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Ultrasound Imaging of the Deep Peroneal Nerve

Marco Becciolini, MD, Christopher Pivec, MD, Georg Riegler, MD

Ultrasound is considered an excellent imaging modality to evaluate the nerves of the limbs. The deep peroneal nerve (DPN) is one of the terminal branches of the common peroneal nerve. The DPN may be affected by various disorders, which may be clinically challenging to show. This Pictorial Essay reviews the normal ultrasound anatomy of the DPN and presents disorders that may involve the nerve and its main branches along its course, from proximal to distal.

Key Words—anterior tarsal tunnel syndrome; deep fibular nerve; foot drop; nerve; palsy; ultrasound

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Abbreviations

ATTS, anterior tarsal tunnel syndrome; CPN, common peroneal nerve; DPN, deep peroneal nerve; EDB, extensor digitorum brevis; EHB, extensor hallucis brevis; LBDPN, lateral branch of the deep peroneal nerve; MBDPN, medial branch of the deep peroneal nerve; MRI, magnetic resonance imaging; SPN, superficial peroneal nerve; US, ultrasound

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High-resolution ultrasound (US) is an excellent imaging modality with which to show normal anatomy and disorders of the nerves of the extremities.[1–5] Thanks to the recent improvements in transducer quality, not only large and medium-sized nerves can be assessed but also small peripheral nerves, especially when they are superficially located.[6–11]

The deep peroneal nerve (DPN), also referred to as the deep fibular nerve, is one of the two main terminal branches of the common peroneal nerve (CPN). Deep peroneal nerve neuropathy is linked to acute or chronic injuries that may involve different levels from proximal to distal, which are clinically challenging to correctly diagnose and which require a specific therapy.[12] The US depiction of the CPN and the superficial peroneal nerve (SPN) anatomy and pathologic appearances is well described in the literature, whereas similar articles about the DPN are lacking.[13–15]

In this Pictorial Essay, our aims are as follows: review the normal anatomy and more frequent anatomic variations of the DPN; describe the most useful US technique to depict a normal DPN and its terminal branches; and present a wide range of disorders that can be shown by US and that involve different levels. This study received a waiver from the Institutional Review Board. The requirement for informed consent was exempted for this study.

Normal US Anatomy and Examination Technique for the DPN

Normal Anatomy

The DPN is one of the terminal branches of the CPN, which divides around the proximal fibula. The CPN follows the course of the distal biceps femoris, winding around the neck of the fibula and located superficially, to enter the fibular tunnel, passing under a musculoaponeurotic arch formed by the posterior intermuscular

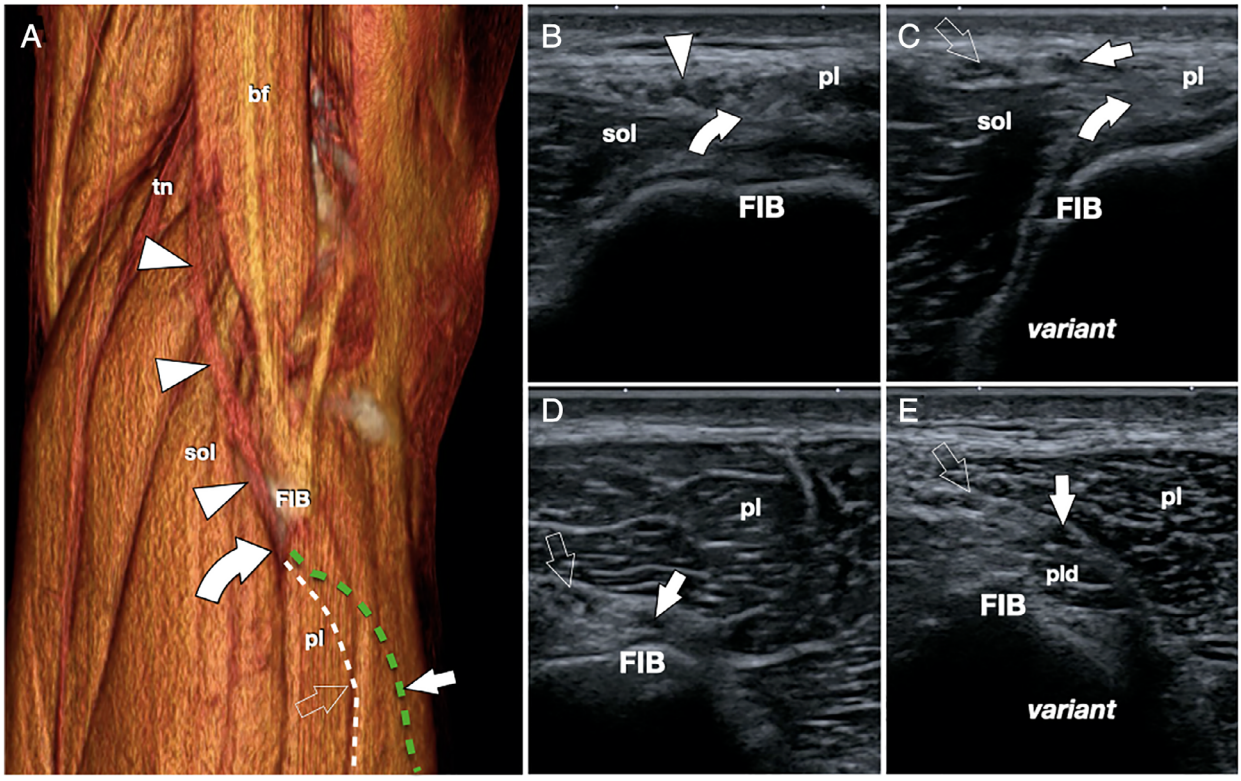
septum, the soleus, and the peroneus longus muscle.[16] Within the tunnel, between the fibular neck and the peroneus longus origin, the CPN usually divides into the DPN, the SPN, and a third smaller branch (the anterior recurrent peroneal nerve); the DPN runs anteriorly and more closely to the fibula than the SPN (Figure 1A).[17–20]

The DPN continues to travel caudally and anteriorly in an oblique direction to pierce the anterior intermuscular septum, passing from the lateral to the anterior compartment of the leg.[17] Then the DPN travels downward, anterior to the interosseus membrane, together with the anterior tibial artery, and is located posterior to the extensor digitorum longus between the extensor digitorum longus and the tibialis anterior muscles (Figure 2A). Along its course, the DPN sends motor branches to the muscles of the anterior compartment of the leg.[12]

At the lower third of the leg, the nerve passes posterior to the extensor hallucis longus and the extensor digitorum longus. At the ankle, the nerve runs in the so-called anterior tarsal tunnel, created by the extensor tendon retinaculum, the extensor hallucis longus and extensor digitorum longus tendons, and the joint capsule (Figure 3A).[21–23]

Usually, at approximately 1 cm distal to the ankle mortise, the DPN divides into its terminal branches, the medial branch (MBDPN) and the lateral branch (LBDPN).[24] The LBDPN travels laterally to course deep to the extensor digitorum brevis (EDB), which

Figure 1. The DPN and SPN originate from the CPN. **A**, Three-dimensional computed tomographic schematic drawings at the level of the posterolateral aspect of the knee of the DPN (green dashed line) and the SPN (white dashed line) originating from the CPN (white arrowheads). Note that the CPN follows the course of the distal biceps femoris (bf). **B**, Axial sonogram at the proximal fibula showing the CPN (arrowhead) entering the fibular tunnel (curved white arrow) passing between the soleus and the peroneus longus. **C** represents a variant in which the CPN is already divided into the DPN (white arrow), which lies anteriorly, and the SPN (open arrow). **D**, Axial sonogram at the level of the fibular tunnel. The CPN is divided into the DPN (white arrow) and the SPN (open arrow). **E** represents a variant of the proximal origin of the deep portion of the peroneus longus, so that the DPN passes more distally to the fibula. Curved arrows indicate fibular tunnel; FIB, fibula; pl, peroneus longus; sol, soleus; and tn, tibial nerve.



