Anomalous muscles: Imaging findings with anatomical correlation

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Authors: A. Tagliafico¹, M. Miguel Perez², A. Marchetti³, E. Capaccio¹, L. Altafini¹, A. Ravenna¹, C. Martinoli¹, ¹Genoa/IT, ²Bercellona/ES, ³genova/IT
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Purpose

A wide array of muscle anatomic variants exists, including absence, supernumerary bellies, anomalous tendon origin and insertion and deviation from the normal course of a muscle\(^1\). Accessory muscles represent distinct structures that are encountered in addition to the normal array of skeletal muscles. In many instances, they are believed to represent possible remnants of animal muscles lost during the evolution process. The genetic code of these atavistic muscles should be normally repressed during embryogenesis but, in some cases and for unexplained reasons, a derepression of these genetic loci occurs\(^2\). Although accessory muscles are most often asymptomatic and non palpable, they may be implicated as a potential source of clinical symptoms. Generally speaking, the clinical relevance of accessory musculature may be related to i) the mass effect produced by the additional muscle belly, possibly mimicking any soft-tissue pathology; ii) a secondary compression or displacement of adjacent structures, such as nerves, vessels and tendons both inside and outside osteofibrous tunnels; iii) exercise-related pain as a probable result of localized compartment syndrome or inadequate blood supply received by the muscle.

Before the advent of cross-sectional imaging modalities, detection of accessory muscles has been essentially based on unexpected findings at surgery or at anatomic dissection. Nowadays, ultrasound (US) and magnetic resonance (MR) imaging are able to identify and characterize accessory musculature, thus helping differentiate it from other soft-tissue masses\(^1\). This article describes the gross anatomic and imaging appearance of the more commonly encountered accessory muscles of the upper and lower limb.

Methods and Materials

See results.

Results

Axilla and Upper Arm

The most clinically relevant accessory muscles about the axilla and the upper arm are the axillary arch (AAM) and the chondroepitrochlearis (CHEP). These muscles may incidentally cause entrapment of adjacent nerves.
Axillary Arch (Axillopectoral)

The AAM (also known as axillopectoral muscle) is a fleshy accessory slip crossing the axilla. It looks like a triangle, the base of which arises from the external border of the latissimus dorsi as an independent muscle belly\(^3\), whereas the apex lies laterally in a variable location. Most often, the muscle joins the pectoralis major, but it may also attach into either the coracoid or the short head of the biceps\(^4,5\). Several authors have described this muscle variant pointing out its possible causative role for neurovascular compression in the axillary area\(^6\). US demonstrates the AAM as a slender slip bridging the axilla, in close relationship with the main nerves of the upper limb (Fig. 1 on page 11).

Chondroepitrochlearis (Chondrohumeralis)

The CHEP is an extremely rare muscle variant that arise from either the ventral edge of the pectoralis major muscle, the osteochondral junction of the 5\(^{th}\) and 6\(^{th}\) costal cartilages or the aponeurosis of the external oblique muscle and inserts into the medial intermuscular septum or the medial epicondyle after crossing the axilla and the upper arm\(^2,7\). In its typical configuration, the CHEP muscle appears as a very long, narrow slip closely applied to, but distinct from, the inferolateral margin of the sternocostal head of the pectoralis major (Fig. 2A-C). In the axilla, the CHEP muscle curves away from the parent pectoralis and assumes an arched course as it is tethered to the axillary fascia. More distally, it descends almost vertically along the medial aspect of the arm and continues in an elongated slender tendon that courses posteriorly to the ulnar nerve. More rarely, the muscle may remain fleshy down to its insertion. From the phylogenetic point-of-view, this muscle seems to be an atavistic anomaly duplicating the far distal insertion of the pectoralis major existing in quadrupeds\(^8\). In fact, in most mammals, the pectoralis major inserts much farther down the humerus than it does in primates\(^2\). Interestingly, the pectoralis major tendon is almost invariably untwisted when a CHEP muscle is present. This can be explained by the fact that the CHEP is derived from the inferior edge of the pectoralis. Fibers from this region in humans normally twist under the rest of the muscle to insert high in the humerus, but if they are attached to the medial epicondyle they would not insert high up on the humerus to produce the usual twisted insertion. The clinical relevance of the CHEP is mainly related to the ulnar nerve entrapment as a possible result of compression by the anomalous muscle\(^9\). The muscle can be identified at US or, more accurately, at MR imaging (Fig. 2D-F on page 11).

