Ultrasound of the Lateral Femoral Cutaneous Nerve

A Review of the Literature and Pictorial Essay

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We review the ultrasound (US) findings in patients who present with meralgia paresthetica (MP). The anatomy of the lateral femoral cutaneous nerve at the level where the nerve exits the pelvis and potential entrapment sites that can lead to MP are discussed. A wide range of pathological cases are presented to help in recognizing the US patterns of MP. Finally, our experience with US-guided treatment is discussed.

Key Words—entrapment; lateral femoral cutaneous nerve; meralgia paresthetica; ultrasound; US-guided

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Abbreviations

ASIS, anterior superior iliac spine; CSA, cross-sectional area; DCIV, deep circumflex iliac vessels; IL, inguinal ligament; LFCN, lateral femoral cutaneous nerve; MP, meralgia paresthetica; NRS, numeric rating scale; US, ultrasound

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The lateral femoral cutaneous nerve (LCFN) is a sensory nerve that originates from the lumbar plexus, which is characterized by high anatomic variability, particularly at the level of the inguinal ligament (IL) and anterior superior iliac spine (ASIS).[1,2]

Meralgia paresthetica (MP), also known as Bernhardt–Roth syndrome, is a disorder related to the entrapment of the LCFN. Patients usually complain of burning pain and/or dysesthesia located at the anterolateral thigh, which may radiate to the knee, with a subacute onset. MP has an approximate incidence of 3.4–4.3/10,000 person-years.[3] Obesity, diabetes mellitus, pregnancy, and advancing age are associated with MP.[3–6]

Ultrasound (US) is a well-demonstrated imaging modality with which nerves are assessed, particularly when superficially located, due to its spatial resolution.[7] It is well accepted by patients, allows dynamic studies, and it can also guide therapeutic choices.[8] US has been demonstrated to be effective for the diagnosis and treatment of patients with MP.[9–12]

This Pictorial Essay describes our approach to the study of the lateral femoral cutaneous nerve (LFCN). We discuss the normal anatomy and the US technique to demonstrate the nerve. Then, we focus on abnormalities, presenting our pathological cases and how to report them. Finally, we discuss US-guided therapy with practical tips.

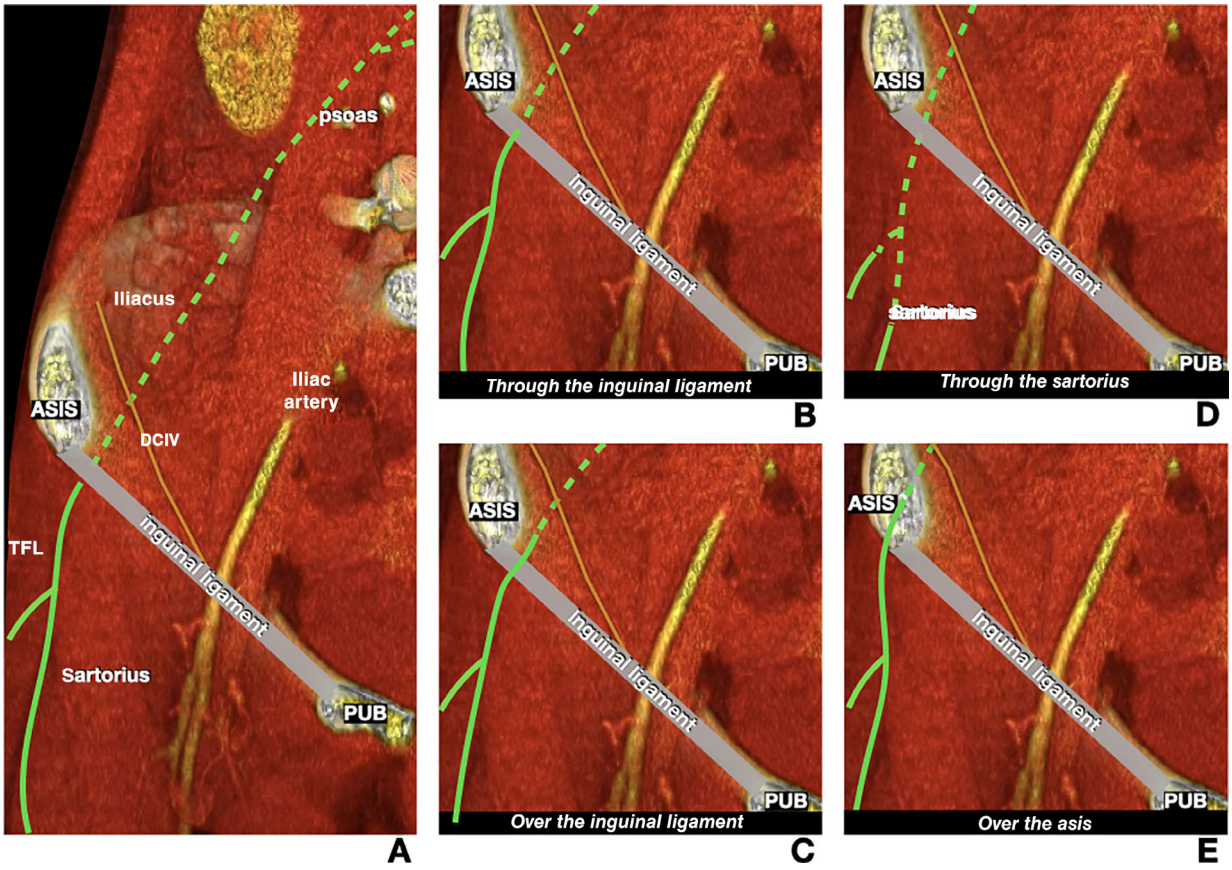
This study was waived by local Institutional Review Board; obtaining informed consent was exempted for this study.

Anatomy of the LFCN

The LFCN usually originates from the posterior division of L2 and L3;[1] it travels within the retroperitoneum, through the psoas muscle, to reach the iliacus muscle and passes it obliquely, located

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Figure 1. Anatomic CT 3D schematic drawings of the LFCN course and some of the possible variants. **A**, The LFCN crosses the psoas muscle, then passes over the iliacus muscle. It is crossed by the DCIV, then exits the pelvis passing deep to the IL, and medial to the ASIS. It then descends the thigh vertically to divide into posterior and anterior branches. This is, according to Tomaszewski, the most frequent pattern. **B,** The LFCN passes through the IL. **C,** The LFCN passes over the IL. **D,** The LFCN passes through the sartorius muscle. **E,** The LFCN passes over the ASIS. Other variants include the passage of the LFCN lateral to the ASIS and through the ASIS. In the drawings, we have considered the LFCN as dividing into two branches distal to the ASIS, which is the more frequent pattern; however, the LFCN may already be divided before crossing the IL into up to five branches. ASIS, anterior superior iliac spine; CT, computed tomography; DCIV, deep circumflex iliac vessels; IL, inguinal ligament; LFCN, lateral femoral cutaneous nerve; PUB, pubis; TFL, the tensor fasciae latae.



