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# Meralgia paresthetica: from qualitative ultrasound assessment to quantitative multimodality imaging

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**Abstract**

Meralgia paresthetica is a sensory mononeuropathy of the lateral femoral cutaneous nerve that remains frequently underdiagnosed despite its characteristic clinical presentation. Burning pain, paresthesia, and numbness over the anterolateral thigh may mimic hip, lumbar, or pelvic disorders, contributing to diagnostic delay. Imaging has gained increasing relevance in the evaluation of meralgia paresthetica, both for confirming neuropathy and for identifying contributory anatomical factors. High-resolution ultrasound enables direct visualization of the lateral femoral cutaneous nerve, characterization of its anatomical variants, and detection of focal changes at typical entrapment sites. Quantitative ultrasound parameters, particularly cross-sectional area, provide additional objective information and may help distinguish symptomatic nerves from normal variants, while elastography offers preliminary insight into chronic stiffness alterations. Magnetic resonance imaging complements ultrasound by allowing assessment of deeper nerve segments and by differentiating intrinsic signal abnormalities from extrinsic compression. Advanced techniques such as diffusion tensor imaging, although still investigational for this small sensory nerve, may eventually provide microstructural information beyond the capabilities of conventional sequences. This review summarizes current knowledge on the anatomy of the lateral femoral cutaneous nerve, outlines qualitative and quantitative ultrasound approaches, and discusses how multimodal imaging can support a more comprehensive and confident evaluation of patients with meralgia paresthetica.

## Introduction

Meralgia paresthetica (MP) is a neuropathy of the lateral femoral cutaneous nerve (LFCN) characterized by burning pain, numbness, and dysesthesia over the anterolateral aspect of the thigh[1]. Because the LFCN is a purely sensory nerve, its impairment often causes considerable discomfort without motor deficits, making the condition both bothersome and frequently underrecognized. MP is among the most common mononeuropathies of the lower limb, with an estimated incidence of 3.4–4.3 cases per 10,000 person-years, typically affecting individuals between the fourth and sixth decades of life[2]. Several predisposing factors may contribute to LFCN injury along its course from the lumbar plexus to the thigh, including obesity, pregnancy, diabetes mellitus, and a variety of surgical or interventional procedures such as pelvic or spine surgery, iliac bone graft harvesting, femoral artery catheterization, cesarean section, and appendectomy[3]. Although MP has been known for more than a century – first described by Bernhardt in 1878 and subsequently termed "meralgia paresthetica" by Roth – its diagnosis remains challenging, and many cases go unrecognized despite classic symptoms[4]. Clinical evaluation relies on history and physical examination, including the pelvic compression test, neurodynamic testing, and Tinel's sign[5]. Electrophysiological studies, such as electromyography and somatosensory evoked potentials, may support the diagnosis, while magnetic resonance imaging (MRI) is currently considered the most accurate imaging modality for assessing neuropathies[6]. Advanced MRI techniques, including diffusion tensor imaging, offer quantitative insights into nerve integrity and may detect both acute injury and recovery-related changes[7].

Conservative therapy is usually the first-line approach and includes physical therapy, weight reduction when appropriate, and nonsteroidal anti-inflammatory medications. In patients who do not respond to these measures, ultrasound-guided injection of local anesthetics and steroids targeting the LFCN can provide significant symptom relief[8].

## Anatomy of the LFCN

The LFCN is a purely sensory branch of the lumbar plexus, most commonly arising from the posterior divisions of the L2–L3 spinal nerve roots. After emerging from the lateral border of the psoas major, it travels obliquely across the iliacus muscle, situated between layers of the iliac fascia, and courses toward the anterior superior iliac spine (ASIS)[9]. In its distal abdominal trajectory, the LFCN is crossed by the deep circumflex iliac vessels before entering an aponeurotic–fascial tunnel, also referred to as the iliopubic tract. This region, composed of fascial extensions of the abdominal wall and the iliac fascia, is anatomically complex, and differing descriptions in the literature have contributed to inconsistencies between anatomic and radiologic accounts.