Elbow and Forearm
The anconeus epitrochlearis (AE), the Gantzer (GM) and the anomalous palmaris (PLM) can be considered among the most common anomalous muscles of the upper limb. Similar to the AAM and the CHEP, these latter muscles have potential implication in compressive neuropathies. In its reversed form, the anomalous PLM may mimic a soft-tissue mass on the ventral wrist.

Anconeus Epitrochlearis (Accessory Anconeus)

The AE is a small aberrant muscle of the posteromedial aspect of the elbow which extends from the medial epicondyle to the olecranon with a transverse course (Fig. 3A,B on page 12). It takes exactly the same course as the cubital tunnel retinaculum (Osborne ligament): this feature has suggested some authors to postulate that the retinaculum could represent a fibroaponeurotic remnant of this atavistic muscle. In functional terms, the AE shortens during elbow extension and, therefore, might be considered an accessory slip to the medial head of the triceps. Based on cadaveric studies, its prevalence has been reported in the literature ranging from 1% to 34%. Due to its small size, the AE is not palpable and needs imaging studies for its depiction. On US and MR imaging, it typically appears as an isolated ovoid mass forming the roof of the condylar groove, just superficial to the ulnar nerve. Transverse planes across the cubital tunnel seem particularly helpful i) to assess that the muscle is a separate entity from the adjacent medial head of the triceps and the ulnar head of the flexor carpi ulnaris; ii) to define the relationships of the aberrant muscle with the underlying ulnar nerve and iii) to assess the status of the nerve. In the event of coexisting neuropathy, a definite change in the nerve cross-sectional area is found between the anconeus epitrochlearis and the proximal edge of the arcuate ligament. The compressed nerve appears swollen, hypoechoic and exhibits high T2-signal intensity (Fig. 3C-D on page 12). During elbow flexion, US can show dynamic impingement of the muscle on the underlying nerve. Edematous changes in the AE have been also reported as a cause of medial elbow pain and possible ulnar neuropathy. In symptomatic patients, excision of the AE and cubital tunnel release without anterior transposition of the nerve is indicated.

Gantzer (Accessory Head of the Flexor Pollicis Longus) Muscle

The accessory slip of the flexor pollicis longus, or GM, is a common variant of the proximal forearm muscles. Often bilateral, it has either a single or a dual origin from the medial epicondyle (75%-85% of cases), the coronoid process or, more rarely, the flexor digitorum superficialis (FDS) and inserts distally into the ulnar border of the flexor pollicis longus muscle (Fig. 4A-C on page 14). The GM receives nerve supply from a branch of the anterior interosseous nerve. The clinical relevance of this small accessory slip is mainly related to the close relationship with the median and the anterior
interosseous nerves with respect to potential implication in compressive neuropathies, especially when the muscle is hypertrophied\textsuperscript{16,17}. In fact, the GM belly may bridge the anterior interosseous nerve either anteriorly or posteriorly, possibly predisposing it to local entrapment. In symptomatic patients, US and MR imaging reveal loss in bulk of the muscles (i.e. flexor pollicis longus, flexor digitorum profundus and pronator quadratus) innervated by the anterior interosseous nerve (Fig. 4D,E on page 14).

