CME

Best Solutions for Perineal and Pressure Sore Reconstruction

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Learning Objectives: After studying this article, the participant should be able to: 1. Understand variations of the myocutaneous rectus abdominis muscle flap as it is used for perineal reconstruction and discuss common and alternative options for perineal defect reconstruction. 2. Review primary options and alternatives to pressure sore reconstruction if the primary option is not available and recognize when pressure sore reconstruction is not feasible. 3. Highlight pertinent anatomy and techniques for the flaps described.

Summary: Perineal reconstruction following tumor resection is often complicated by irradiated tissue and multiple comorbidities, making reconstruction challenging. Management of these conditions can have complication rates as high as 66 percent, which further compounds the costs and implications of managing these wounds. These complication rates can be significantly decreased using flap closure rather than primary closure. Pressure ulcers also occur in patients with poor overall health, multiple comorbidities, and often numerous prior failed reconstruction attempts. Comprehensive management of pressure sores is a significant burden to the health care system, at a cost of $9.1 to $11.6 billion per year. There exists an extensive body of literature describing the pathophysiology and management strategies for these problems. The focus of this article is to discuss best solutions for perineal and pressure ulcer reconstruction, and to explore alternative options for reconstruction. (*Plast. Reconstr. Surg.* 148: 1026e, 2021.)

Perineal defects and pressure sores are frequently encountered in practice, and their management may be challenging. Colorectal cancer is the third most common cancer in the United States, with an estimated 43,300 new cases diagnosed in 2020.[1,2] An estimated 2.5 million patients yearly are treated for pressure ulcers.[3] Management of these conditions can be associated with complication rates as high as 66 percent in some series, which further compounds the costs and implications of managing these wounds.[4–10] Even with optimized care, they still represent a tremendous burden to health care systems, costing upward of $9.1 billion dollars per year.[3] The goal of this article is to provide an update on the newly available evidence in the management of perineal defects and pressure sores by addressing knowledge gaps and areas of controversy that exist in the reconstruction of these defects.

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PERINEAL RECONSTRUCTION

Many factors are known to affect the outcomes of perineal defect reconstruction.[10–13] These factors need to be considered and optimized to achieve successful reconstruction of perineal defects (Table 1). Although the restoration of sexual function is an important part of the reconstructive process, its discussion is beyond the scope of this review.

Perineal reconstruction can be complicated in patients who require neoadjuvant radiation therapy before resection. Studies have shown a significant difference in local recurrence rates with increased circumferential resection margins. Patients with 10-mm margins have a 5-year survival rate of 80 percent in comparison to a 34 percent 5-year survival rate in patients with less than 1-mm

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Table 1. Factors Affecting Outcomes in Patients Undergoing Perineal Reconstruction

Patient factors affecting reconstruction outcomes
Preoperative nutritional status (albumin >2 g/dl)
Poor glycemic control
Urinary/fecal tract reconstruction or diversion
Smoking
Perineal bacterial counts
Chemotherapy
Radiation therapy
External pressure on reconstruction

margins.[14] Patients with a positive pathologic circumferential resection margin and T4 tumors may benefit from postoperative neoadjuvant chemotherapy.[15]

Perineal Reconstruction Algorithms

Different algorithms for perineal reconstruction have been reported.[4,16,17] Westbom and Talbot describe approaching perineal reconstruction based on the complexity and size of the defect by creating an algorithm for simple and complex defects (Figs. 1 and 2).[17] Simple defects, which are defined as small or superficial defects, are treated with primary closure or local flaps. Complex defects, involving reconstruction of multiple anatomical structures, are reconstructed using muscle or myocutaneous flaps based on size and location.[17] An algorithm by John et al. describes reconstruction according to size and location of defect after resection,[16] whereas Mericli et al. approach perineal reconstruction using a subunit approach. Each subunit is paired with flap choices based on anatomical and aesthetic considerations.[4]

Reconstruction of Perineal Oncologic Defects

Table 2 summarizes the advantages and disadvantages of a variety of flaps used for perineal reconstruction.

Rectus Abdominis Flaps

When compared to primary perineal wound closure, myocutaneous flaps reduce major and overall complications.[18] Traditionally, the vertical rectus abdominis myocutaneous flap was the workhorse behind these reconstructions, especially in the setting of radiation therapy (Fig. 3).[19] Recently, alternative fasciocutaneous and perforator flaps have been described for these defects, in addition to variations in skin paddle design of the vertical rectus abdominis myocutaneous flap. In the case of prior ipsilateral ostomy placement or abdominal scars that may have violated the rectus abdominis muscle from previous operations, alternatives to the vertical rectus abdominis myocutaneous flap should be considered. In addition, with extensive scarring of the abdomen, care must be taken when designing the skin paddle of the flap to both ensure adequate perfusion and to allow for donor-site closure. By designing the flap skin paddle obliquely including periumbilical perforators or crossing the costal margin, a much longer flap can be created, which can be used to reconstruct defects where a traditional vertical rectus abdominis myocutaneous flap would not be sufficient.[20] (**See Figure, Supplemental Digital Content 1**, which displays the variations of vertical rectus abdominis myocutaneous flap design, ***http://links.lww.com/PRS/E730***.) [**See Video 1 (online)**, which displays variations in rectus abdominis myocutaneous flaps.]

By modifying the traditional flap harvest technique, it may be possible to decrease donor-site morbidity and still harvest a myocutaneous flap. The muscle-sparing vertical rectus abdominis myocutaneous flap technique avoids harvesting the entire width of the rectus abdominis muscle and preserves a larger portion of the anterior rectus sheath, thereby preserving innervated rectus abdominis muscle and reducing the potential for donor-site hernia.[21,22]

Minimally Invasive Techniques

Minimally invasive techniques in abdominoperineal surgery have become more common. Laparoscopic abdominoperineal resection has been shown to reduce operative times and lead to faster postoperative recovery. These benefits are negated when a traditional open vertical rectus abdominis myocutaneous flap harvest technique is used, necessitating the development of minimally invasive techniques for vertical rectus abdominis myocutaneous flap harvest. A recent study by Agochukwu et al. evaluating patients after laparoscopic rectus abdominis flaps for perineal reconstruction reported shorter operative times, average flap harvest time of 60 to 90 minutes, and no postoperative abdominal wall hernias.[23] Although there are many potential benefits of minimally invasive rectus abdominis flap harvest, the steep learning curve has led to limited adoption. Robotic harvest offers an easier learning curve with the benefits of shorter operative time, average harvest time of 60 minutes, and decreased postoperative complications, making this the preferred method of minimally invasive rectus abdominis muscle flap harvest among plastic surgeons.[24,25]

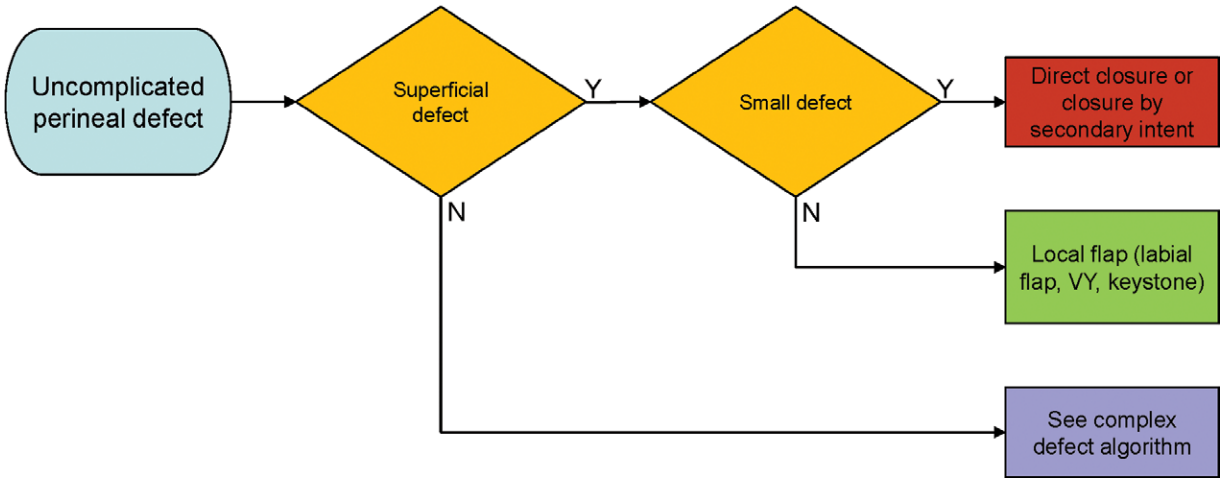

Fig. 1. Reconstruction of simple perineal defects. (From Westbom CM, Talbot SG. An algorithmic approach to perineal reconstruction. *Plast Reconstr Surg Glob Open* 2019;7:e2572.)

