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Flap choice does not affect complication rates or functional outcomes following extremity soft tissue sarcoma reconstruction

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Summary *Background:* Flap reconstruction plays an essential role in facilitating limb preservation in patients with extremity soft tissue sarcoma (ESTS). However, the effect of flap choice on the rates of postoperative complications and functional outcomes has not been clearly established. This study directly compares the outcomes of free and pedicled flap reconstructions in patients with ESTS.
Methods: Two hundred sixty-six patients who underwent flap reconstruction following ESTS resection were included. Associations between flap type and complications were determined using logistic regression analyses. Functional outcome was evaluated using the Toronto Extremity Salvage Score (TESS) and the Musculoskeletal Tumor Society Scales (MSTS).

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Results: There was no significant difference between complication rates in the pedicled and free flap groups (32% vs. 38%, p = 0.38). In the lower limb, pedicled flaps had complication rates similar to those of free flaps on univariate analysis (odds ratio [OR] = 1.12, 95% confidence interval [CI] = 0.56–2.26, p = 0.75). Conversely, in the upper limb, pedicled flaps were associated with fewer complications on univariate analysis (OR = 0.31, 95% CI = 0.11–0.86, p = 0.03), but this was not significant on multivariate analysis (OR = 0.45, 95% CI = 0.13–1.59, p = 0.22). Obesity was a strong predictor of complications in the upper limb group on multivariate analysis (body mass index [BMI] ≥ 30 kg/m^2, OR = 7.01, 95% CI = 1.28–38.51, p = 0.03). There was no significant difference in functional outcomes between both flap groups in either upper or lower limbs.

Conclusions: Postoperative complications and functional outcomes for patients undergoing free and pedicled flaps are similar in ESTS reconstruction. Selecting the most suitable reconstructive option in each individual case is paramount to preserving function while minimizing postoperative morbidity.

Introduction

Soft tissue sarcomas are rare heterogeneous neoplasms that commonly involve the extremities. Historically, these patients were treated by amputation, but improvements in surgical techniques, radiological imaging, and adjuvant therapies have now made limb preservation possible in the majority of cases.[1,2] Multidisciplinary management of patients with extremity soft tissue sarcoma (ESTS) frequently involves both wide resection to achieve clear margins and (neo)adjuvant radiation to minimize local recurrence. In many cases, this results in extensive soft tissue defects that cannot be managed using simple wound closure or skin grafting techniques. Reconstruction using pedicled or free flaps is therefore often necessary to provide coverage of vital structures or prostheses and facilitate limb preservation.

We previously reported that although flap reconstruction increases the complexity of surgery, it does not significantly increase postoperative complication rates in patients with ESTS.[3] However, the effect of the choice of flap on postoperative morbidity has not been clearly established in this patient population. As free flaps require microvascular anastomosis, they may be perceived to be more complicated and therefore associated with higher risks of complications. On the other hand, pedicled flaps often involve extensive surgical dissection adjacent to the zone of tumor ablation, which might adversely affect functional outcomes. Reports on patients with extremity trauma suggest that postoperative outcomes of free and pedicled flaps are similar.[4–6] However, this may not necessarily be the case following ESTS resection, as the patient population is more heterogeneous and variables such as older age and comorbidities may affect outcomes.[7,8] In addition, adjuvant treatments such as chemotherapy and particularly neoadjuvant radiation must be considered in oncological reconstruction.[9–11]

This study compares the complication rates and functional outcomes of free and pedicled flap reconstructions in a large cohort of patients with ESTS at a single major tertiary referral center.

Methods

Institutional Research Ethics Board approval was obtained for this study. Patients who underwent resection of a soft tissue sarcoma of the upper or lower extremity and required either free or pedicled flap reconstruction between January 2006 and January 2015 were identified from a prospectively maintained database at Mount Sinai Hospital, Toronto, Canada. Patient demographics (age, sex, body mass index [BMI], smoking status, and comorbidities), tumor characteristics (histology, location, stage, grade, depth, diameter, and volume), surgical details (primary or secondary resection, timing of reconstruction, and reconstructive technique), and adjuvant therapies (radiation and chemotherapy) were recorded from the database and retrospective chart review.

