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ORIGINAL ARTICLE

Reconstructive

Use of the Propeller Lumbar Perforator Flap: A Series of 32 Cases

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Introduction: Lumbosacral substance defect is a challenge in reconstructive surgery because few coverage solutions are available in this anatomical region. Lumbar artery perforator flaps (LAPs) have been progressively developed and make it possible to solve very complex situations. We report a multicenter study on LAP performed to treat medium and low lumbar defects of various etiologies, to highlight the versatility of this flap as well as its robustness and reproducibility.

Methods: Between 2012 and 2019, 32 LAPs were performed in the Toulouse and Strasbourg University hospitals. Etiologies of the defects encountered were diverse: chronic wounds following neurosurgery, oncodermatology, burn sequelae, and ballistic injury. All LAPs were used in their pedicled form, turned as propeller, and combined or not with other flaps.

Results: We treated 31 patients with 32 LAPs. Average flap size was 14.3 cm (range 8–26) × 6.5 cm (range 5–10), and average arc of rotation was 131.3 degrees (range 70–180 degrees). Only 4 patients (12.9%) presented partial necrosis, but required no other covering procedure because secondary healing was sufficient. No coverage failure was reported. Average follow-up duration was 9.7 months (range 1–18).

Conclusions: In the case of lumbosacral defects of various etiologies, propeller LAP is a reliable and efficient surgical procedure, offering the advantage of low donor site morbidity. The reconstructive surgeon should propose this technique to patients as a first-line option where surgery is indicated. *(Plast Reconstr Surg Glob Open 2020;8:e2522; doi: 10.1097/GOX.0000000000002522; Published online 24 January 2020.)*

INTRODUCTION

Medial lumbar and lumbosacral defects are a relatively common problem in reconstructive surgery but remain difficult to manage because few local coverage solutions exist. In recent years, the advent of perforator flaps has allowed us to respond to defects that are often very complex in terms of coverage. Using lumbar perforating arteries, lumbar artery perforator flaps (LAPs) can be performed in such clinical contexts.

LAPs were first described by Kroll and Rosenfield[1] in 1988 as a new type of perforator flap, based on perforators that had not yet been named. Since then, several studies have highlighted the possible use of LAPs in their pedicled form to cover lumbosacral[2–5] defects, but also as free flaps, mainly in autologous breast reconstruction where other solutions are not possible, particularly at abdominal or gluteal donor sites.[6,7]

Recent cadaveric and radio-anatomical studies have specifically studied lumbar perforating arteries.[8–11] Average pedicle diameters, their locations in relation to the median line and the bone prominences, and their musculocutaneous or septocutaneous courses are now better known for the first 4 pairs of lumbar arteries. Clusters have been defined, making it possible to identify the statistically preferential locations of potential perforators.[10,12] According to Lui et al,[9] LAPs allow harvesting a

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Received for publication March 31, 2019; accepted September 11, 2019.

DOI: 10.1097/GOX.0000000000002522

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

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large volume of tissue, with a theoretical average perforasome[13] of 30 cm² (range 14–64).

We report here a multicenter study on LAPs performed to treat lumbar defects of various etiologies. Our goal was to highlight the versatility of this flap as well as its robustness and reproducibility using a surgical procedure that allows the flap to be harvested with minimum risk.

METHODS

Thirty-one patients were operated on between November 2012 and March 2019 at Toulouse and Strasbourg University hospitals. The same procedure was taught by the senior author (BC) to all teams. For 29 of the patients, 1 LAP was sufficient to cover the defect; for 2 patients, we combined LAP with another flap (a second LAP and 2 superior gluteal artery perforator flaps [S-GAPs]). Indications were diverse: neurosurgical complications, extensive burns, oncodermatology, and ballistic injury. Table 1 summarizes all the data in this series.

All perforator arteries were identified preoperatively using an acoustic handheld Doppler (HADECO Bidop ES-100 8 MHz). Color Doppler identification was also performed where there was any doubt about the perforator path. Surgery performed under general anesthesia, with patients in prone position. All procedures were accompanied by antibiotic prophylaxis and secondarily targeted antibiotics based on previous microbiology samples.