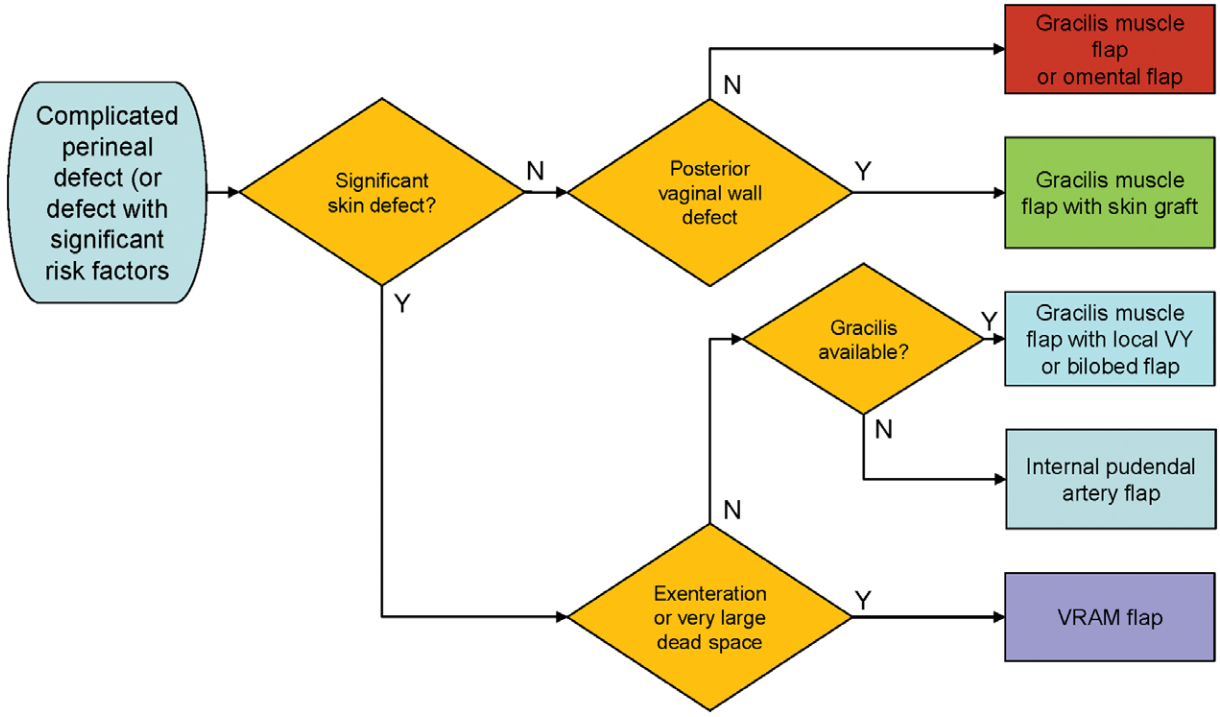

Fig. 2. Reconstruction of complex perineal defect. (From Westbom CM, Talbot SG. An algorithmic approach to perineal reconstruction. *Plast Reconstr Surg Glob Open* 2019;7:e2572.)

Gluteal Flaps

In patients who have a large hernia defect, the hernia may preclude the use of the rectus muscle for perineal reconstruction.[19,20] The use of the rectus abdominis flap in cases where both urinary and fecal diversion are planned can leave the patient an abdominal cripple. This limits regional donor sites to the thighs or gluteal regions. In these cases, it may be best to use peripelvic flaps for reconstruction.[26]

Fasciocutaneous bilateral gluteal flaps have been described with dead space obliteration completed by partial deepithelialization of the flap.[27] A modification of this includes the adipofascial-cutaneous gluteal fold flap based on the perforators of the internal pudendal artery. Using bilateral flaps, one is deepithelialized to obliterate the dead space and the other to resurface the cutaneous defect. Bilateral gluteal artery perforator fasciocutaneous flaps have several advantages: they provide

Table 2. Advantages and Disadvantages of Flaps for Perineal Reconstruction

Flap	Blood Supply	Advantages	Disadvantages
VRAM	Deep superior and inferior epigastric arteries	Workhorse flap; reliable; can be harvested with or without skin paddle; adequate bulk and volume to obliterate dead space; outside of radiation zone	Risk of hernia or abdominal bulge; limits future abdominal operations; large visible scar; patients with multiple prior abdominal operations may not be candidates
SGAP/IGAP	Superior and inferior gluteal arteries	Abundant soft-tissue available; minimizes donor-site morbidity; spares gluteus muscle; preserves gluteal cleft; no abdominal incision	Less bulk than VRAM; shorter arc of rotation; meticulous dissection; may require omental flap if large amount of dead space
Gracilis	Medial circumflex femoral artery	Good for small defects; no abdominal incision	Less reliable skin paddle; small flap size
Posterior thigh	Descending branch of inferior gluteal artery	Large amount of soft tissue available; shorter operative time, less blood loss; can be harvested as a sensate flap if needed; no abdominal incision	Higher donor- and recipient-site complications; can be bulky in patients with higher BMIs
ALT	Descending branch of lateral circumflex femoral artery	Large arc of rotation; reliable blood supply; large amount of soft-tissue bulk available	Meticulous dissection; can be bulky in patients with higher BMIs

VRAM, vertical rectus abdominis myocutaneous; SGAP, superior gluteal artery perforator; IGAP, inferior gluteal artery perforator; ALT, anterolateral thigh; BMIs, body mass indexes.

abundant tissue for posterior perineal defect reconstruction, they allow preservation of the gluteal cleft, and they minimize donor-site morbidity by allowing preservation of the underlying gluteal muscles.[26,28–30] This is particularly important for ambulatory patients. In addition, gluteal artery fasciocutaneous flaps can be supplemented with an omental flap for better pelvic dead space obliteration. The omental flap can be raised by laparoscopic or robotic techniques in the absence of a midline laparotomy.[31]

When rectus abdominis–based flaps and gluteal artery perforator fasciocutaneous flaps are not available, V-Y advancement flaps have been described for reconstruction of large perineal defects. Smaller versions of these based on the internal pudendal arteries have also been described.[32]

Gracilis Flap

Gracilis muscle–based flaps have traditionally been an option for thigh-based flap reconstruction of smaller perineal defects, especially for partial vaginal reconstruction. Skin paddle design can be challenging, leading to concerns about the viability of the skin paddle in myocutaneous gracilis flaps, with modifications of surgical planning aiming to address this potential disadvantage. The bilobed gracilis myocutaneous flap was designed as a means of increasing the bulk and reliability of the skin paddle in patients with a compromised abdominal wall (Fig. 4).[33]

Free Flaps

Given the abundance of local options, free flaps are not commonly used in perineal

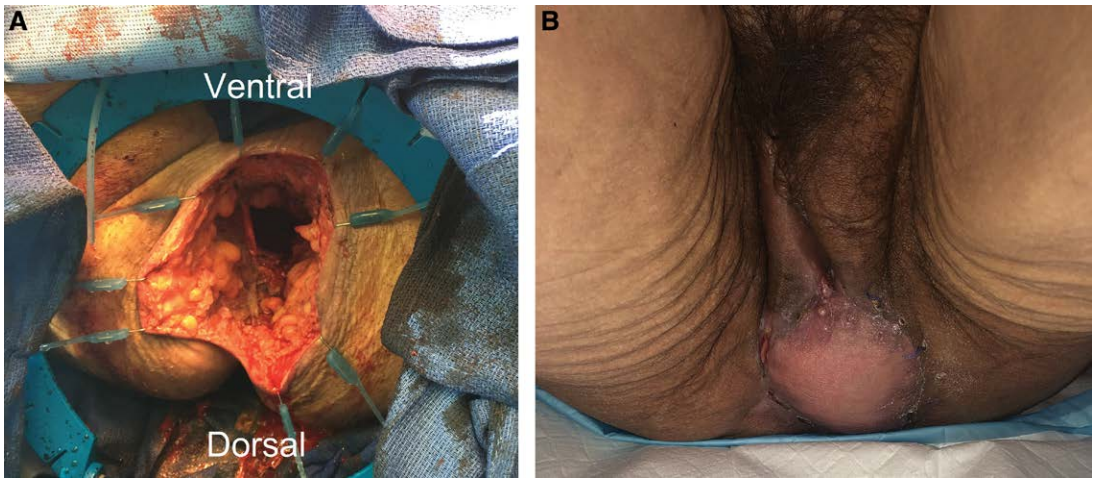

Fig. 3. (*Left*) Typical perineal defect following abdominoperineal resection. (*Right*) Reconstructed perineal defect with vertical rectus abdominis myocutaneous flap.

