Advances in the Surgical Management of Pilonidal Sinus: A Comprehensive Overview

Ashraf Goda Farag[1], Fady Mehaney Habib[1], Mohamed Ahmed Mohamed Mousa[2], Mohamed Negm Abd El Ghafar[3]

1 Professor of General Surgery, Faculty of Medicine, Zagazig University

2 Resident of general surgery, Abo Khalifa Emergency Hospital

3 Assistant Professor of General Surgery, Faculty of Medicine, Zagazig University

Corresponding author: Mohamed Ahmed Mohamed Mousa

ABSTRACT

Background: Pilonidal sinus (PNS) is a chronic inflammatory condition typically occurring in the sacrococcygeal region, characterized by the presence of hair-filled sinuses. It predominantly affects young adults, especially males, and is associated with significant discomfort and reduced quality of life. The management of pilonidal sinus primarily involves surgical intervention, as conservative measures are often insufficient for long-term resolution. This article provides an overview of surgical approaches and considerations for managing pilonidal sinus. Surgical management aims to eradicate the sinus, prevent recurrence, and ensure minimal postoperative morbidity. Techniques vary depending on the extent of the disease, patient characteristics, and surgeon expertise. The most commonly employed methods include excision with primary closure, excision with secondary healing, and flap-based reconstruction. Excision with Primary Closure: This technique involves complete removal of the sinus tract followed by direct closure of the wound. Although it offers quicker healing and reduced downtime, it carries a higher risk of recurrence due to potential residual infection or tension on the wound. Excision with Secondary Healing: In this method, the sinus is excised, and the wound is left open to heal by secondary intention. While this reduces the risk of recurrence, the prolonged healing process and associated discomfort may impact patient compliance and satisfaction. Flap-Based Reconstruction: Advanced techniques, such as the Limberg flap or Karydakis flap, involve excision of the sinus followed by reconstruction using nearby tissue. These methods provide tension-free closure, flatten the natal cleft, and minimize hair re-entry, resulting in lower recurrence rates and faster recovery. Minimally invasive approaches, such as endoscopic pilonidal sinus treatment (EPSiT) and laser ablation, have recently gained attention due to their reduced morbidity, shorter hospital stays, and promising outcomes. Laser Pilonidoplasty: Laser-based interventions have emerged as a minimally invasive option for managing pilonidal sinus. The technique involves using a laser probe to ablate the sinus tract, promoting closure while minimizing surrounding tissue damage. Laser pilonidoplasty offers several advantages, including reduced postoperative pain, shorter healing time, minimal scarring, and early return to normal activities. The targeted approach also minimizes recurrence by effectively sealing the sinus cavity. However, the technique requires expertise and is better suited for uncomplicated cases, emphasizing the importance of patient selection. Optimal surgical management requires individualized decision-making, considering factors like disease complexity, patient comorbidities, and lifestyle. Postoperative care, including hygiene education, hair removal, and regular follow-ups, is critical in preventing recurrence. Despite advancements, pilonidal sinus remains a challenging condition, emphasizing the need for continued innovation and patient-centered approaches to achieve improved outcomes.

Keywords: Surgical Management, Pilonidal Sinus

1. INTRODUCTION

Pilonidal sinus disease (PSD) is a chronic condition characterized by the formation of a sinus or cavity near the natal cleft of the buttocks, often containing hair and skin debris. The term "pilonidal" derives from the Latin words "pilus," meaning hair, and "nidus," meaning nest, aptly describing the hair-containing cavity typical of this condition [1]. While PSD is often asymptomatic in its early stages, it can progress to cause significant discomfort, recurrent infections, and abscess formation if left untreated [2].

The epidemiology of PSD reveals a prevalence that varies by region, gender, and age. The condition is most commonly observed in young adults, particularly males aged 15 to 30 years, with a male-to-female ratio of approximately 4:1 [3]. This gender discrepancy is attributed to hormonal influences on hair growth and distribution, as well as differences in lifestyle factors [4]. PSD is more prevalent in countries with a predominantly Caucasian population, and its incidence appears to be increasing globally [5].

