Chapter 36
Surgical Approach and Management of Tumors of the Sartorial Canal
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BACKGROUND
- Tumors of the sartorial canal are a unique group of tumors: they are extracompartamental space tumors with close proximity to the superficial femoral artery and vein.
- The sartorial canal, synonymous with the subsartorial canal, canal of Hunter, and femoral and adductor canal, runs from the femoral triangle proximally to the popliteal fossa on its distal end.
- Soft tissue sarcomas of the sartorial canal are rare, accounting for less than 2.5% of all soft tissue sarcomas.
- In the extremities, the distinction is made between intracompartmental and extracompartamental tumors because the two behave differently (Enneking stage Ia versus IIb). Tumors arising in the extracompartamental spaces may spread rapidly longitudinally far beyond their intracompartamental counterparts, and wide resection of these tumors is more demanding due to their proximity to major neurovascular structures.
- Space tumors are a subgroup of tumors of the extracompartamental spaces. Such extracompartamental spaces are namely the sartorial canal, popliteal space, femoral triangle, and axilla.
- A common assumption is that intracompartamental tumors are more amenable to control by local procedures (ie, easier to evaluate preoperatively and easier to resect surgically, with lower recurrence rates) compared with extracompartamental tumors. The only tumor factors proven to have a real prognostic effect are size, malignancy grade, depth, histotype, and local recurrence. Anatomic space or compartmental space has not been shown to have a significant prognostic impact. The surgical assumption is that treatment of space tumors is difficult, has more complications and a higher local recurrence rate, and may require primary amputation.

ANATOMY
- The canal lies between the anterior (quadriceps) compartment and the medial adductor compartment, connecting the tip of the femoral triangle in the proximal thigh to the popliteal space in the distal posterior aspect of the thigh. All three are considered “spaces” of the thigh, and each carries its own unique soft tissue tumors, presentation, treatment options, and hazards.
- Cross-section of the sartorial canal is shaped like an inverted triangle. The roof of the canal is the sartorius muscle, which lies anterior and medial to the canal. The adductor longus makes up the floor of the canal. The lateral border is the thick fascia of the vastus medialis. Posteriorly the border of the canal is the adductor compartment, namely the adductor magnus. Both the posterior and lateral borders are covered with thick fascia. The superficial femoral artery and the femoral vein enter the canal through the tip of the femoral triangle. These structures lie deep in the canal, where they are surrounded throughout its length with very thick fascial sheath. The vessels exit the canal at the distal medial end, through the adductor hiatus, a foramen in the distal part of the adductor magnus.

INDICATIONS
- Tumors of the sartorial canal are often malignant and should all be removed as soon as possible. Tumors of the canal are all deep tumors that are in intimate proximity with the main vessels to the lower limb. Small tumors are as suspicious as large tumors because they may be high-grade tumors about to invade the vessels. Early resection avoids vessel involvement and thus lessens the need for arterial resection and reconstruction and most likely lowers the risk of metastatic disease with high-grade tumors. Tumors of the sartorial canal should not undergo core needle biopsy but rather excisional biopsy with frozen section during surgery.
- Patients present initially with a painless mass in the medial thigh. Some of the masses may be larger than 20 cm and may have been growing slowly for years. There is no clear correlation between the size of the tumor at presentation and its malignancy.

IMAGING AND OTHER STAGING STUDIES
Plain Radiography
- Plain radiography studies are performed to rule out local invasion of the femur by the tumor and to rule out soft tissue calcifications (pathognomonic of synovial sarcoma and hemangiomas).

Computed Tomography and Magnetic Resonance Imaging
- CT with 3D reconstruction and arterial contrast has been used to assess the anatomic relation between the main vessels of the limb and the tumor. Due to the small space in the canal and the proximity to the vessels, tumors distort the normal anatomy early in their growth and may displace the vessels. Therefore, good imaging is crucial.
- MRI is used to assess the tumor’s anatomic relation to the vessels and to evaluate the tumor’s size and invasion of neighboring anatomic structures, namely the muscles bordering the canal and the proximal and distal extent, the femoral triangle, and popliteal spaces (FIG 1, 2A).
- MRI often identifies the specific structure from which the tumor arises and invades the canal (sartorius, vastus medialis, and adductor muscles).

Bone Scan
- Bone scan is used to rule out distant metastatic disease and may give a clue about the malignancy of the tumor: high-grade tumors show a strong tumor blush in the late arterial flow phase of the three-phase technetium bone scan.
Angiography and Other Studies
- Angiography is used to assess the vascularity of the tumor, tumor blush, the location of the vessels feeding it, and the relation between the tumor and the femoral artery, which indicates whether the vessel was displaced by the tumor or is invading the vessels (FIG 2B).
- Venography of the limb is used to rule out venous thrombus, tumor thrombus (mural thrombus), or direct tumor involvement.

