

CASE SERIES GENERAL RECONSTRUCTION

The cool table—limiting warm ischaemia in fillet-of-leg free flap harvest: a case series

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Abstract

The amputated part is an ideal donor for sarcoma defect reconstruction in proximal lower limb amputation; however, these composite tissues are at risk of tissue ischaemia during long operations. A retrospective case investigation of four patients receiving fillet-of-leg flaps for proximal lower limb and pelvis sarcoma reconstruction was performed. A 'cool table' was used for fillet-of-leg harvest from the amputated part to limit warm ischaemia. Three flaps were myocutaneous, the other osseomyocutaneous including tibia. Ischaemia time ranged between 75 and 150 minutes. All flaps survived with no vascular complications.

Introduction

Soft tissue sarcoma involving the pelvic girdle or proximal lower limb presents a difficult surgical dilemma with associated high recurrence rate.¹⁻³ For recurrent or high-grade disease involving multiple compartments, or with invasion into proximal neurovascular structures, limb amputation with hemipelvectomy or hip disarticulation (HDA) is required.⁴ The defects are often large and require a large flap for coverage and support of abdominoperineal viscera (**Figure 1**). When standard posteriorly based gluteal flaps, anterior compartment or adductor compartment flaps are insufficient given the extent of resection, alternative solutions are required.⁵⁻⁷ To preserve workhorse upper limb myocutaneous flaps, including the latissimus dorsi, spare parts from the amputated limb have been described. One of the major concerns of harvesting these flaps is their viability given the complexity of dissection



Fig 1. Hemipelvectomy defect in Case 3

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Table 1. Patient and disease characteristics

	Age/sex	Comorbidities	Diagnosis	Enneking stage	Pre-surgical treatment
Case 1	59F	HTN, GORD, hyperparathyroid	Recurrent R thigh UPS, invading medial and posterior compartments	IIB	NAdj RTx, WLE
Case 2	52F	Ehlers Danlos, asthma, PSC, RA	L thigh UPS, invading medial and lateral compartments	IIB	NAdj RTx
Case 3	63M	Femoral neck GCT, femoral neck fracture	R proximal femur giant cell rich osteosarcoma	IIB	Femoral drilling + curette (previous femoral neck GCT), DHS, hemiarthroplasty, NAdj CTx
Case 4	48F	Psoriasis	R acetabular dedifferentiated chondrosarcoma, invading piriformis, abutting gluteal vessels	IIB	Nil

HTN = hypertension, GORD = gastro-oesophageal reflux disorder, PSC = primary sclerosing cholangitis, RA = rheumatoid arthritis, UPS = undifferentiated pleomorphic sarcoma, NAdj = neoadjuvant, RTx = radiotherapy, WLE = wide local excision, CTx = chemotherapy, GCT = giant cell tumour, DHS = dynamic hip screw

Table 2. Surgical and outcome details

	Surgery	Defect	Flap	Duration of ischaemia (mins)	Flap-related complication	Adjuvant therapy	Functional recovery	Survival
Case 1	HP	50x45 cm ²	FLF	150	Deep space infection	Nil	Mobilising with 4WW	Died 10 mo, metastatic disease
Case 2	TFA	50x40 cm ²	TOFF	120	–	Nil	Mobilising AKA prosthesis, considered for OI	Alive 25 mo
Case 3	HDA	40x40 cm ²	FLF	100	Deep space infection	Nil	Mobilising HP prosthesis	Alive 31 mo
Case 4	HP	45x50 cm ²	FLF	75	–	Adj RTx	Never mobile	Died 4 mo, metastatic disease

HP = hemipelvectomy, TFA = transfemoral amputation, HDA = hop disarticulation, FLF = fillet-of-leg flap, TOFF = tibial osseomyocutaneous fillet flap, AKA = above-knee amputation, Adj RTx = adjuvant radiotherapy, 4WW = Four-wheel walker gait aid, mo = months, OI = osseo-integration

and their muscular composition.⁸ Various methods have been attempted to decrease warm ischaemia time, including flap submerging, banking the flap on intact upper limb vasculature and staging flap raise and inset.^{7,9–11} Here we report a series of lower limb fillet flaps where an ice-cooled dissection table was used to limit warm ischaemia time during flap harvest.