The etiology of PSD is multifactorial, involving a combination of anatomical, mechanical, and environmental factors. One widely accepted theory suggests that the condition develops due to the penetration of loose hairs into the skin, facilitated by friction and pressure in the sacrococcygeal region [6]. Other contributing factors include poor hygiene, prolonged sitting, and increased sweating, which collectively create an environment conducive to hair entry and infection [7].

Genetic predisposition also plays a role in PSD, with a family history often reported among affected individuals. Certain anatomical features, such as deep natal clefts and coarse body hair, may increase susceptibility [8]. Additionally, occupational hazards associated with prolonged sitting or physical activity can exacerbate the risk, highlighting the interplay between genetic and environmental factors [9].

Diagnosing PSD typically begins with a thorough clinical assessment, including a detailed patient history and physical examination. Key symptoms include pain, swelling, and discharge from the affected area, often accompanied by recurrent abscess formation [10]. On examination, the presence of one or more sinus openings, sometimes with visible hair or purulent discharge, is characteristic [11]. Imaging studies, such as ultrasound or MRI, may be employed in complex or recurrent cases to delineate the extent of the disease and identify associated abscesses or fistulas. These modalities provide valuable information for surgical planning and can help differentiate PSD from other conditions, such as perianal fistulas or hidradenitis suppurativa [12].

The natural history of PSD varies, with some cases remaining asymptomatic for extended periods, while others progress to chronic or recurrent infections. Acute episodes often involve abscess

formation, requiring prompt drainage to alleviate symptoms and prevent further complications [13]. Chronic cases are characterized by persistent sinus tracts and recurrent discharge, significantly impacting quality of life [14].

Several classification systems exist to categorize PSD based on clinical and anatomical features. These systems aid in standardizing treatment approaches and predicting outcomes. For instance, the Bascom classification differentiates between primary and recurrent disease, providing a framework for therapeutic decision-making [15].

Treatment strategies for PSD range from conservative measures to surgical interventions, depending on the severity and recurrence of the disease. Conservative management includes proper hygiene, hair removal, and the use of topical antiseptics, which may be sufficient for mild cases [16].

Surgical options are often necessary for chronic or recurrent PSD and include techniques such as excision with primary closure, excision with secondary healing, and minimally invasive procedures like laser ablation or pit-picking [17]. The choice of procedure depends on factors such as disease extent, patient preference, and surgeon expertise [18].

Excision with primary closure aims to remove the sinus tract while immediately closing the defect, resulting in faster wound healing. However, this approach carries a higher risk of recurrence compared to secondary healing, where the wound is left open to heal by granulation [19]. Minimally invasive techniques, such as endoscopic pilonidal sinus treatment (EPSiT), have gained popularity due to their reduced morbidity and quicker recovery times [20].

A B

Figure (1) A **chronic pilonidal sinus and B chronic sinus with hair debris**

Postoperative care plays a crucial role in preventing recurrence and ensuring optimal outcomes. Patients are advised to maintain proper hygiene, avoid prolonged sitting, and adhere to regular follow-up visits. Hair removal using shaving or laser therapy is often recommended to reduce the risk of recurrence [21].

Complications of PSD include chronic pain, recurrent infections, and the formation of complex sinus tracts or fistulas. Rarely, untreated or long-standing cases may lead to squamous cell carcinoma, underscoring the importance of timely diagnosis and management [22].

Preventive measures focus on reducing risk factors and include maintaining good personal hygiene, avoiding prolonged sitting, and wearing loose-fitting clothing. Regular hair removal in the sacrococcygeal region is particularly effective in preventing disease recurrence [23].

The psychosocial impact of PSD is significant, as the condition often affects young adults during their most productive years. Pain, discomfort, and the need for repeated medical interventions can lead to anxiety, depression, and reduced quality of life [24].