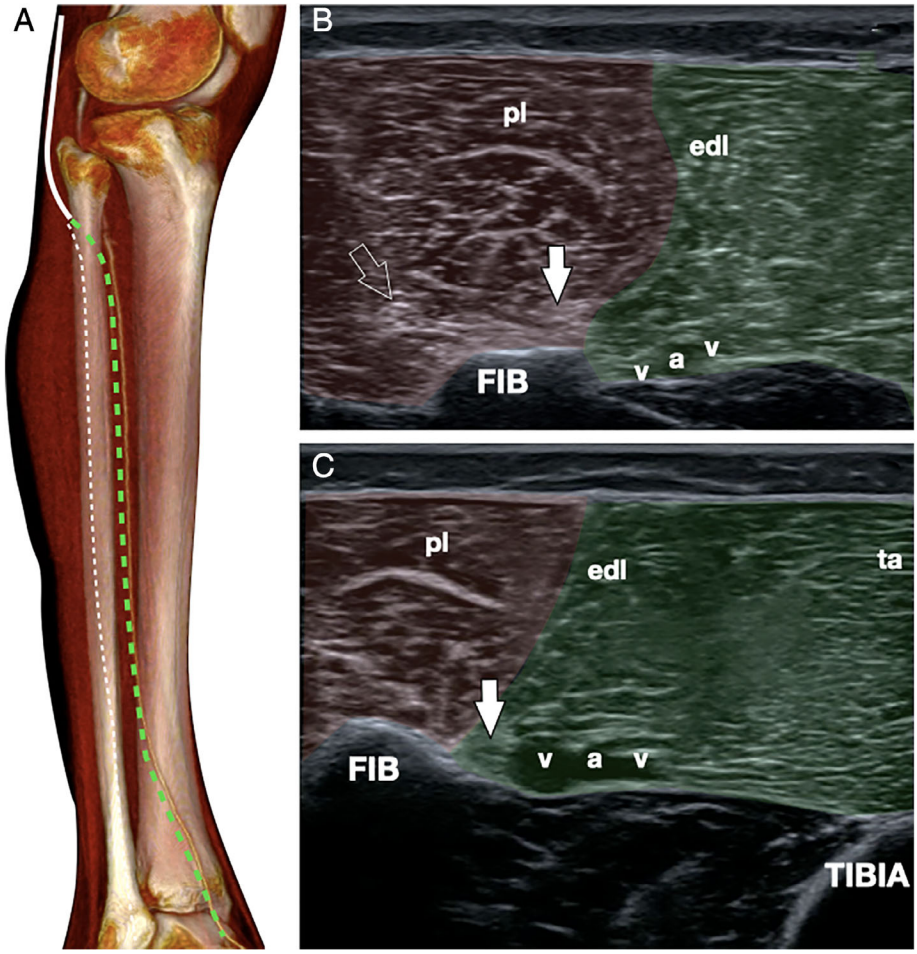
the nerve innervates; it then divides into several tiny branches for the sensorial innervation of the sinus tarsi and the lateral ankle.[25] The MBDPN has a straight path, accompanied by the dorsal pedis artery (which lies usually medially),[26] over the talonavicular joint, across the middle and medial cuneiform and the first intermetatarsal space. At the level of the Lisfranc joint line, the MBDPN runs below the tendon of the extensor hallucis brevis (EHB), covered by the superficial fascia. The EHB tendon crosses the nerve from lateral to medial. Distally, the MBDPN divides into the sensorial terminal branches for the skin of the first commissural space.[12]

Variants

There is variability of the CPN division. In fact, according to Deutsch et al,[27] in approximately 81% of cases, it occurs distal to the fibular neck, in 10% proximal to the knee joint line, and in 9% between the joint and the fibular neck (Figure 1C).

In the fibular tunnel, the DPN is usually found near the fibula, but, according to Aigner et al,[16] in 27% of cases, the deep portion of the peroneus longus has a high origin, so that the DPN passes between the two heads of the peroneus longus (Figure 1E). Variations also exist in the muscular branching pattern of the DPN.

Figure 2. Course of the DPN at the leg. **A**, Three-dimensional computed tomographic schematic drawings of the course of the DPN (green dashed line) and the SPN (white dashed line) at the lateral leg. **B**, Axial sonogram at the proximal leg. The DPN (white arrow) can be seen passing from the lateral compartment (shaded in red) to the anterior compartment (shaded in green). **C**, Axial sonogram at the middle third of the leg. The DPN has entered the anterior compartment, located laterally to the tibial artery (a) and veins (v). edl indicates extensor digitorum longus; FIB, fibula; open arrow, SPN; pl, peroneus longus; and ta, tibialis anterior.



The accessory DPN is a reported accessory nerve that originates from the SPN, underneath the peroneus brevis muscle, which travels distally, posterior to the lateral malleolus to innervate the EDB muscle and to provide sensory innervation of the lateral part of the foot and ankle.[28] This is not rare and has been reported in around 25% of anatomic studies.[12] The clinical importance of this variant is related to fact that electromyographic studies may be misleading, showing normal EBD activity even when there is a DPN lesion, and the patient will be able to dorsiflex the fourth and fifth toes.[28]

The dorsal pedis artery may lie lateral to the DPN or the MBDPN; moreover, they may also cross over each other multiple times.[26] There may also be variations in the level of the division of the DPN in its two distal branches.[24] Anastomosis between branches of the SPN and DPN at the foot and ankle have been described as well.[24]

Ultrasound Examination Technique and Anatomy

Ultrasound can delineate the normal fascicular nerve appearance, composed of hypoechoic nerve fascicles and surrounded by hyperechoic connective tissue. This honeycomb structure can be well depicted on short-axis sonograms.[1,4,29]

The patient lies supine with the hip and knee in a neutral position, except for the evaluation of

Figure 3. Course of the DPN at the ankle and its main branches at the foot. **A**, Three-dimensional computed tomographic schematic drawings of the DPN (green dashed line) and divisional branches (lateral is indicated as L and medial as M) at the ankle and foot. **B**, Axial sonogram at the ankle joint, from proximal to distal. The DPN (white arrow) lies lateral to the tibialis anterior artery (a) and veins (v) and deep to the muscle of the extensor hallucis longus. **C**, Distally, the nerve divides into its two main terminal branches: the MBDPN (white arrowhead) and the LBDPN (open arrowhead). **D**, Axial sonogram at the Lisfranc joint, where the EHB tendon (open arrow) crosses the MBDPN over the second metatarsal (M2). Note that the artery (a) is now the dorsal pedis artery. CN1 indicates first cuneiform.

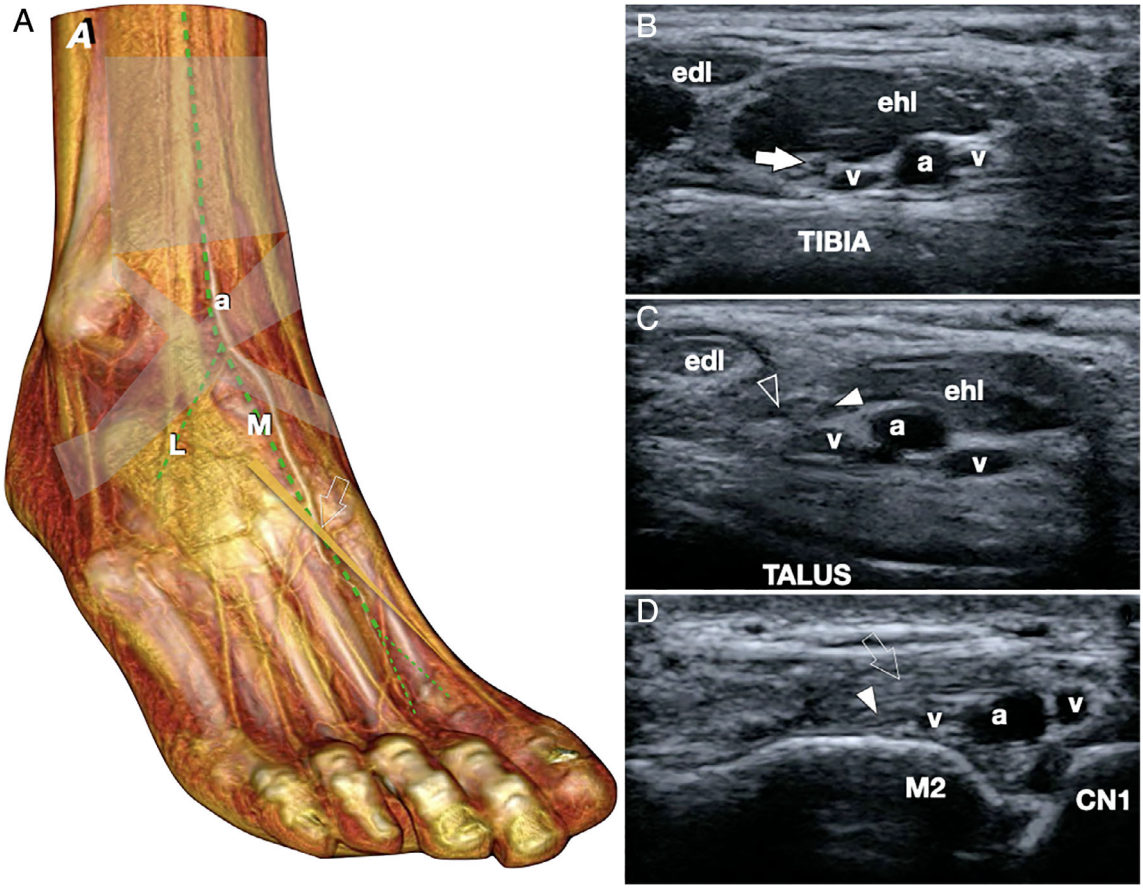


Figure 4. Muscular atrophy in DPN and LBDN injuries. **A**, Comparative axial sonograms at the proximal leg in a patient with fibular exostosis compressing the DPN. Note atrophy and increased echogenicity of the muscle of the anterior compartment of the leg compared to the healthy side. **B** and **C**, Comparative sagittal oblique (**B**) and axial (**C**) sonograms in a patient with an LBDPN injury. The EDB (edb) appears diffusely hyperechoic, with volume loss due to atrophy. a indicates tibialis anterior artery; edl, extensor digitorum longus; FIB, fibula; and ta, tibialis anterior.

