A wide array of supernumerary and accessory musculature has been described in the anatomic, surgical, and radiology literature. In the vast majority of cases, accessory muscles are asymptomatic and represent incidental findings at surgery or imaging. In some cases, however, accessory muscles may produce clinical symptoms. These symptoms may be related to a palpable swelling or may be the result of mass effect on neurovascular structures, typically in fibro-osseous tunnels. In cases in which an obvious cause for such symptoms is not evident, recognition and careful evaluation of accessory muscles may aid in diagnosis and treatment.

Abbreviations: ADM = abductor digiti minimi, AIN = anterior interosseous nerve, ECR = extensor carpi radialis, EDBM = extensor digitorum brevis manus, FCR = flexor carpi radialis, FDAL = flexor digitorum accessorius longus, FDS = flexor digitorum superficialis, FHL = flexor hallucis longus, FPL = flexor pollicis longus, PAES = popliteal artery entrapment syndrome, PCI = peroneocalcaneus internus, TCI = tibiocalcaneus internus

©RSNA, 2008
Introduction

Muscle anatomic variants are commonly encountered. These variants may consist of absence of a muscle, supernumerary muscles, deviation from the normal course, or an anomalous origin or insertion. Accessory muscles are anatomic variants representing additional distinct muscles that are encountered along with the normal complement of muscles.

Historically, the majority of data regarding accessory musculature has been based on serendipitous findings at surgery. However, with the advent of modern cross-sectional imaging techniques such as ultrasonography (US), computed tomography (CT), and magnetic resonance (MR) imaging, accessory muscles are regularly encountered and can be accurately identified noninvasively.

Accessory muscles are commonly overlooked at imaging evaluation (1). Although they are typically asymptomatic and encountered as incidental findings, accessory muscles have been implicated as a potential source of clinical symptoms. Such symptoms are usually due to mass effect of the supernumerary muscle, with the patient presenting with either a palpable swelling or secondary compression of adjacent structures such as nerves, vessels, or tendons.

Cross-sectional imaging can accurately demonstrate accessory muscles and help differentiate them from other soft-tissue masses. In this article, we describe the gross anatomic and radiologic appearances of the normal musculature and the more commonly encountered accessory muscles in the shoulder, elbow, wrist, knee, and ankle, with emphasis on features that help distinguish between normal and accessory muscles. In addition, we discuss and illustrate the patterns of clinical symptoms associated with specific accessory muscles.

Accessory Muscles of the Shoulder

The biceps brachii muscle has two heads: a long head, which arises from the supraglenoid tubercle within the capsule of the shoulder joint; and a short head, which lies medial to the long head and arises from the coracoid process. The two muscular bellies fuse, and a flattened distal tendon attaches to the posterior margin of the radial tuberosity.

Additional heads of the biceps brachii resulting in a three- or four-headed variant have been described. These variants are extremely rare, and the data are limited to case reports.

In a case report of a cadaveric dissection of a four-headed biceps (2), the first supernumerary head arose from the humerus in the area between the lesser tuberosity and the coracobrachialis and brachialis muscles and joined the long head of the biceps at the level where the short head joined. The second supernumerary head originated from the humerus at the site of insertion of the coracobrachialis and joined the long head at the bicipital aponeurosis in the distal third of the arm.

Other accessory heads have been described that originate from the intertubercular sulcus adjacent to the insertion of the pectoralis major muscle (3). A muscular slip may pass to the posterior fascia of the pronator teres muscle, forming a tunnel that encircles the median nerve and brachial artery. This entity is postulated as a potential cause of compression with ensuing symptoms.

Accessory Muscles of the Elbow

Accessory Brachialis

The brachialis arises from the anterior surface of the lower half of the shaft of the humerus and inserts into the tuberosity of the ulna and the adjacent surface of the coronoid process.
An accessory brachialis originates from the medial midshaft of the humerus and the medial intermuscular septum, with a distal insertion into the common tendon of the antebrachial flexor compartment muscles (4). The accessory brachialis runs medial to the elbow and crosses the median nerve and the brachial artery. The distal tendon has been observed to split and enclose the median nerve, which may result in symptoms of median nerve compression (4).

**Anconeus Epitrochlearis Muscle**
The anconeus epitrochlearis muscle takes the same course as the cubital tunnel retinaculum, running from the medial cortex of the olecranon to the inferior surface of the medial epicondylo (Fig 1). It runs superficial to the ulnar nerve and serves to keep the nerve in position. The cubital tunnel retinaculum is postulated to be the remnant of the anconeus epitrochlearis. The reported prevalence of the anconeus epitrochlearis from cadaveric studies is 11% (5). The anconeus epitrochlearis may be unilateral but was found to be bilateral in one of four patients with cubital tunnel syndrome in a study by Masear et al (6).

The relationship to the ulnar nerve explains the association of the anconeus epitrochlearis with cubital tunnel syndrome (6,7). The anconeus epitrochlearis can be identified at US (8) or, more accurately, at MR imaging (Fig 2) (7) and needs to be distinguished from the ulnar head of the flexor carpi ulnaris muscle, which occurs more distally and merges with the humeral head of that muscle.

**Accessory Head of the Flexor Pollicis Longus Muscle**
The flexor pollicis longus (FPL) muscle arises from the anterior surface of the radius inferior to the anterior oblique line and superior to the pronator quadratus muscle, with additional fibers arising from the interosseous membrane. At the wrist, the tendon passes deep to the flexor retinaculum to insert into the base of the distal phalanx of the thumb.

