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ARTICLE

Free flap reconstruction of sarcoma defects in the setting of radiation: a ten-year experience

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ABSTRACT

Neoadjuvant treatment and surgical resection for sarcoma patients can often leave devastating wounds necessitating soft-tissue coverage in the form of free flaps. There is still debate as to the optimal flap for reconstruction of defects in irradiated fields. We aim to describe our experiences with free fasciocutaneous and free muscle flaps for sarcoma reconstruction in the setting of radiation therapy. A retrospective chart review was conducted encompassing all patients requiring soft-tissue reconstruction secondary to sarcoma resection from January 2010 to June 2019. Patient characteristics, flap viability and post-operative healing outcomes were all recorded and examined. In total, 49 patients who underwent 51 free-flaps were identified. Of these, 30 flaps were fasciocutaneous, while 21 were muscle-based. Most patients received pre-operative radiotherapy (76.5%), although these rates were not different between groups of flap type, and had no significant association with post-operative outcomes. Complication rates (31.3%) and re-operative rates (21.6%) were also comparable between flap types. Diabetes mellitus was significantly associated with delayed wound healing ($p < .016$), while the presence of peripheral vascular disease had a significant association with post-operative infection ($p < .006$). This study shows that free fasciocutaneous and free muscle-based flaps are both viable options for soft-tissue reconstruction demanded by sarcoma resection, even in the setting of radiation. Peripheral vascular disease and diabetes mellitus may confer increased wound complications.

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Introduction

There are approximately 143,000 new diagnoses of patients with bone or soft tissue sarcomas diagnosed per year, and, with an increasing annual incidence, sarcoma represents a growing challenge for the United States population, with complications including limb amputation and death [1,2]. Multidisciplinary treatment for cure of these patients requires surgery in all cases, and often radiation or chemotherapy dependent upon patient age, tumor histology and tumor location. More specifically, radiation therapy used an adjunct treatment can prolong survival and improve limb-salvage rates [3,4]. Unfortunately, radiation may also compromise the intrinsic healing function of the body, and can have deleterious effects that confer chronic and nonhealing wounds, particularly after sarcoma resection [5,6].

Flaps have long been used to prevent or resolve wound healing complications, and sarcoma-related wounds are no exception [7]. The ability of microsurgeons to transfer vascularized soft tissue over sizable distances to reconstruct large defects with high success rates has helped enable limb salvage for sarcoma patients needing resection [8,9]. Microsurgical reconstruction has allowed for reconstruction of not only soft tissue defects, but also composite defects involving soft tissue and bone [8–10].

There has been debate centered upon the optimal flap for sarcoma-related tissue defects. Recent research has established that pedicle versus free flaps have no significant bearing on flap and wound-coverage outcomes for sarcoma reconstruction [11]. At times, a local flap is not available, and free tissue rearrangement remains as a sole option. It was once believed that free muscle flaps were superior to free fasciocutaneous perforator flaps. However, recent data have brought this into question, as the literature has shown that free muscle flaps are associated with greater donor site morbidity as well as increased difficulty in re-elevation [12–14]. Additionally, the muscle-based flap is associated with increasingly unaesthetic results, as well as increased rates of revision procedures due to initial bulk overcorrection [12–14]. As a result, the use of free fasciocutaneous flaps across differing clinical scenarios is now being examined more closely, as some studies have compared these free flaps in the context of chronic osteomyelitis and traumatic lower extremity repair [15,16]. We have found no studies evaluating the utility of both the free fasciocutaneous perforator and free muscle flap across various anatomical locations in patients with sarcoma, particularly examining the setting of radiation. Here, we review our experience with soft-tissue reconstruction of sarcoma defects using free fasciocutaneous and free muscle flaps in the setting of radiation therapy.

