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The use of vascularised muscle flaps for treatment or prevention of wound complications following arterial surgery in the groin

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Abstract

Wound complications following arterial surgery in the groin are relatively common and can result in significant morbidity and mortality. Vascularised muscle flaps (VMF) may be used as an adjunct to aid healing, either to manage complications or prophylactically. This series describes 46 patients who received sartorius or gracilis muscle flaps, of which 70% were performed as a salvage procedure to treat complications ranging from wound breakdown to vascular graft infection. The remaining 30% were performed at the time of the arterial surgery in patients with risk factors such as re-do surgery or immunosuppression. The peri-operative mortality rate was 9% and the major amputation rate was 26%, reflecting the complexity of patients that require intervention. Overall, 85% achieved successful healing in the groin without the need for further treatment following VMF. Only one case of flap necrosis occurred. Wound healing complications occurred more commonly after sartorius muscle flaps. The gracilis muscle offers a bulkier mass and greater mobility and so may be preferable, particularly for larger groin defects. This series has shown that VMF offer a safe and reliable option for selected cases to achieve wound healing in the groin in patients with often significant co-morbidities.

KEYWORDS

groin, surgery, surgical flap, wound healing

1 | INTRODUCTION

Wound complications following arterial revascularisation in the groin can result in significant morbidity and mortality. Complications include surgical site infection, wound breakdown, and poor healing with risk to the integrity of any underlying graft. Management of such problems may require prolonged hospital stay, re-admission, and surgical re-intervention.[1-4] Rates of groin wound complications vary in the literature depending on definitions and reporting standards. Nguyen et al (2007) reported wound complications in 39% of patients within 30-days of infra-inguinal bypass surgery, the most common being infection and haematoma or haemorrhage.[4] Audu et al (2019) reported groin complications after vascular surgery in 20.7% of patients during a 6 month

follow-up period, ranging from minor infection treated with antibiotics as an outpatient, to major complications requiring re-admission and often surgery.[1]

Wound dehiscence may be caused by a post-operative haematoma and dermal or fat necrosis.[5] Another problem is that of lymphatic leak (LL) following uncomplicated arterial revascularisation, which reportedly occurs in as many as 5% to 8% of all cases.[6,7] Trauma to the lymphatic system in the groin is often unavoidable during dissection; this may result in lymphorrhoea which if persistent, can progress to the formation of a lymphocele or lymphocutaneous fistula. A persistent LL may also lead to wound infection with all the secondary complications this situation may entail, in particular graft colonisation and infection.

Groin wound infections may be superficial, involving the skin and soft tissues, or deep, involving the vascular graft (Table 1). Deep infections involving prosthetic material can present up to 1 year following implantation.[8] Vascular graft infections can present with mild symptoms, such as fever, localised erythema, pain, or localised swelling. Severe complications include sepsis or anastomotic rupture with major haemorrhage.

There are several risk factors for groin wound complications (Box 1). Patients with co-morbidities that alter their immune response and wound healing ability are more prone to developing infections. Re-do procedures necessitate an incision through scar tissue, which often increases the complexity of the dissection and the likelihood of poor healing post-operatively. The increased risk in females may be explained by differences in skin flora and body fat distribution.[4] The higher risk due to obesity can be attributed to increased subcutaneous fat and higher groin crease bacterial density.[9]

The use of a vascularised muscle flap (VMF) to provide coverage of a graft when the superficial tissues have failed to heal is well recognised. The aim of a VMF is to reduce any dead space, improve local oxygenation, and decrease the microbial count at the wound site.[10,11] Full debridement and appropriate antibiotics are also required in conjunction with a VMF. Shermak et al (2005) proposed active intervention with a muscle flap as opposed to conservative measures with drainage for persistent LL, and suggested that a VMF allowed formation of new lymphatic channels to divert the leaking lymph.[6] Hence a VMF may be used to treat a simple LL, established deeper infection or prophylactically at the time of surgery in those deemed high risk for developing complications. The two types of VMF commonly used to provide soft

Key Messages

- vascularised muscle flaps are useful in the management of groin wounds following arterial reconstruction
- a case series of 46 patients who underwent sartorius and gracilis muscle flaps following arterial surgery in the groin is presented
- whilst the majority were salvage procedures, some were also performed prophylactically at the time of arterial surgery if considered at high risk of developing complications
- successful wound healing without the need for further intervention was achieved in 85% of cases
- the gracilis muscle flap was associated with fewer complications and may be preferable particularly to cover larger defects

