Clinical outcomes after wide resection of lower extremity soft tissue sarcomas with femoral vessel reconstruction

Samy Khalefa, Amr El Bahaey, Ayman El-Samadoni, Haitham A. Eldmarany

Department of Vascular Surgery, Kasr Alaini Hospital, Cairo University, Cairo, Egypt

Correspondence to Haitham Ahmed AbdelAzez, BSc, MCs, PhD, 4 Omr Bin Khatab St., Western Omarnia, Giza, 12511, Egypt. Tel: 0023652700; e-mail: haithamdmarany@gmail.com

Received: 10 September 2019
Revised: 7 October 2019
Accepted: 27 October 2019
Published: 14 February 2020

The Egyptian Journal of Surgery 2020, 39:206–214

Introduction
With advancements in local control of lower extremity soft tissue sarcoma (STS) by modern oncology protocols, limb salvage surgeries have become the standard of care with good results in both limb function outcome and quality of life.

Patients and methods
This is a retrospective analysis of all patients with a localized STS of the lower extremity presented to Vascular Surgery Unit at Faculty of Medicine, Cairo University, and who underwent en bloc vascular resection of the tumor between January 2018 and April 2019.

Results
We have found 17 patients during the study period. In three patients, iliofemoral arterial repairs were performed. Above-the-knee femoropopliteal bypasses were implanted in six patients. In four patients, popliteoposterior tibial bypasses were performed. Venous reconstructions consisted of three iliofemoral, one femorofemoral, and four femoropopliteal bypass reconstructions. Another four venous reconstructions were performed in the popliteal region. All patients developed moderate degree of pitting lower limb edema at the early postoperative period. Only one patient had undergone lower limb above-knee amputation. There was one synthetic Dacron graft occlusion in a patient with arterial bypass procedures. Regarding venous bypasses, occlusion occurred in three patients. Freedom from local tumor recurrence at 6 months was 64.2%. The freedom from distant metastases at 6 months after primary tumor excision was 85.7% for more than 10 mm margins and 20% for less than or equal to 10 mm margins. The cumulative overall survival proportion at 6 months was 53.9%.

Conclusion
Vascular reconstruction after wide local excision of lower extremity STS prevents the complications of vascular ligation and local recurrence in case of subradical excision. The use of autogenous vein graft yields better patency rates than synthetic grafts.

Keywords:
bypass, recurrence, sarcoma

Egyptian J Surgery 39:206–214

1110-1121

Introduction

Soft tissue sarcomas (STS) are malignant tumors that can affect any part in the body. These tumors are rare, with an annual incidence of five per 100 000 populations. They commonly affect the extremities and the retroperitoneal region [1,2]. STS arise from mesenchymal tissue origins and differentiate heterogeneously forming diverse groups of malignant tumors [3]. Pathologically, sarcomas are known to grow within their anatomical compartments and extend into the plane of the least resistance respecting the local anatomic barriers [4–6]. For STS affecting the limbs, especially those tumors arising close to the neurovascular bundle, amputation was the standard treatment in the past. However, with advancements in local disease control by modern protocols of radiotherapy and chemotherapy as well as improvements of vascular reconstructive techniques, limb salvage surgeries have become the standard of care with good results in both limb function outcome and quality of life [3]. Surgery being the main line of treatment for lower limb STS, it aims basically at both complete resection of all macroscopic visible malignant tumor tissues and at the same time avoiding the risk of local recurrence by obtaining microscopically tumor-free surgical margins [3–8]. For vascular reconstruction following wide local excision of lower limb STSs invading or encroaching on the major limb vessels, arterial reconstruction is almost always indicated to prevent postoperative limb ischemia but venous reconstruction is still debatable.

The patency rates of venous grafts is still unsatisfactory; moreover, data regarding ligations of major limb veins show no direct interference with overall limb viability [9–11]. The aim of this retrospective study was to evaluate the primary arterial and venous patency rates, vascular and nonvascular complications, tumor recurrence rate, and overall patient survival after wide local resection of lower extremity STS with vascular involvement.

Patients and methods

Patients

This is a retrospective analysis of all patients with a localized STS of the lower extremity presented to Vascular Surgery Unit at Faculty of Medicine, Cairo University, and who underwent en bloc vascular resection of the tumor between January 2018 and April 2019. The review of patients files were done after obtaining an approval from the hospital ethical committee and concerned hospital authorities to avoid any illegal breach of patients' confidentiality. In all reviewed patients, computed tomography (CT) and/or MRI were performed initially for diagnosis, which was confirmed later by histological biopsies obtained by either open incision, needle ultrasound, or CT-guided biopsy (Fig. 1). For vascular involvement, magnetic resonance angiography, catheter angiography, or CT angiography or a combination of these was performed to diagnose the extent of vascular invasion and the plan for reconstruction. Duplex scanning to the contralateral great saphenous vein was used in all patients to estimate the vein adequacy (diameter and length) as a conduit to all patients especially those designed for vein reconstructive procedures. A written informed consent was obtained from all patients before surgery explaining the nature of the procedure, expected benefits, and all possible complications, including major limb amputation.