An accessory head of the FPL, or Gantzer muscle, is relatively common, with a prevalence from cadaveric studies of 45%–66% (9–11). The origin of an accessory head of the FPL can be variable. Some studies have found the medial epicondyle to be the origin in 75%–85% of cases (9,11), whereas others have demonstrated the coronoid process as the most common origin (10). Other described origins of an accessory head of the FPL include the flexor digitorum superficialis (FDS) muscle (11) and a dual origin from the medial humeral epicondyle and the coronoid process (Figs 3, 4) (9). An accessory head of the FPL inserts distally into the ulnar border of the FPL in 100% of cases (9,11) and is innervated by a branch of the AIN (9).

The relationship of the accessory head of the FPL to the median nerve and the AIN is important with respect to potential symptom causation. There are conflicting reports in this regard, with some investigators finding the AIN typically coursing posterior to the muscular portion of the accessory head of the FPL (12) and others finding the AIN coursing anterior (9). A study of 120 cadavers by Mahakkanukrauh et al (11) showed the AIN coursing anterior to the accessory head of the FPL in 13.4% of cases, lateral in 65.8%, posterior in 8.1%, and posterolateral in 12.8%. An accessory head of the FPL has been implicated in compressive neuropathies of either the median nerve or the AIN. Impingement on the AIN results in anterior interosseous nerve syndrome, particularly when the nerve runs deep to the muscle (11), whereas compression of the median nerve leads to pronator syndrome (9).
Bifurcated Distal Biceps Brachii
The distal insertion of the biceps brachii normally consists of a tendinous insertion onto the radial tuberosity and the lacertus fibrosus, the latter being an aponeurosis arising from the medial side of the tendon and continuing onto the deep fascia covering the common flexor muscles of the forearm.

Anomalies of the insertion of the biceps brachii have been described, including a bifurcated tendon inserting onto the radial tuberosity (13). The bifurcated distal tendon attaches via medial and lateral myotendinous units onto the radial tuberosity. Isolated complete tear of one of the myotendinous units clinically simulating a partial tear has been described (13).

Accessory Muscles of the Hand and Wrist
Volar Aspect

Accessory Flexor Digitorum Superficialis Indicus Muscle.—The FDS arises from humeral (common flexor origin), ulnar, and radial heads. It extends through the forearm, dividing into superficial and deep planes, before passing through the carpal tunnel. The distal tendon to the index finger arises from the deep plane and inserts into the base of the middle phalanx.

An accessory FDS indicis muscle is a rare but well-described accessory muscle originating from the FDS tendon adjacent to the transverse carpal ligament and inserting into the index finger, typically in the region of the A1 pulley (14). Several variants of the accessory FDS indicis tendon have been reported in the literature, including a muscle belly located wholly within the palm and replacing the normal tendon. A second variant consists of a digastric muscular component with part of the muscle located in the forearm and part located in the palm. A third variant is characterized by a muscle belly that is located within the forearm and extends into but not beyond the carpal tunnel (15,16).

An accessory FDS with a muscular component in the palm may manifest clinically with a palpable soft-tissue mass. In cases involving a digastric component, more proximal extension of the accessory FDS can be associated with compression of the median nerve within the carpal tunnel (14). To our knowledge, there are no data regarding the prevalence of an accessory FDS indicis.

MR imaging has been successfully used to demonstrate an accessory FDS indicis. The anomalous muscle belly may be visualized in the palm, deep to the subcutaneous tissues and volar to the second metacarpal bone. The distal tendon of the anomalous muscle belly may be seen extending into the flexor tendon sheath as the superficial tendon (17). More proximal axial MR images through the carpal tunnel may help identify the FDS tendon continuous with the muscle belly in the palm; alternatively, an additional, more proximal muscle belly may be evident in cases with digastric morphologic features (18).
Accessory Hypothenar Muscles.—The hypothenar eminence is composed of the abductor digiti minimi (ADM), flexor digiti minimi, and opponens digiti minimi muscles; hence, accessory muscles of the hypothenar eminence will be described together. The ADM arises from the pisiform bone and flexor carpi ulnaris and inserts into the ulnar side of the base of the proximal phalanx of the little finger. The flexor digiti minimi arises from the flexor retinaculum and the hook of hamate. It inserts into the proximal phalanx with the abductor and acts to flex the fifth metacarpophalangeal joint.

Of the accessory hypothenar muscles, the accessory ADM is the most common, with a prevalence of 24% (19). It originates from the antebrachial fascia, coursing superficial to the ulnar nerve (arrowhead), and inserting into the base of the fifth proximal phalanx with the ADM (curved arrow).

An accessory flexor digiti minimi is an extremely rare variant that arises from the intercompartmental septum on the ulnar aspect of the forearm just proximal to the wrist joint, with a distal insertion into either the proximal phalanx of the fifth digit or the flexor digiti minimi (21).

The relationship of these accessory muscles to the Guyon canal has been implicated in compression neuropathy of the ulnar nerve at this level (20,22). An accessory ADM is still fleshy as it crosses the Guyon canal, a characteristic that may contribute to compression of the ulnar nerve and helps identify the presence of an accessory muscle, since under normal circumstances no muscular structures are visualized in this location.

Variations in Palmaris Longus Muscle Anatomy.—The palmaris longus muscle arises from the common flexor origin and inserts into the palmar fascia. It consists of a short muscle proximally and a long tendon distally. The palmaris longus is a vestigial flexor of the wrist and is the most variable muscle in the forearm. It is commonly used for the surgical repair of tendon tears.

