Title
Pes Anserinus: Anatomy and Pathology of Native and Harvested Tendons.

Journal
American Journal of Roentgenology, 213(5)

ISSN
0361-803X

Authors
Curtis, Brian R
Huang, Brady K
Pathria, Mini N
et al.

Publication Date
2019-11-01

DOI
10.2214/ajr.19.21315

Peer reviewed

Pes Anserinus: Anatomy and Pathology of Native and Harvested Tendons

Brian R. Curtis[1,2]
Brady K. Huang[1]
Mini N. Pathria[1]
Donald L. Resnick[1]
Edward Smitaman[1]

OBJECTIVE. The purpose of this article is to review the anatomy and pathology of the pes anserinus to increase the accuracy of imaging interpretation of findings affecting these medial knee structures.

CONCLUSION. The pes anserinus, consisting of the conjoined tendons of the sartorius, gracilis, and semitendinosus muscles and their insertions at the medial aspect of the knee, is often neglected during imaging assessment. Common pathologic conditions affecting the pes anserinus include overuse, acute trauma, iatrogenic disorders, and tumors and tumorlike lesions.

Pes anserinus, Latin for "goose foot," describes the gross appearance of the insertion of the conjoined distal sartorius, gracilis, and semitendinosus tendons at the anteromedial aspect of the tibia. This medial region of the knee has complex anatomic features that include not only these myotendinous structures and their entheses, but nearby ligaments, fascia, nerves, and bursae. Abnormalities of these structures may be related to overuse, inflammation, acute or repetitive trauma, surgery, and tumors or tumorlike lesions. Despite the complex anatomy and range of pathologic conditions that can be encountered in this region, the literature devoted to the pes anserinus is sparse, focusing primarily on pes anserinus bursitis and complications related to tendon harvesting for anterior cruciate ligament (ACL) reconstruction [1–10]. The purpose of this article is to review the normal anatomy and range of pathologic conditions that can affect the pes anserinus.

Anatomy of the Pes Anserinus and Nearby Structures

As originally described by Warren and Marshall [1, 2], the soft-tissue structures at the medial knee can be divided into three anatomic layers. Layer 1, the most superficial layer, consists of the medial portion of the thin crural fascia, which is a circumferential structure that encircles the knee and includes the medial patellar retinaculum, popliteal fascia, and fascia lata. Layer 2 consists primarily of the superficial medial collateral ligament (MCL), which has fibers that blend with the posterior oblique ligament and in turn fuse with layer 3, the deepest. Layer 3 consists of the joint capsule, which includes the meniscotibial and meniscofemoral components of the deep MCL. Regarding the pes anserinus, the distal sartorius muscle and tendon are enveloped by the crural fascia (layer 1), and the deeper gracilis and semitendinosus tendons are situated between layers 1 and 2 (Figs. 1A and 1B).

Pes Anserinus Muscles

The sartorius, Latin for "tailor" in reference to the cross-legged sitting position of garment makers, is a strap muscle innervated by the femoral nerve. It originates from the anterior-superior iliac spine, traverses the anterior compartment of the thigh from the lateral to medial direction as it courses inferiorly, and inserts into the proximomedial tibia. It is the longest muscle in the human body, but is fairly weak, acting only as a synergistic muscle.

Gracilis, Latin for "slender," describes the long, thin appearance of this strap muscle, which is innervated by the obturator nerve. It originates from the ischiopubic ramus and courses inferiorly within the medial compartment of the thigh toward the knee, where it runs and inserts just posterior to the sartorius muscle and tendon.

The semitendinosus, named after its long insertional tendon that forms in the midthigh, is a fusiform pennate muscle innervated by

Keywords: anterior cruciate ligament, gracilis, neotendon, pes anserinus, reconstruction, sartorius, semitendinosus

doi.org/10.2214/AJR.19.21315

Received February 15, 2019; accepted after revision May 21, 2019.

The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or as representing the views of the U.S. Department of Veterans Affairs.

Based on a presentation at the ARRS 2018 Annual Meeting, Washington, DC.

[1]Division of Musculoskeletal Radiology, University of California San Diego Health System, San Diego, CA.

[2]Veterans Health Administration National Teleradiology Program, 1001 Sneath Ln, San Bruno, CA 94066. Address correspondence to B. R. Curtis (brcurtis123@gmail.com).

AJR 2019; 213:1–10

0361–803X/19/2135–1

the sciatic nerve. It originates from the ischial tuberosity as a conjoined tendon in common with the long head of the biceps femoris muscle and courses inferiorly in the posterior compartment of the thigh behind the semimembranosus muscle toward the knee, where it inserts posterior to the gracilis tendon.

Pes Anserinus Tendons

The anatomy of the pes anserinus is intricate. The sartorius tendon remains intimate with the crural fascia (layer 1), and the gracilis and semitendinosus tendons are located on the deep surface of this superficial layer over the medial tibia. Importantly, the pes anserinus lies superficial to and inserts proximal and anterior to the superficial MCL (layer 2) [1–3]. The pes anserinus tendon complex consistently inserts into the proximomedial tibia 42 ± 7 mm below the level of the tibial plateau, distal and medial to the tibial tuberosity [9, 10]. Each tendon attaches in a nearly linear arrangement—the sartorius proximally, followed by the gracilis and semitendinosus tendons (average tendon widths of 8.0, 8.4, and 11.3 mm, respectively)—at the lateral edge of the pes anserinus bursa [3]. These tendons can have individual insertions; however, accessory tendons and fascial bands are often present that have independent osseous and soft-tissue attachments. The semitendinosus tendon, the most morphologically variable tendon of the pes anserinus, can have as many as three tendinous insertions and various soft-tissue extensions, including a constant band that attaches to the gastrocnemius fascia [4–10] (Fig. 1B).

Pes Anserinus Bursa

The synovium-lined pes anserinus bursa is a consistently present anatomic bursa situated between the pes anserinus and the distal superficial MCL. Unlike the popliteal bursa at the posterior aspect of the knee, the pes anserinus bursa does not communicate with the articular cavity of the knee. It is irregularly circular and follows the course of the sartorius muscle and tendon. In cadaveric dissections, the pes anserinus bursa typically extends proximally to the joint line (i.e., proximal articular surfaces of the medial and lateral tibial condyles), though it can extend as far as 20 mm above this line, as seen in approximately 24% of specimens [7]. Additional bursae situated along the medial aspect of the knee include the semimembranosus and MCL bursae. The semimembranosus bursa is posterior and superior to the pes anserinus bursa, whereas the MCL bursa is between the deep and superficial fibers of the MCL at the central third of the knee. Although bursitis of these bursae can coexist with pes anserinus bursal fluid, the bursae are not known to communicate with each other [11–15].