TABLE 1 Samson classification of vascular graft infections[12]

Samson classification	Extent of infection
Group 1	Infection extending no deeper than dermis
Group 2	Infection involving subcutaneous tissue but not in contact with graft
Group 3	Infection involving body of graft but not anastomosis
Group 4	Infection surrounding an exposed anastomosis
Group 5	Infection surrounding an exposed anastomosis with septicaemia and/or bleeding

BOX 1 Risk factors for groin wound complications following vascular surgery[1,2,4,9]

Female gender
Age > 80 years
Elevated body mass index
Co-morbidities, for example, renal failure requiring dialysis, chronic obstructive pulmonary disease
Long operative time
Re-do procedure
Urgent revascularisation procedure

tissue coverage and enable wound healing in the groin are the sartorius (SMF) and gracilis (GMF).

This series from a single vascular unit presents our experience with VMF to treat and prevent complications following arterial surgery in the groin. VMF were used either prophylactically at primary intervention or as a salvage procedure to treat complications that developed post-operatively. Also discussed is how our practice has evolved over a 9-year period.

2 | METHODS

This was a retrospective cohort study of outcomes of patients who underwent a VMF to the groin by a single vascular surgeon between January 2011 and March 2020. The patients were identified from the surgeon's operative diaries and electronic medical records. Operative and clinical notes were reviewed to ascertain demographics, relevant co-morbidities, operative details, microbiology results, and the use of adjunct therapies such as antibiotics and negative pressure wound therapy (NPWT). The proportion of patients with successful wound healing post-VMF without the need for further treatment was analysed. Other outcomes recorded were flap failure, limb amputation, and peri-operative mortality. Analysis was largely descriptive due to the cohort size.

Standard care for all surgery involving the groin area included the administration of broad-spectrum prophylactic antibiotics during anaesthetic induction. Post-operatively, antibiotics were not given prophylactically but were commenced either if there were signs of infection or if there was indication of wound breakdown, particularly with a graft in situ. Simple dressings were used routinely, with antimicrobial dressings and NPWT selected only when clinically indicated based on the individual patient circumstances.

VMF were performed either as a prophylactic or salvage procedure. Following risk assessment for each patient prior to any intervention a decision was made as to whether a VMF was used. Prophylactic muscle flaps were considered for the following factors; previous groin surgery or vascular reconstruction, ongoing immunosuppression therapy, infected pseudoaneurysm and chronic disease states such as diabetes or renal failure. All those who underwent a non-prophylactic VMF had a culture of the groin wound taken as a swab at the time of surgery. The severity of any infection in the groin was determined by the Samson classification.[12]

2.1 | Sartorius muscle flap

This muscle derives its segmental blood supply from the superficial femoral artery (SFA). The blood supply from the SFA enters the muscle body on the medial aspect so in order to preserve its blood supply, the muscle must be mobilised from the lateral aspect and twisted 180° to cover the vascular graft (Figure 1). There are very few functional problems with the lower limb after mobilisation of the sartorius muscle.

2.2 | Gracilis muscle flap

This muscle derives its pedicled blood supply from the profunda femoris artery (PFA). Hence in the frequently encountered situation of an occluded SFA, there is less concern regarding the integrity of its arterial supply. Another advantage of the GMF is that it provides a bulkier muscle mass for groin coverage and if the proximal insertion of the muscle is also detached, the GMF becomes a very mobile flap (Figure 2). Again, there is little functional loss in the lower limb following its use as a flap.

3 | RESULTS

Between January 2011 and March 2020, 46 patients underwent a VMF procedure. The majority of patients

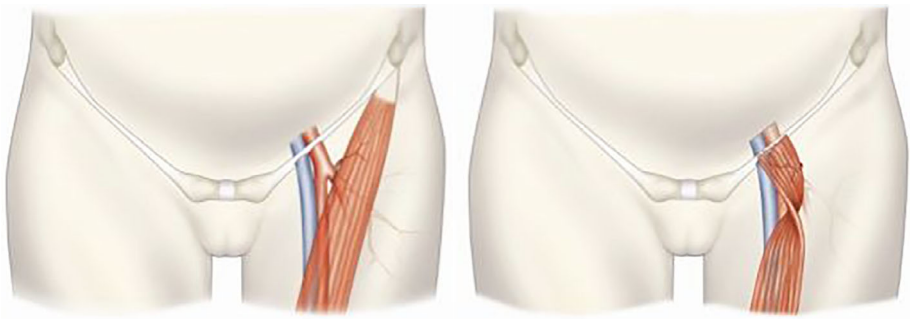

FIGURE 1 The sartorius muscle flap. The sartorius muscle derives its segmental blood supply from the superficial femoral artery via 6 to 8 pedicles that enter on its medial aspect. It is detached from the anterior superior iliac spine and dissected along the lateral border in order to preserve the vascular pedicles, before being twisted to cover the vessels in the groin.