The palmaris longus may have a variable appearance in the forearm and wrist. It may be duplicated, digastric, entirely muscular, or tendinous proximally and muscular distally (reverse palmaris longus) (18). An accessory or epifascial palmaris longus is an extremely rare variant that arises from the subcutaneous fascia of the forearm, with a distal insertion into the superficial palmar aponeurosis. In an MR imaging study...
of 42 asymptomatic wrists, Zeiss and Guilliam-Haidet (19) reported a prevalence of 7% for a muscular palmaris longus, but no cases of an accessory palmaris longus were identified.

Palmaris longus variants may manifest clinically with a forearm soft-tissue mass or symptoms of compression of the median nerve (23) or ulnar nerve (24). Symptomatic cases of epifascial palmaris longus have been successfully treated with surgical excision of the accessory muscle (25).

Epifascial palmaris longus, reverse palmaris longus, and the digastric and completely muscular varieties of palmaris longus are characterized at axial cross-sectional imaging of the wrist by excess muscle tissue in the midline immediately superficial to the flexor retinaculum. Imaging of the more proximal forearm may serve to fully delineate the morphologic features of the palmaris longus variant (18). Palmaris longus anomalies are commonly overlooked at MR imaging (25).

**Flexor Carpi Radialis Brevis Vel Profundus Muscle.**—There is very little literature on the rare short radiocarpal flexor muscle known as the flexor carpi radialis (FCR) brevis vel profundus muscle (26,27). This accessory muscle arises from the volar aspect of the distal radius, distal to the origin of the FPL. The muscle passes anterior to the pronator quadratus and crosses deep to the FCR. Distally, the tendon inserts onto the capitate bone and the base of the third and fourth metacarpals (Figs 7, 8). Although this rare accessory muscle has typically been described in cadaveric specimens, its position may potentially cause symptoms of carpal tunnel syndrome. To our knowledge, there are no descriptions of the imaging characteristics of this muscle.

**Dorsal Aspect**

**Extensor Digitorum Brevis Manus Muscle.**—An extensor digitorum brevis manus (EDBM) muscle is a well-described accessory muscle that occurs on the dorsum of the hand. An EDBM is rare: In a recent study of 128 cadavers by Rodriguez-Niedenfuhr et al (28), this accessory muscle was found in four limbs (1.6%). The muscle can be unilateral or bilateral.

The origin of an EDBM can vary, although the most common origin is the dorsal wrist.
capsule deep to the extensor retinaculum (28). The muscle may also arise from the distal radius or the deep carpal fascia (29). It typically inserts onto the extensor hood of the index finger or middle finger (Fig 9) (28) but may also insert into the extensors of the fourth and fifth fingers by way of either a tendon or a slip (29).

An EDBM can manifest clinically as a soft-tissue swelling on the dorsum of the hand that becomes firm on extension of the fingers. It is often clinically diagnosed as a ganglion, synovitis, or a carpal boss. An EDBM is usually painless but may occasionally be associated with exercise-induced pain or tenosynovitis of the extensor tendons. The EDBM tendon has been used in surgical restoration of function of ruptured tendons.

At MR imaging, an EDBM typically appears as a masslike lesion with low T1 and T2 signal intensity, usually located between the second and third metacarpals, with the bulk of the muscle at the level of the carpometacarpal joints. Because of its low T1 and T2 signal intensity, the muscle may mimic a giant cell tumor of the tendon sheath (Fig 10) (30). US can be used to demonstrate the normal echotexture of the muscle as well as morphologic changes of the muscle upon flexion and extension, resulting in dynamic contraction-induced protrusion of the muscle between the extensor tendons (31).

Treatment of a symptomatic EDBM may include extensor retinaculum release or excision of the muscle (32).

**Accessory Extensor Carpi Radialis Muscle and Variations.**—The extensor carpi radialis (ECR) longus muscle originates from the distal lateral supracondylar ridge of the humerus and the lateral epicondy and inserts into the dorsal surface of the base of the second metacarpal. The ECR brevis muscle originates from the lateral epicondy of the humerus and the radial collateral ligament of the elbow and inserts into the dorsal surface of the base of the third metacarpal. The two tendons pass through the second extensor compartment at the wrist, located radial to the Lister tubercle.

A variety of accessory musculature related to ECR muscles has been reported in the literature, including accessory ECR brevis, ECR intermedius, and ECR accessorius muscles.

An accessory ECR brevis arises from the medial aspect of the normal ECR brevis (33). The accessory tendon passes deep to the main tendon and enters the second extensor tunnel of the wrist. Variable insertions of the accessory ECR brevis have been described, including the base of the second metacarpal, the base of the third metacarpal, and the dorsal digital expansion of the index finger, and may occur bilaterally (33,34). An accessory ECR brevis may manifest clinically as a soft-tissue mass in the forearm that can be accurately distinguished from other masses at US and MR imaging (35). It may mimic a split tear of the ECR tendons in the second extensor tunnel, but more proximal images will demonstrate the presence of the anomalous muscle belly.
Accessory Muscles of the Knee

Accessory Slips of the Medial and Lateral Gastrocnemius Muscle

The gastrocnemius muscle has two bellies, which arise from the posterior surface of the femur just above the femoral condyles and from the adjacent capsule of the knee joint. The two bellies unite to form the Achilles tendon.

