



Chapter **35** Soleus Resection

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BACKGROUND

- Malignant tumors of the soleus and gastrocnemius muscles are rare and have been traditionally treated with above-knee amputation. During the past 20 years, the treatment of soft tissue sarcoma of the lower extremities has undergone a dramatic shift toward limb-salvage procedures.
- Better understanding of the biologic behavior of these tumors, the availability of effective neoadjuvant chemotherapy (which often decreases the tumor size and facilitates a more conservative resection), and the recognition that close negative surgical margins in conjunction with postoperative radiation therapy often provide good local control now allow tumor resection instead of amputation in most cases.

ANATOMY

- The soleus and gastrocnemius muscles form a tripartite muscle sometimes referred to as the triceps surae muscle. Together with the plantaris muscle they form the superficial posterior muscle group of the leg. These muscles act together in plantarflexing the foot and ankle joint.
- The gastrocnemius muscle is the most superficial in the superficial posterior compartment and forms most of the prominence of the calf. It has two heads of origin. Its medial head is slightly larger and extends a little more distal than its lateral head. The two heads converge at the inferior margins of the popliteal fossa, where they form the inferolateral and inferomedial boundaries. The lateral head originates from the lateral surface of the lateral femoral condyle and the medial head arises from the popliteal surface of the femur, superior to the medial condyle.
- The soleus muscle is a broad fleshy muscle that lies deep to the gastrocnemius muscle. It arises from the posterior aspect of the head and superior fourth of the fibula, the soleal line, and the middle third of the medial border of the tibia. It also arises from the tendinous arch between the tibia and fibula, which arches over the tibial vessels. The soleus muscle and both heads of the gastrocnemius converge to form the Achilles tendon, which inserts into the posterior surface of the calcaneus.

INDICATIONS

- Tumors that arise from and are completely within the soleus muscle
- Most low-grade and some high-grade sarcomas

IMAGING AND OTHER STAGING STUDIES

Computed Tomography and Magnetic Resonance Imaging

- Careful examination of the CT and MRI is essential in determining resectability. Tumors that extend to and around the popliteal trifurcation or into the gastrocnemius muscles usually require an amputation (**FIG 1**).
- The popliteal space must also be evaluated. Proximal tumors arising within the soleus muscle often extend into the popliteal space and may involve the popliteal vessels, the sciatic nerve, or both.

Bone Scan

- Bone scans may show involvement of the adjacent tibia, fibula, or both.
- Areas of uptake should lead to close examination of the corresponding cuts of the MRI and CT scans.

Angiography and Other Studies

- Biplane angiography is very useful in determining vascular displacement or encasement.
- Careful analysis of the popliteal trifurcation is necessary before surgery and may indicate tumor involvement and thus the need for an amputation.

Biopsy

- The biopsy site should be in line with the planned incision for resection and must be located over the most prominent portion of the tumor.
- Core needle biopsy has been shown to provide reliable pathologic diagnoses and is our preferred method. Multiple samples can be collected from the same puncture site.
- Areas where major arteries and veins traverse should be avoided so as not to penetrate the vessels and risk tumor cell contamination.

SURGICAL MANAGEMENT

Positioning

- Resection is performed with the patient in a prone position. General or epidural anesthesia is used.

