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RESEARCH ARTICLE

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Surgical management of soft tissue tumors of the abdominal wall: A retrospective study in a high-volume sarcoma center

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Abstract

Background: The aim of the study is to evaluate functional and oncological outcomes of patients undergoing abdominal wall soft tissue tumors (AWSTT) surgery.

Methods: All consecutive patients that underwent surgery for malignant and intermediate AWSTT from 1999 to 2019 were retrospectively analyzed.

Results: Ninety-two patients were identified, 20 (22%) operated on for a desmoid tumor and 72 (78%) for a soft tissue sarcoma (STS). Fifty-two patients (57%) had in toto resection of the abdominal wall (from the skin to the peritoneum) and 9 (10%) required simultaneous visceral resection. The closure was direct in 28 patients (30%) and requiring a mesh, a flap or a combination of the two in respectively 42, 16, and 6 patients (47%, 17%, 6%). The postoperative complications rate was 26%. Thirteen patients (14%) developed an incisional hernia after a median delay of 27 months. After a median follow-up of 40 months, out of the 72 patients operated on for STS, 7 (10%) developed local recurrence and 11 (15%) distant recurrence. The median recurrence-free and overall survivals were 61 and 116, months respectively.

Conclusions: Management of AWSTT requires extensive surgery but allows good local control with an acceptable rate of incisional hernia.

KEYWORDS

abdominal wall, flap, mesh, recurrence, sarcoma, surgery

1 | INTRODUCTION

Soft tissue tumors developing within the abdominal wall encompass a wide spectrum of pathologies ranging from benign to high-grade malignancies. Desmoid tumor (DT) and soft tissue sarcomas (STS) are the two most common soft tissue tumors.[1,2] DT is a rare and locally aggressive monoclonal, fibroblastic proliferation that is characterized by an unpredictable clinical course and has an estimated yearly incidence of 5–6 cases per million. Active surveillance (i.e. "wait & see") is the recommended primary approach in case of abdominal wall DT, and surgery is only discussed after failing observation.[3] STS is a rare heterogeneous tumor accounting for 1% of all cancers, with an estimated annual incidence of 40–50 cases per million.[4] Primary abdominal wall STS accounts for less than 5% of all STS for which en bloc resection of the tumor is the standard treatment.[5]

Radiotherapy and/or chemotherapy may be used in addition to surgery in selected cases.[6,7] Abdominal wall surgery remains challenging because, apart from achieving tumor-free margins, it is essential to provide adequate coverage of the defect and restore abdominal wall functionality. Closure can be performed either by direct repair or by using several other reconstructive options such as skin graft, musculocutaneous flaps, and prosthetic mesh. There is limited data to conclusively suggest the most appropriate method. The current study aimed to evaluate the functional and oncological results after the surgical resection and reconstruction for abdominal wall soft tissue tumors.

2 | METHODS

2.1 | Study population and data collection

All consecutive patients with a primary or recurrent non-benign soft tissue tumor of the abdominal wall who underwent surgery in our tertiary care center between January 1999 and May 2019 were identified. Data pertaining to demographic variables, primary tumor characteristics and management, operative data, tumor pathology, and outcomes were retrospectively retrieved from a prospectively maintained database. The final follow-up was in October 2019. All patients underwent preoperative imagine, either abdominal and thoracic computed tomography (CT) or magnetic resonance imaging (MRI) and thoracic CT in case of STS.