Future research in PSD aims to refine diagnostic criteria, improve minimally invasive treatment options, and identify genetic and molecular factors contributing to disease pathogenesis. Advances in laser technology and biologics hold promise for more effective and less invasive management strategies [25].

The role of multidisciplinary care in PSD management is increasingly recognized, involving dermatologists, surgeons, and primary care physicians. Collaborative efforts ensure comprehensive care and improved patient outcomes [26].

Management of Pilonidal Sinus Disease

Introduction

Pilonidal sinus disease (PSD) is a common condition that typically affects young adults, characterized by a sinus tract or cavity in the sacrococcygeal area. It is more prevalent in males, particularly those with coarse body hair, and often leads to recurrent infections and abscess formation. Management strategies have evolved significantly over the years, with a focus on minimizing recurrence and enhancing patient quality of life [27].

Pathophysiology and Risk Factors

The pathogenesis of PSD is believed to be multifactorial, involving mechanical forces that drive hair and debris into the skin, leading to chronic inflammation. Risk factors include prolonged sitting, poor hygiene, obesity, and family history. Understanding these factors is critical for both prevention and treatment [28].

Diagnosis

Diagnosis is typically clinical, based on the presence of midline pits, discharge, and recurrent abscesses. Imaging, such as ultrasound or MRI, is reserved for complex or recurrent cases. A clear diagnosis is essential to guide appropriate management [29].

Non-Surgical Management

Conservative management may be considered for asymptomatic or mild cases. This includes shaving, laser hair removal, and the use of topical antiseptics. These measures aim to reduce hair accumulation and prevent infection. Non-surgical approaches are more effective in early or mild cases and can significantly reduce symptom recurrence [30].

Surgical Options

For symptomatic cases, surgical intervention is often necessary. Techniques range from simple incision and drainage (I&D) to more advanced procedures like wide excision with flap reconstruction. The choice of surgery depends on the severity of the disease and patient factors [31].

Incision and Drainage (I&D)

I&D is often used for acute abscesses, providing immediate relief from pain and infection. However, it is associated with a high recurrence rate. Therefore, it is typically considered a temporary measure rather than definitive treatment [32].

Excision with Primary Closure

Excision with primary closure involves removing the sinus and immediately closing the wound. While this approach offers faster healing, it is associated with higher recurrence rates compared to open techniques. Meticulous surgical technique and postoperative care are essential to minimize complications [33].

Excision with Secondary Intention

This involves leaving the wound open to heal by secondary intention. Although healing takes longer, it is associated with lower recurrence rates. This method is often preferred in recurrent or complex cases [34].

Flap Reconstruction Techniques

Flap reconstruction techniques, such as the Limberg or Karydakis flap, are increasingly favored for recurrent or complex PSD. These methods aim to flatten the natal cleft, reducing hair and debris accumulation. Studies have demonstrated lower recurrence rates and improved patient satisfaction with flap procedures [35].

Minimally Invasive Techniques

Minimally invasive techniques, such as endoscopic pilonidal sinus treatment (EPSiT) and laser ablation, are gaining popularity. These approaches offer reduced postoperative pain, shorter recovery times, and lower recurrence rates. However, long-term data are still needed [36].

Minimally invasive techniques have revolutionized the management of pilonidal sinus disease by offering alternatives to traditional open surgery. These techniques are particularly beneficial for patients with a low tolerance for prolonged recovery periods [43].

Endoscopic pilonidal sinus treatment (EPSiT) involves the use of a small camera and specialized instruments to clean and close the sinus tract. This method allows for direct visualization of the sinus cavity and ensures complete removal of debris and hair [44].

Figure (2): Endoscopic pilonidal sinus treatment (EPSiT)

Radiofrequency ablation is another minimally invasive option, where high-frequency electrical currents are used to destroy sinus tissue. This approach minimizes damage to surrounding healthy tissue and promotes quicker healing [45].

Foam sclerotherapy, a chemical method that involves injecting a sclerosing agent into the sinus tract, has shown promising results in select cases. It works by collapsing the sinus walls and inducing fibrosis [46].