After locating the pertinent perforating artery, then tracing the contours of the skin paddle dermographic pen, the flap was raised in a suprafascial plane, laterally to medially. (**See** Video **[online],** which shows the harvest of a LAP with a skin paddle of 16 cm × 7 cm, on the right side, which was turned with an arc of rotation of 100 degrees, with a suprafascial dissection, and a single lumbar perforator pedicle.) Once the perforator pedicle was identified and isolated, depending on the arc of rotation and cutaneous constraints, the perforator was more or less skeletonized. The flap was then turned and sutured without tension and with appropriate drainage. The donor site, always primarily closed, was also sutured with appropriate drainage.

Case No. 1 (Number 6 in Table 1) (Fig. 1)

A 35-year-old man received a gunshot to the spine next to L1, causing flaccid paraplegia. The mixed ballistic mechanism, combining contusion and burn, did not allow healing even after 2 months of negative pressure wound therapy (NPWT). A pressure sore persisted for more than

Table 1. Data Summary

Patient	Age	Sex	Comorbidity	Osteosynthesis Material	NPWT before Surgery	Etiology of Defect	Defect Localization	Defect (cm)
1	58	M	Diabetes	No	4 wk	Laminectomy	L2–L4	5 × 5
2	46	M	No	No	No	Melanoma	L2–L3	7 × 4
3	60	M	Radiotherapy	No	No	Sarcoma	L3–L5	10 × 7
4	40	M	Schizophrenia	No	2 wk	Burns	T12–L5	24 × 7
5	63	F	Radiotherapy	No	2 wk	Sacral chordoma	L3–S1	8 × 5
6	35	M	No	Spinal osteosynthesis	4 wk	Ballistic injury	L1–L2	3 × 3
7	69	M	No	No	No	Melanoma	L1–L2	6 × 4
8	73	F	Diabetes	No	3 wk	Spondylitis	L3	8 × 6
9	60	F	Radiotherapy	Spinal osteosynthesis	26 wk	Metastasis of kidney cancer	T12–L3	18 × 6
10	76	M	Radiotherapy	Spinal osteosynthesis	No	Sacral chordoma	L4–S1	N/A
11	77	M	Radiotherapy	Spinal osteosynthesis	18 wk	Sacral chordoma	T12–L5	15 × 5
12	72	F	Obesity, diabetes	Spinal osteosynthesis	4 wk	Material infection and postsurgical dehiscence	Between T7 and sacrum	15 × 8
13	64	F	Obesity	Spinal osteosynthesis	5 wk	Material infection and postsurgical dehiscence	Between L2 and S1	20 × 8
14	67	F	No	No	No	Malignant tumor excision with iliac crest resection	Left posterior superior iliac spine	8 × 8
15	62	M	Obesity, diabetes, chronic renal insufficiency	No	No	Neuroendocrine tumor excision Merkel	T10–T12	10 × 10
16	55	M	Radiotherapy, diabetes	Spinal osteosynthesis	No	Chronic fistula on infected material	T12–L5	15 × 3
17	64	F	No	No	No	Chronic fistula on sacro-lumbar osteitis	Sacrum	15 × 6
18	44	M	No	No	No	Exeresis dermatofibrosarcoma	L2–S1	12 × 7
19	40	F	No	No	No	Squamous cell carcinoma	T12–L3	10 × 7
20	69	M	No	No	No	Melanoma	No	5 × 6
21	79	F	Radiotherapy	Spinal osteosynthesis	No	Sacral chordoma	L5–S1	9 × 4
22	60	F	No	No	No	Burns	L2–L4	9 × 7
23	49	F	No	No	No	Squamous cell carcinoma	L3–L4	19 × 7
24	52	M	No	No	No	Basal cell carcinoma	L2–L3	8 × 5
25	60	F	No	No	No	Melanoma	L1–L2	3 × 3
26	51	M	No	No	No	Melanoma	L1–L2	6 × 4
27	78	F	Diabetes	No	No	Spondylitis	L3	8 × 6
28	46	M	No	No	No	Dermatofibrosarcoma	L3–L4	14 × 6
29	45	M	Radiotherapy	Spinal osteosynthesis	3 wk	Sacral chordoma	L5–S1	12 × 6
30	80	F	Obese	No	No	Basal cell carcinoma	L1–L2	11 × 5
31	89	M	Hypertension	No	No	Basal cell carcinoma	T10–T12	26 × 8

F, female; M, male.