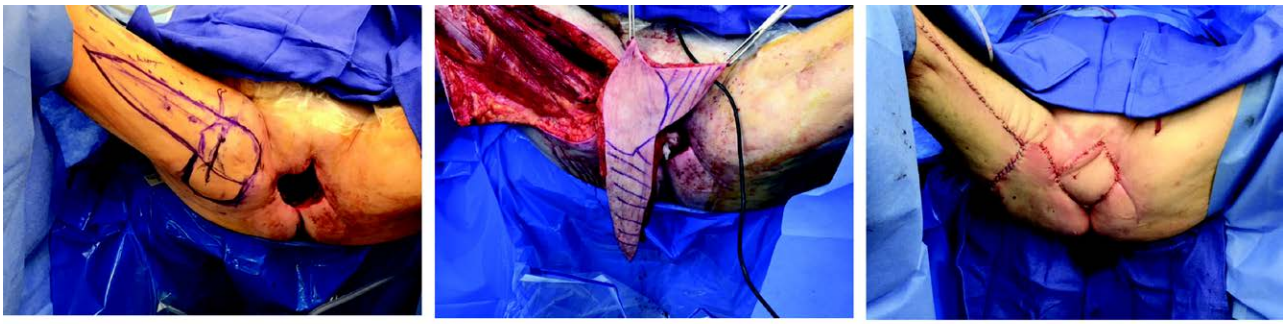

Fig. 4. The bilobed gracilis myocutaneous flap. (From Weinstein B, King KS, Triggs W, Harrington MA, Pribaz J. Bilobed gracilis flap: A novel alternative for pelvic and perineal reconstruction. *Plast Reconstr Surg*. 2020;145:231–234.)

reconstruction. Patients with extensive disease undergoing resection with large defects may require free flap reconstruction. Latissimus dorsi flaps are a commonly described option, as they provide sufficient soft tissue for large defects.[34,35]

Complications

Complications after pelvic reconstruction can be subdivided into major and minor. Major complications are typically defined as any outcome that requires procedural reintervention, such as reoperation, abscesses requiring surgical or percutaneous drainage, or complete flap loss. Minor complications can be defined as any outcome that can be managed nonoperatively. Typical minor complications include wound dehiscence/delayed wound healing, perineal hernia, and partial flap necrosis.[36]

The majority of studies that evaluate the complication rate following reconstruction involve patients undergoing vertical rectus abdominis myocutaneous flap surgery, as this is the most commonly used flap for perineal reconstruction. [**See Video 2 (online)**, which describes methods of optimizing outcomes in perineal reconstruction.] Smaller studies have compared complication rates following vertical rectus abdominis myocutaneous flap surgery to other reconstructive options. Chaudhry et al. reviewed outcomes in patients who underwent vertical rectus abdominis myocutaneous flap versus omental flap surgery. Patients who underwent vertical rectus abdominis myocutaneous flap surgery were more likely to develop wound dehiscence, most commonly at the recipient site, whereas patients who received an omental flap were found to have significantly higher rates of seroma, pelvic abscess, and cellulitis. The omental flap patients were also found to have a significantly higher rate of tumor recurrence.[37]

When comparing complication rates between vertical rectus abdominis myocutaneous and thigh-based flaps, there have been conflicting results regarding donor-site healing and infection.[32,33] Despite the proposed benefits of various alternative flap options, the vertical rectus abdominis myocutaneous flap continues to be the preferred flap for perineal reconstruction.

PRESSURE SORE RECONSTRUCTION

Pressure sores remain a major burden for a significant number of patients and for health care systems. It is estimated that 2.5 million pressure ulcers are treated yearly in the United States, at a cost of $9.1 to $11.6 billion per year.[38–43] Previous CME articles have extensively reviewed the pathophysiology, staging, and strategies for prevention of pressure sores.[44,45] In the present article, we focus on reviewing key updates on the best surgical options available for these wounds.

Preoperative Optimization

Preoperative optimization remains one of the most fundamental pillars for successful pressure sore management. This is especially true for cases in which comorbidities preclude sufficient optimization to enable surgery. Numerous studies have investigated the role of nutrition in the context of wound healing with sufficient evidence to support a target prealbumin of greater than 2.0 g/dl and a goal protein intake of 1.5 to 3.0 g/kg per day to promote adequate healing. In addition to ensuring adequate protein intake, the use of vitamin and mineral supplementation has been shown to have a moderate impact on wound healing.[45]

Once the patient has been optimized and deemed a surgical candidate, it is important to note that the location of the ulcer has a significant impact on healing. Even with ideal optimization, long-term pressure ulcer recurrence is common[45,46] (Table 3).

Conservative Treatment

Because of the significant risk to the patient undergoing surgical reconstruction of pressure ulcers and high recurrence rates, conservative management continues to be a mainstay of treatment. Although some have advocated the use of hyperbaric oxygen therapy for enhanced wound healing, there remains a lack of robust evidence to support its use.[39,45] Negative-pressure wound therapy can reduce preoperative pressure ulcer size, but it remains to be determined whether this translates into lower postreconstruction infection rates.

Bone Biopsy

The role of preoperative bone biopsy and an extended course of preoperative antibiotics remain controversial. However, evidence has shown that confirmed osteomyelitis is an independent predictor for postreconstruction wound dehiscence, highlighting the importance of adequate bone débridement before definitive flap coverage in addition to culture-guided antibiotics.[47] Bone cultures should be taken both before and after débridement, as postdébridement cultures will help guide necessary antibiotic treatment. In the setting of culture and intraoperative bone biopsy–proven osteomyelitis, a course of 3 to 6 weeks of postreconstruction antibiotics is indicated.[45]

The effect of patient age on outcomes remains unclear, with more recent data showing no association between age and postreconstruction complications.[46,47] For patients that have been appropriately optimized, reconstruction may proceed based on the location of the wound, previous operations, and the patient's ambulatory status.

Pressure Sore Reconstruction Algorithms

Cushing and Phillips outlined an approach to management of pressure sores by stage and location (Figs. 5 through 8).[45] In this algorithm, pressure ulcers are first delineated by their stage, with stage I to II managed conservatively and stage III to IV likely requiring operative intervention. If the patient is an operative candidate, the algorithm approaches treatment based on pressure sore location, size/depth of wound, and prior surgical procedures.

Reconstructive options include both fasciocutaneous flaps, musculocutaneous flaps, and muscle flaps. Fasciocutaneous flaps offer durable tissue without functional deficit; however, they may lack the bulk needed to fill large wounds. Musculocutaneous flaps can be used to treat large wounds and fill dead space but can leave patients with a functional deficit. When possible, musculocutaneous flaps and muscle flaps are avoided in ambulatory patients (Table 4).

Table 3. Preoperative Optimization before Pressure Ulcer Reconstruction

Albumin >2.0 g/dl
Protein intake of 1.5–3 g/kg/day
Vitamin and mineral supplementation
Glycemic control

Sacral Pressure Sore Reconstruction

Gluteal based flaps remain the mainstay for sacral pressure ulcer reconstruction. This is a versatile flap, which can be advanced into the defect in a V-Y fashion or as a rotational flap. In addition, this flap can be mobilized as a musculocutaneous flap, a fasciocutaneous flap, or a muscle-only flap. One of the main advantages of using gluteal fasciocutaneous flaps is the ability to preserve the muscle function for patients that can ambulate. In addition to gluteal flaps, other less commonly used options are the transverse and vertical lumbosacral flaps. These flaps are based on lumbar perforating vessels, and their main limitation remains their lack of bulk to obliterate dead space effectively.