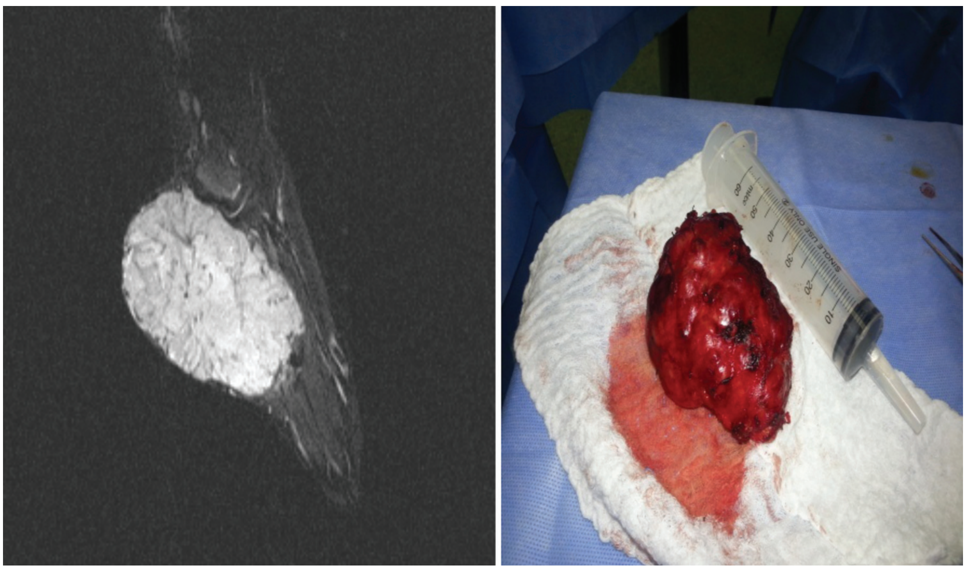
Treatment

After routine preoperative assessment, including cardiopulmonary and anesthetic evaluation, en bloc resection of the tumor mass was indicated by the surgical team. Surgical excision was considered grossly complete in the absence of macroscopically visible residual disease, and macroscopically complete resections were classified as R2. All macroscopically complete resections were analyzed microscopically and classified according to the closest surgical margin as follows:

(1) If tumor was detected within 1 mm of the inked surface, then it is marked as R1.
(2) If no tumor was detected within 1 mm from the inked surface, then it is marked as R0.

Criteria that were used for vascular resection included encasement of the vessels by the tumor as well as invasion of the sidewall of the vessels when pushed at the periphery of the lesion. Vascular clamping and resection were done at the last stage of en bloc excision, after selection of the vascular graft to be used for reconstruction. If the contralateral saphenous vein was used as an interposition graft, it was harvested and prepared before tumor resection to shorten the

Figure 1



MRI of lower limb soft tissue sarcoma and the resected tumor after surgical excision.

duration of tissue ischemia and to avoid venous congestion of the limb. In all patients, the saphenous vein of the contralateral limb was used to avoid edema in the limb already undergoing extensive manipulation of the lymphatic and deep venous systems in case ipsilateral saphenous vein was used. Regarding vascular reconstruction, the policy used was mandatory arterial reconstruction with selective venous reconstruction. Veins were decided for reconstruction only if they were found patent at the time of surgery and had no clinical or radiological evidence of collateralization to improve the functional outcome. Veins that were found already occluded by the tumor, especially in presence of radiological evidence of collaterals, were never attempted at reconstruction. Graft of choice in arterial reconstruction was the contralateral great saphenous vein, unless it was deemed unsuitable. Polytetrafluoroethylene (PTFE) vascular synthetic grafts represented the second preferred graft material followed by coated Dacron knitted grafts. Synthetic graft was preferred than autogenous vein whenever reconstructing after recurrent tumor or when the disease was highly extensive with high probability for recurrence. Anticoagulant was administered to all patients starting with intraoperative intravenous sodium heparin at a loading dose of 80 IU/kg with maintenance of 20 IU/kg/h with postoperative low-molecular-weight heparin like Enoxaparin at 1 mg/kg every 12 h at early postoperative period in cases of problems with the inflow or the outflow vessels, which was substituted with vitamin K antagonists (warfarin) titrated to achieve international normalized ratio of two to three for the first 6 months postoperatively then replaced later with Aspirin 81 mg once daily.