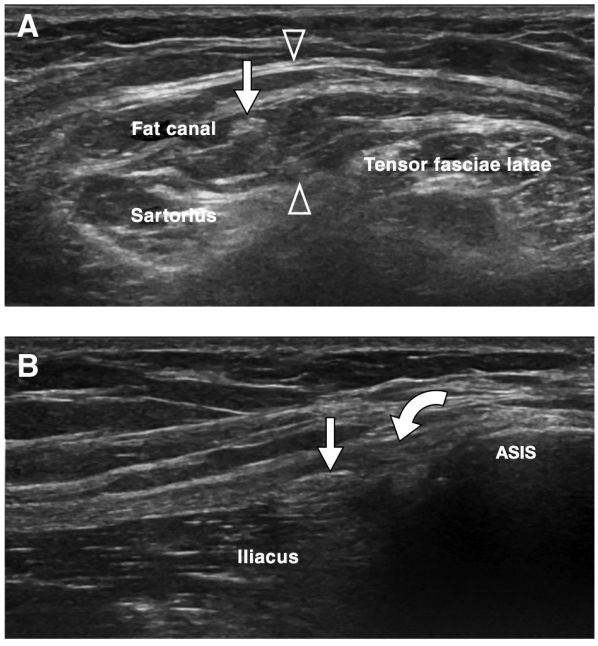
between two layers of the iliac fascia superficial to it.[13] In its distal abdominal course, the LFCN is crossed by the deep circumflex iliac vessels (DCIV).[14] It then passes through an "aponeuroticofascial tunnel," also referred to as the iliopubic tract, composed of the iliac fascia and fascial layers that originate from the lateral abdominal wall muscles, to reach the region of the IL, near the ASIS. The anatomy is complex at this level, and anatomical variants are common. Furthermore, these fascial planes are described differently by authors, mainly in anatomic studies, whereas they are usually not described in the radiological literature.[3,13,15,16]

The nerve usually passes medial to the ASIS (Figure 1A), deep to the IL. According to Tomaszewski, who reviewed 18 articles, the mean distance of the LFCN from the ASIS is 19 mm[1]; in a study by Grothaus, the distance ranged from 6 to 73 mm.[17] Nevertheless, many potential variants have been described, for example, the LFCN may pass through or over the IL or over the ASIS.[1]

The course of the nerve, as well as some of the variants at the level of the IL and ASIS, are presented in Figure 1.

The LFCN exits the pelvis and enters the thigh to travel downward vertically, over the sartorius or

Figure 2. US anatomy of the LFCN and the technique to demonstrate it. **A**, Axial sonogram at the level of the left proximal thigh, obtained with a 15 MHz transducer. The LFCN (white arrow) can be demonstrated as a small honeycomb-like structure composed of tiny fascicles, running inside a fat canal bounded by two fascial planes (open arrowheads). **B**, The nerve is tracked cranially: axial-oblique sonogram parallel to the course of the IL (curved arrow) depicts the nerve superficial to the iliacus muscle, deep to the IL, medial to the ASIS. ASIS, anterior superior iliac spine; IL, inguinal ligament; LFCN, lateral femoral cutaneous nerve; US, ultrasound.



between the sartorius and tensor fasciae latae muscle, in a fat, roughly triangular canal bounded by two fascial layers. It then usually divides into two main branches: a larger anterolateral branch to innervate the anterolateral thigh, extending to the knee; and a smaller posterior branch to the region of the greater trochanter. These branches become subcutaneous distally.[3,18]

US Technique to Study the Normal LFCN and Pathological Findings in MP

Before starting the US examination, we review the clinical indication for the exam and previous diagnostic tests. Since not all patients are referred with a suspicion of MP, we have a brief medical history and clinical examination, in which patients are particularly asked about previous trauma and/or surgery along the course of the LCFN.

Even when the clinical suspicion of MP is high, a quick US assessment of the anterolateral hip is performed and possible differential diagnoses are ruled out, for example, greater trochanter pain syndrome, hip joint arthropathy, femoral neuropathy, iliac mass[3] then, the examination is focused on studying the course of the LCFN.[19]

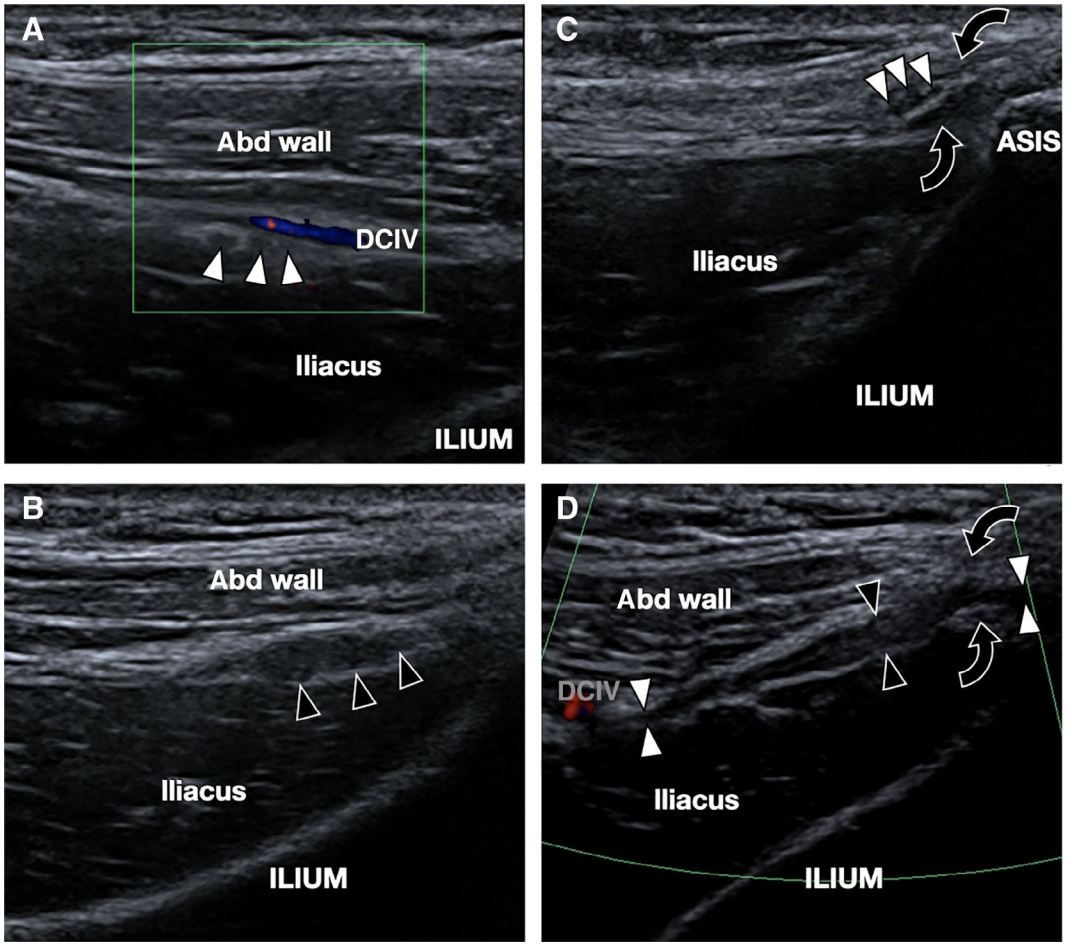
The patient lies supine. We start the US exploration with a linear multifrequency transducer with frequencies up to 12 or 15 MHz, and a footprint of around 5 cm to provide a large view of the area. Then, we focus the examination with a higher frequency transducer (≥18 MHz) with a smaller footprint to better delineate the anatomy of the LFCN; however, in obese patients, the higher frequency may be not useful due to the increased thickness of the subcutaneous fatty tissue.