**Anomalous Palmaris Longus**

The PLM is a vestigial flexor of the wrist (absent in 11.2\% of population) and can be considered one of the most variable muscles in the forearm, with an overall incidence of anomalies of 9\%.\textsuperscript{1,18} In its typical configuration, the PLM arises from the medial epicondyle of the humerus together with the flexor tendons. The muscle belly is located proximally and continues distally with a very long slender tendon that inserts at the proximal edge of the flexor retinaculum and the palmar fascia. The distal tendon of the PLM is subcutaneous in location and lies just superficial to the median nerve and the flexor digitorum tendons. Occasionally, the muscle belly lies in a central position, between discrete proximal and distal tendons (digastric variant), or even distally. When located distally, the muscle has a long proximal tendon, an appearance resembling a "reversed" palmaris (palmaris inversus)\textsuperscript{19}. A PLM with double muscle bellies separated by a central tendon lying in between or fleshy throughout its entire length may be also encountered (Fig. 5A on page 14)\textsuperscript{18}. US and MR imaging can assess PLM variants. A careful technique based on sagittal and transverse planes obtained from the elbow through the palm is required not to overlook these anomalies. In case of a reversed PLM, an excess of muscle tissue can be seen immediately superficial to the FDS and the flexor retinaculum (Fig. 5B-F on page 14)\textsuperscript{1,19}. The carpal and Guyon tunnels should be investigated to exclude possible distal extensions of this muscle. In individuals with a reversed PLM, the distally placed muscle belly can cause a mass effect on the underlying flexor tendons and the median nerve. This may cause a dynamic effort-related median nerve compression during muscle contraction\textsuperscript{20}. In these cases, the surgical resection of the muscle belly is usually sufficient to relieve symptoms.

**Wrist and Hand**

The four most relevant muscles about the distal forearm and the wrist and hand are the accessory abductor digiti minimi (AADM), the anomalous FDS of the index finger (AFDS), the palmaris profundus (PP) and the extensor digitorum brevis manus (EDBM). Owing to their relation to osteofibrous tunnels, the first may potentially cause symptoms of ulnar neuropathy (Guyon tunnel syndrome), the second and third compression of the median
nerve (carpal tunnel syndrome). The EDBM and AFDS may mimic a palpable soft-tissue mass.

Accessory Abductor Digiti Minimi

The AADM is the most common anomalous muscle of the wrist with a reported prevalence ranging from 24% to 47%\textsuperscript{1,21,22}. It takes its origin from the antebrachial fascia or, less commonly, from the PL tendon and inserts into the abductor digiti minimi and, at least in some cases, into the ulnar aspect of the base of the proximal phalanx of the fifth finger\textsuperscript{14}. In most cases, the AADM is asymptomatic, but it may cause ulnar neuropathy by squeezing the ulnar nerve against the pisohamate ligament during contraction\textsuperscript{22-26}. US and MR imaging demonstrate the AADM as a fleshy band forming the roof of the Guyon tunnel, anterior to the ulnar neurovascular bundle (Fig. 6A,B on page 15). Transverse planes are best suited to assess the AADM and evaluate the status of the underlying ulnar nerve. A significant difference in muscle thickness between normal subjects (mean thickness =1.7mm) and patients with clinical signs of ulnar nerve entrapment at the wrist (mean thickness =4mm) was found\textsuperscript{22}. A flattened shape of the ulnar nerve, that has usually a rounded appearance, within the Guyon tunnel may suggest compression by this accessory muscle. During abduction of the 5\textsuperscript{th} finger, dynamic US can show an increase in muscle thickness and impingement on the ulnar nerve. In some instances, the AADM is "S"-shaped, passing superficial to the artery and deep to the nerve (Fig. 6C,D on page 15).

Anomalous Flexor Digitorum Superficialis of the Index Finger

In individuals who have an AFDS, the FDS has usually a normal origin and insertion, except for the index finger where an accessory muscle belly accompanies or replaces the respective tendon. Several variants of the AFDS have been reported, including: i) a muscle belly located entirely within the palm and replacing the normal tendon; ii) a digastric muscle, with one belly located proximally in the forearm and the other in the palm; iii) a muscle belly located within the forearm and extending into but not beyond the carpal tunnel\textsuperscript{1,27,28}. When located in the palm, the AFDS muscle inserts normally into the index finger, typically in the region of the A1-pulley, and may cause discomfort and pain during finger movements. The anomalous muscle belly often sends a distal tendon which enters the flexor tendon sheath of the 2\textsuperscript{nd} finger as the superficial tendon. In cases of a more proximal extension, the AFDS may be associated with median neuropathy\textsuperscript{29}. US and MR imaging typically show additional muscle tissue where only tendons should be present and may help identify the continuity of the FDS tendon with the anomalous muscle or with an additional more proximal muscle belly in cases of a digastric variant.
Compared with MR imaging, US has the main advantage to be able to assess the AFDS dynamically. With this technique, the accessory muscle can be seen entering the carpal tunnel during extension and exiting from it during flexion of the index finger. The repeated "to-and fro" passages of the AFDS in the carpal tunnel may lead to chronic flexor tenosynovitis.

