Orthopaedics & Traumatology: Surgery & Research 105 (2019) 47–54

Contents lists available at ScienceDirect

Orthopaedics & Traumatology: Surgery & Research

journal homepage: www.elsevier.com

Original article

Free fillet lower leg flap for coverage after hemipelvectomy or hip disarticulation

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ARTICLE INFO

Article history:
Received 30 March 2018
Accepted 18 October 2018

Keywords:
Free leg flap
Fillet flap
Hemipelvectomy
Hip disarticulation
Transpelvic amputation
Spare part concept

ABSTRACT

Introduction: Tumor resection is the gold standard treatment for soft tissue and bone sarcomas. In the pelvis, this may require a hemipelvectomy that can compromise primary skin closure. Flaps are essential in this context; however the vascularization of potential pedicled flaps may have been removed during tumor excision. Using healthy tissue from the amputated limb as a free flap is an excellent coverage option.
Hypothesis: The free fillet flap from an amputated lower limb is a simple and reliable coverage technique after hemipelvectomy or hip disarticulation.
Material and methods: Seven patients were operated on at three specialty centers: six transpelvic amputations (external hemipelvectomy) and one hip disarticulation. In three cases, the flap consisted of the superficial posterior compartment of the calf area and in the three other cases, the lower leg compartments with the fibula and its intact periosteum. Complications were documented.
Results: Clear resection margins were achieved in all patients. The mean follow-up at the final visit was 13 months (range, 6.5 to 21 months). Six patients had complications but only one resulted in loss of the flap. Four patients were able to be fitted with a hip prosthesis.
Discussion: The free fillet flap from an amputated lower limb is a reliable coverage technique (86%) after hemipelvectomy or hip disarticulation. In the 16 cases previously reported in the literature, there were no wound-healing failures. Local flaps are often too fragile with insufficient muscular padding. This free flap is the preferred first-line technique as it spares other potential free flaps in case of failure without increasing the morbidity of a procedure that is already extensive. This coverage technique should be one the options considered after external hemipelvectomy.
Level of evidence: IV, retrospective study.

1. Introduction

Tumor resection is the gold standard treatment for soft tissue and bone sarcomas. The local recurrence rate ranges from 6 to 33% and depends on the histological grade and resection margins [1–5]. In the pelvis, this may require hemipelvectomy or transpelvic amputation (TPA) [6]. The subsequent skin closure may be challenging and can compromise the adjuvant radiation therapy or chemotherapy because of complications. If primary closure is not possible, use of a flap is essential; however, the vascularization of pedicle flaps may have been removed during tumor excision. A large free flap is needed in this scenario. To preserve the other flaps, especially the latissimus dorsi (LD) in patients who will likely need to use their shoulders, in 1992 Workman et al. [7] described using a free flap consisting of the muscles from the amputated leg. Since then, 10 publications have reported 15 other cases [8–17]. Here, we describe a series of seven cases involving patients with a primary soft tissue or bone sarcoma of the pelvis or proximal femur

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https://doi.org/10.1016/j.otsr.2018.10.018
1877-0568/

Table 1
Individual patient characteristics.

	Age (years) Sex	Diagnosis	Origin	Tumor invasion	Enneking classification [18]	History of local surgery and neoadjuvant treatment
Case 1	61 Male	High-grade osteosarcoma, fibroblastic type	Left proximal femur	Circumferential invasion of femur, gluteus medius and femoral blood vessels	Stage II B	IM nailing for pathological fracture Neoadjuvant chemotherapy
Case 2	32 Male	Clear-cell sarcoma	Base of right thigh	Circumferential invasion of soft tissues of the buttock and iliac blood vessels	Stage II B	None
Case 3	61 Male	Chondrosarcoma mostly grade 1 with localized grade 2	Left obturator ring	Invasion of hip joint, pelvis-trochanter muscles, adductor muscles and deep femoral artery	Stage II B	None
Case 4	56 Female	Grade 2 chondrosarcoma	Left iliopubic branch	Endopelvic invasion from the femoral triangle, infiltration of the lateral wall of the pelvis and invasion of the iliac and femoral blood vessels	Stage II B	Resection of the left iliopubic branches due to low-grade chondrosarcoma 10 years prior and resection of anterior side of the wing of the ilium due to grade 2 chondrosarcoma 3 years prior
Case 5	62 Male	Clear-cell chondrosarcoma	Left proximal femur	Invasion of soft tissues of the buttock and base of the thigh; vascular invasion	Stage II B	Resection and THA due to clear-cell chondrosarcoma 22 years prior; change of THA implant 5 years prior
Case 6	50 Male	Osteosarcoma secondary to fibrous dysplasia	Left proximal femur	Invasion of soft tissues of the buttock, left thigh and blood vessels	Stage II B	Fixation of pathological fracture Neoadjuvant chemotherapy
Case 7	59 Male	Non-classified high-grade sarcoma with fusiform cells	Right proximal femur	No invasion but iatrogenic hip contamination	Stage II B	THA 12 years prior; change of THA implant due to pathological fracture 7 months prior

THA: total hip arthroplasty.

with local extension such that tumor resection required TPA or hip disarticulation resulting in a coverage defect at the end of the procedure. The aim of our study was to assess the reliability of the free fillet leg flap and to provide technical details on how to carry out this procedure.