Methods

A retrospective chart review examined all patients aged 18 years or older with a bone or soft tissue sarcoma diagnosis that required soft-tissue flap reconstruction performed by the senior author (SJK) from January 2010 to June 2019. All reconstructive operations were conducted in concert with the extirpative surgical procedure. Patients were further identified by free flap

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reconstruction and divided into two groups: *(1)* those receiving a free fasciocutaneous flaps and *(2)* those receiving a free muscle-based flap. Patients who were not 18 years or older were excluded from analysis. Additionally, patients who received local pedicled flaps or free flaps containing a combination of tissue other than free fasciocutaneous, myocutaneous, or free muscle-based flaps, such as osteocutaneous free flaps, were also excluded. Furthermore, patients required a minimum follow-up time of 180 days to confirm healing of the flap.

Demographic data were collected, including age, sex and body mass index. Additionally, any history of hypertension, diabetes mellitus (DM), obesity (defined as $>$ 30 BMI), peripheral vascular disease and smoking was collected. Surgical site outcomes, including wound complications encompassing infections, delayed wound healing, seroma and hematoma, were examined, as well as re-operations related to flap survival, takebacks, and wound healing or wound breakdown. Additional data points include defect size, and neoadjuvant or adjuvant radio and chemotherapy. Tumor location was also identified and categorized into broad groups (head & neck, upper extremity, trunk and lower extremity).

Descriptive statistics were used to calculate total cohort and individual group characteristics. Chi-squared and Fisher's exact testing were used to examine differences between categorical variables, while Mann–Whitney *U* testing was to identify differences between continuous variables. Analyses were conducted using IBM SPSS® Version 25 (Armonk, NY).

Results

A total of 164 patients were identified as having undergone flap reconstruction for sarcoma. After inclusion and exclusion criteria, 49 patients with a total of 51 free-flaps were identified as appropriate for analysis (Figure 1). A total of 30 flaps were included in the fasciocutaneous flap group, while 21 met the criteria for free muscle flaps. Of the muscle-based flaps, 7/21 (33.3%) were pure free-muscle requiring overlying skin grafts. The average age of our cohort was 59.6 ± 17.6 years, with 66.7% of patients being male. The mean patient BMI was found to be 27.3 ± 5.8 kg/m^2, with 14 (28%) patients being obese. Other common comorbidities included hypertension (52.9%), diabetes mellitus (13.7%) and

