Research article

Surgical reconstruction tips and pearls of pressure injury

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ABSTRACT

Background Pressure injuries are localised tissue defects that occur due to increased pressure on the skin that causes ischemic damage.These injuries are more frequently seen in patients who are immobile, elderly, malnourished, or have a history of intensive care unit stays. The management of pressure injuries consists of conservative treatment, including wound care and ultimately, surgical closure of the wound.

Aim The aim of this study is to compare the long-term clinical outcomes of patients who underwent surgery for pressure injuries in our chronic wound clinic and to develop an algorithm for flap selection, highlighting the most appropriate options for approaching pressure injuries.

Methods Our study includes 97 patients are people with grade 3 and 4 pressure injuries, who were followed up between January 2017 and December 2024. The patients were classified and followed up based on factors such as the location of tissue defects, length of hospital stay, type of surgery performed, presence of bacterial growth in cultures, use of NPWT, comorbidities, wound size, and the success of the surgical treatment.

Results Cases reconstructed with flaps had 30.6% detachtment rates and were observed at the same time as cases with skin grafts who showed an 86.5% viability rate. Average hospital stay for patients with skin graft was avarage of 11.3 days, and for patients reconstructed with flaps 37.1 days.

Conclusion Pressure injuries require different approaches from other chronic wounds. Treatment should be tailored according to patient and surgeons should take every possible outcome into consideration.

Implication for clinical practice Reconstruction with flaps, even with high complication rates, should be first line of choice and skin grafting should be limited with patients who are immobile and have superficial skin defects.

Keywords flap reconstruction, pressure injury, wound management.

For referencing Pala A, et al. Surgical reconstruction tips and pearls of pressure injury. Journal of Wound Management. 2025;26(2):111-117.

DOI https://doi.org/10.35279/jowm2025.26.02.10

Submitted 31 January 2025, Accepted 16 June 2025

KEY MESSAGES

- This paper discusses the surgical reconstruction techniques for pressure injuries, focusing on the importance of wound management strategies and reconstructive options, such as flap and graft repair.
- The aim of this study is to evaluate the clinical outcomes of patients with pressure injuries and propose an algorithm for selecting the appropriate reconstructive method based on wound characteristics and patient mobility.
- The results highlight that patients undergoing flap reconstruction experienced longer hospital stays and higher detachment rates compared to those treated with grafts, with a significant difference in the recurrence of pressure injuries based on mobility status.

INTRODUCTION

Pressure injuries are localised tissue defects that occur due to increased pressure on the skin (32mmHg), leading to tissue ischemia. The localisation of pressure injuries is associated with the patient's immobility. Quadriplegic patients, who lie on their backs or stomachs, may have affected areas such as the sacrum, heels, and anterior iliac crest. Hemiplegic patients, who spend most of their time in wheelchairs, typically have pressure injuries in areas like the soles of the feet, and ischium.[1-4] As a result, the most common wound locations are, in order, the ischium (28%), trochanter (19%), and sacrum (17%).[5] These injuries are more frequently seen in patients who are immobile, elderly, malnourished, or have a history of intensive care unit stay. Risk populations for pressure injuries can be identified using Norton or Braden risk assessment scales.[2,3,6] Currently, according to the European Pressure Ulcer Advisory Panel (EPUAP) pressure injuries are classified into six grades based on the depth of tissue involvement: Grade 1 describes the most superficial defects; while Grade 2 includes partial thickness skin injury; Grade 3 includes full thickness skin injury; while Grade 4 describes tissue defect effecting skin, bone and muscle tissue classifies as grade 4. Furthermore, patients with unidentifiable depth of tissue damage are categorised into two groups, either as unstageable or suspected deep tissue injury, which may indicate potential deep tissue damage.[3,7]