2. Material and methods

The medical records of seven patients (one woman, six men) with an average age of 54 years (32 to 62 years) operated on between 2012 and 2016 at three orthopedic oncology centers within the French bone and soft tissue sarcoma network (NetSarc-ResOs) were reviewed (Table 1). Five patients had already undergone surgery. The diagnosis was made based on a surgical tissue biopsy in every case. All patients were Stage IIB in the Enneking classification [18]; these were high-grade tumors with extra-compartment invasion without metastasis. In two cases, neoadjuvant chemotherapy was done. The imaging assessment included, at a minimum, CT angiography and/or MRI to rule out secondary locations in the amputated limb and to confirm the presence of high-quality vascular elements. Preserving the limb was not possible in any of the seven patients. For six patients, the tumor volume and invasion of vascular elements made conservative surgery impossible (Fig. 1). In the other patient, the limb could not be preserved because of a major bone and soft tissue defect from a prior hip replacement with femoral reaming for a pathological fracture; this required monoblock hip arthrectomy with no possibility of a pedicled flap. There were six cases of TPA and one of hip disarticulation with resection of the gluteal region.

The patients were positioned in lateral decubitus with anterior and posterior padding that allowed the patient to be rolled forward and backward (Fig. 2); no pelvic support was used. The flap was developed as described by Workman et al. [7] through an anterior incision on the tibial crest and circumferential incisions at the ankle and popliteal fossa. An incision centered over the posterior aspect of the thigh was used to dissect the femoral blood vessels needed to obtain a long pedicle (Fig. 3). When all four compartments in the leg were being used, the fibula was shortened but preserved to protect the flap's vascular elements. In two cases, it was secured to bone cuts with absorbable suture to help it stabilize the flap. Preserving the fibula also provided support for the pelvis reconstruction and potential reinforcement when the patient is fitted with a prosthesis.

The various surgical stages were broken up in the following manner depending on the surgical teams: a single team with flap dissection then pelvis approach and amputation then severing of the flap and anastomosis; the pelvis approach and amputation were performed then dissection and raising of flap on the back table; when two teams were involved, one team did the pelvis approach and the other did the flap dissection in parallel with the amputation and raising of the flap. The anastomoses were performed by a vascular surgeon (Table 2). In five cases, the flap was rinsed with heparinized saline and in three cases, an IV injection of heparin was done.

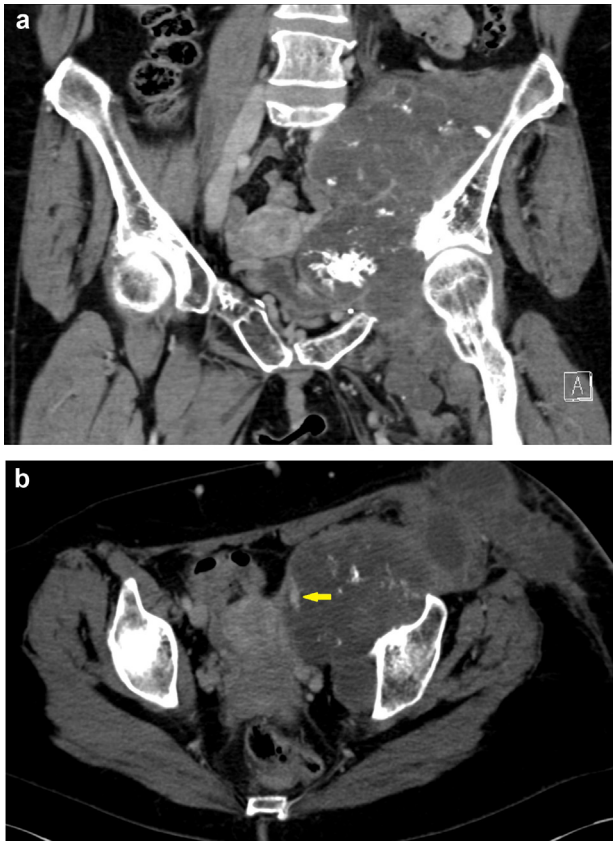

Fig. 1. Patient No. 4. A. Frontal CT slice showing local chondrosarcoma invasion. B. Axial CT slice with tumor in the external iliac artery (←).

Fig. 2. Patient positioning.