All postoperative surgical complications occurring within 120 days of surgery were recorded and categorized. Major complications were defined as those requiring return to the operating room (OR), intravenous antibiotics, or prolonged wound care beyond 120 days. Minor complications included those requiring oral antibiotics, nonsurgical management of seroma or hematoma, and wound care concluding within 120 days of surgery. Any complications that delayed delivery of adjuvant therapies were considered major.

Functional outcomes were assessed using three measurement tools: the Toronto Extremity Salvage Score (TESS) and the Musculoskeletal Tumor Society (MSTS) 87 and 93 rating scales. The TESS was specifically developed for extremity sarcoma patients and is a patient-reported outcome tool that measures performance on activities of daily living.[12,13] Twenty-nine items are rated from 0 to 5, with higher scores indicating better function. The MSTS87 is a physician-derived assessment that evaluates seven aspects of joint function (mobility, pain, stability, deformity, strength, functional, and emotional acceptance).[14] The MSTS93 is a more limb-specific measure also assessed by physicians, which includes six domains of function (pain, function, emotional acceptance, positioning, dexterity, and strength) to determine functional impairment.[15] The MSTS87 and MSTS93 systems both score each item from 0 to 5. The TESS and

MSTS93 total scores are expressed as a percentage. The MSTS87 usually has a maximum score of 35, but for ease of comparability, it was also expressed as a percentage. The differences between the preoperative and postoperative (9–12 months) TESS, MSTS87, and MSTS93 scores were calculated and compared.

Statistical analyses were performed using STATA/SE version 12.0 (StataCorp, Texas, USA). Mean, standard deviation, and range were calculated for all continuous variables. Differences between experimental groups were calculated using the t-test for continuous variables and Chi-square or Fisher's exact test for categorical variables. Clinical factors associated with postoperative complications were identified using logistic regression analysis. For comparison of the functional scores between pedicled and free flap reconstruction patient groups, the Mann–Whitney test was used. P-values ≤0.05 were considered statistically significant.

Results

Two hundred sixty-six patients who underwent ESTS resection followed by reconstruction with a free or pedicled flap were evaluated in this study. There were 145 (55%) male and 121 (46%) female patients with mean age of 59.2 (standard deviation [SD] + /-18.6) years and mean BMI of 26.4 (SD +/-5.7) kg/m^2. One hundred thirty-two (50%) patients had comorbidities and 43 (16%) were smokers. Preoperative radiation therapy was administered in 197 patients (74%). One hundred seventy-four (65%) patients had deep tumors, thus indicating that they were deep to or involved the deep fascia. The majority of patients (92%) presented with a primary tumor and the mean tumor diameter was 9.01 ± 6.1 cm. All patient and tumor variables are outlined in Table 1.

Pedicled flaps were performed in 195 (73%) patients and consisted of 82 muscle flaps with split-thickness skin graft, 64 musculocutaneous, and 49 fasciocutaneous flaps. Free flaps were performed in 71 (17%) patients and consisted of 47 fasciocutaneous, 14 muscle with split-thickness skin graft, and 10 musculocutaneous flaps. One hundred eighty-one (68%) patients had lower limb tumors and 136 of these tumors had pedicled flap reconstruction whereas 45 had free flaps. Free flaps were significantly more common than pedicled flaps in patients with tumors distal to the knee (62% vs. 33%, p = 0.001). There was no other significant difference between the pedicled and free flap groups in lower limb ESTS. Eighty-five (32%) patients had tumors of the upper limb. Fifty-nine of these tumors had pedicled flaps, whereas 26 had free flap reconstructions. Free flaps were significantly more common than pedicled flaps when tumors were larger (46% vs. 16% for tumor diameter ≥10 cm, p = 0.003; 34% vs. 9% for tumor volume ≥ 650 ml, p = 0.02) and deep (92% vs. 56%, p = 0.001). Patients in the free flap group also had significantly higher mean BMI compared to pedicled flaps (27.9 + /- 4.8 vs. 24.9 + /- 4.8, p = 0.007) in upper limb cases. Differences between the free and pedicled flap groups in upper and lower extremity cases are outlined in Table 1. The flaps performed are listed in Table 2.