Saphenous Nerve and Its Branches

The saphenous nerve arises from the femoral nerve at the femoral triangle and then courses distally through the adductor canal, crosses medially to the femoral vessels, extends toward the knee between the sartorius and gracilis tendons (Fig. 1C), and continues inferiorly within the medial subcutaneous fat of the leg along with the greater saphenous vein. Just above the knee joint, the saphenous nerve bifurcates into infrapatellar and sartorial branches. The infrapatellar branch can pierce the sartorius muscle or course anterior or posterior to it. It provides sensory innervation to the medial infrapatellar region (Fig. 1D). Its subcutaneous location and horizontal course along the medial knee place it at risk of injury during surgical procedures involving the pes anserinus, such as graft harvesting for ACL reconstruction. Some authors [10, 16, 17] have suggested that an oblique incision paralleling this branch, rather than a perpendicular vertical incision, may lower the risk of nerve injury. The sartorial branch is intimate with the gracilis tendon for approximately 5 cm before crossing it an average of 12 cm above the pes anserinus insertion to pierce the crural fascia and become subcutaneous [18, 19]. It provides sensory innervation to the medial aspect of the leg (Fig. 1D). The proximity of the sartorial branch to the gracilis tendon also places it at risk of injury during tendon harvest.

Disorders of the Pes Anserinus

Disorders of the pes anserinus can be divided into four broad categories: overuse, acute trauma, iatrogenic causes, and tumors and tumorlike lesions (Table 1).

Overuse

Pes anserinus bursitis—Pes anserinus bursitis is mostly related to overuse by active persons, typically runners. It has also been associated with inflammatory arthritides, diabetes mellitus, obesity, injury, and friction from nearby osteophytes or exostoses. The diagnosis of pes anserinus bursitis is usually established by the characteristic clinical finding of pain localized to the proximomedial tibia, but in some instances the clinical picture is unclear, and advanced imaging is requested.

With ultrasound, the pes anserinus bursa can be identified in its usual position (i.e., between the pes tendons and the tibia) in approximately 67% of volunteers without symptoms, between the pes tendons and MCL in 21%, and between the constituents of the pes anserinus in 8% [20]. At MRI, fluid is seen within the bursa deep to the pes anserinus tendons and superficial to the superficial MCL [21]. Classically, distention of the bursa occurs near the pes anserinus insertion, distal and medial to the tibial tuberosity (Fig. 2), and fluid may invaginate deep to the superficial MCL. The pes anserinus bursa can also extend above the joint line [7].

Pes anserinus bursitis is typically managed conservatively with rest and oral antiinflammatory agents. In refractory cases, aspiration of the bursal contents and local injection of anesthetics or corticosteroids may be required. Importantly, the infrapatellar branch of the saphenous nerve often lies adjacent to the proximal surface of the bursa, and the sartorial branch often courses along the bursa posteriorly. Therefore, the distal and anterior aspects of the bursa, located approximately 2 cm medial and 1.2 cm superior to the inferomedial point of the tibial tuberosity, has been suggested as a safe access site for such procedures [7].

TABLE 1: Pathologic Conditions of the Pes Anserinus

Overuse	Acute Trauma	Iatrogenic Causes	Tumors and Tumorlike Lesions
Pes anserinus bursitis	Musculotendinous injury	Neotendon injury	Tenosynovial giant cell tumor
Posteromedial knee friction syndrome	Complete pes anserinus tear	Failed regeneration	Periosteal ganglion cyst of the tibia
Pes anserinus snapping syndrome	Superficial medial collateral ligament tear with Stener-like lesion	Adjacent nerve injury	Gout

Posteromedial knee friction and pes anserinus snapping syndromes—Posteromedial knee friction syndrome has been described as a cause of posteromedial knee pain in active patients. It occurs in the narrow space between the medial femoral condyle and the overlying sartorius or gracilis tendon and is caused by friction between bone and tendon [22]. MRI shows poorly marginated edema between the medial femoral condyle and the sartorius or gracilis tendon. More common causes of posteromedial edema—including medial meniscal tear, ligament injury, and leaking popliteal cyst—should be excluded before this diagnosis is suggested.

Pes anserinus snapping syndrome occurs when the semitendinosus or gracilis tendon snaps over the tibial condyle or semimembranosus tendon at the posteromedial aspect of the knee during knee flexion and extension [23–27]. Diminutive pes anserinus accessory fascial bands may contribute to pes anserinus snapping syndrome by allowing forward subluxation of the gracilis and semitendinosus tendons over the posteromedial corner of the tibia [25]. Although the imaging findings associated with this syndrome have received little attention, sonography has been suggested as the imaging method of choice owing to its dynamic capability [26, 27]. In a small series of patients [26], tenotomy has been reported to be a successful treatment method.

Trauma

Pes anserinus musculotendinous injuries—Isolated musculotendinous injuries to the pes anserinus are uncommon. When such injuries do occur, the sartorius is most commonly affected [28]. The sartorius muscle is predisposed to strain injury because it is the longest muscle in the human body, spans two joints, and is superficially located. Its superficial location also puts it at risk of blunt concussive injury that can result in intramuscular hematoma or interstitial hemorrhage and injury to nearby osseous and soft tissues [29]. Isolated myotendinous strains and distal tendinous avulsions of the semitendinosus are rare but have been reported in high-level athletes [30–33] (Fig. 3). These injuries can be difficult to treat. Cooper and Conway [31] reported that conservative treatment failed in 42% of patients with partial semitendinosus tendon tears. In some cases, however, tenotomy has been performed with good outcomes [32].

Complete pes anserinus tendon tears—Complete tears of the pes anserinus tendons are uncommon, typically resulting from forceful trauma, such as a knee dislocation, in which multiple ligaments are torn. The torn pes anserinus tendons typically retract proximally and can be displaced into a proximal tibial fracture or the medial femorotibial compartment if the underlying MCL complex is also disrupted (Fig. 4).

Superficial medial collateral ligament tear with Stener-like lesion—The MCL complex (i.e., superficial and deep MCLs) and posterior oblique ligament are the primary valgus stabilizers of the knee and are commonly injured. The superficial MCL, deep MCL, and posterior oblique ligament fail at forces of 557, 101, and 256 N, respectively [34]. The pes anserinus is a secondary valgus stabilizer and is not commonly injured in isolation. Instead, it is occasionally injured when one or more of the primary valgus stabilizers of the knee fails.

The superficial MCL originates near the medial femoral epicondyle. Most MCL tears occur proximally in this region and are treated nonoperatively [35]. The main distal attachment of the superficial MCL is at the tibia, approximately 60 mm below the joint line, distal to the pes anserinus insertion. Although injuries to the distal superficial MCL are uncommon, complete tears have the potential to retract and become displaced superficial to the pes anserinus tendons, resulting in a Stener-like lesion. MRI plays a key role in the diagnosis of a distal superficial MCL tear with a Stener-like lesion, because valgus instability testing of the knee can be inconclusive. Normally, the superficial MCL lies deep to the pes anserinus tendons. When the superficial MCL is proximally retracted and its distal end is superficial to the pes anserinus tendons, a Stener-like lesion should be described, because anatomic healing of the injured superficial MCL at its tibial attachment is prevented by the interposed pes anserinus tendons [36] (Fig. 5).