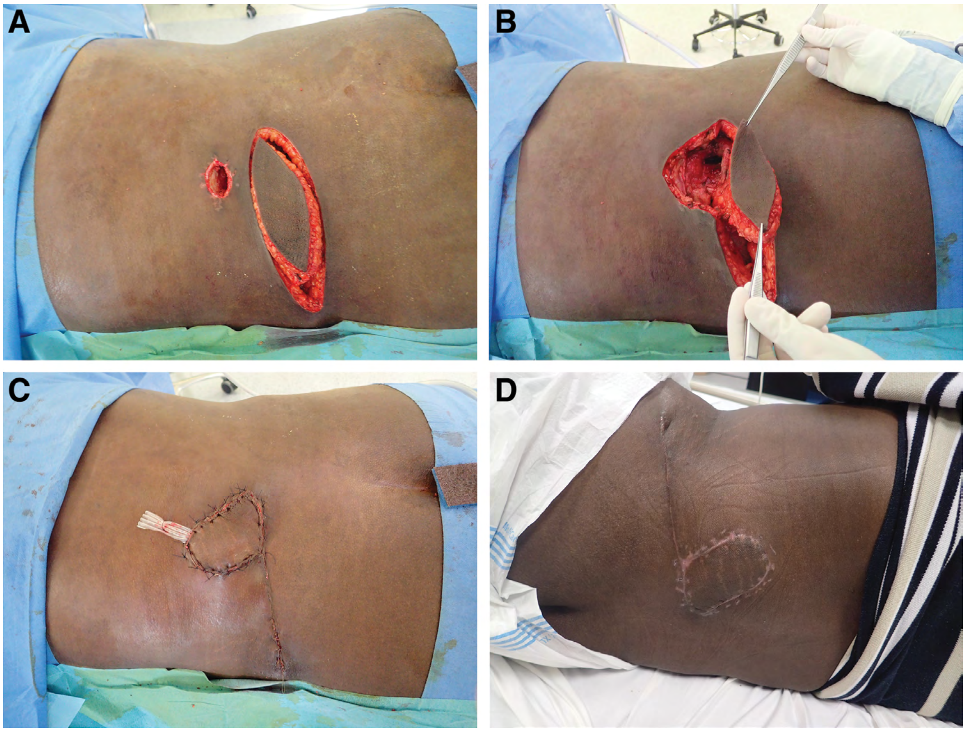

Fig. 1. A, Skin defect with material exposure secondary to a gunshot in the spine. B, Debridement and flap harvesting with careful dissection of its perforating pedicle. C, Direct closure with drainage. D, At 6 months, scarring is reasonably satisfactory.

2 months, so we decided to cover the exposed osteosynthesis material by a flap. A left LAP was harvested with a 14-cm × 5-cm skin paddle and a 90 degrees arc of rotation. Bacteriological samples were taken intraoperatively from both osteosynthesis material and soft tissues. The postoperative course was without complication, with a 6-week antibiotic coverage corresponding initially to broad-spectrum antibiotics and then adapted to samples over time. Eighteen months after surgery, there was no evidence of chronic infection of the osteosynthesis material.

Case No. 2 (Number 11 in Table 1) (Fig. 2)

A 77-year-old patient was treated for a lumbosacral chordoma by the neurosurgery team. The need for adjuvant radiotherapy, combined with the patient continuing to smoke, led to exposure of the osteosynthesis material. Two attempts at direct closure by the neurosurgery team and a prolonged period of NPWT over 4 months were all unsuccessful.

Thus, we used a LAP with a skin paddle of 16 cm × 7 cm, harvested on the right side, and which was turned with an arc of rotation of 100 degrees. The procedure was accompanied by antibiotic therapy for 6 weeks, again initially broad spectrum and then adapted to intraoperative sampling.

The postoperative period was marked by distal venous congestion and epidermolysis covering a 2-cm area without coverage failure. At 8 weeks, healing was complete. Due to chronic spinal pain, the patient still struggled to walk, but no longer required nursing care. Nine months postoperatively, there was no evidence of chronic infection of the osteosynthesis material, and tissue coverage was stable (Figs. 3–4).