2.2 | Tumor diagnosis and classification

Preoperative histopathological diagnosis was systematically made following percutaneous needle core biopsy or a review of pathologic material from prior resection in cases of recurrence or those wherein previous surgery was unsuccessful or inadequate. All surgical specimens were analyzed by an expert pathologist and retrospectively classified according to the 2013 World Health Organization (WHO) classification of Tumors of Soft Tissue and Bone; further molecular analysis was performed when necessary.[8] Accordingly, tumors were subdivided into four categories according to their biological behavior: benign, locally aggressive, intermediate, and malignant.[8] The pathological analysis included tumor grading using the FNCLCC classification and the UICC TNM staging system.[8,9]

2.3 | Treatment

The need to perform a complex surgery or the provision of preoperative chemotherapy or radiotherapy was determined based on the decision of a multidisciplinary tumor board (MTD) which included surgeons, medical oncologists, radiation oncologists, and radiologists specializing in sarcoma care. For DT, surgery was planned after failure (i.e. tumor growth) of initial observation or medical treatment. In case of STS, surgery was scheduled upfront for malignant, intermediate, or locally aggressive tumors. Chemotherapy was considered for high-grade tumors or in cases wherein it would facilitate subsequent surgery. Radiotherapy was considered for high-grade tumors, tumor size of more than 5 cm in diameter and in cases wherein planned marginal (R1) resection is indicated. The surgical technique involved a 4-step procedure, as illustrated in Figure 1. First, the lateral margin is defined either to achieve complete resection with a microscopically clear margin (R0) or with planned complete resection with positive contact margin (R1, i.e. planned marginal resection) to spare critical structures (the bone, testis, inguinal ligament, limb root, ribs, etc.). Second, the superficial and deep margins were defined to achieve a compartmental resection within two non-invaded anatomical barriers (skin and subcutaneous fat, superficial aponeurosis, muscle, deep aponeurosis, peritoneum, including abdominal viscera, but only when overtly invaded). Third, the need for chemotherapy and/or radiotherapy were determined pre-operatively. Lastly, the method for reconstruction was chosen depending on the abdominal wall defect; direct closure was preferred for closing defects smaller than 5 cm and those with a tension-free repair, whereas surgical repair with mesh reinforcement (either biological or synthetic mesh) was preferred for larger defects. Primary closure of the defect before placement of the mesh was performed when possible.

2.4 | Postoperative outcomes

Postoperative morbidity and mortality were assessed within 90 days of surgery using the Clavien-Dindo classification.[10] Postoperative complications were considered significant when the grade was greater than 2. Follow-up evaluation was performed every 3 months during the first 3 years, biannually until the fifth year, and annually thereafter.

2.5 | Statistical analysis

Quantitative variables were presented as median (range) and compared using the Wilcoxon's test. Qualitative variables were presented as count (percentage) and compared with the χ^2-test or Fisher's exact test, as appropriate. The Kaplan-Meier method was used to estimate recurrence-free survival (RFS) and overall survival (OS) of STS. Desmoid tumor were excluded of the survival analysis.

3 | RESULTS

3.1 | Studied population and tumor characteristics

The patients' baseline characteristics are detailed in Table 1.