As it approaches the inguinal ligament (IL), the LFCN displays substantial variability. In most cases, the nerve passes medial to the ASIS and deep to the IL. A large review by Tomaszewski et al. reported a mean distance of approximately 19 mm from the ASIS, although wider ranges, from as little as 6 mm to more than 70 mm, have been documented[9]. Other studies have described distances spanning 0–40 mm, reflecting how closely the nerve may run to the bony prominence; in some cases, it may lie immediately adjacent to the ASIS[10]. This proximity has been associated with increased susceptibility to compression or traction injuries, and case–control studies have shown that patients with meralgia paresthetica often present with a shorter nerve–ASIS distance than asymptomatic individuals[11]. At the level of the IL and ASIS, multiple exit variants have been described. Tomaszewski et al. identified four main zones of exit relative to the ASIS[9]:

- Medial to the ASIS and below the IL, the most common configuration (over 70%).
- Medial to the ASIS and above the IL.
- Directly over the ASIS.
- Lateral to the ASIS, the rarest variant, observed in fewer than 1% of cases.

Similarly, Aszmann and colleagues proposed a classification based on anatomic relationships to the IL, ASIS, and adjacent musculature[4,12]. Their five-type system includes (Fig. 1):

- Type A (4%): nerve located posterior to the ASIS.
- Type B (27%): nerve passing through the substance of the IL.
- Type C (23%): nerve coursing within the tendinous origin of the sartorius muscle.
- Type D (26%): nerve positioned between the iliopsoas and the sartorius tendinous origin.
- Type E (20%): nerve travelling within connective tissue over the iliopsoas muscle, without contact with the IL; in this pattern, some fibers may contribute to the femoral branch of the genitofemoral nerve.

After leaving the abdominal cavity, the LFCN undergoes a sharp angulation as it enters the inguinal region, a transition that can increase tension on the nerve, particularly in certain anatomic variants. Limb extension may further accentuate this tension, whereas in patients with obesity, downward traction of the abdominal pannus can impose chronic compression or stretch forces. In the thigh, the nerve typically descends vertically and may course superficial to the sartorius muscle or between the sartorius and tensor fasciae latae, within a fat-filled triangular canal bordered by two fascial layers[13].