The management of pressure injuries primarily involves conservative treatment, including wound care and ultimately the surgical closure of the wound. As the duration of tissue ischemia increases, deeper tissues become affected, and the treatment plan adjusts accordingly. For patients with pressure injuries, the first goal should be to facilitate mobilisation, if possible, or at least ensure regular repositioning if mobilisation is not feasible. This should be followed by debridement of necrotic tissue in order to achieve an appropriate wound bed.[8-10]

After the debridement of the necrotic tissue, the reconstruction should be tailored according to the wound size, considering treatment options, such as secondary healing, primary closure, local or regional flaps. Prior to final reconstruction, the wound bed should be prepared and optimised using Negative Pressure Wound Therapy(NPWT) with sponges, (CONFORT; Eskişehir, Turkiye) or appropriate dressing materials. After surgery, the patient should be encouraged to reposition regularly, and if needed, measures such as incisional NPWT should be used to prevent dehiscence.[11]

However, even with protective measures used, complications, such as wound dehiscence and reccurrence, usually occur. For this reason, mostly flap reconstruction is preferred over primary closure. Additionally, grafts should not be the first choice because the potential risk of friction and repetitive pressure that may affect skin graft viabilty.[8, 9]

The most commonly used flaps for reconstruction include the medial thigh flap, gluteus maximus muscle flap, V-Y hamstring advancement flap, gluteal thigh island flap, gluteus maximus myocutaneous flap, tensor fascia lata flap and gracilis muscle flap. In sacral pressure injuries, the most frequently used flaps include cutaneous transposition, double opposing V-Y advancement flaps, gluteal rotation flaps and gluteus maximus muscle flaps.[8,9,12,13]

The aim of this study is to compare the long-term clinical outcomes of patients who underwent surgery for pressure injuries in our wound clinic and to develop an algorithm for flap selection, highlighting the most appropriate options for approaching pressure injuries.

PATIENTS AND METHODS

Our study includes 97 patients with grade 3 or 4 pressure injuries, who were followed up in the chronic wound ward of our clinic between January 2017 and December 2024. Data was collected from hospital system of Kartal Dr Lutfi Kırdar City Hospital and our study was approved by the human research review committee of our institution. All data obtained were evaluated anonymously and in accordance with the principles of the Helsinki Declaration.

All patients were monitored by a team of experienced plastic surgery specialists and wound care nurses working in the chronic wound unit of Kartal Dr Lutfi Kirdar Training and Research Hospital. Prior to admission, patients and their relatives were informed of the treatment plan, the estimated duration of hospitalisation, and potential complications. Patients with HbA1C levels above 8 and patients with cancer were excluded from the study because of higher possibility of post-operative infection and wound dehissence. Albumin level was not selected as a exclusion criteria. The mean albumin level was 2.9g/dL among the patients and we referred every patient to internal medicine specialists and dieticians. Therefore, their diets were regulated accordingly. The patients were classified and followed up based on factors, such as the location of tissue defects, length of hospital stay, type of surgery performed, presence of bacterial growth in cultures, use of NPWT, comorbidities, wound size, and the success of the surgical treatment (Table 1).

Among these patients, 72 were male and 25 were female. The most common location of the pressure injuries was the gluteal region (45), followed by sacral (25), trochanteric (12), thigh (2), ischium (4), inguinal (2), calcaneus (2) and lateral foot (2). (Table 2)

Surgery was planned for patients with mid and high socioeconomic status who would cooperate with the treatment and perform proper wound care themselves, or receive it from their family or from wound care nurses in their homes in the post-operative period. They were treated with debridement and wound care until cultures returned negative for two consecutive tests, after which reconstruction was performed. In pressure injuries with exposed bone, bone resection was performed, and sharp areas that could contribute to increased pressure were eliminated.

Reconstruction was planned with the consideration of the reconstruction elevator, initially using regional flaps, followed by local flaps. Finally, for cases where these were not suitable, skin grafting was employed (Figure 1).