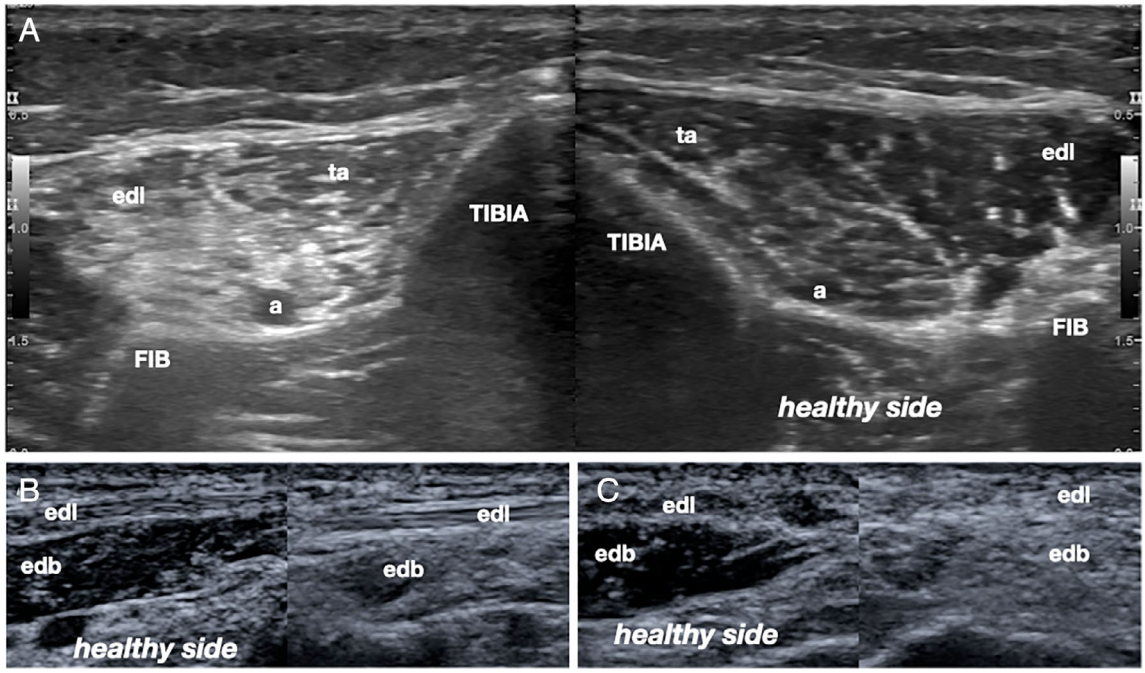
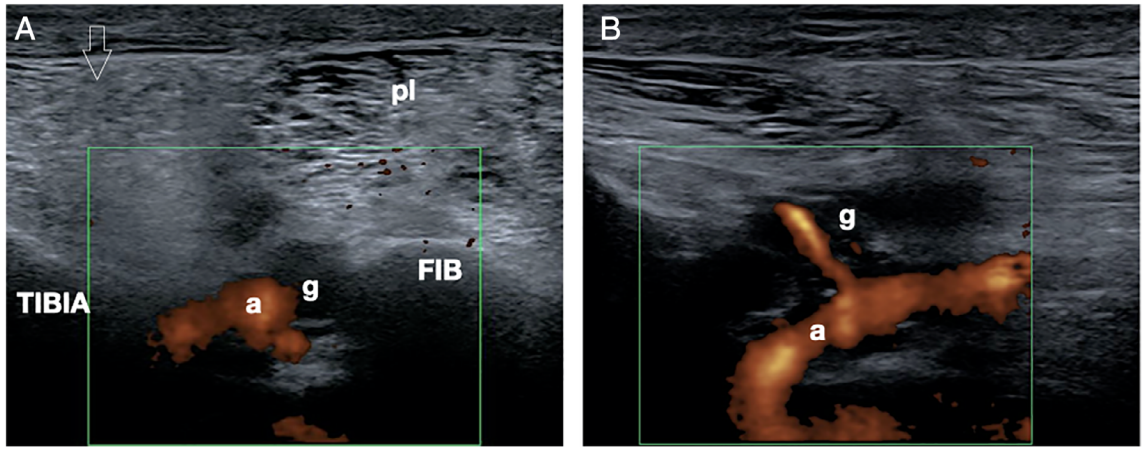


Figure 5. Proximal leg: ganglion compressing the DPN. **A** and **B**, Transverse (**A**) and longitudinal (**B**) power Doppler sonograms obtained at the level of the proximal leg in a patient who presented with foot drop. A ganglion cyst (g) is depicted near the course of the anterior tibial artery (a), compressing the DPN, which could not be clearly identified by US because of ganglion compression. In **A**, note that the muscles of the anterior compartment of the leg (open arrow), innervated by the DPN, appear diffusely hyperechoic compared to the peroneus longus (pl), which is innervated by the SPN due to atrophy. Surgery confirmed an extraneural ganglion compressing the DPN. FIB indicates fibula.



the proximal DPN, in which we suggest scanning the patient in a lateral decubitus position to visualize the cranially and posteriorly located CPN. A linear multifrequency transducer with frequencies up to 12 to 14 MHz is required. The frequency may need to be lowered for patients of larger body habitus. Higher-frequency transducers, up to 17 to 18 MHz, are useful for scanning the nerve at the ankle and distally; they may also be used to evaluate the proximal course of the nerve at the fibular tunnel, particularly in slender patients. Hockey stick transducers, thanks to their small footprint, also allow accurate compression of the pathologic DPN to confirm pain radiating distally (the so-called US Tinel sign).[29]

We suggest following the DPN in the short-axis view, from proximal to distal (using the so-called elevator technique) to promptly evaluate long segments of the nerve, thus showing its relationship with surrounding structures.[1,29] We usually do not acquire longitudinal sonograms of a normal DPN. Color Doppler sonograms are obtained in this case and are important to locate the nerve, depict the near vascular bundle, and assess for local hyperemia. Ultrasound may also be used as a guide both for diagnostic (eg, biopsy of a nonspecific mass compressing the nerve or US-guided blockades) and therapeutic purposes (eg, aspiration of a ganglia).[29]

The proximal DPN can be located by following the course of the CPN at the fibular tunnel, at the

Figure 6. Fibular tunnel: fibular head exostosis displacing the DPN. **A–C**, Transverse sonograms at the level of the fibular tunnel from proximal (**A**) to distal (**C**) in a patient who presented for weakening of the muscles of the anterior compartment of the proximal leg. In **A**, the CPN (white arrowhead) does not appear enlarged, with a normal fascicular pattern. In **B**, note that the DPN (black arrows) is displaced and stretched by a fibular exostosis (curved white arrow). Distally (**C**), the DPN appears thickened and hypoechoic, whereas the SPN is normal. **D**, Corresponding proton density–weighted MRI shows the cartilaginous cap (hyperintense) of the cartilaginous exostosis (curved white arrow). The exostosis was removed, and the patient fully recovered after surgery. Asterisk indicates the hypoechoic cap of the exostosis; FIB, fibula; pl, peroneus longus; and sol, soleus.

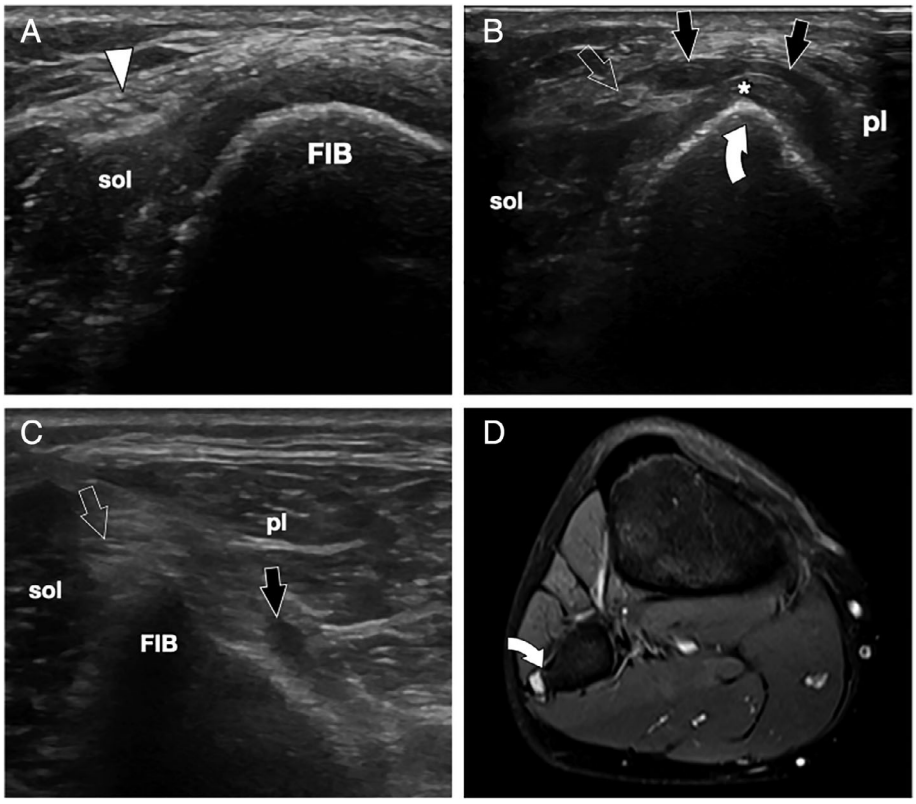


Figure 7. Fibular tunnel: fibular fracture compressing the DPN. **A**, Axial sonogram at the level of the fibular tunnel. The DPN (black arrow) can be seen passing near a fibular fragment (curved white arrow) in a patient with a recent fibular fracture. The SPN (open arrow) is normal. **B**, Longitudinal oblique sonogram over the long axis of the DPN. The nerve proximally is regular (white arrow), whereas it is hypoechoic and swollen near the fragment. Intraoperative findings confirmed that the nerve was diffusely enlarged and entrapped underneath the fragment. A nerve transfer (sural nerve) was performed. FIB indicates fibula; and pl, peroneus longus muscle.