Palmaris Profundus

The PP is a rare but well-known anatomic variant of the ventral wrist. This small accessory muscle is supplied by the anterior interosseous nerve and has been classified into three main subtypes based on its origin from the proximal or mid-third of the radius (type-1), the fascia of the FDS (type-2) or the distal ulna (type-3). In most cases, the PP muscle gives off a distal tendon which passes beneath the flexor retinaculum and after traversing the carpal tunnel, it fans out attaching into the deep surface of the distal retinaculum or the palmar aponeurosis (Fig. 8A on page 17). The clinical relevance of the PP muscle is related to the intimate association of its tendon with the median nerve, leading to a potential for nerve compression. In some instances, the nerve and the tendon may adhere or share a common sheath (Musculus Concomitants Nervi Mediani). In addition, the PP tendon may penetrate the median nerve or cause a split in it at the distal forearm and wrist. US and MR imaging may suspect this anomaly when an slender tendinous structure is visible superficial to the median nerve (Fig. 8B-E on page 17). Care should be taken not to confuse it with a normal palmaris.

Extensor Digitorum Brevis Manus

The EDBM is a supernumerary muscle of the dorsum of the hand which occurs in approximately 1-3% of individuals. It originates from the dorsal wrist capsule deep to the extensor retinaculum or the distal radius and inserts onto the extensor hood of the 2nd or 3rd finger by way of either a tendon or a slip. It is innervated by the dorsal interosseous nerve. At physical examination, the EDBM appears as a fusiform lump located alongside the extensor tendons of the index finger and can be misinterpreted for tenosynovitis of the IV compartment, dorsal ganglion, benign soft-tissue tumour or carpal boss (Fig. 9A on page 17). It is usually asymptomatic but it may be associated with exercise-induced pain or tenosynovitis. Ganglia associated with EDBM have been reported and this occurrence may make a correct diagnosis of this accessory muscle less straightforward. Active resisted extension of the fingers results in an increased firmness of the mass: this sign suggests the correct diagnosis. US can confirm the diagnosis showing the typical muscle echotexture and is able to depict muscle shape changes dynamically, during active contraction and relaxation (Fig. 9B,C on page 17). MR imaging shows an additional fusiform structure over the dorsum of the hand that is
isointense to muscle. Due to its relatively low intensity signal in T2-weighted sequences, the mass may be misinterpreted as a giant cell tumour of the tendon sheath.

**KNEE**

At the level of the popliteal fossa, rare accessory muscles have been reported in the literature. They may be superficial in location mimicking a soft-tissue mass, such as the tensor fasciae suralis (TFS) and the accessory semimembranosus (ASM) or deep-seated, such as the accessory popliteal (AP).

Tensor Fasciae Suralis and Accessory Semimembranosus

The TFS (third head of the gastrocnemius) is an accessory slip arising from the semitendinosus muscle and the medial head of the gastrocnemius to continue into a thin long tendon that inserts into either the posterior fascia of the leg, or the medial head of the gastrocnemius or the superficial aspect of the Achilles tendon. This anomalous circumpennate muscle would represent a vestigial prolongation of the hamstrings. In fact, in mammals below man, the hamstring insertion may extend more distally to allow a permanent position of flexion of the knee. Imaging is usually required to evaluate a palpable popliteal mass or a suspected Baker cyst. With US and MR imaging, the diagnosis of a TFS is based on demonstration of the typical echotexture and signal intensity of a muscle. Difficulties may arise to distinguish the TFS from the ASM, especially if the full extent of the muscle is not imaged on transverse planes as it may occur during a routine MR imaging examination of the knee. The ASM muscle takes its origin from the distal part of the semimembranosus muscle (not from the semitendinosus!) and, after crossing the popliteal fossa in a near vertical orientation, inserts into the medial head of the gastrocnemius (Fig. 10 on page 18).