Reported variations of the origin of the medial and lateral heads of the gastrocnemius consist of anomalous origins and accessory slips. The medial head of the gastrocnemius may have an aberrant origin, arising from the region of the intercondylar notch rather than the medial femoral condyle. Similarly, the lateral head of the gastrocnemius may have an aberrant origin, arising more medially from the posterior femur but maintaining its position lateral to the popliteal artery. An accessory slip of the medial head of the gastrocnemius may arise from the intercondylar notch, passing between the popliteal artery and vein and inserting into the medial head of the gastrocnemius (Fig 13). An accessory slip of the lateral head of the gastrocnemius has also been described originating from the posterior cortex of the distal femur, medial to the lateral head. The slip courses anterolateral to the popliteal vessels, inserting into the lateral head of the gastrocnemius (Fig 14) (39,40).

An anomalous relationship between the popliteal artery and the proximal gastrocnemius may manifest clinically with PAES. PAES results...
around a normally situated medial head of the gastrocnemius. Type II anomaly is characterized by an anomalous medial head of the gastrocnemius compressing the popliteal artery deep to it. In type III anomaly, the accessory slip of the medial head of the gastrocnemius forms a sling around the popliteal artery. In type IV anomaly, the popliteal artery courses deep to the popliteus, whereas type V anomaly is characterized by concomitant involvement of the popliteal vein. Type VI involves a normally located artery that is entrapped by gastrocnemius hypertrophy. An anomalous lateral head of the gastrocnemius and an accessory slip of the lateral head have also been implicated in PAES (39).

An accessory slip of the medial head of the gastrocnemius has been found to occur in 21% of patients with PAES, and an accessory slip of the lateral head of the gastrocnemius was found in 30% of patients with PAES (39).

CT and MR imaging have been used to identify such accessory slips, as well as an anomalous relationship of the popliteal vessels to the gastrocnemius. MR angiography has proved effective in demonstrating popliteal artery occlusion and is useful in surgical planning (Fig 15) (39,40).

Tensor Fasciae Suralis Muscle

A tensor fasciae suralis muscle is a very rare accessory muscle. Although it may arise from the distal aspect of any of the hamstring muscles, in the majority of reported cases it originates from the distal semitendinosus muscle. It may insert into the posterior fascia of the leg, into the medial
the posteromedial capsule. MR imaging demonstrates an accessory muscle located between the popliteal vessels and the posterior knee capsule and coursing obliquely through the popliteal fossa (Fig 17). Although in this reported case the accessory muscle was asymptomatic, the authors postulated that the proximity of the muscle to the neurovascular bundle might result in compressive symptoms (46).

Accessory Muscles of the Ankle

Lateral Aspect: Accessory Peroneal Muscles

The peroneus longus muscle (arising from the proximal fibula) and the peroneus brevis muscle (arising from the lower two-thirds of the fibula) contribute tendons, which pass behind the lateral malleolus. The peroneus brevis tendon lies more anterior and separates the peroneus longus from the peroneal groove of the distal fibula. More distally, the peroneus longus and peroneus brevis tendons are typically separated by the peroneal tubercle of the calcaneus.

A third peroneal tendon, the peroneus tertius tendon, is encountered in 83%–95% of cases in cadaveric studies (47). The tendon and muscle are located in the anterior compartment of the leg and arise from the anterior surface of the distal fibula and the extensor digitorum longus muscle. The tendon passes deep to the inferior extensor retinaculum, either in the same compartment as the extensor digitorum longus or in a different compartment. The peroneus tertius inserts onto the base and the dorsal surface of the shaft of the
radiologic studies demonstrate a similar range of prevalence, with 10% in an ankle MR imaging study (52) and 22% in a US study (53). Peroneus quartus muscles are frequently bilateral and are more commonly seen in men (52,54).

In the majority of cases, a peroneus quartus originates from the peroneus brevis. Other origins that have been described include the posterior surface of the fibula and the peroneus longus (54). The peroneus quartus descends medial and posterior to the other peroneal tendons (Fig 18) (52). The distal insertion of peroneus quartus tendons varies and has been classified into several types (51). Insertion into the calcaneus is known as peroneocalcaneus externum and represents the most common type (54). The calcaneal attachment may be onto the peroneal tubercle (50) or the retrotrochlear eminence posterior to the peroneal tubercle (52). Insertion of the tendon onto the retrotrochlear eminence may lead to significant hypertrophy of the latter structure (52). However, other studies have found no difference in the size of the retrotrochlear eminence in persons with a peroneus quartus and those without (55). A peroneus quartus may also rarely insert onto the cuboid (peroneocuboideus) (50,54), the peroneus longus (peroneoperoneolongus), or the inferior peroneal retinaculum adjacent to the retrotrochlear eminence (54).

The peroneus digiti minimi arises from the peroneus brevis to insert via two tendons into the base and head of the fifth metatarsal and the base of the proximal phalanx (50,52). The peroneus
accessorius has been reported to arise from the muscular portion of the peroneus brevis, inserting onto the peroneus longus (56).

Similar to the other peroneal muscles, a peroneus quartus acts predominantly as a pronator of the foot. It is commonly encountered as an asymptomatic variant but may cause lateral ankle pain or ankle instability, particularly in athletes (54). Hypertrophy of the bone attachments has been implicated in peroneal tenosynovitis (50). The presence of an extra tendon may result in crowding of tendons deep to the peroneal retinaculum, leading to anterior subluxation, mechanical attrition, or longitudinal tears of the peroneal tendons (50,57). In some cases, surgical excision has provided symptomatic relief (54).