The adjuvant therapy protocol

The indication for preoperative/postoperative radiation therapy was assessed by both the operating surgeon and the oncologist and delivered when a high risk of local recurrence was deemed to exist on clinical grounds. However, no definitive selection criteria for those receiving radiation were recorded. Preoperative/postoperative chemotherapy was given according to the protocol of the sarcoma board of the oncology department. All histologies underwent a re-evaluation regarding histopathological type and grading according to French Federation of Cancer Centers Sarcoma Group (FNCLCC) by an experienced sarcoma pathologist.

Regarding chemotherapy, patients were offered four cycles of chemotherapy. Chemotherapy was started within the first 4 weeks after completion of postsurgery reconvalescence and wound healing. The protocol used consisted of doxorubicin (75 mg/m^2 intravenous over 1 h on day 1) followed by ifosfamide (5 g/m^2 intravenous over 24 h starting on day 1). The cycle was repeated every 21 days. The first two cycles were given followed by radiotherapy. After completion of local radiotherapy, chemotherapy was resumed with cycles 3 and 4, at least 10 days after the last dose of radiotherapy.

Regarding radiotherapy, radiation therapy was given between chemotherapy cycles 2 and 3. A total dose of 50.4 Gy fractionated in daily 1.8±2 Gy on 5 days/week was applied onto the operative field by modern CT-guided radiation planning, and a boost was applied to a cumulative dose of 60 Gy.

Follow-up protocol

Follow-up of the treated patients was done by thorough clinical examination and duplex ultrasound assessment of the repaired vessels every hospital visit during the course of adjuvant therapy. Assessment of possible tumor recurrence was done in oncology outpatient clinics. In case of recurrence, patients were referred back again to vascular surgery department for further resections whenever indicated. The duration of follow-up was until the end of the adjuvant chemoradiotherapy, with a maximum of 6 months after the surgical resection and vascular reconstruction, looking mainly at the patency of the vascular reconstruction and any local tumor recurrence during each hospital visit, as our aim was mainly to assess the feasibility of combined resection and vascular reconstruction regardless of the oncologic results beyond this period.

Statistical analysis

The Kaplan–Meier method was used to estimate overall survival as well as the rates of arterial and venous patency. The patency rate was calculated on the basis of the time from surgery to the first vascular complications (occlusion or rupture) observed.

Results

We have found 17 patients during the study period, including seven (41.2%) females and 10 (58.8%) males. The age range was from 15 to 76 years (median, 38.0 years). Table 1 lists the sites of the tumors, the histological types of the sarcomas, the tumor grade, and the previous oncologic treatment strategies used. The most frequently involved site was the thigh region, accounting for 58.8% of all sarcomas.

All reviewed patients in the study underwent complete resection of the tumor with macroscopically free surgical margins (R2). At the time of the vascular resections, 14 (82.4%) patients had R0 (negative microscopic) resections margins and three (17.6%) patients had microscopic positive margins (R1).

Vascular reconstruction

Table 2 shows the types of vascular reconstructions (venous and arterial) that were done. The most common procedure was femoral-popliteal bypass in both arterial and venous reconstructions.

Arterial reconstruction

In three patients, iliofemoral arterial repairs were performed; this repair consisted of two PTFE grafts (8 mm) and one Dacron graft (8 mm). In one of those patients, the profunda femoris artery was ligated. Femorofemoral replacement in four patients was performed by using great saphenous vein (GSV) graft (n=2) and PTFE graft (6 mm; n=2). Above-the-knee femoropopliteal bypasses were implanted in six patients; five of these patients were treated by reversed contralateral GSV graft, and in one case, a PTFE graft (6 mm) was used. In four patients, popliteoposterior tibial bypasses were performed using contralateral GSV graft.