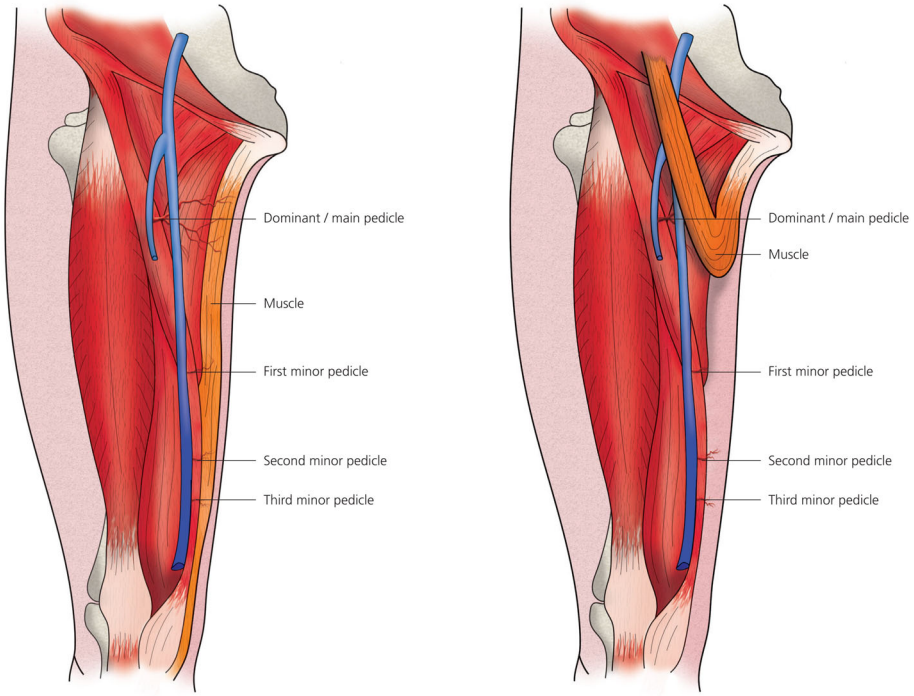

FIGURE 2 The gracilis muscle flap. The gracilis muscle (shown in orange) originates from the ischiopubic ramus and inserts distally into the medial upper tibia. The arterial supply is via the medial circumflex artery which is a branch of the profunda femoris artery (shown in blue) and is located 10 to 12 cm distal to the ischiopubic ramus. The tendinous aspect of the muscle in the lower thigh is divided enabling the muscle to be retroflexed in order to cover the groin defect. For greater mobilisation the origin of the muscle may also be divided at the ischiopubic ramus.

TABLE 2 Original vascular procedures

Infra-inguinal bypass	17
Femoral artery repair / ligation	11
Femoro-femoral crossover	9
Aorto-bifemoral bypass	6
Abdominal aortic aneurysm repair	2
Axillo-bifemoral bypass	1
Total patients	46

TABLE 3 Graft material at original procedure

Graft material	
Vein or endarterectomised SFA	9
Prosthetic	32
Biological patch	2
No graft	3
Total patients	46

were male (n = 32). The patients were aged between 35 and 94 years with a median age of 70 years. Tables 2 and 3 show the original vascular procedures performed and the graft materials used. Seventy percent (32/46) had a prosthetic graft as a conduit. A total of 13 (28%) procedures were re-do. The indications for a VMF are shown in Figure 3. Thirty-two (70%) VMF were performed as a salvage operation due to complications arising following the initial vascular procedure. The median number of days between the original vascular procedure and the VMF was 28, with a range of 7 to 1309 days. Fourteen VMF were performed prophylactically (Table 4).