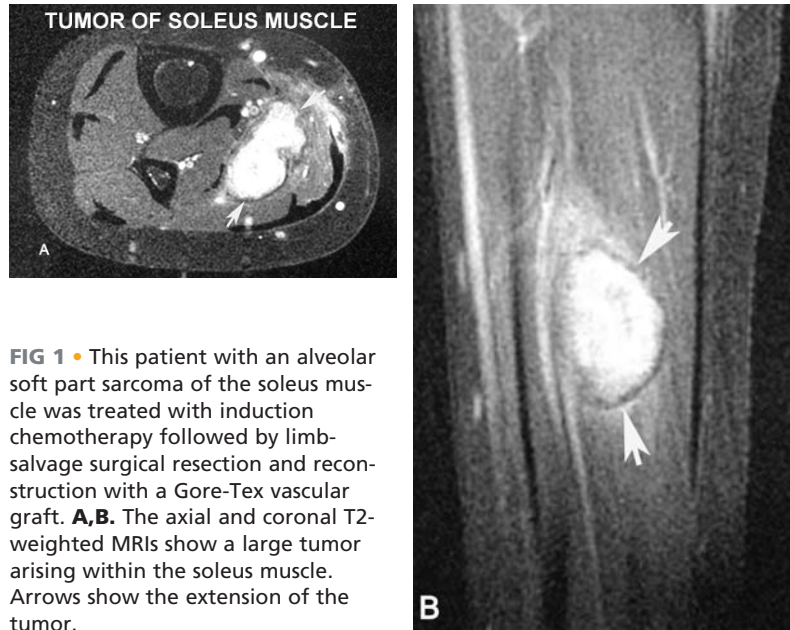
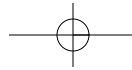
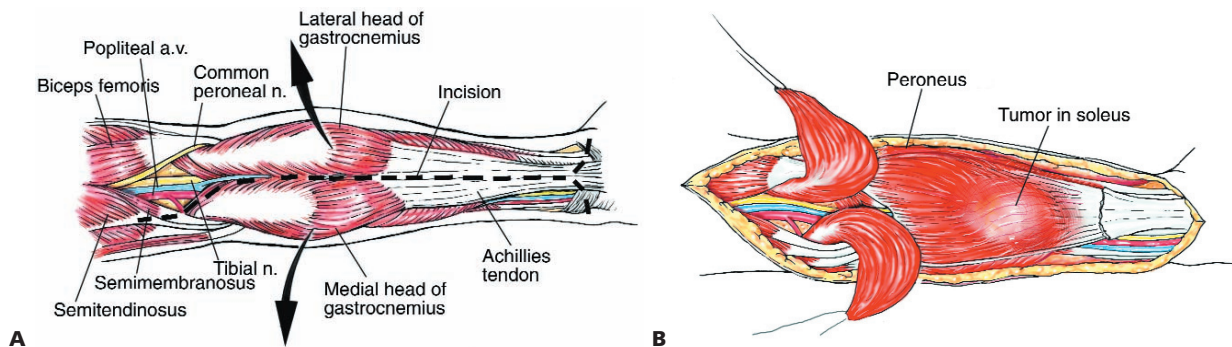


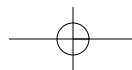
FIG 1 • This patient with an alveolar soft part sarcoma of the soleus muscle was treated with induction chemotherapy followed by limb-salvage surgical resection and reconstruction with a Gore-Tex vascular graft. **A,B.** The axial and coronal T2-weighted MRIs show a large tumor arising within the soleus muscle. Arrows show the extension of the tumor.