Variations on the gluteal flaps include perforator flaps based on the inferior or superior gluteal arteries. As with traditional fasciocutaneous gluteal flaps, these can provide ample bulk for wound coverage. In line with this, keystone flaps have been described to help close various defects and have made their way into pressure sore reconstruction as well.[48,49] Modifications of these include the Pac-Man flap and elongating the outer arc margin to address the traditional sacral ulcer wound.[48]

Ischial Pressure Sore Reconstruction

Ischial location has been found to be independently associated with a higher risk for overall surgical-site complications, including wound infection, dehiscence, and pressure sore recurrence.[47] This might be caused by patients resuming their prereconstruction sitting habits where the postreconstruction suture line can be exposed

to significant pressure, and hip flexion further increases tension on the closure. Given all this, the reconstructive approach for this region should allow for readvancement or rerotation of the flap to deal with recurrences even more so than the other pressure sore counterparts.

Posterior Thigh Flaps and Variations

The workhorse flaps for ischial pressure sore reconstruction are posterior thigh flaps. They are typically harvested as fasciocutaneous flaps, preserving further reconstruction options; however, they are also raised as myocutaneous or muscle-only flaps. A common first-line option is the medially based posterior thigh flap. This flap offers a reliable consistent flap design. The robust blood supply can be augmented with the preservation of perforators during flap elevation. This flap is easily able to be reelevated and rerotated if necessary.[50]

Another commonly used option for ischial pressure sore reconstruction is the V-Y hamstring advancement flap. Although this flap can be readvanced for managing recurrences, previous evidence has shown that V-Y hamstring flaps are associated with higher rates of ischial pressure sore recurrences, again related to the higher tension with hip flexion.[47] Related to the V-Y hamstring flaps, Demirseren et al. described turnover flaps using the biceps femoris and a separate fasciocutaneous component in a group of 15 patients. They reported moderate success with complications addressed by readvancing the flaps.[51]

A muscle-only variation includes advancement of the hamstring and adductor magnus muscles. Burm et al. described releasing the origin of the muscles from the ischial tuberosity and advancing them to cover the wound followed by closing the wound directly over them.[52] This varies from the turnover flap described by Demirseren et al. in that the proximal muscle covers the defect not the distal portion of the muscle. Although this study has a small number of patients, they found the flap had adequate bulk and promising results.[51,52]

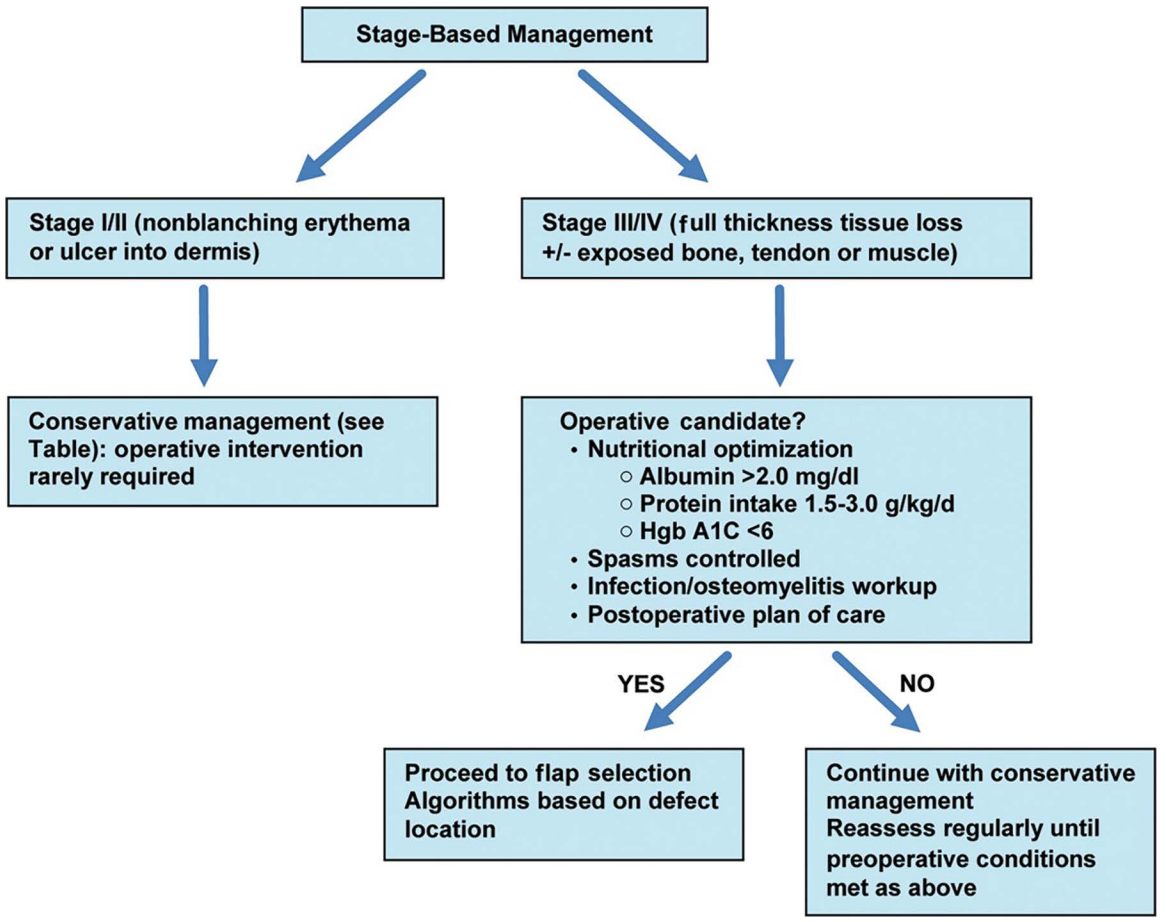

Fig. 5. Stage-based management of pressure sores. (From Cushing CA, Phillips LG. Evidence-based medicine: Pressure sores. *Plast Reconstr Surg*. 2013;132:1720–1732.)

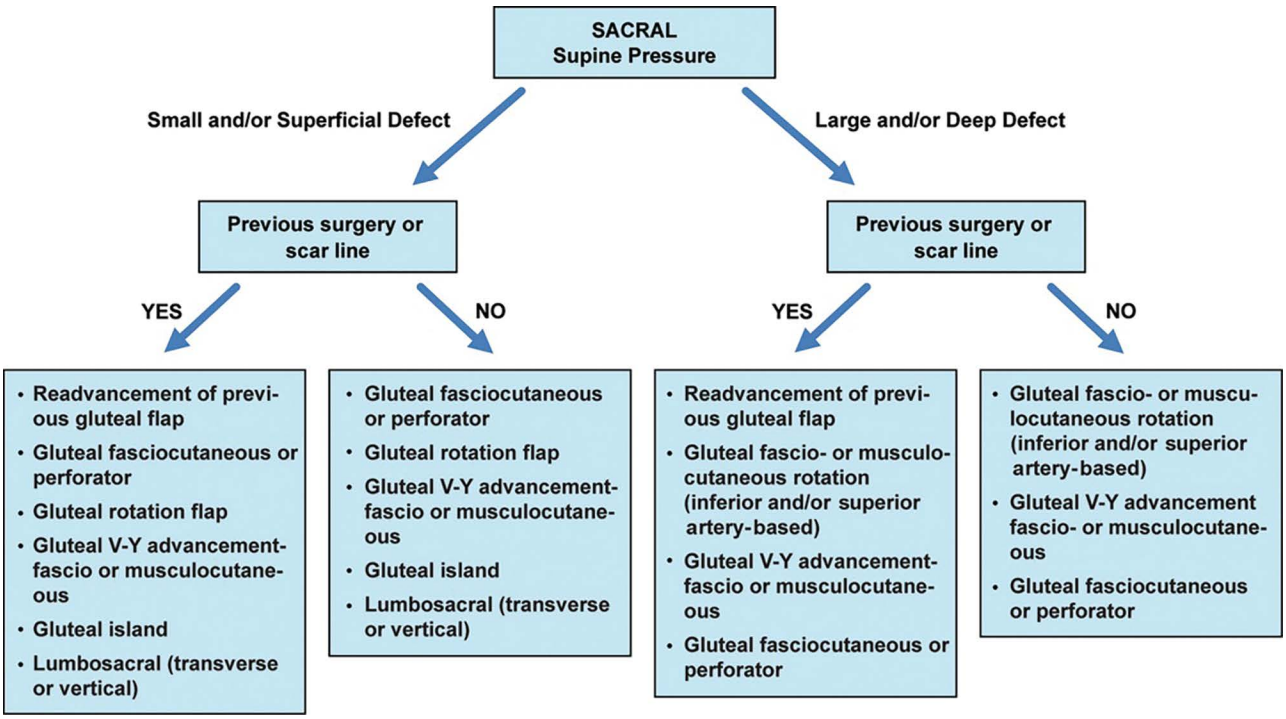

Fig. 6. Management of sacral pressure sores. (From Cushing CA, Phillips LG. Evidence-based medicine: Pressure sores. *Plast Reconstr Surg*. 2013;132:1720–1732.)