Accessory Popliteus

The AP muscle (popliteus biceps, double-headed popliteus) takes its origin from the lateral femoral condyle or the fabella as a conjoint tendon with the lateral head of the gastrocnemius and crosses obliquely deep within the popliteal fossa, passing anterior or posterior to the popliteal neurovascular bundle to insert into the posteromedial capsule of the knee joint. It has been speculated that the AP might have potential implication in the entrapment of the adjacent popliteal vessels.
ANKLE

Accessory muscles are fairly common about the ankle. They include the accessory peroneals (peroneus quartus and peroneus tertius), the accessory flexors (flexor digitorum accessorius longus, peroneocalcaneus internus) and the accessory soleus.

Peroneus Quartus (Peroneus Calcaneus Externus) and Peroneus Tertius (Peroneus Anterior)

The term "peroneus quartus" (PQ) encompasses a variety of accessory peroneal muscles which, in their different forms, have an estimated prevalence ranging from 6.6% to 22% of cases. Almost invariably, the PQ takes its origin from the peroneus brevis (PB) muscle (Fig. 11A on page 19). The most common distal insertions of this accessory muscle are onto the retrotrochlear eminence or the peroneal tubercle of the calcaneus (peroneus calcaneus externum). However, the PQ may rarely attach onto the cuboid (peroneo-cuboideus) or the peroneus longus (peroneo-peroneolongus). It may have a variable appearance, ranging from a fleshy structure continuing with a very short distal tendon or, inversely, a short muscle in the lower leg prolonging distally with a long slender tendon. In the retromalleolar fibular groove, the PQ lies posteromedial to the PB and the peroneus longus (PL) and beneath the superior peroneal retinaculum (Fig. 11B on page 19). In most cases, the PQ is asymptomatic. However, it can cause crowding in the retromalleolar groove and local inflammation from friction among the PB, PL and PQ, possibly predisposing to tenosynovitis, longitudinal splits and instability of the PB. On imaging, the PQ can be distinguished from a low-lying PB muscle based on detection of a distal tendon that diverges from the one of the PB. Similarly, differentiation between the PQ and the underlying calcaneofibular ligament may be sometimes difficult. Full depiction of the ligament from its origin to its attachment on axial planes may be helpful to separate the two structures. Symptomatic patients are usually treated with surgical excision of the accessory muscle, repair of the PB split and tenosynoviectomy.

The peroneus tertius (PT) is a very common (estimated prevalence 83%-95% of cases) accessory muscle of the anterior leg which originates from the mid-distal fibular shaft and the lateral aspect of the extensor digitorum longus muscle and inserts onto the fifth or the fourth metatarsal through a long slender tendon (Fig. 11C on page 19). Phylogenetically, it is considered a young structure, which appears for the first time in humans, coinciding with the change to upright body position, as a result of which the function of the foot becomes mainly supportive. The PT is easily palpable and can be assessed with US as a small, flattened tendon that passes deep to the inferior peroneal retinaculum, superficial to the extensor brevis muscles, diverging from the slip for the fifth toe of the extensor digitorum longus (Fig. 11D on page 19).
The flexor digitorum accessorius longus (FDAL) is expressed in approximately 6%-8% of population with higher prevalence in males. This muscle varies widely in its origin arising either from the posterior aspect of the tibia or the interosseous membrane or the lateral margin of the fibula distal to the origin of the flexor hallucis longus (FHL). After crossing the tarsal tunnel, the FDAL inserts into the quadratus plantae or the flexor digitorum longus tendon. Within the tarsal tunnel, the FDAL is usually fleshy and wedges between the flexor retinaculum and the FHL tendon, wrapping around the neurovascular bundle (Fig. 12 on page 20). The close relationship with the tibial nerve may explain the relatively high prevalence (12.2%) of this accessory muscle in patients with tarsal tunnel syndrome. The FDAL is easily depicted on axial scans and can be distinguished from the more common accessory soleus (AS) due to its location beneath the retinaculum.