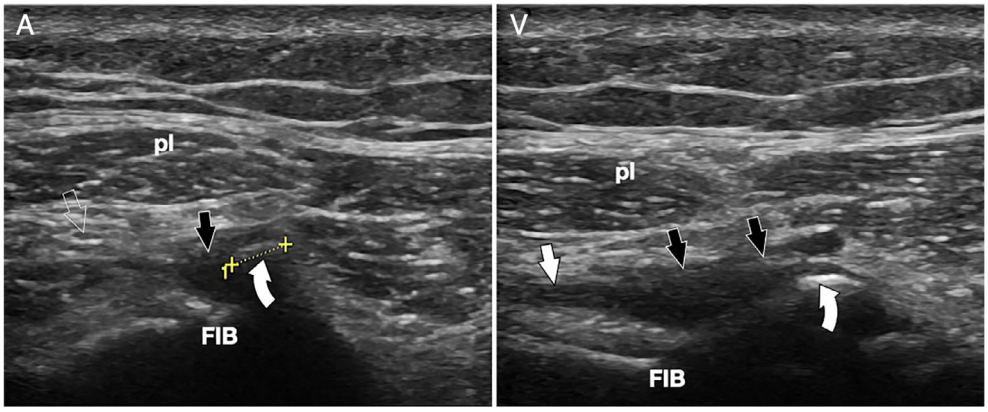
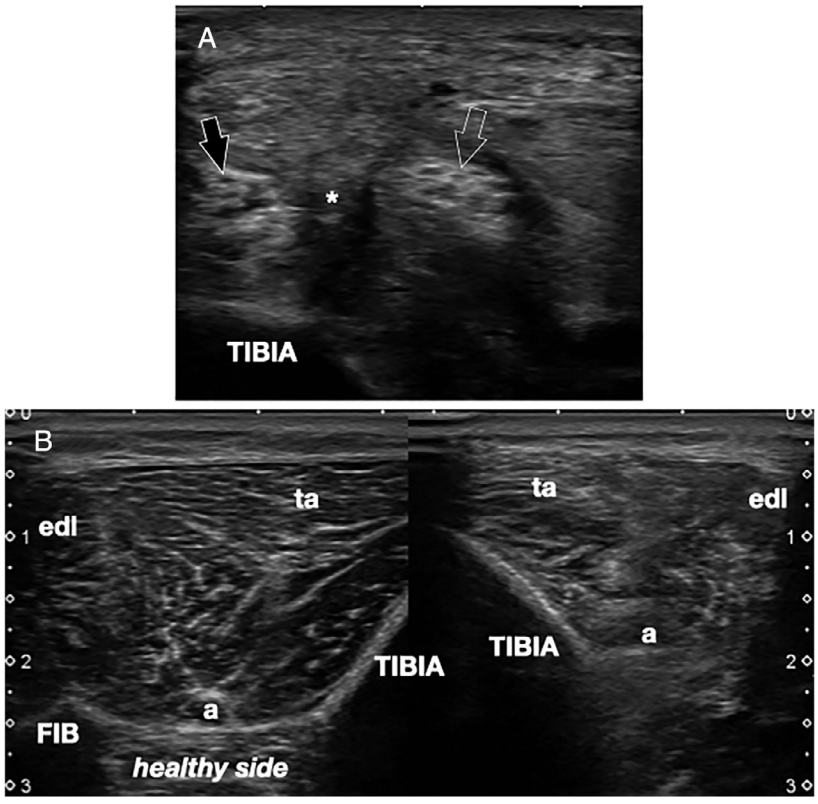


Figure 8. Proximal leg: scar encasing the DPN and SPN. **A**, Axial sonogram below the knee joint in a patient who underwent surgery and radiotherapy for a fibular Ewing sarcoma. Scar tissue (asterisk) can be seen encasing the DPN (black arrow) and the SPN (open arrow). **B**, Comparative axial sonograms of the anterior proximal legs. Note, on the right, atrophy of the muscle bellies of the tibialis anterior (ta) and extensor digitorum longus (edl). a indicates tibial artery; and FIB, fibula.



level of the proximal fibula, which is the main palpable anatomic landmark. Depending on the anatomic variability previously described, the CPN may be already divided at this level (Figure 1C). Moreover, according to Kudoh and Sakai,[30] even proximal to the CPN division, the anterior fascicle of the nerve will constitute the DPN, whereas the posterior fascicle will constitute the SPN.

The DPN at the level of the anterior leg may be difficult to depict correctly with US, especially in obese and older patients, because of its small size and its deeper location. The anatomic landmark that can enable easier detection of its location is the accompanying anterior tibial artery, which lies medially at the proximal leg (Figure 2). Once the nerve is detected, it is easier to follow with the elevator technique.

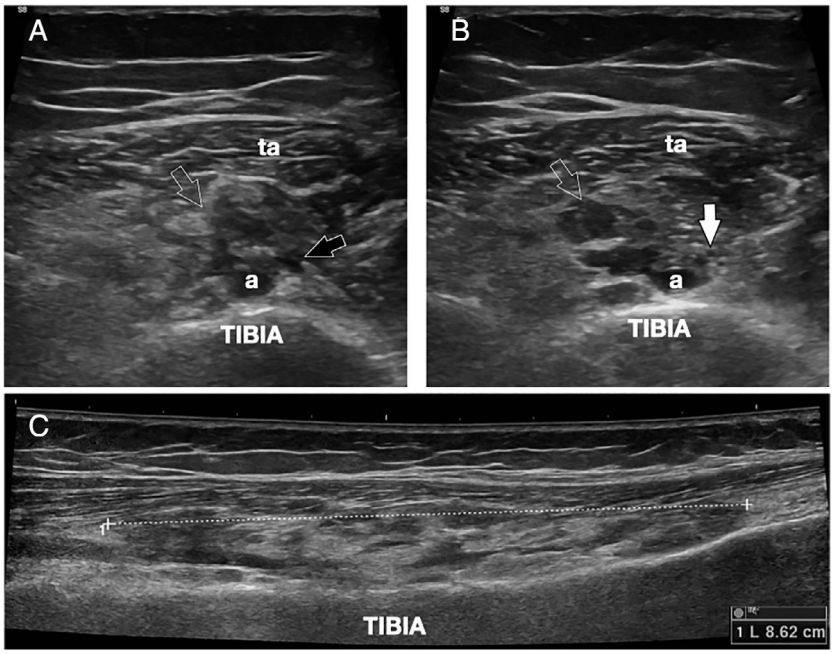
At the level of the ankle joint, the nerve is more superficially located and, therefore, can be depicted with high-frequency transducers, near the vascular bundle, usually lateral to the artery (Figure 3). The two main terminal branches of the DPN can be depicted as well, with the LBDPN going deep to the EDB muscle, whereas the MBDPN follows the dorsal pedis artery. When evaluating the EHB tendon crossing over the MBDPN at the Lisfranc joint, dynamic scanning during dorsal and plantar flexion of the hallux may help confirm the EHB tendon.

The course of the accessory DPN has not been reported in the radiologic literature, to the best of our knowledge. This nerve is a small branch of the SPN; therefore, it may be difficult, in our experience, to clearly show it. In patients with DPN palsy, who have an accessory DPN, the EDB is not affected by atrophy.

Clinical Presentations in DPN Nerve Palsy

We have schematically divided nerve involvement from proximal to distal in an attempt to classify different types of injuries and related clinical patterns. Patients with proximal DPN disorders may present

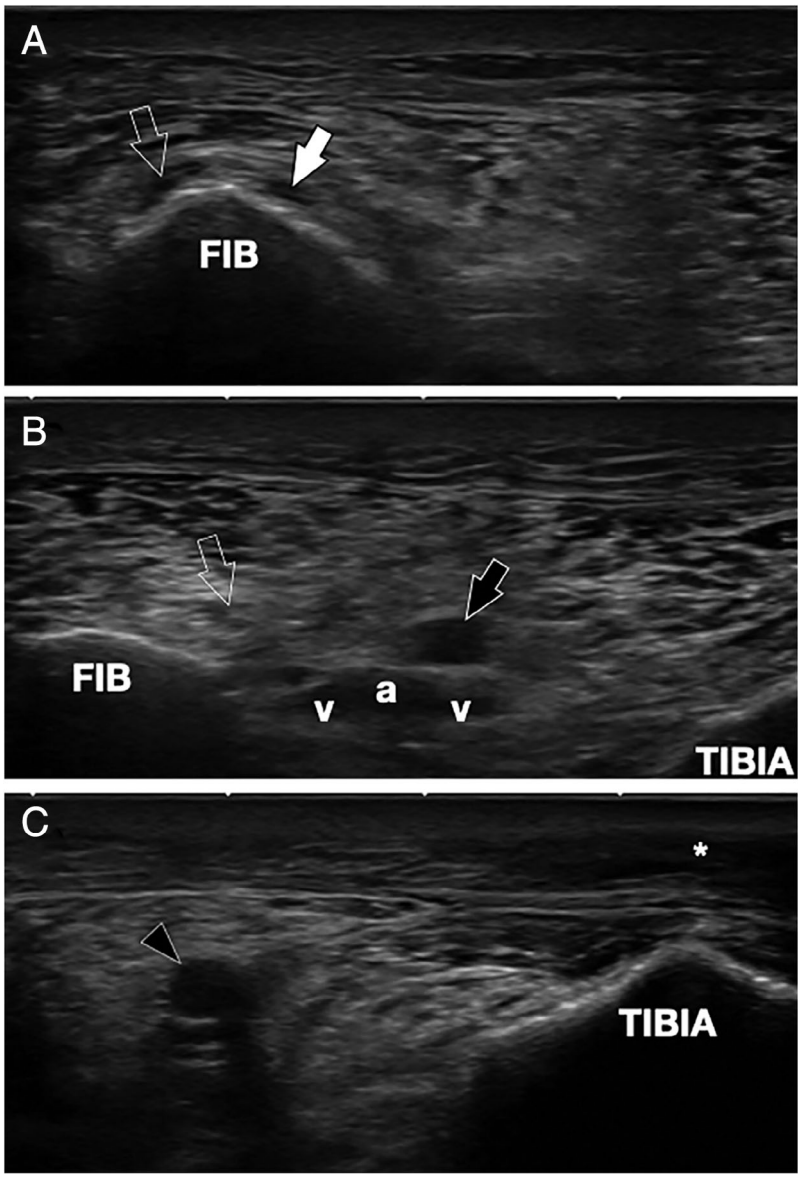
Figure 9. Middle third of the leg: vascular tumor compressing the DPN. **A** and **B**, Transverse sonograms at the middle third of the leg in a patient who presented with swelling of the anterior compartment, with an incomplete foot drop. In **A**, the DPN (black arrow) is thickened and hypoechoic, passing through a mainly hypoechoic mass that was assumed to be a partially thrombosed low-flow vascular malformation (open arrow). Distally (**B**), normal nerve fascicles of the SPN (white arrow) are shown. **C**, Sagittal extended field of view shows the craniocaudal extension of the mass (between calipers). Note the clearly depictable difference between the tibialis anterior muscle and the mass. Electrodiagnostic tests suggested axonal damage to the DPN. a indicates tibialis anterior artery.



