

Diplomarbeit

**Pilonidal Sinus Disease  
– Options for Surgical Treatment – Review**

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Wien, am 20.09.2017

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# Zusammenfassung

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## Hintergrund

Die Erkrankung des Sinus Pilonidalis ist eine Entzündung der Haut, in der Regel chronisch und rezidivierend verlaufend, und betrifft die Präsakralregion. Die Krankheitsfälle werden hauptsächlich von jungen Männer in einem Verhältnis von 2:1 gegenüber Frauen dominiert. Für die Erkrankung wird eine allgemeine Inzidenzrate von 26/ 100.000 angegeben.

Die Symptome reichen dabei von asymptomatischen Zysten über sinus-ausbildende Läsionen in der Mittellinie bis hin zu Fällen mit schwerwiegender Manifestation, die Umgebung der Rima Ani betreffend. Die Ätiologie der Erkrankung wird nach wie vor diskutiert. In Anbetracht der veröffentlichten Literatur vertritt der Großteil der Autoren die Hypothese einer erworbenen Ursache.

Das Spektrum der Behandlungsmethoden des Sinus Pilonidalis reicht von konservativen Therapieansätzen über minimal invasive und einfachere chirurgische Verfahren bis zu komplexeren Eingriffen und verschiedenen Formen von Lappenplastiken.

## Zweck und Maßnahmen

Die Erkrankung ist generell mit einer hohen Rezidivrate verknüpft, welche die Heilungsanstrengungen in hohem Maß negativ beeinflusst. Zusätzlich wird das Etablieren eines Gold-Standards in der Behandlung der Entität durch die Vielfalt und Komplexität der Manifestation der Krankheit erschwert und wird daher nach wie vor diskutiert.

Infolgedessen soll diese Arbeit einen Überblick über zwölf bewährte chirurgische Behandlungsoptionen, bezugnehmend auf postoperative Komplikationen, Rezidivraten und den Heilungsverlauf, geben. Hierzu wurden Studien aus den letzten 15 Jahren, die operative Behandlungen des Sinus Pilonidalis einschlossen, die zwei oder mehr chirurgische Methoden verglichen, und die Fälle mit einem Mindestalter von 18 Jahren einbezogen, berücksichtigt.

## **Schlussfolgerungen**

Basierend auf endemischen Erkenntnissen sollten weitere umfangreichere Studien, mit dem Fokus auf einer familiären Häufung, durchgeführt werden, um die Diskussion über den ätiologischen Ursprung der Erkrankung zu klären.

Die Evidenz von konservativen Behandlungsansätzen, insbesondere von Laser Depilation und von der Behandlung mit Phenol sollte mit weiteren Studien verbessert werden um das Behandlungsspektrum zu erweitern.

Maßnahmen zur Langzeit-Prävention sollten besondere persönliche Hygiene, konsequente Haarentfernung sofern notwendig, und das Vermeiden von zu langem durchgehenden Sitzen beinhalten.

Verfahren mit primären Wundverschluss zeigen einen schnelleren Heilungsverlauf als offene Behandlungstechniken. Die zweite Gruppe weist im Gegensatz dazu ein niedrigeres Rezidivrisiko auf. In Bezug auf Komplikationen und die gesamte Heilungsrate konnten vergleichbare Ergebnisse in beiden Gruppen gefunden werden.

## **Keywords**

pilonidal sinus, surgical treatment, etiology, risk factors, guidelines

# Abstract

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## **Background**

Pilonidal sinus is described as an infection of the skin affecting the sacrococcygeal region and shows a chronic, recurrent course in general. Men predominate the cases in a ratio of two to one compared to women. The overall incidence rate is reported with 26 per 100,000.

The symptoms of the entity range from asymptomatic cysts to sinus evolving lesions in the midline to cases with extended manifestation affecting the surrounding area of the natal cleft. The etiology of pilonidal sinus remains under debate. Regarding the issued literature, the major part of the publishers supports the acquired theory of origin.

A wide range of treatment options in PSD is in use reaching from conservative approaches to minimal invasive and simpler surgical techniques to more complex procedures and various forms of flap plastics.

## **Purpose and measures**

The entity is associated with high recurrence rates, which impede the healing efforts in great measure. Due to that and based on the variety and complexity of manifestation and symptoms of the disease a definitive treatment as gold standard is still under discussion.

Hence this work will give an overview of twelve established surgical treatment options, regarding the postoperative complications, the recurrence rates and the healing process. Studies of the last 15 years, surveying operative treatment in PSD, comparing two or more surgical options and publications examining patients at least 18 years old were included in the research.

## **Conclusions**

Based on endemic recognitions further comprehensive studies, focusing on familial clustering of PSD, should be performed to resolve the discussion of the etiological origin of the disease.

The evidence of conservative treatment options, particularly laser depilation and phenolization should be improved to broaden the range of treatment modalities.

Long-term prevention measures should include increased personal hygiene, consequent hair removal if required, and the reduction of prolonged sitting intervals.

Primary closure procedures perform with faster healing rates than secondary wound healing. On the contrary the second group impresses with a decreased recurrence risk. According to complications and overall healing rates similar findings were detected in both groups.

## **Keywords**

pilonidal sinus, surgical treatment, etiology, risk factors, guidelines

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# 1. Introduction

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Pilonidal disease is an infection of the skin, ordinarily performing with a recurrent progression, located in the sacrococcygeal area. This condition was first described by Mayo in 1833 as a hair-containing sinus. Later in 1880 Hodge expanded the description by “pilonidal”, which means “nest of hair” (Latin: pilus = hair, nidus = nest) to indicate a better circumscribed term for the disease. [1]

The overall incidence of the disease is reported with 26/ 100,000 in the population with a peak appearance between 15 and 24 years and the entity is associated with a familiar genetic disposition in 12 – 38 percent of the cases. Although both sexes are affected by pilonidal sinus, men prevail the cases in a ratio of two to one. [2-4]

Two main hypotheses referred to the etiology of the disease have been developed actually – an acquired and congenital mechanism.

The congenital hypothesis was proposed first by Gage in 1935. According to that theory the disease is originated from caudal remnants of the neural tube, dermal inclusions or dermal tractions which are produced during the involution within embryonic development. [5]

On the other hand, following the acquired hypothesis, it is assumed that the pilonidal infection has its origin in hair follicles in the natal cleft, distended with keratin, which become inflamed and form in addition pilonidal abscesses. [6]

Corresponding PSD (pilonidal sinus disease) cases have been reported frequently in U.S. service members. In a period of five years during World War II nearly 80,000 soldiers required longer hospitalization periods due to PSD treatments. That is the reason for another term for PSD called “Jeep Seat Disease”. The main factor for the development of the sinus in this case is suspected to be the combination of long bumpy rides over rough terrain and the concussion of the vehicles itself, which causes excessive friction in the sacrococcygeal area. [7]

Additional factors for the skin irritation and consequential infection in this region are adolescent hormones, inadequate personal hygiene, sedentary professions (e.g.

drivers, desk workers), type (density) and amount of body hair, long distance travels in seated positions, obesity and anatomic predispositions as the depth of the natal cleft. [7,8]

The diagnose of the disease is made based on the clinical presentation. The symptoms range from asymptomatic pilonidal cysts or sinuses to painful turgid lesions with tenderness up to high inflammatory absceding areas. The lesions can manifest with intermittent serous-purulent discharge in this state. These pits or sinuses are predominantly located in the gluteal cleft, fluctuating over the sacrococcygeal region. No further medical imaging is required in general. [1,8,9]

Other inflammatory lesions, with similar histological features as tracts, granulation tissue, foreign-body giant cells and granuloma, should be excluded in the differential diagnoses. They include anal fistula, hidradenitis suppurativa and pyoderma gangrenosum among others. A rectal palpation should be performed within the examination therefore to rule out fistulous diseases as well as a pre-sacral mass due to tumorous processes. [1,10]

Hidradenitis may contain hair shafts, though it is primary located in the axillae, perineum and inframammary regions. Hair shafts can be found in the lesions of pyoderma gangrenosum. They are affecting the lower limbs in general and the disease is presenting most commonly in its necrolytic ulcerative form. [1,11,12]

The choice of treatment options depends on the acute or recurrent presence of the disease. So far conservative treatment options as for example laser and light treatment, and various surgical options are in use. They range from incisions, excision techniques with primary or secondary wound closure over minimal invasive procedures as pit excision and marsupialization up to various flap techniques as plastic surgery methods. Due to the variety of clinical symptoms and appearances the gold standard for surgical treatment for pilonidal sinus is still under debate. [13,14]

Hence this work will give an overview of twelve established surgical treatment options, regarding the postoperative complications, the recurrence rates and the healing process after the performed procedures.

## 2. Scientific Background

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### 2.1. Historical Overview

The structured recording of pilonidal sinus started in 1924 when Stone MD resumed eight articles published in the preceding 60 years on that topic. He described the lesions at the height of the sacrococcygeal joint, becoming apparent by a small orifice with a diameter of three to five millimeters, partially including a hank of hair in the opening. The epithelium lined sinus tracts were reported ending blindly in a pouch. Stone quoted the hypothesis, postulated by Warren in 1867, a reversed hair follicle being a basis of the disease. [15]

In further consequence recommendations and options for the treatment of pilonidal sinus have been established.

In 1932 Lahey suggested the radical excision of the lesions down to gluteus maximus muscle fibers combined with a relaxing incision for the mobilization of a flap of skin from one side of the wound margin to avoid wound dehiscence. [15]

Newell described eleven case reports of women in 1933. These patients underwent a radical excision of the lesions after a treatment with lipiodol injections followed by a radiograph. The sinuses and joining tracts were excised in the shape of an asymmetric dumbbell and ensued by primary closure without drainage. Postoperative sepsis was reported as a common complication in these cases. [15]

According to Buie during Second World War the rate of operations of excisions with primary closure increased to reduce the number of rejected members in the U.S. armed forces. These interventions resulted in prolonged postoperative hospitalization and a substantial loss of duty times of the affected soldiers. Due to that Buie preferred the exclusive excision of the superficial component followed by the marsupialization of the lesions. [15]

Karydakos asserted in 1973 that previously described operation techniques would facilitate the accumulation of new hairs by arising a gate of entry at the depth of the excision ground. He invented another approach for the surgical treatment of pilonidal sinus for that reason. Within his procedure he raised a full thickness flap and sutured it to the sacrococcygeal fascia and to the skin subsequently, with the intention to avoid any scar or cavity in the depth of the wound. [15]

The treatment options had been extended in the following decades by Bascom and his procedures, by Kitchen introducing a modification of the Karydakos flap and by less invasive approaches as fistulotomy with marsupialization. [15]

## **2.2. Morphology and Clinical Presentation**

According to contemporary textbooks of pathology, dermatology and surgery pilonidal sinus is described as a pyopoietic, cavernous inflammatory response affecting the natal cleft respectively the sacrococcygeal region. Underlying cysts or sinuses and tracts, supposed being evolved secondarily within the progression of the disease, are recorded as major histological characteristics. 75 percent of them are invading the subcutis enclosed by chronically inflamed tissue, and are accompanied by dislocated hairs and fibrosis. [16]

Pilonidal sinus disease is diagnosed based on the clinical presentation. The disease can occur in form of asymptomatic sinuses and with recurrent cysts and tracts in terms of a chronic stage. The appearance can include an acute exacerbating state with rubor, painful swelling, purulent discharge of the lesions and abscess formation. The main part of the abscesses can be observed in this case in the cranial cleft. The entity shows ordinarily a chronic recurrent course. [16-18]

## **2.3. Histology and Microbiology**

In 92 percent of the examined PSD cases hyperkeratosis of the terminal follicles was detected. Further on hyperplasia of the follicular epithelium was found in 80 percent of the samples and distinctive peri-folliculitis in 64 percent of the cases. Sinus tracts formations could be shown in 44 percent of the specimens and follicle ruptures appeared with a rate of 40 percent. A dermal infiltrate of inflammatory cells combined with epidermal hyperplasia, similar as in psoriasis, was evident in 93 percent of the surveyed samples. It occurred in contrast to real psoriasis without a para-hyperkeratosis and the absence of an impaired stratum granulosum. [16]

More than 59 percent appeared with an acute inflammation including more than 50 percent of the dermal layers, 70 percent of the samples presented with a chronic scarring inflammation affecting more than 50 percent of the dermis as well. Apocrine glands were involved in 57 percent with surrounding inflammation, stasis of secretion, dilatation and hyperplasia. The subcutis showed inflammatory infiltration signs in 89 percent and dislocated hairs being in place in 74 percent of the samples. [16]

In inflammatory hot spots CD8 positive lymphocytes were revealed spread in the stratum basale and the suprabasal epithelial layers above. Indications for cell-mediated cytotoxic processes in the epidermis were missing. [16]

These findings confirmed the authors assumption sinus tracts being more likely a result of inflammatory processes in the follicles than being developed primarily before the onset of the symptomatic disease. [16]

### **Microbiology**

The microbiology of pilonidal sinus contains generally a polymicrobial flora and a prevail of anaerobic species, though differences in primary pilonidal sinus cases compared to recurrent lesions of the disease were detected. [19,20]

Surveying the specific bacteria species in primary pilonidal sinus cases a preponderance of *Veillonella* spp., followed by *Peptostreptococcus* spp. and coagulase-negative *Staphylococcus*, as a representative of aerobic bacteria, was recorded. [20]

In recurrent pilonidal sinus specimens *Fusobacterium* spp. and *Veillonella* spp. were detected, dominating the anaerobic field, behind them *Prevotella oralis* and *Peptostreptococcus*. In the range of aerobic/ facultative anaerobic bacteria coagulase-negative *Staphylococci* prevailed. [20]

In other studies, whereas no difference between primary and recurrent pilonidal sinus cases has been made, specifically *Staphylococcus aureus*, *Streptococcus intermedius* and *Streptococcus constellatus* have been found. [19]

Tocchi et al [21] surveyed 103 patients affected by chronic, non-recurrent pilonidal sinus, inactive at the time of the study. The microbiologic examination of the excised specimens detected aerobic and anaerobic bacterial species in 84.4 percent of the cases. Most common *Staphylococcus aureus*, *Streptococcus haemolyticus* and gram-negative cocci occurred. 90.2 percent contained foreign-body giant cells, granulation tissue was found in all cases and 56.3 percent of the specimens contained hairs in the sinus cavities. [21]

The main difference between primary pilonidal sinus and recurrent cases of the disease proved to be the ratio of anaerobic to aerobic bacteria spp. In primary pilonidal sinus samples, it was 107:61, as opposed to this in the recurrent section it was reported with 30:28. [20]

The rate of bacterial growth in the samples of patients with primary and recurrent pilonidal sinus disease was analogous with 84 – 93 percent to 86 – 96 percent. The resemblance between the gut flora and the flora found in primary pilonidal sinus samples can be explained by the anatomic vicinity. [20]

The microbiological flora of recurrent pilonidal sinus samples shows a greater proportion of Gram-positive bacteria than the primary PSD samples. As the severest postoperative complications of surgical interventions in pilonidal sinus cases are associated with gram-positive and facultative anaerobic/ aerobic bacteria this is notably. It has been proved that gram-positive bacteria are the most frequent reason for complex skin infections in an analysis of over 5,000 skin abscesses. [20]

Despite these facts the presence of bacteria in symptomatic pilonidal sinus infections and in the chronic manifestation of the disease is not associated with a higher rate of postoperative wound complications and the supportive effect of the use of an antibiotics prophylaxis for the reduction of complications or recurrences remains controversial. The mainstay of the treatment of a pilonidal abscess is the adequate surgical drainage. [19]

If a peri- or postoperative antibiotic therapy is employed it should include beside anaerobic coverage remedies against aerobic and gram-positive bacteria as well, e.g. a combination of metronidazole with a  $\beta$ -lactam antibiotic, as penicillin, ampicillin or cephalosporines. It is suggested to apply the treatment at least for several days. [20]

To mention another point tubercular pilonidal sinus is rare but should be kept in mind especially in countries with endemic tuberculosis and when treating immigrants of these regions. Tubercular PSD appears atypically in its clinical presentation but should be considered in patients with recurrent sinuses showing a prolonged discharge, in general thin and diluted, as well as in patients with perianal sepsis and a concurrent tubercular lesion on another location of the body. In suspected cases, the diagnosis relies primarily on the histological evidence of a classical tubercle in a surgical biopsic sample. [18]

## 2.4. Etiology and Genesis

The etiology and pathogenesis of pilonidal sinus is remaining unclear by this time. Both theories of congenital and of acquired mechanisms causing the disease are in debate. So far it is not clear how pilonidal sinus disease is developed during early adolescence, in its most vulnerable state with the peak of incidence, specifically if sinuses and tracts are evolved while that time or if preexisting asymptomatic sinuses are converting into symptomatic lesions. [22,23]

### 2.4.1. Congenital Hypothesis of Origin

Many authors proposed a congenital origin in the 19<sup>th</sup> century, based on the studies of the human embryo. These theories assumed the following points as a cause for the disease. [1]

