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A Guide to Perforator Flap Selection for Buttock Pressure Sore Reconstruction

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Abstract: Perforator flaps have been increasingly used to repair stage IV buttock pressure ulcers. However, no one has proposed an approach for stage IV buttock pressure ulcers repairing based on the subregion of buttock pressure ulcers. This study aims to evaluate the effect of perforator flaps in the repair of stage IV buttock pressure ulcers, and flap selection was based on the location of the pressure ulcers. Over the past 5 years, we evaluated 65 cases of stage IV buttock pressure ulcers repaired using perforator flaps. Flap selection was based on the subregion of each buttock pressure ulcer, following our approach. A total of 87 perforator flaps were used for 65 cases, including 42 superior gluteal artery perforator flaps, 19 fourth lumbar artery perforator flaps, and 26 descending inferior gluteal artery perforator flaps. All patients showed satisfactory reconstruction. The authors' approach can support surgeons in selecting the appropriate flaps to repair stage IV buttock pressure ulcers and achieve excellent reconstructive outcomes. This method makes the selection of flaps for pressure ulcer repair systematic, simple, and highly feasible and thus is worthy of promotion.

Key Words: inferior gluteal artery, lumbar artery, perforator flap, pressure ulcer, superior gluteal artery

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Pressure ulcers are skin and soft tissue injuries that develop as a result of prolonged pressure on a specific part of the body, as well as a serious health problem worldwide.[1] Anatomical pressure points such as buttocks, heels, ankles (lateral rather than medial), greater trochanter, and occiput are more likely to be affected.[2] Pressure ulcers on the buttocks are the most common, including the sacral and ischial regions. Stage IV pressure ulcers are full-thickness skin defects throughout the fascia with extensive tissue loss that may involve muscle, bone, tendon, or joint.[3] Repairing stage IV buttock pressure ulcers is complicated and challenging as there is no universally established treatment approach. Surgical treatment is inevitable, with the goal of filling the dead space and providing durable skin through flap reconstruction.[4] Perforator flaps have been increasingly used to repair buttock pressure ulcers.[5–8]

However, little attention has been paid to the selection of perforator flaps according to the subregion of buttock pressure ulcers, and no one has proposed such an approach. Flap selection plays a vital role in achieving a satisfactory result in the repair of buttock pressure ulcers. We performed a retrospective analysis of 65 patients who had undergone reconstruction for stage IV buttock pressure ulcers with perforator flaps selected according to the subregion of pressure ulcers. In this study, we proposed an approach to assist with perforator flap selection for the repair of buttock pressure ulcers. The effectiveness of our flap selection approach was evaluated through validated patient repair outcomes.

MATERIALS AND METHODS

From January 2017 to December 2021, 65 patients with stage IV buttock pressure ulcers were enrolled at the Department of Burns and Plastic Surgery of our hospital. The average age of the patients was 60 years (range, 43–74 years) (Table 1). Inclusion criteria are as follows: (1) all patients had stage IV buttock pressure ulcers; (2) the number of pressure ulcer wounds was ≦3; (3) there were no absolute contraindications for surgery; and (4) they had not undergone prior repair surgery. Exclusion criteria are as follows: (1) patients with multiple organ dysfunction who could not tolerate surgery; (2) patients who had received prior repair surgery; and (3) patients with blood system disease and significantly abnormal coagulation function. All the patients were repaired using perforator flaps based on our flap selection approach. We routinely and retrospectively collected perioperative and follow-up data for all patients. The demographics and baseline data are shown in Tables 1 and 2. The mean follow-up time after surgery was 14 months (range, 6–24 months).

Buttock Subregions

The whole buttocks were divided into 3 subregions (central, upper lat, and lower lat) by a longitudinal line along the femoral sulcus and a horizontal line through the sacrococcygeal joint (Fig. 1). With the intersection as the center, a circular area with a diameter of 10 cm is defined as the central region, where sacral pressure ulcers form. The upper lat corresponds to the location of iliolumbar pressure ulcers. The lower lat corresponds to the location of hip and ischial tuberosity pressure ulcers.

Debridement

Before the flap repair operation, the wound bed must be optimally prepared in advance by performing drastic wound debridement and applying wound dressings or negative pressure wound therapy. The criteria for reconstruction included the following: (1) wound margins were free of redness and swelling, and perioperative swabs taken from the wound bed did not show any pathological microbial colonization; (2) necrotic bone was completely removed and treated with

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The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Clinical Research Ethics Committee of the Affiliated Hospital of Zunyi Medical University. All patients gave preoperative informed consent, and the authors were allowed to use their photographs for scientific purposes.
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.
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TABLE 1. Demographics Data