Table 1 Clinicopathologic factors

Characteristic	*n* (%)
Sex	
Male	10 (58.8)
Female	7 (41.2)
Presentation	
Primary tumor	12 (70.6)
Local recurrence	5 (29.4)
Histological diagnosis	
Fibrous histiocytoma	6 (35.3)
Synovial sarcoma	5 (29.4)
Leiomyosarcoma	3 (17.6)
Pleomorphic sarcoma	1 (5.9)
Malignant peripheral nerve sheath tumor	1 (5.9)
Hemangiopericytoma	1 (5.9)
Tumor localization	
Thigh	10 (58.8)
Inguinal region	3 (17.7)
Infrageniculate region	4 (23.5)
Tumor grade	
High grade	9 (52.9)
Low grade	6 (35.3)
Unclassified	2 (11.8)
Vessel infiltration	
Artery	4 (23.5)
Vein	2 (11.8)
Artery and vein	11 (64.7)
Tumor size (cm)	
$<$5	0
5–10	6 (35.3)
$>$10	11 (64.7)
Margin of resection (mm)	
0	3 (17.6)
1–9	6 (35.3)
≥10	8 (47.1)
Adjuvant treatment	
Surgery alone	8 (47.1)
Surgery and radiotherapy	9 (52.9)

Venous reconstruction

Unlike the arterial repair, cases for venous repair were selected for those with main outflow vein involvement, and veins were reconstructed predominantly only if they were patent at the time of surgery and had no clinical or radiological evidence of collateralization. Venous reconstructions consisted of three iliofemoral, one femorofemoral, and four femoropopliteal bypass reconstructions. For proximal iliofemoral reconstruction, PTFE grafts were used (8 or 12 mm, n=3). In the latter cases, the profunda femoris vein was ligated. One femorofemoral bypass was implanted by using contralateral GSV graft. Another four venous reconstructions were performed in the popliteal region. For these procedures, PTFE graft was used in one patient (8 mm, n=1) and contralateral GSV in three patients. A resected superficial femoral vein was ligated in nine patients in whom it was possible to preserve a functional ipsilateral GSV during sarcoma resection.

The use of synthetic PTFE graft was justified by the severe size mismatch of the contralateral GSV. Table 3 shows the types of synthetic and autogenous grafts used as conduit for both arterial and venous reconstructions. The most common type of conduit that was used in both venous and arterial reconstruction was the great saphenous vein. Synthetic ringed expanded PTFE and Dacron grafts were used in 40% of the reconstruction procedures.

Complications

The most frequent vascular complication was mild to moderate lymphedema, which affected almost all patients. All patients developed moderate degree of

Table 2 Types of venous and arterial reconstructions performed

Type of bypass performed	Arterial	Venous
Femoral-popliteal bypass	6	4
Iliofemoral bypass	3	3
Superficial femoral to superficial femoral bypass	4	1
Popliteal to posterior tibial bypass	4	0

pitting lower limb edema at the early postoperative period. All patients continue their anticoagulant therapy with addition of mild diuretics, and only five cases had only mild to moderate edema at the time of their discharge. Only one patient had undergone lower limb above-knee amputation; in the early postoperative period, a severe wound infection occurred that necessitate surgical debridement and the use of a remote pedicle longitudinal rectus abdominis myocutaneous flap for coverage, but on the 10th postoperative day, he developed severe secondary hemorrhage that necessitated arterial ligation that was soon followed by high above-knee amputation owing to severe limb ischemia. Table 4 shows the percentage of each recorded complication.

Limb survival and vascular graft function

There was one synthetic Dacron graft occlusion in a patient with arterial bypass procedures. Regarding venous bypasses, occlusion occurred in two patients with a PTFE graft and in one patient with a great saphenous vein graft. Table 5 shows the distribution of occlusion according to the type of vascularization performed and the vascular conduit utilized. The proportion of patients with graft occlusion was significantly greater in patients whose vascular conduits were done utilizing synthetic grafts than in those whose revascularization was done using saphenous vein grafts (P=0.02). By contrast, the rate of occlusion in venous conduits was higher than arterial revascularization (P=0.61).

Patient outcome

The median follow-up period was 7 months (range, 2–12 months). Local recurrences were identified in four (23.5%) patients. All of the four patients were found to have tumor size greater than 10 cm in maximum diameter. Freedom from local tumor recurrence at 6 months was 64.2%. During the follow-up period, distant metastases were detected in six patients, with cumulative survival rate of 58.3%. The freedom from distant metastases at six months after primary tumor excision was 85.7% for more than 10 mm margins and 20% for less than or equal to 10 mm margins. The cumulative overall survival proportion at 6 months was 53.9%.