- A caudal remnant of the embryonic neural canal remained persistent adherent to the surface of the cutis and forms in its progress cysts, which end blind in sinuses due to subsequent rupture.
- Sequestered epithelial remnants during the embryotic evolution are causing dermal inclusions and develop into cysts.
- During the involution of the fetal tail dermoid tractions are created caused by insufficient development of the caudal appendix. These tractions form an epithelium-lined tract by attracting the surfaced skin into a subcutaneous region.
- The lesions are considered as preen gland like structures as a phylogenetic representation of the preen gland, located in the sacrococcygeal area of some species of birds, which opens through the skin with a duct. [1]

Bronshtein et al [24] are supporting the congenital hypothesis of origin. They carried out transvaginal ultrasound inspections in 40,000 gravid women within the early second trimester over a period of 20 years to detect fetal malformations. Sonographic characteristics apposite to the “human fetal tail” were apparent in 25 of the surveyed cases. The main part of the affected fetuses presented with rubor, a skin tag or scar tissue and a lumbo-sacral dimple located in the midline after

delivery. These cutaneous abnormalities were considered being remnants of the fetal tail which is regressing by eight weeks of gestation ordinarily. [24]

Following this hypothesis, the fetal buttocks cover vestigial remnants of the fetal tail within their development in the embryonic progression. Epidermal residues get buried in the midline, and a potential undermined space is created as a result. Beholding the etiology, it is evident that most of the pilonidal sinus cases and abscesses occur in males (69 percent), up to 75 percent of the lesions contain hairs and 31 percent emerge after the age of 17 years. These three factors support the “tail theory” as followed. [24]

The male predominance compared to women and the mainly affected age of the pilonidal sinus cases can be explained by the excessive stimulation of growth of hair due to higher androgen secretion after the pubescence. This emphasizes the fact that the sinuses contain hair and the preponderance of the disease among young soldiers, as mentioned above under the term “Jeep Seat Disease”. The hair follicles developing after puberty may lay the base for a formation of a potential canal as a virulent focus. Excessive friction and pressure, the possibility of relative hypoxia and subsequent infection in the area promotes the evolution of an abscess. [7,24]

According to that the evidence of a deeper natal cleft in PSD patients compared to the unconcerned population has been proved. Akinci et al [8] performed a study evaluating that fact including 50 patients with pilonidal sinus who underwent prior operations and 51 non-affected volunteers. The depth of the natal cleft was gauged in millimeters by using a special tool which was constructed for that purpose. The differences between the two surveyed groups turned out statistically significant with a mean depth of the natal sulcus of 27.06 mm in the pilonidal sinus group and of 21.07 mm in the non-affected control group ( $p < 0.01$ ). [8]

Bronshtein et al [24] adduced another fact as argument for the hypothesis of the congenital origin PSD. The midline location of the primary lesions dissents the acquired theory of abnormal internal developing hair. The pressure affecting the buttocks is stronger than the force in the midline due to the anatomic circumstances. Although the gluteal area presents with substantial hair follicles, pilonidal abscesses hardly ever develop in that region compared to the midline. This zone is the location of the former embryonic fetal tail moreover. [24]

Pilonidal sinus disease in its asymptomatic form may be supposed to be of congenital origin and is more abundant than assumed so far. It is found not uncommonly in uteri, though only serious PSD cases are revealed by ultrasound. These lesions are frequently classified as dimples with no treatment consequences. [23]

Chamberlain and Vawter could detect tracts or residues of tracts suitable to the characteristics of pilonidal sinus in eight percent of the surveyed cases, when performing a study examining excised natal clefts in autopsies of 100 children aged between one day and 14 years. According to them and to Akinci et al the abundance of asymptomatic sinus remnants remains tenfold higher than the incidence of asymptomatic pilonidal sinus cases in the overall population. [23,25]

#### **2.4.2. Acquired Hypothesis of Origin**

By contrast the acquired hypothesis of the genesis of pilonidal sinus has been developed based on the following statements. [1]

- Similar lesions are described in other locations of the body.
- Abnormities of the fetal development located in the cervical and dorsal regions of the spine are occurring apart of pilonidal sinus. They show comparable characteristics to malformations appearing in the sacrococcygeal area.
- The appearance of the disease in the adolescence period and in the time following puberty is not consistent with a defect based on a genetic maldevelopment.

- The preponderance of the male gender in the affected population is mentioned as a point against the congenital hypothesis whereas a more balanced ratio of both sexes should be expected in the cases.
- The combination of the manifestation of the symptomatic disease and the specific occupation of the patients, e.g. Jeep or truck driving soldiers, sheep shearers and dog groomers is another argument against a congenital genesis.
- Histological findings revealed free hair shafts buried in granulation tissue or scars in the nidi of the disease. The main part of them appears without lining epithelium or hair follicles in the walls of the sinuses. This absence was invoked as substantial dissent contrary to the congenital thesis. [1]

Bascom surveyed pilonidal sinus lesions in the typical location in the midline of the natal cleft and invented a pathogenetic hypothesis for the disease, based on microscopical examinations in 1980. He identified them as enhanced and distorted hair follicles. He assumed furthermore that gravity and the motion of the gluteal folds would cause friction and the formation of a vacuum in the natal cleft. [1]

Due to that the extension of the follicles subsequently occurs. Secondary inflammation by bacteria leads to the occlusion of the follicles' mouth through debris and edema and to a further consequent expansion of the follicle itself. These extended midline pits are getting filled with keratin and debris within the process. [1,16]

This may be followed by ruptures, the development of foreign body reactions and micro-abscesses. If the inflammation increases and leads to laterally protruding tracts combined with a buried sustained infection a pilonidal sinus is emerging. These tracts are partly epithelialized and 50 to 75 percent of them contain hair shafts in their cavity, which was confirmed by explorations of the lesions. [1,25]

Hairs are a main factor for the development of the disease. They can remain in the enlarged hair follicle and support the formation of micro-abscesses on one side. The opening of the follicle on the other hand acts as portal of entry for free hair from other locations and facilitates a foreign body reaction. Additional hairs in the closer environment of the lesion cause irritations mechanically and affect healing that way. [1]

Focusing on the pathogenesis of PSD Karydakis ascribed the hair insertion process to the invading detached hair, to the force, as a reason for the penetration, and to the vulnerability of the skin in the depth of the natal cleft. He released large pilonidal sinus case series in 1992, confirmed the acquired hypothesis and stated, minor local trauma combined with hair invasion being the main predisposing factor for this entity. [1,5]

Stelzner classified pilonidal sinus disease as a dermatopathy, whereby the detritus and hairs are pressed through the skin into the depth by rolling, grinding and suction movements. Followed by the occlusion of the entry at the surface this leads to abscess formation, the development of suppurative fistulas and foreign-body granulomas. He supported the idea that pilonidal sinus is a special mono-localized form of hidradenitis suppurativa. According to other studies 23 to 30 percent of the hidradenitis suppurativa cases are presenting with pilonidal sinus as comorbidity. This was endorsed by Kurokawa et al, who could detect comparable cytokeratin expressions in samples of pilonidal sinus and hidradenitis suppurativa. This conclusion underscores the possible follicular origin of both diseases. [16]

## **2.5. Incidence, Prevalence, Risk Factors**

Pilonidal sinus disease is affecting in general young adults and the over-all incidence rate is quoted with 26 per 100,000 in the population. The peak of incidence is reported with 21 years for men and with 19 years for women, whereas men prevail the cases proportional to women two to one. Within the infantile population the entity is mentioned to occur 4.5-fold more often in females, which changes radically with the onset of puberty. In countries surrounding the Mediterranean Sea an elevated incidence can be observed, by contrast the disease occurs comparable rare in Asian and African populations. [26-28]

According to specific populations adjusted ratios of the incidence have been published: 11/ 1,000 in 1,997 neonates, 63/ 1,000 in 19,750 examined school children in turkey, 14.4/ 1,000 in 5,132 adolescents in Russia, and 61/ 1,000 in 1,000 recruits of the Turkish army. Routine examinations in the University of Minnesota revealed an incidence rate of 1.1 percent in male and 0.11 percent in female students. [25,29]

Duman et al [29] published a study concerning the Turkish population and the incidence of PSD, including 19,013 subjected persons between 17 and 28 years based on clinical examinations. They could detect an increased incidence within the Turkish population with a detection rate of 6.6 percent (1,258 patients), 6.23 percent in male and 0.37 percent in female subjects. The overall incidence for other countries is reported with 0.026 percent. [29]

Allen-Mersh suspected already a progression of the incidence of pilonidal sinus. This could be confirmed by Evers and Doll, who detected a tenfold increase of the disease inside the German military forces from 0.3/ 1,000 in 1985 to 2.4/ 1,000 in 2007. [27]

Within the United States armed forces there could be 35,517 cases of pilonidal cysts detected during an observation interval from 2000 to 2012. Despite a prevail of the male gender is evident in this disease, the incident rates of male and female cases proved to be almost equal in this case with 1.9/ 1,000 for male and 1.7/ 1,000 for female service members. Female affected soldiers evolved recurrent disease symptoms later than their male counterparts with 11.7 percent compared to 10.9 percent. [7]

Approving to other data the highest incident rates occurred in recruits and junior enlisted soldiers and decreased with proceeding age. During the Second World War 79,000 patients underwent surgical interventions based on a diagnosis of pilonidal sinus, 2,000 US army members a year were operated due to that entity over the Second Indochina War. [7,29]

According to Aysan et al [25], the prevalence of pilonidal sinus is mentioned with 4.6 percent (patients showed at least one visible sinus tract as a sign of symptomatic PSD). Clinical ordinary cases underwent histological examinations based on the following histopathological indicators: dilated pilus bulb with or without inflammation, intrafollicular keratinous debris, infiltration of inflammatory cells, fibrosis, one or more hair shafts at any depth of the sub-epidermal layers and/ or in the sinuses. 3.7 percent of the patients revealed at least three positive histopathological parameters and were classified as asymptomatic silently affected. A total prevalence rate of 8.3 percent was defined therefore. [25]

Another conclusion of the study was that pilonidal sinus developed in nearly half of the cases apart from inflammatory processes and that external factors play a substantial role in the genesis of the disease. [25]

As mentioned above according to Karydakos local minor trauma is one of the main ransoming factors for the onset of pilonidal sinus. Further factors are the anatomic predisposition of patients with large buttocks and a deep natal cleft, occupations requiring extended sitting or driving, distinctive hairiness of the body, stiff and coarse hair in general, folliculitis at another location, inadequate local hygiene respectively excessive transpiring and obesity. [28,30]

Referring to comorbidities of the entity it turned out in a study about the Turkish population especially that pilonidal sinus was attended by acne vulgaris and conglobate acne in 0.4 percent and by hidradenitis suppurativa in 0.32 percent of the cases. [29]

In this context, it is important to quote that there is no time-effect relation of the disease and the external factors. Neither long-term exposure to them nor the appearance of a prolonged pilonidal sinus outside the vulnerable window does determine further sinus production by itself. [23]

Additional to the pandering factors above it is shown that a genetic predisposition plays a role in the genesis of pilonidal sinus as well. Doll et al [23] published a study with 578 patients who underwent primary surgery in three German military hospitals between 1980 and 1996 and have been analyzed in relation to long-term recurrence rate and family history of pilonidal sinus. Twelve percent of the patients group had a positive family history including first-degree relatives. 28 brothers and 25 fathers have been involved in these cases. [23]

Harlak et al [28] mentioned in a case control trial lasting for three years with 587 pilonidal sinus patients a slightly elevated ratio of positive family history in first degree family members between the patients and the control group, 16.7 percent versus 14.6 percent, though it didn't turn out statistically significant. [28]

PSD is reported as a family attribute as well, whereat especially male relatives are affected of the disease and share it through sequential generations. Sibling research found out that 16 percent of brothers and 5.7 percent of sisters in the concerned families expose the disease. Hence a higher incidence of primary pilonidal sinus disease within these families is supposed. [23]

A study of Sondenaa et al to determine the risk factors for the genesis and persistence of the disease in 322 patients showed a family history in 38 percent of the patients. In another study, the rate of a positive family history in pilonidal sinus patients was mentioned with 20.4 percent. [14]

The examination of the long-term follow up after primary surgery in PSD, based on the data of the German military, revealed distinctive differences between patients with a pilonidal sinus positive family history and cases which presented with spontaneous appearance of the disease. The long-term recurrence rate was up to two-fold higher after the primary intervention in the first group compared to the cohort without a familiar accumulation. 35 percent versus 22 percent after 15 years and 52 percent contrary to 28 percent after 25 years ( $p = 0.02$ ) were reported for the two surveyed groups. [23]

On closer inspection of the family history positive cases, recurrences occurred in patients with individually affected family members with 35 percent and in cases with multiple relatives afflicted by PSD in 50 percent. It could be detected as well that the recurrence rate was higher if the onset of the disease and associated primary surgery took place at a younger age ( $p = 0.03$ ). [23]

This occurred more often in cases with a familiar predisposition. As time-to-recurrence intervals turned out to be equivalent in family history positive and negative cases different intervals as a cause for the elevated recurrence rate could be excluded. Summarized it can be maintained that a positive family history of pilonidal sinus predisposes to an earlier onset and a higher recurrence rate, though not to an earlier date of recurrence. The conception of the vulnerable phase supports these findings as family history positive patients come within the ambit of that period connected to puberty inside their postoperative interval after primary surgery. [23]

The recurrence rate is decreasing after the vulnerable interval despite prolonged exposure to the external risk factors on the other hand. [23]

Sievert et al [27] examined the influence of smoking and obesity as external risk factors for wound healing and long-term recurrence in primary pilonidal sinus disease. They included 534 patients presenting with primary manifestation of the disease in the study. The majority underwent open treatment (56 percent) or primary midline closure (36 percent) and was surveyed over a mean follow-up of 14.7 years (range 7 – 25 years). [27]

Akinci postulated that a body weight of 90 kg and more and folliculitis could be accountable for the entity based on Balik's findings that the pre-sacral fat showed a raised thickness in patients affected by pilonidal sinus. He rejected this hypothesis after discovering the natal cleft being deeper in PSD patients without a correlation to a significant elevation of the BMI. [27]

The evidence of obesity as an independent coefficient for wound infection and wound rupture in  $BMI > 30 \text{ kg/ m}^2$  has been proved in gynecology so far. Reduced Wound healing was described in muscle flaps as well as in procedures concerning

the fatty tissue. Smoking leads on to reduced healing in bone fractures and compromises soft tissue healing in addition. [27]

The cessation of smoking subsequent to surgical interventions supports symptom-free wound healing on the other side. Regarding to pilonidal sinus, it is reported that smoking may increase the conversion from chronic asymptomatic fistulating PSD to acute abscess formation within the development of the disease. [27]

The results of the study revealed no connection between a BMI of 25 kg/ m<sup>2</sup> and higher and reduced wound healing. Despite that a BMI of 25 kg/ m<sup>2</sup> and above could promote a better wound healing in general. The examination of the wound healing according to smoking showed no impairment of the healing process for the first 20 years after primary surgical intervention. [27]

By contrast it has been stated by Cubukcu et al that obesity in PSD patients leads to an elevated risk of recurrence after surgery. Surveying 114 pilonidal sinus patients who underwent excisions and Limberg flap operations he could reveal a mean BMI of 27.4 kg/ m<sup>2</sup> in the recurrence-free group compared to 29.4 kg/ m<sup>2</sup> in cases affected by recurrences ( $p < 0.05$ ). [14,28]

Regarding to the published literature obesity should be considered as a widely independent risk factor in the manifestation of pilonidal sinus disease, as it is not resolved yet if patients with obesity develop more primary pilonidal sinus cases per se. [27]

In an analysis of previously proposed risk factors for pilonidal sinus disease three most predictive factors have been pointed out, increased body hair rate, poor personal hygiene (affected persons showered or had a bath two or less times a week) and long sitting intervals (more than six hours per day). The authors included 587 patients affected by PSD in the case group and 2,780 non-concerned subjects in the control cohort in the study. [28]

72.07 percent of the patients group showed all three factors above contemporary. Contrary to that they were absent in 602 cases overall, only 1.16 percent of them belonged to the affected patients section. It is assumed that the frequency of showers or baths is related to the amount of free hair in the natal cleft and therefore an increasing factor for the invading process, following Karydakis hypothesis of the origin of the disease. [28]

A logistic regression analysis revealed a 219-fold higher risk for patients who fulfilled the criteria above to develop pilonidal sinus. Focusing on hygiene habits an adjusted risk of a positive diagnosis of pilonidal sinus was reported with a 6.33-fold increased rate for patients who bathed or showered up to two times a week compared to subjects applying a hygiene behavior with a higher frequency per week. [28]

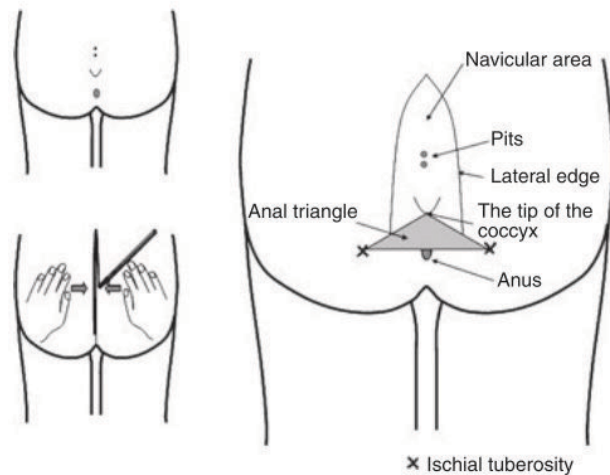
A final recommendation for the prevention of the disease included careful cleaning of the natal sulcus, especially according to people with hirsutism. Patients should direct their attention to an increased hygiene in this aspect. Concerning to people living in a community, e.g. soldiers in barracks, there must be provided sufficient bathing facilities and opportunities. [28]

## **2.6. Classification**

The ongoing research of pilonidal sinus disease revealed the necessity of establishing a classification for a sufficient treatment of the entity.