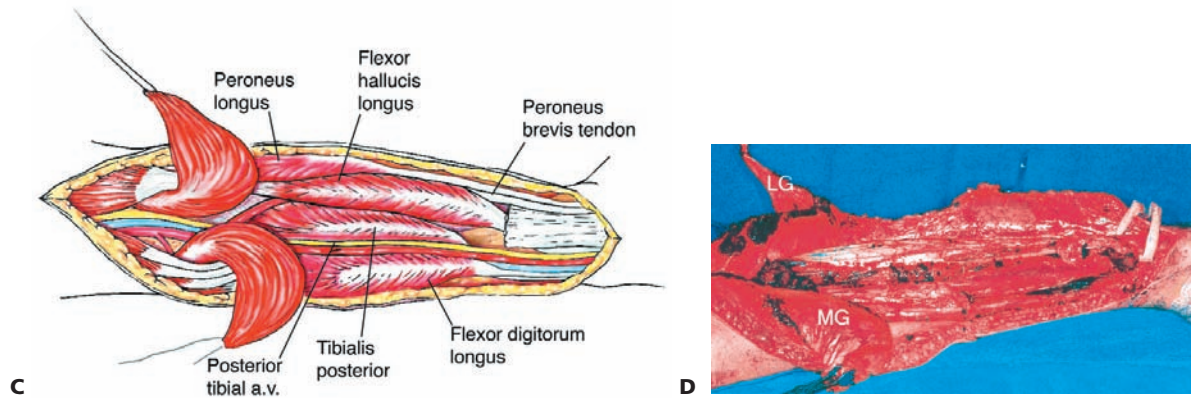
RESECTION OF SOLEUS MUSCLE WITH OR WITHOUT ADJACENT GASTROCNEMIUS MUSCLE

- The initial incision is made longitudinally on the posterior aspect of the leg and shifted medially or laterally, depending on the anatomic location of tumor (**TECH FIG 1A**). A lateral incision is used if resection of the lateral gastrocnemius is planned. A midline posterior incision is used for resections of the medial gastrocnemius, soleus, and deep posterior compartment.
- The fascia is dissected with the subcutaneous tissues, and large fasciocutaneous flaps are raised. The peroneal nerve is first identified and placed within a vessel loop; this is followed by careful dissection to identify the sciatic and tibial nerves.
- The popliteal vessels are identified by opening up the deep fascia overlying the two heads of the gastrocnemius. Radical excision of the medial or lateral heads of the gastrocnemius is achieved by ligation of their main pedicle (medial or lateral sural artery and vein, respectively) and transection of their femoral origin and insertion to the Achilles tendon.
- Exposure for resection of the soleus muscle is achieved by partial or complete Achilles tenotomy and reflection of the medial and lateral heads of the gastrocnemius muscle proximally (**TECH FIG 1B**).
- By blunt dissection the soleus is separated from the transverse intermuscular septum, which outlines the deep posterior compartment (**TECH FIG 1C,D**). The soleus can then be detached from its tibial and fibular origins and calcaneal insertion.
- Residual defects in the Achilles tendon should be reconstructed. The wound is then closed over closed suction drains.



TECH FIG 1 • **A.** Anatomy and a utilitarian approach to the posterior compartment of the leg. **B.** Exposure of the tumor and identification of the posterior vessels requires the release of the medial and lateral heads of the gastrocnemius muscle from the Achilles tendon. (continued)

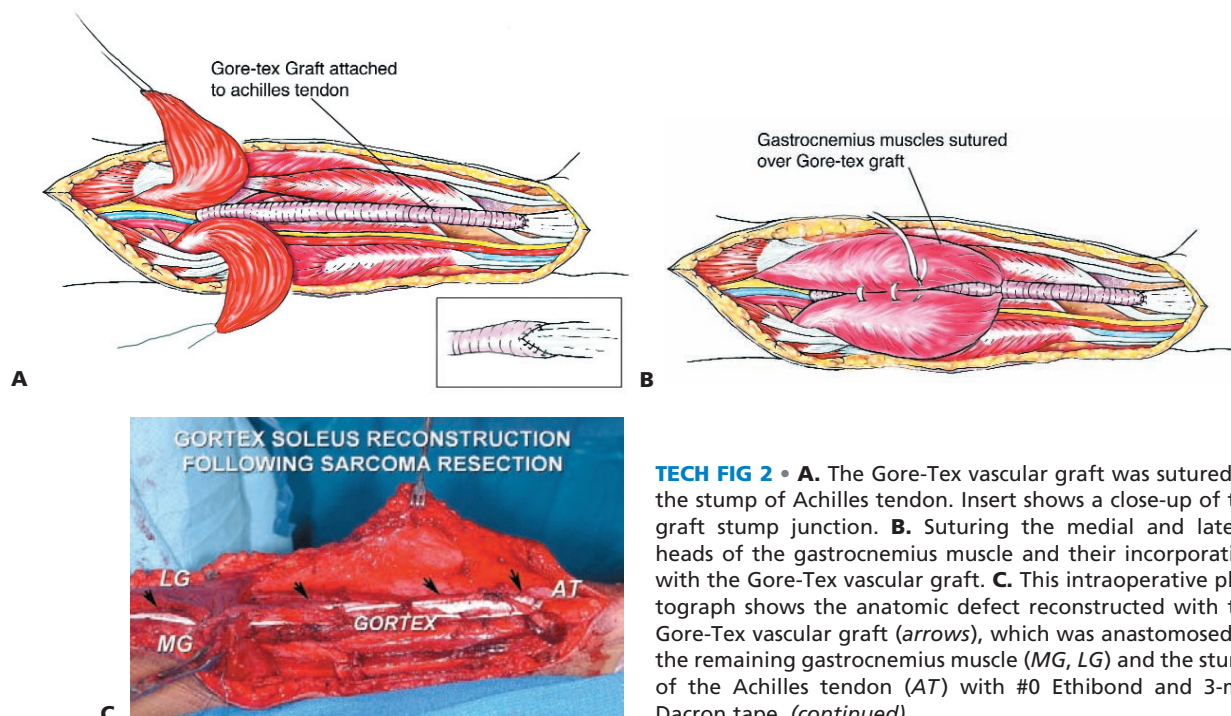




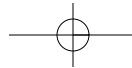
TECH FIG 1 • (continued) **C,D.** Completion of tumor removal. **C.** The massive defect created by wide resection of a soleus muscle sarcoma or carcinoma. **D.** This intraoperative photograph shows the anatomic defect after tumor resection. The medial and lateral gastrocnemius muscles (MG, LG) were both mobilized and retracted proximally.