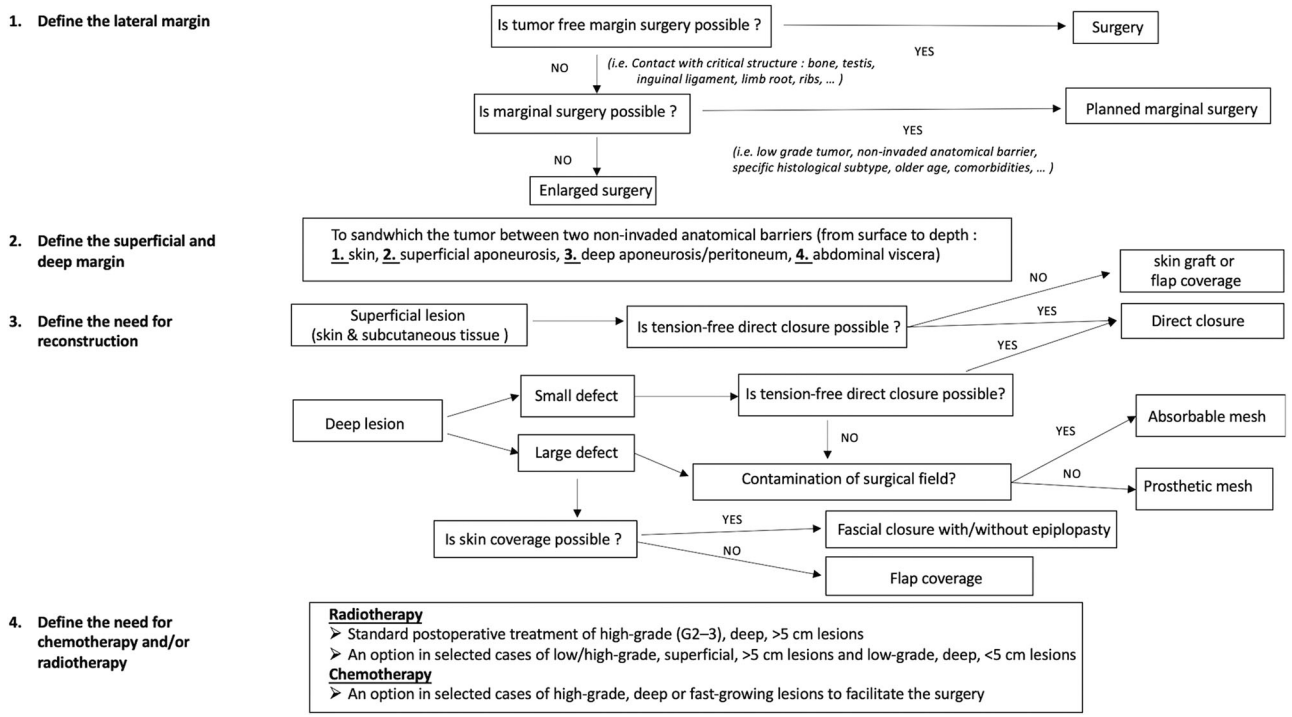


FIGURE 1 Management strategies for surgical and adjuvant treatment

3.2 | Soft tissue sarcomas

Seventy-two patients (median age: 54 [range, 17–89] years) with soft tissue sarcomas of the abdominal wall were identified. Of these, 43 (60%) were male and 29 (40%) were female. Forty-one (57%) patients had previously undergone a surgery resulting in incomplete resection (R2). The mean time to local recurrence was 18 months (IQR, 25-75: 3–35). The median tumor size was 10 cm (range, 1–88 cm) and almost all tumors (93%) were located beneath the superficial aponeurosis. Sixty patients (83%) had a malignant tumor and 12 (17%) had an intermediate tumor. The most frequent histological subtypes were dedifferentiated liposarcomas in 31 (43%) patients, undifferentiated (pleomorphic) sarcomas in 11 (15%), and synovial sarcomas in 6 (8%). Twenty patients received preoperative treatment—15 (21%) patients received chemotherapy and 5 (7%) received radiotherapy. No tumor progression under treatment was recorded.

3.3 | Desmoid tumors

Twenty patients with desmoid tumors of the abdominal wall were identified. Unlike STS, desmoid tumors demonstrated a predilection for female patient (18 patients [90%] were women). Median age for this cohort was 32 [range, 23–56] years. All tumors were located beneath the superficial aponeurosis and the median tumor size was 12 cm (range, 2–21 cm). Five patients (25%) had a locally recurrent tumor previously treated elsewhere; these patients underwent immediate surgery for progression. For the remaining 15 (75%) patients, a "wait & see" approach was initially adopted. These patients received various systemic treatments, including nonsteroidal anti-inflammatory drugs, hormone deprivation therapy (tamoxifen, triptorelin), or chemotherapy (methotrexate or vinorelbine). Surgery was performed only in case of volumetric progression and/or symptom worsening.