Postoperative surgical complications occurred in 90 (34%) patients, with 52 being classified as major (Table 3). There was no significant difference in complication rates between patients who underwent free or pedicled flaps (38% vs. 32%, p = 0.38). Flap reconstructions of the lower limb tended to have higher complication rates than those of the upper limb, but this did not reach statistical significance for either major (38% vs. 26%, p = 0.06) or minor complications (22% vs. 14%, p = 0.15).

Logistic regression analysis was used to examine whether flap type was a significant predictor of complications in patients with lower or upper ESTS (Table 4). In the lower limb, pedicled flaps had a slightly increased association with complications compared to free flaps but this was not significant (OR = 1.12, 95% CI = 0.56–2.26, p = 0.75). Conversely, in the upper limb, pedicled flaps were associated with fewer complications on univariate analysis (OR = 0.31, 95% CI = 0.11–0.86, p = 0.03). A multivariate model was therefore constructed and included other variables that, according to current literature, may affect postoperative complication rates. On multivariate analysis, free flaps were no longer significantly associated with complications (OR = 0.45, 95% CI = 0.13–1.59, p = 0.22). However, high BMI was a strong independent predictor of complications in the upper limb group on multivariate analysis (BMI ≥ 30, OR = 7.01, 95% CI = 1.28–38.51, p = 0.03).

To determine if free or pedicled flaps were superior in particular "high risk" clinical scenarios, we compared their respective complication rates in patients who had large tumors, preoperative radiation, and tumors of the distal extremity or additional bone or vascular resections requiring reconstructive procedures. In the upper extremity, free flap reconstructions distal to the elbow had higher complication rates (58% vs. 21%, p = 0.03), but this was not significant on multivariate analysis (OR = 0.13, 95% CI = 0.01–1.58, p = 0.11, Table 5).

Preoperative and postoperative functional scores were available for just more than half of patients included in this study (TESS: 140 patients (53%), MSTS87: 134 patients (54%), and MSTS93: 144 patients (55%)). The difference between the mean preoperative and postoperative functional scores is outlined in Table 6, where positive scores indicate improved function, whereas negative scores signify deterioration. There was no significant difference between functional outcomes for patients with free or pedicled flaps in either upper or lower limb reconstructions. Patients with upper limb ESTS who experienced complications were found to have significantly worse function based on MSTS93 scores compared to those without complications (-8.5 ± 10.4 compared to 1.6 ± 11.5, p = 0.02).

Discussion

This is, to our knowledge, the largest and most comprehensive study comparing the complications and functional outcomes for patients with ESTS who underwent free or pedicled flap reconstructions. This study confirms that ESTS resection is associated with high complication rates, which is consistent with the results of previous reports and reflects the complexity of limb salvage surgery and frequent use of adjuvant treatments, especially preoperative radiation.[9,11,16–18] As soft tissue reconstruction is a major component of these procedures, the type of reconstruction performed might be expected to strongly influence postoperative morbidity and function. The results of this study, however, demonstrate

Table 1 Differences in patient, tumor and treatment characteristics between free and pedicled flaps in patients with upper and lower limb ESTS.