3.1 | Culture results

Culture results were available for 40 patients, and the majority (23/40, 58%) showed mixed growth. This included *S. aureus* in 11 patients, *Pseudomonas sp.* in 6 patients and other Gram-negative bacteria in 17 patients. Only 1 patient grew methicillin resistant *Staphylococcus aureus* (MRSA).

3.2 | Treatments

The SMF was used in 19 (41%) and GMF in 27 (59%) patients. Concurrent therapies used alongside VMF were systemic antibiotics in 40 (87%) and NPWT in 17 (37%) patients. Whilst only 10 (22%) were diagnosed with a superficial or deep infection, many more received antibiotics due to a non-healing wound or lymphatic leak occurring in the presence of a vascular graft. In addition, 6 (13%) were intravenous drug users with infected pseudoaneurysms, mandating that

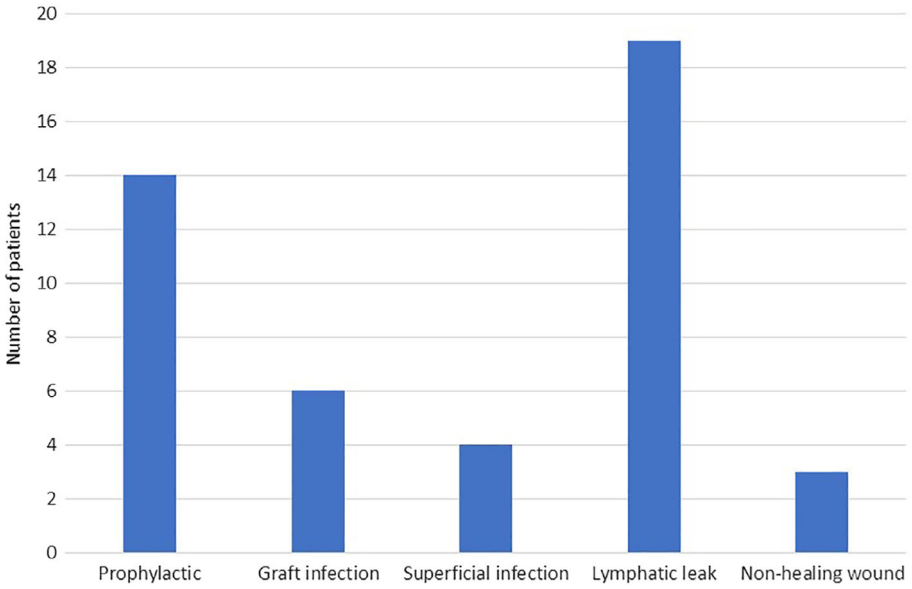

FIGURE 3 Indications for vascularised muscle flaps

TABLE 4 Patients who underwent prophylactic VMF

Indication for prophylactic VMF	Age (years), sex	Vascular procedure	Graft material	Type of VMF	Outcome
Infected pseudoaneurysm in IVDU	49, male	Infra-inguinal bypass	Vein	GMF	Groin healed, AKA within 30 days
	50, male	Infra-inguinal bypass	Vein	GMF	Groin healed
	45, male	Femoral artery repair	None	GMF	Groin healed
	47, male	Infra-inguinal bypass	Vein	GMF	Groin healed
	35, male	Femoral artery repair	None	GMF	Groin healed
	39, female	Ligation of femoral artery	None	GMF	Groin healed
Redo surgery in groin	62, male	Femoro-femoral cross-over	Prosthetic	SMF	Groin healed
	82, male	Infra-inguinal bypass	Vein	GMF	Groin healed
	79, female	Infra-inguinal bypass	Prosthetic	GMF	Groin healed
	57, male	Infra-inguinal bypass	Prosthetic	GMF	Groin healed, AKA within 30 days
	85, female	Femoro-femoral cross-over	Prosthetic	GMF	Groin healed, bilateral AKA within 30 days
Re-do surgery in groin and immunosuppressed for inflammatory arthritis	78, female	Infra-inguinal bypass due to femoral artery injury during TAVI	Prosthetic	GMF	Groin healed
Renal transplant, diabetes	63, female	Infra-inguinal bypass due to femoral artery injury during coronary angiogram	Vein	SMF	Lymphatic leak and delayed healing. Managed conservatively, healed
Diabetes, obese	78, male	Infra-inguinal bypass	Prosthetic	GMF	Groin healed, AKA within 30 days

Abbreviations: AKA, above knee amputation; GMF, gracilis muscle flap; IVDU, intravenous drug user; SMF, sartorius muscle flap; TAVI, transcatheter aortic valve implantation.