3.4 | Surgery

The operative details are depicted in Table 2. The median operative time for all procedures was 166 min (range, 20–323 min). Fifty-two (57%) patients required full-thickness abdominal wall resection. Twenty (22%) patients underwent an associated inguinal ligament resection with or without orchidectomy, and 4 (4%) patients underwent an associated bone resection (either iliac crest or rib). Nine (10%) patients required a visceral resection (colon ($n = 4$), kidney ($n = 3$), spleen ($n = 1$), and pancreas ($n = 1$). Direct closure was performed in 28 patients (30%). In 48 patients, a mesh reconstruction was required (GORE-TEX® mesh in 38 patients, polypropylene mesh in 5 patients, and long-acting absorbable mesh in 5 patients). A pedicled flap was used in 15 (16%) patients and a free flap in 11 (12%) patients. In 10 (11%) patients, reconstruction was performed using both a flap and a mesh.

3.5 | Postoperative outcomes and treatments

There were no postoperative deaths. The overall complication rate was 26% ($n = 24$) and that of severe morbidity (Dindo-Clavien 3/4) was 16% ($n = 15$). Wound-related complications occurred in 23 (25%) patients,

TABLE 1 Baseline characteristics of the patients and the tumors

Patients' characteristics		All histologies	Sarcomas	Desmoïd tumors
Number of patients	92	72	20	
Sex				
	Female	47 (51%)	29 (40%)	18 (90%)
	Male	45 (49%)	43 (60%)	2 (10%)
Median age, years [range]		50 ± 13.4 [17–89]	54 ± 13.4 [17–89]	32 ± 7.3[23–56]
Tumor size	10 [1–88]	10[1–88]	12[2–21]	
	< 5 cm	16 (17%)	11 (15%)	5 (25%)
	5–10 cm	51 (56%)	48 (63%)	3 (15%)
	> 10 cm	25 (27%)	13 (18%)	12 (60%)
Localization				
	Superficial	5 (5%)	5 (7%)	0
	Deep	87 (95%)	67 (93%)	20 (100%)
Histological subtype (WHO 2013)				
	Dediferenciated liposarcoma	31 (34%)	31 (43%)	N/A
	Desmoïd tumor	20 (22%)	N/A	20 (100%)
	Undifferentiated sarcoma	11 (12%)	11 (15%)	N/A
	Synovial sarcoma	6 (7%)	6 (8%)	N/A
	Solitary fibrous tumor	5 (5%)	5 (7%)	N/A
	DFSP	4 (4%)	4 (6%)	N/A
	Leiomyosarcoma	3 (3%)	3 (4%)	N/A
	Fibrosarcoma	3 (3%)	3 (4%)	N/A
	Mixoid liposarcoma	2 (2%)	2 (3%)	N/A
	Other	7 (8%)	7 (10%)	N/A
FNCLCC grade				
	1	11 (12%)	11 (15%)	N/A
	2	40 (43%)	40 (56%)	N/A
	3	10 (11%)	10 (14%)	N/A
	N/A	31 (34%)	11 (15%)	N/A

Abbreviations: DFSP, dermatofibrosarcoma protuberans; N/A, not available.

including cellulitis ($n = 4$) treated with antibiotic, hematoma ($n = 3$) requiring surgical drainage, noninfected lymphatic collection ($n = 2$) treated with needle aspiration, flaps/skin necrosis ($n = 3$ of 22 flaps; 14%), and deep abscesses ($n = 11$) drained surgically ($n = 6$) (with early mesh removal in two patients) and percutaneously ($n = 5$). Two patients developed delayed mesh infection, 8 and 44 months after surgery, respectively, therefore requiring mesh removal. In the four cases requiring mesh removal, abdominal wall defect was treated either with exclusive skin closure ($n = 3$) or with absorbable mesh as bridging repair ($n = 1$). In 15 cases, complications were caused by bacterial infection. The most common causative microorganisms were *Staphylococcus aureus*, *Escherichia coli*, and anaerobic bacteria.