Reconstruction with flaps was performed in 60 patients, graft repair in 22 patients, and both flap and graft reconstruction in 15 patients. A fasciocutaneous flap was applied to 17 patients, a single-lobed skin flap to 13 patients, a rotation flap to seven patients, a V-Y advancement flap to nine patients, a gluteus maximus muscle flap to five patients, bilateral V-Y advancement flaps to three patients, a pedicled gracilis muscle flap to six patients, a pedicled muscle-skin flap to five patients, and a transposition flap to five patients. (Table 3)

In paraplegic patients who were able to sit, flaps were prioritised, while in bedridden patients, skin grafts were preferred. In cases where adequate granulation tissue and optimal wound bed maturation were not achieved within a sufficient time period, consecutive debridements and negative pressure wound therapy (NPWT) were applied (Figure 2). In our clinic, nurses ensured position changes every two hours and the use of air mattresses and weekly consultations with hospital dieticians were implemented to ensure adequate protein intake. After creating an appropriate wound bed, suitable surgical treatment was provided, and post-operative complications, including dehiscence and surgical site infections, were monitored both in the clinic and during regular follow-up visits after discharge.

RESULTS

The patients' length of hospital stay ranged from a minimum of one day to a maximum of 120 days, with an average of 34.7 days. The median length of hospitalisation for patients who underwent tissue repair with grafts was 11.3 days, while for those who were reconstructed with flaps, the median length of hospitalisation stay was 37.1 days. The size of the tissue defects caused by pressure injuries ranged from a minimum of 4cm-squared to a maximum of 450cm-squared, with an average of 27.8cm-squared. NPWT was applied pre-operatively

Table 1. Patient classfication and distrubition

Category	Subcategory	Data
Total number of patients		97
Gender	Male	74.2% (72)
	Female	25.8% (25)
Localisation	Sacrum	23.7% (23)
	Gluteal	38.1% (37)
	Trochanter	11.3% (11)
	Thigh	5.2% (5)
	Ischium	7.2% (7)
	Inguinal	4.1% (4)
	Calcaneal	6.2% (6)
	Lateral of the foot	4.1% (4)
Size	Min size (cm-sq)	2x2
	Max size (cm-sq)	15x30
Comorbidities	Paraplegia	37.1% (36)
	Klippel Weber	9.3% (9)
	Bone tumor	3.1% (3)
	Spina bifida	9.3% (9)
	Hypertension	7.2% (7)
	Glaucoma	1.0% (1)
	Nephrectomy	2.1% (2)
	CAD	2.1% (2)
	PAH	1.0% (1)
	Stroke	5.2% (5)
	Hemiplegia	4.1% (4)
	DVT	1.0% (1)
	PTE	2.1% (2)
	Breast cancer	1.0% (1)
	Hypothyroidism	2.1% (2)
	Diabetes mellitus	6.2% (6)
	CHF	1.0% (1)
	CKD	1.0% (1)
	MS	2.1% (2)
	Alzheimer's disease	1.0% (1)
	Tongue cancer	1.0% (1)
Culture results	*P.aureginosa*	21.6% (21)
	E.coli	15.5% (15)
	S.aureus	5.2% (5)
	A.baumannii	4.1% (4)
	K.pneumoniae	5.2% (5)
	E.faecalis	7.2% (7)
	S.marcenscens	1.0% (1)
	C.freundii	1.0% (1)
	B.fragilis	4.1% (4)
	Culture Negative	35.1% (34)
NPWT treatment	Not applied	42.3% (41)
	Preoperative and Postoperative	26.8% (26)
	Preoperative	21.6% (21)
	Postoperative	9.3% (9)

for 21 patients, post-operatively for nine patients, and both pre-operatively and post-operatively for 26 patients, while 41 patients did not receive NPWT at all. The average waiting time for reconstruction was 21.4 days, with a minimum of three days and a maximum of 67 days.

In the post-operative follow-up of patients, it was observed that 30.6% of the cases reconstructed with flaps experienced dehiscence, within an average of 7.2 days after surgery.