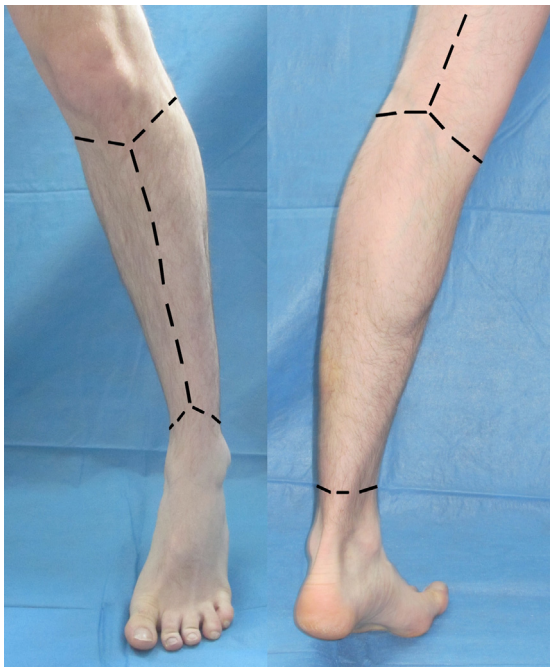

Fig. 3. Drawing of the flap on the skin of the lower leg.

3. Results

In three cases, the flap consisted of the superior posterior compartment of the calf (gastrocnemius and soleus muscles) and in four cases, all the compartments of the lower leg with the fibula and its periosteum were used (Fig. 4). Surgical details and postoperative complications are given in Table 2. Six of the seven patients experienced a flap-related complication. One flap was considered a failure (14%). In this patient (case 4, Table 2), the anterior tibial artery was damaged during flap dissection. The flap had to be removed on the 21st day, after several reoperation attempts because of a deep vein thrombosis (DVT) despite the flap being rinsed with heparinized saline associated with IV injection of heparin during the initial procedure. A negative pressure dressing was used secondarily with coverage using a thin skin graft. A second patient had a DVT of the flap on the 5th day treated by curative doses of heparin, then suffered an infection requiring revision on the 12th day, which responded favorably to antibiotics. Another patient was reoperated due to a local infection of the flap on the 17th day, which responded favorably to antibiotics. A fourth patient had a small necrotic region in the flap that was trimmed surgically on the 15th day. In a fifth patient, the vein anastomosis had to be revised on the evening of the procedure due to a flawed suture. Two patients had urological complications: one urethra wound requiring the implantation of a double-J catheter on the 2nd day postoperative, one calyceal rupture also requiring a catheter on the 15th day postoperative. In one case, skin ulceration occurred on the 80th day at the tip of the fibula through the flap that required surgical revision with shortening osteotomy. Overall, six of the seven patients had a flap-related complication but only one flap was lost (Table 2). No hernias were reported. In one patient, unexpected ossification of the space between the fibula and pubic symphysis occurred at 4 months postoperative (Figs. 5 and 6). Clear resection margins were achieved in all patients.

Four patients were fitted with a Canadian-type hip-disarticulation prosthesis and could walk with or without crutches (supplementary material). The mean follow-up at the final visit was 13 months (6.5 to 21 months) (Fig. 7). Five patients had

Table 2
Surgical technique used, flap-related complications and follow-up.

	Surgery	Surgical sequence	Flap	Anastomoses	Duration of ischemia	Flap-related complications	Additional post-surgery treatments	Survival and follow-up (FU)
Case 1	Left TPA	Amputation then dissection and flap development on back table then anastomoses	Superficial posterior compartment of leg	End-to-end between the external iliac and femoral pedicles	ND	DVT Local infection	None	Died during the course of disease 17 months FU
Case 2	Right TPA	Amputation then dissection and flap development on back table then anastomoses	Superficial posterior compartment of leg	End-to-end between primary iliac artery and femoral artery End-to-side between iliocaval confluence and femoral vein	ND	Small area of necrosis	None	Died during the course of disease 6.5 months FU
Case 3	Left TPA	Two teams: pelvis approach and flap dissection in parallel then amputation and raising of flap and anastomoses	Lower leg with fibula and intact periosteum	End-to-side between primary iliac and femoral pedicles	70 min	None	None	Still alive, no recurrence or metastasis 8 months FU
Case 4	Left TPA	Two teams: pelvis approach and flap dissection in parallel then amputation and raising of flap and anastomoses	Lower leg with fibula and intact periosteum	End-to-side between primary iliac and femoral pedicles	75 min	Fistula at fibula	None	Still alive, no recurrence or metastasis 12 months FU
Case 5	Left TPA	Flap dissection, amputation then flap development and anastomoses	Lower leg with fibula and intact periosteum	End-to-side between external iliac artery and femoral artery End-to-side between common iliac vein and femoral vein	ND	Poor suturing of venous anastomosis	None	Died during the course of disease 7 months FU
Case 6	Right hip disarticulation with gluteal resection	Flap dissection, amputation then flap development and anastomoses	Superficial posterior compartment of leg	End-to-side between the external iliac and femoral pedicles	ND	Local infection	None	Died during the course of disease 21 months FU
Case 7	Right TPA	Flap dissection, amputation then flap development and anastomoses	Lower leg with fibula and intact periosteum	End-to-side between external iliac artery and femoral artery End-to-side between external iliac vein and femoral vein	130 min	Failure, flap lost due to DVT	Multiple rounds of chemotherapy	Died during the course of disease 19 months FU

TPA: transpelvic amputation; DVT: deep vein thrombosis; ND: not determined.