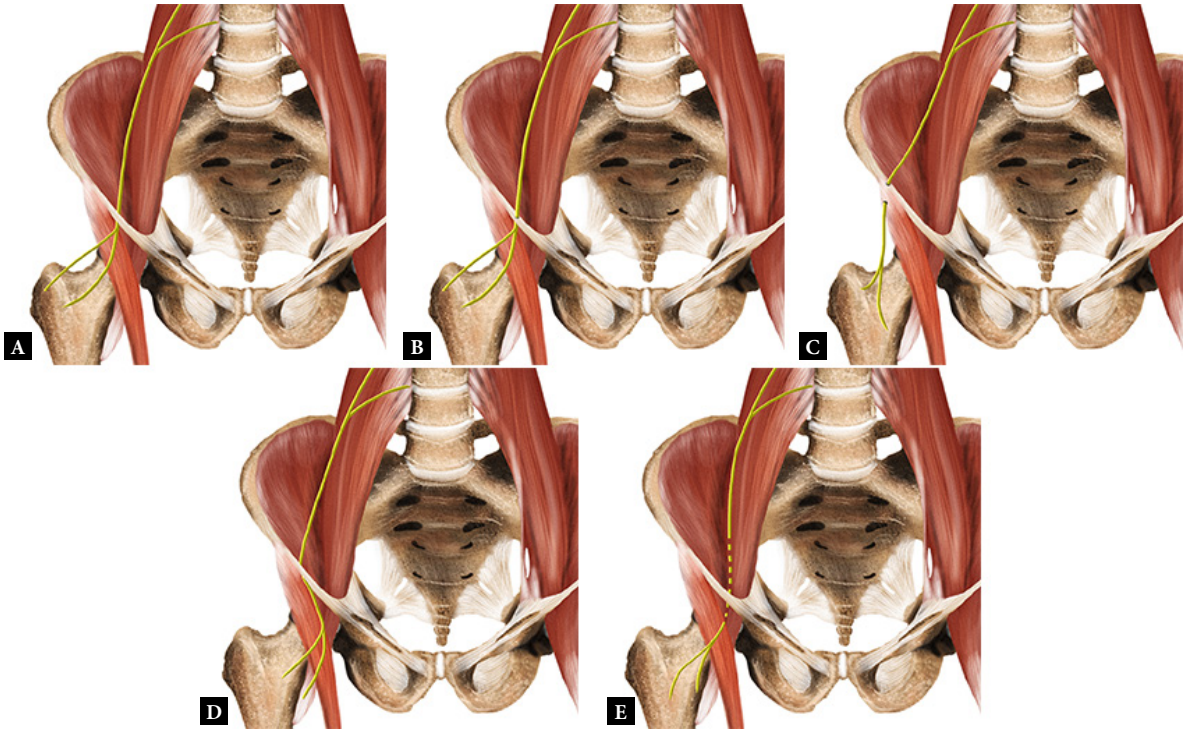


**Fig. 1.** *Anatomic variants of the anterolateral femoral cutaneous nerve according to the classification proposed by Aszmann et al.[4] The nerve may course:* **A.** *posterior to the anterior superior iliac spine (ASIS) (4%);* **B.** *through the iliac ligament (IL) (27%);* **C.** *within the tendinous origin of the sartorius muscle (23%);* **D.** *between the iliopsoas and the sartorius tendinous origin (26%); or* **E.** *within the connective tissue over the iliopsoas muscle without contacting the IL, occasionally giving fibers to the femoral branch of the genitofemoral nerve (20%)*

Distally, it usually divides into two principal branches: a larger anterior branch supplying the anterolateral thigh toward the knee, and a posterior branch innervating the region of the greater trochanter and the proximal lateral thigh. Both branches become subcutaneous as they continue distally. The combination of variable points of emergence, differing fascial relationships, and multiple branching patterns underscores why the LFCN is particularly vulnerable to entrapment – and why imaging plays a key role in delineating its course in each patient.

## Ultrasound visualization of the LFCN

High-resolution ultrasound (US) represents a reliable method for assessing the course of the LFCN, provided that the examination is performed with appropriate technique and a solid understanding of the regional anatomy. Patients are positioned supine, and the scan begins with a linear multifrequency transducer (12–15 MHz), which offers a sufficiently wide field of view for an initial survey of the anterolateral hip region and for excluding alternative causes of lateral thigh pain, such as trochanteric disorders, hip joint pathology, femoral neuropathy, or iliac masses. Once the area of interest is localized, a higher-frequency probe (≥18 MHz) with a smaller footprint is used to delineate the nerve more precisely, although increased subcutaneous fat in obese patients may limit its utility.

The most practical starting point for visualizing the LFCN is just caudal to the anterior ASIS, which is easily palpated. On axial images, the tensor fasciae latae and sartorius muscles serve as consistent landmarks, lying superficial to the proximal rectus femoris[14]. Between these muscles, a characteristic fat-filled canal bounded by fascial layers becomes apparent; within this space, the LFCN appears as a small honeycomb-like structure composed of multiple tiny fascicles (Fig. 2). From this location, the nerve can be followed cranially and caudally through sequential short-axis scanning, allowing continuous assessment of its morphology and course[15]. Proximally, the transducer is oriented parallel to the inguinal ligament, a maneuver that facilitates clear visualization of the nerve's relationship to both the IL and the ASIS – an essential step, as these regions represent the most common sites of entrapment. In slender patients, the LFCN may be traced further until it is crossed by the deep circumflex iliac vessels, with color Doppler aiding in the distinction between vascular and neural structures. Beyond this point, visualization becomes limited as the nerve courses deep to the psoas major, where US resolution is insufficient. Distally, further assessment is usually unnecessary unless trauma or symptoms suggest involvement of the lower thigh.

## Pathological US findings of the LFCN

US can identify a wide spectrum of abnormalities affecting the LFCN, providing valuable information on both intrinsic nerve changes and extrinsic sources of compression[16]. The most consistent sonographic hallmark of neuropathy is focal or diffuse enlargement of the nerve, often accompanied by reduced echogenicity and blurring of the normal fascicular pattern[17]. These alterations are best appreciated through systematic, sequential short-axis assessment along the expected nerve trajectory. When findings are subtle, contralateral comparison is particularly helpful, as even small differences in diameter or cross-sectional area (CSA) may be clinically meaningful for such a small-caliber nerve (Fig. 3). Application of gentle, localized probe pressure can reproduce symptoms at the site of pathology, functioning as a sonographic analogue of Tinel's sign, although this response is not consistently present[18].

Entrapment most frequently occurs as the nerve crosses the IL or passes in close proximity to the ASIS[19]. Variants in which the LFCN traverses a split within the IL typically show neuroma-like swelling proximal to the ligament, whereas nerves running deep to a thickened IL or tightly adjacent to the ASIS may demonstrate focal flattening at the point of compression with upstream or downstream dilatation[18]. Post-traumatic or postoperative changes, including scarring, fascial thickening, heterotopic ossification, or irregularities of the iliac crest, may create additional sites of mechanical conflict[20,21]. Hardware placed near the ASIS may similarly impinge on the nerve. Scar encasement appears as hypoechoic, irregular tissue surrounding the nerve and is a well-recognized cause of persistent neuropathic symptoms following pelvic or hip surgery.