The easiest way to locate the LFCN is to start with axial sonograms caudal to the level of the ASIS, which can be palpated. The tensor fasciae latae and sartorius muscles are easily depicted, superficial to the proximal tract of the rectus femoris. The fat canal bounded by two fascial layers can be demonstrated superficial to these two muscles.[20] Inside this fat canal, the LFCN can be located: due to the small size of the nerve, it appears as small honeycomb structures on axial planes (Figure 2A), which can be followed up and down using the elevator technique through continuous scanning.[21] Usually, we do not study the course at the distal thigh of the LFCN, unless it is clinically relevant (e.g., in case of a wound of the distal anterolateral thigh).

The nerve is tracked proximally at the level of the ASIS. We suggest orienting the probe along the course of the IL, as this maneuver has the advantage of better demonstrating the relationship of the LFCN to the IL and ASIS, which are, in our experience, the main sites of the compressive neuropathy. Moreover, this allows detection of the correct short axis of the LFCN (Figure 2B).

In the pelvis, the nerve may be difficult to be further tracked, particularly in obese patients. In slender subjects, it can usually be detected until it is crossed by the DCIV, located anterior to the iliacus muscle. Color Doppler enables discrimination between the nerve and the vessels (Figure 3A and D).

Figure 3. A, 40-year-old man with a 3 -year history of left lateral burning thigh pain. **A–C,** Short-axis sonograms of the LFCN from proximal (**A**) to distal (**C**), obtained with an 18-MHz hockey-stick probe, using the "elevator technique." In (**A**), normal nerve fascicles (white arrowheads) can be seen crossed by the DCIV, depicted with color Doppler. In (**B**), nerve fascicles are swollen (black arrowheads), reflecting entrapment neuropathy. In (**C**), the LFCN fascicles are compressed between a splitting of the IL (curved arrows). **D,** Long-axis color Doppler sonogram of the LFCN confirms the neuromatous appearance of the nerve (black arrowheads), compressed at the level of the splitting of the IL (curved arrows). Distally and proximally, the nerve is normal (white arrowheads). The DCIV is well depicted on the left of the image using color Doppler. The patient refused to have a therapeutic injection at the time. No follow-up was obtained. Abd wall indicates the lateral abdominal wall muscles. DCIV, deep circumflex iliac vessels; IL, inguinal ligament; LFCN, lateral femoral cutaneous nerve.



Proximal to the DCIV, the course deep to the psoas major muscle and the LFCN origin is almost blind to US; this is related to the loss in resolution when imaging deep small structures. The structures of the anatomically described "aponeuroticofascial" tunnel just before the IL are difficult to be clearly differentiated at US because fascial planes are contiguous.

The US features of entrapment neuropathies are swelling with a more hypoechoic appearance of nerve fascicles ("neuromatous appearance"), which can be demonstrated during the aforementioned elevator technique (Figure 3).[22,23] When nerve disorders are depicted, we suggest acquiring a longitudinal sonogram of the LFCN to demonstrate the neuroma location and to possibly measure its craniocaudal extension (Figure 3D).

US-guided compression with the transducer at the level of the pathological nerve, the sonographic Tinel test, may help to confirm the diagnosis by eliciting the patient's symptoms. However, in patients with MP, the Tinel sign may be negative.[24] In case of subtle findings, US offers the possibility to quickly

Figure 4. A 49-year-old obese woman with a previous trauma of the right groin region, complaining of right anterolateral thigh dysesthesia. Comparative short-axis sonograms (14 MHz transducer) at the level of the ASIS. The IL is thickened on the affected side (on the left, black curved arrow, 1.8 mm; 1 mm on the healthy side, white curved arrow). The LFCN is also enlarged, reflecting entrapment neuropathy (black arrowhead: CSA 11 mm^2; 6.7 mm^2 on the healthy side, white arrowhead). A therapeutic US-guided injection with 1 cc lidocaine 1% and 1 cc diprophos (7 mg betamethasone) was proposed, which reduced the NRS of pain (4 to 1). We have no further follow-up information. ASIS, anterior superior iliac spine; CSA, cross-sectional area; IL, inguinal ligament; LFCN, lateral femoral cutaneous nerve; NRS, numeric rating scale; US, ultrasound

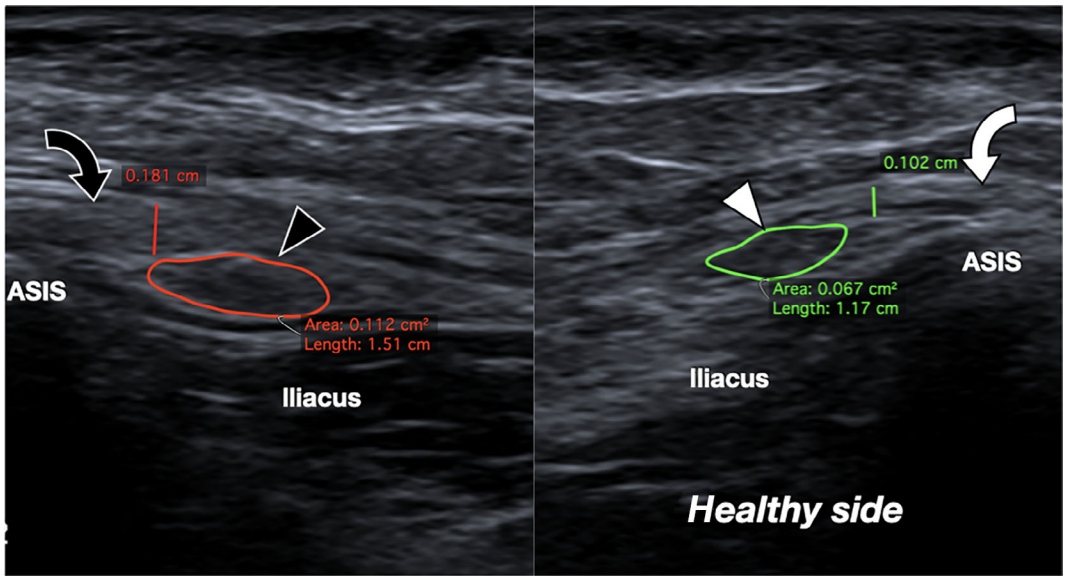
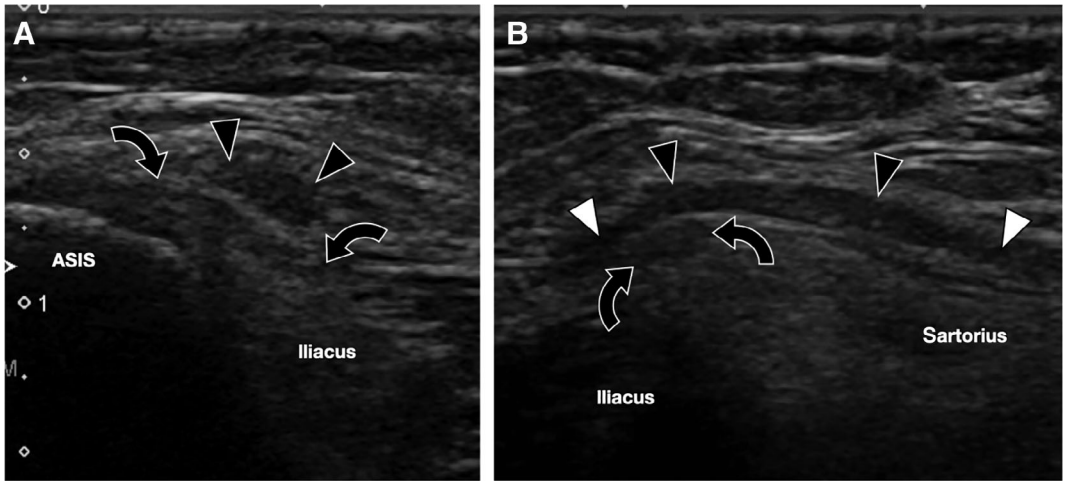
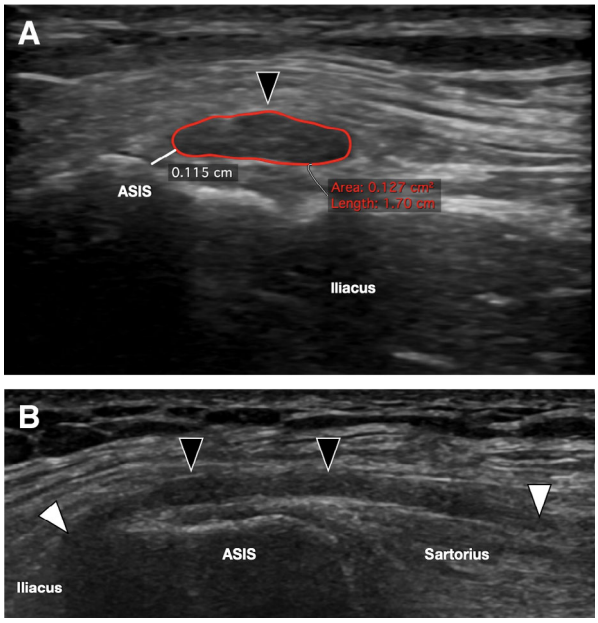