Case series, methods and results

Institutional ethics review board approval was obtained [HREC 18.11.2019] and a retrospective chart audit performed. A single surgeon's patients receiving fillet-of-leg free flaps for reconstruction post-lower limb amputation for sarcoma between 2015 and 2019 were included. Patient and disease data, including age, sex, tumour characteristics, neoadjuvant treatment (**Table 1**),

level of amputation, reconstruction method, defect characteristics, ischaemia time, complications, mortality and functional recovery, were recorded (**Table 2**).

Four patients across four years were included in the series, aged between 48 and 63 years old. Patient details are highlighted in **Table 1**, treatment and outcome details are highlighted in **Table 2**. In Case 1, the disease was recurrent following previous neoadjuvant radiotherapy and wide local excision. All others were primary tumours. All patients required a myocutaneous fillet-of-leg flap from the amputated part consisting of the posterior skin and superficial posterior muscle compartment, except in Case 3 where the flap was an osseomyocutaneous flap containing tibia. The vascular basis of this flap is the popliteal artery and vein. Flap technique is detailed below.

Three of the four patients were mobile postoperatively, with Case 2 and Case 3 both successfully fitted with lower limb prostheses appropriate for their level of amputation. Two patients required a return to theatre for a washout of a deep space infection. The patients in Case 1 and Case 4 died of metastatic disease within the initial 10 months from surgery.

Technique

Once oncological resection reaches a stage where it requires division of the external iliac vessels, or resection time is estimated to be a further two hours, the limb is amputated at the level of the knee. The ligation of popliteal vessels is performed proximally to facilitate more vascular reach. With the resection still ongoing, the fillet flap is harvested concurrently to reduce tissue ischaemic time and overall operative time.

The amputated part is taken to a separate cold ice dissection table (**Figure 2**). The dissection table is layered with waterproof sealed ice bags, a sterile plastic drape, two sterile fabric drapes and a final surgical drape, providing an insulated and even surface to prevent rapid flap cooling and a stable platform for dissection.

Flap elevation follows a similar approach described by Workman and colleagues.⁶ A longitudinal incision is made over the subcutaneous tibia from knee joint to ankle. The skin is elevated to the anterior and posterior tibial border where the plane of dissection is changed to subfascial (**Figure 3**). Subfascial dissection continues medially for a very short distance looking for posterior tibial vessel septocutaneous perforators as they emerge from the septum between superficial and deep posterior compartments. At this point the plane dissection takes a turn deep, following this particular plane. Laterally, subfascial skin elevation continues looking for the peroneal perforators at the lateral intermuscular septum. The dissection plane too is changed at this point to stay on the fibular periosteum, separating lateral and anterior compartment muscles, taking care not to disrupt the peroneal vessels and its skin perforators. The foot is amputated at the level of the ankle joint. The peroneal and posterior tibial vessels are traced proximally and the anterior tibial vessels ligated at their branch point.

The final flap consists of circumferential skin with only the superficial posterior compartment musculature, based on popliteal vessel via posterior and peroneal vessels. In Case 2, the composite flap included tibia and the intervening



Fig 2. (Left) Amputate (Case 3) on sterile draped cool table with underlying ice-filled bags. Markings depict subcutaneous border of tibia and anterior midline incision.

Fig 3. (Right) Fillet-of-leg flap mid-dissection post-isolation of tibia and fibula (Case 4). Surgeon's forceps depict tibio-peroneal trunk bifurcation.



Fig 4. Musculocutaneous fillet-of-leg flap post-dissection on cool table

deep posterior compartment additionally.¹² The popliteal artery and veins are then prepared for anastomosis (**Figure 4**) and the flap is flushed with heparin saline.