Discussion

Wide local excision with limb salvage surgery has become the standard treatment for lower extremity STS [1–8]. In modern surgical principle, locally advanced STSs invading the neurovascular bundle still can be safely excised en bloc with the affected structures followed by vascular reconstruction [12]. The recent advances in multimodal treatment regimens, the preference for a wide margin, and the introduction of function-sparing surgical excision together with radiotherapy and chemotherapy have decreased the amputation rate to 4–2%, with no effect on the rate of recurrence or survival rate and still with good quality of life [7,9]. Some previous studies have already shown better quality of life in patients who had undergone STS tumor excision

Table 3 Types of venous and arterial reconstructions

Variables	*n* (%)
Arterial reconstruction	
Vein (GSV)	11 (64.7)
PTFE	5 (29.4)
Dacron	1 (5.9)
Venous reconstruction	
Vein	4 (23.5)
PTFE	4 (23.5)
Dacron	0

GSV, great saphenous vein; PTEF, polytetrafluoroethylene.

Table 4 Complications

Complications	*n* (%)
Skin necrosis	3 (17.6)
Hematoma	2 (11.8)
Wound infection	3 (17.6)
Seroma	2 (11.8)
Edema at discharge	5 (29.4)
DVT	5 (29.4)
Hemorrhage	1 (5.9)
Amputation	1 (5.9%)
Mortality	0

Table 5 Patency distribution according to the type of vascularization performed and vascular substitute used

	Occlusion	No occlusion	Total	*P*
Type of revascularization				
Arterial	1	16	17	0.609
Venous	3	5	8	
Vascular substitute				
Great saphenous vein	1	14	15	0.02
Synthetic graft	3	7	10	

with limb salvage considering that most affected patients are young adults who can be rehabilitated [10].

Still there is controversy regarding the indication for vascular reconstruction following STS excision. Gerrand *et al.* [13] in their report stated that planned positive margins resection for any STS that arises adjacent to critical structures does not affect the local recurrence rate, which remained low even without vascular reconstruction. Leggon *et al.* [14] reported that vascular resection and reconstruction for extremity STS typically is not needed until more than 50% of major vessels are encased by tumors. If the area of vessel wall infiltration is limited, a partial or limited resection can be performed in some cases, to maintain the vascular continuity of the uninvolved vessel parts, and this is followed by a patch type repair [14]. If the tumor is adjacent to, but does not infiltrate, the wall of a main vessel, then we can avoid vascular resection by leaving the vascular wall outer coat (adventitia) as a margin with the tumor [14–16]. Mack *et al.* [17] reported that iliac and femoral vessels and/or femoral nerves were excised en bloc with the tumor mass only if the adventitial layer was involved with the tumor, and none of their patients experienced a local recurrence. However, vascular affection in STS may be either primary (i.e. the tumor arising directly from the vessel wall layers) or secondary, such as when a tumor infiltrates or encases major blood vessels. If a STS is primary, then vascular resection cannot be avoided. Primary vascular involvement cannot be accurately denied in sarcomas adjacent to major vessels; therefore, as an indication for vascular excision and in order to achieve tumor-free surgical margins, vascular reconstruction can be performed if the tumor arises from a vascular structure (especially in cases of leiomyosarcoma or synovial sarcoma) and if MRI findings show a sarcoma encompassing or adjacent to femoral vessels [18]. In fact, STS located adjacent to or encasing major vessels presents a unique challenge to the vascular surgeons because tumor-positive surgical margins are known to be associated with high rate of local recurrence and eventually death [4,9,13,17,19,20]. A lot of previous research studies have reported that vascular involvement in STS is not necessarily a contraindication for comprehensive surgical resection [21–25]. In the present series, R0 resection rate was achieved undoubtedly facilitated by resection of involved major vessels. It is vital that any resected arteries to be reconstructed to avoid ischemia. In patients with malignant tumors, the collateral blood vessels running in the surrounding muscles and tissues are generally excised with the tumor mass, which means that vascular reconstruction is inevitable in those cases to avoid severe ischemia [9]. Furthermore, the incidence of sarcomas is high among young individuals who usually have few or no collateral vascular pathways that can provide sufficient blood supply after major trunk ligation.

There has been no significant difference in patency rates between autogenous vein grafts and vascular synthetic grafts used in vascular reconstruction following lower limb STS excision in the previous studies, probably owing to the limited number of patients in all of the published studies. However, these studies had shown lower incidence of graft and wound infection when saphenous vein grafts were used [22,26]. Because of the lower infection rate and greater caliber compatibility with the vessels in the lower limbs, we routinely use saphenous vein grafts as the first option in our vascular reconstructions, and they were used in ∼60% of patients requiring arterial or venous revascularization.