High-grade traction or direct intraoperative injury can result in neuroma formation. Neuromas present as hypoechoic nodules with loss of the normal fascicular pattern and an increased diameter compared with the adjacent unaffected nerve, and they are often markedly tender to compression[20]. They may occur in continuity along a partially injured nerve or at the proximal stump of a transected nerve. Inflammatory neuritis, by contrast, manifests as diffuse nerve swelling with preserved but less conspicuous fascicular architecture; associated regional edema or hematoma may also be present[22]. In mild cases, echogenicity and morphology may remain

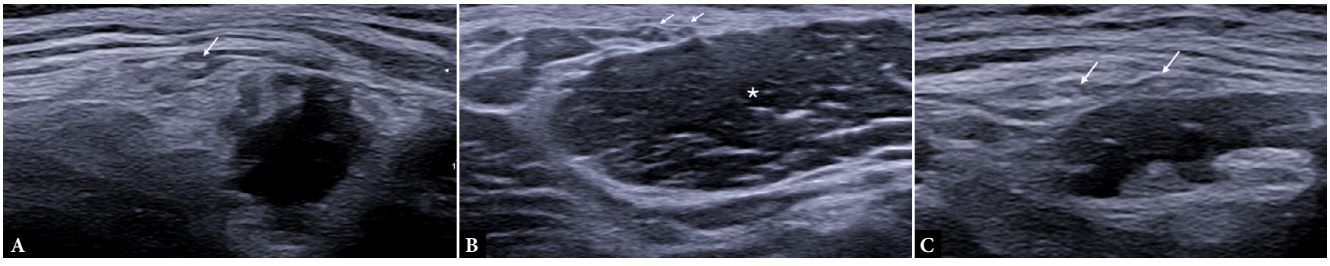


**Fig. 2.** *Transverse US images of the inguinal–femoral region showing the course and bifurcation of the anterolateral femoral cutaneous nerve.* **A.** *The nerve is identified (arrow) in a more proximal plane, prior to its bifurcation, located superficially within the subcutaneous tissue and just above the deep fascia.* **B.** *At a slightly more distal level, the nerve bifurcates into two terminal branches (arrows), which remain within the subcutaneous tissue and course over the deep fascia covering the sartorius muscle (asterisk).* **C.** *In a further distal plane, the two branches (arrows) appear more widely separated as they continue along their superficial course*

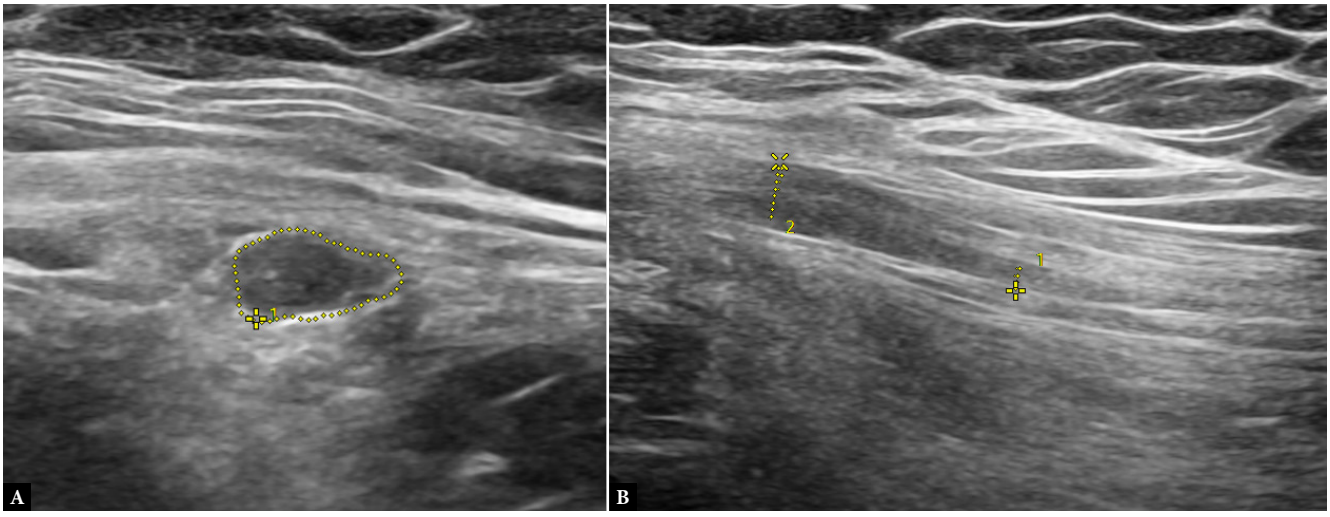


**Fig. 3.** *Short-axis high-resolution US image (***A***) of the lateral femoral cutaneous nerve showing marked focal enlargement with increased cross-sectional area (3.4 mm²) and hypoechoic fascicular swelling, consistent with neuropathic thickening at a typical site of entrapment near the inguinal region. Loss of the normal crisp fascicular definition supports the presence of structural nerve alteration. Long-axis view (***B***) of the LFCN demonstrating segmental enlargement and decreased fascicular echogenicity*