No	Age, y	Male/Female	Paraplegia/Tetraplegic/Ambulatory	Time Since Initial Injury, mo	Prior Surgeries	Albumin, and Prealbumin Level	Weight, kg	Location and Average Size of Defects	Operation Time
1	48	Male	Paraplegia	15.5	No	33.2 g/L; 136 mg/L	61	Sacral (9 × 7 cm); left ischial tuberosity (8 × 5 cm)	3 h 14 min
2	59	Female	Paraplegia	11	No	32.3 g/L; 136 mg/L	53	Left ischial tuberosity (6 × 4 cm)	2 h 15 min
3	62	Male	Paraplegia	23.5	No	23.1 g/L; 121 mg/L	55	Left ischial tuberosity (15 × 10 cm); right ischial tuberosity (15 × 6 cm)	3 h 22 min
4	57	Male	Paraplegia	3	No	35.1 g/L; 219 mg/L	76	Sacral (6.5 × 4 cm)	1 h 55 min
5	65	Female	Paraplegia	10	No	23.5 g/L; 193 mg/L	46	Left iliolumbar (5 × 4 cm)	1 h 30 min
6	57	Female	Paraplegia	14.5	No	30.5 g/L; 201 mg/L	61	Sacral (6.5 × 3 cm)	1 h 45 min
7	56	Female	Tetraplegic	4	No	33.3 g/L; 122 mg/L	49	Left hip (6 × 4.5 cm)	2 h 30 min
8	71	Male	Paraplegia	30	No	20.4 g/L; 127 mg/L	75	Sacral (3 × 3 cm); right ischial tuberosity (3 × 4 cm)	2 h 20 min
9	43	Male	Paraplegia	18	No	27.3 g/L; 133 mg/L	71	Sacral (6 × 3 cm); right iliolumbar (10 × 10 cm); right hip (12 × 9 cm)	2 h 50 min and 2 h
10	57	Female	Ambulatory	3.5	No	28.1 g/L; 175 mg/L	57	Sacral (9 × 8 cm); right iliolumbar (14 × 8 cm)	2 h 50 min
11	69	Male	Paraplegia	8	No	20.3 g/L; 178 mg/L	73	Right iliolumbar (7.5 × 3 cm)	1 h 40 min
12	68	Female	Ambulatory	4.5	No	28.6 g/L; 185 mg/L	62	Right iliolumbar (6 × 5 cm)	2 h
13	57	Female	Tetraplegic	9.5	No	31.1 g/L; 168 mg/L	60	Sacral (6 × 5 cm)	1 h 30 min
14	61	Male	Paraplegia	9	No	31.9 g/L; 242 mg/L	67	Sacral (8 × 4.5 cm)	1 h 55 min
15	58	Male	Paraplegia	7	No	30.8 g/L; 119 mg/L	63	Sacral (6 × 8 cm)	2 h 5 min
16	62	Male	Paraplegia	17	No	29 g/L; 161 mg/L	70	Left ischial tuberosity (6 × 3 cm)	2 h 25 min
17	49	Female	Tetraplegic	2.5	No	39.8 g/L; 247 mg/L	50	Right ischial tuberosity (10 × 4 cm)	2 h 20 min
18	52	Male	Paraplegia	20	No	24 g/L; 115 mg/L	71	Sacral (6 × 8 cm)	1 h 55 min
19	56	Male	Ambulatory	1.5	No	22.2 g/L; 109 mg/L	68	Left iliolumbar (5 × 4 cm)	1 h 40 min
20	65	Male	Paraplegia	11	No	26 g/L; 146 mg/L	75	Sacral (5 × 5 cm); left iliolumbar (8 × 5 cm)	3 h 15 min
21	54	Male	Paraplegia	19	No	25.8 g/L; 176 mg/L	65	Left hip (7 × 6 cm)	1 h 40 min
22	62	Female	Paraplegia	3	No	25.7 g/L; 170 mg/L	50	Left iliolumbar (7 × 5 cm); right ischial tuberosity (5 × 4 cm); sacral (6 × 4 cm)	3 h 20 min and 1 h 30 min
23	61	Male	Paraplegia	9	No	26.1 g/L; 68 mg/L	63	Sacral (8 × 8 cm)	1 h 50 min
24	58	Male	Paraplegia	21.5	No	22.3 g/L; 58 mg/L	69	Sacral (7 × 6.5 cm)	2 h 10 min
25	64	Male	Paraplegia	2.5	No	25.5 g/L; 115 mg/L	69	Sacral (4 × 3 cm)	1 h 30 min
26	69	Male	Paraplegia	23	No	15.8 g/L; 80 mg/L	49	Sacral (7 × 5.5 cm); right iliolumbar (6 × 4 cm)	3 h 10 min
27	47	Male	Paraplegia	5.5	No	21.9 g/L; 127 mg/L	71	Sacral (5 × 5 cm)	1 h 35 min
28	53	Female	Paraplegia	5	No	25.3 g/L; 111 mg/L	46	Right ischial tuberosity (6 × 6 cm)	2 h
29	58	Male	Paraplegia	9	No	22.4 g/L; 101 mg/L	57	Sacral (6 × 4 cm)	1 h 10 min