Figure 5. A 65-year-old woman with a 10-year-old unrecognized MP. **A,** Short-axis sonograms with an 18-MHz transducer at the level of the ASIS. The LFCN (black arrowhead) passes over the IL (curved black arrows), near the ASIS, and appears hypoechoic and swollen. **B,** Longitudinal sonogram of the LFCN depicts its enlargement at the level of the IL and of the proximal thigh. The normal nerve is indicated by the white arrowhead. No ultrasound-guided injection was performed. No further follow-up of the patient was obtained. ASIS, anterior superior iliac spine; IL, inguinal ligament; LFCN, lateral femoral cutaneous nerve; MP, meralgia paresthetica.



produce comparative scans with the contralateral side, which may be helpful to confirm pathology.[8] The examiner must always remember to correlate US findings to clinical data: in our practice, mild nerve enlargement may be present with nondisturbing symptoms, particularly in the elderly. When the clinical and US findings

Figure 6. A 49-year-old man with long-lasting MP. The LFCN crosses over and close to the ASIS. **A**, Short-axis sonogram of the LFCN at the level of the ASIS obtained with an 18-MHz hockey-stick probe. The nerve (black arrowhead) appears thickened and hypoechoic, with a loss of the normal fascicular pattern. The CSA of the nerve is 12.7 mm^2. Note the close proximity of the nerve to the ASIS (around 1.1 mm). **B,** Long-axis sonogram of the LFCN obtained with a 15-MHz linear transducer provides a more panoramic view of the nerve course. Note that the nerve is thickened (black arrowheads) at the level of the ASIS, whereas it appears normal proximally and distally (white arrowheads). An ultrasound-guided injection with 1 cc lidocaine 1% diminished the patient's NRS pain level by more than 50%. A subsequent ultrasound-guided injection with 1 cc lidocaine and 1 ml diprophos (7 mg/ml betamethasone) was performed a week later and clearly diminished the pain for 9 months. A further injection with lidocaine/betamethasone was performed after 9 months. No further follow-up was obtained. ASIS, anterior superior iliac spine; CSA, cross-sectional area; LFCN, lateral femoral cutaneous nerve; MP, meralgia paresthetica; NRS, numeric rating scale.



are equivocal, other differential diagnoses should be excluded. Lumbar radiculopathy usually presents with more diffuse symptoms than MP and can be demonstrated by magnetic resonance imaging. Space-occupying lesions (e.g., pelvic mass) over the course of the LFCN may also compress the nerve. In addition, in these cases, symptoms are usually not limited to anterolateral thigh pain, which is the typical presentation of MP.[3]

The LFCN is usually entrapped where it passes the IL, in proximity to the ASIS. It is the location where the nerve is predisposed to mechanical constraints.[16] Dias Filho hypothesized that it is the "aponeuroticofascial tunnel" that may lead to the nerve entrapment rather than the IL.[13] As already stated, the anatomy is complex at this level, with contiguous structures that are difficult to be clearly differentiated at US. Radiological studies usually consider the IL as the point of nerve entrapment.[9,12,14]

In our experience, the anatomical variations that mostly predispose patients to MP are related to the passage of the nerve through a splitting of the IL or when the LFCN is close to the ASIS.

In MP, due to passage through a splitting of the IL (Figure 1B), the neuromatous swelling is usually found proximal to the IL (Figure 3D).

The LFCN may also be entrapped when it travels underneath the IL (Figure 1A), particularly when passing near the ASIS. Previous trauma may result in thickening of the IL (Figure 4), leading to neuropathy.

The LFCN may pass over the IL (Figure 1C). In patients with MP, the nerve enlargement is commonly located over the IL and distal to it (Figure 5). MP is frequently associated with the nerve traveling close to the ASIS (Figure 1E; Figure 6): the neuroma is mostly found over and possibly slightly distal to the bone.[16] ASIS irregularities may lead to nerve disorders. Enthesopathy (Figure 7), avulsion (Figure 8), as well as previous iliac bone harvesting, may stretch or damage the LFCN.[14]

Uncommon variants, such as an intrasartorius course of the LFCN (Figure 1D), may also lead to MP, which has not been demonstrated yet at imaging to the best of our knowledge (Figure 9). Nerve swelling in this case usually involves its intramuscular tract.

Other reported causes of MP include the following:

- chronic compression exerted by the sartorius in dancers.[25]
- iatrogenic injuries: in particular, during the direct anterior approach for hip arthroplasty, for which US has been proposed as a preoperative tool to prevent damage and identify the nerve courses.[26] The nerve can also be injured during other regional surgery, such as hernia repair.[3]
- a mass or an infectious process that may compress the nerve (e.g., chronic appendicitis).[3]

Figure 7. A 56-year-old man with left-sided MP and enthesopathy of the ASIS. Comparative short-axis sonograms of the LFCN at the level of the ASIS, obtained with an 18-MHz hockey-stick transducer. The healthy side is shown on the left: nerve fascicles can be well depicted (white arrowheads). On the right, the LCFN is thickened and hypoechoic (black arrowheads). Note diffuse cortical irregularities (black arrow) of the ASIS, related to enthesopathy. The patient denied a previous major trauma. An ultrasound-guided injection with 1 cc lidocaine was performed and the pain diminished significantly (NRS 4 to NRS 1). No follow-up was obtained. ASIS, anterior superior iliac spine; LFCN, lateral femoral cutaneous nerve; MP, meralgia paresthetica; NRS, numeric rating scale.