largely normal, underscoring the importance of comparative scanning[23]. Beyond intrinsic nerve pathology, a variety of extrinsic factors can contribute to symptoms. Mass lesions, infectious processes, or unusual anatomic variants, such as an intrasartorial course, may produce focal compression[24]. Chronic mechanical irritation from repetitive hip motion, described for example in dancers, or from abdominal soft-tissue traction in obesity may also play a role[25]. The ability of US to depict these diverse mechanisms of injury in real time makes it exceptionally well suited as a first-line modality in the evaluation of suspected meralgia paresthetica.

## Quantitative ultrasound assessment of the LFCN

Quantitative US has become an increasingly valuable component in the assessment of the LFCN, providing objective data that complement traditional qualitative findings. Among the available parameters, CSA is the most widely used and best validated. In healthy individuals, the LFCN's CSA typically ranges between 1 and 3 mm², although values vary slightly across populations and equipment settings[26,27]. Studies have consistently shown that patients with meralgia paresthetica exhibit a significantly enlarged CSA on the symptomatic side, often accompanied by loss of the normal fascicular pattern[26,28]. Given the very small caliber of the nerve, side-to-side comparison is essential, and even minimal asymmetry may be clinically relevant.

CSA is generally measured in short-axis views, most commonly just below the ASIS or immediately proximal to the IL, where the nerve is most reproducibly identified and where entrapment most frequently occurs. Some authors have proposed that CSA values exceeding 3.0–3.5 mm² should raise suspicion for neuropathy, although clinical context and contralateral comparison remain indispensable for accurate interpretation[26,28].

In addition to CSA, several other quantitative descriptors, such as nerve diameter, fascicular hypoechogenicity ratios, and perineural fat thickness, have been explored; however, none has reached the same degree of standardization.

More recently, US elastography has been investigated as a promising addition to the quantitative assessment of the LFCN, aiming to characterize changes in nerve stiffness associated with meralgia paresthetica (Fig. 4). Strain elastography provides a qualitative impression of tissue deformability and may demonstrate reduced compressibility of neuropathic nerve segments in chronic entrapment[29]. Shear-wave elastography offers a more quantitative estimate of stiffness, and preliminary data suggest that affected nerves may show higher shear-wave velocities, potentially reflecting chronic fibrosis or altered elastic properties[29,30]. Although early results are encouraging, elastography of the LFCN remains under active investigation, and further work is needed to define standardized acquisition protocols and establish reference thresholds.

## Magnetic resonance imaging and diffusion tensor techniques

Magnetic resonance imaging (MRI) plays a central role in the evaluation of peripheral neuropathies[31] and offers substantial advantages when assessing the LFCN in suspected meralgia paresthetica[32]. Conventional MRI sequences, particularly T1-weighted and fluid-sensitive sequences such as STIR or fat-suppressed T2-weighted imaging, allow visualization of the nerve along its retroperitoneal and inguinal course and help distinguish primary neuropathic changes from adjacent soft-tissue abnormalities. In symptomatic patients, the LFCN may appear thickened, with increased T2 signal intensity, or accompanied by perineural edema – features that can extend proximally toward the iliac fascia or distally into the upper thigh depending on the site of entrapment[32]. MRI is particularly useful in identifying extrinsic causes of compression, including scarring, postsurgical changes, heterotopic ossification, pelvic masses, or structural irregularities of the ASIS. Given the depth and complex fascial relationships of the nerve near the inguinal ligament, MRI often provides complementary information when US findings are inconclusive or when deeper segments of the nerve require evaluation[33].