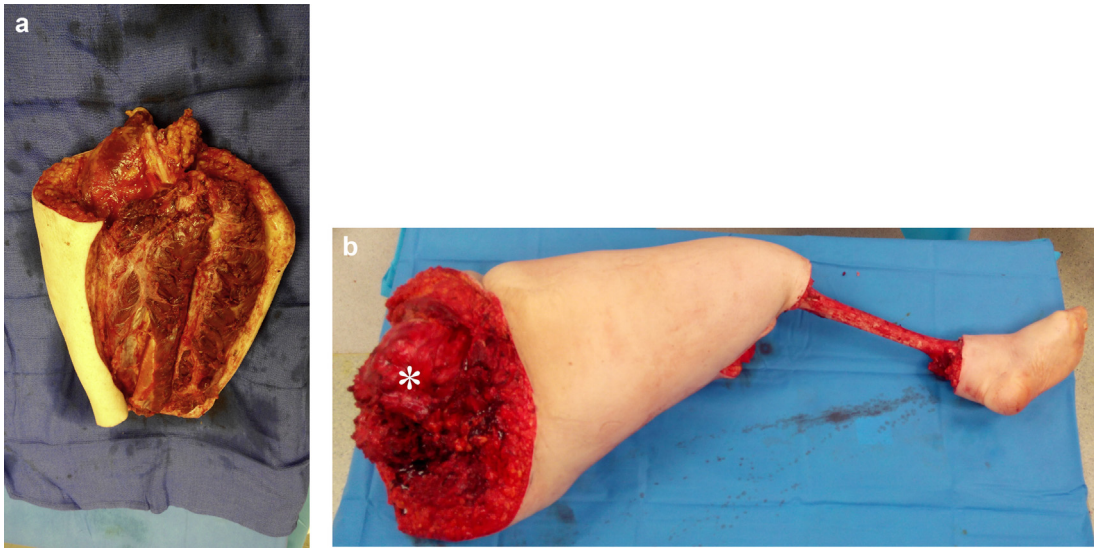

Fig. 4. A. Total lower leg flap with fibula and intact periosteum. B. Intraoperative view of the leg after the flap has been raised (*: chondrosarcoma).

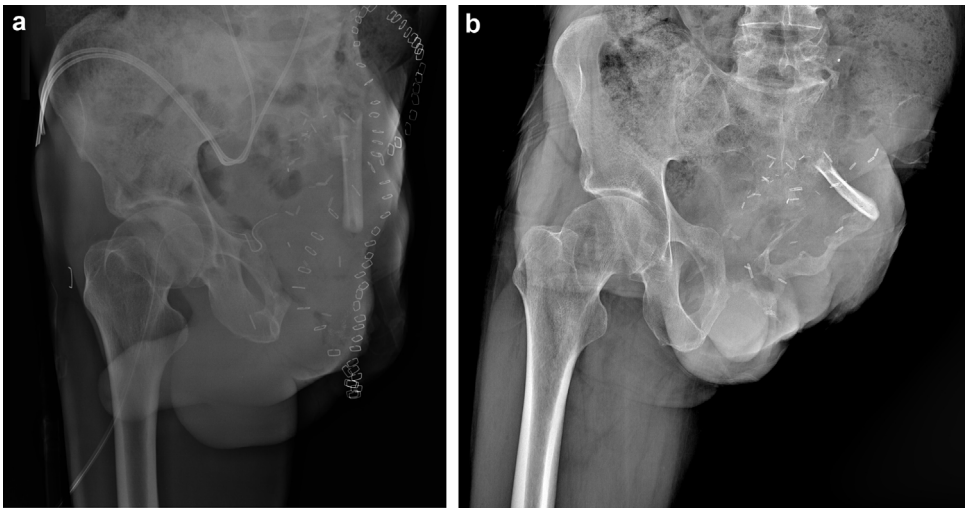

Fig. 5. A. Postoperative X-rays of left transpelvic amputation. B. X-rays at 4 months postoperative showing the ossification between the pubic symphysis and fibula.