Solla et al classified pilonidal sinus in 1990 in three categories, 1. acute, 2. chronic, 3. complex or recurrent. In 2002 Bascom sought for a new surgical approach and focused on the deep natal cleft in searching for a major elicitor in the development of pilonidal sinus. The deep sulcus facilitates the expression of the disease by the fact that the skin, particularly the epidermis, is subjected to moisture, debris, (external) hair, anaerobic conditions and bacterial flora in great measure. [15,31]

According to this approach a classification of PSD based on an artificial anatomic demarcation of the natal cleft, the concept of the “navicular area”, was invented by Tezel [31], demonstrated in Fig. 1 [32]. [31,32]



**Figure 1** determination of the “navicular area”

*Note.* Reprinted from Tezel E. A new classification according to navicular area concept for sacrococcygeal pilonidal disease. *Color Dis.* 2007;9(6):575–576. Figure I, definition of the navicular area; p. 575. Copyright 2007 by The Association of Coloproctology of Great Britain and Ireland.

The term “navicular area” has the aim to specify the extension of the natal sulcus. For that the patient is fixed in jackknife position, the buttocks are pressed together from the exterior and are marked with a pen along their contact line in the middle. After the releasing of the tissue a contour running up to a pointed cranial bow-like end appears. The outer lines represent in this case the lateral verge of the cleft. Caudally the area is determined by the cranial posterior margin of the anal triangle, which extends between the apex of the coccyx as its cusp and the ischial tuberosities as its bases, illustrated in Fig. 1 [32]. The nomination of the circumscribed area originated in its vessel-like outline. [31,32]

Based on this consideration and the pathology of pilonidal sinus the differentiation of the disease in five groups was suggested: [31]

- Type I: Asymptomatic pits with the lack of abscesses or spontaneous drainage, located inside the “navicular area”.

- Type II: Acute symptomatic abscesses.
- Type III: Symptomatic pits in the “navicular area” with or without abscesses and previous spontaneous drainage.
- Type IV: Extensive manifestation of the disease with at least one sinus opening beyond the “navicular area”; patients of this group show in general multiple abscesses associated with drainages but without conclusive surgical treatment.
- Type V: Recurrent pilonidal sinus following any surgical intervention. [31]

He added furthermore recommendations for the treatment of the disease. Referring to Bascom’s statement of the importance of the natal cleft as a factor for the progress of PSD, the focus of treatment should be laid on superficial surgical techniques instead of deep wide excisions, which tend to be accompanied by wound dehiscence, delayed healing and increased recurrence rates. These techniques have additionally the disadvantage of removing deep and eventually unconcerned tissue. [31]

For patients with type I pilonidal sinus he advises local hair removal and specific personal hygiene to avoid the progress of the disease. No requirement of surgical intervention exists in this state. [31]

In type II the first line treatment should be drainage with a lateral incision of the focus. Further surgical intervention is mandatory in general at this stage of the disease. [31]

For the types III to V Bascom’s procedure is recommended as definite surgical option, in type IV and eventually V combined with an additional pit excision outboards the “navicular area”. [31]

Especially the chronic, complicated form of the disease is leading to a grave encroachment of the quality of life in affected patients. Hence Guner et al [33] introduced a more specific staging system based on 367 primary chronic symptomatic pilonidal sinus cases which underwent surgical treatment between June 2011 and December 2014. [33]

Based on the morphological dimension and the analysis of the cases in the period above the following fragmentation was clarified. [33]

- Stage I: Single lesion in the midline without a lateral extension.
- Stage II: At least more than one pit limited to the midline.
- Stage IIa: Two to three lesions in the midline.
- Stage IIb: More than three pits (IIa and IIb following the determination of II).
- Stage III: Midline pits and a lateral expansion in one direction.
- Stage IV: Symptoms according to stage III with amplifications in both directions.
- Stage R: Recurrent pilonidal sinus subsequent to any form of treatment. [33]

Patients who presented with acute absceding events were excepted in this system as the development of an abscess may occur in any stage of the disease and is not in need of specific treatment. Asymptomatic cases were not included as well, as they do not require prophylactic surgical interventions and therefore do not underlie a consequence in treatment interventions. [33]

The authors analyzed additionally the applied surgical procedures and postulated recommendations according to the staging system based on previous experiences. [33]

For stage I, up to stage IIa the minimal invasive procedure of “pit-picking” is recommended with the advantage of the possibility to perform the operation under local anesthesia. Apart from that this procedure showed a higher recurrence rate and an increased subsequent intervention rate in patients with more lesions. Despite the possibility of the application of this technique in cases with up to 10 pits, in this case the performance is advised in patients affected by a maximum of three lesions. [33]

For all higher stages Bascom’s Clef Lift or Modified Bascom’s Cleft Lift procedure (BCL/ MBCL) turned out as the best fitting first line treatment, in stage IV the “rhomboid excision with Limberg flap” is preferred as it allows wider tissue excision on both sides and performs with advantageous outcomes. [33]

Irkorucu et al [34] proposed an easy practical staging system for pilonidal sinus, resembling to Tezel's conclusions with the aim to reflect the local expansion of the disease and to form a basis for the comparison of surgical interventions, illustrated in detail in Table 1 [35]. [34,35]

**Table 1** classification of pilonidal sinus disease

Type	Definition	Recommended Management
Ia Pit(s) on the natal cleft	Asymptomatic, one or more pit(s) on the natal cleft	Conservative methods (e.g. local hair removal, epilation)
Ib	Symptomatic and / or more than one pit on the natal cleft	Simple surgical managements (e.g. phenol application, incision and open treatment, etc.) or Bascom's procedure
Ila Pit(s) on one side of the natal cleft in both directions	Distance to the natal cleft under 2,5 cm	Moderate surgical procedures (e.g. unroofing, Karydakis flap, Bascom's cleft lift)
Ilb	Distance to the natal cleft over 2,5 cm	Simple flap procedures (e.g. rhomboid excision and Limberg flap, V-Y-advancement flap)
III Pits on both sides of the natal cleft		Flap procedures with wide excision (e.g. modified rhomboid excision and Limberg flap, Dufourmentel flap)
IV Complex pilonidal disease with multiple pits on the natal cleft and aside of it in both directions		Wide excision and large flap procedures (e.g. rotational flaps, double rhomboid transposition flap, crossed triangular flaps)
V Recurrent Pilonidal Disease		Surgical procedures should be preferred according to the extension of the recurrent disease.

*Note.* Adapted from Irkorucu O, Erdem H, Reyhan E. The best therapy for pilonidal disease: Which management for which type? *World J Surg.* 2012;36(3):691–692. Table 1, The classification of pilonidal disease; p. 692. Copyright 2011 by Société Internationale de Chirurgie.

## 2.7. Treatment Guidelines

As mentioned above already for a sufficient prevention of the progress of pilonidal sinus consequent hair removal respectively shaving of the gluteal cleft and the buttocks combined with specific thorough personal hygiene in this area is an evident factor. This can be considered as a first line treatment in patients with asymptomatic sinuses without abscess formation as well as a part of the postoperative management to inhibit recurrence. Furthermore, it turned out that a consequent hair removal leads to a reduced hospitalization time and a decreased quantity of surgical interventions in affected patients. [36]

Apart from this a wide range of conservative and surgical treatment options with different approaches for the therapy of pilonidal sinus has been established and is in use so far.

Segre et al [36] introduced general based guidelines for the treatment of the disease as members of an expert committee of the SICCR (Italian Society of Colorectal Surgery) with the following statements. These conclusions are concurring for the most part with the practice guidelines for the management of PSD published by Steele et al [10] two years earlier. [10,36]

### Conservative Management

**1.** In absence of an abscess laser epilation shows sufficient results to reduce the amount of possibly invading hairs compared to hair removal through shaving with the advantage of less effort in every day hygiene. Following Steele et al [10] it can be performed as a primary or adjunct measure for acute and chronic PSD cases as well. [10,36]

**2.** The application of fibrin glue can be used as a first-line-therapy in chronic pilonidal sinus cases after smaller surgical interventions as sinus and tract curettage combined with the resection or with the retaining of the cavity, resulting in an early reuptake of normal activities and high satisfaction of the affected persons. [36]

Phenol injections have the advantage of being performed under local anesthesia and can be applied to the same patients group as fibrin glue treatment. They can be conducted uncomplicated in an ambulant setting and are performing with success rates from 60 to 95 percent. [36]

**3.** Antibiotics have been evaluated as prophylaxis in perioperative treatment, in topical application and in postoperative care. Regarding to the literature the use of antibiotics does not support neither increased rates in healing nor lowered rates in recurrence. Despite that they are recommended in immunosuppressed patients or in cases presenting with associated systemic diseases. [10,36]

### Surgical Management

**1.** Pilonidal abscesses should be treated in any case with incision and drainage in first line, lateral incision should be added as it shortens the healing period. Subsequent surgical treatment such as excision with primary closure is necessary within up to 40 percent of the cases. Drains should be used based on individual aspects in surgical procedures. [36]

Patients presenting with acute absceding pilonidal sinus who underwent drainage by incision combined with and without curettage were evaluated in a randomized trial by Matter et al. The cases in which an additional curettage of the sinus cavity with clearance of inflammatory debris and of granulation tissue was performed, showed a significant higher healing rate at ten weeks compared to the group which only underwent incision and drainage. Results with 96 percent versus 79 percent,  $p = 0.001$  were recorded in the two groups. A lower recurrence rate was detected as well in the first group up to 65 months after the intervention, 10 percent versus 54 percent,  $p < 0.001$ . [10]

Excision and primary closure can be regarded as the first definitive surgical treatment option of absceding pilonidal sinus disease. In this case the existence of an acute abscess plays a larger role for the indication of the operative intervention than chronic inflammation. The recurrence rates reside in 30 percent. [36]

Using of drains is common within the surgical treatment with the aim of removing inflammatory effluent and debris and of maintaining the irrigation of the wound bed. In a nonrandomized study about chronic pilonidal sinus it was shown that drain placement within the wound closing process enables faster healing rates and a lower amount of complete wound dehiscence. Despite that the recurrence rates revealed on a similar level as in cases without drain placement. [10]

In further case-studies mainly suction drains were inserted for two to six days postoperatively. A healing rate of over 85 percent and complication rates of up to 10 percent without directly to the drain associated morbidities were detected. In combination with flap procedures drains turned out to support a lower appearance of postoperative wound fluids but recurrence rates and postoperative infections remained on the same level. According to that drains should be used on individual basis by the performing surgeon. [10]

**2.** When it comes to the decision between open healing and excision techniques with primary closure no distinctive advantage for one of the two approaches could be detected. This conclusion was based on the 2010 Cochrane systematic review, which included all Randomized Control Trials referring to that task between 1985 and 2009. If primary wound closure is intended, off-midline closure should be used. [36]

The advantages of the primary closure approach are obvious shortened healing times, 10 to 27 days compared to 41 to 91 days in open-treatment groups and shorter operation times. This is a major cause for the choice of these methods regarding to the earlier return to work of the patients. On the other side, the recurrence risk can be decreased by 35 percent in when performing an open healing method in comparison to primary closure procedures. [10,36]

When primary wound closure is the aim of the intervention, off-midline closure should be applied as a standard procedure as an explicit lower recurrence rate is reported in the use of these techniques compared to midline closure procedures, 1.7 percent versus 10.5 percent. The risk of postoperative complications and recurrences in the midline closure section is mentioned with 22 to 41 percent on its own. [10,36]

**3.** Patients who are affected of mild-to-moderate PSD can gain from the use of minimal invasive procedures with successful outcome. [36]

Marsupialization, subtotal excision, Bascom's procedure with the lateral incision and "pit-picking" should be contemplated within this group. In the last case, the disadvantage of high recurrence rates is predominated by the facility of the performance and the success rates if subsequent operations are required (85 percent healing rate by the first operation, 95 percent by a secondary surgical intervention). [36]

**4.** High-risk patients with hirsutism, deep natal clefts, chronic infected unhealed lesions after prior surgical treatment failure, and with extended affection of the disease combined with multiple-recurrent manifestation may warrant flap based operations. [10,36]

The main targets of these interventions are to flatten the natal sulcus, to provide the coverage of the lesion with healthy tissue and to avoid the risk of tension of the suture lines. Though eliminating the main ransoming factors for the development of PSD, they demand general anesthesia and prolonged hospitalization. Beside that they are technically challenging to obtain a good esthetic outcome. A wide range of procedures has been established by that time, including Karydakis flap, Limberg flap, Bascom's Cleft Lift procedure, V-Y-advancement flap and Z-plastics. [10,36]

## **2.8. Conservative Management**

### **2.8.1. Laser Depilation**

As mentioned above the application of laser depilation is a very efficient instrument to reduce the amount of hair in the natal cleft and its surrounding area to avoid absceding forms of pilonidal sinus. By limiting one main factor for the onset and progress of the disease the laser application is used to prevent recurrences as well. In addition to the possibility of an outpatient treatment one major advantage of laser treatment compared to conventional shaving lays in the outreach of the light to the deeper areas of the natal cleft, which are accessible more difficult with other methods. Since 1996 lasers are used in a wider frame for hair removal connected to the treatment of PSD. [37-40]

The aftercare of the skin subsequent to repeated treatment is compared simple and complications are rare. Adverse reactions include hyper- and hypopigmentation, erythema and crusting, which are reported as being transient and depending on fluence, pulse duration and wavelength of the used laser. It is recommended that the treatment location is kept clean of hair at least for two years after intervention. A reduction of 60 to 80 percent in the hair growth lasting up to six months following the therapy is reported, and a various range of different laser types is in use in this treatment section. [37,38]

Dragoni et al [40] reported about the application of the Nd-YAG laser in treatment of recurrent pilonidal sinus. Ten patients with established recurrent disease and being treated with one surgical intervention at least underwent laser epilation in a period of five years. Soft tissue ultrasounds were performed in advance and subsequent to the last treatment session for a prove of evidence of the procedure. Follow-up ultrasounds were proceeded two and four years after the treatment period. [40]

The Nd-YAG Laser enables deep tissue penetration. Through the uptake of the redundant energy by oxy-hemoglobin and melanin the destruction of pigmented hair follicles is maintained and inflammation is reduced in further consequence as well. [40]

Treatments were performed at a wavelength of 1,064 nanometers in intervals of 30 days. 90 percent of the treated patients were asymptomatic after the fourth application, averaged after six sessions clinical symptoms vanished in the treated cases. Temporary erythema and slightly pain were documented as by-effects but the treatment was tolerated with satisfaction overall and resulted in efficient and swift hair reduction. [40]

Patients remained relapse-free in the follow-up period and the final soft tissue ultrasound confirmed the absence and disappearance of the lesions. [40]

Treatment either with Diode Laser or Intense Pulsed Light Laser (IPL) was performed by Sadick and Yee-Levin [13] following surgical intervention in five patients with recurrent disease and multiple prior cyst excisions (between one and twelve). The advantage of this treatment option relies on the extended wavelength of the Diode Laser (810 nanometers) and the wide spectrum of the IPL (500 – 1,200 nanometers). Both are most effecting dark hair. [13]

The recurrence-free interval after laser treatment was stated between seven months and three years. Compared to that, the point of time of recurrences before laser application ranged from permanent affection of the disease with inflammation signs to a symptom-free interval of one year. [13]

Another type, a long-pulsed Alexandrite Laser was used by Khan et al [38] in 19 patients with recurrent pilonidal sinus. All of them presented relapsing sinuses despite various surgical interventions (between two and eight) in advance. [38]

The applicability for potential treatment was determined based on the hair color and skin type of the patients. Controls for the response of the therapy were conducted through photographs preceding each laser session. The treatments were performed with an Alexandrite Laser at a wavelength of 755 nanometers and patients underwent between four and twelve sessions. [38]