In our series, graft occlusion occurred more frequently in patients who underwent vascular repair with use of synthetic grafts, consistent with the results of prior studies [3,9,24]. Saphenous graft stenosis occurred because of intimal hyperplasia in the distal anastomosis in one patient who underwent arterial superficial femoral-superficial femoral bypass. This patient underwent balloon angioplasty followed by stent insertion inside the graft owing to elastic recoil of the stenotic lesion. Follow-up duplex ultrasound done 3 months later showed no residual stenosis. Conversely, the only case of surgical wound infection in our series was an arterial reconstruction done using Dacron graft, which ruptured, ending with graft ligation and above-knee amputation.

The results in our review match well with a study by Nishinari and colleagues, who reported ∼25 patients with lower extremity STS and vascular involvement who underwent wide local excision of the tumor mass including the affected vessels followed by arterial or venous reconstruction. A total of 44 revascularization procedures were performed. The 5-year survival probability was 42.1%. The graft occlusion rate was significantly higher after reconstruction with synthetic grafts than after reconstruction with saphenous vein substitutes. They concluded that vascular reconstruction provides favorable long-term patency outcomes and low complication rates, allowing limb preservation and disease control in a select group of patients [3].

Our patency rates match with the results of a study by Radaelli and colleagues, where vascular reconstructions consisted of 52 arterial and 16 venous grafts in extremities and 12 arterial and 33 venous grafts in the retroperitoneum. Graft thrombosis occurred in 16 patients (7/64 arterial and 9/49 venous reconstructions). The occlusion of venous grafts occurred at a median of 4 months after the vascular repair and all were treated conservatively. The overall patency rates were 89% for arterial reconstruction and 82% for venous reconstruction. They concluded that vascular resection to facilitate resection of STS has an acceptable long-term patency rate despite the high risk of distant spread [9].

Postoperative edema is a major complication after resection of STS and is caused by disruption of the lymphatic drainage system and removal of extensive surrounding muscle tissue containing important collateral veins. Edema can become more severe in patients with vascular involvement who require excision or ligation of the venous system [3]. We realized that two patients in our review developed severe postoperative edema. Those patients were treated by the standard conservative anti-edema measures including graduated elastic compression stockings, limb elevation, manual lymphatic drainage, and anticoagulation (in the patient with the occluded graft).

The avoidance of lower limb edema and unpleasant venous congestion after surgery by venous reconstruction remains unknown. Nonetheless, in the long-term, a patient subjected to venous resection without reconstruction may experience severe edema, claudication, and hyperpigmentation of the affected limb [10,11,18]. Depending on the clinical setting and the surgeon's preference, it was believed that venous reconstruction is clinically important for preventing early postoperative limb edema, and for that reason, venous reconstruction was performed in eight patients owing to venous occlusion by the tumor. Radaelli and colleagues confirmed our policy of venous repair, where veins were reconstructed predominantly only if they were patent at the time of surgery and had no clinical or radiological evidence of collateralization. The need of vein replacement is controversial, mainly owing to its related risk of developing graft thrombosis and subsequent pulmonary embolism (PE) [9]. Moreover, in our series, we report a high venous patency rate after reconstruction (above 60%) with few cases of vein thrombosis and no case of PE. These results are at least not against our policy of vein replacement.

Some published studies that advised ligation of involved veins have reported control of postoperative edema over time using standard clinical measures, such as limb elevation and compression therapy [6,14]. On the contrary, some other surgeons who advocate venous repair have reported that the occlusion rates are high after revascularization, which indicates that the value of venous reconstructions is controversial [26]. In our series, we found no significant difference in the rate of occlusion between patients who underwent arterial repair and those who underwent venous repair, which solves these arguments against performing venous reconstruction. Furthermore, as reported by Matsushita *et al.* [26], many patients may develop severe venous insufficiency symptoms, such as claudication, uncontrollable edema, hyperpigmentation, and eczema, which limit the quality of life.

Extensive vascular involvement by extremity STS raises a major consideration regarding not only the risk of local recurrence after limb preserving surgery but also the high incidence of increased risk for distant metastatic disease. In general, patients presenting with extremity sarcoma complicated by vascular involvement are at a higher risk of requiring amputation, and only a subset are eligible for limb salvage procedures [24]. However in our analysis, we realized only four (23.5%) local recurrences, and this supports the safety of limb salvage procedures. We realized in this review an incidence of distant metastasis in more than 35.3% of patients. However, these results can be explained on the basis of specific biological factors of each relevant to each tumor type, typically associated with vascular encasement, along with malignancy grade. In most patients in this series, the malignancy grade was found high, and this is well known to be the strongest prognostic factor of failure of systemic disease control [1]. Although resection of major vessels was surgically feasible and facilitated local disease control, it could not however offset the high biological risk of these tumors.