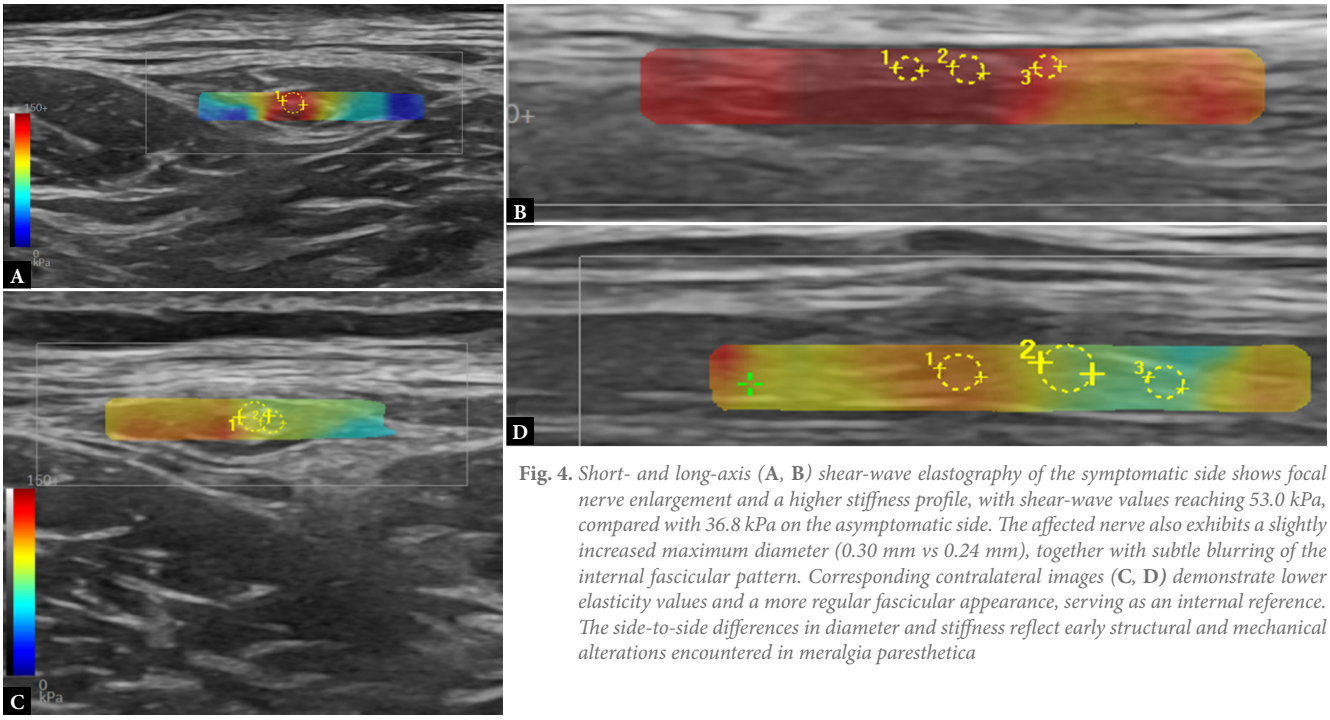


**Fig. 4.** *Short- and long-axis (***A***,* **B***) shear-wave elastography of the symptomatic side shows focal nerve enlargement and a higher stiffness profile, with shear-wave values reaching 53.0 kPa, compared with 36.8 kPa on the asymptomatic side. The affected nerve also exhibits a slightly increased maximum diameter (0.30 mm vs 0.24 mm), together with subtle blurring of the internal fascicular pattern. Corresponding contralateral images (***C***,* **D***) demonstrate lower elasticity values and a more regular fascicular appearance, serving as an internal reference. The side-to-side differences in diameter and stiffness reflect early structural and mechanical alterations encountered in meralgia paresthetica*

The introduction of MR neurography has markedly improved the ability to visualize small-caliber sensory nerves such as the LFCN. High-resolution 3D sequences with fat suppression, including 3D STIR or 3D T2-weighted techniques with variable flip angles, provide thin-slice isotropic datasets that can be reformatted along the nerve's long axis. These sequences highlight changes in nerve signal and morphology, and improve contrast between neural and extraneural tissues. In meralgia paresthetica, MR neurography may reveal signal hyperintensity, fascicular enlargement, or loss of internal fascicular detail, often localized at the level of the inguinal ligament or immediately proximal to it.