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TABLE 1. *(Continued)*

No	Age, y	Male/Female	Paraplegia/Tetraplegic/Ambulatory	Time Since Initial Injury, mo	Prior Surgeries	Albumin, and Prealbumin Level	Weight, kg	Location and Average Size of Defects	Operation Time
30	58	Male	Ambulatory	3.5	No	29.9 g/L; 143 mg/L	49	Sacral (5 × 5 cm)	1 h 15 min
31	65	Female	Paraplegia	22	No	18.9 g/L; 87 mg/L	45	Sacral (6 × 5 cm)	1 h 35 min
32	69	Female	Ambulatory	4	No	31.6 g/L; 188 mg/L	45	Right iliolumbar (7 × 5 cm)	2 h 25 min
33	74	Male	Paraplegia	19	No	29.4 g/L; 194 mg/L	74	Left iliolumbar (7 × 5 cm)	1 h 50 min
34	67	Male	Paraplegia	17	No	31.6 g/L; 163 mg/L	61	Left iliolumbar (5 × 4 cm)	1 h 30 min
35	50	Male	Paraplegia	21	No	19.8 g/L; 104 mg/L	55	Sacral (6 × 4 cm)	1 h 40 min
36	64	Female	Paraplegia	2.5	No	28.8 g/L; 117 mg/L	58	Left hip (8 × 7 cm)	1 h 40 min
37	57	Male	Tetraplegic	2.5	No	27.9 g/L; 164 mg/L	54	Sacral (7 × 6 cm); left ischial tuberosity (6 × 4 cm)	3 h 10 min
38	70	Male	Ambulatory	4	No	22.3 g/L; 136 mg/L	66	Left ischial tuberosity (4 × 4 cm)	1 h 45 min
39	66	Male	Paraplegia	7		34.2 g/L; 244 mg/L	74	Right iliolumbar (8 × 5.5 cm)	2 h 25 min
40	61	Male	Paraplegia	19	No	24.8 g/L; 117 mg/L	55	Sacral (6 × 6 cm)	1 h 40 min
41	58	Male	Paraplegia	2	No	35.1 g/L; 277 mg/L	84	Sacral (4 × 5 cm); right iliolumbar (4 × 3 cm)	2 h 25 min
42	59	Female	Paraplegia	7	No	23.1 g/L; 123 mg/L	45	Sacral (6 × 6 cm); right hip (5 × 4 cm)	3 h
43	65	Male	Ambulatory	2.5	No	31.4 g/L; 206 mg/L	74	Sacral (8 × 8 cm)	2 h 15 min
44	68	Female	Paraplegia	17	No	20.7 g/L; 110 mg/L	44	Sacral (5 × 5 cm); right iliolumbar (6 × 4 cm)	2 h 40 min
45	60	Male	Paraplegia	30	No	27.4 g/L; 191 mg/L	55	Left iliolumbar (6 × 5 cm), sacral (5.5 × 4 cm)	1 h 45 min
46	62	Male	Paraplegia	4.5	No	30.5 g/L; 200 mg/L	71	Sacral (9 × 9 cm)	2 h 25 min
47	52	Male	Tetraplegic	2	No	23.2 g/L; 98 mg/L	55	Sacral (7 × 5 cm)	1 h 30 min
48	63	Male	Paraplegia	4.5	No	26.7 g/L; 133 mg/L	52	Left ischial tuberosity (4 × 3 cm)	1 h 30 min
49	63	Male	Paraplegia	1	No	30.3 g/L; 151 mg/L	56	Left ischial tuberosity (5 × 5 cm); right ischial tuberosity (6 × 5 cm); sacral (5.5 × 3 cm)	3 h and 1 h 15 min
50	64	Male	Paraplegia	8	No	23.1 g/L; 88 mg/L	75	Sacral (7.5 × 3 cm); left ischial tuberosity (4 × 4 cm)	2 h 40 min
51	58	Female	Paraplegia	9.5	No	26.1 g/L; 114 mg/L	66	Sacral (5 × 4 cm)	1 h 20 min
52	67	Male	Paraplegia	5.5	No	24.2 g/L; 98 mg/L	57	Sacral (4 × 3 cm), left iliolumbar (8 × 9 cm)	3 h 20 min
53	59	Male	Paraplegia	14.5	No	21.1 g/L; 113 mg/L	59	Sacral (7 × 3 cm)	1 h 35 min
54	61	Female	Paraplegia	3.5	No	27.4 g/L; 134 mg/L	62	Right ischial tuberosity (3 × 3 cm)	1 h 20 min
55	56	Male	Paraplegia	3	No	27.3 g/L; 175 mg/L	73.5	Left ischial tuberosity (5 × 4 cm)	1 h 50 min
56	68	Male	Paraplegia	16	No	36.5 g/L; 224 mg/L	78	Sacral (10 × 7 cm)	1 h 45 min
57	56	Male	Paraplegia	7	No	20.7 g/L; 132 mg/L	70	Sacral (5.5 × 4 cm)	1 h 35 min