RESULTS

From November 2012 to March 2019, we performed 32 LAPs on 31 patients. There were 17 men and 14 women with a mean age of 60.7 years (35–77). Loss of substance had various etiologies, including postoperative neurosurgical complications (n = 13), oncodermatologic resections (n = 15), deep burns (n = 2), and ballistic trauma (n = 1) (Fig. 5).

Twenty-nine defects were covered by a single LAP. One further patient required 2 LAPs, and yet another by a LAP combined with 2 S-GAPs. Defects averaged 11.3 cm (range 3–24) × 5.9 cm (range 3–10) and the LAP skin paddle averaged 14.3 cm long (range 8–26) × 6.5 cm wide (range 5–10). The average arc of rotation for LAPs was 131.3 degrees (range 70–180 degrees). Table 2 reports all of these clinical data.

In 10 cases, NPWT had previously been used, implemented for an average duration of 7.1 weeks. In 9 cases of osteosynthesis, material was present during the coverage procedure. In terms of comorbidities, 25.8% of patients had a history of radiotherapy (8/31), 19.4% of patients had diabetes (6/31), 12.9% were morbidly obese (4/31), and 6.5% had chronic renal failure (2/31). At least 10 smoked daily, but some patients did not report their true smoking status.

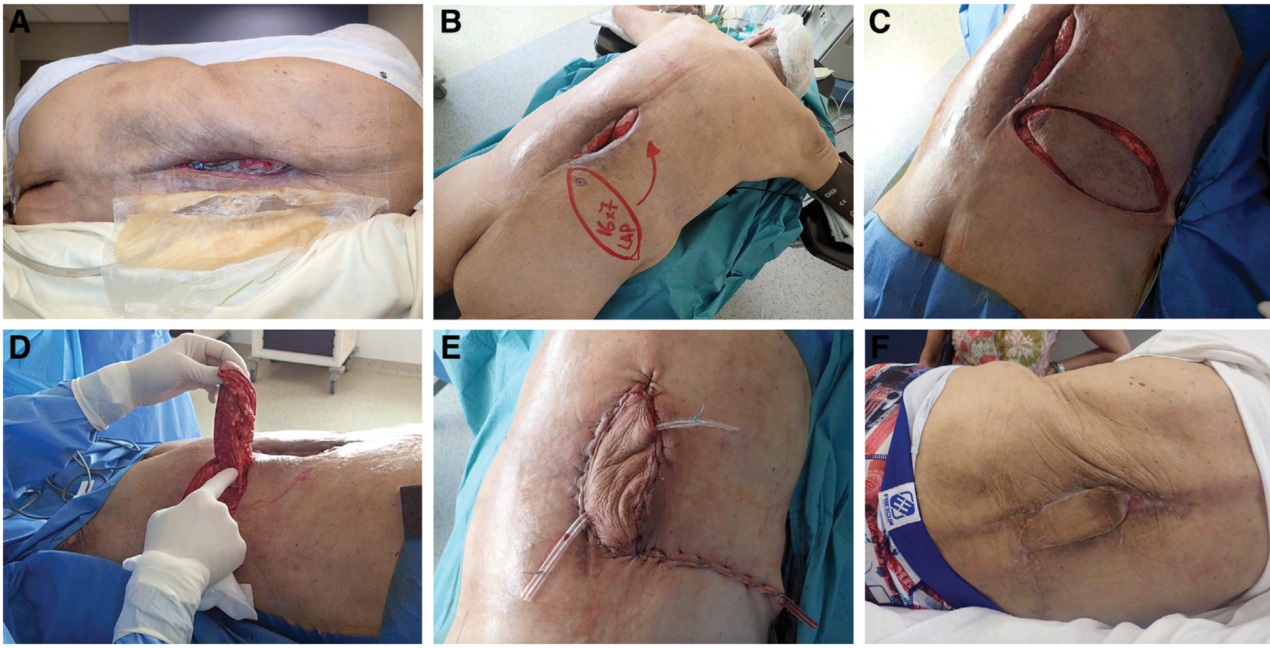

Fig. 2. Examples of cases. A, Wound dehiscence following radiotherapy with exposure of material in a patient having been treated for lumbosacral chordoma. B, Acoustic Doppler identification of the chosen perforator followed by drawing of the skin paddle. C, Flap harvesting. D, Dissection and partial skeletonization of perforator vessels. E, Placement of the flap on the defect with tension-free stitches and a primary closure of the donor site. F, At 3 months, healing was complete.