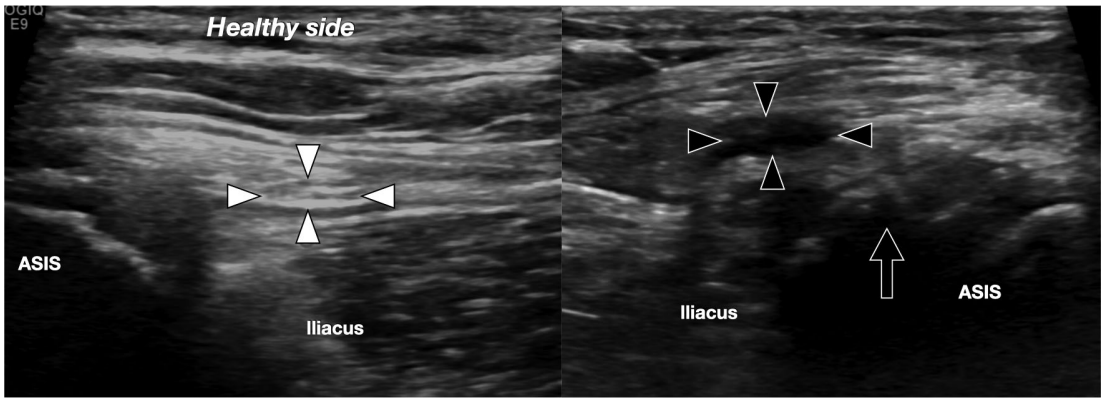


Figure 8. A 17-year-old man with an acute avulsion of the ASIS. **A**,**B,** Axial sonograms from proximal (**A**) to distal (**C**) demonstrate an osseous avulsion of the ASIS. Nerve fascicles (black arrowhead) look swollen and hypoechoic related to a traction injury, whereas distally (**C**), they appear normal (white arrowhead). **D,** Coronal sonogram clearly depicts the avulsed fragment. No follow-up information was available for this patient. Asterisks indicate the fresh hematoma. ASIS, anterior superior iliac spine; glutm, glutei muscles; sart, sartorius; TFL, tensor fasciae latae.

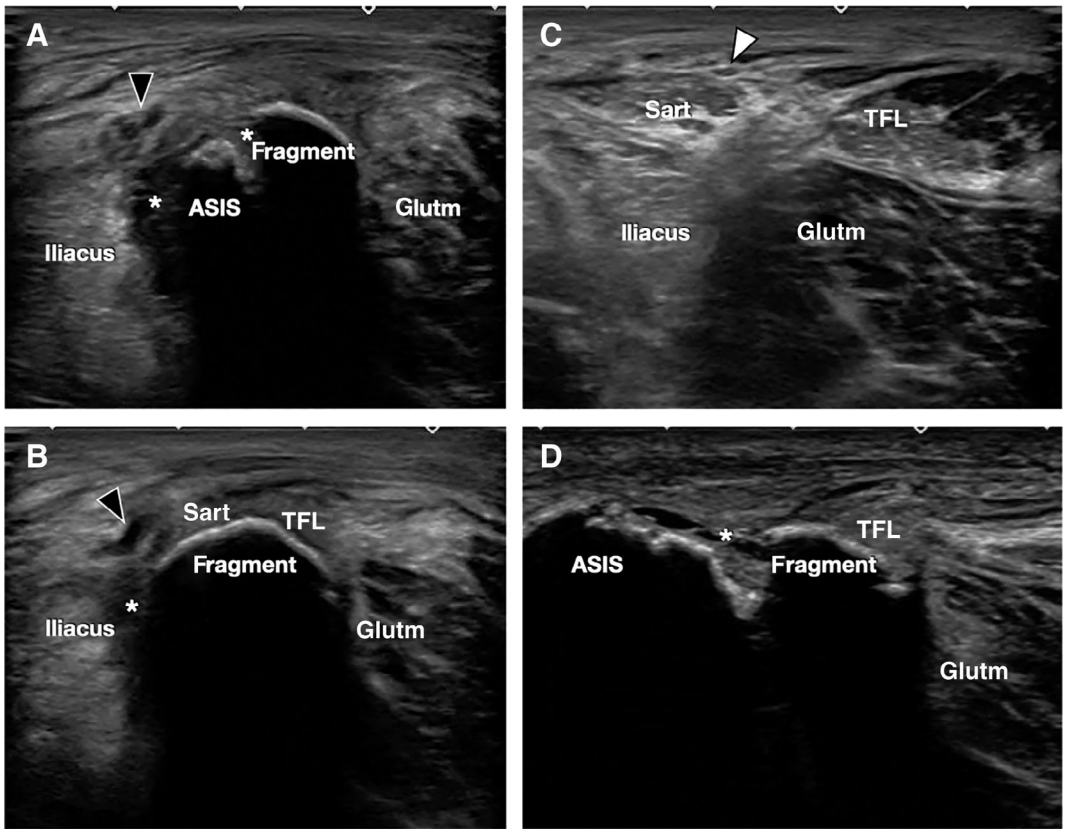
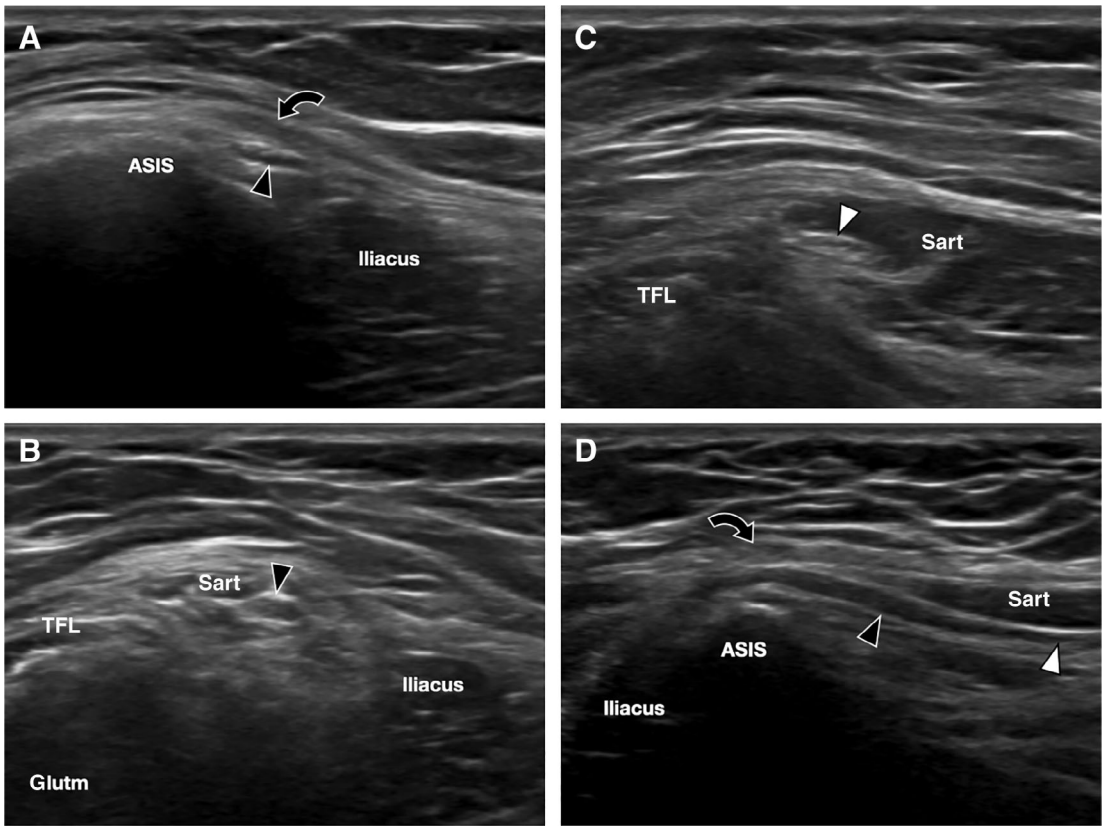