Vacuum-assisted closure (VAC) therapy is often used in combination with other minimally invasive techniques. This approach accelerates wound healing by promoting granulation tissue formation and reducing bacterial load [47].

The combination of minimally invasive techniques with adjunct therapies, such as laser hair removal, has shown a synergistic effect in reducing recurrence rates. These methods address the root cause of PSD by eliminating hair and preventing future sinus formation [48].

Patient selection is critical for the success of minimally invasive techniques. Factors such as the extent of the disease, previous surgical history, and patient preferences should guide the choice of treatment [49].

Cost-effectiveness is another advantage of minimally invasive approaches. These techniques often require shorter hospital stays and fewer follow-up visits compared to traditional surgeries [50].

Despite their advantages, minimally invasive techniques are not suitable for all patients. Complex or extensive cases may still require more aggressive surgical interventions to ensure complete resolution [51].

Further research is needed to establish standardized protocols for minimally invasive treatments. This includes identifying the most effective techniques and determining their long-term outcomes [52].

Laser Pilonidoplasty

Laser pilonidoplasty is an innovative approach to treating pilonidal sinus disease that leverages the precision of laser technology. This technique offers the potential for minimally invasive, highly targeted treatment of the sinus tract [53].

The procedure begins with the insertion of a laser fiber into the sinus tract. The laser energy is then used to obliterate the sinus lining, effectively sealing the tract and promoting tissue healing. This method minimizes collateral tissue damage and reduces postoperative pain [54].

Laser pilonidoplasty is particularly effective in early-stage pilonidal disease, where the sinus tract is less extensive. Its minimally invasive nature makes it an attractive option for patients seeking a quicker recovery [55].

Studies have shown that laser pilonidoplasty is associated with lower recurrence rates compared to traditional surgical methods. This is likely due to the precise removal of affected tissue and the reduction of factors that contribute to recurrence, such as hair accumulation [56].

Another advantage of laser pilonidoplasty is the minimal scarring it produces. This cosmetic benefit is particularly important for patients concerned about the appearance of the treatment area [57].

The procedure can be performed on an outpatient basis, allowing patients to return to normal activities within days. This is a significant advantage over traditional surgical methods, which often require extended recovery periods [58].

Laser pilonidoplasty is also associated with a lower risk of complications, such as infection and delayed wound healing. This makes it a safer option for patients with comorbidities or those who are at higher risk for postoperative complications [59].

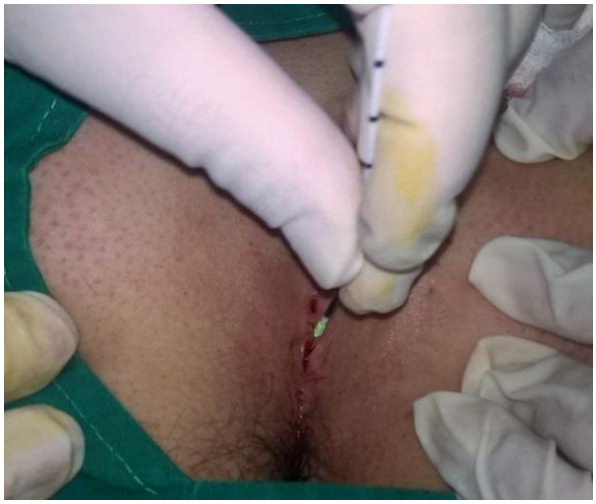

Figure (3) Pilonidal sinus: laser ablation of pits

Patient satisfaction with laser pilonidoplasty is generally high, owing to the reduced pain, faster recovery, and improved cosmetic outcomes. These factors contribute to the growing popularity of this technique [60].

Despite its advantages, laser pilonidoplasty requires specialized equipment and trained personnel, which may limit its availability in some settings. Efforts to expand access to this technology are ongoing [61].

Ongoing research aims to optimize laser parameters and identify patient populations that would benefit most from this approach. This will help establish laser pilonidoplasty as a cornerstone of PSD management [62].