In patients who underwent repair with grafts, the viability rate was observed to be 86.5%. New pressure injury formation was observed in 28 patients, all of whom were immobilised. Of these, 24 patients had new pressure injuries in the sacral region, and four in the ischial region. A second surgery was required for 15 patients, and more than two operations were required for 32 patients.

For patients reconstructed with skin graft, multiple surgeries were performed, whereas in the group reconstructed with a combination of grafts and flaps, treatment was completed with a single surgery. (Figures 3 and 4) The Chi-square test showed a p-value of <0.001, indicating statistical significance.

During clinical follow-up, no bacterial growth was observed in the cultures of 34 patients, while the most commonly identified bacteria were *Pseudomonas aeruginosa* (21 cases), followed by *Escherichia coli* and *Klebsiella pneumoniae*. In all 65% of the patients had bacterial growth in their cultures.

Among the patients, 28 were completely bedridden, while 69 were able to sit. It was noted that bedridden patients required two or more surgeries for complete treatment, while those who were able to sit or were mobile had their treatment completed with a single-stage reconstruction. (3-4) Overall, 15.4% of patients required a two-stage operation, while 32.98% required more than two surgeries.

For patients who underwent combined reconstruction with grafts and flaps, the hospitalisation duration was higher compared to other groups, with a significant result (p=0.009) found in the Chi-square test. Furthermore, patients with bacterial growth in their wound cultures experienced longer hospital stays and reconstruction times.

Table 2. Flaps used for reconstruction

Flap type	Flaps	Detachment
Fasciocutaneous flap	19.6% (19)	6.2% (6)
Single lobe skin flap	16.5% (16)	5.2% (5)
Rotation flap	7.2% (7)	3.1% (3)
V-y advancement flap	9.3% (9)	3.1% (3)
Gluteus maximus muscle flap	5.2% (5)	1.0% (1)
Bilateral v-y advancement flap	3.1% (3)	0.0% (0)
Pedicled muscle flap	6.2% (6)	2.1% (2)
Pedicled muscle and skin flap	5.2% (5)	1.0% (1)
Transposition flap	5.2% (5)	2.1% (2)