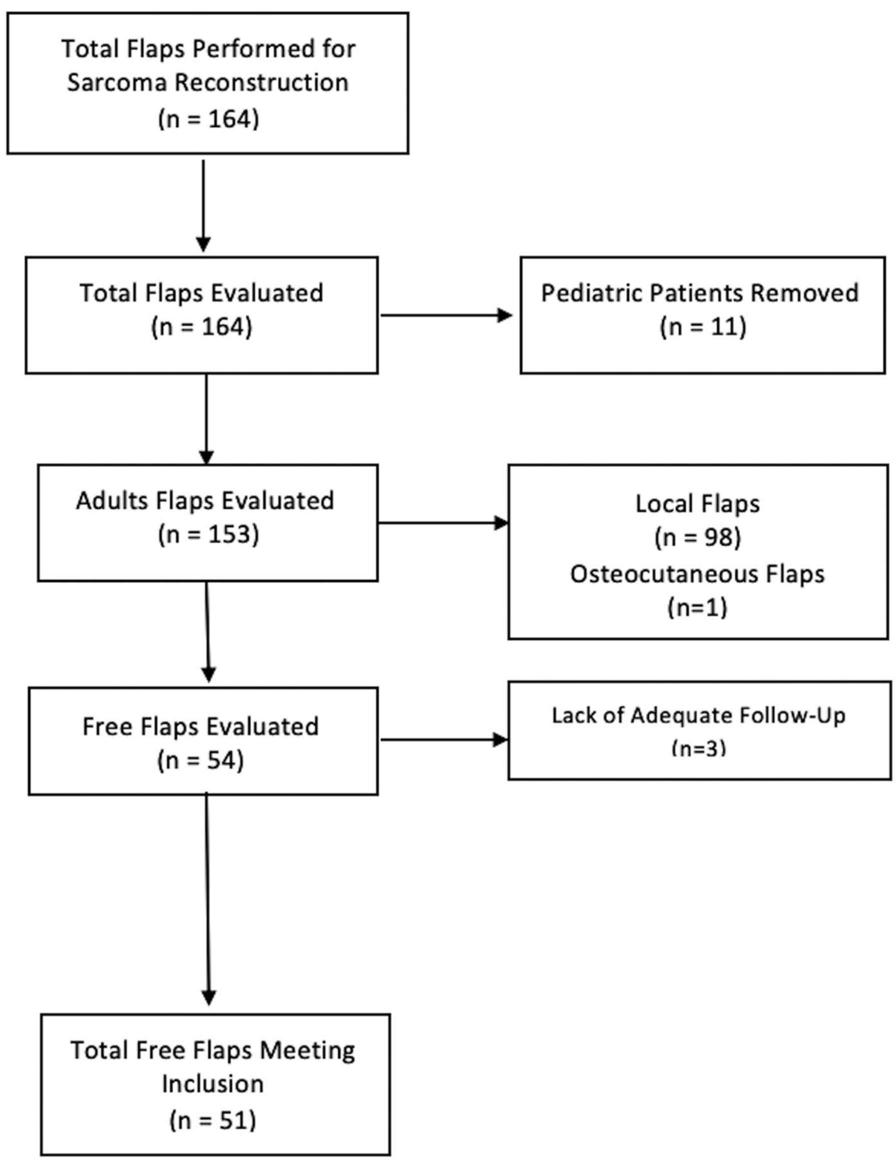

Figure 1. Flow diagram of inclusion and exclusion criteria.

peripheral vascular disease (17.6%). Most patients had no smoking history (64.7%), although some identified as a former smoker (31%), and a few patients (3.9%) identified as current smokers within six-weeks of operation. Patient demographics and characteristics did not differ significantly between groups based upon flap type (Table 1). Our median length of hospital stay was 6 days.

The mean defect size was 180.7 ± 105.7 cm^2. Regarding anatomical location, the lower-extremity (LE) was the most frequent amongst patients (51%), with head and neck (HN) (37.3%) and upper-extremity (11.8%) being the other locations of diagnosis. Notably, there were no primary sarcomas of the trunk repaired with free tissue transfer.

The most common histological tumor diagnosis was myxofibrosarcoma/dermatofibrosarcoma (27.6% of patients), with the least common being rhabdomyosarcoma with 1 patient (2%). Other diagnoses included undifferentiated pleiomorphic sarcoma (17.6%), spindle-cell sarcoma (13.7%), leiomyosarcoma and liposarcoma (both 9.8%), chondrosarcoma (7.8%), and angiosarcoma and synovial sarcoma (both 5.9%). The majority of cases were high grade tumors (52.9%), with 27.5% being intermediate, and 19.6% being low grade. Stage II (39.2%) and stage III (37.3%) tumors were the most commonly encountered staging classification tumor classes, with stage I (17.6%) and IV (5.9%) being less common. Most procedures resulted in negative margins with no residual tumor (80.4%), although 19.6% were left with involved margins post-operatively (Table 2).

The majority of patients did not undergo chemotherapy (54.9%). A smaller subset under pre-operative chemotherapy only

Table 1. Patient characteristics.

	Pooled (*n*, %)	Fasciocutaneous (*n*, %)	Muscle-based (*n*, %)	*p* Value
Total (*n*)	51	30	21	
Age (y SD)	59.6 ± 17.6	57.9 ± 17.8	62.1 ± 17.4	.416
Sex				.227
Male	34 (66.7%)	22 (73.3%)	12 (57.1%)	
Female	17 (33.3%)	8 (26.7%)	9 (42.9%)	
BMI (kg/m^2)	27.3 ± 5.8	27.4 ± 6	27 ± 5.6	.798
Obesity	14 (28%)	8 (27.6%)	6 (28.6%)	.939
Smoking history				.089
Never	33 (64.7%)	18 (60%)	15 (71.4%)	
Former	16 (31.%)	12 (40%)	4 (19%)	
Current	2 (3.9%)	0 (0%)	2 (9.5%)	
Hypertension	27 (52.9%)	16 (53.3%)	11 (52.4%)	.947
Diabetes mellitus	7 (13.7%)	5 (16.7%)	2 (9.5%)	.685
Peripheral vascular disease	9 (17.6%)	6 (20%)	3 (14.3%)	

Table 2. Reconstructive and tumor characteristics.