Fig. 3. A, A 73-year-old patient having undergone osteosynthesis surgery for vertebral collapse presented with spondylodiscitis secondary to postsurgical wound dehiscence. B, Acoustic Doppler detection of chosen lumbar perforating arteries was performed. Debridement of the septic zone followed, collecting bacteriological samples. C, Flap rotation of approximately 100 degrees. D, Placement of flap and suture without tension on drainage. The donor site was primarily closed. E, Results at 6 months showing definitive healing.

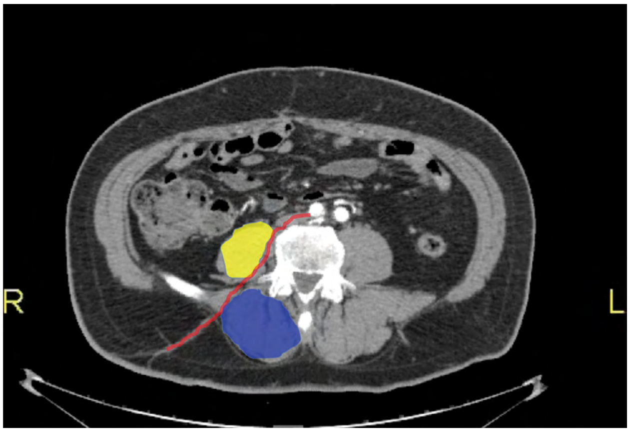

Fig. 4. The septocutaneous path of the L4 artery, which runs between the psoas muscle and the paravertebral muscles. The lumbar perforating pedicle, with its length, its septal cutaneous path, and its final arborization makes it possible to harvest an interesting flap for locoregional reconstruction.

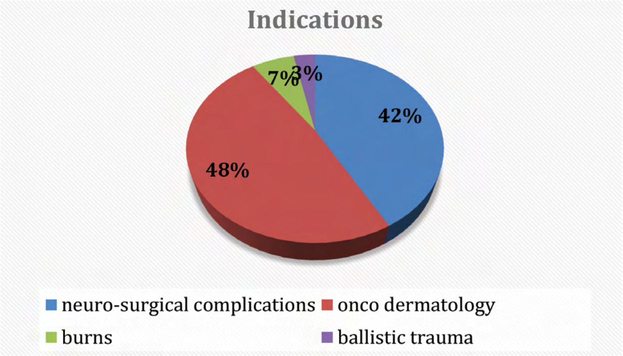

Fig. 5. Distribution of the indications of our series.

Some skin congestion at the flap site was noted; however, in 4 cases (12.9% of our series), no further coverage procedure was required. In 3 cases, this complication consisted of distal epidermolysis not exceeding 1.5–2 cm, and in 1 case, necrosis of 8 cm. All cases of distal skin necrosis were left as secondary healing with favorable outcome. No coverage failure was reported at an average follow-up of 9.7 months, nor were there any complications at the donor site, in all cases primarily closed.

DISCUSSION

Lumbar defects can be reconstructed in different ways, but few reliable local or locoregional coverage solutions exist in this anatomical area. Before the advent of perforator flaps, there was frequently no cover solution to offer to these patients.

V–Y advancement flaps, or other skin-pedicled flaps can be proposed, but the range of their advancement is quite limited, especially in a cicatricial or postradiation context. Yoshino et al[14] reported the advantage of skin-pedicled flaps compared to island flaps in terms of tension reduction, but Milton preferred the reliability of islands flaps.[15] Indeed, the outcome of random fascio-cutaneous advancement flaps or rotation flaps is often very uncertain in patients with comorbidities or a history of radiotherapy.