The peroneocalcaneus internus (PCI) is found in approximately 1% of cases. This accessory muscle takes its origin in the leg from the inner aspect of the lower fibula and may have some interdigitations with the FHL. After descending the tarsal tunnel posterior and lateral to the FHL, the PCI tendon passes inferior to the sustentaculum tali together with the FHL and inserts onto a small tubercle on the medial aspect of the calcaneus. Although usually asymptomatic, the PCI has been described as a potential cause of ankle pain and limitation of movement. Due to its deep location in the posterior ankle, this muscle is commonly missed during routine ankle US. On the other hand, MR imaging demonstrates it accurately. Depiction of its calcaneal insertion is the feature of value to distinguish the PCI from the FDAL.

Accessory Soleus

The AS arises from the posterior aspect of the tibia and the anterior aspect of the soleus muscle with a prevalence of 0.7%-5.5%. Based on its distal insertion, five types of this accessory muscle have been reported: in type-1, the muscle inserts into the Achilles tendon and ends 1-2cm from the calcaneus; in type-2 and -3, the muscle inserts on the upper surface of the calcaneus, anterior and medial to the Achilles tendon, either with a fleshy insertion (type-2) or through a short tendon (type-3); in type-4 and -5, the AS inserts onto the medial surface of the calcaneus either with a muscular (type-4) or a tendinous (type-5) insertion. Usually unilateral, the AS may manifest as an indolent posteromedial mass of the ankle which may become stiff and tense when the patient is standing or on the tiptoe as a result of contraction (Fig. 13A on page 21). Occasionally, the AS can cause local pain, which is typical exertional, during
sporting activities such as running. Muscle debulking, fasciotomy or tendon release may be required to treat refractory symptomatic cases. At lateral plain films, the AS may partially obscure the normal radiolucency of the Kager fat pad (Fig. 13B)\(^1\). Cross-sectional imaging modalities, such as US, CT and MR imaging are more sensitive and specific to correctly identify an AS (Fig. 13C)\(^{58,59}\). The muscle typically extends between the medial edge of the Achilles and the medial malleolus.

Images for this section:

Fig. 1: Axillary arch muscle. A, Schematic drawing of the axilla illustrates an axillary arch muscle (asterisk) originating from the latissimus dorsi (LD) and inserting into the coracoid after bridging the axillary artery and the nerve cords of the brachial plexus. The short head of the biceps (SHB) and the pectoralis minor muscle (pm) also arise from the coracoid. B, Cadaveric image of the axilla shows the axillary arch muscle (arrowheads) as a slender myotendinous band crossing over the nerve cords and the axillary artery (arrows). C, Transverse 10-5MHz US image shows the axillary muscle (dashed line) in its cross-section, adjacent to the median nerve (arrow). Note the intramuscular tendon (void arrowhead) of the accessory muscle.
**Fig. 2:** Chondroepitrochlearis muscle. A, Schematic drawing with (B) cadaveric and (C) surgical correlation illustrates the chondroepitrochlearis muscle (black arrow) arising from the lowest fibers of the pectoralis major (PMj) and descending the medial aspect of the arm with a slender tendon (white arrow), between the biceps (1) and the triceps (2). The chondroepitrochlearis tendon travels alongside the medial neurovascular bundle (arrowhead) of the arm. D-F, Axial T1-weighted MR imaging of the upper arm obtained from cranial (D) to caudal (F) demonstrate a hypointense cord (void arrowhead) descending the arm in close relationship with the neurovascular bundle (white arrowhead) reflecting the long tendon of a chondroepitrochlearis muscle.
Fig. 3: Anconeus epitrochlearis muscle. A, Schematic drawing of a cross-sectional view of the cubital tunnel shows the anconeus epitrochlearis (arrowheads) forming the roof of the cubital tunnel between the medial epicondyle (ME) and the olecranon (O). Arrow indicates the ulnar nerve. B, Surgical view of the cubital tunnel in a patient with ulnar neuropathy demonstrates the close relationship between the ulnar nerve (UN) and the accessory muscle (arrowheads). ME, medial epicondyle. C,D Cubital tunnel syndrome. Axial T1-weighted (C) and fat-suppressed T2-weighted (D) MR images of the
posteromedial elbow demonstrates the anconeus epitrochlearis (arrowheads) encircling the ulnar nerve (arrow) at the cubital tunnel. In the T2-weighted image, the hyperintensity of the nerve is consistent with an entrapment neuropathy.