	Pooled (*n*, %)	Fasciocutaneous (*n*, %)	Muscle-based (*n*, %)	*p* Value
Location				.425
Head & Neck	19 (37.3%)	13 (43.3%)	6 (28.6%)	
Upper extremity	6 (11.8%)	4 (13.3%)	2 (9.5%)	
Lower extremity	26 (51%)	13 (43.3%)	13 (61.9%)	
Defect size (cm^2)	180.7 ± 105.7	178.2 ± 113.6	184.2 ± 96.3	.602
Tumor size (cm^2)				
Histology				.292
Myxofibrosarcoma/Dermatofibrosarcoma	14 (27.5%)	10 (33.3%)	4 (19%)	
Liposarcoma	5 (9.8%)	2 (6.7%)	3 (14.3%)	
Chondrosarcoma	4 (7.8%)	1 (3.3%)	3 (14.3%)	
Synovial sarcoma	3 (5.9%)	2 (6.7%)	1 (4.8%)	
Pleomorphic sarcoma	9 (17.6%)	5 (16.7%)	4 (19%)	
Spindle-cell sarcoma	7 (13.7%)	6 (20%)	1 (4.8%)	
Angiosarcoma	3 (5.9%)	2 (6.7%)	1 (4.8%)	
Leiomyosarcoma	5 (9.8%)	1 (3.3%)	4 (19%)	
Rhabdomyosarcoma	1 (2%)	1 (3.3%)	0 (0%)	
Tumor stage				.935
I	9 (17.6%)	6 (20%)	3 (14.3%)	
II	20 (39.2%)	11 (36.7%)	9 (42.9%)	
III	19 (37.3%)	12 (40%)	8 (38.1%)	
IV	3 (5.9%)	1 (3.3%)	1 (4.8%)	
Tumor grade				.862
Low grade	10 (19.6%)	6 (20%)	4 (19%)	
Intermediate	14 (27.5%)	9 (64.3%)	5 (23.8%)	
High grade	27 (52.9%)	15 (50%)	12 (57.1%)	
Margin status				1.00
Negative margins	41 (80.4%)	24 (80%)	17 (81%)	
Involved margins	10 (19.6%)	6 (20%)	4 (19%)	
Chemotherapy course				.260
None	28 (54.9%)	15 (50%)	13 (61.9%)	
Pre-operative	12 (23.5%)	7 (23.3%)	5 (23.8%)	
Post-operative	6 (11.8%)	3 (10%)	3 (14.3%)	
Pre and post-operative	5 (9.8%)	5 (16.7%)	0 (0%)	
Radiation course				.318
None	6 (11.8%)	4 (13.3%)	2 (9.5%)	
Pre-operative	30 (58.8%)	20 (66.7%)	10 (47.6%)	
Post-operative	6 (11.8%)	3 (10%)	3 (14.3%)	
Pre and post-operative	9 (17.6%)	3 (10%)	6 (28.6%)	

(23.5%), post-operative chemotherapy only (11.8%), or both pre- and post-operative chemotherapy (9.8%). In total, 30 patients (58.8%) solely underwent pre-operative radiation, while 6 (11.8%) underwent post-operative radiation, while 9 patients (17.6%) underwent both pre and post-operative radiation therapy. In total, 39 patients underwent pre-operative radiotherapy (76.5%). When grouped by flap type, there were no significant differences between patients regarding tumor location, defect size, histology, or radiotherapy sequence (Table 2).

When examining flap utilization, the anterolateral thigh (ALT) flap was used for all 30 cases of the fasciocutaneous flap group (100% of cases). Flap harvest varied more in the free muscle group, with the free latissimus dorsi being the most commonly used (57.1%). A myocutaneous ALT with vastus lateralis muscle-based flap was used in three patients (14.3%), with the free gracilis and free vastus lateralis muscle flap also each used three times (14.3%, each).