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TABLE 1. *(Continued)*

No	Age, y	Male/ Female	Paraplegia/ Tetraplegic/ Ambulatory	Time Since Initial Injury, mo	Prior Surgeries	Albumin, and Prealbumin Level	Weight, kg	Location and Average Size of Defects	Operation Time
58	64	Female	Paraplegia	11	No	26.7 g/L; 198 mg/L	52	Sacral (8 × 4 cm)	1 h 30 min
59	56	Male	Ambulatory	3	No	32.5 g/L; 232 mg/L	69	Sacral (7 × 4 cm)	1 h 35 min
60	63	Female	Paraplegia	12	No	22.5 g/L; 86 mg/L	49	Sacral (7 × 5.5 cm); left ischial tuberosity (6 × 5 cm); left iliolumbar (6 × 6 cm)	3 h 10 min and 1 h 35 min
61	57	Male	Paraplegia	9	No	27.7 g/L; 184 mg/L	58	Left iliolumbar (6.5 × 4.5 cm)	1 h 45 min
62	68	Male	Paraplegia	15	No	30.2 g/L; 167 mg/L	81	Sacral (6.5 × 4.4 cm)	1 h 40 min
63	58	Female	Paraplegia	2.5	No	29.5 g/L; 132 mg/L	55	Left ischial tuberosity (6.5 × 5 cm)	1 h 15 min
64	56	Female	Ambulatory	3		27.6 g/L; 180 mg/L		Sacral (4 × 3.5 cm)	1 h 25 min
65	65	Male	Paraplegia	5		28.2 g/L; 114 mg/L	71	Left ischial tuberosity (6 × 6 cm); right hip (9 × 9 cm)	3 h

antibiotics until there were no signs of bone infection and osteomyelitis; (3) albumin levels greater than or equal to 30 g/L; (4) hemoglobin levels greater than or equal to 90 g/L; (5) diabetic patients maintaining fasting blood glucose levels no greater than 8 mmol/L and 2-hour postprandial blood glucose levels no greater than 10 mmol/L; and (6) patients with 3 pressure ulcer wounds were repaired in 2 separate procedures.

Selection and Design of Perforator Flaps

According to the location of the buttock pressure ulcers and the characteristics of the available perforator flaps, 3 types of flaps were used for corresponding repairs (Fig. 2). Pressure ulcers in the central region were repaired with a superior gluteal artery perforator flap; pressure ulcers in the upper lateral region were repaired with fourth lumbar artery perforator flaps, and pressure ulcers in the lower lateral region were repaired with inferior gluteal artery descending branch perforator flaps. Operative variables are listed in Table 2.

Portable Doppler ultrasound was used to locate the perforators. As is well known, the junction of the medial one third and lateral two thirds of a line drawn between the posterior-superior iliac spine and the apex of the greater trochanter of the femur forms the projection of the superficial branch of the superior gluteal artery on the body surface.[9] The perforators of the superior gluteal artery distribute in the middle of the gluteus maximus near the main trunk. Four lumbar arteries arise from each side of the posterolateral surface of the abdominal aorta, opposite to the upper 4 lumbar vertebrae.[10] Doppler ultrasound allows the location of the perforator as the rotation point so that a flap can be designed with the fourth lumbar artery as the axis.

The inferior gluteal artery originates from the internal iliac artery in the pelvis and passes through the lower hole in the piriformis toward the lower border of the gluteus maximus.[11] Branches of the inferior gluteal artery descend into the posterior thigh, accompanied by the posterior femoral cutaneous nerve. The design of the inferior gluteal artery descending branch perforator flap is mainly based on the vertical axis of the thigh.[12] The axis of the flap is the line connecting the midpoint of the inferior border of the gluteus maximus with the midpoint of the medial and lateral condyles of the femur. Doppler ultrasound can be used to identify the descending branch of the inferior gluteal artery.

The size of the defect area was marked, and the shape and range of the flap were determined according to the defect area. In addition, the skin of the donor flap was pinched to simulate the tension of the donor area and ensure that the donor site could be sutured directly.

TABLE 2. Baseline Data

Characteristic	Value (%)
No.	65
Mean age ± SD, y	60 ± 6.2
Sex	
Female	21 (32.3%)
Male	44 (67.7%)
Sensory lost	43 (66.2)
Diabetes	18 (27.7)
Bone infection or necrosis	24 (36.9)
Pressure ulcer in only one zone	47 (72.3)
Pressure ulcers in 2 or more zones	18 (27.7)

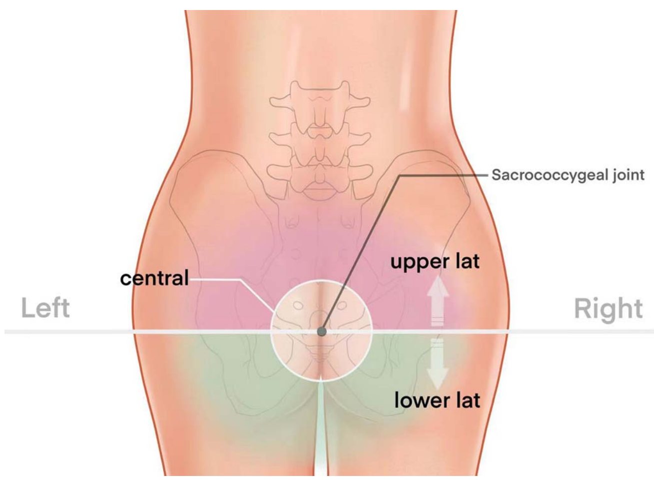

FIGURE 1. Subregions of the buttocks.