Iatrogenic Causes

The most commonly used autografts for ACL reconstruction are either bone-patellar tendon-bone, or pes anserinus tendon preparations, specifically the gracilis and semitendinosus. Use of an autograft derived from the pes tendons results in less morbidity than a bone-patellar tendon-bone autograft and appears to be just as strong or stronger once fully matured. The double-bundle hamstring autograft has been reported to have more than twice the tensile strength of native ACL, and patellar tendon has been reported to have 160% of such tensile strength [37, 38].

After harvesting for ACL reconstruction, the pes anserinus tendons regenerate, albeit with altered anatomic and histologic characteristics that are not typically clinically evident [39–43]. Although regenerated neotendon appears normalized on ultrasound and MR images within 2 or 3 years after surgery [40, 41] (Fig. 6), histologic analysis shows focal scar, irregular collagen, increased capillary formation, and fibroblastic proliferation [44, 45]. These histologic characteristics of the pes anserinus neotendons may explain their higher risk of injury (Fig. 7), although this is not entirely clear. The consensus is that regenerated neotendons should not be reharvested if revision surgery is needed. Moreover, regeneration of the medial hamstring tendons after harvesting does not always occur. In such cases, the muscle bellies lack distal attachments and can retract into the thigh, creating a palpable lump similar to the "Popeye" deformity that occurs in the upper arm after disruption of the distal biceps brachii tendon [46] (Fig. 8).

Other complications of pes anserinus tendon harvesting include intraoperative premature graft rupture and damage to surrounding structures, such as the MCL and saphenous nerve (Fig. 9). Accessory tendons and fascial bands are often associated with the pes anserinus. These extensions must be released before tendon harvesting because they can divert a tendon stripper, causing premature amputation of the ACL graft tissue, resulting in an inadequate, short graft [9, 10].

Tumors or Tumorlike Lesions

A variety of tumors and tumorlike lesions occur in the vicinity of the pes anserinus. Tenosynovial giant cell tumor, previously called giant cell tumor of the tendon sheath, is a fairly common benign soft-tissue tumor that originates from synovium. It is histologically identical to pigmented villonodular synovitis. Tenosynovial giant cell tumor often arises in the wrist and hand but can occur adjacent to any tendon, including the pes anserinus. It is typically slow growing. MRI shows characteristic low signal intensity on T1- and T2-weighted images (Fig. 10A).

Osteochondromas and tibial spurs, which lack a true cartilage cap, can occur near the pes anserinus and result in frictional pes anserinus bursitis. These bone outgrowths can be successfully treated with surgical removal [47].

The periosteum at a tubular bone is composed of an outer fibrous layer containing fibroblasts and an inner cambium layer containing progenitor cells. Periosteal ganglion cysts are thought to arise by mucoid degeneration of the fibrous periosteum. The proximal tibia, near the pes anserinus insertion, is the most common site of such cysts [48–50] (Fig. 10B), although the cysts also occur at the medial malleolus and the distal shafts of the radius, ulna, and femur. Imaging shows a periosteal cystic mass with subjacent cortical scalloping, a margin of bone sclerosis, and, occasionally, spiculated periosteal bone formation that may raise suspicion of malignancy. The typical location and appearance of this lesion, however, generally lead to the correct diagnosis.

Gout, although a well-recognized cause of bursitis at locations such as the anterior knee and olecranon, is an infrequent cause of symptomatic pes anserinus bursitis [51] (Fig. 10C). Calcium pyrophosphate dihydrate (CPPD) crystal deposits are common in both hyaline cartilage and fibrocartilage, where it is called chondrocalcinosis. Less commonly, CPPD crystal deposition occurs in capsular, tendinous, ligamentous, and synovial tissues. With bursal involvement, an inflammatory response to CPPD deposition can also result in bursitis.

Conclusion

The pes anserinus consists of the conjoined tendons of the sartorius, gracilis, and semitendinosus muscles. It inserts into the proximomedial tibia and acts as a secondary valgus restraint augmenting the medial supporting structures of the knee. The imaging appearance of conditions affecting the pes anserinus can be classified into four broad categories: overuse, acute trauma, iatrogenic causes, and tumors and tumorlike lesions. An understanding of the anatomic features and pathologic processes of the pes anserinus will guide radiologists in interpreting imaging findings at the medial aspect of the knee.