Wound complications included infection, dehiscence, hematoma, seroma, delayed wound healing and flap takeback. In total, 16 (31.3%) flaps were afflicted, of which 7 were from the free-fasciocutaneous group (23.3%), and 9 were of the muscle-based group (42.3%). These differences were not statistically significant ($p < .139$). When examining pre-operatively irradiated flaps, 23 flaps were identified in the fasciocutaneous group and 16 were identified in the free-muscle group. Within the fasciocutaneous group, 21.7% of patients experienced complications, which was a similar rate to the muscle-based group (37.5%) ($p = 1.00$) (Table 3). All complications were resolved with standard treatment and no further complication.

Re-operation rates were also examined, with 11 total flaps (21.6%) undergoing re-operation. Six of these were in the fasciocutaneous group (20%), while 5 were in the free-muscle group (23.8%), although these were not statistically different ($p < .745$). Similarly, isolating flaps that underwent pre-operative radiation also revealed no significant differences between groups ($p < .694$) (Table 4). Reasons for re-operation included infection, wound dehiscence, flap congestion due to arterial occlusion requiring revision with successful flap salvage (two flaps), and two flap failures (3.9%). One patient suffered from complete flap loss secondary to necrosis of his ALT flap three weeks post-operatively. The non-viable ALT was removed and a free muscle latissimus dorsi flap was used for the subsequent coverage. There were no further complications. A second patient also suffered from complete flap loss of his ALT perforator flap in the immediate post-operative period. This was removed and replaced with a contralateral ALT flap. Unfortunately, this patient succumbed to his underlying comorbidities. There were no partial flap failures (Table 3).

Factors associated with complications were examined. Peripheral vascular disease was significantly associated with post-operative infection ($p < .006$). Patients with diabetes were also associated with suffering from delayed wound healing post-operatively as compared to those without diabetes ($p < .016$). Notably, radiation was not associated with any complications. Additionally, no other factors were associated with any single wound complication or aggregate wound complications (Table 4).

Discussion

Modern treatment for sarcoma, while effective, can present its own set of obstacles. Large wounds secondary to surgical excision coupled with the need for adjuvant treatment modalities can result in nonhealing wounds and significant morbidity. The capability to transfer tissue over distances with the aid of microsurgery has revolutionized sarcoma care and helped mitigate some of these challenges [8–10]. Although the optimal free flap has long been debated for a variety of purposes, and several authors have described good success with each, no study to date has detailed the fasciocutaneous free flap against the free muscle flap across numerous anatomical locations for sarcoma reconstruction, particularly in the setting of radiotherapy. This study demonstrates the efficacy of free flaps for sarcoma reconstruction, even with the implementation of radiotherapy, allowing for the successful coverage of various defects secondary to sarcoma resection.

Research has indicated that outcomes are similar for pedicle-flaps compared to free-flaps for sarcoma defects [11]. However, pedicled flaps are not always available given the tumor location, defect size, and/or previous neoadjuvant treatment. This study shows that there may not be significant differences in outcomes between the fasciocutaneous and muscle based free flap, even when considering anatomical location, defect size, and time course of radiation therapy, although diabetes and peripheral vascular disease may confer worsened outcomes. These findings of a lack of differences between flaps corroborate the use of

Table 3. Post-operative outcomes and pre-operative radiation.

	Pooled (*n*, %)	Fasciocutaneous (*n*, %)		Muscle-based (*n*, %)		*p* Value	
	Total ($n = 51$)	Total ($n = 30$)	Irradiated ($n = 23$)	Total ($n = 21$)	Irradiated ($n = 16$)	Total	Irradiated
Any wound complication	16 (31.3%)	7 (23.3%)	5 (21.7%)	9 (42.9%)	6 (37.5%)	.227	.139
Infection	6 (11.8%)	3 (10%)	2 (8.7%)	3 (14.3%)	1 (6.3%)	.165	1
Wound dehiscence	2 (3.9%)	2 (6.7%)	2 (8.7%)	0 (0%)	0 (0%)	.506	.503
Seroma	2 (3.9%)	0 (0%)	0 (0%)	2 (9.5%)	2 (12.5%)	.165	.162
Hematoma	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	–	–
Delayed wound healing	2 (3.9%)	0 (0%)	0 (0%)	2 (9.5%)	1 (6.3%)	.165	.41
Flap takeback	4 (7.8%)	2 (6.7%)	1 (4.3%)	2 (9.5%)	2 (12.5%)	1	.557
Re-operations	11 (21.6%)	6 (20%)	4 (17.4%)	5 (23.8%)	4 (25%)	.745	.694

Table 4. Factors associated with complications.