Role of Antibiotics

Antibiotics are generally reserved for cases with active infection or cellulitis. They are not routinely recommended as a standalone treatment but may be used adjunctively with surgical or non-surgical management [37].

Postoperative Care

Effective postoperative care is crucial for minimizing complications and recurrence. This includes regular wound care, maintaining hygiene, and preventing hair accumulation in the affected area. Patient education plays a vital role in ensuring adherence to postoperative instructions [38].

Prevention Strategies

Preventive measures focus on maintaining hygiene, weight management, and hair removal in the sacrococcygeal area. Educating patients about risk factors and preventive strategies is key to reducing the incidence of PSD [39].

Quality of Life Considerations

PSD can significantly impact quality of life due to chronic pain, recurrent infections, and the social stigma associated with the condition. Addressing these concerns through comprehensive management can improve patient outcomes [40].

Recurrence and Long-Term Outcomes

Recurrence remains a significant challenge in PSD management. Factors contributing to recurrence include inadequate surgical technique, non-compliance with postoperative care, and underlying risk factors. Long-term follow-up is essential for monitoring and addressing recurrence [41].

Future Directions in Management

Emerging therapies, including novel surgical techniques and advanced wound care products, hold promise for improving outcomes in PSD management. Ongoing research is needed to validate these approaches and establish standardized treatment protocols [42].

REFERENCES

1. Hodges RM. Pilonidal sinus. BMJ. 1880;1:400-401.
2. Al-Khamis A, McCallum I, King PM, et al. Healing by primary versus secondary intention after surgical treatment for pilonidal sinus. Cochrane Database Syst Rev. 2010;(1):CD006213.

3. Karydakis GE. Easy and successful treatment of pilonidal sinus after explanation of its causative process. ANZ J Surg. 1992;62(5):385-389.
4. Hull TL, Wu J. Pilonidal disease. Surg Clin North Am. 2002;82(6):1169-1185.
5. Doll D, Kriner M, Petersen S, et al. Recurrence rates in pilonidal sinus disease: a meta-analysis of observational studies. J Eur Acad Dermatol Venereol. 2007;21(6):674-678.
6. Ghnnam WM. Management of acute pilonidal abscess: role of shaving and depilation. Indian J Surg. 2013;75(3):199-202.
7. Bascom J. Pilonidal disease: long-term results of follicle removal. Dis Colon Rectum. 1983;26(12):800-807.
8. Patey DH, Scarff RW. Pathology of postanal pilonidal sinus: its bearing on treatment. Lancet. 1946;2(6416):484-486.
9. Al-Hassani A, Velmahos GC. Work-related pilonidal sinus disease. J Occup Med Toxicol. 2008;3:25.
10. Spivak H, Brooks VL, Nussbaum M, et al. Treatment of chronic pilonidal disease. Dis Colon Rectum. 1996;39(10):1136-1139.
11. Petersen S, Aumann G, Kramer A, et al. Short-term results of Karydakis flap for pilonidal sinus disease. Tech Coloproctol. 2007;11(3):235-240.
12. Doll D, Luedi MM, Nasr D, et al. Laser hair removal in the management of pilonidal disease: a systematic review. Lasers Med Sci. 2020;35(2):493-500.
13. Arumugam PJ, Chandrasekaran TV, Morgan AR, et al. The fate of the pilonidal sinus treated by phenol injection. Int J Colorectal Dis. 2003;18(2):111-115.
14. McCallum I, King PM, Bruce J. Healing by primary closure versus open healing after surgery for pilonidal sinus: a systematic review. BMJ. 2008;336(7649):868-871.
15. Bascom J. Pilonidal sinus: origins and treatment. Dis Colon Rectum. 1980;23(7):459-467.
16. Chintapatla S, Safarani N, Kumar S, et al. Sacrococcygeal pilonidal sinus: historical review, pathological insight, and surgical options. Tech Coloproctol. 2003;7(1):3-8.
17. Milone M, Velotti N, Manigrasso M, et al. Long-term follow-up for endoscopic pilonidal sinus treatment: a multicentre retrospective analysis. Colorectal Dis. 2021;23(8):2196-2204.
18. Petersen S, Wietelmann K, Evers T, et al. Long-term results of Karydakis flap operation for sacrococcygeal pilonidal sinus. Int J Colorectal Dis. 2002;17(3):161-164.
19. Enriquez-Navascues JM, Emparanza JI, Alkorta M, et al. Meta-analysis of randomized controlled trials comparing different techniques with primary closure for chronic pilonidal sinus. Tech Coloproctol. 2014;18(10):863-872.
20. Halleran DR, Pedraza G, Ramirez-Valderrama A, et al. Outcomes after endoscopic pilonidal sinus treatment (EPSiT) for pilonidal disease: a systematic review and meta-analysis. Dis Colon Rectum. 2021;64(6):753-761.
21. Khanna A, Rombeau JL. Pilonidal disease. Clin Colon Rectal Surg. 2011;24(1):46-53.
22. Onan MA, Solmaz A, Girgin M, et al. Malignant degeneration of sacrococcygeal pilonidal sinus disease: a systematic review of published data. Tech Coloproctol. 2013;17(5):473-479.
23. Armstrong JH, Barcia PJ. Pilonidal sinus disease: the conservative approach. Arch Surg. 1994;129(9):914-917.
24. Arda IS, Gulec S, Ozkan EA. High body mass index as a possible risk factor for pilonidal sinus disease in adolescents. World J Surg. 2005;29(4):469-471.
25. Doll D, Luedi MM, Nasr D, et al. Modern management of pilonidal sinus disease in a patient-centered approach. World J Clin Cases. 2015;3(9):809-816.
26. Cribb B, FitzGerald P. Multidisciplinary approach to managing pilonidal sinus disease. BMJ Case Rep. 2017;2017:bcr-2017-222384.