References

1. Warren LF, Marshall JL. The supporting structures and layers on the medial side of the knee: an anatomical analysis. *J Bone Joint Surg Am* 1979; 61:56–62
2. De Maeseneer M, Van Roy F, Lenchik L, Barbaix E, De Ridder F, Osteaux M. Three layers of the medial capsular and supporting structures of the knee: MR imaging-anatomic correlation. *RadioGraphics* 2000; 20:S83–S89
3. LaPrade RF, Engebretsen AH, Ly TV, Johansen S, Wentorf FA, Engebretsen L. The anatomy of the medial part of the knee. *J Bone Joint Surg Am* 2007; 89:2000–2010
4. Ivey M, Prud'homme J. Anatomic variations of the pes anserinus: a cadaver study. *Orthopedics* 1993; 16:601–606
5. Candal-Couto JJ, Deehan DJ. The accessory bands of gracilis and semitendinosus: an anatomical study. *Knee* 2003; 10:325–328
6. Yasin MN, Charalambous CP, Mills SP, Phaltankar PM. Accessory bands of the hamstring tendons: a clinical anatomical study. *Clin Anat* 2010; 23:862–865
7. Lee JH, Kim KJ, Jeong YG, et al. Pes anserinus and anserine bursa: anatomical study. *Anat Cell Biol* 2014; 47:127–131
8. Mochizuki T, Akita K, Muneta T, Sato T. Pes anserinus: layered supportive structure on the medial side of the knee. *Clin Anat* 2004; 17:50–54
9. Reina N, Abbo O, Gomez-Brouchet A, Chiron P, Moscovici J, Laffosse JM. Anatomy of the bands of the hamstring tendon: how can we improve harvest quality? *Knee* 2013; 20:90–95
10. Pagnani MJ, Warner JJ, O'Brien SJ, Warren RF. Anatomic considerations in harvesting the semitendinosus and gracilis tendons and a technique of harvest. *Am J Sports Med* 1993; 21:565–571
11. De Maeseneer M, Shahabpour M, Van Roy F, et al. MR imaging of the medial collateral ligament bursa: findings in patients and anatomic data derived from cadavers. *AJR* 2001; 177:911–917
12. Lee JK, Yao L. Tibial collateral ligament bursa: MR imaging. *Radiology* 1991; 178:855–857
13. Hennigan SP, Schneck CD, Mesgarzadeh M, Clancy M. The semimembranosus-tibial collateral ligament bursa: anatomical study and magnetic resonance imaging. *J Bone Joint Surg Am* 1994; 76:1322–1327
14. Rothstein CP, Laorr A, Helms CA, Tirman PF. Semimembranosus-tibial collateral ligament bursitis: MR imaging findings. *AJR* 1996; 166:875–877
15. Steinbach LS, Stevens KJ. Imaging of cysts and bursae about the knee. *Radiol Clin North Am* 2013; 51:433–454
16. Kerver AL, Leliveld MS, den Hartog D, Verhofstad MH, Kleinrensink GJ. The surgical anatomy of the infrapatellar branch of the saphenous nerve in relation to incisions for anteromedial knee surgery. *J Bone Joint Surg Am* 2013; 95:2119–2125
17. Mochizuki T, Akita K, Muneta T, Sato T. Anatomical bases for minimizing sensory disturbance after arthroscopically-assisted anterior cruciate ligament reconstruction using medial hamstring tendons. *Surg Radiol Anat* 2003; 25:192–199
18. Sanders B, Rolf R, McClelland W, Xerogeanes J. Prevalence of saphenous nerve injury after autogenous hamstring harvest: an anatomic and clinical study of sartorial branch injury. *Arthroscopy* 2007; 23:956–963
19. Dunaway DJ, Steensen RN, Wiand W, Dopirak RM. The sartorial branch of the saphenous nerve: its anatomy at the joint line of the knee. *Arthroscopy* 2005; 21:547–551
20. Imani F, Rahimzadeh P, Abolhasan Gharehdag F, Faiz SH. Sonoanatomic variation of pes anserine bursa. *Korean J Pain* 2013; 26:249–254
21. Forbes JR, Helms CA, Janzen DL. Acute pes anserine bursitis: MR imaging. *Radiology* 1995; 194:525–527
22. Simeone FJ, Huang AJ, Chang CY, et al. Posteromedial knee friction syndrome: an entity with medial knee pain and edema between the femoral condyle, sartorius and gracilis. *Skeletal Radiol* 2015; 44:557–563
23. Lyu SR, Wu JJ. Snapping syndrome caused by the semitendinosus tendon: a case report. *J Bone Joint Surg Am* 1989; 71:303–305
24. Bae DK, Kwon OS. Snapping knee caused by the gracilis and semitendinosus tendon: a case report. *Bull Hosp Jt Dis* 1997; 56:177–179
25. Karataglis D, Papadopoulos P, Fotiadou A, Christodoulou AG. Snapping knee syndrome in an athlete caused by the semitendinosus and gracilis tendons: a case report. *Knee* 2008; 15:151–154
26. Bollen SR, Arvinte D. Snapping pes syndrome: a report of four cases. *J Bone Joint Surg Br* 2008; 90:334–335
27. Marchand AJ, Proisy M, Ropars M, Cohen M, Duvauferrier R, Guillin R. Snapping knee: imaging findings with an emphasis on dynamic sonography. *AJR* 2012; 199:142–150
28. Bencardino JT, Rosenberg ZS, Brown RR, Hassankhani A, Lustrin ES, Beltran J. Traumatic musculotendinous injuries of the knee: diagnosis with MR imaging. *RadioGraphics* 2000; 20:S103–S120
29. Flores DV, Mejía Gómez C, Estrada-Castrillón M, Smitaman E, Pathria MN. MR imaging of muscle trauma: anatomy, biomechanics, pathophysiology, and imaging appearance. *RadioGraphics* 2018; 38:124–148
30. Lempainen L, Sarimo J, Mattila K, Heikkilä J, Orava S, Puddu G. Distal tears of the hamstring muscles: review of the literature and our results of surgical treatment. *Br J Sports Med* 2007; 41:80–83; discussion, 83
31. Cooper DE, Conway JE. Distal semitendinosus ruptures in elite-level athletes: low success rates of nonoperative treatment. *Am J Sports Med* 2010; 38:1174–1178
32. Schilders E, Bismil Q, Sidhom S, Robinson P, Barwick T, Talbot C. Partial rupture of the distal semitendinosus tendon treated by tenotomy: a previously undescribed entity. *Knee* 2006; 13:45–47
33. Sivasundaram L, Matcuk GR Jr, White EA, Hatch GF 3rd, Patel DB. Partial semitendinosus tendon tear in a young athlete: a case report and review of

the distal semitendinosus anatomy. *Skeletal Radiol* 2015; 44:1051–1056

34. Wijdicks CA, Ewart DT, Nuckley DJ, Johansen S, Engebretsen L, Laprade RF. Structural properties of the primary medial knee ligaments. *Am J Sports Med* 2010; 38:1638–1646
35. Indelicato PA. Non-operative treatment of complete tears of the medial collateral ligament of the knee. *J Bone Joint Surg Am* 1983; 65:323–329
36. Corten K, Hoser C, Fink C, Bellemans J. Case reports: a Stener-like lesion of the medial collateral ligament of the knee. *Clin Orthop Relat Res* 2010; 468:289–293
37. Larson R. Anterior cruciate ligament reconstruction with hamstring tendons. *Oper Tech Orthop* 1996; 6:138–146
38. Noyes FR, Butler DL, Grood ES, Zernicke RF, Hefzy MS. Biomechanical analysis of human ligament grafts used in knee-ligament repairs and reconstructions. *J Bone Joint Surg Am* 1984; 66:344–352
39. Cross MJ, Roger G, Kujawa P, Anderson IF. Regeneration of the semitendinosus and gracilis tendons following their transection for repair of the anterior cruciate ligament. *Am J Sports Med* 1992; 20:221–223
40. Papandrea P, Vulpiani MC, Ferretti A, Conteduca F. Regeneration of the semitendinosus tendon harvested for anterior cruciate ligament reconstruction: evaluation using ultrasonography. *Am J Sports Med* 2000; 28:556–561
41. Rispoli DM, Sanders TG, Miller MD, Morrison WB. Magnetic resonance imaging at different time periods following hamstring harvest for anterior cruciate ligament reconstruction. *Arthroscopy* 2001; 17:2–8
42. Carofino B, Fulkerson J. Medial hamstring tendon regeneration following harvest for anterior cruciate ligament reconstruction: fact, myth, and clinical implication. *Arthroscopy* 2005; 21:1257–1265
43. Lipscomb AB, Johnston RK, Snyder RB, Warburton MJ, Gilbert PP. Evaluation of hamstring strength following use of semitendinosus and gracilis tendons to reconstruct the anterior cruciate ligament. *Am J Sports Med* 1982; 10:340–342
44. Ferretti A, Conteduca F, Morelli F, Masi V. Regeneration of the semitendinosus tendon after its use in anterior cruciate ligament reconstruction: a histologic study of three cases. *Am J Sports Med* 2002; 30:204–207
45. Eriksson K, Kindblom LG, Hamberg P, Larsson H, Wredmark T. The semitendinosus tendon regenerates after resection: a morphologic and MRI analysis in 6 patients after resection for anterior cruciate ligament reconstruction. *Acta Orthop Scand* 2001; 72:379–384
46. Järvinen TL, Järvinen TA, Penttilä T, Harilainen A, Sandelin J, Paakkala T. Failed regrowth of the harvested semitendinosus tendon: a rare complication of tendon harvest after anterior cruciate ligament reconstruction. *Arthroscopy* 2003; 19:E31
47. Fraser RK, Nattrass GR, Chow CW, Cole WG. Pes anserinus syndrome due to solitary tibial spurs and osteochondromas. *J Pediatr Orthop* 1996; 16:247–248
48. Byers PD, Wadsworth TG. Periosteal ganglion. *J Bone Joint Surg Br* 1970; 52:290–295
49. Valls R, Melloni P, Darnell A, Muñoz J, Canalies J. Diagnostic imaging of tibial periosteal ganglion. *Eur Radiol* 1997; 7:70–72
50. Abdelwahab IF, Kenan S, Hermann G, Klein MJ, Lewis MM. Periosteal ganglia: CT and MR imaging features. *Radiology* 1993; 188:245–248
51. Grover RP, Rakhra KS. Pes anserine bursitis: an extra-articular manifestation of gout. *Bull NYU Hosp Jt Dis* 2010; 68:46–50