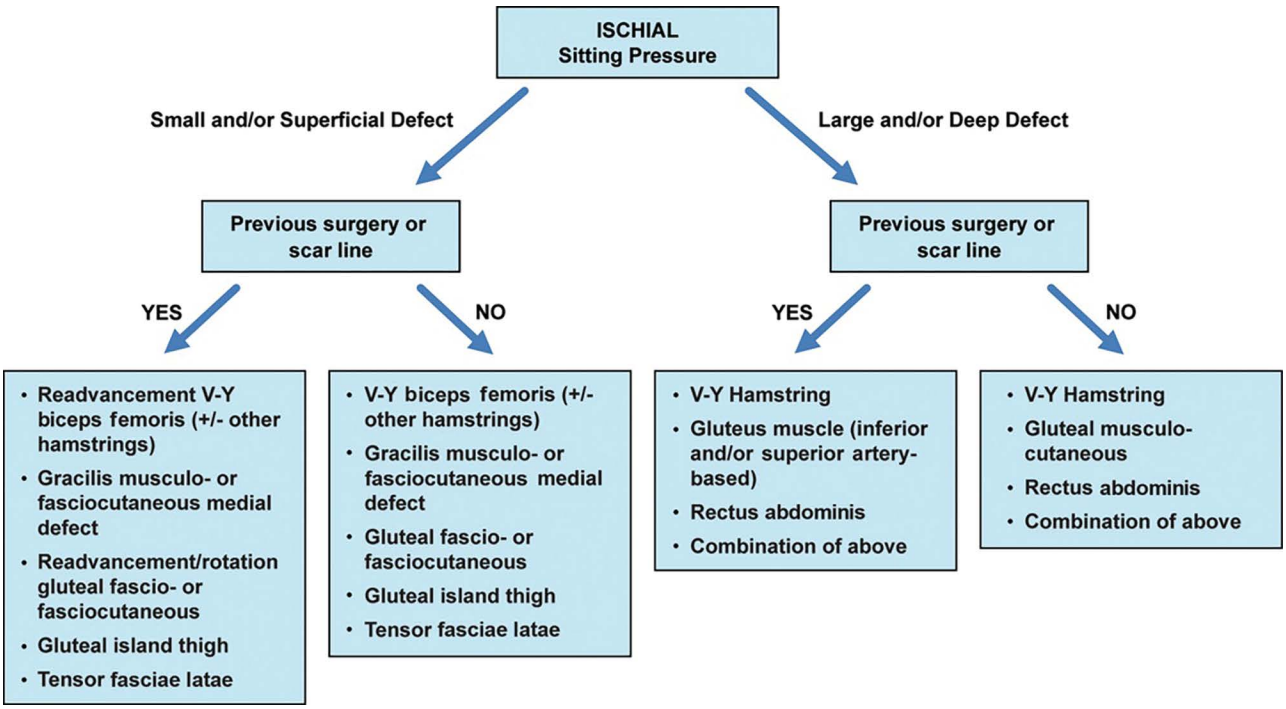

Fig. 7. Management of ischial pressure sores. (From Cushing CA, Phillips LG. Evidence-based medicine: Pressure sores. *Plast Reconstr Surg*. 2013;132:1720–1732.)

Gluteal-Based Flaps

Similar to sacral pressure ulcers, gluteal-based flaps represent an option for reconstruction, as these flaps can be rotated or advanced into the defect and allow for readvancement or rerotation for recurrences. Also analogous to sacral pressure

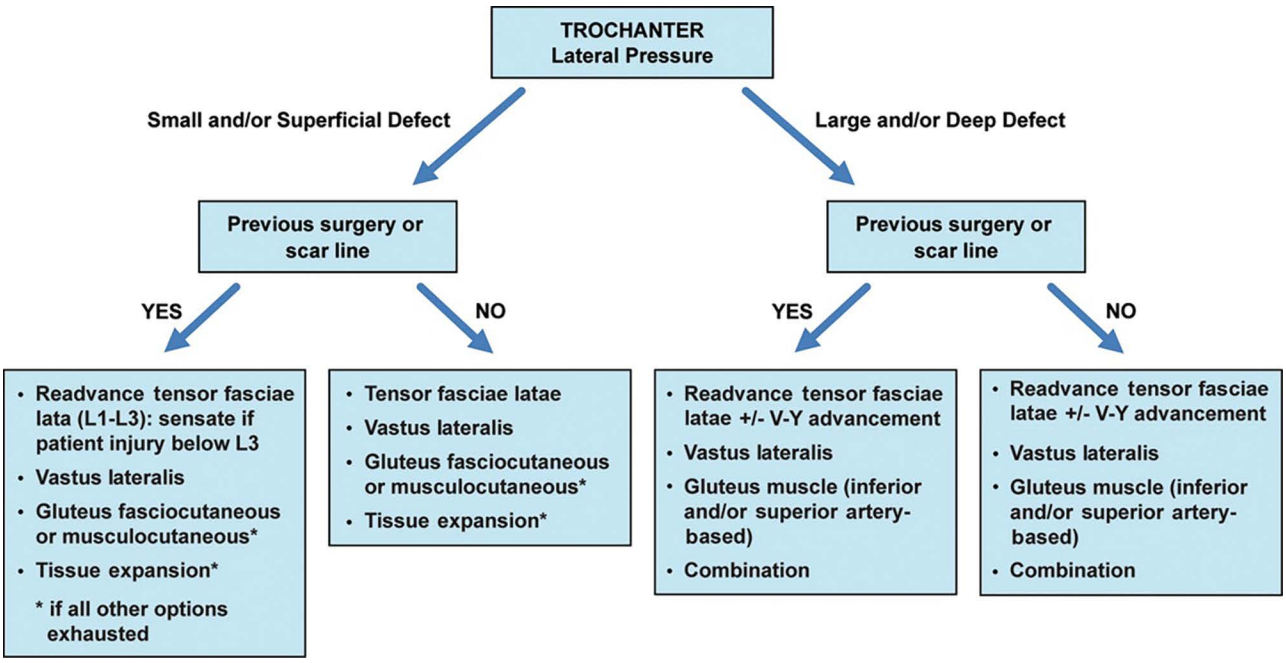

Fig. 8. Management of trochanteric pressure sores. (From Cushing CA, Phillips LG. Evidence-based medicine: Pressure sores. *Plast Reconstr Surg*. 2013;132:1720–1732.)

sore reconstruction, gluteal flaps can be performed as fasciocutaneous, musculocutaneous, or muscle-only flaps. Other less commonly used options for ischial pressure sore reconstruction include the medial thigh, gracilis, and tensor fasciae latae flaps.

Trochanteric Pressure Sore Reconstruction

The workhorse for trochanteric pressure sore reconstruction is the tensor fasciae latae flap. This flap can be rotated, advanced as a V-Y, or advanced as a bipedicled flap into the defect. Rotation or a V-Y advancement allows for further advancement in case of recurrences. It is critical to note that trochanteric pressure ulcers develop secondary to prolonged periods of lateral decubitus, typically in patients with hip flexion contractures. Therefore, hip contractures must be addressed as part of the preoperative optimization process to decrease the risk of recurrence.[45] The tensor fasciae latae flap can be combined with vastus lateralis, rectus femoris, and gluteal thigh flaps for deep pressure sore reconstruction.

Freestyle Perforator Flaps

As mentioned, gluteal perforator flaps have had some success for pressure sore reconstruction (Fig. 9). Variations in perforators have been described to include freestyle flaps, perforator-based peninsular flaps, and wound edge perforator flaps.[53] One perforator flap that deserves special mention is the internal pudendal artery perforator flap.