Figure 9. A 45-year-old obese woman referred for "right thigh pain." She had a history of a 3-year burning pain. She preferred to use a waist bag on the right side during work. **A–C,** Axial sonograms from proximal (**A**) to distal (**C**) acquired with a 12-MHz transducer depict a quite enlarged LFCN in **A** and **B** (black arrowhead), passing inside the sartorius muscle (sart). The nerve appears normal in **C**. The US-guided Tinel test was positive. **D,** Longitudinal sonogram of the LFCN confirms the intramuscular passage and its proximal swelling. Weight loss and avoiding the use of waist bags were advised as an initial treatment. At a phone call follow-up 6 months later, the patient referred a partial relief of symptoms. Curved arrow indicates the IL; IL, inguinal ligament; glutm, glutei muscles; LFCN, lateral femoral cutaneous nerve; TFL, tensor fasciae latae; US, ultrasound.



- thigh trauma involving the region of the fat canal, which, to our knowledge, has not been reported in the radiological literature (Figure 10).

US Report

The clinical indication for US and a brief clinical history of the patient are detailed in the US report.

The report should describe the course of the LCFN at the IL and report the minimum distance between the LFCN to the ASIS.

The cross-sectional area (CSA) of the LFCN is reported at the level of the enlargement (Figure 6A) and mentioning the CSA of the contralateral side might be helpful (Figure 4). However, due to the high variability of the nerve, which may have been divided into as many as five branches before the IL,[17] it may sometimes be difficult to measure it correctly: when patients with such a variant are encountered, it should be described and reporting the CSA may be avoided. In the literature, there are studies that report the CSA of the LFCN.[24,27–29] Suh in 2013 and Powell in 2020 have proposed that a CSA > 5 mm^2 of the LFCN has 95.7% (Suh) and 87% (Powell) sensitivity, and 95.5% (Suh) and 90% (Powell) specificity for the diagnosis of MP. However, it is difficult to define a clear cutoff for normal and pathological values, possibly related to the described variability and the low numbers of participants. Also, in these two studies, the transducer frequency used was relatively low

Figure 10. A 32-year-old man with left anterolateral thigh pain after a direct thigh trauma after falling from a height of around 1.5 m. **A**,**B,** Axial sonograms from proximal (**A**) to distal (**B**) acquired with an 18-MHz probe, at the thigh. In **A**, the LFCN can be seen with the typical honeycomb appearance, composed of small fascicles (white arrowheads), running in the fat canal, and bounded superficially and deeply by fascial layers (white curved arrows). In **B**, note the more medial fascicles forming a neuroma (black arrowheads), whereas the lateral fascicles look normal. The nerve at the level of the IL and in the proximal fat canal, over the sartorius and tensor fasciae latae, was normal. The LFCN was studied distally in relation to the trauma region, as pointed out by the patient. Avoiding tight pants was the first suggested treatment, and an injection was proposed if symptoms persisted or worsened. The patient did not call back at 6 months. LFCN, lateral femoral cutaneous nerve.

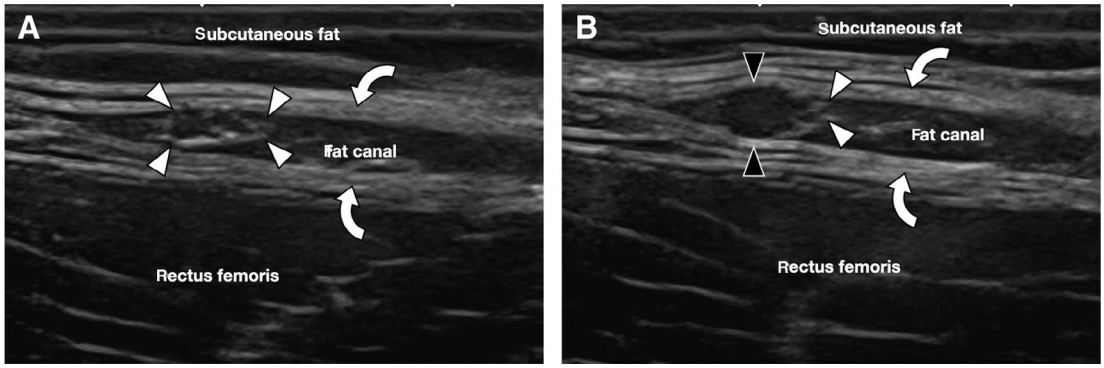
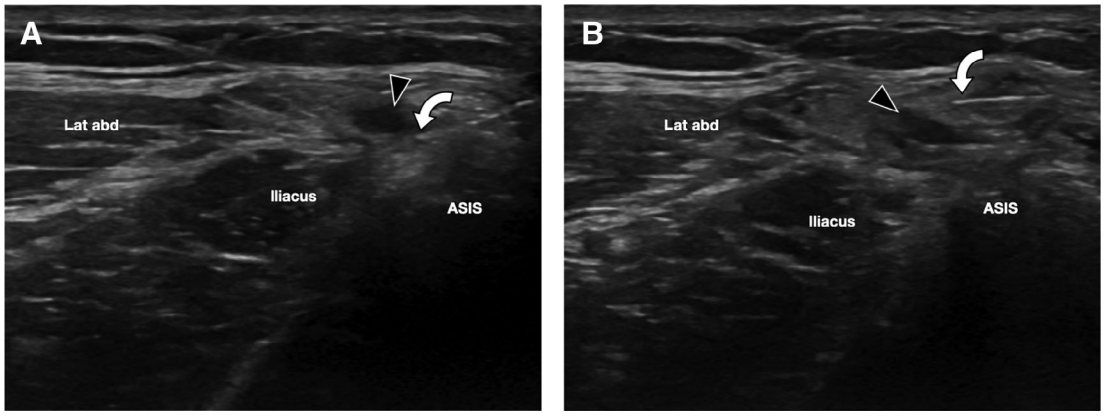


Figure 11. A 49-year-old man with a left-sided MP. US-guided injection. **A**,**B,** Axial sonograms at the level of the ASIS. In **A**, the needle (curved arrow) is advanced deep to the thickened LFCN (black arrowhead). Around half of the mixture is injectate. In **B**, in this patient, the needle is repositioned over the nerve, so that the rest of the mixture is injected to provide a circumferential coverage of the injection. The injectate consisted of 1 cc lidocaine and 1 cc diprophos (7 mg betamethasone). The patient recovered well after the treatment with a nearly pain free interval for approximately 9 months. After 9 months, the treatment was repeated. A further follow-up was not reported. ASIS, anterior superior iliac spine; Lat abd, lateral abdominal wall muscles; LFCN, lateral femoral cutaneous nerve; MP, meralgia paresthetica; US, ultrasound.