Peroneus quartus tendons have been used successfully for surgical repair of superior and inferior peroneal retinacular injuries (58).

US can help identify a peroneus quartus and its calcaneal insertion (53), but the muscle is optimally delineated at MR imaging (59). On axial MR images, a peroneus quartus is visualized posterior to or medial to the peroneus brevis and is separated from it by a fat plane (Fig 19) (52,53). The accessory tendon may be mistaken for a longitudinal split tear of the peroneal tendons. However, the accessory tendon can be differentiated from a split tear by evaluating the more proximal images, which will demonstrate an anomalous muscle belly. The muscle belly of a peroneus quartus may vary in size, and the myotendinous junction may extend distally to a variable extent. In the retromalleolar region, the myotendinous unit may range from completely tendinous to completely muscular (53).

Medial Aspect

Flexor Digitorum Accessorius Longus.—The flexor digitorum longus arises from the shaft of the tibia below the soleal line. Its tendon passes behind the medial malleolus and, in the sole, splits into four slips to insert into the distal phalanges of the second through fifth toes.

A flexor digitorum accessorius longus (FDAL) originates either from the medial margin of the tibia (60) and the fascia of the deep posterior compartment, or, with equal frequency, from the lateral margin of the fibula distal to the origin of the flexor hallucis longus (FHL) (61). However, an FDAL can vary widely in origin, arising from any structure in the posterior compartment, including adjacent muscles such as the FHL (62).

The FDAL tendon descends posterior and superficial to the tibial nerve (63), courses beneath the flexor retinaculum through the tarsal tunnel, and is intimately related to the posterior tibial artery and tibial nerve (61). Within the tarsal tunnel, it may contain fleshy fibers (62), a factor that helps identify an FDAL at MR imaging. The distal tendon inserts into the quadratus plantae
sory muscles within the tarsal tunnel, such as peroneocalcaneus internus (PCI) and tibiocalcaneus internus (TCI) muscles, which insert onto the calcaneus. However, demonstration of the insertion of an FDAL onto the flexor digitorum longus tendon or the flexor digitorum longus tendon (Fig 20) (61,63).

An FDAL has a prevalence of 6%–8%, is more common in males, and is infrequently bilateral (61,62).

Because of the close relationship of the tendon in the tarsal tunnel to the neurovascular bundle, it is not surprising that the presence of an FDAL is associated with tarsal tunnel syndrome (63,64). An FDAL has a prevalence of up to 12.2% in patients with tarsal tunnel syndrome (65) and has also been associated with tenosynovitis of the FHL tendon (60).

An FDAL can be optimally identified on axial MR images (62), which demonstrate the muscle within the tarsal tunnel, typically superficial to the neurovascular bundle (Fig 21). Attachment onto the flexor digitorum longus or quadratus plantae allows differentiation from other accessory muscles within the tarsal tunnel, such as peroneocalcaneus internus (PCI) and tibiocalcaneus internus (TCI) muscles, which insert onto the calcaneus. However, demonstration of the insertion of an FDAL onto the flexor digitorum longus may be difficult in some cases. MR imaging may also exclude other causes of tarsal tunnel syndrome, including ganglia, tumors, varicosities, and FHL tenosynovitis (Fig 22).

**Peroneocalcaneus Internus.**—The largest series describing the MR imaging characteristics of a PCI showed the muscle to originate at the inner aspect of the lower fibula, below the origin of the FHL, with interdigitation between these two muscles (66). A PCI descends posterior and lateral to the FHL and displaces it anteriorly.
and medially, which may cause encroachment on the neurovascular bundle as the tendons pass through the tarsal tunnel (67). Both tendons pass inferior to the sustentaculum tali, with the PCI tendon inserting onto a small tubercle on the medial aspect of the calcaneus below the sustentaculum (Fig 23). In a study of asymptomatic volunteers, a PCI was seen in 1% of cases, with bilaterality in 75% (66).

A PCI is usually asymptomatic, since it is not directly related to the neurovascular bundle and typically becomes tendinous 2–3 cm above the tibiotalar joint. However, cases of ankle pain and limitation of movement have been described (66,67), although the exact causative mechanism is unclear. A PCI has been demonstrated in the clinical setting of posterior ankle impingement and FHL tenosynovitis (67).

MR imaging can accurately delineate the origin and insertion of a PCI. At imaging, a PCI may be difficult to differentiate from an FDAL, with both tendons taking a similar course through the ankle and hindfoot. Distinctive features of a PCI include insertion onto the calcaneus, with a fat plane between the PCI and quadratus plantae. In contrast, an FDAL inserts into the flexor digitorum longus tendon or the quadratus plantae itself. The calcaneal insertion of a PCI may be optimally evaluated on coronal oblique images (66). The relationship of the accessory muscle relative to the neurovascular bundle may also help differentiate between an FDAL and a PCI. The latter is typically located posterior and lateral to the neurovascular bundle and separated from it by the FHL (Fig 24); in contrast, an FDAL lies immediately superficial to
An accessory soleus may manifest clinically as a soft-tissue mass in the posteromedial aspect of the ankle. Clinically evident accessory soleus muscles have a male predilection and commonly manifest in the 2nd and 3rd decades of life (69), a fact that may be attributable to the increase in muscle mass and activity during this period. There may be associated pain, which is typically exertional, with a higher prevalence in athletes (69,71). There are various explanations for pain associated with an accessory soleus, including development of a localized compartment syndrome due to an increase in intrafascial pressure (71,73) or an inadequate blood supply from the posterior tibial artery (69). Alternatively, accessory soleus hypertrophy may cause compression of the adjacent posterior tibial nerve. Although an accessory soleus lies outside the tarsal tunnel, it has been implicated in tarsal tunnel syndrome in cases in which the muscle attaches to the medial aspect of the calcaneus (65). Symptomatic cases have been successfully treated with fasciotomy, tendon release, excision, or debulking (69,74). In a case report of an accessory soleus with congenital clubfoot, Chotigavanichaya et al (72) found the talipes equinus and talipes varus deformities resistant to percutaneous Achilles tenotomy, necessitating concomitant release of the accessory soleus.