with "foot drop," related to weakness of the muscles of the anterior compartment of the leg. In contrast to CPN injury, there is usually no limitation in ankle eversion. At the leg, depending on the level of compression, one or more muscles of the anterior compartment may be unaffected.[31]

Distal neuropathy may present a clinically challenging diagnosis. Deep peroneal nerve compression at the ankle is a condition described as anterior tarsal tunnel syndrome (ATTS).[32] It is characterized by pain, dysesthesia of the dorsum of the ankle and foot radiating to the hallux and second toe, and weakness

Figure 10. Proximal leg: amputation neuroma of the DPN and the SPN. **A–C**, Transverse sonograms of the proximal leg, from cranial (**A**) to caudal (**C**), in a patient with a previous amputation of the leg. In **A**, the DPN (white arrow) and the SPN (open arrow), can be seen winding around the fibular head. In **B**, note the amputation neuroma of the DPN (black arrow). Distally (**C**), there is also a neuroma of the SPN (black arrowhead). Also note anechoic fluid (asterisk) in the subcutaneous tissue anterior to the tibia, related to adventitious bursitis secondary to impingement with an external prosthesis. FIB indicates fibula.



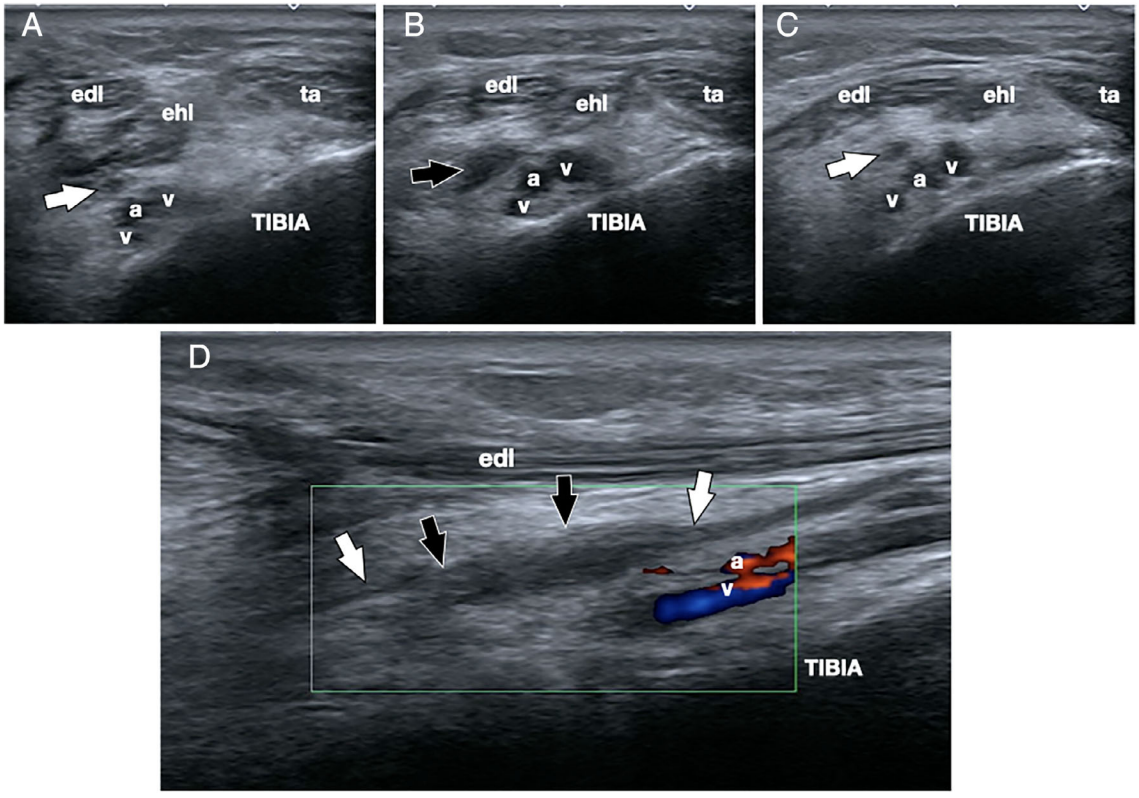
and difficulty in hyperextending the toes related to EDB palsy.[33]

Partial ATTS refers to a syndrome in which one of the two main branches of the DPN is involved.[34] When only the MBDPN is pathologic, patients usually report pain on top of the first two toes. In contrast, when the LBDPN is involved, patients may report dysesthesia over the dorsolateral aspect of the foot, extending to the sinus tarsi region and the lateral part of the Lisfranc joint (fourth and fifth tarsometatarsal joints).[35] Specifically, tight shoes may exacerbate the symptoms in ATTS and partial ATTS, and patients may present with an antalgic gait. Pain may diminish with rest but may be also present at night due to nerve stretching in a particular sleep position.[12]

Pathologic US Findings

Ultrasound is able to depict pathologic variations of the nerve. In particular, in a case of direct or traction trauma, the nerve appears swollen and hypoechoic, with a loss of the normal fascicular pattern. In entrapment neuropathies, US can show nerve flattening at the site of compression and hypoechoic enlargement proximal or distal to the compression. In laceration by penetrating trauma, US can show a hypoechoic neuroma and can differentiate a complete (stump neuroma) or a partial (in-continuity neuroma) tear. Similar findings can be shown in iatrogenic trauma (eg, after surgery), and nerves may also be entrapped in fibrous scars. In cases of space-occupying lesions, US is able to show these, as well as the relationship with the nerves.[4,29]

Figure 11. Distal third of the leg: In-continuity neuroma of the DPN. **A–C**, Axial sonograms, from proximal (**A**) to distal (**C**), in a patient who had a previous motorcycle collision. The normal DPN (white arrow) fascicular pattern cannot be depicted. In **B**, note nerve swelling consistent with an in-continuity neuroma (black arrow). **D**, Sagittal color Doppler scan shows the in-continuity neuroma (black arrows). White arrows represent the normal DPN proximal and distal to the neuroma. a indicates tibial anterior artery; edl, extensor digitorum longus; ehl, extensor hallucis longus; and ta, tibialis anterior.



When the DPN or the LBDPN is chronically involved, US may show fatty infiltration, atrophy of the muscle(s) innervated by the branches, or both (Figure 4). Magnetic resonance imaging (MRI) can also depict muscle edema in the initial stages of nerve compression, which cannot be depicted by US.[36,37] Nevertheless, US can better show the DPN and the anatomy and pathologic appearances of the nerve branches, particularly distal to the ankle, because of their small size.[25,29]

Proximally, the DPN may be compressed around the fibula by a ganglion cyst. Intraneural ganglia have been extensively reported in the literature; they usually extend to the CPN and, therefore, are not described in this Pictorial Essay.[38] Extraneural ganglia that compress the CPN, the

Figure 12. Ankle: DPN enlargement after talus fracture. **A** and **B**, Transverse sonograms at the level of the talus, proximal (**A**) and distal (**B**). In **A**, the DPN (white arrow) appears normal, lateral to the dorsal pedis artery (a). In **B**, note that nerve fascicles are swollen (black arrow) near an osseous fragment (black arrowhead) related to a previous talus fracture. The inferior extensor retinaculum appears thickened, related to the previous injury, especially in its deep part (black curved arrow). edl indicates extensor digitorum longus.