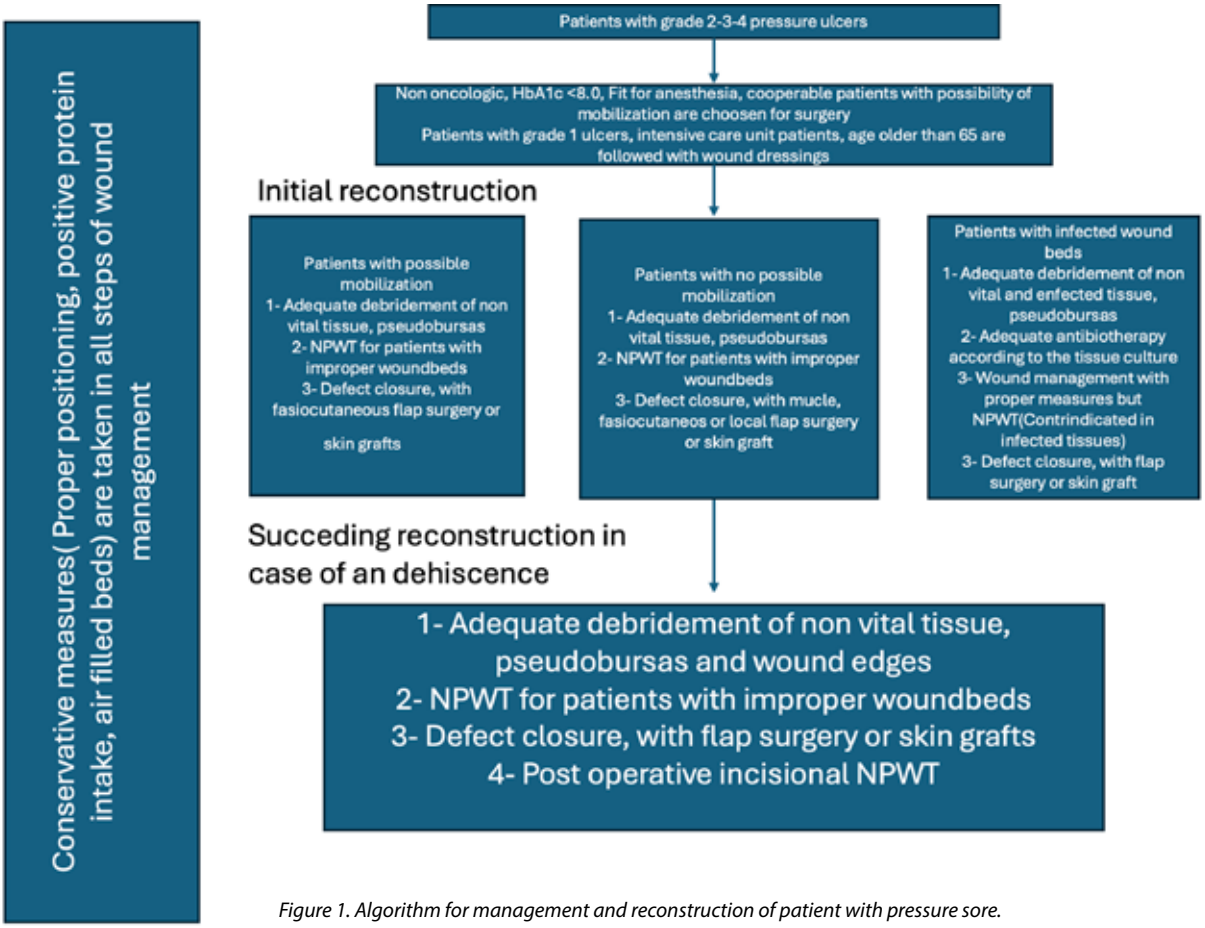

Figure 1. Algorithm for management and reconstruction of patient with pressure sore.

Table 3. Comparison of locations of pressure injury and method of reconstruction with complication rates

Localisation	Flap	Skin Graft	Flap and Skin Graft	Flap Detachment	Graft Lysis
Sacrum	14.4% (14)	5.2% (5)	6.2% (6)	4.1% (4)	1.0% (1)
Gluteal	32.0% (31)	7.2% (7)	7.2% (7)	14.4% (14)	2.1% (2)
Trochanter	9.3% (9)	1.0% (1)	2.1% (2)	3.1% (3)	0% (0)
Thigh	0% (0)	2.1% (2)	0% (0)	0% (0)	0% (0)
Ischium	4.1% (4)	1.0% (1)	0% (0)	2.1% (2)	0% (0)
Inguinal	2.1% (2)	0% (0)	0% (0)	0% (0)	0% (0)
Calcaneal	0% (0)	5.2% (5)	0% (0)	0% (0)	1.0% (1)
Lateral of the Foot	0% (0)	2.1% (2)	0% (0)	0% (0)	0% (0)

DISCUSSION

Pressure injuries have become a challenging chronic wound type for both patients and surgeons. A multistaged approach is often required. While there are different approaches for the management of pressure injuries firstly we should primarily consider tailoring our management strategy according to the grade of the pressure wound. For instance, for Grade 1 and 2 pressure injuries management with only wound care can be sufficent and surgical intervention may be considered for suitable patients that don't show improvement with conservative approach. In cases involving Grade 3 and 4 injuries, where deeper tissues are affected by ischemia, proper and adequate debridement should be performed, and a more complex, multistaged reconstruction should be planned.[8,9]

