals: the most substantial increase in sweat production with rising sports participation occurs in this group, suggesting a more efficient sweating mechanism as fitness levels improve. This supports the concept that individuals with higher physical conditioning develop more responsive sweat gland function, thereby enhancing their ability to regulate body temperature effectively. These findings align with existing literature, which suggests that sports participation and physical activity substantially enhance sweat production as part of the body's adaptation to exercise. Studies have shown that regular exercise increases sweating capacity by improving sweat gland activity and initiating earlier sweat onset. Highly trained athletes tend to sweat more and at lower core temperatures than untrained

Table 1. Pilocarpine-induced sweating (µl) in northern German healthy volunteers aged ≥16 (n = 332), cross-table for body weight versus sports activity

Level of sports activity	Total sweat response (n)	BMI group 1 (normal weight) (n)	BMI group 2 (overweight) (n)	p
1: No sports	15.95±1.4 (144)	16.84±1.3 (45)	15.95±1.4 (99)	0.238
2: Sport once or twice a week	17.89±1.3 (110)	17.69±1.2 (54)	18.74±1.6 (56)	0.825
3: More than twice a week	24.47±2.2 (78)	27.20±2.9 (49)	24.47±1.6 (29)	<0.001
Total	18.57±2.6 (332)	20.74±2.5 (148)	17.10±2.8 (184)	<0.001

BMI: Body mass index

individuals, enabling more effective thermoregulation during intense exercise. Thus, higher fitness levels correlate with a greater sweat response, consistent with the data presented in this study, where normal-weight individuals engaging in frequent sports activity demonstrate the most substantial increase in sweat response.

Obesity is associated with elevated sweat rates at rest and during low-intensity activities. However, studies suggest that overweight individuals may not enhance their sweating as effectively during intense physical activity compared with trained individuals. This may be attributed to lower overall fitness levels, reduced sweat gland efficiency, and a greater reliance on alternative heat dissipation mechanisms, such as increased cutaneous blood flow. Nonetheless, any form of physical training, regardless of intensity or body weight, has the potential to enhance sweat production. This finding has implications not only for personal fitness and physiological well-being but also for the potential prevention of PSD.

The present study has certain limitations. The sample size is of moderate scale, and the cohort of normal-weight participants is representative of the typical behavior and physiological responses observed in a northern German population. However, variations in activity levels, sweating responses, BMI, and other physiological parameters may differ substantially across populations in Mediterranean, sub-Saharan, and Asian regions, where climate, dietary patterns, and lifestyle habits vary considerably.

Conclusion

This study indicates that sports participation plays a crucial role in enhancing sweat response. Although overweight individuals tend to exhibit a higher baseline sweat output, their ability to further increase sweating during intense exercise appears somewhat constrained compared with normal-weight individuals. These findings suggest that fitness level, rather than BMI alone, serves as a more substantial determinant of an individual's sweat response and thermoregulatory efficiency during physical activity.

Ethics

Ethics Committee Approval: Ethical approval was granted in advance through formal application to and approval by the Institutional Review Board of the Ärztekammer Hannover (approval number: BO/33/2016, dated: 08.122016).

Informed Consent: Informed consent was obtained from all participants prior to sweat testing.

Footnotes

Authorship Contributions

Surgical and Medical Practices: D.D., I.B., Concept: D.D., I.B., Design: D.D., I.B., Data Collection or Processing: D.D., M.K., Analysis or Interpretation: D.D., J.S., MK., Literature Search: D.D., J.S., MK. Writing: D.D., J.S., MK.

Conflict of Interest: No conflict of interest was declared by the authors.

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CASE REPORT

Recurrent Inter-Sphincteric Pediatric Fistula in Ano Cured by Kshar Sutra (a Medicated Seton): A Case Report

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ABSTRACT

Fistula in ano (FIA) in the pediatric population is infrequent and poorly understood. The management of paediatric FIA remains a matter of debate. This case report highlights a 10-year-old boy with an inter-sphincteric fistula successfully treated with Kshar Sutra (a medicated herbal seton), with weekly thread changes. The procedure was conducted under local anaesthesia. Antibiotics were not given to prevent infection. The wound was completely healed in 7 weeks. The child has been fistula-free for 5 years, indicating that the Kshar Sutra method is an effective treatment option for similar pediatric cases.