A significant reduction of hair density could be reported after laser treatment ( $p < 0.001$ ). The relapse-free interval following laser application compared to the symptom-free period subsequent to surgical intervention was significantly longer as well, 3 to 28 months versus one to two months ( $p > 0.001$ ). Laser depilation turned out to be an economical and efficient procedure to avoid morbidity of PSD and relapses in comparison to surgery. [38]

Odili and Gault [39] made experiences with treating 14 recurrent pilonidal sinus patients with the Ruby Laser and the Alexandrite Laser. All patients were surveyed in a follow-up period of five years. The application was performed with a wavelength of 755 nanometers and a fluence of 12 to 40 J/ cm<sup>2</sup> in the Alexandrite Laser, the Ruby Laser was deployed featuring a wavelength of 694 nanometers and a fluence of 14.5 to 25 J/ cm<sup>2</sup>. Hair density was measured in hairs/ cm<sup>2</sup> and two sessions were applied on average to the patients. [39]

Pretreatment hair density was quoted with eleven hairs per cm<sup>2</sup>, the ordinary concentration after treatment resulted in four hairs/ cm<sup>2</sup> after a period of twelve months, which implies a statistical significant decrease. Follow-up examinations were performed every three to four months per year. 57 percent were stated as healed after the first year and the permanent hair-free interval in the treated area lasted from six weeks to four months. As side effect pain was stated by all patients and therefore the procedure was carried out under local anesthesia. [39]

A retrospective study with a quantity of 60 patients according to Alexandrite Laser treatment after surgical treatment in pilonidal sinus was performed by Oram et al [41] at dermatology units in Turkey between 1999 and 2007. 91.7 percent of the examined cases presented with primary PSD and 8.3 percent with recurrent

disease. The majority underwent excision followed by flap reconstruction (67.2 percent) and incision and drainage (21.7 percent) prior to laser treatment. 6.7 percent were treated with excision and primary closure and the smallest part of 3.33 percent with excision followed by open healing. Apposite to a genetical component in the genesis 40 percent had a positive family history of PSD. [41]

The patients underwent laser treatment after complete wound healing due to surgery. The first laser epilation following surgery was applied at a minimum interval of four weeks subsequent to the surgical intervention and at the latest one year thereafter. The quantity of treatments ranged from two to five sessions in six to eight-week intervals. The epilation range was expanded to the perianal area, lower back and to the buttocks in patients with previous larger flap reconstructions within the treatment. [41]

Recurrences were detected with a rate of 13.3 percent, the mean follow-up interval in this case was 4.8 years. Overall 2.7 treatments were performed in average in each patient. Only 25 percent of the relapses occurred during the first two years after laser epilation, the main part, 75 percent, after five to nine years. Secondary intervention and drainage was necessary in 50 percent of the recurrent cases before laser treatment was applicable. In the patients group which underwent excision and primary closure the recurrence rate dropped down to 25 percent with the aid of post-surgical laser epilation. [41]

It turned out that recurrent PSD was detected mostly subsequent to incision and drainage of an abscess if the sinus was not excised in advance and remained as a serious factor for the progress and the performance of a relapse after the initial healing of the drained cavity. [41]

The small number of examined cases and comparable short mean follow-up periods of five years in studies referring to laser treatment in pilonidal sinus impede the validity of an overall impact of the therapy. Despite that a supporting effect in healing time and the prevention of recurrences is documented in almost all studies concerning to this subject. Due to the advantages of cost-effective, compared quick, easy and outpatient setting of potential treatment combined with low side-effects the question of including laser epilation either as adjunctive option to surgical treatment or standing alone therapy should be examined in furthermore comprehensive studies to improve a higher evidence of the procedure. [38,39,41]

### **2.8.2. Phenolization**

Another major conservative treatment option beside laser epilation in pilonidal sinus disease is the injection of liquid or crystalized phenol as a sclerosing agent into the lesions and cavities. Phenol is structured as a mono substituted aromatic hydrocarbon with anesthetic, antiseptic and potent sclerosing capabilities. The basic principle of the treatment is the healing of the infected sinus by the destruction of the epithelium in the sinus tracts and cavities and the removal of embedded hairs. Before carrying out this procedure the choice between liquid or crystalized phenol as a remedy must be concluded. [42,43]

Crystalized phenol is compared to its liquid form supremely fragile. Due to that the transport and handling on the patient requires extreme care. On the contrary, when performing high-pressure application of phenol by a syringe using the crystalized form uncontrolled splashing outside the target area can be avoided. This complication can cause severe skin burns and may occur more easily when using liquid phenol. The surrounding area must be protected with coverage, ointment and gauze in case therefore. Another risk of high-pressure application is the potential penetration of the surrounding tissue. Hence the passive filling of the cavities is advised. [43]

Thus, Kayaalp and Tolan [43] are recommending the use of liquid phenol applied with a cotton stick which prevents a potential damage of the surrounding tissue and allows a mechanical debridement of the cavities and tracts additionally. As the crystallized form changes into liquid phase when reaching body temperature, the decision between the two remedies is principally a question of the preferred application and handling. [43]

#### Preparations and procedures for the application of crystalized and liquid phenol

Prior to the application hair removal in the target and surrounding area is recommended, as it eliminates one serious factor for the disease itself, enables a clean working area for the performing surgeon and reduces the risk of infection after the treatment with crystalized phenol. [44]

Some precautions in the handling with the agent must be kept in mind. It is a white crystalline substance, should be kept in glass bottles and stored strictly in areas which are not exposed to sunlight. As it causes tissue burns in form of white blisters in case of direct skin contact the use of safety measures including wearing a face mask, glasses, gloves and a surgical gown is indispensable. A peripheral venous access should be added in advance for the case of emergency. [44]

After the exclusion of potential allergies to ointments, lidocaine and crystallized phenol a laboratory test including hemoglobin, PTT and INR values should be carried out to detect any prior coagulopathy. The intergluteal area is prepared in sterile circumstances, followed by subcutaneous injections of two percentage lidocaine. Local anesthesia is not mandatory but provides decreased pain when removing hair of the sinuses and supports the comfort of the patient. [44]

After that hair removal of the sinus opening should be performed carefully with a mosquito clamp if necessary. This procedure may result in slight bleeding, in case of that hemostasis can be achieved easiest with gauze pads. [44]

The surrounding area and the anus should be covered and protected with a gauze pad dipped in soluble ointment, 0.2 per cent nitrofurazone can be used in this circumstance. The phenol crystals are inserted into the sinus cavities with a mosquito clamp. Within the reaction of the crystals at skin contact they change to black-brown color and liquify slowly, acting as chemical debridement. [44]

The consequent arising leakage is cleared continuously with gauze pads. At the end of the procedure another gauze pad is located within the natal cleft to protect the closer tissue and especially the anus through absorbing excessive leaking phenol and debris. The lowest quantity of crystalized phenol to achieve sufficient treatment should be used in general. [44]

Dag et al [42] performed phenolization in treatment of 76 patients with primary pilonidal sinus using 80 per cent liquid phenol solution instead of phenol crystals. After the positioning of the patient in prone position, the preparation prior to the procedure included shaving, sterile cleaning of the area and the application of a local anesthetic (two per cent lidocaine with epinephrine). [42]

Following that the entrances of the sinus opening were extended carefully with a small incision to achieve a better communication of the sinuses. Then curettage was performed to purify the cavities of granulation tissue, debris and hair. Occasional bleeding was stopped with compression. To measure the volume of the hollows saline solution was used to estimate the necessary amount of phenol. [42]

The insertion of the liquid phenol solution was carried out with the aid of a dull ended injector and this procedure was repeated two to three times till the cavities were filled up without pressure. Gauze was placed for wound dressing and the patients could be discharged immediately after the intervention. Wound inspections afterwards took place in weekly intervals. [42]

Yuksel [44] treated 50 patients affected by pilonidal sinus with the application of crystalized phenol in a period of two years with a follow-up period of six months. He reported that average postoperative healing was reached 30 days after treatment with a cure rate up to 88 percent. Other studies have shown success in treatment with rates from 60 to 95 percent. Treatment failure was reported in six patients (12 percent) due site infections within the follow-up period. [44]

Girgin et al [37] published the results of pilonidal sinus treatment with a combination of crystalized phenol injections and advanced laser epilation in 42 patients between 2009 and 2012, based on the concept the combination of both would increase the success of the treatment. 90.5 percent of the patients presented with chronic pilonidal sinus and 9.5 percent with recurrent appearance of the disease. The mean number of sinus orifices in each case was detected with 2.4 +- 1 (range one to twelve). The main part (71.4 percent) of the cases showed midline openings, the remaining twelve patients lateral openings. [37]

Instead of the widely used 80 per cent liquid phenol the authors applied three to five milligrams of crystalized phenol, due to its higher purity than the liquid solution. The main part of the treated cases, 61.9 percent recovered after one phenol application. The remaining patients showed an entire remission after repeated interventions, up to eight treatment sessions in an interval of three weeks were necessary in these cases. All patients remained recurrence-free in a follow-up-interval of 24 months. [37]

Calikoglu et al [45] carried out a comparative prospective randomized study between two pilonidal sinus treatment options, crystalized phenol injection and Open Healing. They examined in total 140 patients, who underwent one of the two treatment methods in a ratio of 50:50. All cases were at least 18 years old with the diagnosis of primary or recurrent chronic pilonidal sinus. The quantity of prior surgical treatment due to PSD was comparable in the two groups with 17.1 percent in the phenol treated cases and 28.6 percent in the open healing cohort ( $p = 0.58$ ). 20 percent of the first group were affected by chronic disease and 18.6 percent in the cohort treated by surgery ( $p = 0.83$ ). [45]

According to the procedure of phenolization above crystalized phenol was applied, all sinuses with a diameter smaller than three millimeters were extended by the aid of a mosquito clamp, wound closure was finished with a gauze pack and necrotic debris was removed after 24 hours post-interventional. [45]

Postoperative complications as intergluteal maceration (2.9 percent) and ongoing drainage (11.4 percent) in the phenol group and PONV (postoperative nausea and vomiting) with 4.3 percent and bleeding (1.4 percent) in the surgical section turned out rare. Regarding to the literature abscesses and cellulitis are the most common side-effects in phenol treatment, appearing in 8.7 percent of the cases. [45]

Patients underwent follow-up examinations three and six weeks, in the third and sixth month, and subsequently once a year after the operations. The mean follow-up was mentioned with 39.2 +/- 9.0 months. No significant difference in the recurrence rates between the compared treatment methods turned out in that interval, 18.6 percent in the phenol group and 12.9 percent in the open healing cohort ( $p = 0.92$ ). Patients with symptomatic abscesses did not show a higher rate of recurrence compared to the ones without absceding events neither. The recurrence-free interval of both cohorts was analogical with 45.8 +/- 1.6 months (phenolization) and 47.8 +/- 1.4 months (excision with open healing). [45]

Complete wound healing on average was reached distinctively faster in the phenol injection cohort with 16.2 +/- 8.7 days versus 40.1 +/- 9.7 days in the open healing section ( $p < 0.001$ ). All phenol treated patients showed healing six weeks after the performance of the procedure, by that time 78.6 percent of the surgical group were cured. A single application of crystalized phenol performed with a success rate of 85.7 percent, only eight cases required second treatment three weeks after the first one. [45]

As mention above Dag et al [42] performed a study of using phenol treatment in PSD between 2005 and 2009. They included an analysis of the risk factors for treatment failure in the publication. 60 men with a mean age of 24.3 years and 16 women with 22.7 years on average with non-recurrent pilonidal sinus were included. 22 percent of them showed a history and prior drainage treatment of pilonidal abscesses. Sinus orifices occurred mainly in the midline (64.8 percent) of the affected cases, 35.2 percent showed lateral extensions as well. The total number of sinuses reached from one to ten, on average patients presented with two to three sinuses. [42]

The application of liquid phenol was carried out once in 60.5 percent of the cases, and turned out to be necessary twice for 14 percent and three times for 25.5 percent. The overall success rate turned out with 67 percent (51 of 76 patients) and complete healing could be achieved on average in 16 days. The cases which failed treatment underwent flap procedures subsequently. The rate of side-effects turned out low with 10.5 percent and expressed as superficial skin burns in the lower surrounding area. All these lesions healed with furacine balm without further complications. The mean follow-up was 25 months and only two percent of the cured cases showed recurrence, occurring in the first year after treatment. [42]

According to the cavity volume of the lesions the majority showed a volume of under one milliliter (80 percent). On estimating the factors for failure of treatment the following findings could be detected. Patients who underwent drainage due to purulent abscesses had a higher risk for non-responding ( $p = 0.001$ ). Other significant negative aspects in that point were a higher cavity volume of the sinuses and the amount of sinus openings. Cases which presented with more than three openings showed a higher risk of treatment failure ( $p = 0.046$ ). [42]

In patients presenting with a higher cavity volume the risk was reported increased as well ( $p = 0.016$ ). The positive abscess history and number of sinus orifices was correlated with a higher cavity volume, interestingly the volume was not affected by the sinus localization. There could be found a direct relation between the number of treatment sessions and the unsuccessful attempt of phenolization ( $p = 0.001$ ). 98 percent of the patients who underwent three times phenol injections did not respond to the procedure. [42]

The advantages of phenolization in pilonidal sinus treatment rely on the minimal invasive intervention and the possibility to perform the procedure in an outpatient setting, repeatedly if required. The patients can sit on chairs and the toilet with no special precautions needed and can carry on with their used habits immediately after the treatment, including travels as well. According to wound care the area does not require specific wound dressing. [37,44]

Due to the absence of larger cicatrices and sutural material, which occur in surgical interventions, the cosmetic results are excellent. Potential post-interventional complications include discomfort, slight pain, purulent discharge and abscess development. These side-effects can be treated with antibiotics and non-steroidal inflammatory drugs quite effective. Despite that the treatment of PSD with phenol requires high caution according to the handling of the agent and to the application on the patient. [37,44]

### **3. Surgical Management**

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For the overview of the established surgical procedures in the treatment of pilonidal sinus disease a research of the published literature was performed. Inclusion criteria were in this case an interval of the last 15 years (2002 – 2017), studies containing operative treatment methods, studies comparing two or more surgical options in PSD treatment and publications which included patients at least being 18 years old. Studies in which the cases were restricted to the pediatric population were excluded.

The studies were observed in terms of three main aspects, the postoperative complications of the respective methods, the recurrence rates and the healing process. Side aspects included the differences in the outcome of primary and secondary closure methods.

## **3.1. Minimal Invasive Techniques**

### **3.1.1. Incision and Drainage**

In most cases the first surgical option affected patients undergo in the treatment of PSD is incision and drainage, especially when presenting with acute pilonidal abscesses. This option is in general recommended in patients in an early stage of the disease with a comparable mild performance. Regarding to the literature recurrence rates for incision and drainage as standing-alone treatment in pilonidal sinus are reported ranging from 40 to 76 percent. [46,47]

Thompson et al [46] carried out a comprehensive review, surveying the development and the results of surgical and non-surgical treatment of pilonidal sinus. They mentioned two studies which showed complete healing after incision and drainage. One study detected a symptom-free interval of five years after the intervention with a full healing rate of 57.5 percent (42 of 73 subjects). The patients presented in this case with primary occurring acute abscesses. [46,47]

Doll et al [48] performed a study examining the correlation between incision and drainage prior to other surgical treatment and long-term recurrence of pilonidal sinus based on the suspicion that acute inflammation impedes satisfactory outcome in following soft tissue surgery and has negative consequences in the long-term recurrence as well. They included 583 male active members of the German armed forces who were treated due to pilonidal sinus in three military hospitals in Germany and divided them in a conservative and surgical treatment group. [48]

31.6 percent of them presented with acute absceding inflammations, the remaining 68.4 percent were affected of chronic disease with consisting sinuses and tracts and remitting symptoms. The authors determined a total follow-up period of 25 years. Patients treated by surgery were evaluated on average 14.7 years after the intervention. [48]

297 patients did not undergo incision and drainage and showed spontaneous pus secretion caused by rupturing abscesses. Though the main part did not develop relapses after conservative drainage treatment, a recurrence rate of 28.3 percent within the following 25 years was detected in the remainder. 286 patients underwent incision and drainage and partly subsequent definitive surgical treatment. Recurrences occurred in 49 patients of this group (17.1 percent). Using a Kaplan Meier statistic, a 20-year recurrence rate of 24 percent was detected in the incision and drainage cohort compared to 35 percent in the non-treated group prior to definite surgical treatment. [48]

Vahedian et al [47] compared healing time and recurrence rates of drainage and curettage in PSD treatment in a study including 150 patients presenting with acute pilonidal abscesses. Within a follow-up period of 65 months patients treated with curettage showed a significant lower recurrence rate with 10 percent compared to 54 percent in the incision and drainage cohort ( $p < 0.001$ ). The majority part of both groups achieved healing under two months after treatment and all patients could resume their daily duties seven to ten days postoperatively. [47]

