Skeletal Radiology (2019) 48:807–812
https://doi.org/10.1007/s00256-018-3056-8

CASE REPORT

Partial anterior tunnel syndrome: a retrospective analysis of ultrasound findings in four surgically proven cases

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Received: 28 March 2018 / Revised: 16 August 2018 / Accepted: 27 August 2018 / Published online: 13 September 2018

Abstract

We present the cases of four patients (two men and two women, mean age of 48.5 years) with surgically confirmed partial anterior tarsal syndrome, diagnosed by ultrasound. All patients reported pain in the dorsal aspect of the forefoot radiating to the first intermetatarsal space. Ultrasound showed compression of the medial branch of the deep fibular nerve by the extensor hallucis brevis tendon at the level of the Lisfranc joint, associated with a hypoechoic neuroma. The ultrasound allowed a correct diagnosis to be obtained, which was not evident from clinical examination or by standard radiographs (four patients) or MRI (three patients). Surgery confirmed the sonographic findings, and all patients showed complete recovery.

Keywords Ultrasound · Deep fibular nerve · Anterior tarsal syndrome · Nerve compression · Ankle

Introduction

Ultrasound (US) is an inexpensive, accurate, panoramic, and dynamic imaging tool for the detection and assessment of peripheral nerve entrapment [1–4]. Ultrasound is known to be an accurate method for the assessment of large nerves such as the sciatic, median, or ulnar nerves. More recently, US assessment of smaller peripheral nerves has received attention due to the increased imaging capabilities of small high-frequency transducers [5–8].

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At the anterior aspect of the ankle, the deep fibular nerve (DFN) splits into two terminal branches, the lateral branch (LBDFN), which innervates to the extensor digitorum brevis muscle, and the medial branch (MBDFN), which innervates the skin of the first web space. These nerves can be compressed while inside the anterior tarsal tunnel, a fibrous tunnel composed of the retinaculum of the extensor tendons and the capsular plane (anterior tarsal tunnel syndrome) [9, 10]. In 1977, Krause described a partial anterior tarsal syndrome (PATS) in which only one branch of the DFN was compressed [11]. To the best of our knowledge, no series discussing the US appearance of PATS has been published in the literature.

Case reports

The common characteristics of all case reports are summarized in this paragraph. All patients were examined by the same musculoskeletal radiologist with 31 years of experience in musculoskeletal US, using commercially available US equipment (Affiniti 50, Philips Medical Systems, Bothell, WA, USA) with broadband high-resolution linear transducers working at 17-5 (width = 23 mm) or 18-5 (width = 39 mm) MHz. Patients were examined in a supine position with the affected foot resting on the bed. Ultrasound was performed using a standard technique [12]. The MBDFN was detected by axial scanning at the level of the medial portion of the Lisfranc joint. The close relationship of the nerve with the dorsal pedis artery (DPA) and its internal

fascicular pattern were the main points for nerve detection. The obtained US images and videos were reviewed using our PACS system. Patients were contacted by phone for follow-up, and all reported complete healing with the disappearance of pain and restoration of function.

For this retrospective analysis, the authors declare that they have no conflicts of interest. This analysis did not involve any studies with human participants performed by any of the authors.

Case 1

A 50-year-old man was examined by US due to pain in the left foot. The patient was referred by a sports physician who suspected tendonitis or Morton's neuroma of the first web space. Standard radiographs and MRI of the forefoot, performed prior to US, were considered normal. Ultrasound, including color Doppler, did not show any pathologic changes of the extensor tendons or tendon sheaths. In addition, no masses, including Morton's neuroma, were found inside the first intermetatarsal space. At the level of the Lisfranc joint, US showed a MBDFN neuroma caused by local compression by the extensor hallucis brevis tendon (EHBt). The size of the neuroma was 2.8 × 4.8 mm (transverse × longitudinal diameter). The local compression identified by US was painful, causing distally radiating pain. Due to the persistence of symptoms after medical therapy, the patient underwent subsequent surgical exploration, which confirmed the US diagnosis. Neurolysis of the DBDFN led to complete recovery.