An accessory soleus may be visualized at conventional radiography (Fig 26) (68), CT (Fig 27) (68,73), US (73), and MR imaging (69,71,74–76). At conventional radiography, the normal triangular appearance of the Kager fat pad anterior to the neurovascular bundle. Occasionally, the FHL may demonstrate two tendinous slips, which may be mistaken for a PCI tendon (66).

**Accessory Soleus.**—The soleus lies deep to the gastrocnemius and arises from (a) the posterior aspect of the head and upper shaft of the fibula, (b) the soleal line of the tibia, (c) the middle third of the medial border of the tibia, and (d) a fibrous band bridging its muscular and tendinous origins. The fibers converge on a short tendon, which normally joins the deep surface of the Achilles tendon.

An accessory soleus arises from the anterior (deep) surface of the soleus or from the fibula and soleal line of the tibia (68–70). From its origin, the muscle descends anterior or anteromedial to the Achilles tendon (Fig 25) (68,70).

Five types of accessory soleus have been described on the basis of insertion characteristics. Insertion points include the Achilles tendon, the upper surface of the calcaneus with a fleshy muscular insertion, the superior surface of the calcaneus with a tendinous insertion, the medial aspect of the calcaneus with a fleshy muscular insertion, and finally, the medial aspect of the calcaneus with a tendinous insertion (68,70,71). When the accessory muscle inserts separately into the superior surface of the calcaneus, the insertion is anterior and medial to the calcaneal insertion of the Achilles tendon (70,72). The accessory soleus is innervated by the posterior tibial nerve, and the blood supply is via the posterior tibial artery (69,71).

According to cadaveric studies, an accessory soleus has a prevalence of 0.7%–5.5%, with the muscle most commonly seen as a unilateral finding (69).
or obliterated by a well-defined area of increased soft-tissue density. Cross-sectional imaging is more sensitive and specific in the identification of an accessory soleus. The accessory muscle is demonstrated anterior to the Achilles tendon and superficial to the flexor retinaculum, typically extending medially to the area between the medial edge of the Achilles tendon and the medial malleolus (Fig 28). In some cases, MR imaging may demonstrate abnormal signal intensity, a finding that reflects the presence of trauma, ischemia, or atrophy (Fig 29).

Tibiocalcaneus Internus.—There is scant literature concerning the TCI (77,78), a rare accessory muscle that arises from the medial crest of the tibia and descends deep to the flexor retinaculum and posterior to the neurovascular structures. A TCI inserts distally onto the medial surface of the calcaneus approximately 1–2 cm anterior to the Achilles tendon insertion. The origin and insertion of a TCI is similar to the type of accessory soleus that inserts onto the medial cortex of the calcaneus. However, the two accessory muscles can be distinguished on the basis of their location relative to the flexor retinaculum. A TCI passes deep to the flexor retinaculum, whereas an accessory soleus is located superficial to the flexor retinaculum (Fig 30). The location of a TCI (within the tarsal tunnel and superficial to the neurovascular bundle) may resemble that of an FDAL. The distal insertion of an FDAL onto the flexor digitorum longus or quadratus plantae may be used as a distinguishing feature.

To our knowledge, there are no radiology reports on the TCI. Given its location within the tarsal tunnel and its similarities to the accessory soleus and FDAL, the TCI may be associated with tarsal tunnel syndrome.
Conclusions

A large number of accessory muscles have been described in the surgical and radiology literature, primarily in limited case reports. The vast majority of these accessory muscles are asymptomatic and tend to represent incidental findings at surgery or imaging. However, accessory muscles may result in symptoms in some cases. Symptoms may be related to a palpable swelling, and the differential diagnosis of an accessory muscle should be borne in mind when an obvious mass is not detected at imaging. Furthermore, accessory muscles may result in compression neuropathies, especially in relation to the cubital tunnel, carpal tunnel, Guyon canal, and tarsal tunnel. Careful evaluation of fibro-osseous tunnels for an accessory muscle may help identify such a muscle as a causative factor, which can easily be overlooked unless accessory muscles are specifically sought out during the review process.

References


Accessory Muscles: Anatomy, Symptoms, and Radiologic Evaluation

Paul A. Sookur, MRCP, et al

Page 483
The relationship to the ulnar nerve explains the association of the anconeus epitrochlearis with cubital tunnel syndrome (6,7).

Page 484
In cases involving a digastric component, more proximal extension of the accessory FDS can be associated with compression of the median nerve within the carpal tunnel (14).

Page 488
An anomalous relationship between the popliteal artery and the proximal gastrocnemius may manifest clinically with PAES.

Page 492
The accessory tendon may be mistaken for a longitudinal split tear of the peroneal tendons. However, the accessory tendon can be differentiated from a split tear by evaluating the more proximal images, which will demonstrate an anomalous muscle belly.