The first surgical stage involves preparing an appropriate wound bed. The TIMERS concept serves as a helpful guide in ensuring the proper tissue bed required for reconstruction. TIMERS stands for Tissue Viability (adequate debridement), Inflammation/Infection (antibiotic therapy and antiseptics), Moisture Balance, Edge of Wound (epithelialisation), Repair/Regeneration, and Social/Patient Factors.[7]

Proper wound bed preparation can not occur without debridement. For adequate debridement, all non-viable tissue should first be removed, pseudobursa completely excised and a viable tissue should be resurfaced.[8,14]

Additionally, in areas where bone tissue is exposed, bone resection should be performed to ensure a smooth surface. If necessary, serial debridement should be carried out, and reconstruction should not be planned until an optimal wound bed is established. If necessary, granulation of the wound bed must be facilitated by various techniques. NPWT is one of the prominent options for accelerating this process. Additionally, we should keep in mind that optimal perfusion of the wound bed must be achieved before planning reconstruction.[2,4,11]

Moreover, exposed bone, due to its contact with the external environment, may become a potential source of osteomyelitis. Therefore, osteomyelitis should be considered in treatment planning, and appropriate medical management should be implemented before considering reconstruction if bone resection is not performed.[4,8,15]

For the success of surgical intervention, patients must be mobilised, or if they are not able to mobilise, proper care should be provided to prevent the recurrence of pressure injuries. Also, in order to avoid the progression of the wound and to preserve the proper circulation of flaps post-reconstruction, pressure must be avoided. In non-mobile patients, a treatment plan should prioritise optimal wound care and conservative measures to reduce the wound size before considering surgery including for those who can benefit from reconstruction. Even if no reconstruction is performed, adequate multiple debridement and wound care will help control the tissue defects and improve patients' quality of life.[2,10]

Figure 2. (A) 60-year-old male paraplegic patient with multiple Grade 3 pressure injuries. (B) NPWT on incision lines after reconstructed with lateral thigh advancement and gluteal rotation flap. (C) Closed incision line six-weeks post-operation with scarring.

Figure 3. (A) 35-year-old male patient presented with a pressure injury after ICU stay .(B) Reconstruction with gluteal fasciocutaneous flap and drainage tube. (C) One month post-operation, incison line dehiscence was observed and reconstructed with single-lobed flap.

In the second stage a reconstruction plan is decided, whether to use a flap or graft for reconstruction has always been a question for surgeons. Most of the tissue defects appear to be restorable with simpler reconstruction methods. However, in the case of pressure injuries, recurrence and dehiscence can occur with the same exact methods compared to other chronic wounds. The primary reason for this is excessive tissue tension, increased tissue tension can result in partial or complete flap necrosis, disrupting wound healing and leading to dehiscence due to insufficient nourishment of the wound edge, similar to the mechanism of pressure injury.[8] Therefore, when designing a flap, the rotation arc should be planned in a way that preserves flap circulation and minimises tissue tension at the same time (Figure 5). Additionally, donor site morbidity should be considered, and options where the donor site is suitable for primary closure should be prioritised.[9]

The size and depth of the tissue defect are also crucial factors to consider. In defects with large surface areas, flaps may not be sufficient, and skin grafts should be considered (Figure 6). In deep pressure injuries, muscle or myocutaneous flaps should be preferred to fill dead space. In large pressure injuries with both a significant surface area and depth, a combination of muscle flaps and skin grafts or a staged reconstruction approach is going to be more appropriate.[15, 16]

When planning flap procedures, it is essential to preserve other local and regional flap sources in case a second reconstruction is needed thus incisions should be placed accordingly. Furthermore, in patients with pressure injuries in multiple areas, a staged surgical approach should be considered. On the contrary, when planning local rotation and advancement flaps they should be planned much larger than the existing tissue defect in the manner that circulation must not be compromised. If necessary, tissue defects at the donor site should be repaired with a skin graft. Small planned flaps used to protect surrounding tissue will likely result in complications if they do not have enough rotation and advancement for the closure of the wound.