Once oncological resection is complete, these heavy composite flaps are partially inset prior to vascular anastomosis to prevent tension on the



Fig 5. Post inset of fillet-of-leg flap (Case 3)

pedicle. A drain is placed and the crural fascia is sutured to anterior abdominal wall deep fascia, inguinal ligament and posterior gluteal fascia. Layered skin closure is performed and flap inset is complete (**Figure 5**).

Discussion

Reducing ischaemia time with large composite flaps is a concern in microsurgery, particularly with muscle containing tissues. The aim is to limit warm ischaemia to two hours, as muscle injury becomes irreversible at three hours.⁸ Various methods have been described to minimise warm ischaemia time or convert warm to cool ischaemia, thus decreasing metabolic demands of the fillet flap. However, most studies either describe delaying division of the vascular supply to the spare part^{11,13} or flushing or submerging the flap into ice water once dissection is complete.^{7,14} The concern with submergence is that rapid cooling may cause vasospasm of cutaneous perforators.⁸ There have not been reported complications of skin necrosis or flap failure in previous series using this technique; however, this may add a theoretical risk to the fillet flaps that surgeons may want to avoid when dealing with finite tissue resources.

The theory behind the cool table is suggested by our surgeons to address two main issues surrounding harvest of fillet-of-leg flaps:

1. reducing overall operative time by concurrently performing flap dissection and oncological resection, and
2. performing flap dissection while slowly cooling the fillet-of-leg flaps and avoiding vasospastic reactions to rapid submergence cooling.

Reported concerns with fibular dissection and peroneal vessel protection were easily negotiated on the separate dissection table and no injury was dealt to the peroneal vessels at their division from the tibioperoneal trunk.¹¹ The cool table was stable and did not disturb macroscopic and microscopic dissection, which was performed safely and with adequate operative ergonomics. Flap temperature monitoring was not performed but future studies that quantify the degree and time course of flap cooling would have merit.

As these flaps are heavy, removal of all anterior, lateral and deep posterior compartment musculature reduces the flap weight. Inset of the flap also requires additional fascial or bony anchoring sutures. Ischaemic time was limited to between 75 and 150 minutes (**Table 2**). In all four patients, there were no reported issues with flap viability after vascular anastomosis, and only one patient (Case 4) experienced partial skin necrosis; however, this was in the native gluteal skin, not the flap.

In our series, two patients died within 10 months postoperatively and two were alive and disease-free at last follow-up, limited to a maximum of 31 months. This is consistent with previous reports of survival for hemipelvectomy and HDA for advanced soft tissue sarcoma, ranging from 3.5 to 14 months, with the longest previous recorded survival of 31 months.^{11,15} The two patients surviving past 10 months, however, achieved good functional recovery, mobilising with a lower limb prosthesis, and having well controlled phantom limb pain. One other patient was mobile with a gait aid before death.

Reconstruction of these defects typically requires large well-vascularised and robust flaps. The disease-free amputated limb is the perfect donor site in providing such a flap without adding to the morbidity already associated with oncological resection.

Large lower limb sarcomas with invasion into multiple compartments are often not amenable to concurrent sarcoma resection and fillet dissection. Although limited by case number, this series

demonstrates a technique for limiting warm ischaemia of fillet-of-leg flaps. Future directions could include intraoperative thermal monitoring of these flaps to establish the true cooling effect on the flaps in vivo. This method may be applied to traumatic amputation scenarios, especially during the critical and time-consuming period of amputate assessment, debridement and neurovascular preparation. One other potential benefit of spare-limb fillet flaps is utilisation of abundant donor nerves for neuroma prevention, sensory re-innervation of the flap or targeted muscle re-innervation, which may further reduce the morbidity and enhance recovery for the patient.

Conclusion

The cool table technique was effectively used in four cases of lower limb amputation, covering defects as large as 50 x 45 cm². Advantages include slow flap cooling and improved surgical ergonomics. Further research is required to quantify the in vivo tissue cooling effect, and to establish a larger cohort to determine its true surgical efficacy.

Patient consent

Patients/guardians have given informed consent to the publication of images and/or data.

Conflict of interest

The authors have no conflicts of interest to disclose.

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