The healing process turned out faster in the curetted group with 96 percent versus 78.7 percent in the drainage section ( $p < 0.001$ ). 21.3 percent of the drainage cases were affected by delayed wound healing over ten weeks compared to four percent in the curettage group. Conclusively the authors pointed out the importance of hair removal in a distance from three to four centimeters of the affected location as a major component in the postoperative process. [47]

Incision and drainage is recommended as first line treatment in pilonidal sinus cases presenting with acute absceding events. Combined with curettage an increased positive impact of the procedure is reported in the published literature according to healing rates and the appearance of recurrences. [10,36]

### 3.1.2. Pit Excision

The pit excision or “pit-picking” procedure is one of the minimal invasive surgical options in the treatment of pilonidal sinus, described already by Lord and Millar as “pit excision” in 1965. The operation was described under a variety of names so far. Bascom mentioned it under the term “follicle removal” and Senapati under “Bascom’s operation”. Gips declared it as “minimal surgery” and Thompson described it as “removal of midline pits”. [49,50]

The advantages of the technique relay among others on the comparable quick procedure, the practicability in an outpatient clinical setting, low hospitalization time and high comfort to the patient compared with more comprehensive surgical techniques. The loss of working time is stated with zero to two days. The evidence of the procedure turns out lower than in more established treatment methods due to the small amount of published studies in this field. Despite that the recurrence rate is described with only 10 to 20 percent with follow-ups from twelve up to 83 months in the recent literature. [49-51]

The approach of the method is based on the presumption that pilonidal pits or fistulas, especially the primary nidi located in the natal cleft, are lined with epithelium and therefore inhibiting the spontaneous closure of the lesions during the healing process. Due to that the main target of the operation is the epithelial debridement of the sinus openings. [50]

Olmez et al [49] combined two compared simple techniques, sclerotherapy with liquid phenol and pit excision to increase the results of minimal invasive procedures in the treatment of pilonidal sinus. Success rates of phenolization as exclusive PSD treatment already after one application are reported with 56 to 83 percent. This study included 83 patients with symptomatic pilonidal sinus, presenting with abscesses or purulent discharge, who underwent treatment between 2008 and 2009. [49]

The surgical technique, used by the authors, is given as an example for the procedure. [49]

Patients remained in prone position during the procedure. After the removal of hair and the sterile preparation of the operational area local anesthesia was performed by injecting a solution of lidocaine and adrenaline into the marked incision area. The first pit excision was performed with the aid of a scalpel in the midline close to the sinus openings to remove the lining epithelium, including a small resection border of healthy tissue. The opening of the sinus cavity from one to two centimeters length was sufficient to get access to its inside. Additional midline and lateral sinus orifices underwent separated excisions. [49]

Occasional bleeding was stopped by diathermia. By using surgical forceps, the sinus hollow was cleared of debris and hair subsequently. The peri-incisional and directly surrounding area was protected with ointment, the perianal region with a sponge. Following that 80 per cent phenol was applied to the hollows carefully with a cotton bud until the inner walls changed into a whitish staining. This procedure was performed twice in total and the wounds were covered with a gauze pad. The patient could be discharged immediately after treatment with a prescription of analgetic remedies if required. [49]

Further treatment sessions of phenolization were carried out on the first postoperative day and one week later. Patients with acute abscess formation underwent abscess drainage followed instantly by phenol application and subsequent phenolization treatments in the same interval. [49]

The procedure was carried out in ordinary time of 22.2 +- 7.4 minutes, the mean time for wound closure was mentioned with 28.5 +- 14.9 days. In the majority part of the cases (72 percent) sinus orifices were detected restricted to the midline, prevailing over patients who were affected laterally as well. After a follow-up interval on average of 25.7 +- 8.5 months in total 86.7 percent of the treated patients turned out asymptomatic. [49]

Complete analgesia was achieved in all patients three days postoperatively and it was possible for them to resume daily duties, for example work or school, three days after the intervention. In ten percent of the cases superficial skin combustion occurred due to the phenol treatment as the only documented complication. These burns healed not requiring any further remedies. [49]

In 7.2 percent of the cases small openings persisted despite repeated treatments. Early rates of non-responding to the procedure were stated with 10.8 percent after two months post-interventional. During the follow-up-period the long-term recurrence rate turned out with 2.5 percent, the entire rate of treatment failure according to that with 13.3 percent. Non-responding cases were treated with excisions and reconstructive flap procedures. [49]

The wider evidence of sclerotherapy by the application of phenol is still lacking based on the small amount of studies and included cases. The authors concluded that the reason for so far published lower results of the method is based on the approach only using the preexisting sinus openings as access course for phenolization treatment. They proposed to include an incision at least of one to 1.5 centimeters within the procedure for enabling a better removal of occasional debris and hair and to provide a better access to the sinus cavity for the phenol application. No raised discomfort for the patient after the operation when performing that incision could be detected. [49]

Another study investigating the effects of pit excision as standing alone treatment in PSD was carried out by Iesalnieks et al [50] between 2007 and 2010, including 153 patients in Germany, who underwent 157 "pit-picking" operations. [50]

According to the literature this procedure should be qualified for the use in patients affected by limited pilonidal sinus who did not undergo surgical procedures in advance. Therefore, they determined the following requirements as indication for the treatment: Pilonidal sinus cases with lesions limited to the midline of the natal cleft or cases with lateral pits located in a distance of less than three centimeters to the midline, including clinical signs as abscesses, fistulas, tracts and scars due to prior incision and drainage. [50,51]

The mean age of the examined patients was 27 years with active pilonidal sinus in a period of 5.5 months on average. They presented with a mean number of two pits (total range 1 to 13) and ten percent showed an absceding process in the lesions. 4.6 percent of the patients underwent excision and drainage or previous pit excision at the time they got included in the study. [50]

Postoperative complications turned out rare with 1.3 percent. The two affected patients showed post-interventional bleedings which could be treated with tamponades in an ambulant setting. [50]

Patients presenting with acute pilonidal abscesses underwent incision and drainage and a subsequent “pit-picking” operation. The pit excision was carried out after drainage treatment immediately, if the primary sinuses were detectable distinctive in the midline. In case of an intumescence due to abscess formation “pit-picking” was performed with a delay of two to three weeks. [50]

Recurrent disease evolved in 38 patients (25.7 percent), 74.3 percent were cured after the initial treatment. The mean postoperative recurrence-free interval was five months. 13 patients underwent a second “pit-picking” procedure, 61.5 percent of them remained free of symptoms afterwards, the overall healing rate increased therefore up to 79 percent. [50]

Performing an analysis of intermediate-term results of the study above, including an evaluation of risk factors for recurrence of PSD Ilesalnieks et al [51] concluded the following. Intermediate-term cure could be achieved after one or two “pit-picking” operations in 70 to 80 percent of the patients with the indication stated in their study. The main part of the remaining cases could be treated successfully for instance with Karydakis flap procedure. [51]

According to risk factors a multivariant analysis revealed the following points as causes for increased recurrence: [51]

- Permanence of the disease longer than six months ( $p=0.017$ )
- Anamnestic pilonidal abscesses ( $p=0.02$ )
- Smoking ( $p=0.042$ )

Obesity with a BMI higher than 25 kg/ m<sup>2</sup> was detected in an univariant analysis as increasing factor for recurrences but did not turn out statistically significant in the multivariant evaluation above. [51]

“Pit-picking” should be qualified for pilonidal sinus cases with mild to intermediate appearance of the disease which did not undergo prior surgical interventions beside incision and drainage. In addition, the combination of “pit-picking” and phenolization as two minimal invasive procedures shows a supporting effect in pilonidal sinus treatment regarding to low recurrence- and complication rates. [49,50]

## **3.2. Secondary Closure Techniques**

Reaching a further invasive step in the treatment of pilonidal sinus the decision between open healing procedures or techniques including wound closure on primary intention must be made.

A major advantage of secondary healing techniques relays in the overall low recurrence rate with six percent, compared to rates up to 41 percent in midline closure procedures. Recurrence rates of six percent are reported in open treatment methods based on a meta-analysis including 18 trials with 1,573 cases. On the other hand, they require more time to maintain complete healing due to their technique. [3,46]

The laying open treatment respectively unroofing of pilonidal sinus can be combined with curettage or with sinus excision. Marsupialization can be included within the process as well. The major advantage of achieving healing by secondary intention in PSD treatment relies on the less invasive component compared to primary closure methods. Especially in case of prior curettage no further tissue loss is created. Proponents of this treatment method invoke the argument that healing can be maintained with less complications and a lower recurrence rate. Another important benefit is the reduction of the wound tension which is achievable more difficult in primary wound closure techniques. [3,52]

Thus, the method of laying open is recommended in cases with larger affected areas and a wider range of sinuses and pits to avoid the increased tissue loss which would be involved in wider excision techniques. [52]

Alptekin et al [53] confirmed another negative factor which is associated with procedures requiring wider tissue excisions. They carried a study surveying the rate of surgical site infections in 160 pilonidal sinus patients who underwent either excision with primary closure (98 patients) or a Limberg flap plastic (62 patients), regarding the excised specimen volume. [53]

Surgical site infections occurred with an overall rate of 11.9 percent during the first 30 postoperative days. That resulted in a prolonged median healing time with 33 days in patients affected by site infections compared to the unconcerned part with 15 days. The median period off work was three days longer in the infected group with ten days compared to seven days in the non-affected cohort ( $p = 0.001$ ). [53]

The volume was measured by submerged displacement of the excised tissue in a graduated cylinder filled with a certain amount of water as reference. The results were classified after that in two groups,  $< 28 \text{ cm}^3$  and  $> 28 \text{ cm}^3$ . Site infections were detected in cases which showed a median volume of excised tissue of  $36.1 \text{ cm}^3$  and were absent below  $32 \text{ cm}^3$  ( $p = 0.005$ ). 12.3 percent of the excision and primary closure group and 11.3 percent of the Limberg cohort were affected. [53]

### **3.2.1. Unroofing (with Curettage/ Marsupialization)**

The unroofing procedure displays a range of advantages as the creation of a smaller wound size, a decreased risk of recurrences and of postoperative infections and a short hospitalization time in the treatment of pilonidal sinus. The procedure enables the preservation of the physiological body contour and can be repeated comparable swift and with few efforts if required. On the other side, the granulation respectively the healing process of the wound requires more time than in primary closure methods and thorough postoperative care. [54,55]

Kepekci et al [56] presented an analysis of unroofing combined with curettage in the treatment of 297 PSD patients, affected by acute, recurrent and chronic disease. The major part of the cases presented with chronic pilonidal sinus, 76.1 percent. 15.5 percent of them showed acute pilonidal abscesses and 8.4 percent were recurrent PSD patients. [56]

Preoperative procedures included prone positioning of the patient and the application of local anesthesia. In case of requirement of the patient general anesthesia was performed. The operational area was exposed by fixing the buttocks with adhesive tapes laterally and skin was shaved and prepared under sterile conditions. Following that the sinus tract was detected by using a probe and was opened subsequently. [56]

Then the complete unroofing of the lesion and the extensions was carried out, followed by the curettage of the base of the cavity. Debris, granulation tissue and hair were removed. Careful epithelial debridement of the pit under preservation of the fibrotic wall of the sinus was performed afterwards. The next steps included the excision of the wound margins to prevent preterm bridging and the maintenance of hemostasis by diathermy. Conclusively the operation field remained open and was covered with gauze packs and wound dressings. [56]

The patients were discharged on the operation day after the procedure was performed, and underwent follow-up examinations daily in the first postoperative days and in weekly intervals within the further process. Wound debridement and if necessary separation of premature bridging were performed at the follow-up inspections. [56]

All cases could re-establish their daily duties immediately on first day after the operation and the patients returned to work after a mean duration of 3 +/- 1 days (range one to five days). Postoperative complications as necrosis, seroma or hematoma were not detected in the surveyed cases. The follow-up was performed within a mean period of 54 +/- 28 months. Wound healing could be achieved in a mean time of 5.4 +/- 1.1 weeks. [56]

Recurrent PSD patients showed a mean complete healing time of 5.0 +/- 1.0 weeks, chronic cases performed with 4.9 +/- 0.8 weeks. Compared to them patients with pilonidal abscesses required a mean healing time of 7.2 +/- 0.9 weeks ( $p < 0.001$ ). Recurrences were detected in 2.0 percent of the treated cases within the first six months after the operation. The affected patients could be treated efficiently with repeated surgical interventions using the same technique. [56]

Marsupialization was reported as a treatment method in pilonidal sinus cases by Buie already in 1944. It is determined as a stitching of the wound edges to the surrounding tissue. The margins are sutured either to the sacrococcygeal fascia or to the subcutaneous skin layers after excision. The ground of the pilonidal sinus remains intact within the marsupialization process and the fibrous tissue, bounding the sinus cavity, is used for the suture of the superficial skin borders. Due to the absence of nerve endings in the fibrous wall of the sinuses postoperative pain is reduced, especially in the first days after the intervention. The technique results in a narrowing of the wound orifice which supports the postoperative healing. [6,14,55]

Karakayali et al [55] carried out a study comparing unroofing with marsupialization and rhomboid excision with a Limberg flap in the use of pilonidal sinus treatment between 2005 and 2007. The examined population consisted of 140 pilonidal sinus patients. Cases which presented with acute abscesses and showed a history of prior surgery due to PSD beside abscess drainage were excluded from the study. The patients were randomly divided in two treatment groups. 70 cases underwent unroofing and marsupialization, the other half was treated with rhomboid excision and Limberg flap reconstruction. Prior abscess drainage was performed in 58.6 percent of the first group and in 57.1 percent of the Limberg cohort. [55]

All treated cases remained at least for the first post-interventional day in hospital. Wound dressings were changed daily for the first three days after the operation in the unroofing and marsupialization group and subsequent outpatient follow-up examinations were carried out weekly in this cohort. The mean follow-up period was 15 months (range 12 to 26 months). [55]

The rhomboid excision and Limberg flap group performed with a significant higher postoperative complication rate, 12.9 percent compared to 2.9 percent in the unroofing section ( $p = 0.028$ ). The complications included infections, edema and hematoma in the primary closure group, compared to that only premature bridging occurred as side-effect in the open treatment cases. [55]

The mean time for the resumption of daily duties and of return to work turned out significantly shorter in the unroofing and marsupialization group with  $11.2 \pm 5.8$  days (range 5 – 35 days) versus  $17.9 \pm 9.3$  days (range 2 – 46 days). On the other side time to complete healing was significantly longer in the open treatment cohort with  $43.8 \pm 20.9$  days (range 15 – 122 days) compared to  $23.7 \pm 11.2$  days (range 14 – 96 days). For both parameters  $p$ -levels below 0.001 were detected. Recurrences turned out rare with 1.4 percent in the primary closure group. No relapses could be detected in the unroofing cohort within the total follow-up period. [55]

Examining unroofing and marsupialization in PSD treatment independently mean periods of absence of work are reported with 20.12 +/- 5.10 days for marsupialization and 12.60 +/- 4.65 days for the unroofing procedure on its own ( $p < 0.001$ ). [57]

A meta-analysis surveying unroofing and curettage in PSD treatment including 13 studies with a total study population of 1,445 patients revealed a recurrence rate of 4.47 percent (95% CI = 2.90-6.37) for the procedure. Complications were reported with a rate of 1.44 percent (95% CI = 0.52-2.83) and the mean healing time of the procedure 21 to 72 days. [54]

To compare the healing rate of sinus excision followed by primary closure and laying open treatment with curettage in pilonidal sinus a year after intervention Lorant et al [52] carried out a study in Sweden between 2002 and 2006 with 80 cases in total. Patients were over 18 years old and if they presented with abscesses or active infections they were excluded from the study. [52]

41 randomly chosen patients underwent the laying open treatment. Within the procedure granulation tissue, debris and hair were removed by curettage and the fibrous walls of the sinus tracts remained deliberately without any excision of tissue. [52]

The excision and primary closure group showed a significant higher healing rate than the open healing cohort one month and three months after the intervention as demonstrated in Table 2 [58]. [52,58]

**Table 2** Healing time after excision and primary closure compared to open treatment in PSD

Postoperative healing time in months	Excision and Primary Closure n = 39	Open treatment n = 41	Significance
1	20 of 39	8 of 41	P = 0.005
3	36 of 38	28 of 39	P = 0.013
12	33 of 37	37 of 38	P = 0.198

*Note.* Adapted from Lorant T, Ribbe I, Mahteme H, Gustafsson UM, Graf W. Sinus excision and primary closure versus laying open in pilonidal disease: A prospective randomized trial. *Dis Colon Rectum*. 2011;54(3):300–305. Table 3, Follow-up of 80 patients who underwent surgery for pilonidal disease; p. 303. Copyright 2011 by The American Society of Colon & Rectal Surgeons.