Characteristic		n (%)	Lower limb, n = 181 (68.1%)			Upper limb, n = 85 (31.9%)		
			Free (n = 45)	Pedicled (n = 136)	p-value	Free (n = 26)	Pedicled (n = 59)	p-value
Age (years)	*Mean ± SD*	59.18 (18.59)	55.4 (17.9)	60.7 (19.1)	0.18	53.5 (15.2)	61.1 (17.9)	0.059
	≤45	60 (22.6)	15 (33.3)	28 (20.6)	0.07	6 (23.1)	11 (18.6)	0.16
	45–55	46 (17.3)	4 (8.9)	24 (17.7)		8 (30.8)	10 (17.0)	
	56–69	82 (30.8)	17 (37.8)	38 (27.9)		9 (34.6)	18 (30.5)	
	70 +	78 (29.3)	9 (20.0)	46 (33.8)		3 (11.5)	20 (33.9)	
Sex	*Female*	121 (45.5)	22 (48.9)	66 (48.5)	0.97	11 (42.3)	22 (37.3)	0.66
	Male	145 (54.5)	23 (51.1)	70 (51.5)		15 (57.7)	37 (62.7)	
Comorbidities	*No*	134 (50.4)	23 (51.1)	64 (47.1)	0.64	16 (61.5)	31 (52.5)	0.44
	Yes	132 (49.6)	22 (48.9)	72 (52.9)		10 (38.5)	28 (47.5)	
Smoker	*No*	223 (83.8)	39 (86.7)	119 (87.5)	0.88	18 (69.2)	47 (79.7)	0.30
	Yes	43 (16.2)	6 (13.3)	17 (12.5)		8 (30.8)	12 (20.3)	
BMI[a]	*Mean ± SD*	26.35 (5.65)	27.6 (6.3)	26.2 (5.8)	0.25	27.9 (4.8)	24.9 (4.8)	**0.007**[b]
	<25	107 (40.2)	18 (40.0)	54 (44.3)	0.39	6 (23.1)	29 (49.2)	0.06
	25–29	97 (36.5)	15 (33.3)	47 (38.5)		13 (50.0)	22 (37.3)	
	≥30	48 (18)	12 (26.7)	21 (17.2)		7 (26.9)	8 (13.6)	
Presenting status	*Primary*	245 (92.1)	41 (24.4)	127 (75.6)	0.61	24 (31.2)	53 (68.8)	0.72
	Local recurrence	21 (7.9)	4 (30.8)	9 (69.2)		2 (25.0)	6 (75.0)	
Prior surgery	*No*	193 (72.6)	29 (64.4)	107 (78.7)	0.06	19 (73.1)	38 (64.4)	0.43
	Yes	73 (27.4)	16 (35.6)	29 (21.3)		7 (26.9)	21 (35.6)	
Localization	*Proximal*	157 (59.1)	17 (37.8)	91 (66.9)	**0.001**[b]	14 (53.9)	35 (59.3)	0.64
	Distal	109 (40.9)	28 (62.2)	45 (33.1)		12 (46.1)	24 (40.7)	
Maximal tumor diameter[a]	*Mean ± SD*	9.01 (6.1)	10.67 (8.7)	9.33 (5.8)	0.91	9.28 (5.7)	6.95 (3.6)	0.27
	<10	181 (68)	31 (72.1)	87 (64.4)	0.36	14 (53.9)	49 (84.5)	**0.003**[b]
	≥10	81 (30.5)	12 (27.9)	48 (35.6)		12 (46.1)	9 (15.5)	
Tumor volume[a] **(cm^3 or ml)**	*<35.0*	48 (18)	2 (5.4)	21 (16.5)	0.11	9 (34.6)	16 (30.2)	**0.02**[b]
	35.0–149	82 (30.8)	19 (51.4)	40 (31.5)		4 (15.4)	19 (35.9)	
	150–649	59 (22.2)	8 (21.6)	34 (26.8)		4 (15.4)	13 (24.5)	
	≥650	54 (20.3)	8 (21.6)	32 (25.2)		9 (34.6)	5 (9.4)	
Tumor depth	*Deep*	174 (65.4)	27 (60.0)	90 (66.2)	0.45	24 (92.3)	33 (55.9)	**0.001**[b]
	Superficial	92 (34.6)	18 (40.0)	46 (33.8)		2 (7.7)	26 (44.1)	
Tumor stage[a]	*I*	59 (22.2)	11 (25.0)	31 (23.0)	0.19	5 (19.2)	12 (20.7)	0.97
	II	95 (35.7)	14 (31.8)	44 (32.6)		11 (42.3)	26 (44.8)	
	III	82 (30.8)	10 (22.7)	47 (34.8)		8 (30.8)	17 (29.3)	
	IV	27 (10.2)	9 (20.5)	13 (9.6)		2 (7.7)	3 (5.2)	
Preoperative radiotherapy	*No*	69 (25.9)	7 (15.6)	36 (26.5)	0.14	5 (19.2)	21 (35.6)	0.13
	Yes	197 (74.1)	38 (84.4)	100 (73.5)		21 (80.8)	38 (64.4)	
Postoperative radiotherapy	*No*	241 (90.6)	43 (95.6)	121 (89.0)	0.19	24 (92.3)	53 (89.8)	0.72
	Yes	25 (9.4)	2 (4.4)	15 (11.0)		2 (7.7)	6 (10.2)	
Preoperative chemotherapy	*No*	242 (91)	40 (88.9)	122 (89.7)	0.88	26 (100)	54 (91.5)	0.13
	Yes	24 (9)	5 (11.1)	14 (10.3)		0 (0.0)	5 (8.5)	

[a] Excluding missing values (BMI: 14, tumor size: 4, and stage: 3).
[b] Denotes statistical significance.
BMI = Body mass index.