TABLE 2 Intraoperative details

Intraoperative details (N = 92)	Intraoperative details (N = 92)
Associated resection	
Skin	21 (23%)
Inguinal ligament	20 (22%)
Testis	15 (16%)
Bone	4 (4%)
Colon	4 (4%)
Kidney	3 (3%)
Perineal muscle	3 (3%)
Great vessel	2 (2%)
Great nerve	1 (1%)
Pancreas	1 (1%)
Psoas muscle	1 (1%)
Spleen	1 (1%)
Diaphragm	1 (1%)
Reconstruction	
Direct closure	28 (30%)
Pediculated flap	10 (11%)
Free flap	2 (2%)
Pediculated + free flap	4 (4%)
Goretex mesh	36 (39%)
Goretex mesh + flap	2 (2%)
Polypropylene mesh	4 (4%)
Polypropylene mesh + Pediculated flap	1 (1%)
Long-acting absorbable mesh	2 (2%)
Long-acting absorbable mesh + flap	3 (3%)
Margin	
R0	68 (74%)
R1	24 (26%)

3.6 | Long-term oncological outcomes

3.6.1 | Soft tissue sarcoma

The median follow-up period after surgery was 40 months (IQR, 25–75: 15–106). Thirty patients received postoperative treatment: 1 (1%) patient received adjuvant chemotherapy and 29 (3%) patients received radiotherapy.

Recurrence, either local or distant, was observed in 18 (25%) patients at a mean follow-up period of 34 months (IQR, 25-75: 9–90). Seven patients (10%) developed local recurrence and 11 (15%) developed distant metastasis. Distant recurrence occurred at a single site in 8 (73%) patients and at two or more sites in 3 (27%) patients. Histological subtypes of tumors developing distant recurrence were dedifferentiated liposarcomas ($n = 5$), undifferentiated (pleiomorphic) sarcoma ($n = 4$), and synovial sarcomas ($n = 2$). Histological subtypes developing local recurrence were undifferentiated (pleiomorphic) sarcoma ($n = 6$) and dedifferentiated liposarcoma ($n = 1$). The median RFS was 61 months. The 2- and 5-year RFS rates were 84% and 59%, respectively (Graph 1). The median OS was 116 months. The 2- and 5-year OS rates were 93% and 84%, respectively (Graph 2).

3.6.2 | Desmoid tumors

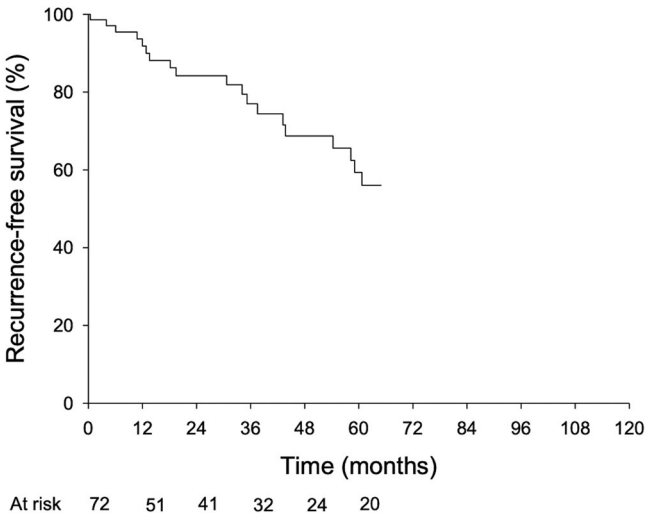
Of the 20 patients with abdominal wall DT, 3 (15%) developed local recurrence at a mean of 31 months (IQR, 25–75: 24–39).