Keywords: Case report, fistula in ano, Kshar Sutra, pediatric, recurrent

Introduction

Fistula in ano (FIA) in the pediatric population is infrequent and poorly understood. Several features distinguish pediatric FIA from its adult counterpart. It occurs almost exclusively in otherwise healthy boys under 2 years of age and originates in contiguous crypts.[1-3] Some authors have hypothesized a congenital etiology due to the high incidence of FIA in infants, the overwhelmingly male predominance, and the higher incidence of associated FIA.[4] The infection in the anal gland forms an abscess, most commonly in the 3 o'clock and 9 o'clock positions, and 20-85% of perianal abscesses are reported to progress to FIA. As such, anal fistula should be considered a continuing disease of perianal abscess.[5] Treatments such as fistula-tract laser closure (FiLaC), ligation of inter-sphincteric fistula tract (LIFT), fistulotomy, cutting seton, seton stitch, fistulectomy, fibrin glue injection, fistula plug, endorectal advancement flap, video-assisted anal fistula treatment, and stem cell therapy are practised throughout the world. The management of FIA during childhood remains controversial because it depends on the surgeon's approach, such as conservative or surgical treatment, use of antibiotics, and surgical timing.[6] Therefore, the search for the best treatment of FIA in children remains ongoing. Herein, we present a rare case of recurrent inter-sphincteric pediatric FIA cured by Kshar Sutra (a medicated herbal seton).

Case Report

A 10-year-old boy had been suffering from recurrent perianal abscesses since August 2018. He had a history of abscess drainage multiple times. A physical examination was conducted in July 2019 at Om Ayurvedic Clinic. On examination in the lithotomy position, the internal opening was at the 12 o'clock position, 1 cm from the anal verge. There was no anal sphincter spasm. Specific non-diagnostic conditions were excluded. Magnetic resonance imaging revealed a linear fistula 3.7 cm in length with an internal opening at the 12 o'clock position (Figure 1). A blind extension toward the scrotum was 1.5 cm from the external opening. The patient was healthy and there

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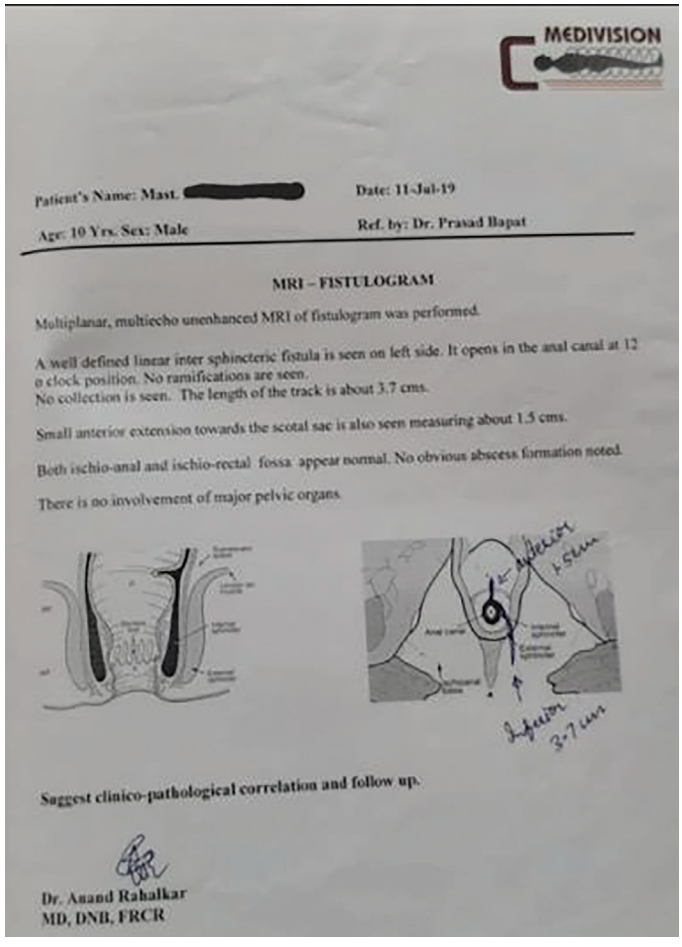
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was no history of Crohn's or any other disease. The Kshar Sutra thread was used to treat the patient's fistula.

