Review article

Various Flaps Used for Reconstruction of Pressure Injuries: A Narrative Review

Shima Bani Assad[1], Peyman Sadri[2*]

1. Department of General Surgery, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
2. Department of Anesthesiology, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

***Corresponding Author:**

Dr. Peyman Sadri

General surgeon, Department of General Surgery, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Email:

peymansadri1989@gmail.com

Received: 11/6/2024
Accepted: 5/2/2025

ABSTRACT

Pressure injury/ulcer is localized damage to the skin and/or underlying tissues primarily caused by prolonged unrelieved pressure, particularly in patients with limited mobility. The increasing incidence of pressure injuries as a result of aging population and growing number of nursing home residents along with the posing socio-economic burden highlights the importance of increasing our understanding of this global problem, and the available preventive and therapeutic strategies. Surgical intervention using flap reconstruction is the mainstay therapy for management of pressure injuries with advanced stages. We present a comprehensive review on various types, indications, advantages and limitations of flaps used in reconstruction of advanced-stage pressure injuries.

KEYWORDS
Pressure injury; Flap reconstruction; Local flaps; Regional flaps; Perforator flaps; Free flaps

Please cite this paper as:
Bani Assad S, Sadri P. Various Flaps Used for Reconstruction of Pressure Injuries: A Narrative Review. World J Plast Surg. 2025;14(1):3-9.
doi: 10.61186/wjps.14.1.3

INTRODUCTION

Pressure injury, also known as pressure ulcer, pressure sore, bed sore or decubitus ulcer is defined as localized damage to the skin and/or underlying soft tissue secondary to intense or prolonged unrelieved pressure or pressure combined with shear [1-3]. The underlying pathophysiology is pressure-induced microcirculatory occlusion and consequent ischemia leading to inflammation and tissue anoxia and subsequently cell and tissue death, necrosis and ulceration [4, 5]. Impaired mobility, advanced age, impaired skin microcirculation and perfusion, altered sensorium, spasticity and contractures, soft tissue edema, cognitive impairments, altered consciousness, unfavorable skin microclimate, impaired nutrition, abnormal body mass index, history of previous ulceration and significant illness or comorbidity are among the most important risk factors contributing to the development of pressure injuries [6-12].

With an approximate incidence of 1.1% to 29% among hospitalized patients, 2 to 6-fold higher mortality rate compared to those without

pressure injuries and a significant financial burden with an annual cost of up to 26.8 billion dollars in the US, pressure injuries compromise an important cause of morbidity and mortality with high medical costs [13-16]. The most common affected regions are the hip and buttock, followed by the lower extremities accounting for 70% and 15-25% of all pressure injuries, respectively [17].

Pressure reduction, radical debridement of necrotic tissue, control of infection, optimizing medical status and eliminating underlying risk factors, defect closure and prophylactic measurements are the key principles for the successful medical management of pressure injuries [18-21]. Advanced-stage pressure injuries with full-thickness skin and tissue loss require surgical intervention (e.g. flap reconstruction) for definitive treatment, although complications and recurrence rates are high [18]. Flap covers provide an adequate well vascularized cushion over the bony prominences [22]. Based on the location and extent of the pressure injury, various reconstructive options could be used including local, regional, perforator and free flaps. While local flaps are suitable for repairing simple defects, the remaining ones are used for reconstructing complex defects [23].

In the current study, we aimed to comprehensively review the pathophysiology of pressure injuries as a relatively common complication with significant burden and increasing incidence as well as the classification, principles, indications, advantages and challenges of different flap techniques applied for reconstruction of pressure injuries. A better understanding could lead to a more careful flap selection, interdisciplinary management of pressure injuries, thus improving the final outcome and decreasing overall health costs and burden.

Pathophysiology of pressure injuries

Constant uninterrupted pressure exceeding the arterial capillary pressure (32 mm Hg) and the venous capillary closing pressure (8-12 mm Hg) impairs tissue perfusion [12, 24]. This is due to impaired mobility mainly observed in bedridden, old and debilitated patients such as those with spinal cord injury, cerebrovascular accident, hip fracture, etc. [11, 24-26]. The prolonged pressure in combination with mechanical shear and friction forces impair blood flow, subsequently leading to ischemia, tissue hypoxia, cell death, inflammation, and necrosis [12, 24, 27].