(12 MHz), with a loss in resolution for superficial structures.[24,30]

We usually detail the craniocaudal extension of the neuroma: in our experience in long-standing MP, the nerve is pathological for a longer tract.

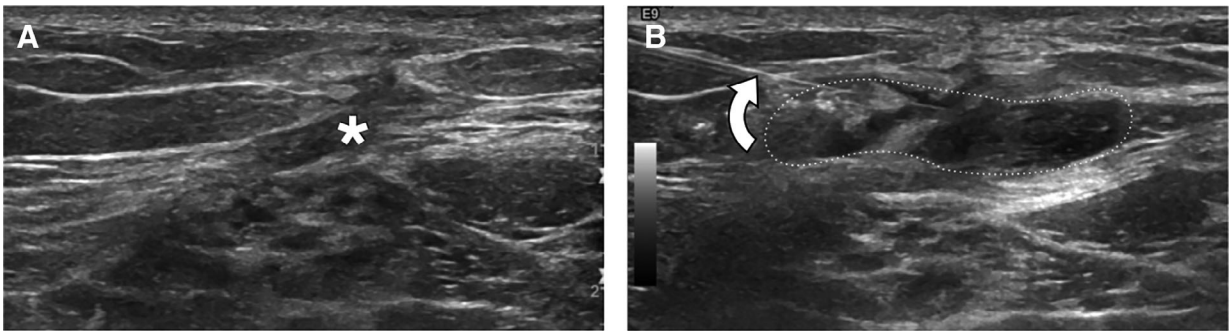
We report any additional findings that can be related to neuropathy, such as ASIS irregularities, and other findings that appear to be related to the patient's symptoms.

US-Guided Treatment

General advice for patients with MP includes weight loss for obese patients, avoiding tight clothes around the waist, and the use of medications to treat symptoms (e.g., analgesic, anti-inflammatory drugs).[3,31]

MP can also be effectively treated under US guidance using anesthetic and/or steroid injection.[32]

Figure 12. A 36-year-old man with a right-sided MP related to a previous removal of a lipoma at the proximal anterior thigh. US-guided hydrodissection. **A,** Axial sonogram of the proximal thigh demonstrates scar tissue (asterisk) along the course of LFCN: the nerve cannot be clearly distinguished, as it is encased in the scar. **B,** US-guided hydrodissection of the nerve. The needle (curved arrow) is advanced to the scar tissue, then a high volume of fluid (20 cc of glucose 5%) is injected. Dashed lines point out the injected fluid. After the procedure, the pain diminished significantly for 3 months (NRS 7 to NRS 2–3). LFCN, lateral femoral cutaneous nerve; MP, meralgia paresthetica; NRS, numeric rating scale; US, ultrasound.



The procedure may directly follow the US examination or may be scheduled for a later time. The patient is informed about the US findings, the possible benefit of the procedure, and how it is conducted. Written informed consent is obtained.[10] Before the procedure, we ask the patient his/her pain level based on the numeric rating scale (NRS) of pain. NRS is also repeated at the end of the injection to demonstrate a reduction.

Appropriate antisepsis is required.[10,11,33] Our preferred approach is in plane with the needle course from lateral to medial. The nerve is imaged in its short axis and the needle is slowly advanced and followed in real time until it is close to the nerve. A US-guided diagnostic block proximal to the nerve enlargement with a low dose of anesthetics (approximately 1 cc), which results in a significant pain reduction (>50% on a NRS), may confirm the diagnosis of MP. For therapeutic options, we use a mixture of 1 cc lidocaine and 1%/1 cc betamethasone. The mixture is injected at the site of nerve compression or slightly above it. When the tunnel of the nerve is punctured, the injection is observed under real time. To obtain a circumferential spreading of the mixture, positioning the needle either above or underneath the LFCN may be enough; however, injecting both sides may be required (Figure 11).[11,32–34] Most importantly, the injectate needs to flow proximally of the nerve compression site. If run-off is present only distal to the nerve compression site, this may be less effective.[4]

Injections may also be performed in a postoperative setting (e.g., total hip replacement), in which perineural scarring may encase the nerve. In such cases, we try to hydrodissect the nerve with a high amount of fluid (10–20 cc glucose 5%) from the scar (Figure 12).[33]

Moreover, US may also guide cryoneuroablation and radiofrequency ablation.[3,35]

Surgery may be proposed when conservative treatments fail.[31,36,37]

Conclusion

US is the first modality—and usually sufficient—to diagnose MP and to guide its treatment. Skills in nerve US and an awareness of the normal anatomy and the main anatomical variants that may be related to pathology are required for the correct diagnostic process.

References

1. Tomaszewski KA, Popieluszko P, Henry BM, et al. The surgical anatomy of the lateral femoral cutaneous nerve in the inguinal region: a meta-analysis. *Hernia* 2016; 20:649–657. https://doi.org/10.1007/s10029-016-1493-7.
2. Carai A, Fenu G, Sechi E, Crotti FM, Montella A. Anatomical variability of the lateral femoral cutaneous nerve: findings from a surgical series. *Clin Anat* 2009; 22:365–370. https://doi.org/10.1002/ca.20766.