TABLE 5 Characteristics of patients who developed wound complications following VMF

Age (years), sex	Original vascular procedure	Indication for VMF	Type and timing of VMF	Complication	Outcome
63, female	Infra-inguinal vein bypass due to femoral artery injury during coronary angiogram	Prophylactic (history of renal transplant)	SMF, day 0	Lymphatic leak and delayed healing	Managed conservatively, healed
75, female	EVAR and femoro-femoral crossover graft (Dacron)	Lymph leak	SMF, day 8	Graft infection presenting with bleeding	Dacron graft removed and replaced with vein graft, healed
71, female	Retroperitoneal abdominal aortic aneurysm repair (Dacron)	Lymph leak	SMF, day 14	Flap necrosis	GMF and skin graft performed, healed
70, male	Femoral artery reconstruction with Dacron patch	Graft infection presenting with abscess formation (Samson IV)	SMF, day 158	Wound dehiscence and failure to heal	Removal of Dacron graft and vein bypass, healed
52, female	Femoro-femoral crossover graft (Dacron)	Lymph leak and wound breakdown	SMF, day 165	Failure to heal and exposure of graft	Re-do vein graft and subsequent AKA, healed
70, male	Femoral endarterectomy and PTFE patch repair	Graft infection presenting with swelling and wound breakdown (Samson IV)	SMF, day 163	Failure to heal and exposure of graft	PTFE graft removed and AKA, healed
75, male	Aorto-bifemoral graft (Dacron)	Lymph leak	GMF, day 1065	Wound healed but collection recurred	Aspiration of collection, healed

Abbreviations: AKA, above knee amputation; EVAR, endovascular aneurysm repair; GMF, gracilis muscle flap; PTFE, polytetrafluoroethylene; SMF, sartorius muscle flap.

antibiotic treatment was required before/at the time of surgery. Twelve patients (27%) required removal of vascular graft and extra-anatomic bypass in addition to VMF.

3.3 | Outcomes

Complete healing of the groin wound without the need for further treatment was achieved in 39 patients (85%). The remaining 7 (15%) had further complications following VMF, of which 6 were SMF (Table 5). Only 1 case of VMF necrosis occurred. This was a SMF in a patient with a lymphatic leak following abdominal aortic aneurysm repair who then required a re-do VMF with gracilis and a skin graft to achieve wound healing. Four patients (9%) died in hospital or within 30 days of VMF and 12 (26%) later required an amputation (above or below knee). Of these, 8 were performed within 30 days of the original vascular procedure.

4 | DISCUSSION

Vascularised muscle flaps were performed prophylactically for particularly high-risk cases and also used to manage complications ranging from LL with wound breakdown to graft infection. Successful groin healing without further wound complications was achieved in 85%. The remaining 15% (7 patients) developed wound complications following VMF, six of whom had received a SMF. Of the 7 with complications, 1 had a prophylactic VMF and the remaining 6 had a VMF as treatment—4 for LL and 2 for infection. It is difficult to ascertain reasons for treatment failure as only 1 patient developed necrosis of the muscle flap. This was a SMF and may have been caused by inadequate vascular supply due to disease in the SFA or even after mobilisation of the muscle. Two of these patients whose initial reconstructions were a femoro-femoral crossover graft and a femoral endarterectomy with patch repair subsequently required an above knee amputation (AKA). Neither patient had any