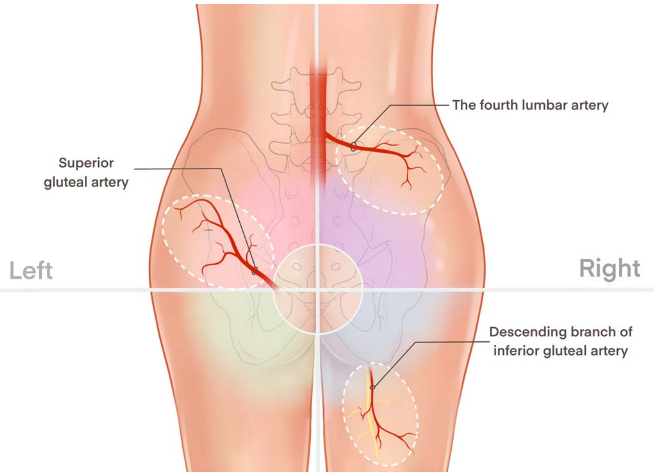

FIGURE 2. Schematic illustration of perforator flaps for the repair of buttock pressure ulcers.

Surgical Procedure

The flap was dissected with entrainment of the deep fascia layer and sufficiently deep dissection of the pedicle to allow twisting of the pedicle without kinking. If a deep cavity was present, the excised fascia flap should supply sufficient volume to obliterate the dead space. Subsequently, the skin was incised and the flap was rotated clockwise or counterclockwise to achieve a tension-free closure. After the operation, a negative pressure drainage tube was placed beneath the flap.

Postoperative Management and Follow-up

After the operation, intravenous infusion of sensitive antibiotics was administered routinely. The flap temperature, color, and capillary response were closely observed. Given the high recurrence rate of these ulcers, postoperative care for patients undergoing reconstructive surgery is crucial. It is essential to prevent pedicle compression after perforator flap operation. During the first 2 weeks, patients were placed on air-fluid beds until the stitches were removed. They were not allowed to lie or sit on their buttocks for 4 weeks after surgery. After this initial period, patients were allowed to lie or sit freely. However, paralyzed patients required repositioning and turning every 2 hours. All patients were followed up for 6 to 24 months, with an average of 14.3 months.

Statistical Analysis

This study was conducted as an evaluation of therapeutic effect. Therefore, there is no need to test the hypothesis and thus no power calculation. All the data presented are descriptive.

RESULTS

Data from consecutive cases were available for analysis (Tables 1–3). A total of 87 perforator flaps were used for 65 cases. Among them, 42 superior gluteal artery perforator flaps, 19 fourth lumbar artery perforator flaps, and 26 inferior gluteal artery descending branch perforator flaps were used, respectively. Primary closure of the donor site was achieved in all patients, and the recipient sites of all 65 patients achieved tension-free closure. All patients showed satisfactory reconstruction, and there were no cases of total or partial flap failure. However, 6 cases of subcutaneous hematoma (9.2%) were observed, with 2 cases requiring surgical revision, while the others were treated conservatively. In addition, 5 patients developed incision infection (7.7%) caused by fecal contamination, and secondary healing was achieved after dressing changes and laser physiotherapy. The average follow-up time was 14 months, ranging from 6 to 24 months. During the follow-up period, none of the patients exhibited late-stage infection, necrosis, or flap shrinkage. All the patients showed satisfactory reconstruction with a pleasing overall appearance of the flaps, good texture, and color.

TABLE 3. Operative Data

Variable	Value (%)
No. patients	65
Total number of flaps	87
Selection of flaps	
Superior gluteal artery perforator flap	42 (48.3)
Forth lumbar artery perforator flap	19 (21.8)
Inferior gluteal artery descending branch perforator flap	26 (29.9)
Wound healing	
Primary healing	60 (92.3)
Secondary healing	5 (7.7)
Wound repairing	
One-time wound repair	57 (87.7)
Two-time wound repair	8 (12.3)
Hematoma	6 (9.2)

Two patients developed recurrent pressure ulcers during the follow-up. One patient developed a pressure ulcer (grade II, central) at 16 months of follow-up with an area of 4 cm × 3 cm. After debridement and negative pressure suction, it was repaired by a split skin graft. Another patient developed recurrent pressure ulcers (grade III, lower lat) at 2 years of follow-up with an area of 3 × 2 cm, which was repaired by local flap transfer after debridement. One patient with spinal cord injury and paraplegia died of pulmonary infection at 1 year of follow-up.