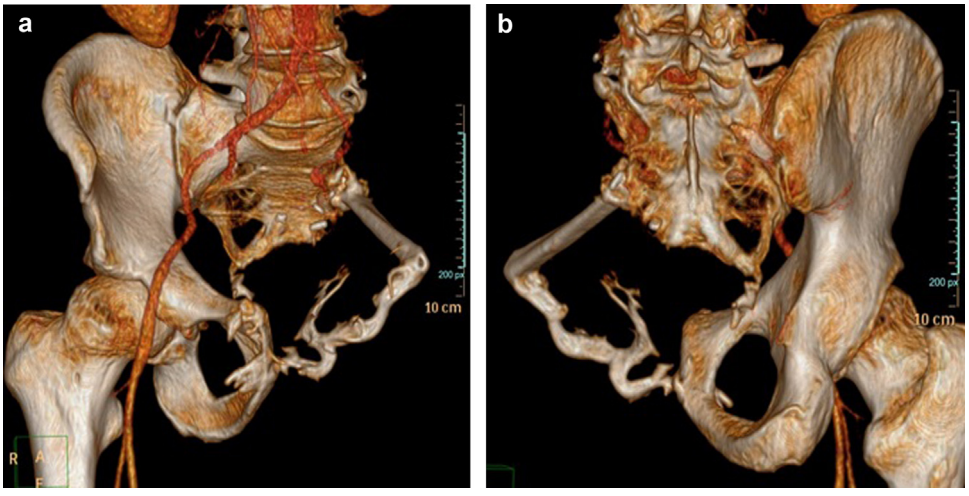

Fig. 6. CT at 4 months postoperative showing the ossification between the pubic symphysis and fibula. A. Anterior view. B. Posterior view.

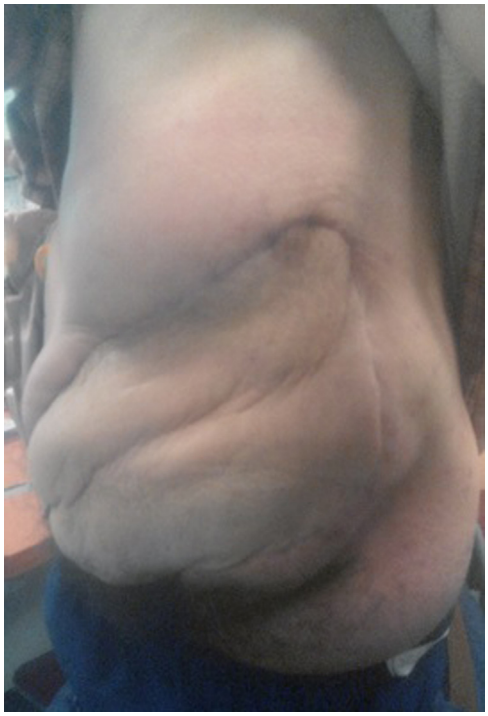

Fig. 7. Clinical presentation of the flap at 8 months postoperative.

secondary tumors (bone, lung and/or adrenal metastasis) and died because of their disease. The mean survival was 14 months (6.5 to 21 months).

4. Discussion

This multicenter series of seven cases using a filleted lower leg free flap shows that this flap has considerable reliability (86% success rate). This case series is larger than any other published study, which consisted of 16 cases in 11 articles [7–17] (Table 3) and no failures.

After hip disarticulation or hemipelvectomy, healing must be achieved quickly to allow adjuvant treatments to be performed such as radiation therapy and/or chemotherapy, and the surgical site must be able to accept a hip prosthesis [9–12,19–21]. Not using a local flap makes the tumor resection strategy simpler as there is no need to worry about pedicle dissection. Local flaps are often too fragile [8,21] with insufficient muscular padding. Complications can affect up to 80% of local flaps [7,11,19,22,23]. The gluteal maximus flap [20,24–31] is a musculocutaneous flap vascularized by the inferior gluteal artery stemming from the internal iliac artery and perforators from the sacrum [19,23,25,30,32]. When its pedicle can be preserved, it is difficult to dissect in the endopelvic area with a high risk of lesions [13,33]. The reported necrosis rate is up 55% [7,19,22,30]. Posterior fasciocutaneous flaps, without muscle tissue, can suffer necrosis in up to 80 or 90% of patients [23]. Flaps using the anterior thigh compartment [19,20,27,30,34–39] are vascularized by the lateral circumflex artery stemming from the deep femoral artery, thus they cannot be used if the proximal vascular structures have been invaded by the tumor. Complications have been reported in 37.5% to 67% of cases [19,30,39].

While the vertical rectus abdominis myocutaneous (VRAM) flap [11,20,21,40–42] is a potential coverage option, donor site morbidity is very high. It requires that the abdominal wall be reconstructed with synthetic material. On the other hand, if the ipsilateral inferior epigastric vessels on which the flap is pedicled cannot be preserved, the flap must be harvested from the contralateral side, which increases the procedure's morbidity. Also, during pelvis surgery, it is often necessary to carry out stomas, which makes the latter difficult to use [20]. As for free flaps, the LD flap is typically used [11,20,24,43,44] to cover large defects; however, it reduces the muscle strength in the shoulder girdle in these patients. The LD is activated during wheelchair or crutch use [7]. The quality of these two flaps (VRAM, LD) is also lower in terms of vascularization and mechanical resistance relative to leg flaps, which contribute a large amount of fascia and muscle [12,45].

Taking into consideration the technical simplicity of raising the flap, the fact that tumor resection does not compromise its vascularity, the muscular padding helping to prevent hernias of the wall [7,19,46] and the absence of donor site morbidity, a free leg flap from the amputated limb appears to be an appropriate solution when a pedicled gluteus maximum or quadriceps flap cannot be used. It is known that when hemipelvectomy is performed in a surgically traumatized site, the risk of complications (dehiscence, necrosis, infection) and local recurrence is higher [46,47]. Good quality coverage is preferable for patients who have already undergone multiple surgeries due to multiple osteochondromas (case 4, Table 2).