Biopsy
- Core needle biopsy and open incisional biopsy are problematic in the sartorial canal. Therefore, biopsy should be done using frozen section at the time of definitive surgery. Most tumors within the sartorial canal are malignant, so all should be removed. The risk of a biopsy with either an inaccurate diagnosis or local contamination warrants the consideration of primary resection.
- The proximity of the tumor to the vessels carries several disadvantages when considering biopsy:
  - Hematoma from the biopsy site may spread along the vessels, thus contaminating the extremity and necessitating an amputation.
  - Tumors such as leiomyosarcomas may arise from the vessel walls; therefore, the main vessels may be punctured at the time of biopsy, causing significant bleeding.

Surgical Management
- Tumors of the sartorial canal are space tumors. The goal of treatment is function-preserving limb conservation.
- Wide surgical resection can be achieved by respecting intact biologic barriers such as fascia. Vascular involvement may occur in patients with high-grade tumors of the canal and should be treated with resection and reconstruction; a vascular surgeon needs to be on standby. Soft tissue reconstruction with the sartorius muscle or with gracilis muscle transfer is important to protect the resection bed and vessels to avoid postoperative complications. Radiation therapy and chemotherapy should be used based on the grade, histology, and size of tumor and the surgical margins.
- Unique anatomic and surgical considerations:
  - To identify the vessels, wide exposure is essential in a canal distorted by a large tumor. Vessels may be identified either at the entrance to the canal near the femoral triangle, or at the canal’s distal end, near the adductor hiatus, as they come in from the popliteal fossa between the two heads of the gastrocnemius. If necessary, the head of the medial hamstring and gastrocnemius is detached to achieve...
wide exposure. Proximal and distal control of the vessels should be achieved before beginning to resect the tumor.

There are two main venous tracts that drain blood from the limb, the popliteal vein and the greater saphenous vein. Care must be taken not to damage the saphenous vein because resection of the femoral vein may be unavoidable due to tumor invasion. Ligation of both veins would lead to severe venous insufficiency of the limb.

A thick fascial sheath covers the superficial femoral artery and vein throughout its length. This fascia often separates the tumor from these major vessels and provides a safe plane of dissection. This fascia is routinely analyzed under frozen section during surgery to confirm the adequacy of resection. In these extracompartamental resections, achieving 1 cm of normal tissue borders is often not possible. Sarcomas are known to respect fascial boundaries; therefore, dissecting an intact adventitia off the vessels that is free of tumor on pathologic inspection should provide sufficient resection margins.

Preoperative Planning

Tumors of the sartorial canal may be divided according to their anatomic and surgical location into three types of resections. This classification is designed to serve as a guideline for the surgeon. By analyzing preoperative imaging and the initial intraoperative surgical impression, the surgeon can assess the structures from which the tumor arises and the appropriate plane of resection. These guidelines correlate with the surgical margins and, in general, the higher the number the more difficult the surgical resection and reconstruction will be.

Tumors are classified according to the location from which they originate (FIG 3):

- Type 1 (luminal) tumors arise from within the space. Typically they originate from fat or fibrous tissue within the space and lie loose in the space. We call these tumors “luminal” because they may approximate but are not adherent to the walls of the space or any of the arteries, veins, and nerves in the sartorial canal.

![FIG 3](image-url) Systematic resection of extracompartamental space tumors of the sartorial canal. The left column shows axial MR images of the three different types of tumors in the sartorial canal. The middle column shows a schematic of the tumor location and the right column shows the recommended planes of surgical resection (dotted line). Resections from 1 to 3 are presented in the rows from top to bottom. Type 1 (luminal) tumors lie within the space and are resected with a thin cuff of tissue that surrounds them. Type 2 (wall) tumors arise from the muscles surrounding the space and are resected as a typical muscle resection. Type 3 (vessel) tumors invade the vessels and are therefore resected en bloc with the vessels.
TECHNIQUES

- Type 2 (wall) tumors arise from one of the walls that border the sartorial canal (sartorius, vastus medialis, adductor magnus or adductor longus muscles). These tumors arise from within a muscle or the muscle’s fascia that borders the space.

- Type 3 (vessel) tumors involve arteries, veins, or nerves. These lesions originate from the vessel wall and are not simply juxtaposed to it.

- Tumors are classified into one of these three types according to the preoperative imaging and the surgeon’s intraoperative impression. Each type of tumor should be resected with different plane of resection:
  - Type 1 tumors are resected with a thin layer of normal tissue that abuts the tumor. This normal tissue is typically the thick encasing fascia over the vessel. Vascular resection is not required. At times these tumors almost deliver themselves once the space is opened. Tumor margins, although negative, are often close. The fibrous sheath surrounding the vessels is inspected by carefully resecting it and examining the sheath on frozen section to rule out tumor invasion.
  - Type 2 tumors are essentially resected with the muscle from which they originate. Wide surgical resection is achieved by resecting the tumor with a large cuff of muscle of origin, the fascia covering that muscle, and adjacent fat from within the canal.
  - For type 3 tumors, there is no safe way to resect the lesion and guarantee negative margins without resecting the vessel itself. The vessel and the lesion must be resected en bloc with adjacent muscle or fascia as required. If the artery is resected it must be reconstructed with a synthetic graft or a reverse saphenous vein graft. Venous resections do not need reconstruction as long as the ipsilateral saphenous vein is intact. Because the tumor is resected en bloc with the vessel, these resections, although challenging surgically in their reconstructive aspects, are relatively simple in their tumor resection aspects and in achieving wide surgical margins.