Table 4. Advantages and Disadvantages of Flaps for Pressure Ulcer Reconstruction

Flap	Advantages	Disadvantages
Gluteal	Provides muscle bulk for large defects; able to be readvanced or rerotated in recurrences	May require bilateral flaps for large defects; not indicated in ambulatory patients
SGAP/IGAP	Good for smaller defects in ambulatory patients; may be designed to cover defects in a variety of locations	Meticulous dissection; small flap size; cannot be revised in recurrences
V-Y hamstring advancement	Less dissection, shorter operative time, less blood loss; easily revised; robust blood supply	Not indicated in ambulatory patients; higher rate of recurrence in ischial ulcers
Posterior thigh	Robust blood supply; easily rerotated	May not provide enough bulk to eliminate dead space
TFL	Primarily for trochanteric ulcers; can be revised and readvanced	Small flap size
Internal pudendal artery flaps	Easily customized to defect size and location; shorter surgical times; does not preclude use of traditional gluteal or thigh flaps	

SGAP, superior gluteal artery perforator; IGAP, inferior gluteal artery perforator; TFL, tensor fasciae latae.

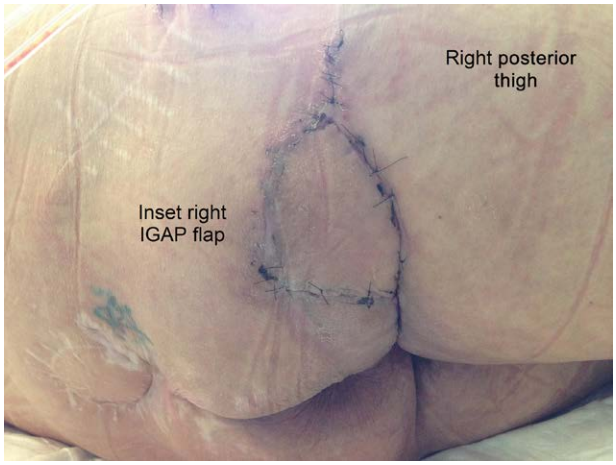

Fig. 9. Inferior gluteal artery perforator (*IGAP*) flap. Note the numerous scars from previous flaps and closures.

Since the introduction of perforator-based flaps for pressure ulcer reconstruction by Koshima et al. in 1993, a variety of flaps based on the gluteal and posterior thigh perforators have been described. These flaps quickly gained popularity because of the lack of donor-site morbidity. Originally described for vulvar and vaginal reconstruction, internal pudendal artery perforator flaps have recently been shown effective in reconstruction of sacral and ischial pressure ulcers. Hashimoto et al. were the first to describe the use of a posterior thigh internal pudendal artery perforator flap for ischial pressure ulcer reconstructions (Fig. 10).[54] Since then, other variations of flaps based on the internal pudendal artery have been described for sacral and ischial reconstruction.[55]

Flap design and orientation can be customized to the patient's defect. For ischial pressure ulcer reconstruction, Hashimoto et al. describe a longitudinally oriented flap along the long axis of the medial thigh that is then transposed into the defect.[54] The rich vasculature allows for easy identification of cutaneous perforators.[54,56] In contrast, Legemate et al. orient the flap along the gluteal crease. During flap elevation, the distal aspect of the flap is deepithelialized and inset into the ulcer to provide bulk around the ischial tuberosity, theoretically preventing recurrence. The proximity of the pedicle prevents the need for a long pedicle or extensive dissection, which allows for a shorter operative time and less blood loss.[55]

When evaluating the complication rate of internal pudendal artery perforator flaps, Legemate et al. described a 27 percent reoperation rate; however, they reported that all patients had successful secondary reconstructions.[55] In addition to the previously described advantages of this flap, the use of this flap does not preclude the use of traditionally described fasciocutaneous or myocutaneous flaps, making this an excellent option for patients who have failed prior reconstruction with traditional flaps.

Free Flaps

Locoregional flaps are by far the most used flaps for reconstruction of pressure ulcers; however, there is a role for free flap reconstruction. Previous studies have described the use of free gastrocnemius flaps, plantar artery flaps, and latissimus dorsi flaps. Free flaps are used in patients

Fig. 10. Cadaver dissection of internal pudendal artery perforator flap for ischial ulcer.

with recurrent ulcers or large ulcers that cannot be treated with locoregional flaps.[57,58]

Multiple Ulcers

Patients can also present with multiple ulcers following previous failed reconstruction attempts. In some cases, local flaps can still be used; however, in patients with extensive of cases of multiple ulcers, filet of thigh flaps with hemipelvectomy may be necessary (Fig. 11).[59] Those cases often present with extensive osteomyelitis recalcitrant to antibiotic therapy and surgical débridement. It is difficult to convince the patient that amputation is the best option for treatment, even in the cases of nonfunctional limbs. Other than sporadic case reports, there is little on the decision-making and design of these flaps, but it is still an important adjunct to pressure sore treatment. [**See Video 3 (online)**, which displays complex and multiple pressure sores.]

Postoperative Care Protocol

Postoperative care represents a continuation of the preoperative optimization process, but with some variations. In addition to continued nutrition optimization, shear, friction, spasms, and moisture control, pressure offloading for a period of 3 to 6 weeks to allow maximum tensile healing strength is critical.[60–63] For patients who lack a social support system to enable this on an outpatient basis, inpatient admission to an acute care hospital, inpatient rehabilitation facility, or skilled nursing facility is indicated. In addition, the use of a pressure offloading mattress and every-2-hour repositioning should be continued postoperatively. Once the 3- to 6-week period of pressure offloading has concluded, pressure mapping should be performed, and support surfaces should be adjusted to enable even distribution of pressure while sitting. While sitting, pressure should be less than 35 mmHg for immobile patients and less than 60 mmHg for patients that can shift positions and pressure offload.[62] Multiple sitting protocols have been reported, without sufficient evidence to support one protocol over another. As previously mentioned, for patients with evidence of osteomyelitis, culture-guided antibiotic therapy for 3 to 6 weeks is indicated. Drains are kept in place until minimal drainage is noted for 3 consecutive days, to allow proper healing to take place.

Complications

The ideal pressure sore reconstruction is one that is void of complications and long lasting. This has proven to be a challenge, with multiple recent large series reporting overall complication rates between 58 and 73 percent.[46,47]

Overall complications after pressure ulcer reconstruction can be subdivided into major (e.g., wound dehiscence, infection, flap necrosis, and pressure sore recurrence) and minor (e.g., seroma and hematoma) complications. Wound dehiscence has been found to be the most common complication following pressure sore

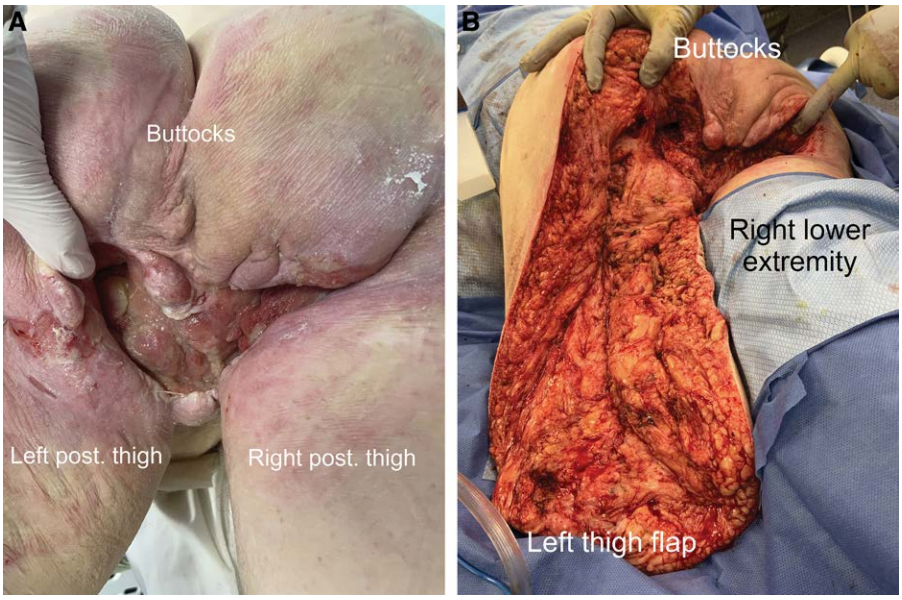

Fig. 11. (*Left*) Large complex pressure sore with extensive underlying osteomyelitis. (*Right*) Posterior thigh flap for reconstruction of hemipelvectomy defect.