Pressure injury staging

The National Pressure Injury Advisory Panel (NPIAP) has provided a classification for categorizing pressure injuries as follows [28, 29]:

Stage 1: Pressure injury: intact skin with non-blanchable erythema

Stage 2: Pressure injury: Partial-thickness skin loss with exposed dermis

Stage 3: Pressure injury: Full-thickness skin loss

Stage 4: Pressure injury: Full-thickness skin and tissue loss reaching muscle, tendon, ligament, cartilage or bone

While stage 1 and 2 pressure injuries are managed by conservative treatment including wound care and dressings, repetitive necrotic tissue debridement and further flap reconstruction are indicated for stage 3 and 4 pressure injuries [18].

Principles of flap reconstruction

The final goals of flap reconstruction for pressure injuries consist of providing durable and tension-free coverage, protecting underlying structures, distributing pressure away from the affected area, reducing pressure injury recurrence and minimizing donor site morbidity [30-32]. Selection of the appropriate flap is made based on several factors including the size and depth of the defect, location of the pressure injury, local tissue health, and underlying comorbidities and overall health status of the patient [31, 32].

Types of flaps used in reconstruction of pressure injuries

Flaps can be classified based on several ways including their location, movement, blood supply and tissue composition. The primary classification relevant to pressure injury repair consists of local, regional, perforator and free flaps [31, 33, 34]. A comprehensive comparison of various aspects of flaps used in pressure injury reconstruction is provided in Table 1. In the following sections, these flaps, their indications, advantages and challenges will be discussed in details.

Table 1: Detailed comparison of different aspects of local, regional, perforator and free flaps used in reconstruction of pressure injury

Aspects	Local flaps	Regional flaps	Perforator flaps	Free flaps
Blood supply	Random-pattern or a defined nearby axial vessel	Pedicled on a defined major regional artery	Perforator vessels emerging from deeper arteries	Microvascular anastomosis with recipient site vessels
Donor Site	Directly adjacent to the defect.	Within the same anatomical region.	Distant or same-region donor tissue with carefully preserved perforators.	Distant sites (e.g., thigh, abdomen, back) tailored to defect needs.
Indications	Small, superficial, or early-stage pressure injuries	Moderate defects in the sacral, ischial, or trochanteric regions	Moderate to large defects requiring thinner tissue or improved aesthetics	Large, deep, refractory defects requiring complex coverage
Operation duration	Short	Moderate	Long	Very long
Technical complexity	Low	Moderate	High	Very high
Tissue availability	Limited to adjacent skin and subcutaneous tissue	Larger, durable tissue from regional anatomy	Larger areas of skin, fascia, and fat with minimal muscle involvement	Unlimited choice of tissue type (skin, muscle, fascia, composite)
Durability	Moderate	High	High	Very high
Donor site morbidity	Minimal	Moderate	Low	Moderate to high
Aesthetic outcome	Acceptable for small defects	Moderate	Excellent	Excellent
Reoperation risk	Moderate	Low	Low	Low to moderate
Scar placement	Near the defect, often visible	May extend into regional donor sites, with visible scarring	Often hidden near perforator site; minimal scarring	Scars located at both donor and recipient sites
Suitability for infected wounds	Limited	Moderate	Good.	Excellent
Training and expertise	Basic	Intermediate	Advanced	Expert-level microsurgical training and experience required
Patient factors	Suitable for frail patients or those with limited surgical tolerance	Moderate tolerance required; suitable for stable patients	Moderate to high tolerance needed; suitable for patients with some reserve	Requires good overall health and ability to withstand long surgery
Cost and resources	Low cost; minimal resources required	Moderate cost; dependent on regional anatomy and tools	High cost; requires imaging and skilled team	Very high; needs microsurgical setup and experienced team

Local Flaps

Local flaps are commonly used for smaller defects in early stages where adjacent tissue can be mobilized to cover the defect (e.g. sacral or ischial pressure injuries with surrounding healthy tissue) and are further divided into advancement, rotation, transposition and V-Y flaps [18, 31, 35]. Local flaps have the advantages of minimal donor site morbidity, preservation of donor site function, simpler surgical techniques and cost-effectiveness, however they have higher risk of dehiscence or recurrence, especially in large or deep defects and may be limited by tissue availability and laxity, flap size and tension on the closure [18, 35].