Another advantage of harvesting a free flap from the amputated leg is that it does not tap into the reconstruction stock and other coverage options still exist if the flap fails. This free flap is preferred as a first-line technique since it spares the other potential free flaps in case of failure without increase the morbidity of a procedure that is already extensive.

Nevertheless, to be reliable, this flap must be performed while complying with certain technical requirements. In our study, the two cases of DVT in the flap, including one that led to flap failure, occurred during a venous anastomosis performed on a ligated vein. It appears vital to perform end-to-side venous anastomosis on a high output vein such as the common iliac veins or vena cava as the last resort, which results in better venous drainage. For the arterial anastomosis, it is preferable not to dissociate the anterior and posterior tibial arteries like Sara et al. [8] who reported a 10% necrosis rate at the flap's surface by doing an anastomosis between the posterior tibial artery and superior gluteal artery, and between the anterior tibial artery and inferior epigastric artery.

To limit the ischemia time, flap dissection must be carried out at the start of the procedure before the blood vessels are ligated and the leg is amputated [17]. Use of all the lower leg's muscular compartments contributes a large muscle volume and anastomosis networks that provide a safety margin if one of the blood vessels were to be damaged. Preserving the fibula and its periosteum [10,11] saves time in the procedure, but most importantly, it avoids damaging the fibula's blood vessels which are inside, support the pelvis reconstruction and provide reinforcement for fitting of the prosthetic hip. However, we recommend performing a distal osteotomy of at least one-third to one-half to prevent fistula-like complications due to flap perforation by the fibular stump (case 4). Proximally, given the proximity of the emergence of the anterior tibial artery through the interosseous membrane, we do not recommend performing an osteotomy. The fibula can be sutured to the sacrum or the ilium's stump. Dissection of the popliteal-femoral pedicle must be extended proximally for it to be long enough to orient the flap as needed and not be restrained during its pelvis positioning. The wearing of customized post-surgical compression garments helps to avoid the pooling and seromas reported in the literature [11,39].

Table 3
Summary of the 16 cases of hemipelvectomy with free leg flap reconstruction reported of the literature.

Article	Age	Diagnosis	Flap	Anastomoses	Complications	Walking/Prosthesis
Workman et al. [7]	33 years	Fibrous histiocytoma	Lower leg with fibula and periosteum removed	Iliac pedicle and femoral pedicle	None	NA
Sara et al. [8]	28 years	Angiosarcoma	Lower leg with fibula (periosteum removed)	Superior gluteal artery and posterior tibial artery Inferior epigastric artery and anterior tibial artery	10% necrosis	NA
Yamamoto et al. [9]	55 years	Chondrosarcoma	Lower leg with fibula (periosteum removed)	Internal iliac pedicle and femoral pedicle	None	Walking with hip prosthesis
Yamamoto et al. [10]	NA	Chondrosarcoma	Lower leg with fibula (periosteum intact)	NA	None	Walking with hip prosthesis
Ross et al. [11]	NA	Malignant tumor	Lower leg with fibula (periosteum removed)	Contralateral superficial femoral pedicle and femoral pedicle	None	NA
Templeton et al. [12]	73 years	Chondrosarcoma	Lower leg with fibula (periosteum intact)	External iliac pedicle and femoral pedicle	None	Walker (no hip prosthesis)
Morii et al. [13]	52 years 41 years	Squamous cell carcinoma Chondrosarcoma	Lower leg with fibula (periosteum removed)	Internal iliac pedicle and femoral pedicle	None	NA
Faria et al. [14]	32 years 42 years 43 years	Malignant fibrous histiocytoma High-grade pleomorphic sarcoma Myxoid liposarcoma	Lower leg with fibula (periosteum removed)	Iliac pedicle and femoral pedicle	None	1 of 3 walking with crutches
Andrex Burd et al. [15]	37 years	Epithelioid sarcoma	Lower leg with fibula (periosteum removed)	NA	None	Walker only
Bibbo et al. [16]	15 years 45 years 50 years	Osteosarcoma Leiomyosarcoma Chondrosarcoma	Lower leg with fibula (periosteum removed) Lower leg with fibula (periosteum removed) Lower leg with fibula (periosteum removed) and distal thigh	External iliac pedicle and popliteal pedicle External iliac pedicle and popliteal pedicle External iliac pedicle and superficial femoral pedicle	None None None	NA NA NA
Boehmler et al. [17]	55 years	Radiation-induced sarcoma	Lower leg with fibula (periosteum removed)	Contralateral superficial femoral pedicle (1 artery, 2 veins) and popliteal pedicle	Wound dehiscence: surgical debridement at 21 days	Walker only

NA: not available.