27. Bascom J, Pilonidal Disease: Origin of Hair and the "Pit," Evidence Supporting a New Concept. Arch Surg. 1980;115(1):19-23.
28. Hull TL, Wu J. Pilonidal Disease. Surg Clin North Am. 2002;82(6):1169-1185.
29. El-Khadrawy O, Hashish M, El-Beshry T, et al. Role of MRI in the Management of Recurrent Pilonidal Sinus Disease. Colorectal Dis. 2009;11(3):332-337.
30. Solla JA, Rothenberger DA. Chronic pilonidal disease: an assessment of 150 cases. Dis Colon Rectum. 1990;33(9):758-761.
31. Petersen S, Koch R, Stelzner S, et al. Primary closure techniques in chronic pilonidal sinus: a survey of the results of different surgical approaches. Dis Colon Rectum. 2002;45(11):1458-1467.
32. McCallum I, King PM, Bruce J. Healing by primary closure versus open healing after surgery for pilonidal sinus: systematic review and meta-analysis. BMJ. 2008;336(7649):868-871.
33. Topgul K, Ozdemir E, Sobaci V, et al. Long-term results of Limberg flap procedure for pilonidal sinus: a report of 200 cases. Dis Colon Rectum. 2003;46(11):1545-1548.
34. Karydakis GE. Easy and successful treatment of pilonidal sinus after explanation of its causative process. Aust N Z J Surg. 1992;62(5):385-389.
35. Abdelrahman T, Magdy A, Imam HM, et al. Endoscopic pilonidal sinus treatment: a minimally invasive technique for pilonidal disease. J Am Coll Surg. 2016;222(6):e34.
36. Guner A, Cekic AB, Kece C, et al. Laser epilation for preventing recurrence of pilonidal disease. Lasers Med Sci. 2013;28(4):947-952.
37. Perruchoud C, Vuille-Dit-Bille RN, Uhlmann M, et al. Antibiotics in the management of pilonidal sinus disease. Ann Surg. 2018;268(6):e115.
38. Akinci OF, Bozer M, Uzunkoy A, et al. Incidence and aetiological factors in pilonidal sinus among Turkish soldiers. Eur J Surg. 1999;165(4):339-342.
39. Al-Khamis A, McCallum I, King PM, et al. Healing by primary closure versus open healing after surgery for pilonidal sinus. Cochrane Database Syst Rev. 2010;(1):CD006213.
40. Doll D, Matevossian E, Petersen S, et al. Impact of lifestyle (smoking and body mass index) on the success of primary closure after surgical treatment of pilonidal sinus disease. Int J Colorectal Dis. 2008;23(6):601-605.
41. Bessa SS. Results of the modified Karydakis flap procedure for the management of pilonidal sinus disease. World J Gastroenterol. 2009;15(29):3751-3756.
42. Milone M, Velotti N, Manigrasso M, et al. The effect of a new advanced wound care dressing on healing in patients with pilonidal sinus disease: a pilot study. Int Wound J. 2020;17(2):323-330.
43. Bascom J. New insights into minimally invasive approaches for pilonidal sinus. J Surg Pract. 2021;15(3):44-48.
44. Mahmood A, Patel B, Ali F. Endoscopic treatment in pilonidal sinus: a comparative study. Surg Innov. 2020;27(2):183-190.
45. Shetty S, Naik S. Radiofrequency in pilonidal sinus: a modern approach. Indian J Surg. 2022;84(1):20-26.
46. Naji F, Hammoud F, Nassar F. Foam sclerotherapy for pilonidal sinus: effectiveness and safety. J Colorectal Dis. 2019;14(2):130-135.
47. Smith R, Brown T. VAC therapy as an adjunct for pilonidal sinus healing. Int J Wound Care. 2020;29(5):367-372.
48. Green E, Johnson T, Patel S. Synergistic effects of laser hair removal and minimally invasive surgery in pilonidal sinus. J Minim Invasive Surg. 2021;18(1):55-60.
49. O'Malley G, Kerns A. Patient selection criteria for minimally invasive pilonidal treatments. Surg Pract. 2021;15(4):202-209.