Complication	Comorbidity	With comorbidity	Without comorbidity	*p* Value
Infection				
	Peripheral vascular disease	4 (44.4%)	2 (4.8%)	.006
Delayed wound healing				
	Diabetes mellitus	2 (28.6%)	0 (0%)	.016

fasciocutaneous flaps in recent studies of other domains that have traditionally first harvested myofascial flaps, but have now shown equivalent or superior outcomes with the utilization of free fasciocutaneous flaps [15–17]. Historically, the free muscle flap was believed to provide superior outcomes in large part owning to its greater 'bulk' and ability to deliver vascularized tissue to the wound bed [18,19]. This was theorized to provide increased surface area to allow greater opportunity for tissue growth, collagen synthesis, adaptation of the flap to its new location with potential for recipient site function, as well as the ability to fill in dead-space and ward off infection [18,19] (Figure 2). Additionally, free muscle flaps were believed to provide increased malleability for contouring of increasingly irregular defect shapes. A further advantage of free muscle flaps is that bone surrounded by muscle may lead to increased bone morphogenetic protein, which simultaneously induces bone growth and healing in the setting of osseous or periosteal defects [20,21]. There have also been isolated reports of free-gracilis flaps to provide favorable outcomes in sarcoma reconstruction [22]. Despite the perceived benefits, research has failed to demonstrate these advantages as clinically significant, and, as a result, the free fasciocutaneous flap has gained momentum over the free muscle flap for a variety of reasons. As mentioned, the advantages of free fasciocutaneous flaps include greater aesthetic outcomes and decreased donor site morbidity through muscle and functional preservation, most notably when compared to the free latissimus dorsi flap, which can compromise shoulder stability and function, particularly in patients partaking in athletic activities [12,17,23,24]. Other advantages include improved revision outcomes, obviation of the need for skin grafting the muscle flap, greater ease of harvest and re-elevation, as well as greater ease for thinning and future revisional procedures (Table 5) [12,17,23,24]. Authors have also demonstrated good success in the usage of free fasciocutaneous flaps for sarcoma defects in smaller series isolated to specific anatomical location [25,26]. For these reasons, the authors have more recently preferred the fasciocutaneous flap for sarcoma reconstruction, although muscle-based flaps may have an advantage in patients with lower BMI where harvesting adequate tissue volume may otherwise be technically challenging without a muscular component to the flap. Regardless, free flaps allow for the successful reconstruction of major sarcoma defects, and, in some cases, limb-salvage, where historically, a lack of coverage would have conferred amputation, chronic, challenging wounds, or prevented aggressive treatment.

An additional consideration in the treatment process is the effects of radiotherapy. This study showed that radiation had no clear associations with post-operative complications. Previous literature also suggests that free-flaps viability is not adversely impacted by neoadjuvant radiation for sarcoma [27–29]. Although there is concern that the deleterious effects of radiotherapy may beget wound healing complications [6], particularly in a generally already sick, cancer-diagnosed patient population [5], this study shows this can perhaps be still be safely performed in sarcoma patients without a significantly increased rate of complications. This may in part be due to smaller doses that are usually needed for sarcoma patients in contrast to other malignant diagnoses [28]. While these results revealed no clear difference between flap choice and outcomes, pure muscle-flaps require skin grafting that can be fraught with loss of the graft over the muscle, rendering any additional reconstructive procedure for epithelial coverage challenging secondary to the known deleterious effects on wound healing from radiation [6]. Taken together, we believe free-flaps for sarcoma defects are safe even in the context of pre-operative radiation. As such, sarcoma defects warrant aggressive pursuit of coverage, particularly where free flaps are indicated, as healing difficulties are a likely challenge with or without radiotherapy, and thus should not preclude the optimal wound coverage technique in the fear of post-operative wound complications. Although the authors note a fairly high complication rate, we advise several recommendations that have helped trend our complication rate downwards. These include adequate debridement of non-viable peripheral wound tissue prior to free flap harvest, an appropriate recipient bed for flap viability, and a multi-disciplinary approach to avoid overexposure to radiotherapy. Furthermore, the authors prefer fasciocutaneous or myocutaneous flaps given the need for additional dermal/epidermal coverage when free-muscle is