3. Witkin LR, Gulati A, Zhang T, Karl HW. Lateral femoral cutaneous nerve entrapment. *Peripheral Nerve Entrapments: Clinical Diagnosis and Management*. Berlin, Germany: Springer International Publishing; 2016: 667-681. https://doi.org/10.1007/978-3-319-27482-9_61.
4. Rossmann T, Zessner-Spitzenberg J, Sandurkov C, Heber UM, Weninger WJ, Meng S. Ultrasound-guided injections at the lateral femoral cutaneous nerve: the inguinal ligament as a barrier. *Pain Physician* 2020; 23:E363–E367. https://pubmed.ncbi.nlm.nih.gov/32709182/. Accessed February 17, 2021.
5. Parisi TJ, Mandrekar J, Dyck PJB, Klein CJ. Meralgia paresthetica: relation to obesity, advanced age, and diabetes mellitus. *Neurology* 2011; 77: 1538–1542. https://doi.org/10.1212/WNL.0b013e318233b356.
6. Proisy M, Rouil A, Raoult H, et al. Imaging of musculoskeletal disorders related to pregnancy. *Am J Roentgenol* 2014; 202:828–838. https://doi.org/10.2214/AJR.13.10988.
7. Bianchi S, Becciolini M, Urigo C. Ultrasound imaging of disorders of small nerves of the extremities: less recognized locations. *J Ultrasound Med* 2019; 38:2821–2842. https://doi.org/10.1002/jum.15014.
8. Nazarian LN. The top 10 reasons musculoskeletal sonography is an important complementary or alternative technique to MRI. *Am J Roentgenol* 2008; 190:1621–1626. https://doi.org/10.2214/AJR.07.3385.
9. Damarey B, Demondion X, Boutry N, Kim HJ, Wavreille G, Cotten A. Sonographic assessment of the lateral femoral cutaneous nerve. *J Clin Ultrasound* 2009; 37:89–95. https://doi.org/10.1002/jcu.20521.
10. Tagliafico A, Bodner G, Rosenberg I, et al. Peripheral nerves: ultrasound-guided interventional procedures. *Semin Musculoskelet Radiol*. 2010; 14:559–566. https://doi.org/10.1055/s-0030-1268066.
11. Klauser AS, Abd Ellah MMH, Halpern EJ, et al. Meralgia paraesthetica: ultrasound-guided injection at multiple levels with 12-month follow-up. *Eur Radiol* 2016; 26:764–770. https://doi.org/10.1007/s00330-015-3874-1.
12. Moritz T, Prosch H, Berzaczy D, et al. Common anatomical variation in patients with idiopathic meralgia paresthetica: a high resolution ultrasound case-control study. *Pain Physician* 2013; 16:E287–E293. https://pubmed.ncbi.nlm.nih.gov/23703427/. Accessed December 22, 2020.
13. Dias Filho LC, Valença MM, Guimarães Filho FAV, et al. Lateral femoral cutaneous neuralgia: an anatomical insight. *Clin Anat* 2003; 16:309–316. https://doi.org/10.1002/ca.10106.
14. Martinoli C, Miguel-Perez M, Padua L, Gandolfo N, Zicca A, Tagliafico A. Imaging of neuropathies about the hip. *Eur J Radiol* 2013; 82:17–26. https://doi.org/10.1016/j.ejrad.2011.04.034.
15. Xu Z, Tu L, Zheng Y, Ma X, Zhang H, Zhang M. Fine architecture of the fascial planes around the lateral femoral cutaneous nerve at its pelvic exit: an epoxy sheet plastination and confocal microscopy study. *J Neurosurg* 2019; 131:1860–1868. https://doi.org/10.3171/2018.7.JNS181596.
16. Hanna A. The lateral femoral cutaneous nerve canal. *J Neurosurg* 2017; 126:972–978. https://doi.org/10.3171/2016.1.JNS152262.
17. Grothaus MC, Holt M, Mekhail AO, Ebraheim NA, Yeasting RA. Lateral femoral cutaneous nerve: an anatomic study. *Clin Orthop Relat Res* 2005; 437:164–168. https://doi.org/10.1097/01.blo.0000164526.08610.97.
18. Sürücü HS, Tanyeli E, Sargon MF, Karahan ST. An anatomic study of the lateral femoral cutaneous nerve. *Surg Radiol Anat* 1997; 19:307–310. https://doi.org/10.1007/BF01637599.
19. Lutterbach-Penna RA, Kalume-Brigido M, Morag Y, Boon T, Jacobson JA, Fessell DP. Ultrasound of the thigh: focal, compartmental, or comprehensive examination? *Am J Roentgenol* 2014; 203:1085–1092. https://doi.org/10.2214/AJR.13.12286.
20. Nielsen TD, Moriggl B, Barckman J, et al. The lateral femoral cutaneous nerve: description of the sensory territory and a novel ultrasound-guided nerve block technique. *Reg Anesth Pain Med* 2018; 43:357–366. https://doi.org/10.1097/AAP.0000000000000737.
21. Bodner G, Bernathova M, Galiano K, Putz D, Martinoli C, Felfernig M. Ultrasound of the lateral femoral cutaneous nerve: Normal findings in a cadaver and in volunteers. *Reg Anesth Pain Med* 2009; 34:265–268. https://doi.org/10.1097/AAP.0b013e31819a4fc6.
22. Bianchi S. Ultrasound of the peripheral nerves. *Jt Bone Spine* 2008; 75:643–649. https://doi.org/10.1016/j.jbspin.2008.07.002.
23. Jacobson JA, Wilson TJ, Yang LJ-S. Sonography of common peripheral nerve disorders with clinical correlation. *J Ultrasound Med* 2016; 35:683–693. https://doi.org/10.7863/ultra.15.05061.
24. Suh DH, Kim DH, Park JW, Park BK. Sonographic and electrophysiologic findings in patients with meralgia paresthetica. *Clin Neurophysiol* 2013; 124:1460–1464. https://doi.org/10.1016/j.clinph.2013.02.003.
25. Petchprapa CN, Rosenberg ZS, Sconfienza LM, Cavalcanti CFA, la Rocca VR, Zember JS. MR imaging of entrapment neuropathies of the lower extremity: part 1. The pelvis and hip. *Radiographics* 2010; 30:983–1000. https://doi.org/10.1148/rg.304095135.
26. Ozaki Y, Baba T, Homma Y, et al. Preoperative ultrasound to identify distribution of the lateral femoral cutaneous nerve in total hip arthroplasty using the direct anterior approach. *SICOT-J* 2018; 4:42. https://doi.org/10.1051/sicotj/2018037.
27. Zhu J, Zhao Y, Liu F, Huang Y, Shao J, Hu B. Ultrasound of the lateral femoral cutaneous nerve in asymptomatic adults. *BMC Musculoskelet Disord* 2012; 13:227. https://doi.org/10.1186/1471-2474-13-227.
28. Park BJ, Joeng ES, Choi JK, Kang S, Yoon JS, Yang SN. Ultrasound-guided lateral femoral cutaneous nerve conduction study. *Ann Rehabil Med* 2015; 39:47–51. https://doi.org/10.5535/arm.2015.39.1.47.
29. Tagliafico A, Cadoni A, Fisci E, Bignotti B, Padua L, Martinoli C. Reliability of side-to-side ultrasound cross-sectional area measurements of lower extremity nerves in healthy subjects. *Muscle Nerve* 2012; 46:717–722. https://doi.org/10.1002/mus.23417.

30. Powell GM, Baffour FI, Erie AJ, Puffer RC, Spinner RJ, Glazebrook KN. Sonographic evaluation of the lateral femoral cutaneous nerve in meralgia paresthetica. *Skeletal Radiol* 2020; 49: 1135–1140. https://doi.org/10.1007/s00256-020-03399-8.
31. Hanna A. Transposition of the lateral femoral cutaneous nerve. *J Neurosurg* 2019; 130:496–501. https://doi.org/10.3171/2017.8.JNS171120.
32. Allen G, Obradov M, Chianca V, Messina C, Sconfienza LM. Ultrasound-guided musculoskeletal interventions for the Most common hip and pelvis conditions: a step-by-step approach. *Semin Musculoskelet Radiol* 2019; 23:E58–E67. https://doi.org/10.1055/s-0039-1683965.
33. Nwawka OK, Miller TT. Ultrasound-guided peripheral nerve injection techniques. *Am J Roentgenol* 2016; 207:507–516. https://doi.org/10.2214/AJR.16.16378.
34. Tagliafico A, Serafini G, Lacelli F, Perrone N, Valsania V, Martinoli C. Ultrasound-guided treatment of meralgia paresthetica (lateral femoral cutaneous neuropathy): technical description and results of treatment in 20 consecutive patients. *J Ultrasound Med* 2011; 30:1341–1346. https://doi.org/10.7863/jum.2011.30.10.1341.
35. Manoharan D, Sudhakaran D, Goyal A, Srivastava DN, Ansari MT. Clinico-radiological review of peripheral entrapment neuropathies—part 2 lower limb. *Eur J Radiol* 2021; 135:109482. https://doi.org/10.1016/j.ejrad.2020.109482.
36. De Ruiter GCW, Wurzer JAL, Kloet A. Decision making in the surgical treatment of meralgia paresthetica: neurolysis versus neurectomy. *Acta Neurochir (Wien)* 2012; 154:1765–1772. https://doi.org/10.1007/s00701-012-1431-0.
37. Morimoto D, Kim K, Kokubo R, et al. Deep decompression of the lateral femoral cutaneous nerve under local anesthesia. *World Neurosurg* 2018; 118:e659–e665. https://doi.org/10.1016/j.wneu.2018.06.252.