Table 2 Types of flaps used in the study cohort.

Flap type	Pedicled flaps (n = 195, 73.3%)		Free flaps (n = 71, 26.7%)	
	n (% of total)		n (% of total)	
Gastrocnemius	62	(23.3)		
Latissimus dorsi	29	(10.9)	12	(4.5)
Radial forearm	26	(9.8)	6	(2.3)
Sartorius	23	(8.6)		
Rectus abdominis	16	(6.0)	6	(2.3)
Anterolateral thigh	16	(6.0)	44	(16.5)
Perforator	7	(2.6)		
Gluteus maximus	3	(1.1)		
Soleus	3	(1.1)		
Pectoralis	2	(0.8)		
Gracilis	3	(1.1)	2	(0.8)
Tensor fascia lata	2	(0.8)		
Vastus lateralis	1	(0.4)		
Rectus femoris	1	(0.4)		
Semimembranosus	1	(0.4)		
Parascapular			1	(0.4)

that this is not the case, as the type of flap used was not an independent predictor of complications in patients with either upper or lower extremity reconstructions. In addition, free and pedicled flaps were associated with similar postoperative functional outcomes.

Soft tissue reconstruction following resection of ESTS aims to maximize functional outcomes while minimizing the associated perioperative morbidity. A thorough understanding of the risks and benefits of the proposed reconstructive technique is therefore essential to the informed consent process. This study quantifies the relative complication and functional outcome profiles of free and pedicled flaps in ESTS reconstruction and makes an important contribution to evidence-based decision-making in these complex oncological cases.

In this series, free flaps were more commonly selected for upper limb reconstructions when tumors were large and deep, which is consistent with the relative absence of large pedicled flaps in this region. In the lower limb, however, there was no association between mean tumor size and the use of free or pedicled flaps, which is in line with our clinical experience. For example, in the proximal lower extremity, there are a number of large pedicled flap options that can be utilized to reconstruct large soft tissue defects, whereas in the distal lower limb, there are very few reliable pedicled options; hence, free flaps are more frequently required even when tumors are small. This was confirmed by the significant increase in distal leg tumors that required free flap reconstruction.

In the lower limb group, pedicled flaps were associated with a slightly higher risk of complications, but this did not reach significance. Conversely, in the upper limb group, free flaps were more commonly associated with complications on univariate testing, although this association was not found to be significant on multivariate regression analysis. Patients in the upper limb free flap group had higher mean BMI (Table 1), which probably accounted for their increased complication rate, as increasing BMI was identified as the only significantly independent predictor of complications in the

Table 3 Complications stratified for flap type and tumor location.

Complication	Total (n = 266)		Pedicled (n = 195)		Free (n = 71)		p-value	Lower limb (n = 181)		Upper limb (n = 85)		p-value
	n	%	n	%	n	%		n	%	n	%	
Minor surgical complications	38	14.3%	28	14.4%	11	15.5%	0.82	29	16%	10	11.8%	0.36
Infection	14	5.3%	10	5.1%	4	5.7%		12	6.6%	3	3.5%	
Wound dehiscence	13	4.9%	9	4.6%	4	5.7%		10	5.5%	3	3.5%	
Delayed wound healing	6	2.3%	5	2.6%	1	1.4%		5	2.8%	1	1.2%	
Seroma	1	0.4%	1	0.5%	-	-		1	0.6%	-	-	
Hematoma	1	0.4%	-	-	1	1.4%		-	-	1	1.2%	
Partial necrosis	3	1.1%	2	1.0%	1	1.4%		1	0.6%	2	2.4%	
Major surgical complications	52	19.5%	35	17.9%	16	22.5%	0.40	39	21.6%	12	14.1%	0.15
Infection requiring iv antibiotics	18	6.8%	14	7.2%	3	4.2%		16	8.8%	1	1.2%	
Delayed wound healing	6	2.3%	6	3.1%	-	-		5	2.8%	1	1.2%	
Wound dehiscence	5	1.9%	5	2.6%	-	-		5	2.8%	-	-	
Hematoma	3	1.1%	3	1.5%	-	-		2	1.1%	1	1.2%	
Partial necrosis	9	3.4%	3	1.5%	6	8.5%		6	3.3%	3	3.5%	
Flap compromise	4	1.5%	-	-	4	5.7%		1	0.6%	3	3.5%	
Flap failure	7	2.6%	4	2.1%	3	4.3%		4	2.2%	3	3.5%	
Total complications	90	33.8%	63	32.3%	27	38.0%	0.38	68	37.6%	22	25.9%	0.06