Additionally, in patients who can sit, flaps should be preferred, while in bedridden patients, skin grafts should be the choice. In sitting patients, who require more tissue support in the ischial region, a flap capable of providing bulkier tissue should be used for reconstruction.

In bedridden patients, skin grafts are more suitable for repairing superficial and multiple tissue defects, as they offer faster closure of the defect. For skin graft planning, the donor site should be chosen from the posterior thigh if the patient

Figure 4. (A) 52-year-old female presented with multiple Grade 2 pressure injuries and a Grade 3 pressure injury in her sacrum. (B) A transposition flap was performed for reconstruction. (C) Two weeks after the operation and no sign of flap necrosis occurred.

is in a prone position or from the opposite thigh if they have a lateral decubitus position, in order to minimise donor site morbidity and patient discomfort.

In our patients, skin grafts and skin flaps have been unsuccessful when the wound bed was inadequate, so the surgical plan should include fascia involvement for a better outcome. While perforator flaps can also be an option, as shown in a study by Chen et al,[17] fasciocutaneous flaps, which include fascia, should be preferred for patients with comorbidities or those who are at high risk for complications.

However, when muscle is included in flap elevation, we observed better results. Thiessen et al[18] also showed that fasciocutaneous flaps are as well-vascularised as myocutaneous flaps, and for patients who can use muscle function, preserving muscle should be prioritised.

Figure 5. (A) 56 year old male patient with grade 3 pressure injury with pseudobursa (B) Adequate size fasciocutaneus flap planned from lateral gluteal region for reconstruction (C)Two months post operation flap necrosis did not occur, flap [6]dehiscence near anal region flap advanced to close the defect after two weeks of wound care.

Figure 6. (A) 80 year old female bedridden patient presenting with grade 2 gluteal pressure injury (B) [8] Split thickness skin graft was harvested with a surgical dermatome from left posterior thigh and adapted to the large defect (C)2 weeks post operation graft was observed totally viable and no graft failure was present.

In multi-stage reconstructions, the hospital stay duration should also be considered. As the length of hospital stay increases, the likelihood of post-operative complications also rises. Thus, reconstruction processes should be minimised as much as possible, aiming for the patient to return to daily life and begin physical therapy as early as possible.[2,4,19] In a study by Braffhart et al[15] on patients with spinal cord injuries, although single-stage reconstruction was advantageous in terms of cost, surgery time, and hospitalisation duration, two-stage reconstructions led to better results with reduced recurrence rates. The stay time in our study also included the pre-operative stage of the patients, thus we have lengthy stay durations in our study. In order to perform a reliable reconstruction we prepare the wound bed with NPWT treatments and give antibiotics to the patients to reduce complications. We apply the reconstruction when the wound culture is negative and granulated. Our institution is a public hospital that relies on the social security system of the state. We can conclude that longer stay times means that patients had worse wound beds compared to other patients and we needed longer durations to prepare the wound beds.

CONCLUSION

In our experience, management of pressure injuries must include surgical planning. We suggest reconstruction with flaps should be prioritised. Reconstruction with flaps stand out in terms of reducing both costs and treatment time. It has been observed that longer hospitalisation, comorbidities, and bacterial growth in wound cultures increase the risk of dehiscence of wound edges. However, surgery requires experience and surgeons should take every possible outcome and treatment option into account.

IMPLICATIONS FOR CLINICAL PRACTICE

While flap surgery carries a high risk of dehiscence, it provides a more durable reconstruction option by filling spaces, such as cavities, with bulky tissue.

Treatment with grafts, though offering shorter hospitalisation and higher success rates compared to flap surgery, is more suitable for Grade 2 pressure injuries than for Grade 3 and 4 pressure injuries.

ACKNOWLEDGEMENTS

The authors declare that they have no conflict of interest to disclose. No funding was received for this study. Also all costs of the study were covered by the author, Alperen Pala, MD.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

FUNDING

The authors received no funding for this study.

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