**Fig. 4:** Gantzer muscle. A, Schematic drawing illustrates the Gantzer (Gz) inserting into the ulnar border of the flexor pollicis longus (fpl). B, Cadaveric specimen reveals the accessory muscle (Gz) as a small belly intervening between the flexor pollicis longus (fpl) and the flexor digitorum profundus (fdp). Observe the long tendon (white arrowheads) of the Gantzer which inserts into the aponeurosis (open arrowheads) of the flexor pollicis longus and the intimate relationship of this accessory muscle with the median (large arrows) and the anterior interosseous nerve (small arrows). C, Axial cadaveric slice with (D) T1-weighted MR imaging and (E) 12-5MHz US correlation demonstrates the relationship of the Gantzer muscle (arrowheads) with the median nerve (arrow) and the adjacent flexor muscles, including the flexor pollicis longus (fpl), flexor carpi radialis (fcr), flexor digitorum superficialis (fds) and flexor digitorum profundus (fdp).
Fig. 5: Anomalous palmaris muscle. A, Cadaveric view of the ventral forearm demonstrates a completely fleshy palmaris (arrows) with a short proximal tendon (arrowhead) located between the flexor carpi radialis (fcr), the flexor digitorum superficialis (fds) and the flexor carpi ulnaris (fcu). B-F, Reversed palmaris. Schematic drawing of a reversed palmaris shows the distal location of the muscle belly (arrow) in the forearm and a long proximal tendon (arrowhead). C, Photograph of the left wrist of a woman presenting with a fusiform soft-tissue lump (arrow) proximal to the wrist crease and carpal tunnel disease. The lump became stiff and more prominent during contraction of the flexor muscles. D, Transverse 12-5MHz US image obtained over the ventral lump with (E) T1-weighted MR imaging correlation demonstrates additional muscle tissue (arrows) superficial to the flexor tendons and the median nerve (white arrowhead). F, Longitudinal T1-weighted MR image of the wrist demonstrates the revered palmaris (arrows) associated with underlying flexor tenosynovitis (asterisks).
Fig. 6: Accessory abductor digiti minimi muscle. A, Schematic drawing with (B) 17-5MHz US correlation illustrates the Guyon tunnel in cross-section, showing the position of the accessory abductor digiti minimi (asterisk) relative to the pisiform (Pis), the ulnar nerve (UN) and the ulnar artery (UA). The muscle lies superficial to the ulnar neurovascular bundle. C, Schematic drawing with (D) 17-5MHz US correlation shows atypical "S"-shaped course of the accessory muscle intervening between the ulnar artery and the ulnar nerve.
Fig. 7: Anomalous flexor digitorum superficialis of the index finger. A, Schematic drawing illustrates the ventral aspect of the hand, showing the course of the anomalous flexor digitorum superficialis of the index finger (arrow). B, D Transverse 12-5MHz US and (C, E) T1-weighted MR images obtained (B, D) at the distal carpal tunnel and (C, E) at the midpalmar level reveal the accessory muscle (arrowheads) arising in the carpal tunnel between the two components (white arrows) of a bifid median nerve and expanding distally over the flexor tendons (void arrow) of the index finger.