At the final follow-up after twelve months no significant difference was detected in the healing rate between the two groups. Postoperative pain did not differ as well in the examined cohorts. Postoperative complications as infections prevailed in the primary closure group with 7.7 percent compared to 2.4 percent in patients treated with open laying. According to recurrence 10.3 percent showed relapses in the excision and primary closure group and 2.4 percent in the laying open group ( $p = 0.198$ ). [52]

As the sinus excision with primary closure shows a faster healing rate it is preferred rather for the treatment of small sinuses, where not that much tissue loss is to be expected, than in more extensive forms of the disease. The authors ascribed the balanced healing rate after one year to the presumption that pilonidal sinus is particularly affecting the superficial skin layers and deeper subcutaneous tissue is involved secondarily. [52]

Sondenaa et al mentioned a healing time of 12.2 weeks for laying open treatment, surveying the effect of healing by secondary intention compared to primary closure in PSD treatment. Contrary to that he reported a healing period of 3.2 weeks in primary closure interventions. Hassan et al stated findings of 13 weeks versus 10.3 days with the same comparison in 96 cases. [59]

A meta-analysis comparing primary and secondary closure methods in PSD carried out by McCallum et al [3] pointed out open treatment of PSD relating to a 58 per cent decreased risk for the appearance of recurrences than primary closure methods (relative risk 0.42, 95% CI = 0.26-0.66). 18 trials with 1,573 subjected patients were included. [3]

### **3.2.2. Excision with Open Healing**

Pilonidal sinus cases affected by severe manifestation of the disease with a higher number of sinus openings show a distinctive higher recurrence rate. In cases with less than three sinus openings a relapse rate of 4.7 percent is reported. This is increased to 37.5 percent in patients with more than four sinus openings. Hence excision with open healing plays a vital role in the treatment of these cases as the complete excision of all sinuses facilitates complication-free wound healing and decreases the recurrence rate furthermore. [45,52]

As sample for the procedure of excision with open healing the technique used by Calikoglu et al [45], who carried out a study comparing this method with phenolization in PSD treatment is given. [45]

Patients were positioned in prone jackknife position and the whole intervention was performed under spinal anesthesia. To detect the precise margins of the sinuses and tracts methylene blue was injected if necessary. The sinuses were opened with an elliptical incision. Diathermy was used in the following to control occasional bleedings and was applied for the complete excision of the related cysts, down to the level of the sacrococcygeal fascia if required. Subsequently the marsupialization of the sinuses was carried out and the wound was protected with sterile gauze after reaching hemostasis. [45]

Recurrence rates between 0 percent and 13 percent in total are reported in the literature subsequent to excision with open healing. The authors revealed a relapse rate of 12.8 percent comparing phenolization and excision with open healing in PSD treatment. [45]

Gencosmanoglu and Inceoglu [14] carried out a comparative prospective randomized clinical trial between a modified lay-open procedure and total excision with primary closure in pilonidal sinus treatment between 1998 and 2001. A minimal sample size of 69 patients was chosen for each group, excluding cases with acute absceding symptoms, and the complete follow-up was two years. [14]

### Surgical procedure of modified lay-open treatment

First, patients were positioned in prone respectively jackknife position with a pillow placed under the pelvis. All interventions were carried out under general anesthetics and as a pre-operative intravenous antibiotic prophylaxis 15 minutes in advance single doses of cefazoline (one g) and metronidazole (500 mg) were used. The preparations included fixing the buttocks laterally by strapping them apart with adhesive tapes, shaving and disinfection of the operational area. Access to the sinuses was ensued by a vertical incision in the midline using the cautery knife. In case of multiple sinus openings, the incision was made by connecting them in a row vertically. [14]

Next steps were the removal of hairs, debris and granulation tissue of the hollows and subsequent curettage of the bases. After that the skin borders and the superficial third of the lateral incision margins were excised in an angle of 45 degrees by using a scalpel and hemostasis was achieved by diathermy. To perform the marsupialization the surfaced skin margins were attached to the fibrous boundary of the sinus hollows by performing a continuous lock stitch along the borders with absorbable suture material. Conclusively the wound was protected with disinfected gauze for protection. [14]

In total 142 patients were included into the study. The rates of previous interventions were comparable with 8.2 percent in the lay-open group and 10.2 percent in the primary closure cohort. 73 patients underwent the modified laying-open procedure. A family history could be detected in twelve percent of the cases. The mean follow-up period in all patients was 47 months. Patients of the open treatment group were examined weekly till complete healing of the tissue was confirmed. [14]

Regarding the postoperative complications only two patients in the laying-open cohort (2.7 percent) showed complications in form of early bridging and healing failure. The complication rates turned out obviously higher in the excision with primary closure group with 13 percent, including healing failure, infections, wound dehiscence and hematoma. [14]

Due to the procedure healing time is prolonged in surgery techniques based on secondary wound healing compared to operations with primary closure. The mean parameters in this aspect were mentioned with seven weeks (range 3 to 16 weeks) versus two weeks (range between two and nine weeks),  $p < 0.001$ . [14]

The median period before patients returned to work after the treatment was significantly shorter in the laying open group than in the excision with primary closure cohort, three days (range of two to eight days) compared to 21 days (range 14 to 63 days),  $p < 0.001$ . Despite the fact the overall healing time was longer in the modified laying-open group it was assumed that the lower complication rate would be a main reason for that circumstance. [14]

Perruchoud et al performed a study of 38 patients who underwent complete excision and secondary healing with open granulation and stated an average healing period of 72 days and a mean loss of time before returning to work of 38 days. The authors of the study above reasoned their opposing results to these data and the literature on a main difference in the performed technique, the tissue in the wound bed. [14]

In the modified lay-open technique the wound contains the fibrous floor of the sinus hollow whereas it was subcutaneous tissue and eventually sacrococcygeal fascia in methods with excision and secondary healing. Another factor of the used marsupialization technique, the narrowing of the wound margins, resulted in minimal drainage and pain for the patient. This was mentioned as another cause for the shortened postoperative inactive period of tasks according the common life of the patients and the average return to work after the third postoperative day. [14]

Concerning to recurrence rates the modified open-laying method showed 1.4 percent compared to 17.4 percent ( $p < 0.001$ ) in the excision with primary closure group. [14]

The complex and complicate manifestation of pilonidal sinus, which includes persistent or recurrent infections and abscesses and copious dendritic tracts, requires a more comprehensive approach in the surgical treatment. That task is ordinarily combined with wide excisions of the affected area respectively with a higher tissue loss. [59]

In these cases of pilonidal sinus disease morbidity markers as treatment failure, postoperative complications and recurrences were quoted higher in patients who received procedures with primary closure compared to healing by second intention techniques. The rate of wound dehiscence in vast, complex pilonidal lesions treated with primary closure is mentioned with up to 37 percent. [59]

### **3.2.3. Vacuum-Assisted Closure Therapy**

With the ongoing research and use of open operation methods in the treatment of pilonidal disease the application of vacuum-assisted closure techniques to improve the therapy has increased as well.

Vacuum-assisted closure (VAC) or negative-pressure wound therapy (NPWT) has been established two decades ago and was described first by Argenta and Morykwas in 1997. It consists of polyurethane open-pore foam covered by an adhesive semipermeable dressing which is placed in the wound and fixed with an airtight adhesive tape. The connection of the padding to an external vacuum pump creates a sub-atmospheric pressure of -50 to -125 mm Hg. The pressure is variable and can be deployed intermittently or steadily. [60,61]

The approach of the treatment relays on the control of the physiological wound environment by pressure. The benefits of the treatment include an increased local perfusion, less wound edema and less bacterial colonization. By maintaining a continuous pull to the wound bed and a consequent drainage of wound exudate it supports epithelial migration and the development of granulation tissue. Another aspect is the adjunct treatment role of a VAC to fix and secure skin grafts on difficult wound beds or in the therapy of wound dehiscence after major flap operations. [60,61]

The VAC prevents its underlying tissue from movement and avoids shearing forces which facilitates the adherence and healing of grafts and implanted flaps. The application of a mini-VAC allows treatment in an outpatient setting as its device is portable and battery-operated. In addition, it enables full mobility to the patient. [60,61]

Biter et al [61] carried out a randomized control trial to compare VAC-therapy and standard open wound treatment after excision in its effectiveness in the treatment of PSD. 49 patients with symptomatic pilonidal sinus including previous abscess formation in their history in case were involved in the study, exclusion criteria were prior surgical excisions and an age under 16 years. 24 patients under went subsequently vacuum treatment and the remaining 25 the standard open wound therapy. The total follow-up period was determined with six months. [61]

The operational procedure after the excision of the sinuses and tracts was pursued with the positioning of a sponge in the wound adjusted to the borders and the application of a topical skin adhesive to the margins to avoid skin damage. In the following the NPWT device or VAC system was implemented and fixed and a constant undertow of -125 mm Hg was adjusted. After a bi-weekly period negative pressure wound therapy was stopped and was changed into regular wound treatment. [61]

Follow-up inspections were performed on 3, 7, 10 and 14 days postoperatively including the evaluation of the wound size and of complications, pain measurement by the visual analog scale score (VAS) and the substitution of the sponge. [61]

The recovery time on average till the resumption of regular daily activities was possible turned out with 27 days in the NPWT-group and 29 days ( $p = 0.92$ ) in the standard open healing cohort. No significant differences could be detected in the postoperative wound infection rate and recurrence rate between the two groups. [61]

The wound healing rate after 14 days showed significant increased positive results in the NPWT-cohort, where the volume of the wound was decreased with 70 percent compared to 43 percent in the standard open healing group, wound size ratio 0.03 versus 0.57. The ratio was calculated by wound volume measured 14 days after the treatment divided by the volume on day zero postoperatively. Despite that the overall healing rate at the end of the follow up did not differ statistically significant. It was succeeded in 84 days in the VAC-therapy cohort compared to 93 days in the control group ( $p = 0.44$ ). [61]

Bendewald et al [59] published a case series of negative pressure wound therapy in PSD treatment of five patients with a mean age of 21 years. Two cases underwent prior surgical interventions, incision and drainage and Z-plastic, one patient did not show a relapse free interval for 30 years and was treated with five operations in advance. All treated patients could be discharged on the day of the intervention and reevaluation took place in periods of two to three weeks. The application of NPWT was carried subsequently till granulation tissue in the operational sites reached skin level. [59]

Examinations of the affected tissue prior to VAC-therapy yielded in a mean expanse of 124 cm<sup>3</sup> (range of 90 cm<sup>3</sup> to 140 cm<sup>3</sup>), the wound defect on average after excision was measured with 205 cm<sup>3</sup> (range between 90 to 410 cm<sup>3</sup>). NPWT was applied in a mean interval of six weeks (range four to nine weeks) and complete epithelialization could be achieved on average in twelve weeks with an extent of 9 to 22 weeks. The total follow-up period alternated between 6 and 14 months. [59]

A Cochrane systematic review surveying the recurrence and healing intervals for surgery methods in pilonidal sinus detected decreased recurrence rates of PSD following open healing treatment (5.3 percent, 44 of 828 patients) compared to the rates after primary closure procedures (8.7 percent, 73 of 838 patients). [62]

According to that Danne et al [62] carried out a study to improve the results of NPWT compared to alginate-based/ gauze daily dressing in open healing PSD treatment, laying the focus on recurrences and healing time. They reviewed 62 patients over a period of ten years, 30 of them underwent daily dressings and 32 received NPWT (51.6 percent). All patients reported recurrences with florid infections in their history. Nine additional patients presented with small defects (under one cm in diameter) and were treated subsequently with excision and primary closure. They showed complete healing between two and six weeks and were excluded of the further analysis. [62]

Postoperative care included the change of VAC-therapy dressings in an interval of three to four days till granulation reached skin level and were treated afterwards with alginate or gauze dressings. All patients underwent follow-up examinations every two weeks. Within the daily dressing cases the median healing time turned out with ten weeks (95 percent CI: 7-17) with no significant difference to the NPWT cohort of eight weeks on average (95 percent CI: 7-9). Total follow-up intervals were 311 weeks for the NPWT group and 390 weeks for the alginate/ gauze dressing cohort. [62]

Regarding to wound recurrence the NPWT group showed a rate of 3.1 percent and the daily dressing cohort 12.5 percent,  $p = 0.355$ . The overall healing rate of the NPWT treated cases showed an increased positive outcome of 93.6 percent compared to the alginate/ gauze dressing group with 72.4 percent. [62]

Laying open treatment in PSD is impressing with a comparable easy, sparse invasive and if required repeatable performance. Beside that it can be used in cases affected by recurrent and acute pilonidal sinus as well. Other positive aspects are a short hospitalization time and low rates of postoperative infections and of recurrences of the disease. Contrary to that the method requires a prolonged postoperative wound care and performs with a distinct extended healing time. [54-56]

Hence it is recommended in patients affected by larger extension of the disease. Excision with open healing enables a further reduction of the recurrence rate, which is especially achievable in such cases. The use of VAC- or NPWT-therapy is improving the healing process especially in the first two postoperative weeks and reduced recurrence rates are reported comparing the method to standard laying-open procedures. [52,60,61]

### **3.3. Primary Closure Techniques**

Primary closure procedures are part of the standard surgical treatment in Pilonidal disease and were already used in 1932 as mentioned above. Their benefits relay particularly in a faster healing time which allows the quicker return to daily business of the patients with low inconvenient postoperative side effects and less wound care than open treatment methods. On the other hand, increased infection rates and recurrences were reported repeatedly in the literature. [63,64]

The range of primary closure techniques was surveyed and expanded for decades and includes meanwhile a variety of procedures, for instance excision with midline and off-midline closure performed with different suture configuration and material, Bascom's clef lift procedure and flap operations as Karydakakis flap, Limberg flap, V-Y- and Z-plastics, and rhomboid flaps. [63]

#### **3.3.1. Excision with Midline Closure**

Excision with midline closure enables the preservation of the physiological contour of the natal cleft, on the other side increased recurrence rates are reported connected to this method comparing it with off-midline closure techniques. [3,63]

The technique used by Tocchi et al [21] is given as sample for the procedure. All patients received an antibiotics prophylaxis in form of azithromycin for three days before the intervention. The preoperative prearrangements included the positioning of the patient in prone position, the retraction of the buttocks with adhesive tapes to

get access to the operational field, complete shaving of the buttocks and of the natal cleft and sterile preparation. Surgical interventions were carried out under local anesthesia by 30 to 60 milliliters of mepivacaine, one per cent Propofol was given as additional intravenous sedation if necessary. [21]

The injection of methylene blue followed to detect and dye all parts of the tracts. After that an ellipsoid en bloc excision of the affected area was performed, as close as possible to the stained tissue and involving all obvious tracts and sinuses. Subsequently to careful hemostasis the subcutaneous tissue was attached to the sacrococcygeal fascia by using strong resorbable deep sutures. The stitches were guided distanced one inch (2.54 centimeters) through the midline of the fascia. [21]

In case of the implantation of a redon drainage this was placed in the wound bed on the fascia running vertically along the wound poles before the knots were tightened. The deep laying sutures were tied gently to avoid tension in the wound bed. After that skin closure was performed by a row of interrupted non-absorbable mattress-sutures, whereas superficial skin layers and subcutaneous tissue were approximated. The skin sutures were tied over small gauze rolls, placed along the wound margins to protect the tissue from tension and to prevent sutures cutting through. Conclusively the wound was covered with gauze dressings. [21]

Tocchi et al [21] carried out a prospective study surveying excision with midline closure in PSD treatment. They included 103 patients with chronic, non-recurrent, at the time of the study quiescent pilonidal sinus and determined a total follow-up period of five years. Patients presenting with recurrences and acute absceding formations were excluded of the study. [21]

The subjected patients were divided in two groups, the first one containing of 53 cases received intraoperative suction drainages, the second one with 50 patients was operated without the implementation of drains. Symptoms occurred in an average period before surgical intervention of 2.7 years and previous acute inflammations treated medically were detected in 32.1 percent in the drain receiving group and in 26 percent of the non-drained section. [21]

43.4 percent of the surveyed cases presented with up to two lesions located in the midline, the remaining part showed more than two pits. The sacrococcygeal fascia was not part excised as no patient presented intraoperative with the necessity of its removal. The mean duration of the procedure did not differ between the two groups with 29.4 minutes versus 30.4 minutes. [21]

Postoperative examinations took place daily for the first week after the intervention connected with changes of the dressing. Suture removal was performed ten to twelve days after the operation. The drainages were left in place within the wound until no further secretion was detectable with a mean duration of 6.5 days (range four to nine days). [21]

Follow-up supervisions were performed at six weeks, three, six and twelve months after the surgical intervention and then yearly over the complete follow-up period. Wound complications occurred in the non-drained group with hematoma in twelve percent ( $p = 0.01$ ), infection in 34 percent ( $p < 0.01$ ), complete wound dehiscence in 16 percent ( $p < 0.01$ ) and minor wound dehiscence in 26 percent of the cohort treated without drainage. The comparison group showed no complications except minor wound dehiscence in 5.7 percent ( $p = 0.03$ ). The minor dehiscence was determined as incomplete healing affecting less than one fourth of the incision length. [21]