Page 495
Occasionally, the FHL may demonstrate two tendinous slips, which may be mistaken for a PCI tendon (66).
RadioGraphics 2008

This is your reprint order form or pro forma invoice
(Please keep a copy of this document for your records.)

Order and Shipping Information

Reprint Costs (Please see page 2 of 2 for reprint costs/fees.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of reprints ordered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of color reprints ordered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of covers ordered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Taxes $______

(Add appropriate sales tax for Virginia, Maryland, Pennsylvania, and the District of Columbia or Canadian GST to the reprints if your order is to be shipped to these locations.)

First address included, add $32 for each additional shipping address $______

TOTAL $______

Payment and Credit Card Details

Enclosed: Personal Check
Credit Card Payment Details

Checks must be paid in U.S. dollars and drawn on a U.S. Bank.

Credit Card: __ VISA  __ Am. Exp.  __ MasterCard
Card Number _____________________________
Expiration Date _________________________
Signature: ______________________________

Please send your order form and prepayment made payable to:
Cadmus Reprints
P.O. Box 751903
Charlotte, NC 28275-1903

Note: Do not send express packages to this location, PO Box.
FEIN #: 541274108

Invoice or Credit Card Information

Invoice Address Please Print Clearly

Please complete invoice address as it appears on credit card statement

Name _______________________________________________________________________
Institution ____________________________
Department ____________________________
Street ____________________________ City ____________________________ State _____ Zip _____
Country ____________________________
Fax ____________________________
Phone: Day ____________ Evening ____________
E-mail Address ____________________________

Cadmus will process credit cards and Cadmus Journal Services will appear on the credit card statement.

If you don’t mail your order form, you may fax it to 410-820-9765 with your credit card information.

Signature ____________________________ Date ____________________________

Signature is required. By signing this form, the author agrees to accept the responsibility for the payment of reprints and/or all charges described in this document.
## Black and White Reprint Prices

### Domestic (USA only)

<table>
<thead>
<tr>
<th># of Pages</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>$221</td>
<td>$233</td>
<td>$268</td>
<td>$285</td>
<td>$303</td>
<td>$323</td>
</tr>
<tr>
<td>5-8</td>
<td>$355</td>
<td>$382</td>
<td>$432</td>
<td>$466</td>
<td>$510</td>
<td>$544</td>
</tr>
<tr>
<td>9-12</td>
<td>$466</td>
<td>$513</td>
<td>$595</td>
<td>$652</td>
<td>$714</td>
<td>$775</td>
</tr>
<tr>
<td>13-16</td>
<td>$576</td>
<td>$640</td>
<td>$749</td>
<td>$830</td>
<td>$912</td>
<td>$995</td>
</tr>
<tr>
<td>17-20</td>
<td>$694</td>
<td>$775</td>
<td>$906</td>
<td>$1,017</td>
<td>$1,117</td>
<td>$1,220</td>
</tr>
<tr>
<td>21-24</td>
<td>$809</td>
<td>$906</td>
<td>$1,071</td>
<td>$1,200</td>
<td>$1,321</td>
<td>$1,471</td>
</tr>
<tr>
<td>25-28</td>
<td>$928</td>
<td>$1,041</td>
<td>$1,242</td>
<td>$1,390</td>
<td>$1,544</td>
<td>$1,688</td>
</tr>
<tr>
<td>29-32</td>
<td>$1,042</td>
<td>$1,178</td>
<td>$1,403</td>
<td>$1,568</td>
<td>$1,751</td>
<td>$1,924</td>
</tr>
<tr>
<td>Covers</td>
<td>$97</td>
<td>$118</td>
<td>$215</td>
<td>$323</td>
<td>$442</td>
<td>$555</td>
</tr>
</tbody>
</table>

### International (includes Canada and Mexico)

<table>
<thead>
<tr>
<th># of Pages</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>$272</td>
<td>$283</td>
<td>$340</td>
<td>$397</td>
<td>$446</td>
<td>$506</td>
</tr>
<tr>
<td>5-8</td>
<td>$428</td>
<td>$455</td>
<td>$576</td>
<td>$675</td>
<td>$784</td>
<td>$884</td>
</tr>
<tr>
<td>9-12</td>
<td>$580</td>
<td>$626</td>
<td>$805</td>
<td>$964</td>
<td>$1,115</td>
<td>$1,278</td>
</tr>
<tr>
<td>13-16</td>
<td>$724</td>
<td>$786</td>
<td>$1,023</td>
<td>$1,232</td>
<td>$1,445</td>
<td>$1,652</td>
</tr>
<tr>
<td>17-20</td>
<td>$878</td>
<td>$958</td>
<td>$1,246</td>
<td>$1,520</td>
<td>$1,774</td>
<td>$2,030</td>
</tr>
<tr>
<td>21-24</td>
<td>$1,022</td>
<td>$1,119</td>
<td>$1,474</td>
<td>$1,795</td>
<td>$2,108</td>
<td>$2,426</td>
</tr>
<tr>
<td>25-28</td>
<td>$1,176</td>
<td>$1,291</td>
<td>$1,700</td>
<td>$2,070</td>
<td>$2,450</td>
<td>$2,813</td>
</tr>
<tr>
<td>29-32</td>
<td>$1,316</td>
<td>$1,452</td>
<td>$1,936</td>
<td>$2,355</td>
<td>$2,784</td>
<td>$3,209</td>
</tr>
<tr>
<td>Covers</td>
<td>$156</td>
<td>$176</td>
<td>$335</td>
<td>$525</td>
<td>$716</td>
<td>$905</td>
</tr>
</tbody>
</table>