FUNCTIONAL RECONSTRUCTION AFTER RESECTION

- Functional reconstruction is usually necessary after resection of soleus tumors because of the complete resection of the proximal part of the Achilles tendon. It consists of tenodesing the medial and lateral heads of the gastrocnemius muscle and incorporating them with a Gore-Tex vascular graft. The length of the vascular graft depends on the size of the tumor and the gap between the resected stump and the Achilles tendon.
- The Gore-Tex vascular graft is sutured to the stump of the Achilles tendon with a 3-mm Dacron tape and #0 Ethibond sutures (TECH FIG 2A-D).
- The retracted gastrocnemius and soleus muscle stump is pulled out and sewn with the Gore-Tex aortic graft under moderate tension with a 3-mm Dacron tape and #0 Ethibond sutures.
- After resection of the tumor, the surgical specimen consists of the biopsy tract, the tumor, and the entire soleus muscle belly (TECH FIG 2E).
- The foot is kept in the neutral position during these reconstructive procedures. A posterior splint is used to maintain the foot in neutral position and the knee in 15 degrees of flexion.

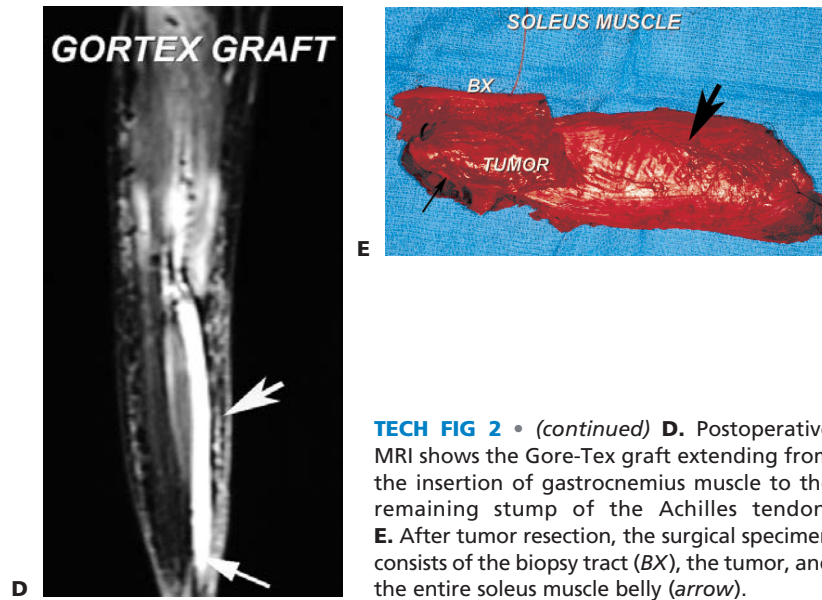


TECH FIG 2 • **A.** The Gore-Tex vascular graft was sutured to the stump of Achilles tendon. Insert shows a close-up of the graft stump junction. **B.** Suturing the medial and lateral heads of the gastrocnemius muscle and their incorporation with the Gore-Tex vascular graft. **C.** This intraoperative photograph shows the anatomic defect reconstructed with the Gore-Tex vascular graft (arrows), which was anastomosed to the remaining gastrocnemius muscle (MG, LG) and the stump of the Achilles tendon (AT) with #0 Ethibond and 3-mm Dacron tape. (continued)



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TECHNIQUES



TECH FIG 2 • (continued) **D.** Postoperative MRI shows the Gore-Tex graft extending from the insertion of gastrocnemius muscle to the remaining stump of the Achilles tendon. **E.** After tumor resection, the surgical specimen consists of the biopsy tract (BX), the tumor, and the entire soleus muscle belly (arrow).



FIG 2 • Clinical photographs taken 3 years after the surgery. **A,B.** This patient has no significant difference in dorsiflexion and plantarflexion of the ankle compared with the contralateral leg. **C.** This patient was able to raise her heel from the floor without pain.