The mean wound healing time performed with 10.3 days in the drain treated group faster compared to the second group with 16.1 days ( $p < 0.01$ ). Median Time before return to work was shortened in the first cohort as well compared to the non-drainage group with 11.7 days versus 17.4 days. Recurrences were developed in 1.9 percent of the drainage group compared to four percent in the comparison cohort. [21]

According to the literature midline closure in primary closure treatment of pilonidal sinus is associated with postoperative problems, recurrences and early and late wound breakdown. The authors reasoned their opposing findings regarding to complications and recurrence rates to a limited sinus excision technique, to space-eliminating fascia sutures, and to the use of drainages. [21]

Gilani et al [63] published a study surveying 114 chronic pilonidal sinus cases without acute absceding formations which underwent excision and midline closure over a period of five years with a follow-up of three years. 38.6 percent of the patients had been treated with incision and drainage prior to the study. [63]

Within the operational procedure non-absorbable deep tension sutures were applied to obliterate dead space in the wound bed by leading them out to the surface laterally puncturing the skin three to five centimeters distantly of the midline. They remained laying open and were tightened above the wound after performing the skin closure in the midline by using interrupted superficial sutures. [63]

A protection layer of rolled gauze was used in between to avoid tension sutures cutting through the skin. Long effective local anesthetic was infiltrated prior to wound closure to reduce postoperative pain and all patients received antibiotic treatment for five days after surgery on average. The tension sutures were removed ten days after the procedure and the superficial skin sutures on the 14<sup>th</sup> postoperative day. [63]

The mean time till reuptake of daily duties was possible was 20.5 days. 69 percent of the cases showed healing of the lesions without postoperative side effects. The remaining 31 percent presented at least with one of the following complications, wound infection occurred in 13 percent, dehiscence in nine percent and the recurrence rate was reported with nine percent. [63]

Milone et al [65] reviewed different methods of skin closure in a randomized control trial in pilonidal sinus treatment. They compared the use of intradermal absorbable sutures and interrupted non-absorbable sutures as superficial stitching in excision with primary closure. 203 patients with chronic pilonidal sinus were included in the study. If they presented with acute inflammations an antibiotic treatment was introduced and the surgery was prolonged two or three weeks later, when the inflammation had subsided. Patients who showed recurrences after being treated with an off-midline closure technique were excluded. [65]

All patients underwent limited excision with retaining of the sacrococcygeal fascia and fixation of the wound bed by absorbable deep tension sutures. No drains were used within the procedure. 103 cases received continuous intradermal absorbable sutures as superficial skin closure. In 100 patients skin closure was performed with interrupted non-absorbable stitches. The stitches were performed for both groups in the midline. Follow-up examinations were carried out one week, two weeks then one month, three months and six months after the surgical intervention. [65]

When comparing the operation time, postoperative time off daily duties, wound infection and recurrence rates no statistic difference between the two groups was detectable. Postoperative wound infection was found in 11 percent of the intradermal suture group and in 9.27 percent of the control group ( $p = 0.64$ ), recurrences were reported with twelve percent in the case group and with 15.4 percent in the interrupted suture cohort ( $p = 0.68$ ). [65]

Regarding to the postoperative satisfaction of the patients and the esthetic appearance the use of continuous intradermal stitches showed a favorable outcome compared to the control group. Satisfaction was measured by a VAS (visual analog scale) questionnaire one month after the operation and 22 percent of the patients rated their condition at that time “very good” in the case group. Compared to that only 11.3 percent of the interrupted suture section rated their status with the same level ( $p = 0.001$ ). [65]

The overall esthetic scar performance was evaluated six months after the operation. It was reported as “good” in 25 percent of the intradermal group, compared to 6.2 percent with the same attribute in the interrupted stitching cases ( $p = 0.01$ ). Hence the authors proposed a clear recommendation for the use of intradermal continuous sutures in the skin closure in pilonidal sinus treatment. [65]

Excision with primary closure turned out being effective especially in chronic or recurrent pilonidal sinus cases with the absence of acute abscesses. It performs with a faster wound healing compared to open treatment methods. Increased postoperative infection- and recurrence rates are reported as adverse side effects, particularly occurring in cases which were treated with midline closure. [36,63,64]

The results of the procedure can be improved by use of drainages on the other side. According to postoperative satisfaction of the patients and to the long-term esthetic appearance of the scar the application of intradermal absorbable sutures in skin closure showed distinctive improved results. [21,65]

## Off-Midline Closure Techniques

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According to the guidelines of treatment of pilonidal sinus of Segre et al [36] and Steele et al [10] off-midline closure should be used in primary closure techniques to reduce the rate of postoperative wound infections, of dehiscence and of recurrences. A meta-analysis revealed significant decreased recurrence rates comparing off-midline- and midline closure techniques, 1.4 percent versus 10.3 percent. Infection rates turned out lower as well in off-midline closures with 6.3 percent compared to 10.4 percent. [3,10,36]

Additional faster healing times are reported in studies surveying off-midline closure in surgical pilonidal sinus treatment. The main target of off-midline closure methods is to create the incision line and later scar laterally to reduce tension and irritations in the midline, the main location of the sinuses and tracts and point of origin of the disease. [10,36,64]

The using of flap techniques allows the flattening of the sulcus and enables due to that the neutralization of the depth of the natal cleft as a main predisposing factor for the disease. [64]

### **3.3.2. Excision with Off-Midline Closure**

The approach of asymmetric sinus excision was first reported by Karydakis. He performed an elliptical eccentric excision followed by a flap mobilization beginning from the medial wound margin and by wound closure laterally of the midline. He reached that way the lateralization of the incision and the flattening of the natal sulcus with the result of a reduced friction within the cleft. [66]

Limongelli et al [66] carried out a study surveying D-shape asymmetric and symmetric excision in pilonidal sinus treatment. Their analysis was based on an electronic database containing all patients who underwent treatment due to pilonidal sinus in a hospital in Naples over a period of 19 years. [66]

Inclusion criteria for the study were chronic and non-recurrent pilonidal sinus. Patients with acute abscesses and distinctive disease with extensive affection of the surrounding tissue (sinus orifices three centimeters distantly of the natal cleft in one direction or orifices 1.5 centimeters apart from the midline bilaterally) did not participate. [66]

In total 569 patients underwent surgical intervention, 447 received D-shape asymmetric excision and in 122 cases standard elliptical symmetric excision on the midline was carried out. The majority part of the included patients presented with pain (82 percent), tumescence (77 percent) and transient discharge (36 percent). The median follow-up period was reported with 11 years (range 3 to 22 years). [66]

The asymmetric excision was performed by conducting a half-moon-shaped incision in a vertical extension of seven to eight centimeters and a horizontal width of three to four centimeters with its center located above the midline. The excision included the affected sinuses and the closer surrounding area was expanded down to the periosteum and the gluteal fascia on its lateral side. Within the procedure a suction drain was implemented and absorbable mattress sutures were used for the wound adaption in layers. The skin was sutured carefully along the concave incision margin with non-absorbable stitches. [66]

According to operation- and healing time, to the hospital stay and to the time of dislocation of the suction drainage no differences between the two groups were detected. Postoperative hematoma occurred in one percent in the asymmetric group and in 1.8 percent in the symmetric cohort as side effects. A significant difference was found in the appearance of partial wound dehiscence with 6.3 percent in the asymmetric section compared to 13.1 percent in patients treated with symmetric excision ( $p = 0.013$ ). [66]

Additional to that a decreased rate of recurrences was surveyed in the asymmetric excision group with 9 percent versus 22 percent ( $p = 0.0001$ ). 20 percent of the relapses after asymmetric excision and 30 percent of the recurrences after symmetric procedure appeared within one year after the intervention. The median recurrence-free interval after undergoing asymmetric treatment in total was reported with nine years (95 percent CI, range 3 to 14 years,  $p = 0.005$ ). [66]

For another approach in surgical PSD treatment, oblique excision and primary closure, recurrence rates are reported with 9.4 to 11 percent in the literature. Mentés et al [67] carried out a study analyzing oblique excision with primary closure in PSD treatment in 493 cases with a total follow up of 18 months. 95.5 percent of the study population presented with primary affection of the disease and 4.5 percent were recurrent pilonidal sinus cases. 12.4 percent of the subjects overall underwent prior abscess drainage before participating to the study. [67]

Within the surgical procedure an oblique fusiform incision stretched over both sides of the natal cleft was performed, followed by en bloc resection of the affected tissue down to the sacrococcygeal fascia and wound closure with non-absorbable sutures without the use of drains. Follow-up examinations were carried out six weeks, and following that 3, 6, 12 and 18 months after the surgical intervention. [67]

Postoperative side effects turned out low with wound infections in 1.2 percent, hematoma in 0.4 percent and wound dehiscence after stitch removal in one percent. The mean length of hospital stay was reported with 5.51 days (range 2 to 17 days) and a total recurrence rate of 5.6 percent was detected when finishing the follow up.

The authors recommended monthly depilation of the operated area and of the natal cleft in general and showers at least five times a week as prophylactic measures to reduce the life-long recurrence of the disease. [67]

Bascom and Bascom [68] laid the focus of pilonidal sinus treatment on refractory, recurrent cases which performed with healing failure and chronic non-healing wounds after preliminary surgical interventions. They detected in the depth and tightness of the natal cleft the main cause for generating morbid conditions for the development of wound and scar break downs. As definitive treatment option in such cases the cleft lift procedure was invented on that score. [68]

Successful treatment of refractory PSD cases could be reasoned by use of that operation due to the reshaping of the sulcus and the resulting reduction of its tightness. Accessorily they reported efficient interventions in the presence of deep inflamed tissue as well. A major benefit of that approach is the absence of the necessity of regularly wound dressings and the easier access to the natal cleft for postoperative depilation by the patient due to its flattening. [68-70]

### **3.3.3. Bascom's Procedure**

Nordon et al [70] carried out a study comparing Bascom's simple procedure with Bascom's cleft closure in the therapy of 55 PSD patients with chronic symptomatic disease presenting with recurrent pilonidal sepsis. All patients fulfilled the requirements of ASA category 1 (American Society of Anesthesiologists), cases with significant comorbidities, measured by ASA > 2, were not included in the study. Bascom's simple surgery was performed in 29 subjected persons. 26 cases underwent cleft lift closure and both groups were surveyed within a median follow up of 36 months (range six months to four years). The follow-up examinations took place weekly starting from two weeks after the intervention until wound healing was achieved or further operative treatment was required. The median required post-operational time off work was equal in both groups with two weeks. [70]

### Surgical steps – Bascom’s Procedure

After the positioning of the patient in prone position and the preparations for the surgery the excision of the midline pits took place, including minimal tissue removal. By creating a lateral incision close to the edge of the natal cleft the underlying abscess hollow was drained off the midline and its substance was curetted. After hemostasis wound closure of the midline lesions with non-absorbable sutures was performed. [70]

#### **3.3.4. Bascom’s Cleft Lift**

According to Tezel [31] and to his concept of the “navicular area” the outer margins of the natal cleft are defined with a pen. After prone positioning of the patient the buttocks are strapped apart to enable better access to the operational field. Following preoperative scheduling the skin incision is carried out on the affected site restricting the subsequent removed area, the point of withdrawal. This later excised tissue, including scars, abscesses, tracts and sinus orifices is elevated in the next step. [31,70]

After that the skin on the contralateral side is undermined from the midline towards the outer margin of the cleft, up to a distance which is required to enable the primary tension-free off-midline closure. Then the former elevated affected tissue is excised, remaining sinuses in the deeper layers are curetted and hemostasis is secured. Following that the subcutaneous fat is approximated with deep absorbable sutures and skin closure is performed. The superficial suture line is located laterally off the midline by shifting the prior undermined tissue across the midline over the prior excised area. [69,70]

Nordon et al [70] included the implementation of a 12F suction drain and superficial wound closure with a continuous subcuticular suture (Prolene 3-0) in the procedure. The drain was removed 24 hours after the surgery and the sutures two weeks later. [70]

17.2 percent of the simple procedure group did not respond to the intervention and required cleft lift closure as definitive treatment. The remaining cases healed at a median time of four weeks (range 3 to 35 weeks). The cleft lift cohort performed with a primary healing rate after the removal of stitches two weeks postoperative with 80.8 percent ( $p < 0.05$ ). The remaining part of the patients in this group healed after a median period of 4.5 weeks (range two to five weeks). All patients of the cleft lift section showed healing within six weeks after the operation. According to recurrences, a rate of eight percent was detected in the simple procedure cohort and relapses were absent in the cleft lift arm within the follow-up period. [70]

Theodoropoulos et al [71] performed a study by using a modified cleft lift procedure in the treatment of PSD surveying 72 active service members of the Greek army. 24 of them were affected by recurrent symptomatic disease and had undergone various surgeries, the majority was treated with cystotomy and curettage, cystotomy with marsupialization and wide excision with open healing. The authors used an asymmetric ellipsoid incision to create a spindle-shaped excision area of the affected skin. Its apex extended beyond the top of the natal cleft and the lateral border coincided with the outer margin of the natal sulcus. Coverage was achieved with mobilized tissue of the contralateral side. [71]

They reported an increase of the incidence of PSD in recruits after their levy into the Greek army and reasoned that with a higher friction in the natal cleft caused by enhanced sweaty activity and the partly reduced possibility for adequate personal hygiene. According to postoperative complications only one patient (1.4 percent) developed serous drainage and partial dehiscence of the upper wound pole. That was treated successfully with wound dressings and healed within three weeks after the operation. No hematomas or seromas and no loss of skin sensation occurred within the operated patients. The time off duty was three weeks postoperative and in the total follow-up period of ten months no relapses developed. [71]

Bascom and Bascom [68] carried out a study including 69 patients with recurrent PSD and prior surgical treatment (three operations on average) when presenting the approach of the cleft lift procedure. 17 patients dropped out during the follow up period. 3.8 percent of the remaining 52 patients developed wound infection and drainage and healed without any additional operational treatment 3 weeks postoperative. 11.5 percent of the surveyed patients required further surgical treatment, five cases required a second cleft lift and one case underwent three lifts in total. All of them healed within the average follow-up period of 30 months and the residual part of the patients, not requiring further treatment, healed without complications within one week after surgery. No recurrences were detected in the surveyed patients within the follow-up period. [68]

Guner et al [69] performed a study of PSD treatment by using a modification of Bascom's cleft lift. 141 patients with primary or recurrent pilonidal sinus were included, 19.9 percent of them underwent incision and drainage of acute abscesses previously and 9.9 percent presented with recurrent disease and prior surgical treatment in their history. Pilonidal sinus cases presenting with acute abscesses were excluded of the study. [69]

Following Tezel's classification, the majority was divided in type III, 61.7 percent, and type IV, 27.0 percent. 24.8 percent of the subjected cases received a suction drain within the operational procedure which was in place for an average time of 1.4 days. The mean follow-up period was 14 months and the follow-up evaluations took place at 3, 10, 30 and 90 days after surgery, followed by half year intervals. [69]

In 124 patients (88 percent) primary healing could be achieved and the mean period till regaining functional recovery was 13.3 days. Wound healing was attained in a mean time of 20 days in cases with postoperative complications, 12.1 percent of the surveyed patients. A superficial wound infection was detected in 4.3 percent of the study population, 6.4 percent developed a seroma and 5.0 percent evolved a partial wound dehiscence. Comparing the complicated cases with primary healed patients without side-effects a distinctive higher BMI was detected in the first group with 27.0 versus 24.6. Within the follow-up period no relapses were evaluated. [69]

The use of flap techniques in the treatment of pilonidal sinus is especially recommended in cases affected by complex and multiple-recurrent manifestation of the disease in which prior surgical treatment has failed. Flap repair is reported as performing with lower rates in complications and recurrences and with an earlier possible postoperative mobilization. In addition, it impedes postoperative wound tension and scar tissue in the midline. [10,26]

### **3.3.5. Karydakis Flap**

Karydakis developed another approach to improve the treatment of pilonidal sinus in 1973 by using a flap technique in that domain, combined with an asymmetric excision, with off-midline wound closure and with the flattening of the natal sulcus. [72,73]

After positioning the patient in prone, the trunk jack-knifed at the hips, and the pre-surgical preparations, including the retracting of the buttocks, shaving and sterile washing of the operational field, methylene blue is applied into the sinus orifices to reveal the extension of the tracts if required. Following that the site with the most lateral sinus opening is marked by a pen two centimeter apart off the midline with a vertical line. The subsequent excision area is marked in an ellipsoid shape including the line and the sinus openings out of the midline. [72]

Then the excision is performed along the marked area down to the sacrococcygeal fascia with a straight verge on the medial side of the flap mobilization and a sloping verge of 45 degree on the lateral side. The tissue on the medial margin is undercut and mobilized across the midline to the contralateral side to create a flap which is used at the end of the procedure for the coverage of the excision site. Hemostasis is performed and a suction drain might be implemented before wound closure if preferred. [72,74]