Table 4 Risk factors for complications.

Factor		Univariate OR (95% CI)	p-value	Multivariate OR (95% CI)	p-value
Lower extremity[a]					
Flap	Free	1.0	0.75	-	-
	Pedicled	1.12 (0.56–2.26)			
Upper extremity[b]					
Flap	Free	1.0	**0.03**[c]	1.0	0.22
	Pedicled	0.31 (0.11–0.86)		0.45 (0.13–1.59)	
BMI	<25	1.0 (ref)		1.0 (ref)	
	25–29	6.30 (1.61–27.75)	0.008	6.09 (1.38–26.85)	**0.02**[c]
	≥30	7.11 (1.48–34.21)	0.01	7.01 (1.28–38.51)	**0.03**[c]
Depth	Deep	1.0 (ref)		1.0 (ref)	
	Superficial	0.51 (0.17–1.57)	0.24	0.68 (0.17–2.70)	0.58
Tumor size	<10	1.0 (ref)		1.0 (ref)	
	10 or more	1.18 (0.39–3.54)	0.78	0.68 (0.05–8.92)	0.77
Volume	<35.0	1.0 (ref)		1.0 (ref)	
	35.0–149	1.13 (0.32–3.91)	0.85	0.80 (0.19–3.42)	0.76
	150–649	0.79 (0.19–3.28)	0.75	0.73 (0.10–5.32)	0.76
	≥650	1.03 (0.24–4.39)	0.97	0.58 (0.03–11.06)	0.72
Preoperative radiation	No	1.0 (ref)		-	-
	Yes	0.70 (0.25–1.95)	0.50		
Localization	Proximal	1.0 (ref)		-	-
	Distal	1.95 (0.73–5.20)	0.18		

[a] No multivariate analysis was performed for the lower extremity because there was no significant difference between free and pedicle flaps in univariate analyses.
[b] Upper extremity multivariate model included variables that may affect postoperative complication rates.
[c] Denotes statistical significance.
BMI = Body mass index.

Table 5 Risk factors for complications stratified for flap type and tumor location.

Factor		Lower limb, n = 181 (68.1%)			Upper limb, n = 85 (31.9%)		
		Free n = 45 (24.86%)	Pedicled n = 136 (75.14%)	p-value	Free n = 26 (30.59%)	Pedicledn = 59 (69.41%)	p-value
Size	<10	10 (32.3)	31 (36.6)	0.73	6 (42.9)	10 (20.4)	0.10
	>10	6 (50.0)	21 (43.7)	0.70	5 (41.7)	1 (11.1)	0.15
Preoperative radiotherapy	No	2 (28.6)	10 (27.8)	0.97	3 (60.0)	5 (23.8)	0.13
	Yes	14 (36.8)	42 (42.0)	0.58	8 (38.1)	6 (15.8)	0.06
Localization	Proximal	9 (52.9)	33 (36.3)	0.20	4 (28.6)	6 (17.1)	0.38
	Distal	7 (25.0)	19 (42.2)	0.14	7 (58.3)	5 (20.8)	**0.03**[a,b]
Additional reconstruction	Yes	12 (54.6)	22 (45.8)	0.50	1 (50.0)	4 (57.1)	0.86
	No	7 (53.9)	7 (30.4)	0.17	1 patient	-	-