### Color Reprint Prices

### Domestic (USA only)

<table>
<thead>
<tr>
<th># of Pages</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>$223</td>
<td>$239</td>
<td>$352</td>
<td>$473</td>
<td>$597</td>
<td>$719</td>
</tr>
<tr>
<td>5-8</td>
<td>$349</td>
<td>$401</td>
<td>$601</td>
<td>$849</td>
<td>$1,099</td>
<td>$1,349</td>
</tr>
<tr>
<td>9-12</td>
<td>$486</td>
<td>$517</td>
<td>$852</td>
<td>$1,232</td>
<td>$1,609</td>
<td>$1,992</td>
</tr>
<tr>
<td>13-16</td>
<td>$615</td>
<td>$651</td>
<td>$1,105</td>
<td>$1,609</td>
<td>$2,117</td>
<td>$2,624</td>
</tr>
<tr>
<td>17-20</td>
<td>$759</td>
<td>$787</td>
<td>$1,357</td>
<td>$1,997</td>
<td>$2,626</td>
<td>$3,260</td>
</tr>
<tr>
<td>21-24</td>
<td>$897</td>
<td>$924</td>
<td>$1,611</td>
<td>$2,376</td>
<td>$3,135</td>
<td>$3,905</td>
</tr>
<tr>
<td>25-28</td>
<td>$1,033</td>
<td>$1,071</td>
<td>$1,873</td>
<td>$2,757</td>
<td>$3,650</td>
<td>$4,536</td>
</tr>
<tr>
<td>29-32</td>
<td>$1,175</td>
<td>$1,208</td>
<td>$2,122</td>
<td>$3,138</td>
<td>$4,162</td>
<td>$5,180</td>
</tr>
<tr>
<td>Covers</td>
<td>$97</td>
<td>$118</td>
<td>$215</td>
<td>$323</td>
<td>$442</td>
<td>$555</td>
</tr>
</tbody>
</table>

### International (includes Canada and Mexico)

<table>
<thead>
<tr>
<th># of Pages</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>$278</td>
<td>$290</td>
<td>$424</td>
<td>$586</td>
<td>$741</td>
<td>$904</td>
</tr>
<tr>
<td>5-8</td>
<td>$429</td>
<td>$472</td>
<td>$746</td>
<td>$1,058</td>
<td>$1,374</td>
<td>$1,690</td>
</tr>
<tr>
<td>9-12</td>
<td>$604</td>
<td>$629</td>
<td>$1,061</td>
<td>$1,545</td>
<td>$2,011</td>
<td>$2,494</td>
</tr>
<tr>
<td>13-16</td>
<td>$766</td>
<td>$797</td>
<td>$1,378</td>
<td>$2,013</td>
<td>$2,647</td>
<td>$3,280</td>
</tr>
<tr>
<td>17-20</td>
<td>$945</td>
<td>$972</td>
<td>$1,698</td>
<td>$2,499</td>
<td>$3,282</td>
<td>$4,069</td>
</tr>
<tr>
<td>21-24</td>
<td>$1,110</td>
<td>$1,139</td>
<td>$2,015</td>
<td>$2,970</td>
<td>$3,921</td>
<td>$4,873</td>
</tr>
<tr>
<td>25-28</td>
<td>$1,290</td>
<td>$1,321</td>
<td>$3,333</td>
<td>$4,347</td>
<td>$4,586</td>
<td>$5,661</td>
</tr>
<tr>
<td>29-32</td>
<td>$1,455</td>
<td>$1,482</td>
<td>$2,652</td>
<td>$3,924</td>
<td>$5,193</td>
<td>$6,462</td>
</tr>
<tr>
<td>Covers</td>
<td>$156</td>
<td>$176</td>
<td>$335</td>
<td>$525</td>
<td>$716</td>
<td>$905</td>
</tr>
</tbody>
</table>

### Tax Due

Residents of Virginia, Maryland, Pennsylvania, and the District of Columbia are required to add the appropriate sales tax to each reprint order. For orders shipped to Canada, please add 7% Canadian GST unless exemption is claimed.

### Ordering

Reprint order forms and purchase order or prepayment is required to process your order. Please reference journal name and reprint number or manuscript number on any correspondence. You may use the reverse side of this form as a proforma invoice. Please return your order form and prepayment to:

**Cadmus Reprints**  
P.O. Box 751903  
Charlotte, NC  28275-1903

**Note:** Do not send express packages to this location, PO Box.

**FEIN #:541274108**

Please direct all inquiries to:

**Rose A. Baynard**  
800-407-9190 (toll free number)  
410-819-3966 (direct number)  
410-820-9765 (FAX number)  
baynardr@cadmus.com (e-mail)

---

Minimum order is 50 copies. For orders larger than 500 copies, please consult Cadmus Reprints at 800-407-9190.

### Reprint Cover

Cover prices are listed above. The cover will include the publication title, article title, and author name in black.

### Shipping

Shipping costs are included in the reprint prices. Domestic orders are shipped via UPS Ground service. Foreign orders are shipped via a proof of delivery air service.

### Multiple Shipments

Orders can be shipped to more than one location. Please be aware that it will cost $32 for each additional location.

### Delivery

Your order will be shipped within 2 weeks of the journal print date. Allow extra time for delivery.