Table 1 Clinical Demographic Data and Functional Outcomes

Case	Sex, Age (yr)	Diagnosis	Size of Tumor	Location	Follow-up (months)	Result (total scores out of 1000 points)	Load Bearing (out of 400 points)	Pain at Rest (out of 300 points)	Function (out of 300 points)
1	F, 12	High-grade synovial sarcoma	5×3 cm	Soleus muscle	8	861	326	300	235
2	M, 45	Metastatic hypernephroma	8×10 cm	Soleus muscle	11, deceased	NA	NA	NA	NA
3	M, 27	Malignant fibrous histiocytoma	8×7 cm	Gastrocnemius and soleus muscles	9, deceased	NA	NA	NA	NA
4	M, 69	Liposarcoma	11×6 cm	Gastrocnemius and soleus muscles	32	867	362	255	250
5	F, 15	Alveolar soft part sarcoma	7×4 cm	Soleus muscle	36	890	340	300	250

NA = Not available.

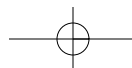


Table 2 Score Template For The Outcome of Surgical Management of Achilles Tendon Ruptures Described by Merkel et al.⁹

	Point Assignment	Maximum Points
Category for Load- (Weight-) Bearing Capacity		
		400
Standing continuously on both toes	1.33 points for each second	40
Standing continuously on toes of ruptured tendon side	2 points for each second	60
Number of times can stand on toes (starting with the heel on the floor) on the side with ruptured tendon	3 points for each time the patient can stand on toes	60
Difference in maximum torque between normal side and side with ruptured tendon	Deduct 14 points for each 10% difference	140
Difference in work performance between the normal side and the side with the ruptured tendon	10 points for each 10% difference	100
Category for Pain		
		300
Pain at rest	No pain 90 points; pain from time to time 45 points; intense pain 0 points	90
Pain on weight bearing	Yes 0 points; no 60 points	60
Pain at the end of maximal dorsal or plantar flexion by the examiner	Yes 0 points; no 60 points	60
Distance to first appearance of pain while walking over uneven ground	< 1 km 0 points; 15 km 45 points; > 5 km 90 points	90
Category for Functional Capacity		
		300
Difference in active dorsal flexion between the normal side and the side with the ruptured tendon	Deduct 3 points for each degree of difference	45
Difference in active plantar flexion between the normal side and the side with the ruptured tendon	Deduct 3 points for each degree of difference	45
Difference between active and passive dorsal flexion on the side with the ruptured tendon	Deduct 5 points for each degree of difference	45
Difference between active and passive plantar flexion on the side with the ruptured tendon	Deduct 5 points for each degree of difference	45
Difference in the maximum kinetic movement Dimension between the normal side and the side with the ruptured tendon	Deduct 25 points for each 10% difference	120

Total score = (points for weight bearing) + (points for pain) + (points for functional capacity)

Interpretation:

Minimum total score: 0

Maximum total score: 1000

The higher the score, the more normal the function on the side with the ruptured tendon.

PEARLS AND PITFALLS

Preoperative	<ul style="list-style-type: none"> ■ Large tumors of the soleus muscle may extend further than anticipated. ■ Preoperative evaluation of the popliteal space and vessels is mandatory.
Intraoperative	<ul style="list-style-type: none"> ■ Reconstruction with a Gore-Tex graft after resection is recommended for large soleus defects. ■ The surgeon should carefully mobilize the popliteal vessels before attempting to resect the tumor. An intraoperative Doppler scan may be useful.

POSTOPERATIVE CARE AND REHABILITATION

- Postoperatively, the leg is immobilized in a long-leg splint, followed by a short-leg walking cast for a total of 3 to 4 weeks, depending on the extent of the soft tissue resection.
- Patients who underwent reconstruction of the Achilles tendon with Gore-Tex graft should be immobilized in an ankle-foot orthosis for an additional 8 weeks.
- Rehabilitation includes leg strengthening, balance, and gait training (FIG 2).

OUTCOMES

- There have been only a few reported cases of soleus muscle resections for sarcomas. Reconstruction with a Gore-Tex graft

allows the patient an almost normal gait (heel-toe, pushoff) and an almost normal range of motion of the ankle (Tables 1 and 2).

- Local recurrence may require an amputation.

COMPLICATIONS

- The most common complications are flap necrosis and tumor recurrence.
- Vascular occlusion of the posterior tibial artery is rare.
- Radiation therapy should be deferred a few weeks to permit the Gore-Tex graft to heal.