Positioning

- The patient is placed in the supine position and the leg is prepared and draped. The contralateral leg should be prepared and draped as well in case a saphenous vein graft is needed for vascular reconstruction.

Approach

- The skin incision is made along the sartorius muscle throughout its length as necessary. Fasciocutaneous flaps are raised anteriorly and posteriorly for wide exposure. (FIG 4).

- The sartorius muscle is disconnected at its distal end and the inferior border of the muscle is retracted anteriorly. The canal is carefully dissected open.

- At this point it is important to identify and control the major vessels at both ends of the canal, near the adductor hiatus and the femoral triangle. Small perforating vessels connecting the tumor to the main vessels are ligated.

- The surgical classification for tumors of anatomic spaces helps dictate the type of resection needed for each type of tumor.

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**LIMB-SPARING RESECTION OF TUMORS OF THE SARTORIAL CANAL**

- In all these tumors, the surgeon should expose the vessels both proximally and distally and should dissect within a few millimeters from the vessels if the tumor is arising from one of the walls of the space and next to their sheath if the tumor is luminal. During this process the surgeon assesses whether the vessels have been invaded.

- From a surgical standpoint the main difference is between space tumors that invade the vessels and those that do not.

- Tumors are resected in a circumferential manner with wide margins. When the lesion is in intimate proximity to the vessels, the sheath of fibrous tissue surrounding the vessels should be resected en bloc with the tumor unless it is evident that it has not been invaded (TECH FIG 1A,B).

- The vessel sheath should be opened from the opposite side of the tumor to assess whether the tumor that adheres to the sheath has invaded the vessel wall as well.

- When the tumor does not seem to grossly invade the vessels, the sheath that has been resected en bloc with the tumor should be examined on frozen section to rule out microinvasion.

- Tumors that continue from the canal into the popliteal fossa need to be dissected free through wide exposure of the popliteal fossa, which necessitates disconnecting the femoral insertions of the medial hamstrings and gastrocnemius.

- In type 3 lesions the vessel must be sacrificed and reconstructed. The vessel is heparinized, clamped, resected, and reconstructed with a reverse saphenous graft taken from the contralateral leg or a Gore-Tex graft.

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**FIG 4 • Surgical approach to resecting a tumor of the sartorial canal. Skin incision is carried along the sartorius muscle. Fasciocutaneous flaps are raised anteriorly and posteriorly for wide exposure. The sartorius muscle is either resected with the tumor if necessary from an oncologic point of view or disconnected distally for wide exposure. The adductor hiatus is opened to better expose the vessels as they pass from the canal into the popliteal space (inset).**
The femoral vein may be sacrificed if the tumor is in intimate contact with it. If the saphenous vein is intact, there is no need to reconstruct the femoral vein.

The wound is marked with hemoclips for postoperative radiation therapy.

After tumor resection, the femoral vessels are covered with muscle flaps comprising either the sartorius muscle or, if that was excised with the tumor, the adjacent gracilis muscle. A gracilis muscle transfer (TECH FIG 1C) is done by dissecting the distal end of the gracilis free and rotating the muscle anteriorly to cover the canal. This provides good soft tissue coverage.

**PEARLS AND PITFALLS**

- Tumor may involve the vessels and necessitate resection of vessels.
- A vascular surgeon should be on call for reconstruction if needed.
- The contralateral leg is draped in case reverse saphenous vein grafting is needed.
- Loss of both the femoral and saphenous vein in the same leg will cause symptomatic edema.
- Injury to the saphenous vein is avoided during dissection, as the femoral vein may have to be resected due to tumor involvement.
- If both veins are nonfunctional, the femoral vein is reconstructed with a saphenous vein graft.
- Cover vessels with muscle to protect them in case of postsurgical superficial wound infection or wound dehiscence after radiation.
- The soft tissue of the canal is reconstructed with sartorius remnants and a gracilis muscle transfer.
- Using a wide anatomic surgical approach and careful surgical and reconstructive technique and tailoring the perioperative oncologic treatment, limb-salvage procedures are possible in most patients with soft tissue sarcomas of the sartorial canal with low residual morbidity.

**COMPLICATIONS**

- Complications of tumor surgery in the sartorial canal occur mainly when there is involvement of the vessels and reconstruction. These complications include deep infection, arterial occlusion, and deep vein thrombosis.

**REFERENCES**