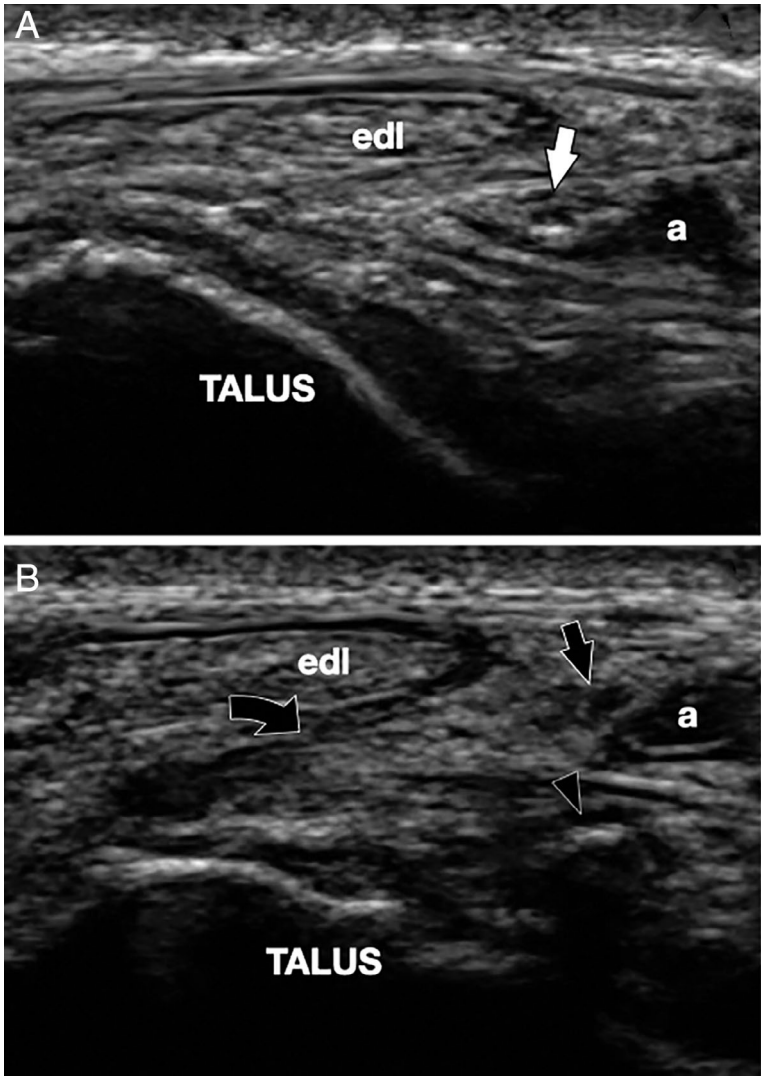


Figure 13. Ankle: DPN scar encasement after fasciotomy. **A–C**, Axial sonograms, from cranial (**A**) to caudal (**C**), at the level of the anterior ankle in a patient who underwent fasciotomy for anterior lower leg compartment syndrome with severe pain at the ankle and the first web space (numeric rating scale score of 7). **A**, Normal nerve pattern of the DPN (white arrows) with a slightly hyperechoic external epineurium cranially. In **B**, note entrapment of the two branches of the DPN (black arrows) within the scar (asterisk); the nerves cannot be clearly distinguished from the hypoechoic scar formation. **C**, Extensive scar formation above the branches of the DPN further caudally. At this level, the nerve branches (white arrows) appear normal. A US-guided block with 0.5 mL of lidocaine 1% revealed immediate pain relief (numeric rating scale score of 2). edl indicates extensor digitorum longus; and ehl, extensor hallucis longus.

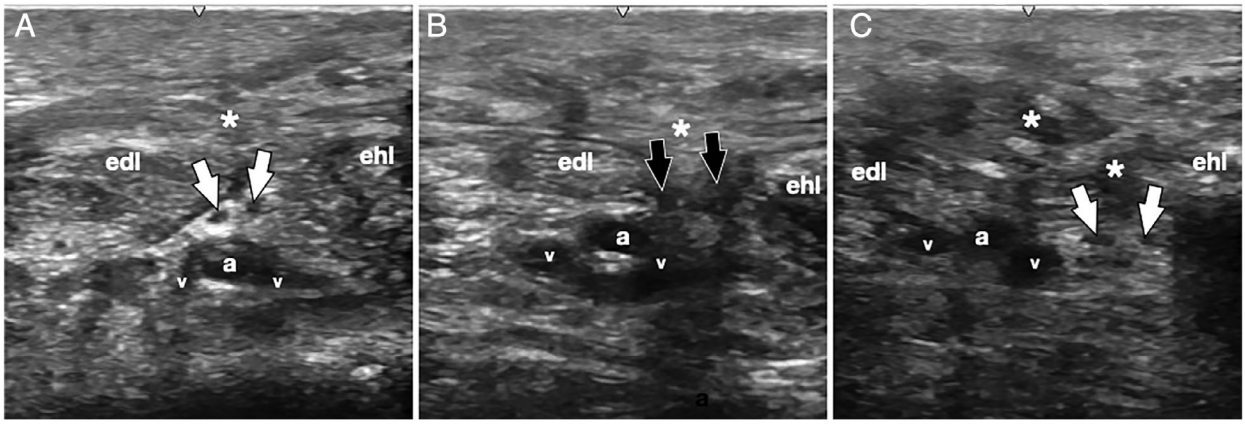


Figure 14. Ankle: ganglion compressing the DPN at the extensor retinaculum. **A** and **B**, Transverse sonograms at the level of the distal tibia (**A**) and ankle joint (**B**). In **A**, the DPN (black arrow) is displaced laterally by a ganglion cyst (g) and superficially (**B**). **C**, Proton density–weighted spectral attenuated inversion recovery axial MRI confirms sonographic findings. **D** and **E**, Sagittal sonogram (**D**) and proton density–weighted spectral attenuated inversion recovery MRI (**E**) showing the ganglion. In **E**, note mild hyperintensity of the EDB (white arrow). a indicates the tibial anterior artery; curved white arrow, extensor retinaculum; edl, extensor digitorum longus; and ehl, extensor hallucis longus.

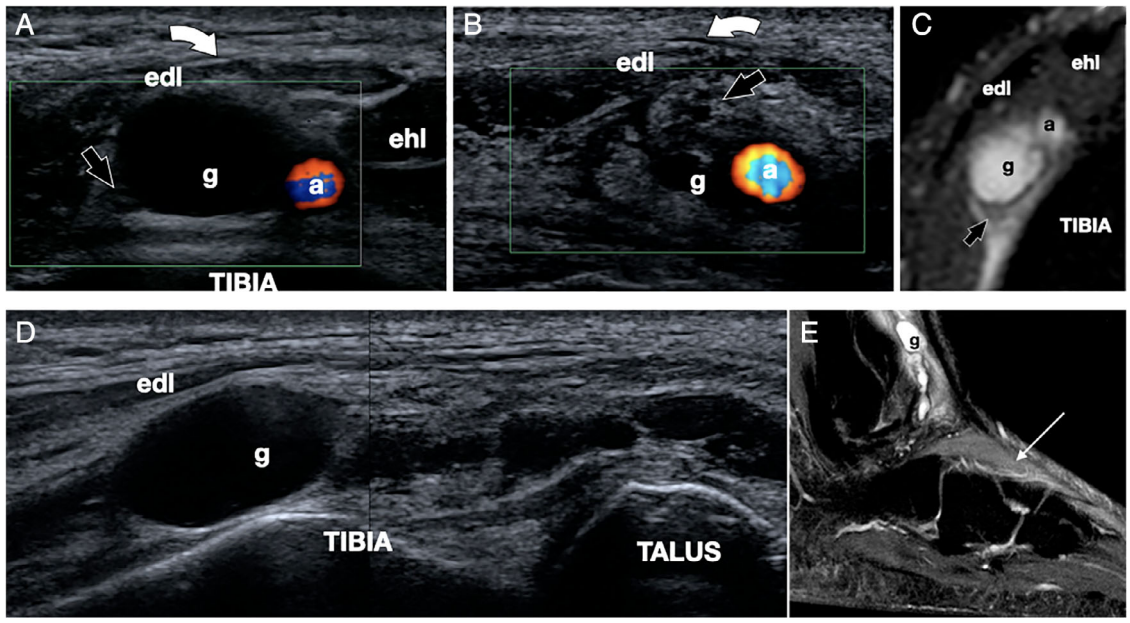


Figure 15. Foot: LBDPN compression in thrombophlebitis. **A** and **B**, Axial sonograms at the level of the Chopart joint. In **A**, the LBDPN (white arrowhead) appears normal. In a slightly distal sonogram (**B**), the nerve becomes thickened (black arrowhead) and partially compressed by a hypoechoic thrombosed vein (black arrow). **C** and **D**, Axial sonograms of the foot at the level of the EDB muscle (edb). The LBDPN appears normal. Vein thrombosis is depicted and confirmed in **D** by pressing the transducer (big black arrow), which, in part, compresses the artery (a) but not the thrombosed veins. Edl indicates extensor digitorum longus; and v, veins.