3.7 | Long-term functional outcomes

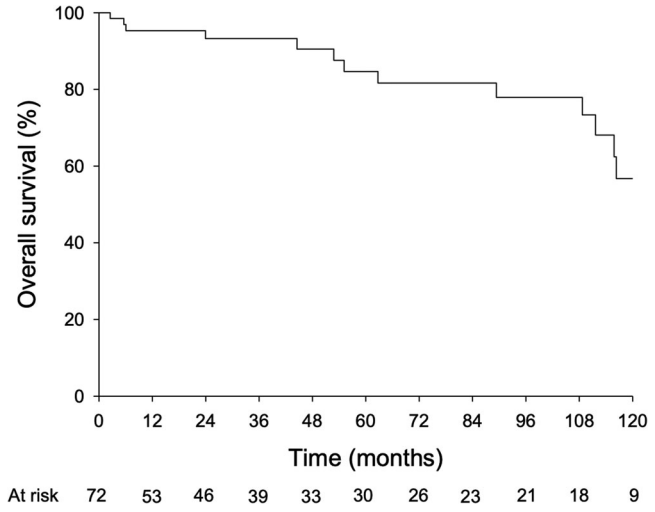
Incisional hernia was diagnosed in 13 patients after a median delay of 27 months (range, 3–72 months). Of these 13 patients, 5 (38%) presented with wound-related complications. Three patients underwent surgery for hernia repair. Ten patients, despite 7 of them being symptomatic, refused to undergo another abdominal wall surgery.

4 | DISCUSSION

Soft tissue tumors involving the abdominal wall included a heterogeneous group with distinct clinical behaviors and patterns of relapse. Although benign tumors outnumber sarcomas by a ratio of at least 100 to 1 and in consideration of the consequences of inadequate treatment, patients with soft tissue mass localized beneath



GRAPH 1 Recurrence-free survival



GRAPH 2 Overall survival

the fascia or with any superficial soft tissue lesion larger than 5 cm should be referred to centers specializing in sarcoma care for diagnosis.[11–15] It is critical to obtain an expert's opinion in the management of these cases. In cases of DT, the second most common tumor in this series, the initial nonsurgical approach is the gold standard and treatment is only suggested in case of tumor growth; starting with systemic treatment (NSAID, low-dose chemotherapy, or tyrosine kinase inhibitors).[16–19]

The quality of initial surgery is also critical in localized STS wherein treatment in a specialized center reduces the risk of relapse and optimization of OS.[15] The definition of a clear margin is still controversial. One millimeter of normal tissue between the tumor and the inked resection is necessary to consider the negative margin using the Union International Union against Cancer (UICC) classification.[20] Nevertheless, the free-margin in sarcoma cannot only depend on distance (i.e., quantity) as the quality of the margin impacts prognosis. Resistant anatomical barriers (fascia, adventitia, perineurium, periosteum, etc.) potentially limit tumor spread, and recent studies suggested multidisciplinary treatment may be suitable in case of anticipated less than 1-mm margin (R1).[21–23] This point is critical as the attainment of 1-mm margin would indicate the need for extensive surgery with considerable postoperative function impairment. Margins must be planned during multidisciplinary discussion with the aim to "sandwich" the tumor within two resistant layers of uninvaded tissue from the shallowest to the deepest layers: skin, superficial aponeurosis, deep aponeurosis/peritoneum/abdominal viscera. If a 1-mm lateral margin cannot be achieved without severe postoperative impairment, several factors, including histological subtype, grade, and localization must be taken in balance to decide whether resection should be performed or if preoperative therapies should be considered. Another factor to be considered when defining the surgical margin is the histological subtype. For instance, dermatofibrosarcoma protuberans (DFSPs) exhibit a specific and highly invasive growth pattern with clinically undetectable fingerlike projections of the tumor which requires a wider surgical excision.[24] Although more than half (57%) of the tumors that were resected required a full-thickness abdominal wall resection, 22% were resected en bloc with bone, 10% with intra-abdominal viscera, 4% with inguinal ligament, and marginal (R1) resection was still observed in 26% of patients but was not associated with higher local recurrence. The margin planification scheme is illustrated in Figure 1.