5. Conclusion

Use of a free leg flap from the limb amputated during proximal amputation gets around the difficulty of using local flaps, which may not be feasible at all, and avoids donor site morbidity associated with traditional remote flaps. The addition of muscle tissue ensures good padding and reduces local complications, ensures a high-quality stump, and thus a better performing hip prosthetic. This coverage technique is reliable and simple but requires a highly trained multidisciplinary surgical team. It should be one of the options considered after hemipelvectomy.

Disclosure of interest

The authors declare that they have no competing interest.

Funding

No funding was received for this study.

Author contributions

SR: data collection and writing of manuscript.
Other co-authors: data collection and reviewing of manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2018.10.018.

References

[1] Anract P, Biau D, Babinet A, Tomeno B. Pelvic reconstructions after bone tumor resection. Bull Cancer (Paris) 2014;101:184–94.
[2] Anderson ME. Update on survival in osteosarcoma. Orthop Clin North Am 2016;47:283–92.
[3] Maretty-Nielsen K, Aggerholm-Pedersen N, Safwat A, et al. Prognostic factors for local recurrence and mortality in adult soft tissue sarcoma of the extremities and trunk wall: a cohort study of 922 consecutive patients. Acta Orthop 2014;85:323–32.
[4] Ould-Slimane M, Thong P, Perez A, Roussignol X, Dujardin FH. The role of Intraoperative 3D navigation for pelvic bone tumor resection. Orthop Traumatol Surg Res 2016;102:807–11.
[5] Sabourin M, Biau D, Babinet A, Dumaine V, Tomeno B, Anract P. Surgical management of pelvic primary bone tumors involving the sacroiliac joint. Orthop Traumatol Surg Res 2009;95:284–92.
[6] Deloin X, Dumaine V, Biau D, Karoubi M, Babinet A, Tomeno B, et al. Pelvic chondrosarcomas: surgical treatment options. Orthop Traumatol Surg Res 2009;95:393–401.
[7] Workman ML, Bailey DF, Cunningham BL. Popliteal-based filleted lower leg musculocutaneous free-flap coverage of a hemipelvectomy defect. Plast Reconstr Surg 1992;89:326–9.
[8] Sara T, Kour AK, Das De S, Rauff A, Pho RW. Wound cover in a hindquarter amputation with a free flap from the amputated limb. A case report. Clin Orthop 1994;304:248–51.
[9] Yamamoto Y, Minakawa H, Takeda N. Pelvic reconstruction with a free fillet lower leg flap. Plast Reconstr Surg 1997;99:1439–41.