Fig. 8: Palmaris profundus muscle. A, Schematic drawing illustrates the palmaris profundus (white arrow) which originates from the radius and sends distally a long tendon (black arrowhead). The tendon enters the carpal tunnel running in proximity to the median nerve (black arrow) and inserts into the deep surface of the flexor retinaculum. B, Longitudinal and (C) transverse 17-5MHz US images in a patient with carpal tunnel syndrome show the anomalous tendon (arrowheads) of the palmaris profundus aligned to the long-axis of the median nerve (MN). In C, during fist clenching the accessory tendon became tense impressing the underlying nerve (MN) dynamically. D-E, Axial T1-weighted MR images of the wrist demonstrate the median nerve (void arrowhead) proximal to (D) or at the distal carpal tunnel (E) level with the variant palmaris profundus tendon (black arrowhead) immediately superficial to it.
**Fig. 9:** Extensor digitorum brevis manus muscle. A, Photograph of the hand during active finger extension demonstrates a firm lump (arrow) over its dorsal aspect reflecting the contracted accessory muscle. B Transverse and (C) longitudinal 12-5MHz US images reveal additional muscle tissue (arrows) along the course of the extensor tendons of the IV compartment. Note the tendon (arrowheads) of the accessory muscle. Scaph, scaphoid; Lun, lunate; Cap, capitate. Compared to the resting state, active contraction leads to an increased thickness and shortening of the muscle belly. This change can be easily palpated at physical examination.
Fig. 10: Accessory semimembranosus muscle. A, Photograph of the left posterior thigh shows a well-circumscribed lump (arrows) located on the medial aspect of the hamstrings. B, Axial T1-weighted MR image of the left thigh reveals an accessory belly (dashed line) of the semimembranosus muscle (1). Arrowhead, semitendinosus. C, Axial T1-weighted MR image of the right thigh obtained for comparison at the same level of B.
Fig. 11: Peroneus quartus and peroneus tertius. A, Cadaveric dissection of the lateral leg shows the peroneus quartus (pq) arising from the posterior aspect of the peroneus brevis (pb) muscle and inserting into the calcaneus through a long slender tendon (arrows). Pl, peroneus longus tendon. B, Transverse 12-5MHz US image of the retromalleolar groove shows a low-lying peroneus quartus muscle (asterisks) located posterior to the peroneus brevis and longus tendons. Note the hyperechoic appearance of the central aponeurosis (arrow) of this muscle. C, Cadaveric dissection of the dorsal midfoot demonstrates the peroneus tertius tendon (pt) diverging from the tendinous slips of the extensor digitorum longus to insert into the fourth metatarsal. More laterally, note the peroneus brevis tendon (pb) as it inserts onto into base of the fifth metatarsal. D, Transverse 12-5MHz US image over the dorsal midfoot reveals the four slips (II, III, IV, V) of the extensor digitorum longus passing superficial to the extensor digitorum brevis muscle (edbm). The tendon of the peroneus tertius (pt) has a more lateral, diverging course relative to them.
Fig. 12: Flexor digitorum accessorius longus. A. Schematic drawing of the tarsal tunnel with (B) transverse 12-5MHz US correlation illustrates the flexor digitorum accessorius longus (asterisk, white arrowheads) lying deep to the flexor retinaculum (FR) and superficial to the tibial nerve (arrow), the posterior tibial artery (a) and veins (v). Note the relationship of this accessory muscle with the tibialis posterior (TP), flexor digitorum longus (FDL) and flexor hallucis longus (FHL) tendons. C. Transverse 12-5MHz US image of the contralateral normal tarsal tunnel obtained for comparison at the same level of B.
**Fig. 13:** Accessory soleus. A, Photograph of the posterior ankle shows a retromalleolar lump (arrows) medial to the Achilles tendon. B, Lateral radiograph and (C) sagittal T1-weighted MR image of the posterior ankle demonstrate a fleshy accessory soleus muscle (large arrow) coursing deep to the Achilles tendon (arrowhead) and superficial to the flexor hallucis longus and the posterior aspect of the ankle joint. The muscle has a fleshy insertion on the upper surface of the calcaneus (type-2). In B, note partial obliteration of the Kager fat pad by the accessory muscle.
Conclusion

Ultrasound (US) and magnetic resonance (MR) imaging are able to identify and characterize accessory musculature, thus helping differentiate it from other soft-tissue masses.

References

REFERENCES

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Personal Information