Informed patient consent was obtained. Under local anaesthesia, the fistula was traced with a probe. The Kshar Sutra seton was then inserted through the external opening of the fistula and taken out through the anus. An artificial opening was created at the end of the blind extension. The second thread was inserted from the existing external opening and taken out through the artificially made opening. Both ends of each thread were tied to fix their positions (Figure 2). The procedure took 30 minutes.

Weekly follow-ups were on an outpatient basis. Local anaesthesia was used in and around the fistula each time. Both threads were replaced with new ones. The patient had follow-ups for 5 weeks, and a new Kshar Sutra was inserted each week using the same procedure. There was an open, clean wound after 5 weeks of treatment (Figure 3). No supplementary medicines were prescribed for wound healing or infection control. A non-steroid anti-inflammatory drug was recommended as a painkiller whenever necessary. There were no complications such as infection, severe pain, severe bleeding, and incontinence following the procedure. Daily dressing with Betadine® 10% liquid was advised. The wound was completely healed in 7 weeks. The patient was placed under observation for 8 weeks. He has been fistula-free for the last 5 years (Figure 4).


MEDIVISION

Patient's Name: Mast. [redacted] Date: 11-Jul-19

Age: 10 Yrs. Sex: Male Ref. by: Dr. Prasad Bapat

MRI – FISTULOGRAM

Multiplanar, multiecho unenhanced MRI of fistulogram was performed.

A well defined linear inter sphincteric fistula is seen on left side. It opens in the anal canal at 12 o clock position. No ramifications are seen.
No collection is seen. The length of the track is about 3.7 cms.

Small anterior extension towards the scotal sac is also seen measuring about 1.5 cms.

Both ischio-anal and ischio-rectal fossa appear normal. No obvious abscess formation noted.

There is no involvement of major pelvic organs.

Suggest clinico-pathological correlation and follow up.

Dr. Anand Rahalkar
MD, DNB, FRCR

Figure 1. Magnetic resonance imaging fistulogram

Discussion

Few data are available on anal fistulas in the pediatric population. The treatment of FIA usually involves fistulectomy or fistulotomy, in which the fistulous tract is excised or opened across its entire length to identify the corresponding abnormal anal crypt. Rojanasakul et al.[7] and Vander Mijnsbrugge et al.[8] reported a success rate of LIFT for FIA treatment of 94.4% and 40.0%, respectively. van der Hagen et al.[9] observed that after 12, 48, and 72 months, the FIA had recurred in 9 (22%), 26 (63%), and 26 (63%) patients of their mucosal advancement flap group. Frountzas et al. conducted a systematic review and meta-analysis of eight studies, which included 476 patients. The study reported that the pooled success rate of the FiLaC



Figure 2. Kshar Sutra end tied



Figure 3. Follow-up 5 weeks after the procedure



Figure 4. Follow-up image taken on April 16, 2025

technique was 63%, and that the complication rate was 8.0%.[8] Following fistulectomy or fistulotomy, parents are instructed to place the child in a sitz bath after each bowel movement, at least twice daily, and to separate the skin edges of the wound during bathing to promote healing by secondary intention.[10] Controversy still surrounds the etiology and proper management of this condition, as well as the recurrence rate after surgery, which may be as high as 68%.[11]

In his writings, Hippocrates described the use of horse hair setons.[12] Sushrut, an ancient Indian surgeon from 500 BC, explained the herbal thread called Kshar Sutra for FIA.[13] Different formulations of drugs are used for the making of the Kshar Sutra thread. The most common herbal mixture used for coating is Snuhi latex (Euphorbia neriifolia Linn), Apamarga (Achyranthes aspera Linn), and turmeric powder. The thread is a blend of herbal medicines and cutting seton, and it has a cutting and a healing action. The medicated seton has a slow drug release, with the chemical action of the herbal mixture on the infected tissue loosening and liquefying it. The slow cutting and healing avoid incontinence and other complications. The Kshar Sutra technique is an ancient Indian para-surgical treatment and presents a compromise between existing aggressive and conservative treatments. Moreover, there is no need for any post-operative medication for healing, with keeping the wound clean sufficient.