reconstruction, with 28 days being the average time to dehiscence (Table 5).[47] Keys et al. found that age younger than 45 years, a history of a previous same-site reconstructive failure, and poor diabetes control (hemoglobin A1C >6 percent) were independent predictors of flap dehiscence requiring return to the operating room for revision.[46] Postreconstruction infection rates have been reported to occur in 6.5 percent of the cases (Table 6).[47]

In terms of pressure ulcer recurrence, rates ranging from 3 to 100 percent have been reported (Table 7).[46,47,60,64–66] The average time to same-site pressure ulcer recurrence has been reported to be approximately 357 days.[47] Poor nutritional status (albumin <3.5 g/dl) has been associated with early (within the first 2 years) pressure sore recurrence, whereas ischial location was associated with late (>2 years after reconstruction) recurrences.[46]

It is important to distinguish the likely precipitating factors that have led to ulcer recurrence. Patients who present several years after reconstruction with a late recurrence may have an inciting event, such as a change in their social support or new medical issues. These patients may benefit from a psychiatric consultation. Psychiatric evaluations can serve both to screen patients for compliance and to diagnose any underlying preexisting conditions, such as depression. The treatment of preexisting conditions is paramount to a successful recovery.[67,68]

Table 5. Risk Factors for Wound Dehiscence

Ischial location
Preoperative osteomyelitis
Albumin <3 mg/dl
Perioperative blood transfusion
Longer operative time

Table 6. Risk Factors for Surgical-Site Infection following Pressure Sore Reconstruction

Perioperative blood transfusion
Longer operative time (>190 min)
Pressure ulcer size (>109 cm^2)
Diabetes
Higher American Society of Anesthesiologists class

Table 7. Risk Factors for Pressure Sore Recurrence

Age <45 yr
African American race
BMI <18.5 kg/m^2
Previous same-site failure
Active smoking
Perioperative blood transfusion
Use of thigh V-Y flap

BMI, body mass index.

CONCLUSIONS

Perineal defects and pressure sores represent significant reconstructive challenges to the practicing plastic surgeon. As in many other reconstructive endeavors, perioperative optimization and evidence-based postoperative care are fundamental for optimizing outcomes and preventing complications. Modifiable risk factors should be addressed to offer these patients the best chance for a successful recovery and a durable reconstruction. Once surgical management is chosen, it is important to be aware of the many variations in flap closure available for these patients.

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REFERENCES

1. Centers for Disease Control and Prevention. Colorectal cancer statistics. Available at: https://www.cdc.gov/cancer/colorectal/statistics/. Accessed December 21, 2020.
2. American Cancer Society. Colorectal cancer statistics: How common is colorectal cancer? Available at: https://www.cancer.org/cancer/colon-rectal-cancer/about/key-statistics.html. Accessed December 21, 2020.
3. Russo CA, Steiner C, Spector W. Hospitalizations related to pressure ulcers among adults 18 years and older, 2006: Statistical Brief 64. Rockville, Md: Agency for Healthcare Research and Quality (US); 2006. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21595131. Accessed August 18, 2020.
4. Mericli AF, Martin JP, Campbell CA. An algorithmic anatomical subunit approach to pelvic wound reconstruction. *Plast Reconstr Surg.* 2016;137:1004–1017.
5. Butler CE, Gündeslioglu AO, Rodriguez-Bigas MA. Outcomes of immediate vertical rectus abdominis myocutaneous flap reconstruction for irradiated abdominoperineal resection defects. *J Am Coll Surg.* 2008;206:694–703.
6. McAllister E, Wells K, Chaet M, Norman J, Cruse W. Perineal reconstruction after surgical extirpation of pelvic malignancies using the transpelvic transverse rectus abdominal myocutaneous flap. *Ann Surg Oncol.* 1994;1:164–168.
7. Yeh KA, Hoffman JP, Kusiak JE, Litwin S, Sigurdson ER, Eisenberg BL. Reconstruction with myocutaneous flaps following resection of locally recurrent rectal cancer. *Am Surg.* 1995;61:581–589.
8. Touran T, Frost DB, O'Connell TX. Sacral resection: Operative technique and outcome. *Arch Surg.* 1990;125:911–913.
9. Shibata D, Hyland W, Busse P, et al. Immediate reconstruction of the perineal wound with gracilis muscle flaps following abdominoperineal resection and intraoperative radiation therapy for recurrent carcinoma of the rectum. *Ann Surg Oncol.* 1999;6:33–37.
10. Guarner F, Malagelada JR. Role of bacteria in experimental colitis. *Best Pract Res Clin Gastroenterol.* 2003;17:793–804.
11. Weichman KE, Matros E, Disa JJ. Reconstruction of peripelvic oncologic defects. *Plast Reconstr Surg.* 2017;140:601e–612e.