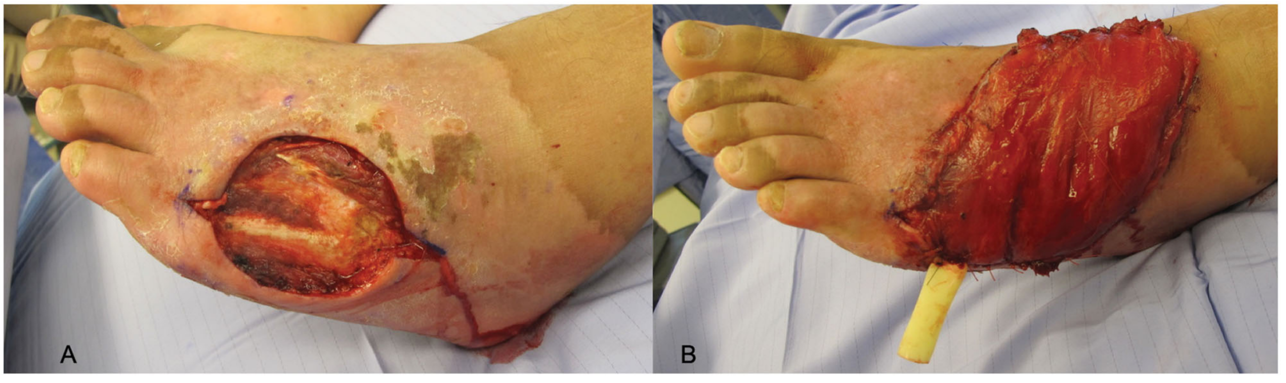

Figure 2. (A) Intraoperative sarcoma-induced lesion of the lower extremity and foot. (B) Intraoperative reconstruction with a free muscle-based flap.

Table 5. Advantages of fasciocutaneous and muscle flaps.

Fasciocutaneous flaps	Muscle flaps
• Improved aesthetics	• May contour more readily
• Ease for thinning, secondary revision procedures, and re-elevation	• Greater malleability for deep and complex defects
• Reduced donor site morbidity	• Provide improved bulk and volume
• Do not require skin grafting (compared to pure muscle flaps)	• Opportunity for function at recipient site
• Preserved donor site muscle, function, and stability	• Potentially induce improved bone healing