Regional flaps

Regional flaps are robust options for larger and deeper pressure injuries, particularly in sacral, ischial, or trochanteric regions and involve

tissue from a nearby anatomical region that are transferred via a pedicle and are further divided into musculocutaneous and fasciocutaneous flaps [31]. Regional flaps are cost-effective, promote healing and infection resistance due to rich reliable vascularity making them appropriate candidates for managing deep and infected wounds, and offer robust durability and pressure relief, however they are limited by the regional anatomy, cause increased donor site morbidity and prolonged recovery and may require secondary procedures for donor site closure [36]. Moreover, probable atrophy of muscles used in musculocutaneous flaps over time and loss of padding function could impair their ability to distribute pressure [37, 38].

Perforator flaps

Perforator flaps represent an advanced reconstructive option in moderate to large defects, sparing underlying muscle function by isolating skin and subcutaneous tissue supplied by specific perforator vessels that are identified through preoperative imaging (e.g., Doppler ultrasound or CT angiography) and are further divided into propeller and island flaps [33, 39, 40]. They have the advantages of reduced donor site morbidity due to the preservation of muscles and nerves, greater freedom in flap design and tailoring, minimal operative blood loss and postoperative pain with shorter hospital stays and reduced costs, improved cosmetic outcomes and robust durability and pressure relief, however they are technically demanding, require detailed anatomical knowledge and susceptible to venous congestion and partial flap necrosis in case the vascular supply is compromised [39-41].

Free flaps

Free flaps are used for extensive, complex or refractory defects where local options are insufficient, not available or have failed and involve the entire detachment and transfer of tissue from a distant site using microsurgical techniques to anastomose blood vessels at the recipient site [31, 42, 43]. Examples of these flaps include latissimus dorsi, rectus abdominis, gracilis, anterolateral thigh or radial forearm flaps. They have the advantages of versatility, better cosmetic outcome and the ability to cover large wounds with adequate volume restoration for proper weight bearing, however they require high technical demands, prolonged operative time, and have risk of flap failure or vascular compromise [31, 42]. A comprehensive preoperative planning, including assessing the recipient site's vascular supply, the availability of a suitable donor site, and the patient's ability to tolerate prolonged surgical procedures are essential before using free flaps for pressure injury reconstruction [42].

Postoperative complications

Postoperative complications are reported in 30% to 50% of patients undergoing pressure injury reconstruction and increase length of hospital stay and costs [44-51]. These complications include the following [49-57]:

- Hematoma
- Bleeding
- Seroma
- Wound dehiscence
- Wound infection
- Flap necrosis
- Fistula formation
- Recurrence of pressure injury

There are several ways to minimize the risk of adverse outcomes of the pressure injury reconstruction including preoperative considerations like correction of preexisting nutritional defects, anemia or urinary tract infections, intraoperative considerations like carefully addressing key technical points including tension-free flap reconstruction, using well-vascularized flaps, suction catheter drainage, meticulous hemostasis, and aggressive debridement as well as postoperative considerations like using pressure-reducing mattresses and pressure-release techniques with a strict and careful regimen for pressure release movements and transition from flat bed rest to sitting and for weight-shifting into and out of the wheelchair in the return to daily living on regular intervals [21, 31, 56, 58-67].

CONCLUSION

Improved medical services and subsequently longer life expectancy of old patients with multiple medical disorders has resulted in increasing incidence of pressure injuries, which are now known as an important cause of morbidity and mortality. Timely and appropriate management of pressure

injuries relies on a comprehensive understanding of the pathophysiology of these injuries and their staging as well as inevitable role of underlying comorbidities. Furthermore, a better understanding of the currently available flaps, their indications, advantages, limitations and complications could lead to a more appropriate flap selection, a more professional surgical intervention with the most durability, functional coverage and optimum healing rate and the least complications and recurrence.

ACKNOWLEDGMENTS

No financial source was received for this study.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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