(Figures start on next page)

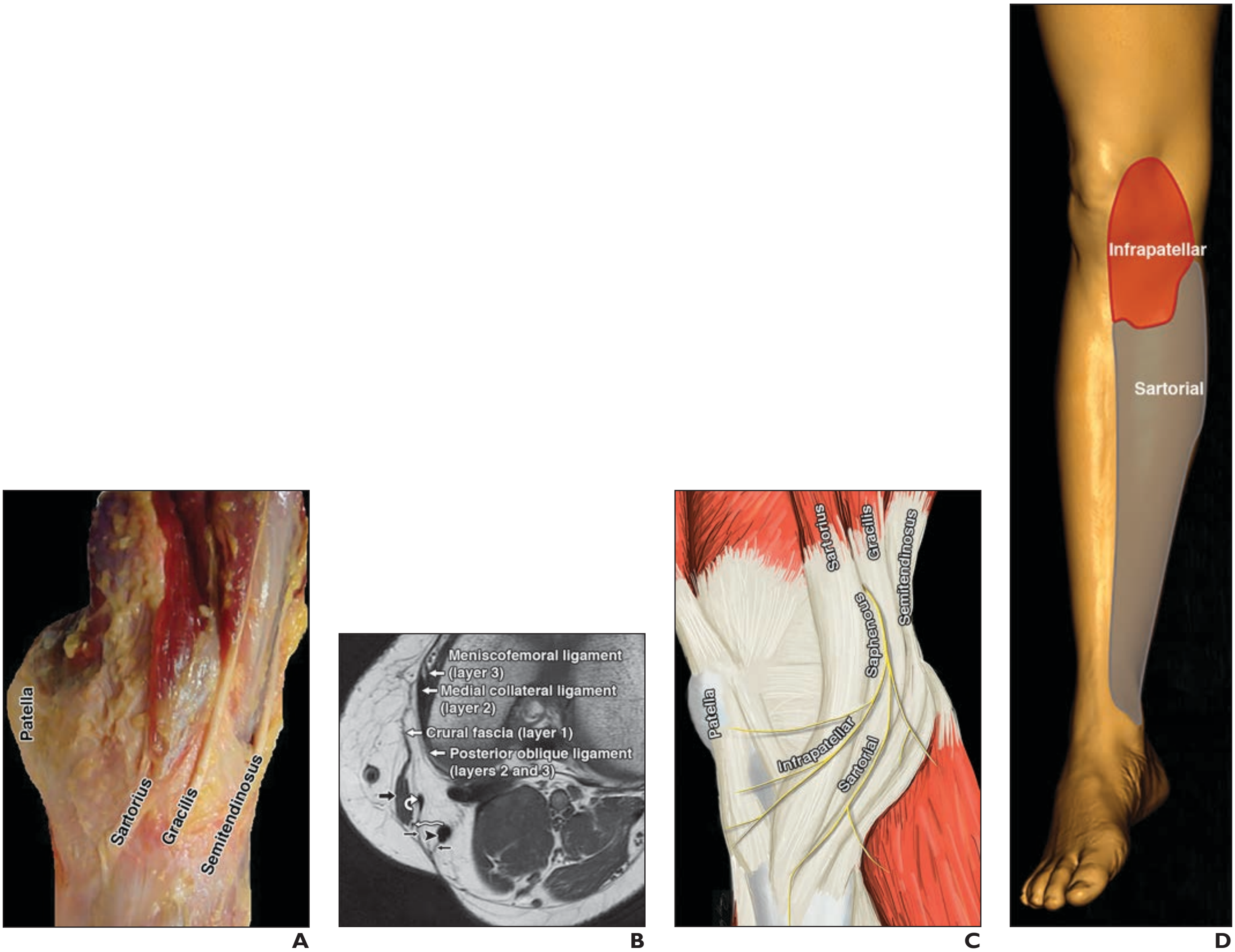


Fig. 1—Medial knee.
A, Photograph of cadaveric knee dissection in medial view shows pes anserinus components.
B, Axial T1-weighted MR image shows three anatomic layers of knee as developed by Warren and Marshall [1]. Sartorius muscle and tendon (*thick arrow*) are enveloped by crural fascia (layer 1), and deeper gracilis (*curved arrow*) and semitendinosus (*arrowhead*) tendons are situated between layers 1 and 2. Wavy arrow denotes saphenous nerve as it pierces deep fascia between sartorius and gracilis tendons to become subcutaneous. Thin arrows denote accessory bands connecting gracilis and semitendinosus tendons to crural fascia.
C and **D,** Schematics show anatomy of saphenous nerve and its infrapatellar and sartorial branches relative to pes anserinus (**C**) and sensory innervation to medial leg (**D**).