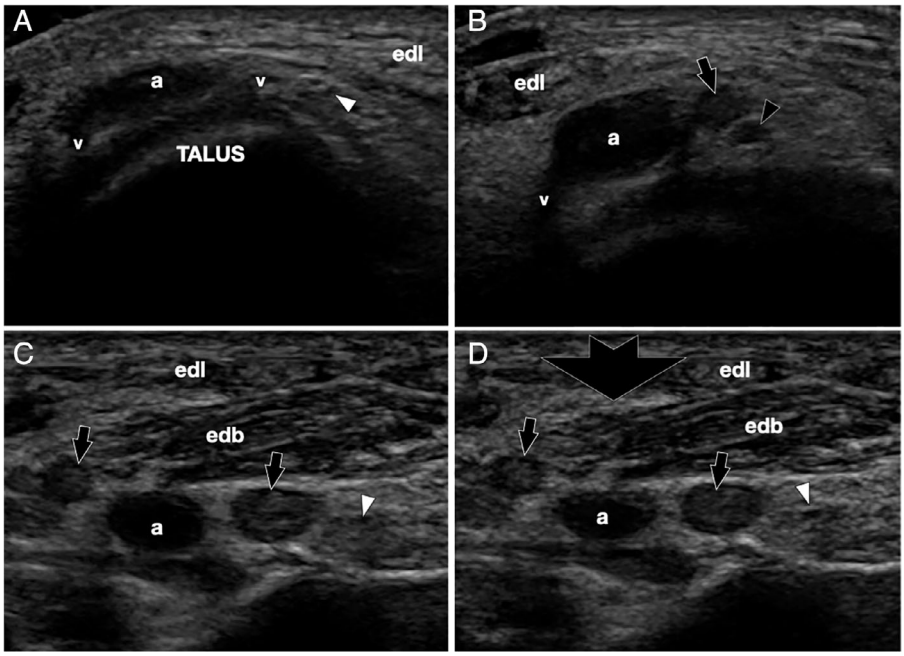
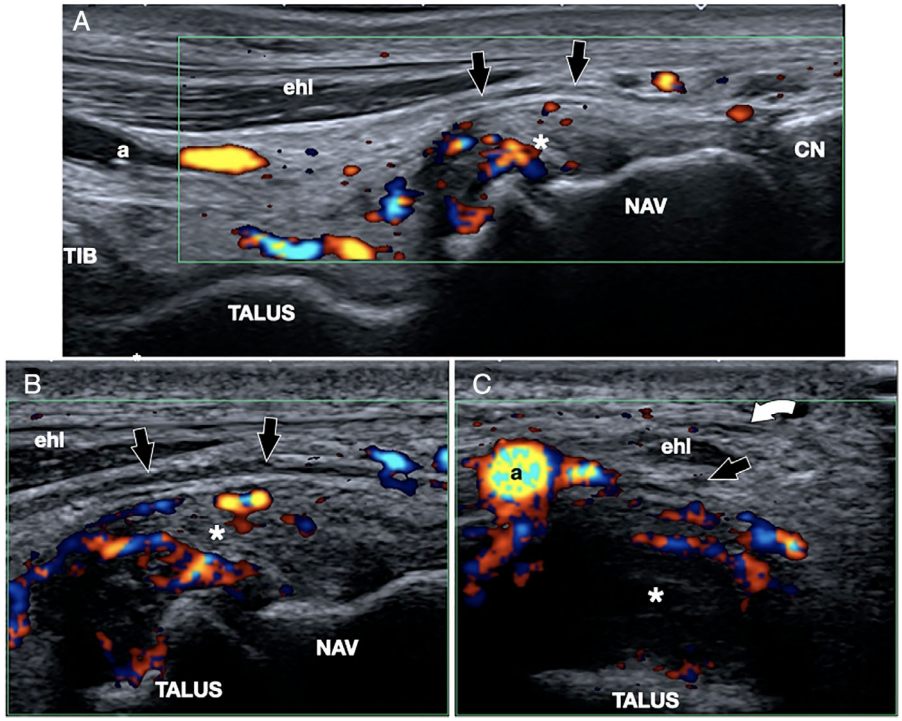


Figure 16. Foot, Chopart joint: MBDPN irritation in rheumatoid arthritis. **A**, Fourteen-megahertz sagittal color Doppler sonogram at the level of the anterior ankle and foot in a patient with known rheumatoid arthritis. Note the active synovitis of the talonavicular joint (asterisk). **B** and **C**, Eighteen-megahertz sagittal (**B**) and axial (**C**) color Doppler sonograms better delineate the intimate relationship of the MBDPN (black arrow) with the inflamed joint. The nerve does not appear swollen, and the patient reported dysesthesia of the first commissural space of the foot, related to the irritation of the nerve. a indicates dorsal pedis artery; CN, cuneiform; curved white arrow, inferior extensor retinaculum; ehl, extensor hallucis longus; NAV, navicular; and TIB, tibia.



DPN, or both may also be found (Figure 5). Due to the superficial location of the nerve, repetitive microtrauma can result in neuropathy.[12]

Other causes of proximal compression are related to bone abnormalities, such as in cases of exostosis (Figure 6)[31] or fibular fractures (Figure 7), associated with the close proximity of the DPN with the fibula.[39] Iatrogenic nerve disorders may be encountered (Figure 8).

At the level of the leg, DPN disorders are rarely encountered: eg, nerve compression caused by tumors (Figure 9) or injuries related to fractures or due to iatrogenic causes (Figure 10). Traumatic and penetrating injuries may also involve the DPN (Figure 11).[39,40]

At the ankle, the DPN may be involved by disorders at the level of the extensor retinaculum, the so-called ATTS. Nerve compression may be the result of direct trauma, repetitive microtrauma (eg, related to tight ski boots or, in soccer players, related to frequent kicking, with trauma to the dorsum of the ankle and foot),[12] previous fractures (Figure 12) or recurrent ankle sprains,[41] and joint arthritis or osteoarthrosis, with prominent osteophytes near the DPN (or its branches), in which the nerve may be stretched by the contiguous dorsal joint capsule. Other causes of DPN disorders include iatrogenic damage: eg, during surgery, in which the nerve may be directly damaged or encased in scar tissue

Figure 17. Foot: LBDPN compression in Chopart osteoarthritis. **A–D**, Axial sonograms, from proximal (**A**) to distal (**D**), at the level of the distal talus. In **A**, the DPN (white arrow) has not yet divided in its terminal branches. In **B**, the MBDPN (white arrowhead) and the LBDPN (open arrowheads) can be depicted. In **C**, the LBDPN (black arrowheads) appears swollen due to impingement with a prominent distal talus at the level of the inferior extensor retinaculum (curved arrow). Note that distally (**D**), the LBDPN appears normal. The EDB (edb), appears atrophic. **E**, Sagittal oblique sonogram of the dorsum of the foot confirms LBDPN entrapment. Note the bony spur of the talus (black arrow). a indicates the dorsal pedis artery and its branch; asterisk, Chopart joint synovitis; edl, extensor digitorum longus; ehl, extensor hallucis longus; and v, veins.

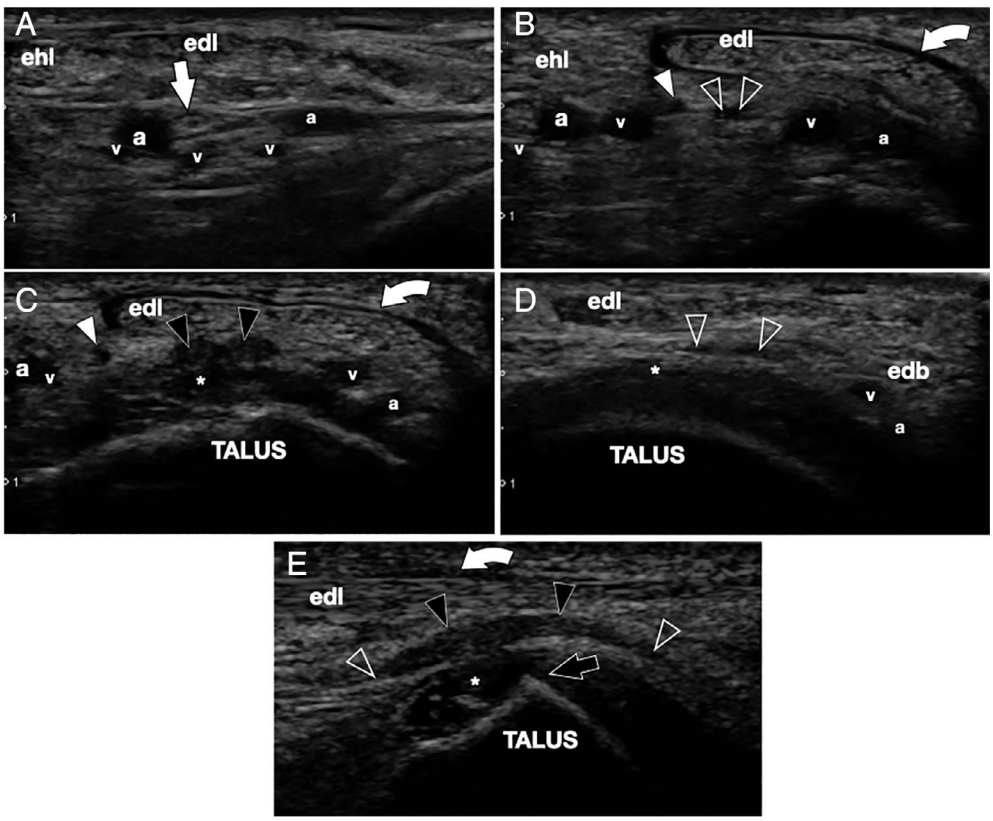
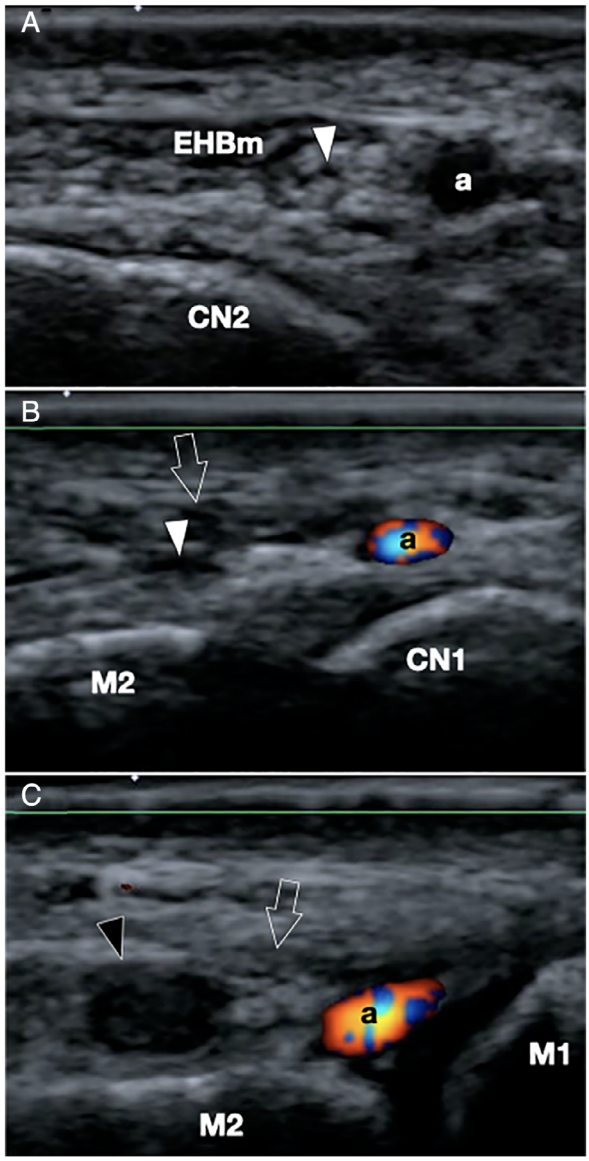