[10] Yamamoto Y, Sugihara T. Pelvic reconstruction with a free fillet lower leg flap. Plast Reconstr Surg 2003;111:1475–6.
[11] Ross DA, Lohman RF, Kroll SS, et al. Soft tissue reconstruction following hemipelvectomy. Am J Surg 1998;176:25–9.
[12] Templeton KJ, Toby EB. Free filet leg flap. Clin Orthop 2001;385:182–5.
[13] Morii T, Susa M, Nakayama R, Kishi K, Morioka H, Yabe H. Reconstruction modality based on the spare part concept for massive soft tissue defects following oncological hemipelvectomy. J Orthop Sci 2009;14:192–7.
[14] Faria JC, Aguiar S, de Oliveira Ferreira F, Lopes A. Fillet flap for reconstruction after hemipelvectomy: report of three cases. J Plast Reconstr Aesthet Surg 2009;62:e110–1.
[15] Burd A, Wong KC, Kumta SM. Aggressive surgical palliation for advanced girdle tumours. Indian J Plast Surg 2012;45:16–21.
[16] Bibbo C, Newman AS, Lackman RD, Levin LS, Kovach SJ. A simplified approach to reconstruction of hemipelvectomy defects with lower extremity free fillet flaps to minimize ischemia time. J Plast Reconstr Aesthet Surg 2015;68:1750–4.
[17] Boehmler JH, Francis SH, Grawe RK, Mayerson JL. Reconstruction of an external hemipelvectomy defect with a two-stage fillet of leg-free flap. J Reconstr Microsurg 2010;26:271–6.
[18] Enneking WF. A system of staging musculoskeletal neoplasms. Clin Orthop Relat Res 1986;204:9–24.
[19] Mat Saad AZ, Halim AS, Faisham WI, Azman WS, Zulmi W. Soft tissue reconstruction following hemipelvectomy: eight-year experience and literature review. Sci World J 2012;2012:702904.
[20] Knox K, Bitzos I, Granick M, Datiashvili R, Benevenia J, Patterson F. Immediate reconstruction of oncologic hemipelvectomy defects. Ann Plast Surg 2006;57:184–9.
[21] Temple WJ, Mnaymneh W, Ketcham AS. The total thigh and rectus abdominis myocutaneous flap for closure of extensive hemipelvectomy defects. Cancer 1982;50:2524–8.
[22] Newsome RE, Warner MA, Wilson SC, Sabeeh VN, Jansen DA, McKee PR. Extracorporeal bypass preserved composite anterior thigh free flap (periosteo-musculo-fascio-cutaneous) for hemipelvectomy reconstruction: utilizing the periosteal component for abdominal wall fascial reconstruction. Ann Plast Surg 2005;54:318–22.
[23] Douglass HO, Razack M, Holyoke ED. Hemipelvectomy. Arch Surg 1960;110:82–5.
[24] Harris GD, Lewis VL, Nagle DJ, Edelson RJ, Kim PS. Free flap reconstruction of the lower back and posterior pelvis: Indications, principles, and techniques. J Reconstr Microsurg 1988;4:169–78.
[25] Kulaylat MN, Froix A, Karakousis CP. Blood supply of hemipelvectomy flaps: the anterior flap hemipelvectomy. Arch Surg 2001;136:828–31.
[26] Chretien PA, Sugarbaker PH. Surgical technique of hemipelvectomy in the lateral position. Surgery 1981;90:900–9.
[27] Frey C, Matthews LS, Benjamin H, Fidler WJ. A new technique for hemipelvectomy. Surg Gynecol Obstet 1976;143:753–6.
[28] Karakousis CP. Hemipelvectomy. In: Atlas of operations for soft tissue tumors. New York: McGraw-Hill; 1985. p. 335–50.
[29] Ariel IM, Shah JP. The conservative hemipelvectomy. Surg Gynecol Obstet 1977;144:406–13.
[30] Senchenkov A, Moran SL, Petty PM, et al. Predictors of complications and outcomes of external hemipelvectomy wounds: account of 160 consecutive cases. Ann Surg Oncol 2008;15:355–63.
[31] Karakousis CP, Vezeridis MP. Variants of hemipelvectomy. Am J Surg 1983;145:273–7.
[32] Higinbotham NL, Marcove RC, Casson P. Hemipelvectomy: a clinical study of 100 cases with five-year-follow-up on 60 patients. Surgery 1966;59:706–8.
[33] Apffelstaedt JP, Driscoll DL, Spellman JE, Velez AF, Gibbs JF, Karakousis CP. Complications and outcome of external hemipelvectomy in the management of pelvic tumors. Ann Surg Oncol 1996;3:304–9.
[34] Luna-Perez P, Herrera L. Medial thigh myocutaneous flap for covering extended hemipelvectomy. Eur J Surg Oncol 1995;21:623–6.
[35] Larson DL, Liang MD. The quadriceps musculocutaneous flap: a reliable, sensate flap for the hemipelvectomy defect. Plast Reconstr Surg 1983;72:347–54.
[36] Dormans JP, Vives M. Wound coverage after modified hip disarticulation using a total adductor myocutaneous flap. Clin Orthop 1997;335:218–23.
[37] Karakousis C, Sugarbaker PH. Sacrectomy. In: Malawer MM, Sugarbaker PH, editors. Musculoskeletal cancer surgery: treatment of sarcomas and allied diseases. Dordrecht, The Netherlands: Kluwer Academic Publishers; 2001. p. 413–22.
[38] Sugarbaker PH, Malawer MM, Henshaw R. Anterior flap hemipelvectomy. In: Malawer MM, Sugarbaker PH, editors. Musculoskeletal cancer surgery: treatment of sarcomas and allied diseases. Dordrecht, The Netherlands: Kluwer Academic Publishers; 2001. p. 305–17.
[39] Marfori ML, Wang EH. Adductor myocutaneous flap coverage for hip and pelvic disarticulations of sarcomas with buttock contamination. Clin Orthop 2011;469:257–63.
[40] Taylor GI, Corlett R, Boyd JB. The extended deep inferior epigastric flap: a clinical technique. Plast Reconstr Surg 1983;72:751–65.
[41] Horch RE, Gitsch G, Schultze-Seemann W. Bilateral pedicled myocutaneous vertical rectus abdominus muscle flaps to close vesicovaginal and pouch-vaginal fistulas with simultaneous vaginal and perineal reconstruction in irradiated pelvic wounds. Urology 2002;60:502–7.
[42] Muramatsu K, Ihara K, Ooi R, Imazyo Y, Taguchi T. Experiences with the “reverse” latissimus dorsi myocutaneous flap. Plast Reconstr Surg 2006;117:2456–9.
[43] Chandrasekhar B, Sloan GM, Beatty JD. The external oblique myocutaneous flap for extended hemipelvectomy reconstruction. Cancer 1988;62:1022–5.
[44] O'Brien BM, Barton RM, Pribaz JJ. The wrist as an immediate free flap carrier for reconstruction of the pelvis; a case report. Br J Plast Surg 1987;40:427–31.
[45] Butler CE. Reconstruction of an extensive hemipelvectomy defect using a pedicled upper and lower leg in-continuity fillet flap. Plast Reconstr Surg 2002;109:1060–5.
[46] Cavadas PC, Landín L. Traumatic complete hemipelvectomy treated with a free fillet flap. J Trauma 2008;65:1551–3.
[47] Conrad EU. Pitfalls in diagnosis: pediatric musculoskeletal tumors. Pediatr Ann 1989;18:45–7 [50–52].