Case 1 (No. 21)

A 54-year-old patient with paraplegia below L1 presented with a grade 4 pressure ulcer on the left hip, with a wound size of 7 × 6 cm. After assessment following our standard protocol, the patient was deemed a suitable candidate for an inferior gluteal artery descending branch perforator flap. In the first stage of the operation, necrotic tissue was thoroughly debrided, and negative pressure wound therapy was applied. A flap of approximately 14 × 8 cm was designed, raised under the deep fascia layer, and dissected to locate the perforator of the descending branch of the inferior gluteal artery. The flap was then rotated clockwise to achieve tension-free wound repair. The patient was discharged 2 weeks later, and there was no recurrence at the 6-month follow-up (Fig. 3).

Case 2 (No. 56)

A 68-year-old man paralyzed below T10 level after a fall from height presented with a grade 4 sacrococcygeal pressure ulcer on the sacral area, with a wound size of 10 × 7 cm. He underwent assessment following our standard protocol and was deemed a suitable candidate for repair with a superior gluteal artery perforator flap. After radical debridement and the application of negative pressure wound therapy, portable Doppler ultrasound was used to map the perforators. A flap of approximately 20 × 7 cm was designed, and it was elevated until the perforator was encountered. The perforator was dissected intramuscularly through the gluteus maximus muscle to its origin at the superior gluteal vessels. The flap was then rotated clockwise to allow for tension-free repair of the wound. The patient was discharged 2 weeks later and was ulcer-free at 12 months of follow-up (Fig. 4).

Case 3 (No. 9)

A 43-year-old woman with a history of diabetes developed paraplegia below T11 level after a traffic accident. Multiple stage IV

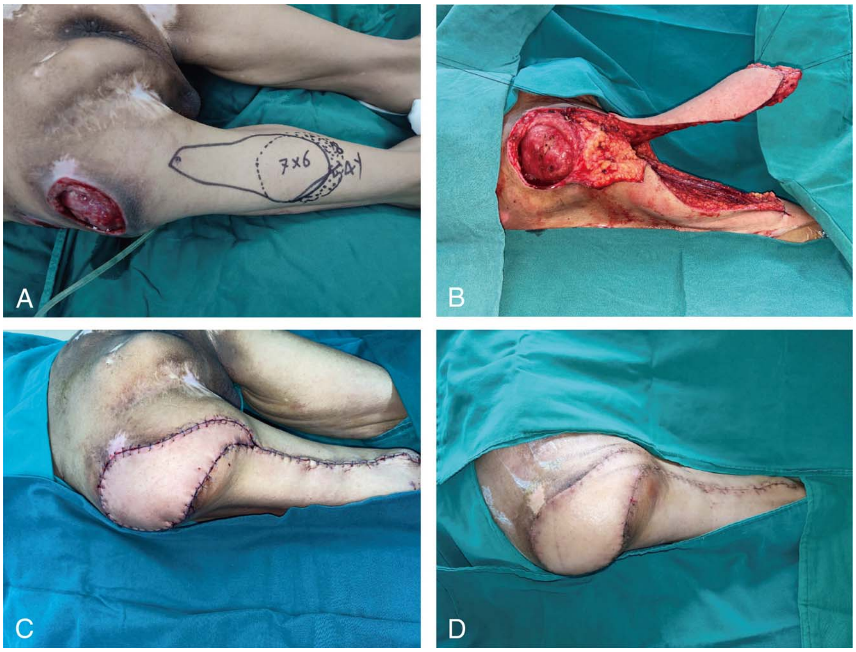

FIGURE 3. A, Preoperative appearance of a pressure ulcer on the left hip and design of an inferior gluteal artery descending branch perforator flap. B, Intraoperative incision of the inferior gluteal artery descending branch perforator flap and the flap was rotated clockwise to provide tension-free repair of the wound. C, The flap survived well and the suture was removed 2 weeks late.

pressure ulcers were distributed on the sacral region (6 × 3 cm), right iliolumbar area (10 × 10 cm), and right hip (12 cm × 9 cm). The wound was repaired by 2 times. In the first repair operation, a fourth lumbar artery perforator flap was used to repair the pressure ulcer on the right iliolumbar area, and an inferior gluteal artery descending branch perforator flap with a fascia flap was used to repair the pressure ulcer on the right hip. After 2 weeks, a superior gluteal artery perforator flap was used to repair the pressure ulcer on the sacral region. The patient was discharged 2 weeks later and was ulcer-free at 12 months of follow-up (Fig. 5).