12. Guarner F, Malagelada JR. Gut flora in health and disease. *Lancet* 2003;361:512–519.
13. Althumairi AA, Canner JK, Gearhart SL, Safar B, Sacks J, Efron JE. Predictors of perineal wound complications and prolonged time to perineal wound healing after abdominoperineal resection. *World J Surg.* 2016;40:1755–1762.
14. Tilney HS, Rasheed S, Northover JM, Tekkis PP. The influence of circumferential resection margins on long-term outcomes following rectal cancer surgery. *Dis Colon Rectum* 2009;52:1723–1729.
15. Lin Y, Lin H, Xu Z, Zhou S, Chi P. Comparative outcomes of preoperative chemoradiotherapy and selective postoperative chemoradiotherapy in clinical stage T3N0 low and mid rectal cancer. *J Invest Surg.* 2019;32:679–687.
16. John HE, Jessop ZM, Di Candia M, Simcock J, Durrani AJ, Malata CM. An algorithmic approach to perineal reconstruction after cancer resection: Experience from two international centers. *Ann Plast Surg.* 2013;71:96–102.
17. Westbom CM, Talbot SG. An algorithmic approach to perineal reconstruction. *Plast Reconstr Surg Glob Open* 2019;7:e2572.
18. Yang XY, Wei MT, Yang XT, et al. Primary vs myocutaneous flap closure of perineal defects following abdominoperineal resection for colorectal disease: A systematic review and meta-analysis. *Colorectal Dis.* 2019;21:138–155.
19. Baumann DP, Butler CE. Component separation improves outcomes in VRAM flap donor sites with excessive fascial tension. *Plast Reconstr Surg.* 2010;126:1573–1580.
20. Campbell CA, Butler CE. Use of adjuvant techniques improves surgical outcomes of complex vertical rectus abdominis myocutaneous flap reconstructions of pelvic cancer defects. *Plast Reconstr Surg.* 2011;128:447–458.
21. McMenamin DM, Clements D, Edwards TJ, Fitton AR, Douie WJ. Rectus abdominis myocutaneous flaps for perineal reconstruction: Modifications to the technique based on a large single-centre experience. *Ann R Coll Surg Engl.* 2011;93:375–381.
22. Weiwei L, Zhifei L, Ang Z, Lin Z, Dan L, Qun Q. Vaginal reconstruction with the muscle-sparing vertical rectus abdominis myocutaneous flap. *J Plast Reconstr Aesthet Surg.* 2009;62:335–340.
23. Agochukwu N, Bonaroti A, Beck S, Liau J. Laparoscopic harvest of the rectus abdominis for perineal reconstruction. *Plast Reconstr Surg Glob Open* 2017;5:e1581.
24. Ibrahim AE, Sarhane KA, Pederson JC, Selber JC. Robotic harvest of the rectus abdominis muscle: Principles and clinical applications. *Semin Plast Surg.* 2014;28:26–31.
25. Pedersen J, Song DH, Selber JC. Robotic, intraperitoneal harvest of the rectus abdominis muscle. *Plast Reconstr Surg.* 2014;134:1057–1063.
26. Hainsworth A, Al Akash M, Roblin P, Mohanna P, Ross D, George ML. Perineal reconstruction after abdominoperineal excision using inferior gluteal artery perforator flaps. *Br J Surg.* 2012;99:584–588.
27. Myers PL, Krasniak PJ, Day SJ, Bossert RP. Gluteal flaps revisited: Technical modifications for perineal wound reconstruction. *Ann Plast Surg.* 2019;82:667–670.
28. Boccola MA, Rozen WM, Ek EW, Teh BM, Croxford M, Grinsell D. Inferior gluteal artery myocutaneous island transposition flap reconstruction of irradiated perineal defects. *J Plast Reconstr Aesthet Surg.* 2010;63:1169–1175.
29. Abbott DE, Halverson AL, Wayne JD, Kim JY, Talamonti MS, Dumanian GA. The oblique rectus abdominal myocutaneous flap for complex pelvic wound reconstruction. *Dis Colon Rectum* 2008;51:1237–1241.
30. Arnold PB, Lahr CJ, Mitchell ME, et al. Predictable closure of the abdominoperineal resection defect: A novel two-team approach. *J Am Coll Surg.* 2012;214:726–732.
31. Bustos SS, Yan M, Forte AJ, Moran SL, Manrique OJ. Options and outcomes of soft tissue reconstruction in patients undergoing surgery for locally recurrent rectal cancer. *Semin Colon Rectal Surg.* 2020;31:100766.
32. Hashimoto I, Abe Y, Nakanishi H. The internal pudendal artery perforator flap: Free-style pedicle perforator flaps for vulva, vagina, and buttock reconstruction. *Plast Reconstr Surg.* 2014;133:924–933.
33. Weinstein B, King KS, Triggs W, Harrington MA, Pribaz J. Bilobed gracilis flap: A novel alternative for pelvic and perineal reconstruction. *Plast Reconstr Surg.* 2020;145:231–234.
34. Matschke J, Armbruster R, Reeps C, Weitz J, Dragu A. AV loop free flap: An interdisciplinary approach for perineal and sacral defect reconstruction after radical oncological exenteration and radiation in a colorectal cancer patient. *World J Surg Oncol.* 2019;17:154.
35. Kieran I, Nugent N, Riordain MÓ, Kelly J. Reconstruction of the pelvis and perineum with a free latissimus dorsi myocutaneous flap: A case report. *Ann R Coll Surg Engl.* 2012;94:e254–e256.
36. Devulapalli C, Jia Wei AT, DiBiagio JR, et al. Primary versus flap closure of perineal defects following oncologic resection: A systematic review and meta-analysis. *Plast Reconstr Surg.* 2016;137:1602–1613.
37. Chaudhry A, Oliver JD, Vyas KS, et al. Comparison of outcomes in oncoplastic pelvic reconstruction with VRAM versus omental flaps: A large cohort analysis. *J Reconstr Microsurg.* 2019;35:425–429.
38. Lyder CH. Pressure ulcer prevention and management. *JAMA* 2003;289:223–226.
39. Reddy M, Gill SS, Rochon PA. Preventing pressure ulcers: A systematic review. *JAMA* 2006;296:974–984.
40. Agency for Healthcare Research and Quality. Preventing pressure ulcers in hospitals. Available at: https://www.ahrq.gov/patient-safety/settings/hospital/resource/pressureulcer/tool/index.html. Accessed October 26, 2020.
41. Filius A, Damen TH, Schuijer-Maaskant KP, Polinder S, Hovius SE, Walbeehm ET. Cost analysis of surgically treated pressure sores stage III and IV. *J Plast Reconstr Aesthet Surg.* 2013;66:1580–1586.
42. Hirshberg J, Rees RS, Marchant B, Dean S. Osteomyelitis related to pressure ulcers: The cost of neglect. *Adv Skin Wound Care* 2000;13:25–29.
43. Levi B, Rees R. Diagnosis and management of pressure ulcers. *Clin Plast Surg.* 2007;34:735–748.
44. Ricci JA, Bayer LR, Orgill DP. Evidence-based medicine: The evaluation and treatment of pressure injuries. *Plast Reconstr Surg.* 2017;139:275e–286e.
45. Cushing CA, Phillips LG. Evidence-based medicine: Pressure sores. *Plast Reconstr Surg.* 2013;132:1720–1732.
46. Keys KA, Daniali LN, Warner KJ, Mathes DW. Multivariate predictors of failure after flap coverage of pressure ulcers. *Plast Reconstr Surg.* 2010;125:1725–1734.
47. Bamba R, Madden JJ, Hoffman AN, et al. Flap reconstruction for pressure ulcers. *Plast Reconstr Surg Glob Open* 2017;5:e1187.
48. Byun IH, Kim CW, Park TH. The modified keystone flap for pressure ulcers: A modification of the keystone flap with rotation and advancement. *Ann Plast Surg.* 2019;82:299–303.
49. Bonomi S, Sgrò A, Salval A. Avoiding skin grafts: The V-Y Pac-Man perforator flap. *Plast Reconstr Surg.* 2016;138:561e–562e.
50. Djedovic G, Morandi EM, Metzler J, et al. The posterior thigh flap for defect coverage of ischial pressure sores: A critical single-centre analysis. *Int Wound J.* 2017;14:1154–1159.
51. Demirseren ME, Ceran C, Aksam B, Demiralp CO. Clinical experience with the combination of a biceps femoris muscle turnover flap and a posterior thigh fasciocutaneous hatchet

flap for the reconstruction of ischial pressure ulcers. *Ann Plast Surg.* 2016;77:93–96.
52. Burm JS, Hwang J, Lee YK. A new option for the reconstruction of primary or recurrent ischial pressure sores: Hamstring-adductor magnus muscle advancement flap and direct closure. *Ann Plast Surg.* 2018;80:400–405.
53. Yoon CS, Kim CG, Kim H, Kim KN. Retrospective study of freestyle perforator-based peninsular flaps: A simple, fast, and safe technique for pressure sore reconstruction. *Medicine (Baltimore)* 2018;97:e0168.
54. Hashimoto I, Goishi K, Abe Y, et al. The internal pudendal artery perforator thigh flap: A new freestyle pedicle flap for the ischial region. *Plast Reconstr Surg Glob Open* 2014;2:e142.
55. Legemate CM, van der Kwaak M, Gobets D, Huikeshoven M, van Zuijlen PPM. The pedicled internal pudendal artery perforator (PIPAP) flap for ischial pressure sore reconstruction: Technique and long-term outcome of a cohort study. *J Plast Reconstr Aesthet Surg.* 2018;71:889–894.
56. Hashimoto I, Murakami G, Nakanishi H, et al. First cutaneous branch of the internal pudendal artery: An anatomical basis for the so-called gluteal fold flap. *Okajimas Folia Anat Jpn.* 2001;78:23–30.
57. de la Fuente TP, González I, Calderón-Muñoz F. The role of medial gastrocnemius free flap in coverage of ischial pressure sore in paraplegic patients. *Int J Surg.* 2008;6:e72–e76.
58. Lemaire V, Boulanger K, Heymans O. Free flaps for pressure sore coverage. *Ann Plast Surg.* 2008;60:631–634.
59. Georgiou I, Kruppa P, Ghods M. Use of a total leg fillet flap to cover multiple pelvic pressure ulcers. *Plast Reconstr Surg Glob Open* 2019;7:e2084.
60. Minami RT, Mills R, Pardoe R. Gluteus maximus myocutaneous flaps for repair of pressure sores. *Plast Reconstr Surg.* 1977;60:242–249.
61. Kierney PC, Engrav LH, Isik FF, Esselman PC, Cardenas DD, Rand RP. Results of 268 pressure sores in 158 patients managed jointly by plastic surgery and rehabilitation medicine. *Plast Reconstr Surg.* 1998;102:765–772.
62. Dover H, Pickard W, Swain I, Grundy D. The effectiveness of a pressure clinic in preventing pressure sores. *Paraplegia* 1992;30:267–272.
63. Levenson SM, Geever EF, Crowley LV, Oates JF III, Berard CW, Rosen H. The healing of rat skin wounds. *Ann Surg.* 1965;161:293–308.
64. Vasconez LO, Schneider WJ, Jurkiewicz MJ. Pressure sores. *Curr Probl Surg.* 1977;14:1–62.
65. Ger R, Levine SA. The management of decubitus ulcers by muscle transposition: An 8-year review. *Plast Reconstr Surg.* 1976;58:419–428.
66. Relander M, Palmer B. Recurrence of surgically treated pressure sores. *Scand J Plast Reconstr Surg Hand Surg.* 1988;22:89–92.
67. Kruger EA, Pires M, Ngann Y, Sterling M, Rubayi S. Comprehensive management of pressure ulcers in spinal cord injury: Current concepts and future trends. *J Spinal Cord Med.* 2013;36:572–585.
68. Galhardo VA, Garroni Magalhaes M, Blanes L, Juliano Y, Masako Ferreira L. Health-related quality of life and depression in older patients with pressure ulcers. *Wounds* 2010;22:20–26.