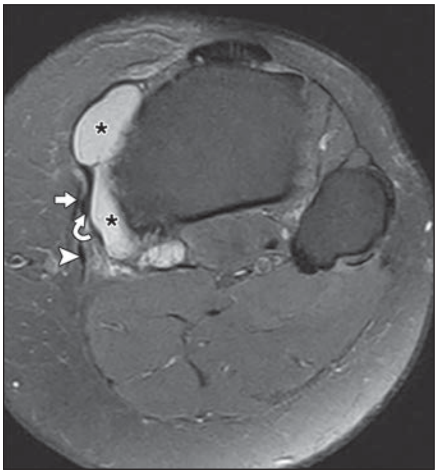
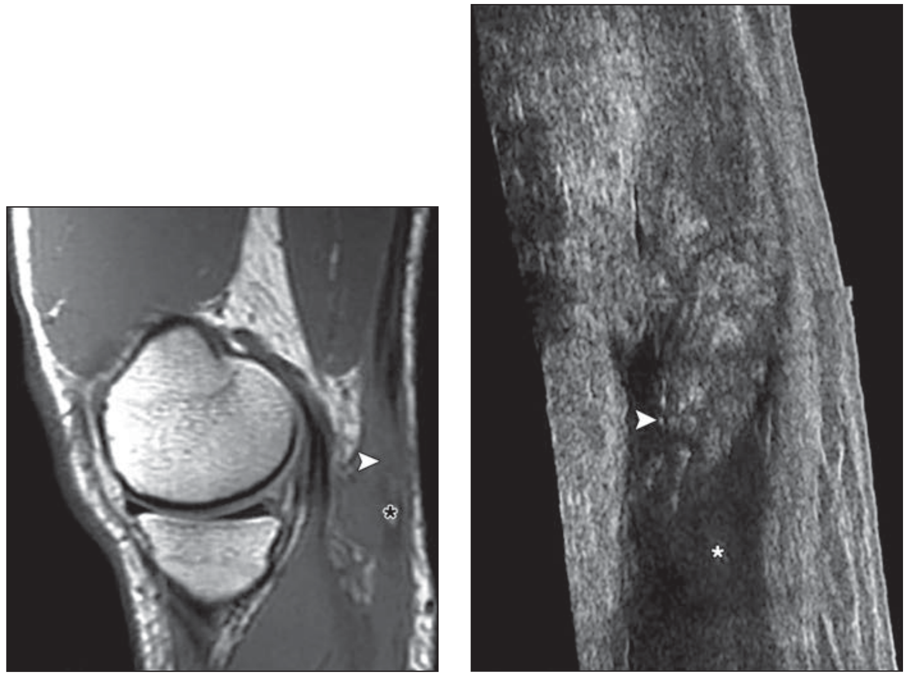


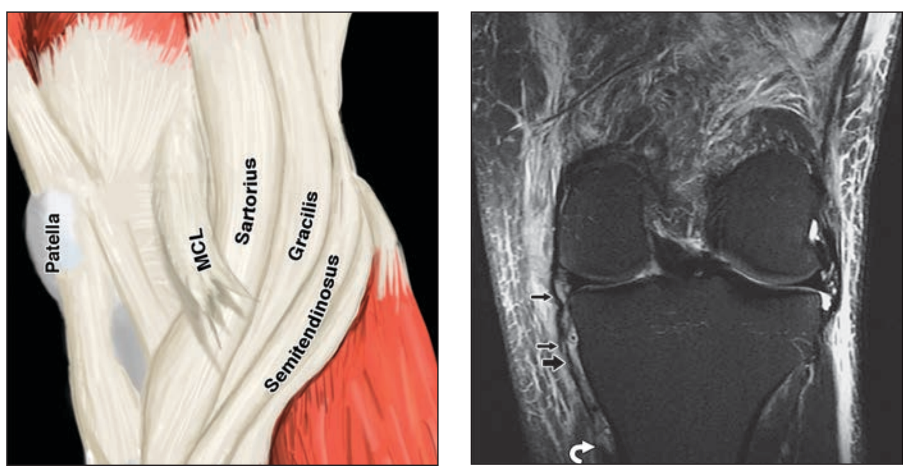
Fig. 2—Adult with medial knee pain and swelling due to pes anserinus bursitis. Axial T2-weighted fat-suppressed MR image shows fluid-filled pes anserinus bursa (*asterisks*), consistent with bursitis. Fluid is deep to pes anserinus tendons. Straight arrow denotes sartorius tendon; curved arrow, gracilis tendon; arrowhead, semitendinosus tendon.



A B

Fig. 3—18-year-old male baseball player with semitendinosus rupture who heard pop with instant pain on sliding into second base.
A and **B,** Sagittal T1-weighted MR image (**A**) and similarly oriented long-axis ultrasound image (**B**) show complete tear of semitendinosus tendon (*arrowhead*) with bony avulsion (*asterisk*).

Fig. 4—39-year-old man with complete avulsion of pes anserinus. Coronal STIR MR image shows uncommon complete avulsion of pes anserinus, which can occur with substantial injury, such as knee dislocation as in this case. Torn tendons (*chevron*) can displace into joint.



A B

Fig. 5—22-year-old man with complete tear of distal superficial medial collateral ligament (MCL) with Stener-like lesion.
A and **B,** Schematic (**A**) and coronal T2-weighted fat-suppressed MR image (**B**) show complete tear of distal superficial MCL (*thin arrows*, **B**) displaced superficial to sartorius (*thick arrow*, **B**) and gracilis (*curved arrow*, **B**), preventing anatomic healing of superficial MCL.

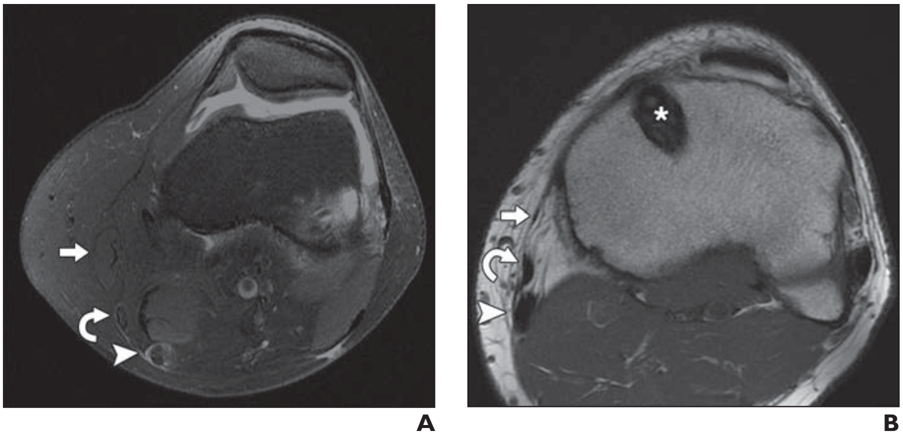


Fig. 6—Gracilis and semitendinosus neotendon formation at different times after medial hamstring harvesting for anterior cruciate ligament (ACL) reconstruction.
A, Axial T2-weighted fat-saturated MR image of 43-year-old man 7 weeks after tendon harvest shows early gracilis (*curved arrow*) and semitendinosus (*arrowhead*) neotendon formation with signal intensity higher than expected of normal tendon. Straight arrow indicates sartorius tendon.
B, Axial T1-weighted MR image of 42-year-old man 14 years after tendon harvest shows thickened gracilis (*curved arrow*) and semitendinosus (*arrowhead*) neotendons with normal low signal intensity. Tibial tunnel (*asterisk*) is related to ACL reconstruction. Straight arrow indicates sartorius tendon.