Therefore, the vascular involvement can be considered as a negative prognostic factor in high-grade malignancy with STS despite the technical feasibility of resection and vascular reconstruction [9,12,20]. Ghert *et al.* [20] found a higher proportion of patients in the vascular reconstruction group presented with systemic disease (32 vs. 8%). In a study by Poultsides and colleagues on 50 patients with sarcoma who underwent vascular resection (VASC), who were compared with 100 patients with similar clinic-pathological features where vascular resection was not done due to absence of vascular invasion (no-VASC), the overall rate of complications (74 vs. 44%), grade 3 or higher complication (38 vs. 18%), and need for transfusion (66 vs. 33%) were all more common in the VASC group. Overall survival after resection (5-year, 59 vs. 53%) and local recurrence (5-year, 51 vs. 54%) was similar between both groups. Within the VASC group, overall survival was not affected by the type of vascular involvement (artery vs. vein) or the presence of microscopic evidence of vessel wall invasion. They concluded that vascular excision and reconstruction during sarcoma resection significantly increases perioperative morbidity and requires meticulous preoperative planning. However, the oncologic outcome and overall survival benefit appear equivalent to cases without major vascular involvement [25].

We did not find differences in survival rates in relation to the resection margin status, although 17.6% of them were microscopically positive. The effect of the microscopic positive resection margins on survival as well as of other oncologic variables, such as tumor histopathologic grade, was probably not observed in our study because of the small sample size. Another important variable is the type of biopsy. As 29.4% of our patients were previously treated in other hospitals before being referred to our department, we lacked precise information about the type of biopsy performed in these cases. However, as a general protocol that was followed by our department, if an incisional biopsy was done, it was a standard to resect the scar en bloc at the time of the definitive resection. In a study by El Zohairy and colleagues, 12 patients with lower extremity STS with vascular involvement had undergone tumor excision with reconstruction of major limb vessels. The cumulative rates of overall survival, local recurrence-free survival, and distant metastasis-free survival were 53.9, 64.2, and 58.3%, respectively. It was noted that survival was significantly longer for surgical margin more than 10 m. They concluded that limb-sparing surgery with vascular reconstruction for extremity STS achieves good local control and functional results in most extremity sarcomas [24]. One limitation in our study is the relatively small sample size, a consequence of the low incidence of lower limb STS, a factor that precludes more detailed statistical analysis. We believe that our findings from this retrospective analysis should encourage other surgeons to consider reconstructing veins instead of ligating them and, whenever possible, to use an autogenous vein graft (e.g. saphenous vein) as the vascular conduit because of the lower rate of occlusion compared with synthetic grafts.

Conclusion

Vascular reconstruction after wide local excision of lower extremity STS is a safe procedure for both arteries and veins and prevents the complications of vascular ligation and local recurrence in case of subradical excision. The use of autogenous vein graft yields better patency rates than synthetic grafts.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 European Sarcoma Network Working Group (ESMO). Soft tissue and visceral sarcomas: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. Ann Oncol 2014; 25 (Suppl. 3): iii102–iii112.
2 Stiller CA, Trama A, Serraino D, Rossi S, Navarro C, Chirlaque MD, Casali PG. RARECARE Working Group. Descriptive epidemiology of sarcomas in Europe: report from the RARECARE project. Eur J Cancer 2013; 49:684–695.
3 Nishinari K, Krutman M, Aguiar Junior S, Ignataro BS, Yazbek G, Zottele Bomfim GA, *et al.* Surgical outcomes of vascular reconstruction in softtissue sarcomas of the lower extremities. J Vasc Surg 2015; 62:143–149.
4 Swallow CJ, Catton CN. Local management of adult soft tissue sarcomas. Semin Oncol 2007; 34:256–269.
5 Gronchi A, Lo Vullo S, Colombo C, Stacchiotti P, Stacchiotti S, Mariani L, Fiore M, Casali PG. Extremity soft tissue sarcoma in a series of patients treated at a single institution: local control directly impacts survival. Ann Surg 2010; 251:506–511.
6 Gronchi A, Colombo C, Raut CP. Surgical management of localized soft tissue tumors. Cancer 2014; 120:2638–2648.
7 Mendenhall WM, Indelicato DJ, Scarborough MT, Zlotecki RA, Gibbs CP, Mendenhall NP, Mendenhall CM, Enneking WF. The management of adult soft tissue sarcomas. Am J Clin Oncol 2009; 32:436–442.
8 Stoeckle E, Italiano A, Stock N, Kind M, Kantor G, Coindre JM, Bui BN. Surgical margins in soft tissue sarcoma. Bull Cancer 2008; 95:1199–1204.
9 Radaelli S, Fiore M, Colombo C, Ford S, Palassini E, Sanfilippo R, *et al.* Vascular resection en-bloc with tumor removal and graft reconstruction is safe and effective in soft tissue sarcoma (STS) of the extremities and retroperitoneum. Surg Oncol 2016; 25:125–131.
10 Nishinari K, Wolosker N, Yazbek G, Zerati AE, Nishimoto IN. Venous reconstruction in lower limbs associated with resection of malignancies. J Vasc Surg 2006; 44:1046–1050.
11 Nishinari K, Wolosker N, Yazbek G, Zerati AE, Nishimoto IM, Penna V, *et al.* Vascular reconstruction in limbs with malignant tumors. Vasc Endovasc Surg 2004; 38:423–429.
12 Schwarzbach MHM, Hormann Y, Hinz U, Bernd L, Willeke F, Mechtersheimer G, *et al.* Results of limb-sparing surgery with vascular replacement for soft tissue sarcoma in the lower extremity. J Vasc Surg 2005; 42:88–97.
13 Gerrand CH, Wunder JS, Kandel RA, O'Suilivan B, Catton CN, Bell RS, Griffin AM, Davis AM. Classification of positive margins after resection of soft-tissue sarcoma of the limb predicts the risk of local recurrence. J Bone Joint Surg Br 2001; 83:1149–1155.
14 Leggon RE, Huber TS, Scarborough MT. Limb salvage surgery with vascular reconstruction. Clin Orthop Relat Res 2001; 387:207–216.
15 Adelani MA, Holt GE, Dittus RS, Passman MA, Schwartz HS. Revascularization after segmental resection of lower extremity soft tissue sarcomas. J Surg Oncol 2007; 95:455–460.
16 Muranatsu K, Ihara K, Miyoshi T, Yoshida K, Taguchi T. Clinical outcome of limb-salvage surgery after wide resection of sarcoma and femoral vessel reconstruction. Ann Vasc Surg 2011; 25:1070–1077.