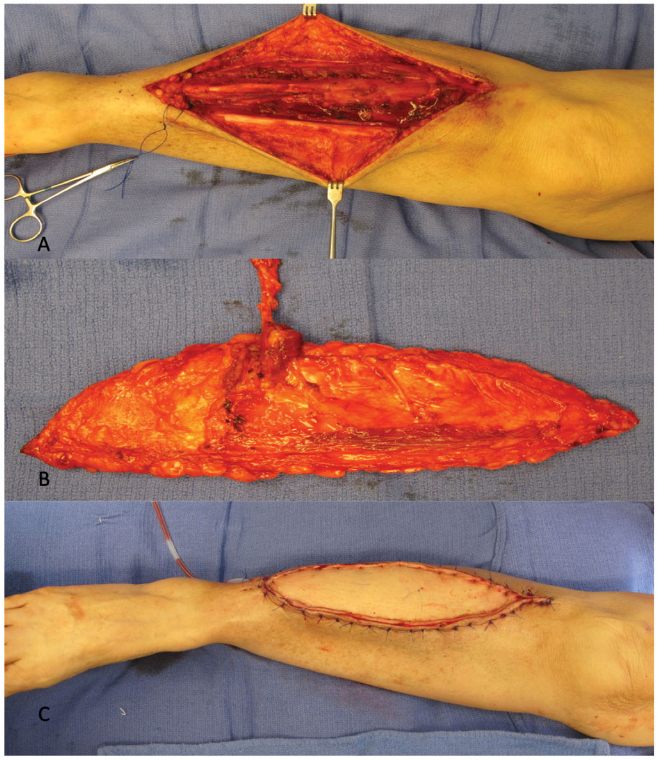

Figure 3. (A) Large pre-operative defect of the lower extremity following resection of sarcoma. (B) A free perforator flap of the anterolateral thigh following elevation and dissection. (C) Successful anastomosis and perforator flap inset into the lower extremity defect.

harvested, which may be prone to additional difficulties with radiotherapy.

Although neither flap type nor radiation was associated with complications, this study found that peripheral vascular disease can predispose infection. Additionally, diabetes was associated with delayed wound healing. An adequate recipient bed is a critical consideration in free flap reconstruction, as flap viability is reliant on the recipient vessels and subsequent vascular ingrowth. Both comorbidities compromise vascular flow and are known to be associated with flap complications for this reason [30–32]. Still, several studies have described good flap success in high-risk patients with both conditions, showing feasibility given careful planning [30–32].

Overall, our flap failure rate was 3.9%. Our institution has a reported .55% free-flap failure rate, and multi-center outcomes have reported 95–99% success rates [13,33]. We hypothesize that the difference in failure rate in this study compared to our institutional data is largely because flaps for sarcoma may portend increased difficulty in comparison to overall free flaps performed for any cause, as well as a smaller sample size magnifying any failures. As mentioned, our series also did not find appreciable differences in re-operation nor wound complications. For the reasons delineated, the authors more often prefer the free fasciocutaneous flap over muscle-based flaps. Indeed, there is now a preponderance of fasciocutaneous perforator flaps done for multiple reconstructive indications [15,16], and flap selection has evolved significantly over the years. In our study, all cases of fasciocutaneous flaps were performed with the ALT. The radial forearm flap (RFF) was once used more frequently, but increasing concerns of donor site morbidity by sacrificing an axial vessel to the extremity as well as poor aesthetic outcomes at the donor site have limited its use [34,35]. The increasing catalog of perforator flaps that are available for use and microsurgeons' familiarity with these options have also likely contributed to the demise of the RFF. In comparison, the ALT is known to provide greater depth and surface area for larger defects over the RFF [36,37]. The authors' preferred fasciocutaneous perforator flap for reconstruction remains the ALT flap secondary to the large area of donor tissue available, limited morbidity at the donor site, and ability to achieve skin to skin closure at the surgical site [23,36–39] (Figure 3).

Limitations to our study are largely driven by our relatively smaller group sizes and inherent biases of a retrospective design. We acknowledge that various other free flaps, such as osteocutaneous flaps, are also utilized for sarcoma reconstruction, although not described here. We also did not collect information on tumor stage nor depth, which can both greatly impact management, flap-selection, and clinical course. Additionally, no free flaps of the trunk were described, as these are most often treated with local pedicle flaps. Further limitations include a single-surgeon study design, as external validity may be compromised in the face of individual assessment, operative planning, and clinician-limited technical skill. The heterogenous nature of the patient population and treatment strategies may also limit the wide-ranging applicability of the conclusions. Finally, it is important to note that we discuss the free fasciocutaneous flap, but that our study used the ALT flap for all cases. This is due to both institutional experience as well as the above cited data.

Conclusion

Soft-tissue coverage can be challenging in the setting of sarcoma reconstruction, particularity when the use of a free-flap is required. Our study shows comparably good outcomes with the use of free fasciocutaneous flaps and the free muscle flaps for sarcoma reconstruction, even in the setting of radiation therapy. Peripheral vascular disease and diabetes mellitus may confer worsened outcomes.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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