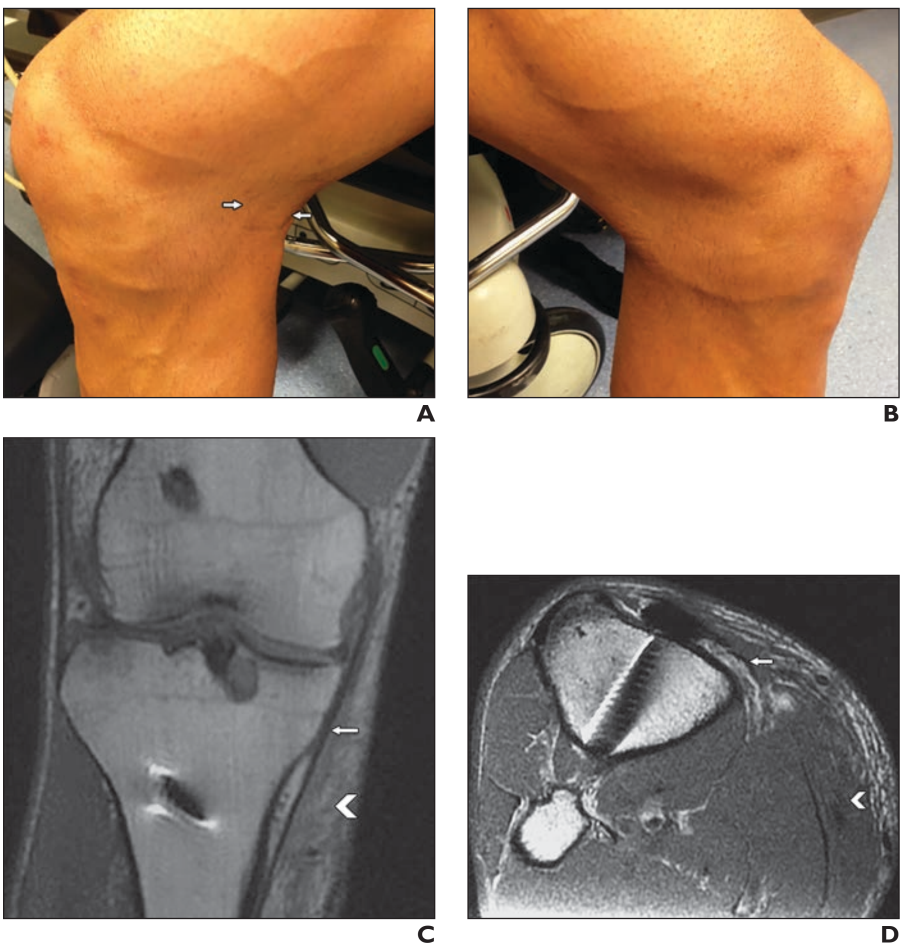
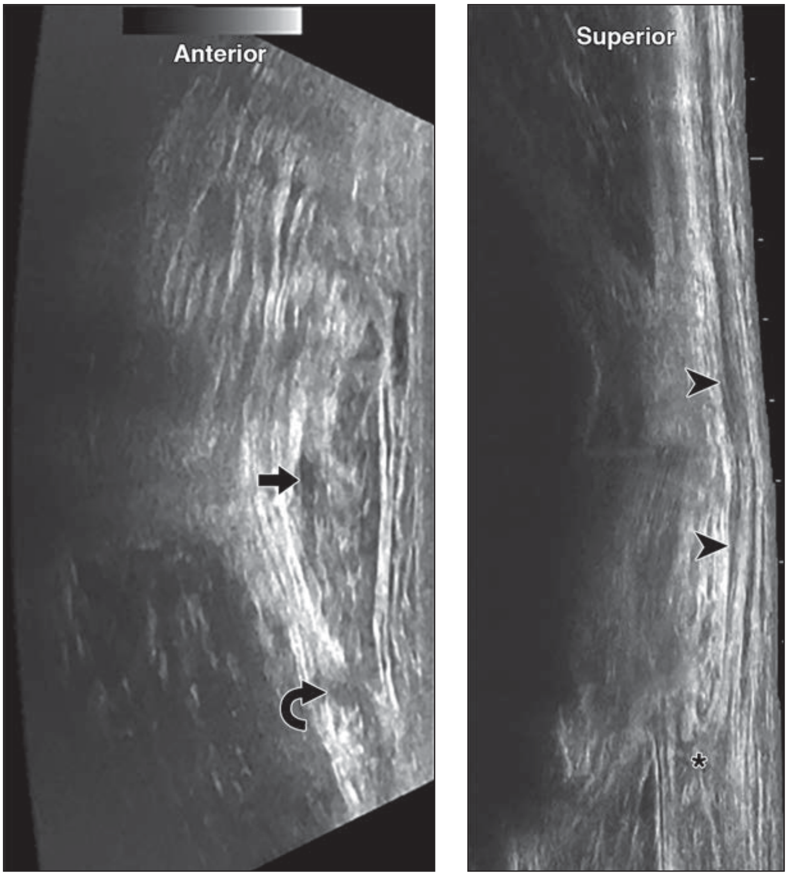


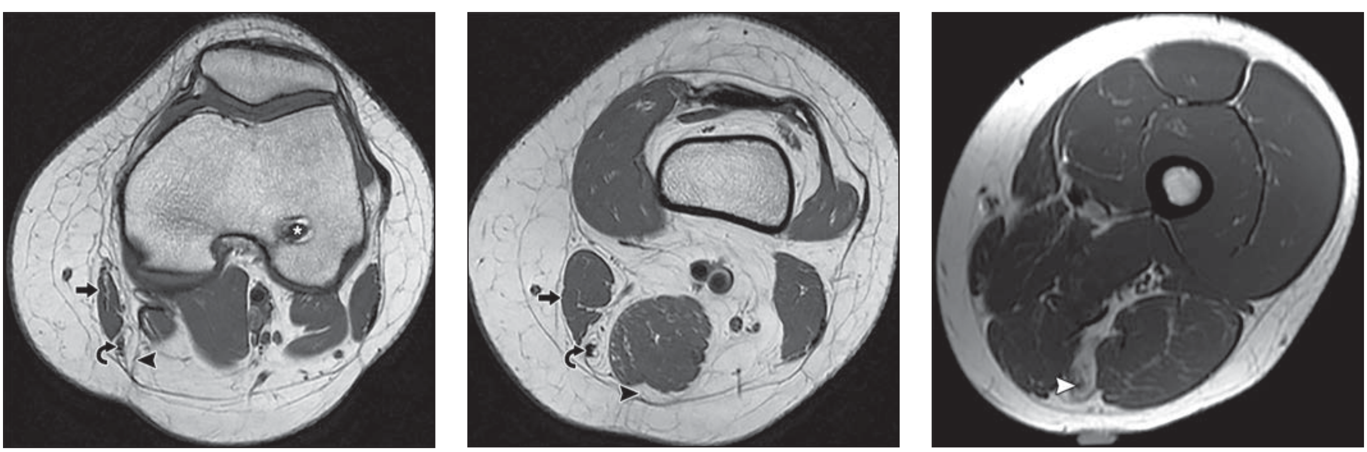
Fig. 7—35-year-old male runner with complete tear of pes anserinus, recent history of right posteromedial knee pain after 83-mile (134 km) run, and remote history of reconstruction of anterior cruciate ligament by hamstring autograft.
A and **B,** Photograph of injured right knee (**A**) shows loss of muscle and tendon definition (*arrows*, **A**) in comparison with normal left knee (**B**).
C and **D,** Coronal proton density–weighted (**C**) and axial T1-weighted (**D**) MR images show complete tears of pes anserinus tendons (*chevron*). Arrow (**C**) denotes intact superficial medial collateral ligament.