17 Mack LA, Temple WJ, Dehaas WG, Schachar N, Morris DG, Kurien E. Groin soft tissue tumors-a challenge for local control and reconstruction: a prospective cohort analysis. J Surg Oncol 2004; 86:147–151.

18 Emori M, Hamada K, Omori S, Joyama S, Tomita Y, Hashimoto N, *et al.* Surgery with vascular reconstruction for soft-tissue sarcomas in the inguinal region:oncologic and functional outcomes. Ann Vasc Surg 2012; 26:693–699.

19 Davidge KM, Wunder J, Tomlinson G, Wong R, Lipa J, Davis AM. Function and health status outcomes following soft tissue reconstruction for limb preservation in extremity soft tissue sarcoma. Ann Surg Oncol 2010; 17:1052–1062.

20 Ghert MA, Abudu A, Driver N. The indications for and the prognostic significance of amputation as the primary surgical procedure for localized soft tissue sarcoma of the extremity. Ann Surg Oncol 2005; 12:10–17.

21 Mason GE, Aung L, Gall S, Meyers PA, Butler R, Krüg S, *et al.* Quality of life following amputation or limb preservation in patients with lower extremity bone sarcoma. Front Oncol 2013; 3:210.

22 Tsukushi S, Nishida Y, Suguiura H, Nakashima H, Ishiguro N. Results of limb salvage surgery with vascular reconstruction for soft tissue sarcoma in the lower extremity: comparison between only arterial and arteriovenous reconstruction. J Surg Oncol 2008; 97:216–220.

23 Aguiar Junior S, Ferreira FO, Rossi BM, Santos EM, Salvajoli JV, Lopes A. Neoadjuvant chemoradiation therapy for soft tissue sarcomas of the extremities. Clinics (Sao Paulo) 2009; 64:1059–1064.

24 El-Zohairy MAF, El-Samadoni A, El-Sherbieny ME, Anwar H. Limb-Sparing surgery with vascular reconstruction for extremity soft tissue sarcomas: surgical, oncological and functional outcomes. J Egypt Nat Cancer Inst 2008; 20:244–252.

25 Poultsides GA, Tran TB, Zambrano E, Janson L, Mohler DG, Mell MW, Avedian RS. Sarcoma resection with and without vascular reconstruction: a matched case-control study. Ann Surg 2015; 262:632–640.

26 Matsushita M, Kuzuya A, Mano N, Nishikimi N, Sakurai T, Nimura Y, *et al.* Sequelae after limb-sparing surgery with major vascular resection for tumor of the lower extremity. J Vasc Surg 2001; 33:694–699.