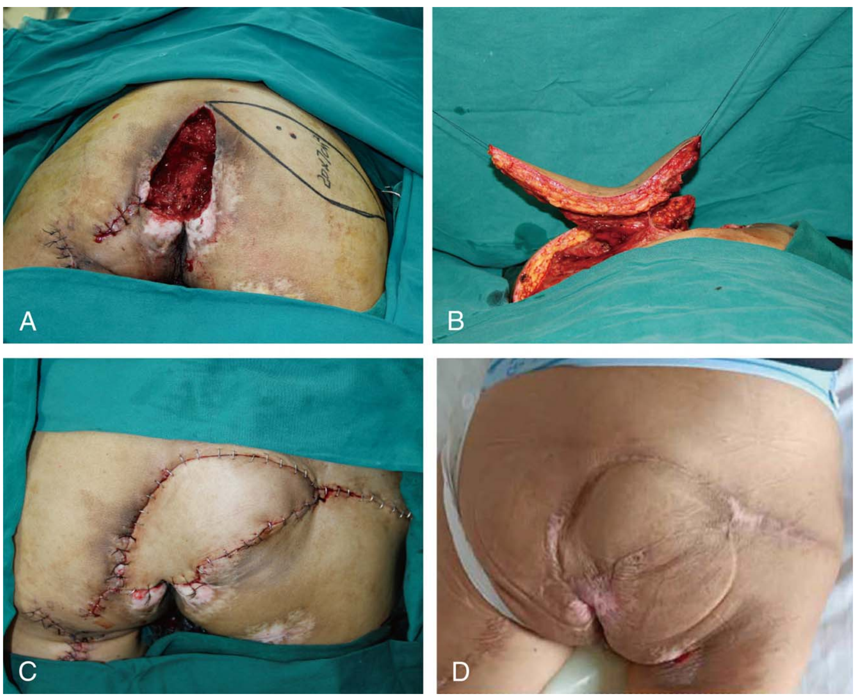

FIGURE 4. A, Preoperative appearance of a pressure ulcer on the sacral area and design of a superior gluteal artery perforator flap. B, Intraoperative incision of the superior gluteal artery perforator flap. C, The flap was rotated clockwise to provide tension-free repair of the wound and the donor site was closed in one stage. D, The wound healed well and the patient was ulcer-free at the 12-month follow-up.

DISCUSSION

Perforator flap selection plays a vital role in achieving a satisfactory result for buttock pressure ulcer repair. In our study, we proposed an approach to select flaps according to the subregion of the buttocks where the pressure ulcers were located, and achieved satisfactory outcomes. We recommend using the superior gluteal artery perforator flap to repair pressure ulcers in the central region; using the fourth lumbar vertebral artery perforator flap to repair pressure ulcers in the upper lateral region, and using the inferior gluteal artery descending branch perforator flap to repair pressure ulcers in the lower lateral region.

Decubitus ulcer formation is multifactorial and long-term persistent pressure is the main culprit. External pressure exceeding arterial capillary pressure (32 mm Hg) and venous capillary pressure (8–12 mm Hg) impedes blood flow and return, ultimately leading to tissue necrosis.[13] Ischemia-reperfusion injury is thought to be another factor in tissue damage leading to pressure ulcers.[14] Reperfusion of ischemic tissue may lead to the formation of reactive oxygen species, which increase and trigger an inflammatory response. The greatest stress usually occurs at the junction of bone and muscle, where the effects of hypoxia and the risk of tissue damage are the greatest, followed by subcutaneous tissue and skin.[13] Therefore, when skin ulcers occur, it is likely that extensive deep tissue damage has already occurred.

Although preventable in most cases, there is still a high prevalence of pressure ulcers burdening the already stretched health economy.[15] Reconstructive surgery for pressure ulcer defects is challenging because of high rates of wound complications and recurrence.[16] Various flaps have been used for the repair of buttock pressure sores including fasciocutaneous, muscle, and myocutaneous flaps.[17–20] Since the introduction of perforator flaps by Koshima et al,[21] the widespread use of perforator flaps has improved reconstruction options and quality of life of patients with skin and soft tissue defects and revolutionized modern reconstructive surgery.[22] Perforator flaps offer several advantages over muscle, myocutaneous or fasciocutaneous flaps, including the preservation of muscle function, reduced donor site damage and complication, versatility, and a reliable blood supply.[22] These factors collectively make perforator flaps a preferred choice for many plastic and reconstructive surgery applications.

Bilobed flaps based on parasacral perforators were used for the treatment of sacral sores.[23] Other double or multiple flaps have also been reported for sacral pressure ulcer repair.[24,25] In addition, a mathematically standardized double-bladed perforator flap was designed for sacral pressure sores repair.[26] However, the use of mathematically standardized bilobed design perforator flaps for covering sacral pressure ulcers is debatable as the wound condition is different in cachectic, mobile, or immobile patients.

The anatomy of the perforating branches of the superior gluteal artery is relatively well understood. The superficial sign of the superior gluteal artery is the junction of the medial one third and lateral two thirds of a line drawn between the posterior-superior iliac spine and the apex of the greater trochanter of the femur. The perforating vessels are widely distributed, the area of a single perforating branch is relatively confirmed, and the blood supply is reliable.[9,27] The superior gluteal artery shows fixed anatomical marks, low variation, convenient location, and rich blood supply, which provides an anatomical basis for the wide clinical application of the perforator flap.[6] Therefore, the superior gluteal artery perforator flap has been used in various forms to repair ischial and sacral pressure ulcers.[24,28–30]

In our study, a superior gluteal artery perforator flap was recommended to repair pressure ulcers in the central region, which could be in the form of island clockwise or counterclockwise rotation or V-Y advancement, and the donor site was sutured directly. In some cases, when a single perforator flap is insufficient because of excessive tension at the donor site, 2 or even multiple perforator flaps can be used and assembled, effectively distributing the tension among multiple flaps for repair.