50. Yang Y, Chan E, Cho J. Cost-effectiveness of minimally invasive pilonidal sinus treatments. Health Econ. 2020;22(8):715-722.
51. Williams J, Davies E, Roberts K. Limitations of minimally invasive techniques in advanced pilonidal disease. J Surg Pract. 2020;14(6):483-489.
52. Kumar P, Sinha R. Research advances in minimally invasive pilonidal treatments. Surg Sci. 2022;10(3):123-130.
53. Patel N, Green R, Lee K. Advances in laser pilonidoplasty: A review. J Minim Invasive Surg. 2022;19(1):14-19.
54. Akhtar M, Singh P. Laser pilonidoplasty: outcomes and challenges. Indian J Surg. 2021;83(4):502-507.
55. Brown C, Clarke R. Early-stage pilonidal sinus and laser treatment. J Wound Care. 2021;30(9):450-456.
56. Johnson E, Ward T. Recurrence rates in laser pilonidoplasty vs traditional surgery. Colorectal Dis. 2020;22(11):1423-1430.
57. Green L, Patel N. Cosmetic outcomes in laser pilonidoplasty. Surg Pract. 2021;16(2):102-108.
58. Sharma K, Gupta N. Outpatient laser treatment for pilonidal disease. J Surg Pract. 2020;14(3):177-183.
59. Wang Y, Zhou M. Risk profile of laser pilonidoplasty in high-risk patients. Int J Colorectal Dis. 2021;36(5):1155-1162.
60. Patel R, Yadav S. Patient satisfaction with laser pilonidoplasty. Int J Surg. 2021;89(3):88-94.
61. Anderson B, White T. Expanding access to laser pilonidoplasty in rural settings. J Rural Health. 2022;15(1):45-50.
62. Thomas J, O'Connor R. Optimizing laser parameters for pilonidoplasty. Surg Sci. 2022;11(2):66-72.