The latissimus dorsi flap in its proximal pedicle version does not allow coverage of low lumbar locations, unless pedicle lengthening is performed by vascular bypass with saphenous vein graft interposition, as proposed by Duroure et al.[16] Otherwise, it is then necessary to harvest this flap with its less reliable accessory pedicles and with increased risk of necrosis. Finally, the superior gluteal flap, which may be of interest for the loss of very low or lateral substance, is often of little use in medial lumbar reconstructions.

Thanks to a large transverse laxity of the donor site, the propeller version of LAP makes it possible to cover large loss of substance, regardless of the axis with a large degree of freedom. To date, LAPs have already been studied scientifically and theoretically,[11,17–19] in various cases of body reconstruction[17,20] and especially as free flaps in breast reconstruction.[20–23] Lumbar perforator pedicles are anatomically constant, and their preferential statistical localizations have already been studied. Boucher and Mojallal[12] describe the cluster of the 4 lumbar perforators as a rectangle with a median limit at 4.5 cm from the median line, a lateral edge at 10 cm from the latter, an upper and lower limit located, respectively, 10 and 3 cm from the superior posterior iliac spine. The cluster of the fourth lumbar perforator is 6 cm from the median line, with a lateral edge 10 cm from the latter, an upper and lower limit, respectively, of 8 and 3 cm from the superior posterior iliac spine. In a radio-anatomical study of 10 cadaver hemithoraces and lumbar regions, Aho et al[10] measured the average location of the lumbar perforating arteries from the coccyx: 7.62 cm and from the median line: 5.14 cm.

If each of the 4 lumbar perforating pedicles can be used to harvest a LAP, it is obvious that the fourth pair (L4) is surgically the most interesting. Indeed, the L4 pedicle has the largest caliber.[8] Kiil et al dissected 28 lumbar regions, finding an average diameter of 4 mm for the L4 pedicle (artery and veins) compared, respectively, to 2, 3.5 and 3.5 for L1, L2, and L3. Moreover, these authors also found that the L4 perforator pedicle most often had a septocutaneous path, facilitating dissection: 54%, in compared to 30%, 42%, and 38% for L1, L2, and L3. Otherwise, the perforators were musculocutaneous.

Bissell et al[11] performed computed tomography (CT) scans with contrast injected into 6 cadavers and performed three-dimensional reconstructions to study the lumbar vessels. Again, the study found that the L4 perforator was most often associated with a septocutaneous pathway (80%, versus 20%, 50% and 57% for L1, L2, and L3). Average diameter of the lumbar perforating arteries was 0.8, 1.4, 1.7, and 1.8 mm for L1, L2, L3, and L4, respectively. The authors also estimated that L4 had the longest pedicle (measured between the vertebral body and the point of perforation of the thoracolumbar fascia) at an average of 106 mm, compared 98, 68, and 78 mm for L1, L2, and L3. Finally, the study showed that L4 (as well as L1) was significantly more arborized than L2 and L3.

Table 2. Clinical Data

Patient	Defect (cm)	Lap Size (cm)	No. Flap	Rotation (Degree)	Follow-up (mo)	Flap Complications	Donor Site Complication	Primarily Closed Donor Site
1	5 × 5	8 × 6	1	180	12	No	No	Yes
2	7 × 4	8 × 5	1	180	12	No	No	Yes
3	10 × 7	11 × 7	1	150	12	No	No	Yes
4	24 × 7	24 × 7	1	120	18	One-third distal necrosis	No	Yes
5	8 × 5	13 × 7	1	150	9	No	No	Yes
6	3 × 3	12 × 5	1	150	12	No	No	Yes
7	6 × 4	12 × 6	1	150	3	No	No	Yes
8	8 × 6	13 × 5	1	100	18	Delayed healing	No	Yes
9	18 × 6	13 × 6 and 13 × 6	2	90	6	No	No	Yes
10	N/A	14 × 6	1 LAP + 2 S-GAP	150	12	No	No	Yes
11	15 × 5	16 × 7	1	100	12	Superficial necrosis on 2 cm (distal)	No	Yes
12	15 × 8	20 × 8	1	110	6	No	No	Yes
13	20 × 8	25 × 10	1	80	4	No	No	Yes
14	8 × 8	15 × 6	1	180	1	No	No	Yes
15	10 × 10	26 × 9	1	90	4	No	No	Yes
16	15 × 3	20 × 6	1	70	8	No	No	Yes
17	15 × 6	23 × 8	1	90	7	No	No	Yes
18	12 × 7	13 × 7	1	180	4	No	No	Yes
19	10 × 7	11 × 7	1	180	9	No	No	Yes
20	5 × 6	8 × 6	1	180	12	No	No	Yes
21	9 × 4	9 × 5	1	180	12	No	No	Yes
22	9 × 7	10 × 6	1	130	12	No	No	Yes
23	19 × 7	19 × 7	1	120	18	No	No	Yes
24	8 × 5	10 × 7	1	150	9	No	No	Yes
25	3 × 3	10 × 6	1	150	12	No	No	Yes
26	6 × 4	11 × 6	1	120	3	No	No	Yes
27	8 × 6	13 × 5	1	90	18	No	No	Yes
28	14 × 6	13 × 6	1	90	6	No	No	Yes
29	12 × 6	14 × 6	1	150	12	No	No	Yes
30	11 × 5	11 × 5	1	100	12	No	No	Yes
31	26 × 8	20 × 8	1	110	6	Distal congestion (1 cm of necrosis)	No	Yes