[a] Univariate OR (95% CI) = 0.19 (0.04–0.85), multivariate (adjusted for age, smoker, and BMI, stage) OR (95% CI) = 0.13 (0.01–1.58); p = 0.11.
[b] Denotes statistical significance.

study (Table 4). Obesity has been recognized well as an important risk factor for wound healing complications following complex reconstruction in many studies, including patients with ESTS.[19–23]

In line with reports from earlier patient cohorts at our center, overall postoperative function following free or pedicled flap reconstruction was well preserved with relatively small differences between preoperative and postoperative functional scores.[24] Flap choice did not significantly affect functional outcomes in our series. Patients who experienced complications exhibited lower postoperative functional scores, although this difference was only significant for patients in the upper extremity group as measured by MSTS93 scores (p = 0.02, Table 6). However, the three functional scores used in this study only consider the site of tumor ablation while flap reconstructions may also result in some degree of impairment at the donor sites, which was not evaluated in this study.

Although this study demonstrates that there is no significant difference between the postoperative complication rates for patients with ESTS following free or pedicled flaps, these data are from a high-volume center with a specialist microsurgical practice and the findings must be interpreted accordingly. Institutions with lower volumes may experience higher rates of complications with more complex free flap reconstructions. Although in most patients the choice of

Table 6 Differences between the mean preoperative and postoperative functional scores, stratified for flap type and complications.

		Lower limb; Mean Difference (SD)			Upper limb; Mean Difference (SD)		
		TESS	MSTS87	MSTS93	TESS	MSTS87	MSTS93
Flap type	Free	−3.6 (26.2)	−1.6 (5.8)	−2.9 (20.5)	5.5 (17.4)	−1.5 (5.3)	−3.3 (13.8)
	Pedicled	1.8 (15.2)	−0.2 (4.1)	0.6 (14.0)	−0.3 (9.4)	−0.1 (4.1)	0.6 (11.1)
P-value		0.41	0.56	0.12	0.48	0.46	0.84
Complications	No	2.0 (18.6)	−0.7 (4.7)	0.6 (14.8)	2.7 (11.5)	−0.06 (4.3)	1.6 (11.5)
	Yes	−2.6 (18.7)	−0.5 (4.5)	−2.0 (18.1)	−3.7 (14.6)	−2.5 (4.6)	−8.5 (10.4)
P-value		0.21	0.65	0.92	0.81	0.08	**0.02**[a]

Mean difference is the difference between the mean preoperative and postoperative functional scores.
Functional results were collected for: TESS: n = 140 patients (53%); MSTS87: n = 143 patients (54%); MSTS93: n = 144 patients (55%). Missing data were excluded from analyses.
[a] Denotes statistical significance.

flap is determined by the site and size of the defect and the availability of local tissues, in some cases, there are other variables that must be considered in the decision-making process. For instance, at our institution, preoperative radiation therapy is used frequently; hence, we have considerable experience performing free flap reconstructions 4–6 weeks after completion of radiation. This influences our reconstructive strategy, as free flaps may be preferable when adjacent pedicled flaps are located within the field of preoperative radiation.[25,26] Achievement of equivalent results in free and pedicled flap reconstructions is likely to rely heavily on clinical experience and prudent patient selection. It is therefore essential that plastic and orthopedic oncology surgeons are proficient in all reconstructive options so that the most suitable flap can be selected for each patient.

Free flaps and pedicled flaps were considered collectively in this study; hence, we could not determine if particular types of flaps such as fasciocutaneous or muscle flaps were associated with higher complication rates. As the numbers of individual flaps were small, subanalyses would be underpowered to identify independent associations with complications. This study only included surgical complications as we have previously reported that medical perioperative complications are rare in this patient population.[23] However, we acknowledge that in certain patients with known medical comorbidities, more complex reconstructive procedures involving extended operating times may be associated with higher complication rates.

In conclusion, this study demonstrates that postoperative complications and functional outcomes associated with either free and or pedicled flaps are equivalent following resection of ESTS. Selecting the most suitable reconstructive option for each individual patient is paramount to achieving good functional outcomes while minimizing postoperative morbidity.

Conflict of interest

There is no conflict of interest for any of the authors of this article.

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