The limitations of the present case report include that only one case is presented and we have not conducted a randomized controlled study. The practical implementation difficulties of the procedure should also be considered, such as the standardization of preparing Kshar Sutra, the lack of runtime imaging technology to ensure the insertion of the thread in the fistula track, and the training of doctors. Large-scale multicentric studies are required to prove the efficacy and safety of Kshar Sutra treatment.

Conclusion

There is no single guaranteed treatment for FIA. Successful results were obtained in the single case reported herein. Ancient Indian Kshar Sutra treatment can present an effective herbal alternative with a high success rate without recurrence or incontinence.

Ethics

Informed Consent: Informed consent was obtained.

Footnotes

Authorship Contributions

Surgical and Medical Practices: P.B., V.B., Concept: P.B., V.B., D.S.P., Design: P.B., V.B., D.S.P., Data Collection or Processing: P.B., V.B., Analysis or Interpretation: P.B., V.B., D.S.P., Literature Search: P.B., V.B., D.S.P., Writing: P.B., V.B., D.S.P.

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LETTER TO THE EDITOR

Refining the Role of Tumor-Infiltrating Lymphocyte Ratio in Colorectal Cancer: A Constructive Perspective of Oğuz İS et al.

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Dear Editor,

I read with great interest the recently published article, "The Relationship of Tumor-Infiltrating Lymphocyte Ratio with Histopathological Parameters and Effect on Survival in Colorectal Cancers." This study examined the interaction between the immune system and tumor microenvironment in colorectal cancer and drew attention to the prognostic effect of the rate of tumor-infiltrating lymphocytes (TIL) ratio. This study addresses an important gap in the field by examining TIL as a prognostic marker, which is commendable for its potential clinical and investigational relevance. [1]

In the article, a 10% cut-off value was used to define high versus low TIL status. However, the literature shows that different cut-off values (e.g., 10%, 20%, or even 50%) have been employed in various cancer types and prognostic studies.[2-4] It would have been informative to explain why a 10% threshold was selected and whether it aligns with any standardization efforts or prior work, such as the International TIL Working Group guidelines or the "Immunoscore" approach proposed by Pagès and colleagues.[5,6] The authors might also consider whether applying multiple cut-off points, rather than a single threshold, could offer greater nuance or predictive value in TIL categorization.

Another point that warrants attention is the possibility that patients with conditions associated with chronic immunosuppression, immune modulation, or hematologic abnormalities (e.g., rheumatoid arthritis, HIV infection, or those receiving immunosuppressive therapies) were not explicitly excluded. These conditions may affect TIL prevalence and the distribution of lymphocyte subpopulations. Were these patients excluded from the study or analyzed separately? Clarifying this would improve the study design and strengthen the results, and I appreciate the authors' rigorous and detailed statistical analyses. Although lymphovascular invasion and nodal status lost their significance in the multivariate model, the protective impact of a high TIL ratio (hazard ratio = 0.68) remained, reinforcing the hypothesis that the TIL ratio may be an independent prognostic indicator. However, I noticed that the confidence interval (confidence interval = 1.005-2.807) was relatively wide, which should ideally be acknowledged as a study limitation.

Additionally, while the authors reported TIL distribution separately for right-sided versus left-sided/rectal tumors, the discussion did not fully address potential biological distinctions between these subsites. Prior research suggests a stronger correlation between TILs and microsatellite instability in right-sided tumors.[7] Exploring such site-specific immunological differences in greater detail could yield even more insightful interpretations.

Lastly, the study showed that disease-free survival results were significant, whereas overall survival (OS) results were not. This may be due to a limited follow-up period or the relatively low number of events (mortality). It is exciting to consider that longer follow-up might reveal a more robust relationship between TIL ratio and OS, further augmenting the strength of these findings.

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In conclusion, this article is important because it highlights points that have rarely been discussed in the colorectal cancer literature. I appreciate the authors' efforts and hope that these observations will pave the way for TIL-based prognostic assessment of colorectal cancer.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.Ö.C., E.D., Concept: A.Ö.C., E.D., Design: E.D., Analysis or Interpretation: A.Ö.C., E.D., Literature Search: A.Ö.C., Writing: A.Ö.C.

Conflict of Interest: No conflict of interest was declared by the authors.

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