Diffusion-based techniques further expand the diagnostic potential of MRI[7,34]. Diffusion Tensor Imaging (DTI), although technically demanding for superficial, small-diameter nerves, has shown promise in assessing microstructural integrity by quantifying parameters such as fractional anisotropy (FA) and apparent diffusion coefficient (ADC)[35]. In healthy nerves, highly ordered myelinated fibers generate relatively high FA values[36]. Although DTI has been extensively explored in larger peripheral nerves, its application to the LFCN remains technically challenging and is not yet validated for routine clinical use. The very small caliber of the nerve, its superficial position near the inguinal ligament, and susceptibility to motion artefacts all contribute to inconsistent results. Nevertheless, DTI offers a theoretical opportunity to investigate microstructural changes associated with meralgia paresthetica, as alterations in FA and ADC have been documented in other peripheral neuropathies[36–38]. Preliminary clinical attempts, including those in our patient cohort, suggest that DTI may provide complementary information when conventional neurography is inconclusive, particularly in identifying focal signal alterations along the inguinal segment of the nerve. However, these observations should be interpreted with caution (Fig. 5). At present, DTI of the LFCN should be considered investigational, and further research is required to establish acquisition protocols, reproducibility, and diagnostic thresholds before the technique can be incorporated into standard imaging workflows for meralgia paresthetica.

## US-guided injection and ablation of the LFCN

Once the LFCN has been identified in short axis, US-guided perineural injection can be performed for both diagnostic and therapeutic purposes. Most protocols involve the use of a mixture of local anesthetic and corticosteroid, typically 1–2 mL of 1% lidocaine or 0.5% ropivacaine combined with 1 mL of a particulate steroid such as triamcinolone acetonide 10–20 mg or methylprednisolone 20–40 mg[39–41]. The total injected volume generally ranges between 3 and 5 mL, sufficient to obtain circumferential spread around the nerve. The injection is usually performed using a 22- to 25-gauge needle, 50–80 mm in length, advanced in-plane under continuous US guidance to allow precise deposition of the injectate while avoiding nearby vessels (Fig. 6). For patients with persistent or recurrent symptoms, US-guided radiofrequency treatments have been described[42,43]. These include continuous radiofrequency ablation, which aims to interrupt nociceptive transmission through controlled thermal lesioning, and pulsed radiofrequency, which delivers lower temperatures and may modulate pain pathways without producing a destructive lesion[44]. These procedures are typically performed with the electrode positioned adjacent to the nerve at the level of the inguinal ligament under real-time imaging guidance. Early clinical experience suggests the potential for prolonged relief in carefully selected cases, although these approaches remain reserved for therapy-resistant patients and should be undertaken within a multidisciplinary context.

## Conclusions

Meralgia paresthetica remains a frequently overlooked mononeuropathy, and its assessment benefits from a coherent, multimodal