Sewefy et al [72] carried out a study evaluating the outcomes of standard Karydakias flap technique compared with the additional use of compressing tie-over interrupted sutures without a suction drain in PSD treatment in a period of five years. They included 154 patients without acute abscesses or cellulitis when presenting for the study. [72]

The operational procedure in the Karydakias group included the implementation of a subcutaneous drain before wound closure. In the second group, it was extended by the implementation of tie-over interrupted sutures, including all layers down to the sacrococcygeal fascia. These sutures were positioned vertically along the incision line in distances of three centimeters with skin openings three centimeters laterally of the wound margins. These stitches remained untied till wound closure was performed same way as in the standard Karydakias group and were tied finally over bulky gauze rolls. This enabled the compression and obliteration of the dead space within the wound and the reduction of tensions of the suture line. [72]

All patients of the tie-over group were discharged on the surgery day, the cases in the standard group after a mean hospital stay of 4.9 days. The average time to resume daily duties was comparable shorter in the first group with 10.2 days compared to 12.6 days in the standard group. According to postoperative complications the cases treated with standard Karydakias flap prevailed with developing seroma in 7.8 percent compared to zero in the tie-over group ( $p = 0.012$ ), wound infections occurred with 9.1 percent versus 1.3 percent ( $p = 0.029$ ). The median follow-up period was with 25 months (range 6 to 50 months). Relapses turned out rare with 2.6 percent in the standard cohort and none were detected in the cases treated with additional tie-over sutures within that time. [72]

Keshvari et al [75] performed a study comparing excision with secondary healing and Karydakias flap procedure in PSD treatment in a prospective RCT. They included 321 patients with primary and recurrent pilonidal sinus, 161 in the Karydakias flap group and 160 in the secondary healing cohort, over a median follow up-period of 49 months (range 3 to 88 months). [75]

They reported decreased rates of wound complications in the Karydakis group compared to the open healing cohort with 18.7 percent versus 31.2 percent ( $p = 0.006$ ) including infection, hematoma, seroma and skin separation. The mean time of wound healing was shortened as well with 16.44 days versus 80.01 days ( $p < 0.001$ ) as the average time to resume daily duties in the Karydakis group with 14.44 days versus 24.19 days ( $p < 0.001$ ). Recurrences turned out distinctive higher in the open healing group with 7.5 percent vs. 1.2 percent ( $p = 0.005$ ), 50 percent of the relapses of the open healing cohort occurred within the first postoperative year. [75]

Karydakis reported a complication rate of eight percent, mainly associated with infection and fluid collection when evaluating the standard Karydakis procedure. Keshava et al mentioned rates of wound dehiscence of 8.4 percent and minor postoperative side-effect rates of 38 percent, in general caused by seromas, hematomas and abscesses. Kumar et al described a wound infection rate of 5.8 percent for the operation technique. [72]

As major advantage of the Karydakis flap procedure the complete removal of the suture out of the midline and its simple technique compared to other asymmetric flap techniques as Z-plastics, rhomboid and V-Y flaps is mentioned, wherein the suture remains partly in the midline. [72]

### **3.3.6. Limberg Flap**

Another surgical approach was introduced and came in use during the 1980s and 1990s beside Bascom's cleft lift procedure, the Limberg flap. The operational procedure is explained below. [73]

After the positioning of the patient and the preoperative preparations the planned excision site is marked with a pen in the shape of a rhombus with 60 degrees vertically and 120 degrees horizontally containing the sinus orifices and tracts. Following that the subsequent mobilized flap is marked with a pen on the contralateral side. This is achieved by drawing a vertical line off the medial corner of the former defined rhombus across the midline to the opposite side. That vertical

line is prolonged within that procedure medially and caudally with an angle of 60 degrees, until it is corresponding to the edge length of the rhombus respectively to the same dimension. [76]

As the required tissue can be estimated better after the removal of the affected area, this step should be performed after the excision of the rhombus down to the sacrococcygeal fascia. In the next step hemostasis is achieved by diathermy, the fasciocutaneous flap is mobilized below the gluteal fascia and transposed tension free medially to cover the excised area. Wound closure is performed after the implementation of a suction drain under the fascia in general. [74,76]

Ates et al [74] carried out a prospective randomized study comparing the outcomes of Karydakis and Limberg flap in PSD treatment over a mean follow-up period of 26.4 months. They included 269 patients, 134 underwent the Limberg flap procedure and 135 received the Karydakis flap. [74]

The required mean operation time turned out significantly shorter for the Karydakis group with 42.32 minutes versus 50.14 minutes ( $p = 0.01$ ) in the Limberg section. A visual analog scale ranging from one to ten was used to evaluate the satisfaction of the patients with the esthetic appearance of the scars three months postoperative. The Karydakis group showed better results in this aspect with  $7.08 \pm 1.75$  compared to the Limberg cohort with  $3.16 \pm 1.40$  ( $p = 0.01$ ). [74]

The rate of wound complications including seroma, hematoma, infection and wound dehiscence was decreased in the Karydakis group as well, 11.1 percent compared to 20.8 percent ( $p = 0.029$ ). The major part of both groups showed complete healing during the first month after the operation. One patient of the Karydakis cohort required a second operation and repeated surgical treatment was necessary in 2.9 percent of the Limberg group due to wound dehiscence. Neither ischemia nor flap necrosis could be detected in all operated cases within the follow-up period. According to recurrences the rates were reported with three percent in the Karydakis cohort and 6.9 percent in the Limberg group ( $p = 0.151$ ). [74]

Daphan et al [77] performed a study, evaluating the Limberg flap procedure in treating 147 PSD patients in a military hospital. 85 percent of them presented with primary disease, the remaining 15 percent underwent excision and primary closure due to recurrent pilonidal sinus. At the time of presenting to the study 46.3 percent of the cases were affected by chronic discharge and 42.9 percent by tumescence. 10.9 percent of the patient underwent prior drainage treatment due to pilonidal abscesses. [77]

The mean follow-up period was 13.1 months (range 1 to 40 months). Recurrences occurred in 4.8 percent of the cases. No postoperative infections could be detected within the follow-up period. Wound complications turned out rare with seroma in two percent, and partial wound dehiscence in 4.1 percent of the surveyed cases. The patients with partial dehiscence improved in 15 to 20 days after been treated with local nonsurgical wound care. All treated cases could return to full duty after a mean time of 18.8 days after the intervention. [77]

Muzi et al [26] performed a prospective RCT comparing Limberg Flap and tension free primary closure in 260 primary and recurrent PSD patients. The ratio between the two groups was 50:50. Patients who presented with an ASA score higher than III, with risk of malignant hyperthermia, obesity (with an BMI over 35), DM I, and the abuse of drugs and alcohol were excluded from the study. In the primary closure group, the mean follow-up was 47.83 months and in the Limberg cohort a mean period of 45.74 months was reported. [26]

Though surgical time was shorter in the primary closure group due to the different technique, the wound infection rate turned out higher with 10.77 percent compared to 3.08 percent in the Limberg arm ( $p = 0.0254$ ). On the other hand, no significant difference was reported regarding to the time absent of work or the presence of wound dehiscence. Relapses occurred in 3.84 percent in the primary closure arm compared to zero in the Limberg flap section ( $p = 0.153$ ). [26]

According to overall healing rates success of the intervention was attained in 84.62 percent (110 patients) of the Limberg flap cases and in 77.69 percent (101 patients) of the primary closure group ( $p = 0.0793$ ). Regarding the total study population, success of the procedure could be achieved in cases affected by chronic infection in 86.1 percent, compared to 74.3 percent in cases free of chronic infection ( $p = 0.1833$ ). In cases which presented with acute infection healing was obtained in 60.0 percent, compared to that a significant higher success rate of 86.8 percent was achieved in the absence of acute infection ( $p < 0.0001$ ). [26]

Ertan et al reported increased outcomes for the Limberg flap procedure when comparing it with primary closure with a recurrence rate of two percent versus 12 percent within a mean follow-up of 19 months. [26]

### **3.3.7. V-Y Flap**

Unalp et al [78] compared the Limberg Flap procedure with another approach, the V-Y flap, in PSD treatment surveying 111 PSD patients retrospectively. 14.4 percent of the study population underwent prior operations for recurrent disease, in 52.3 percent previous infections or chronic purulent discharge occurred and 18.9 percent were treated with incision and drainage in advance. [78]

66 patients were contained into the Limberg group and 45 received V-Y flaps as treatment. The mean follow-ups were 45.4 months in the Limberg section and 48.8 months in the V-Y cohort. Mean postoperative hospital stay was reported with 3.5 days  $\pm$  2.7 days (range 1 – 16 days) and time off work after the procedure with 14.9 days  $\pm$  5.5 days (range 10 – 45 days). [78]

Surveying the study population regarding to wound complications as suture abscesses (9 percent), necrosis (1.8 percent), seroma (3.6 percent), wound infections (7.2 percent) and dehiscence (3.6 percent), no significant differences could be detected between the two groups. Despite that recurrence rates turned out distinctive decreased in the Limberg arm with 1.5 percent compared to 11.1 percent in the V-Y section ( $p = 0.039$ ) and the authors recommended therefore this method in treating extended pilonidal sinus cases. [78]

Eryilmaz et al [79] performed a study examining the use of V-Y flap procedure in PSD treatment, including 43 selected patients with extensive recurrent complicated pilonidal sinus. Complicated cases were determined in this case as being affected by multiple sinuses with openings on both sides of the natal cleft, caused by repetitive infections and located at least in distanced five centimeters away of the midline. [79]

37 of the included cases presented with complicated primary disease and six with recurrent PSD. The mean duration of hospital stay was three days, mean absent time of daily tasks was reported with 17 days and a mean follow-up of 48 months was defined. 7 percent of the cases showed hematoma and 9.3 percent developed postoperative wound infections. 16.3 percent which received bilateral V-Y flaps reported postoperative numbness of the operated area. Recurrences occurred only in one patient (2.3 percent) within the follow-up period. [79]

Full-thickness flaps as V-Y fasciocutaneous flap, Z-plastics, W-plastics and rhomboid flaps as Limberg flap and Dufourmentel flap are more complicate and more complex to perform and are affecting a larger area. They are mainly used in extensive complex cases of PSD for that reason. The potential of more tissue loss and the cause of postoperative morbidity are therefore higher in such cases. One disadvantage of them is the decreased cosmetic outcome, compared for example to the simpler Karydakis flap technique or midline-closure procedures. According to Z- and W-plastics necrosis of the flap tips as a side-effect and non-favorable scars are reported. [46,72,78-80]

In treatment of PSD full-thickness flaps maintain the flattening of the natal sulcus as main target. As most relapses of the disease are developing in the natal cleft these techniques enable a reduced friction and decreased moisture within the cleft and avoid the accumulation of new potential invading hairs. This way they fulfill a chief object in treating patients with complex recurrent pilonidal disease. [72,78]

## 4. Discussion

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The role of hair as main causative factor for the development and progression of the disease has been proved in the published literature. Following an acquired approach hair invasion combined with minor trauma is described as main predisposing component in the evolution of PSD. [1,5,16,25,67]

The theory of an acquired origin and genesis of pilonidal sinus is supported by the majority part of the publishers. Opponents of this hypothesis are suggesting a genetical predisposing component of the disease, based on the predominant prevalence of PSD in certain countries and areas, the absence of the disease in black people and rarely reported cases in Asia. [23,27,28]

The typical location of primary pilonidal sinus lesions, the midline of the natal cleft, and the detection of a familial clustering including first-degree relatives are supporting that theory. According to that PSD shows an increased appearance in families with a positive history of the entity. [23,24]

Since the structured recording of PSD in the literature in 1924 a wide range of surgical treatment methods in the treatment of PSD has been established and is in use so far. The treatment options are reaching from minimal invasive procedures over various excision techniques and secondary closure methods to complex comprehensive flap plastics. [15,21,55,61,66,78]

Conservative treatment methods, particularly laser depilation and phenolization were used for a comparable shorter period as treatment options in this field. So far, a smaller number of examined cases and relative short follow-up periods are included in the published studies concerning these approaches. Due to the minimal invasive aspect and swift performance combined with success rates up to 85.7 percent after the first application phenolization should be established in day-case treatment of moderate PSD cases in larger measure. [36-38,41,44,45]

Pit-excision as a minimal invasive surgical component combined with phenolization revealed lower rates of recurrences and of postoperative complications in addition. As standing alone treatment, it is recommended in moderate PSD cases especially affected by lesions limited to the midline and performs with overall healing rates up to 79 percent and low complication rates in general. [46,49,50]

Incision and drainage treatment in PSD is reducing the long-term recurrence rate, even though affected patients undergo definitive surgical treatment subsequent in their history. Combined with curettage increased healing rates and decreased recurrences were reported. [10,36,48]

Comparing primary and secondary surgical closure methods in the treatment of pilonidal sinus the two groups showed equal performances with no significant differences regarding postoperative complications. Similar findings were detected according to overall healing rates. Open treatment techniques perform with a distinctive decreased recurrence risk compared to the primary closure approach in PSD therapy. On the other hand, remarkable faster healing times are described in primary closure procedures. [3,46,52,56]

In case of open healing treatment additional sinus excision facilitates wound healing by a further reduction of the recurrence rate. The use of VAC- or NPWT-systems improves the healing process particularly in the first two weeks after the operation and results in a reduction of recurrences compared to standard open healing. In general, open treatment of pilonidal sinus is recommended in cases affected by extended and more complex manifestation of the disease. [52,60,61]

Off-midline closure techniques perform with faster healing rates and reduced recurrences in the treatment of pilonidal sinus compared to midline closure procedures. The main approach of these procedures relies on shifting the scar laterally to reduce tension and irritations in the midline of the natal cleft. They include excision techniques, procedures as Bascom's cleft lift and various flap operations. [3,10,36,64,68]

Comparing asymmetric and symmetric excision techniques with off-midline closure, lower rates of wound dehiscence and decreased recurrence rates were detected in the asymmetric approach. Bascom's cleft lift boasted with a more stable healing rate and a reduced recurrence rate compared to Bascom's procedure. [66,70,80]

Surveying Karydakis flap procedure an improved outcome was detected when adapting deep tie-over sutures within the procedure according to postoperative complications and recurrence rates. A better outcome regarding postoperative side-effects and relapses of the disease was reported in Karydakis flap technique, comparing it with laying open treatment and with Limberg flap. On the other hand, decreased recurrence rates were reported for Limberg flap compared to V-Y flap, postoperative complications did not differ distinctively between these two methods. Comparing Limberg flap and tension free primary closure an increased rate of wound infections and of relapses was revealed in the primary closure group. [26,72,74,75,78]

## 5. Conclusion

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The assumption of a genetic predisposition of pilonidal sinus, which increases the outbreak of the disease in the vulnerable age of affected patients remains under debate. The increased incidence in specific countries might be caused by a higher rate of consanguinity in the affected populations. Hence further extended studies should be carried out with the focus on familial clustering of pilonidal sinus including more generations to clarify and to improve this etiological interrogation. [23,29]

The use of laser depilation and phenolization as conservative treatment options should be established in treatment of moderate PSD cases as both procedures perform with comparable low side-effects and enable cost-effective, compared quick and if required repeatable treatment, in an outpatient setting. The evidence of them is still under debate. Thus, supplementary comprehensive studies including a larger number of examined cases and extended follow-up periods should be promoted to improve the validities of these methods and to broaden the spectrum of treatment modalities of pilonidal sinus. [37,38,44]

Three main predictive factors for the appearance and the development of PSD have been revealed, an increased body hair rate, infrequent personal body hygiene and prolonged sitting intervals. Thus, affected patients, especially persons afflicted by hirsutism, should draw attention to increased, frequent personal hygiene and should avoid longer sitting intervals whenever possible. As an increased rate of pilonidal sinus is detected in active members of armed forces in general, sufficient bathing facilities to maintain appropriate hygiene conditions must be provided for this population group. [7,23,27-29,48,71]

Regarding the long-term esthetic appearance of scars the application of intradermal absorbable sutures in skin closure in primary closure methods revealed distinctive improved results compared to the use of interrupted non-absorbable stitches. As no significant differences, according to postoperative complications and recurrences were detected between those two groups the use of intradermal absorbable sutures in wound closure is recommended, if possible. The presence of pilonidal abscess or of acute infection is a major negative influencing factor in surgical PSD treatment, regarding the healing rate and postoperative complications. Therefore, a main approach of surgical treatment in PSD must be the elimination of acute absceding events prior to definitive surgical treatment. [26,65]

Due to the complexity of pilonidal sinus and the wide range of therapy methods a golden standard of the treatment is still under debate. The main targets of surgery techniques in this field should be to ensure a cost-effective procedure, with minimal required absences of daily duties for the patients and uncompliate postoperative wound care if procurable. Furthermore, a distinct reduced rate of postoperative side effects and relapses should be enabled. The decision of the specific treatment option should be finalized based on the individual needs of the presenting patient according to the complexity and severity of the disease. Personal limitations of the patients should be included in the decisioning as they may influence the choice between primary or secondary closure methods. [14,80]

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