The closure is also critical in surgical operation discussions. Direct closure is the easiest technique and it is associated with a low morbidity (11% of severe complications) and good long-term results (11% of incisional hernia) but can only be performed for patients with small tumors (maximal size of 8 cm in our series). Both the benefits and the possible complications need to be considered when deciding the treatment strategy. One patient in our series required emergency flap covering because of skin necrosis and postoperative evisceration. Abdominal wall reconstruction was necessary in 60%–90% of the cases in the literature and in 70% of cases in our study.[25] In most cases (39%), reconstruction of a large defect was accomplished using a prosthetic mesh. Previous studies examining synthetic mesh to repair abdominal wall defects have reported a complication rate of 10.5% and the highest incidence of complication was found when the mesh was placed after intra-abdominal organ resection.[2] Mesh infection remains the most feared complication and occurs between 1% and 8% after ventral hernia repair in non-oncologic setting. In our study, seven patients developed infection of the mesh. Conservative management with percutaneous or surgical drainage was successful in three patients. Although no statistically significant risk factor for infectious complication was identified in our series, a 23% rate of infectious complications was observed in patients with a mesh reconstruction compared to 14% in patients without a mesh. These results may illustrate abdominal wall soft tissue tumor (AWSTT) surgery being at high risk of infection by itself. To prevent complications, strategies intend to reduce modifiable risk factors (including smoking, obesity, diabetes mellitus and COPD) but the use of absorbable material may also be an option. Since a few years, we favor the systematic use of long-acting absorbable biologic mesh as a bridge to avoid infectious complication or the need for mesh removal if infection occurs. This attitude may be associated with a higher rate of postoperative hernia but a definitive repair with a nonabsorbable mesh is still possible afterwards, distant from the oncologic surgery.[26] The use of mesh alone is unsuitable for defects with insufficient skin/soft tissue coverage. In cases wherein only the skin and subcutaneous tissues are involved, the functional integrity of the abdominal wall is rarely compromised, and coverage may be achieved with direct suture or the use of a skin graft or local flap. In cases wherein the anticipated defect is large and coverage using a mesh would be insufficient, flaps provide coverage with well-vascularized multilayer tissue. Another benefit of using flaps is the coverage for exposed vital structures such as femoral vessels or bone. Recently, flaps have been used to restore lost function after surgery, as illustrated with inguinal ligament reconstruction by transposition with a pedicled sartorius muscle flap. The decision between pedicled or free flaps is difficult. Free flap reconstruction is technically more demanding but always feasible. As pedicled flap is

associated with a lower rate of complications, it is especially useful for critically ill patients with comorbidities, but it is associated with specific donor site morbidity and may result in abdominal weakness. The reconstruction scheme is illustrated in Figure 1.

The oncological results observed in our study were comparable to those found in the literature.[4,11,13,23] Seven patients (8%) developed local recurrence and 11 (15%) developed distant metastases (mostly pulmonary) after a median follow-up period of 40 months.

These results were made possible because of a systematic discussion in a specialized MTD to select good indications for surgery and/or radiotherapy. The therapeutic sequence depended on tumor size, grade, and the proximity of radiosensitive viscera (small bowel, liver, and kidney) to balance ballistic performance and postoperative morbidity.[27,28]

Preventing the occurrence of distant metastases is challenging. Determining patient suitability for chemotherapy in non-metastatic STS is still difficult today as illustrated in our study; it was initiated preoperatively for only one patient because of the fast-growing high-grade tumor.

5 | CONCLUSIONS

AWSTT are rare and should be managed in specialized centers to ensure appropriate and effective surgical treatment, including complex reconstruction, for functional restoration. Surgery for AWSTT carries a low risk of complications (16%), but when complications occur, conservative treatment has demonstrated limited success, especially that involving the use of mesh. Using multimodal care enables excellent local control, although preventing distant recurrence remains a challenge.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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