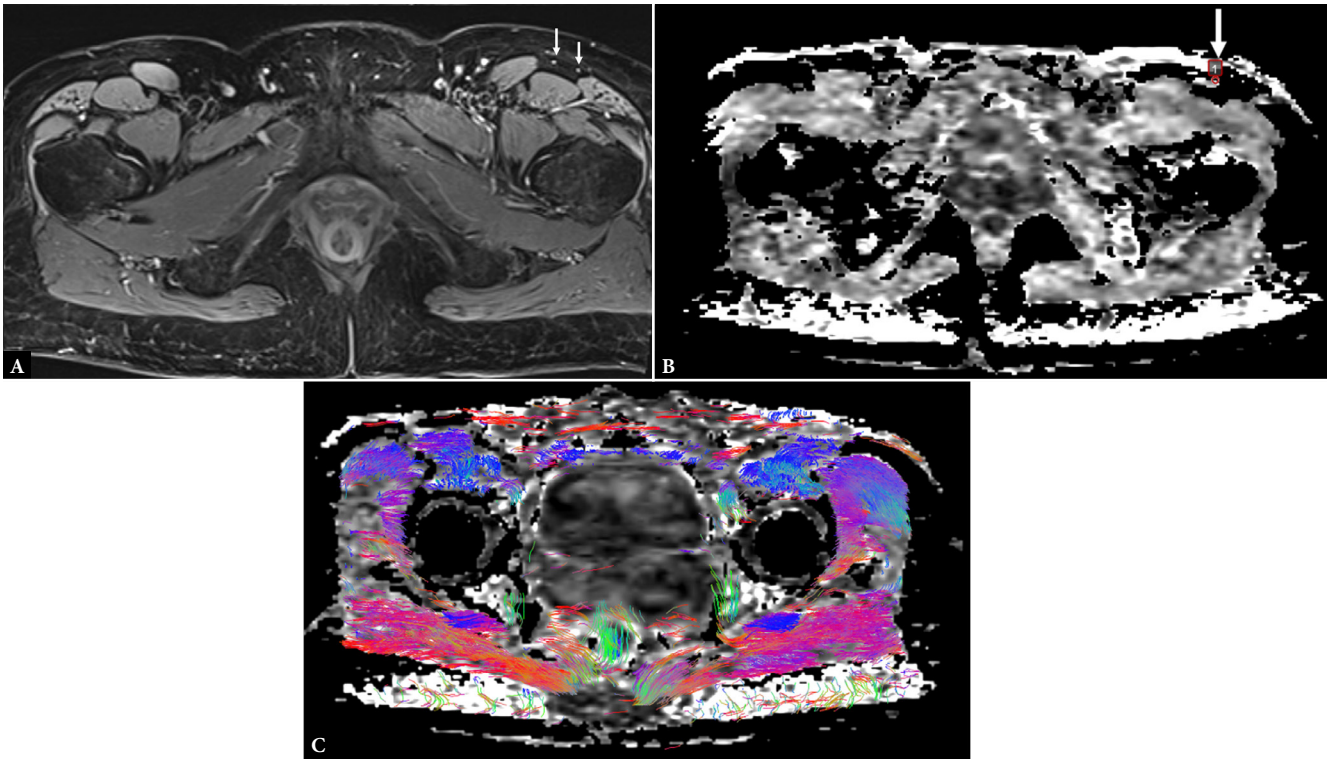


**Fig. 5.** *Axial STIR image (**A**) at the proximal thigh demonstrating the bifurcation of the anterolateral femoral cutaneous nerve on the symptomatic side (arrows). The nerve appears mildly enlarged with increased fluid-sensitive signal, consistent with early neuropathic involvement along its intra-thigh course. Fractional anisotropy map (**B**) combined with diffusion-tensor tractography (**C**). The region of interest (arrow), positioned approximately 4 cm caudal to the inguinal ligament and coregistered with the corresponding axial T2-weighted image, shows a marked FA reduction on the affected side (0.33 vs 0.61) accompanied by a less compact and more dispersed fiber trajectory. These findings indicate localized microstructural disruption of the nerve*

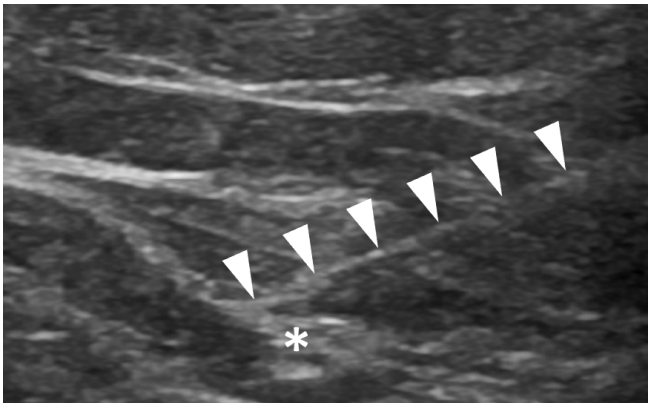

**Fig. 6.** *Ultrasound-guided perineural injection of the anterolateral femoral cutaneous nerve. Arrowheads indicate the in-plane trajectory of the advancing needle, directed toward the perineural fat plane adjacent to the nerve (asterisk). Proper needle positioning allows safe deposition of the injectate around the nerve while avoiding nearby vascular and fascial structures*

imaging strategy. US plays a central role in routine evaluation, allowing direct visualization of the lateral femoral cutaneous nerve along its most vulnerable segments and enabling detection of morphological changes associated with entrapment or injury. Quantitative US provides additional value through objective measurements, while elastography may eventually offer complementary information on tissue stiffness. MRI and MR neurography serve as important counterparts to US, particularly when symptoms are atypical, when deeper or proximal segments require evaluation, or when extrinsic causes of compression are suspected. DTI remains exploratory but holds potential for contributing microstructural insights as techniques evolve.

From a therapeutic perspective, ultrasound-guided injections offer a precise and minimally invasive option for symptom relief, and radiofrequency techniques may extend these benefits in selected patients. Ultimately, combining detailed anatomical knowledge with high-quality US technique and supportive multimodal imaging enables a more confident diagnosis and a more individualized approach to treatment. Ongoing research aimed at refining quantitative thresholds and improving advanced MRI protocols will help define the most reliable imaging markers for disease activity and response to therapy.

## Conflict of interest

*The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.*

## Author contributions

*Original concept of study: AF. Writing of manuscript: VC, EC. Final acceptation of manuscript: MC, FDG. Collection, recording and/or compilation of data: NL. Critical review of manuscript: VC, MZ, FDG.*

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