The reliability of LAPs in covering lumbosacral defects has already been demonstrated in the literature in small series.[17,20] Mathur et al in 2016 also reported a series of 102 perforator-plus flaps (with cutaneous bridge preservation) based on lumbar or gluteal perforators for lumbosacral substance loss and found only 3% of partial flap necrosis, with a mean follow-up of 1.5 years.[19] In Mathur et al's series, preservation of the cutaneous bridge at the flap base does not make it possible to rotate the flap more than 90 degrees and can create distortion during cutaneous suture.

In our experience, certain points are critical to achieve coverage goals and complication rate. Pedicle dissection must of course be carefully performed, and skeletonization must be adapted to each case to ensure rotation without tension on the perforators. The best approach, therefore, is to harvest the flap requiring the least rotation angle to limit twisting the perforator and the risking venous congestion. However, to be primarily closed, the donor site often requires a minimum angle of 90 degrees with loss of substance. Closure should be performed with loose stitches, to prevent postoperative congestive edema adding greater more volume to the flap. If this is not sufficient, removing a few sutures/stitches is always possible immediately postoperatively or within 6–12 hours following surgery, allowing the venous congestive phase to pass.[24] We recommend placing drainage systems both at the donor site and under the flap. Repeated cleaning of this system also helps reduce the risk of infection.

As a general rule, it is common practice during coverage of bone exposure to remove, or at least change, any exposed osteosynthesis material to limit septic problems. In spinal injuries, where removing such material is often very difficult, if not impossible, we have chosen the coverage option, leaving the osteosynthesis material in place. It should be noted that, unlike the osteosynthesis material of long bones (upper and lower limbs), spinal, the coverage by means of a flap, makes it possible to more easily control chronic exposure, even after acute infection. Indeed, in our series, after a period of NPWT, it was never necessary to remove osteosynthesis material, and to date, at a mean follow-up of 8.14 months for this series of patients with hardware in place, no cases presenting infected material had septic recurrence, fistula, or new exposure of the material.

Ultimately, our series of 32 propeller LAPs, carried out in the Toulouse and Strasbourg University hospitals by surgeons skilled in using perforator flaps, highlighted the reliability of these flaps that can be widely proposed to patients in pertinent clinical contexts. Despite the variety of etiologies encountered, and the frequent comorbidities of these patients, LAPs are a solution of choice, with low donor site morbidity. Consequently, we believe that this procedure should be taught to all reconstructive surgeons.

CONCLUSIONS

LAPs can be used for lumbosacral defects with a wide variety of etiologies. The propeller LAP is a reliable and efficient surgical procedure making it possible to harvest a large skin paddle with low donor site morbidity. This series of 31 patients confirms the data found in the literature, with no reports of any failure of coverage, even in patients with significant comorbidities. The reconstructive surgeon should propose it to patients as a first-line option where surgery is indicated.

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ACKNOWLEDGMENTS

Permission to use the angioscan in Figure 4 was generously given by Dr. E. Vigato. The authors wish to thank Dr. Gail Taillefer, native speaker and Emeritus professor of English, for language editing.

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