The lumbar artery perforator flap is an emerging versatile flap that can be used to reconstruct local defects as a pedicled flap or to reconstruct distant structures, such as breasts after mastectomy, as a free transplant.[10] As a pedicled flap, the lumbar artery perforator flap provides a durable solution for reconstruction of lumbosacral and iliolumbar defects, such as those caused by pressure ulcers, tumor resection, congenital anomalies, or trauma, while the donor site is treated by primary closure.[31] This provides a similar solution with similar tissue color and thickness while retaining sensation. In addition to preserving muscle, no deeper dissections as for subcostal perforator flaps are required, thus minimizing donor site morbidity.[32] Because of the

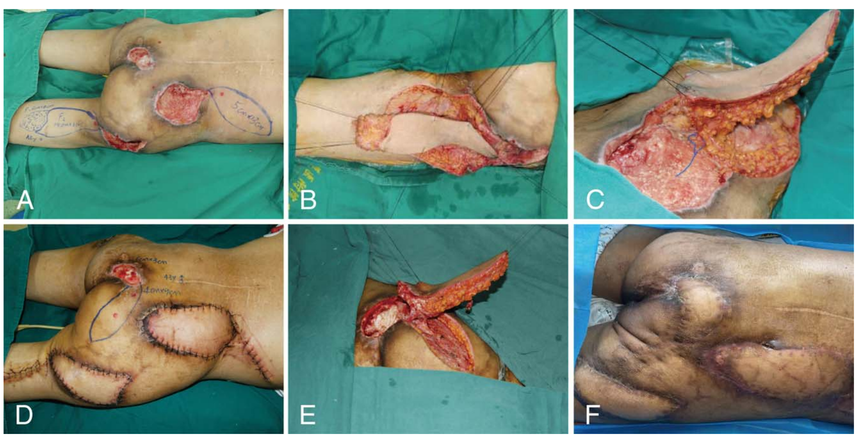

FIGURE 5. A, Preoperative appearance of pressure ulcers on the sacral region, the right iliolumbar area, and the right hip. We designed an inferior gluteal artery descending branch perforator flap and a fourth lumbar artery perforator flap. B, Intraoperative incision of the inferior gluteal artery descending branch perforator flap. C, Intraoperative incision of the fourth lumbar artery perforator flap. D, Two weeks after operation to perform repair with an inferior gluteal artery descending branch perforator flap for the pressure ulcer on the right hip and a fourth lumbar artery perforator flap to repair the pressure ulcer on the right iliolumbar area. In addition, a superior gluteal artery perforator flap was designed. E, Intraoperative incision of the superior gluteal artery perforator flap. F, All flaps survived well, the donor sites healed well after one-stage closure and there was no ulcer-recurrence at the 12-month follow-up.

presence of multiple perforators, another flap can be elevated from the ipsilateral or contralateral side if further reconstruction is required.[33]

Since Higgins et al[34] first reported the application of an inferior gluteal artery perforator flap for pressure sore repair in the sciatic region in 2002, the inferior gluteal artery perforator flap has been widely used clinically. The inferior gluteal artery descending branch perforator flap is a simple and feasible flap preserving the inferior gluteal artery's main vascular perforators in the treatment of sciatic pressure ulcers, which can be used as the first-line treatment for sacral pressure ulcers.[12] In our study, we used the inferior gluteal artery descending branch perforator flap to repair pressure ulcers in the lower lateral region and achieved satisfactory outcomes. The advantages included that the position of the inferior gluteal artery descending branch is constant, the flap is safe with reliable blood supply, and the design and dissection is easy, preserving the inferior gluteal artery's main vascular perforators and having no structural influence on the buttocks or the inner side of the perineum.

The recurrence rate of pressure ulcers is high, and a study on the characteristics of recurrent pressure ulcers showed that the proportion of patients who underwent reconstructive surgery and subsequently suffered recurrence was 11% to 19%.[2] Therefore, postoperative care for patients undergoing reconstructive surgery is of paramount importance. Our experience recommended some effective measures to prevent the recurrence of pressure ulcers after reconstructive surgery, including lying on air-fluid beds until the stitches being removed, avoiding pressure on the buttocks at an early stage, and turning over frequently. In addition, meticulous skin care is necessary.

CONCLUSIONS

To enhance the therapeutic effectiveness of flap reconstruction, it is essential to divide the buttocks into several subregions and choose the appropriate flap for repair based on the specific subregion where the pressure ulcer is located. We propose an approach for selecting flaps according to the subregion of the buttocks where the pressure ulcers are situated. The approach makes the selection of flaps for pressure ulcer repair systematic, simple, highly feasible and results in satisfactory outcome after repair, making it worthy of promotion.

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