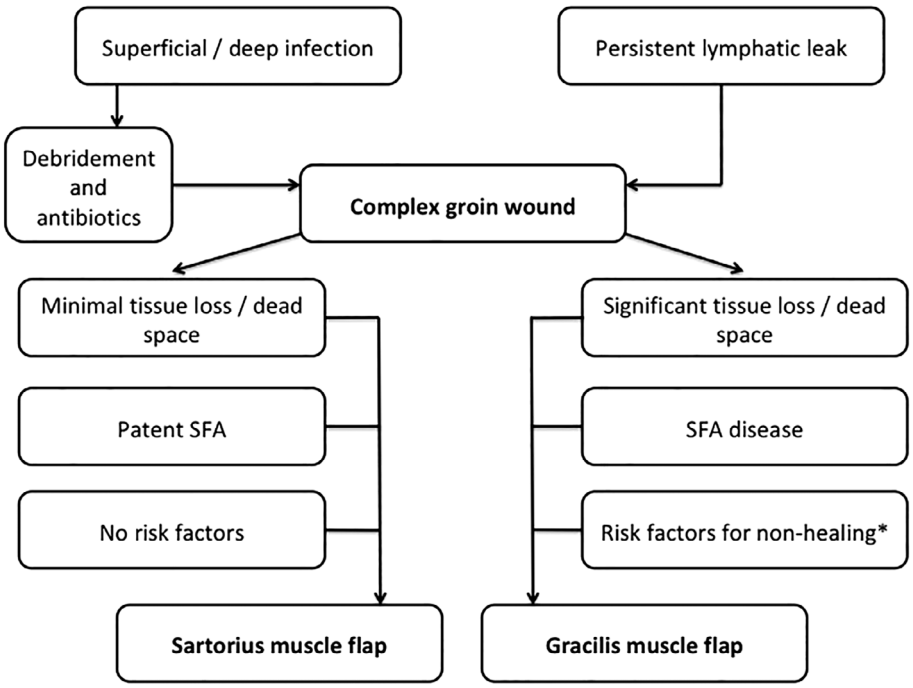

FIGURE 4 Factors to consider when selecting the type of vascularised muscle flap for treating complex groin wounds. SFA, superficial femoral artery. *Examples of risk factors for non-healing include obesity, age > 80, re-do procedure, co-morbidities (see Box 1).

occlusive disease of the SFA (the arterial supply to the SMF). There is evidence that SFA occlusive disease may not be as crucial as previously thought for the long term durability of the SMF as there may be additional blood supply from the femoral circumflex arteries.[13,14] However, reports of SMF failure rates vary in the literature from 6.7% to 14%,[15] possibly due to differing definitions. One study identified a 30-day complication rate of 28% following SMF, defined as wound infection, seroma, dehiscence, or bleeding.[16] For GMF, Ali et al (2016) reported complete healing in 85%[17] and Morasch et al (2004) reported flap failure in 10% caused by tension on the vascular pedicle and acute inflow obstruction.[18]

Overall in this series, 12 (26%) required a major amputation, and of these 75% were performed within 30 days of the original vascular procedure. This group of patients had a range of interventions including 6 in whom the femoral artery was a recipient vessel (either femoro-femoral crossover or ipsilateral ilio-femoral bypass) and 6 where it was a donor vessel for a distal graft. Samson et al (1988) described leaving peri-anastamotic prosthetic graft attached to vital recipient and donor vessels despite possible infection.[12] This was proposed to maintain patency of vital arteries for distal limb perfusion which is particularly relevant in the situation when the SFA is occluded and only the profunda femoris artery (PFA) is patent. Maintenance of the PFA (with a small remnant of oversewn graft) may mean the difference between a below knee amputation (BKA) and an AKA. The 30-day peri-operative mortality rate in this series was 9%. It is difficult to compare limb loss and mortality rates with other studies as they are influenced by many factors. A recent systematic review identified amputation rates ranging from 0% to 38% following SMF for groin wound infections.[19] A further study reported an amputation rate of 19% and a 30-day mortality rate of 14% following GMF for groin infections.[17]

There is little consensus in the literature regarding the most appropriate type of muscle flap for providing tissue coverage in the groin following arterial reconstructive surgery.[20] Several options are available, including SMF, GMF, rectus femoris, and the musculocutaneous anterolateral thigh flap. Furthermore, there are few randomised trials comparing different flap types and most published articles describe retrospective cohort studies.[19] In this series, the SMF was initially the VMF of choice, but latterly the GMF was used. The principle reason for this was the wider muscle base and greater mobility offered by the GMF, ensuring better coverage of often large areas of tissue loss. This choice was also supported by a wound complication rate following GMF of 4%, compared to 32% for SMF. It is difficult to ascertain the significance of this due to the relatively small number of patients in each group, the heterogeneity amongst the patients and the fact that more GMF (vs SMF) were done prophylactically. However, it is possible that the comparatively smaller size of the sartorius muscle contributed to the increased complication rate. A study by Dua et al (2018) noted that only 23% of cases were suitable for a SMF at the time of their arterial surgery due to an

insufficient muscle mass to ensure adequate coverage in the groin.[21]

One major advantage of the SMF is that it does not require a separate skin incision, only a proximal extension to release its proximal origin from the ipsilateral anterior superior iliac spine. This enables the whole of the muscle to be mobilised from the lateral side and rotated medially to provide groin coverage. Harvesting the GMF requires a separate medial thigh incision and particular care must be taken to preserve the vascular pedicle arising 10 to 12 cm distal to the ischiopubic ramus. Clearly evidence from randomised controlled trials comparing different VMF types would be more robust. However, they could be logistically difficult due to a number of factors, including the variety in patient co-morbidities, polypharmacy that could affect healing ability, and the presence of ongoing vascular disease. Treatment decisions, therefore, require an individualised approach. Based on the surgeons' experience in managing complex groin wounds following arterial surgery, Figure 4 demonstrates a number of factors that can assist in the choice of VMF type.