Figure 18. Foot: MBDPN compression under the EHB tendon. **A–C**, Axial sonograms at the level of the Lisfranc joint, proximal (**A**) to distal (**C**). In **A**, note the EHB muscle (EHBm) lateral to the MBDPN (white arrowhead). In **B**, the EHB tendon (open arrow) passes superficial to the nerve, partially compressing it. In **C**, a hypoechoic neuroma can be depicted (black arrowhead) distal to the compression site. In **B** and **C**, color Doppler imaging confirms the dorsal pedis artery (a) and the swollen nerve. Although the patient denied recent trauma, because of the neuroma size, previous foot trauma(s) may have had a role in the pathogenesis. CN1 indicates first cuneiform; CN2, second cuneiform; M1, first metatarsal; and M2, second metatarsal.



(Figure 13), or during the anterior approach to talonavicular or tarsal joint injections, a ganglion cyst (Figure 14), or other masses that compress the nerve.[42,43] Thrombosis of the dorsal pedis artery has also been reported as a possible cause of ATTS[44]; similarly, a rare cause of entrapment, which has not been described to the best of our knowledge, is the compression exerted by foot vein thrombosis (Figure 15).

Figure 19. Foot: MBDPN friction in EHB hypertrophy. **A–C**, Axial sonograms, from proximal (**A**) to distal (**C**), at the Lisfranc joint in a dancer who presented for pain at the first two toes. In **A**, the MBDPN appears normal, medial to a thick EHB muscle (EHBm). In **B**, the nerve is swollen (black arrowhead); note that, in contrast to the EHB tendon (open arrow) impingement, the neuroma is proximal to the tendon crossing point. In **C**, the nerve appears normal. a indicates the dorsal pedis artery; M2, second metatarsal head; and v, vein.

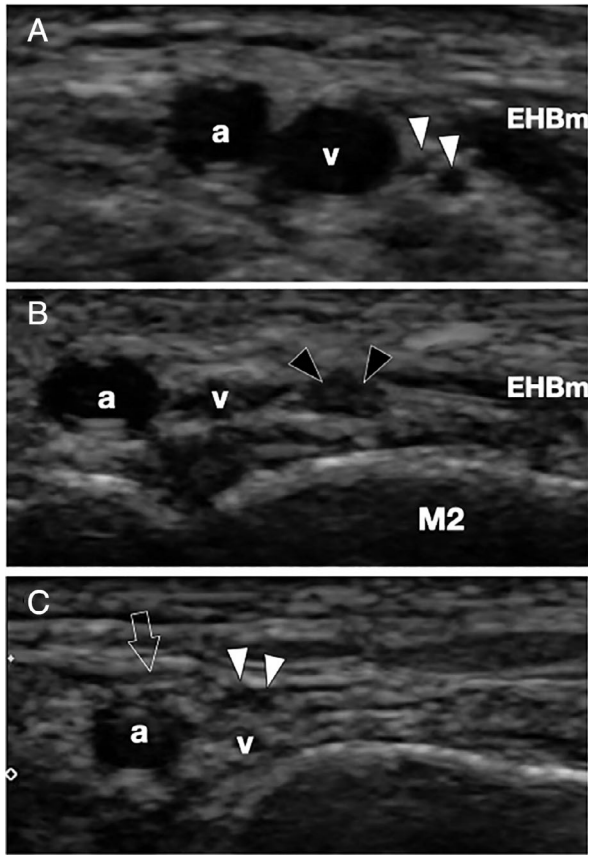
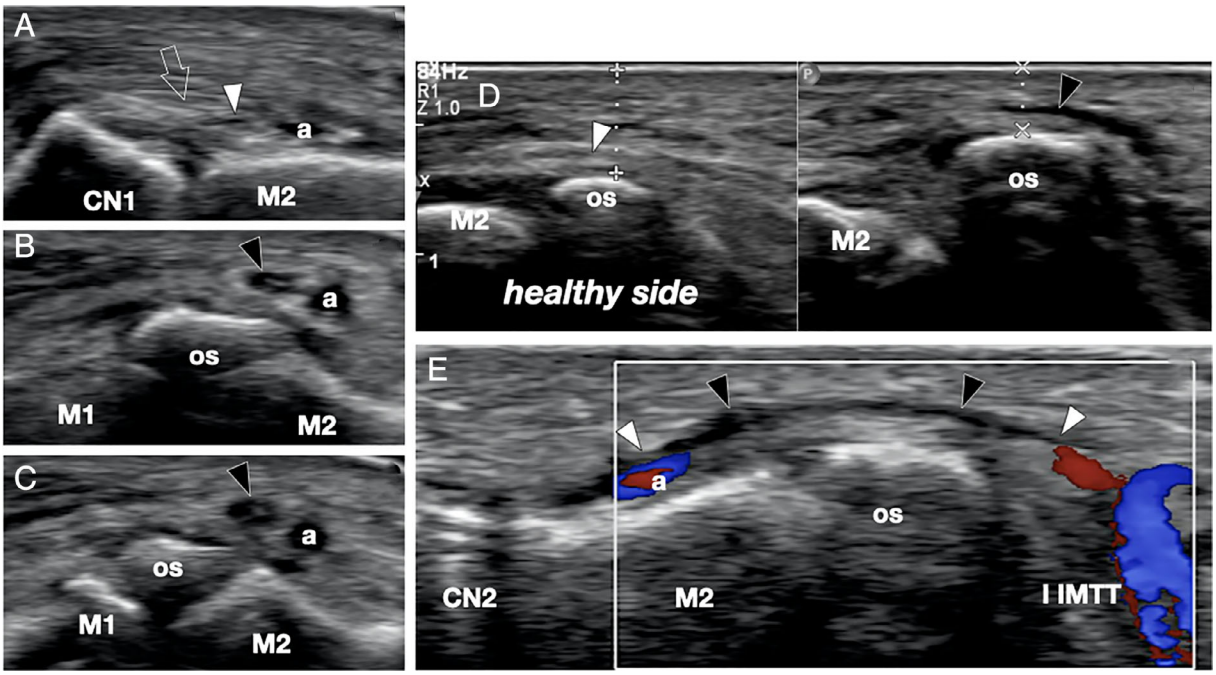


Figure 20. Foot: MBDPN compression related to an os intermetatarseum. **A–C**, Axial sonograms at the level of the Lisfranc joint, proximal (**A**) to distal (**C**), in a patient with a previous injury, in plantar flexion of the foot, who presented for paresthesia over the first two toes. In **A**, the EHB tendon (open arrow) has already crossed the MBDPN (white arrowhead). In **B** and **C**, an os intermetatarseum (os) can be seen, near the nerve, which appears swollen (black arrowhead). **D**, Comparative sagittal sonogram depicts a dislocated superficial os with respect to the normal contralateral side (calipers). Note the normal nerve (white arrowhead) on the healthy side. **E**, Sagittal color Doppler sonogram confirms the described findings. a indicates dorsal pedis artery; CN1, first cuneiform; CN2, second cuneiform; I IMTT, first intermetatarsal space; M1, first metatarsal head; and M2, second metatarsal head.



Partial ATTS is caused by similar alterations. Chopart joint disorders may lead to MBDPN or LBDPN involvement (Figures 16 and 17). Specific involvement of the MBDPN can be found at the Lisfranc joint. Ultrasound has been reported to be feasible in depicting nerve compression under the EHB tendon, as well as in visualizing small neuromas usually distal to the compression, which may be not evident on MRI (Figure 18).[45] More rarely, EHB muscle hypertrophy may lead to MBDPN compression (Figure 19); this condition was, in particular, described in dancers.[46] The os intermetatarseum is an accessory ossicle that is located at the Lisfranc joint, between the medial cuneiform and the first two metatarsal bases; its incidence is variable, reported in 0.2% to 14% of cases. This sesamoid bone may lead to symptoms in patients with local trauma or microtrauma related to sport activities, in which the ossicle may impinge on the MBDPN (Figure 20).[47]

Conclusions

High-resolution US is able to effectively visualize the DPN, its variations, and pathologic changes. High-frequency transducers with good spatial resolution, basic skills in nerve US, and a knowledge of DPN anatomy, as well as potential clinical patterns in DPN disorders, are required to correctly diagnose DPN neuropathies.

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