(Fig. 7 continues on next page)



E F

Fig. 7 (continued)—35-year-old male runner with complete tear of pes anserinus, recent history of right posteromedial knee pain after 83-mile (134 km) run, and remote history of reconstruction of anterior cruciate ligament by hamstring autograft.
E and **F,** Transverse (**E**) and longitudinal (**F**) gray-scale ultrasound images obtained 1 month after **D** and **C** and oriented to them show indistinct sartorius (*straight arrow*, **E**), gracilis (*curved arrow*, **E**), and semitendinosus (*arrowheads*, **F**) tendons, confirming tears. Asterisk (**F**) denotes scar tissue.



A B C

Fig. 8—31-year-old man with failed semitendinosus neotendon regeneration presenting as posterior thigh mass after hamstring autograft anterior cruciate ligament (ACL) reconstruction.
A and **B,** Axial T1-weighted MR images show absence of semitendinosus tendon (*arrowhead*) at level of knee (**A**) and distal femur (**B**). Straight arrow denotes sartorius muscle; curved arrow, gracilis neotendon; asterisk (**A**), femoral tunnel for ACL graft.
C, Axial T1-weighted MR image shows muscle is atrophied and retracted to level of midthigh underlying marker indicating palpable abnormality. Arrowhead denotes semitendinosus tendon.

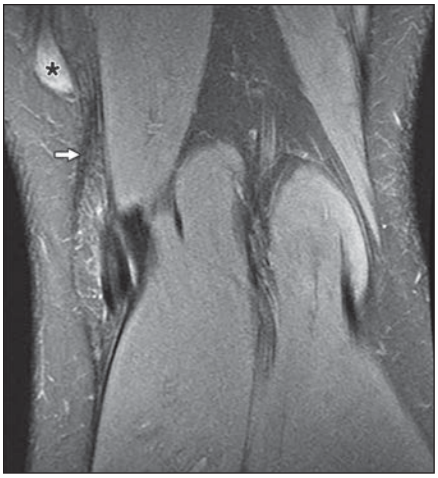
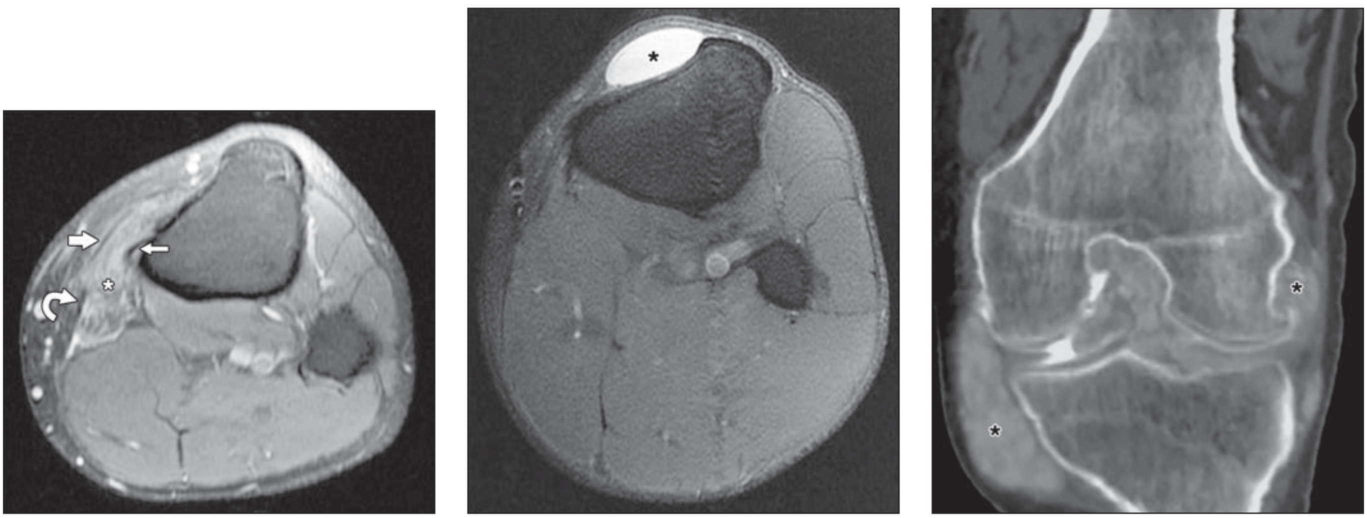


Fig. 9—22-year-old woman with saphenous neuroma after anterior cruciate ligament (ACL) reconstruction 3 years earlier. Coronal T1-weighted fat-suppressed contrast-enhanced MR image shows saphenous neuroma (*asterisk*) with nearby scarring (*arrow*) from prior hamstring autograft harvest for ACL reconstruction. Neuroma was resected, and symptoms resolved.



A B C

Fig. 10—Tumors and tumorlike lesions.

A, 40-year-old man with pathologically proven tenosynovial giant cell tumor involving pes anserinus bursa. Axial T1-weighted fat-suppressed contrast-enhanced MR image shows heterogeneously enhancing soft-tissue mass (*asterisk*) deep to sartorius (*thick arrow*) and gracilis (*curved arrow*) tendons and overlying superficial medial collateral ligament (*thin arrow*).

B, 42-year-old man with anterior tibial mass for several years characteristic of periosteal ganglion cyst. Axial T2-weighted fat-suppressed MR image shows cystic lesion (*asterisk*) at anteromedial tibia near pes anserinus insertion, which is classic location of periosteal ganglion cyst, with subtle scalloping of underlying tibial cortex.

C, 44-year-old man with gouty involvement of knee. Coronal CT arthrogram shows gouty deposits (*asterisks*) at pes anserinus bursa and popliteal sulcus.