Preventing groin wound complications is always preferable. Good skin and wound care pre-, intra-, and post-operatively are vital. Intra-operatively, extensive cautery and prolonged use of skin retractors can produce local tissue damage sometimes resulting in necrotic skin edges.[5] Some advocate the use of antimicrobial dressings (eg, silver dressings) prophylactically,[5] and there is also evidence that incisional NPWT may reduce the risk of complications.[22] In this series, prophylactic VMF were successful in preventing post-operative groin wound complications in 93% of cases. The single case of delayed healing in this group occurred in a patient with a renal transplant and diabetes who developed a LL post-VMF that subsequently resolved with prolonged conservative management. The commonest indications for use of a VMF as a prophylactic measure were infected pseudoaneurysms in patients with a history of recreational drug injection into the femoral vessels and re-do arterial reconstructive procedures. In both of these situations, scar tissue is likely to be present which can impair the wound healing process.

All patients underwent wound debridement at the time of VMF with the majority also receiving systemic antibiotics and some receiving NPWT. Whilst it is, therefore, difficult to tell how much the VMF was responsible for overall healing, one major advantage of a VMF is to secure a base for the groin defect and alleviate any tension in the skin and fascial planes more superiorly. Hence deeper wound coverage (and importantly graft coverage) is achieved whilst treatment to aid wound healing for more superficial layers is instigated. This may include the use of NPWT and the presence of a VMF may reduce the risk of graft exposure during the healing process. Negative pressure wound therapy is also an alternative option to VMF, even for managing groin wound infections with exposed vascular graft (which requires more close monitoring), but may be associated with prolonged healing times. In one study the mean healing time was 51 days, with a mean duration of NPWT of 42 days.[23] Other treatment options have been described for LL, such as oversewing the site of the leak after identification by intraoperative lymphangiography.[24]

Eighty seven percent of patients in this series received systemic antibiotics. Culture results showed a wide variety of causative organisms with half of the major amputations occurring where gram negative organisms were cultured. It is well recognised that virulent gram-negative bacteria (particularly *Pseudomonas sp.*) are a major risk factor for graft dehiscence following arterial reconstruction in the groin.[25] However, the most commonly reported pathogens in the literature are Gram-positive bacteria, particularly *S. aureus*, with increasing rates of MRSA.[5] Not surprisingly, MRSA infections are associated with poor outcomes, including increased risk of limb loss and high 30-day mortality rates.[5] The most commonly associated Gram-negative bacteria are *Escherichia coli*, *Pseudomonas aeruginosa*, *Proteus sp.*, and *Klebsiella pneumoniae*.[5] Surprisingly only one patient in the series grew MRSA as the primary pathogen where a false aneurysm developed in the femoral artery after open aortic reconstruction. This was repaired with an interposition vein graft and GMF followed by long term antibiotics. A white cell scan performed 12 months later was normal and the patient remains well. One of the largest series concerning GMF for groin vascular infections showed excellent rates of healing even with a synthetic graft and multiple organisms on culture.[17]

4.1 | Limitations of series

This was a retrospective review of VMF performed in a single institution over a 9-year period so follow-up duration for some of the later patients is limited. The series numbers are relatively small making the significance of some of the findings difficult to interpret but this does reflect the selective use of the procedure.

5 | CONCLUSIONS

The use of a VMF offers an invaluable treatment option for managing wound complications following arterial reconstruction in the groin. It can also be used

prophylactically for those deemed at high risk of non or delayed healing. Invariably this group of patients have multiple co-morbidities and limb salvage may not always be an option. An individualised approach to each patient is vital as the aim is satisfactory groin wound healing and limb salvage. It seems the GMF offers greater muscle mass and mobility compared to the SMF and may be associated with fewer healing complications.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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