Case 2

A 51-year-old female was referred by her general practitioner for US examination of her right foot. A SFN neuroma was suspected clinically. The patient reported experiencing pain for 2 years without a definite diagnosis, and had been treated with different modalities including orthotics, braces, inserts, physical therapy, NSAIDs, and psychiatric treatment without improvement. Previous X-rays and MRI examinations were considered normal. The US examination revealed a normal appearance of the distal branches of the SFN. There was no evidence of Morton's

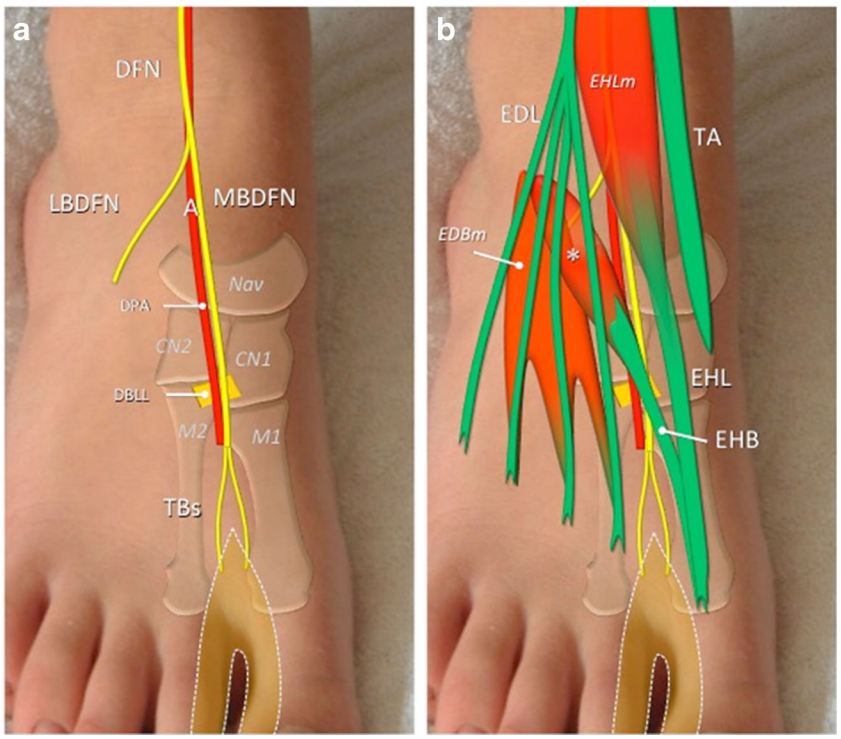

Fig. 1 Normal anatomy. Schematics of the ankle viewed from the anterior side showing the anatomy of the deep fibular nerve (DFN) and its branches with respect to (**a**) deep and (**b**) superficial adjacent anatomic structures. In image **a**, the DFN splits into the medial branch (MBDFN) and lateral branch (LBDFN) at the level of the ankle joint. The MB runs distally to the adjacent dorsalis pedis artery (DPA) over the tarsal bones. At the level of the Lisfranc joint, the branch lies superficial to the region of the joint between the base of the second metatarsal (M2) and the fist cuneiform (CN1). In the first intermetatarsal space, the MBDFN divides into two terminal branches (TBs) that innervate the first commissural space (*spotted area*). In image **b**, the extensor hallucis longus muscle (EHLm) covers the DFN at the distal leg and proximal ankle. The LBDFN extends laterally to innervate the extensor digitorum brevis muscle (EDBm). At the level of the Lisfranc joint, the MBDFN runs below the myotendinous junction or tendon of the extensor hallucis brevis (EHB) muscle (*asterisk*). *Nav* navicular, *CN2* second cuneiform, *M1* first metatarsal, *EDL* extensor digitorum longus tendon, *TA* tibialis anterior tendon

neuroma in the intermetatarsal space, and the extensor tendons were normal. The US showed compression of the MBDFN by a normal EHBt, resulting in a neuroma sized 2.6 × 3.8 mm. Subsequent US-guided Tinel's test was positive. A US-guided perineural injection of 0.5 ml of steroid (Diprophos®; betamethasone dipropionate and betamethasone sodium phosphate) mixed with 0.5 ml of 1% lidocaine led to a temporary reduction in the patient's symptoms, confirming the diagnosis. Due to this positive test and considering the failed medical treatments, surgical neurolysis of the neuroma was performed, associated with tenotomy of the EHBt, with an excellent outcome.

Case 3

A 23-year-old male presented for US examination of the right foot with clinical suspicion of tendinitis, a tumor, or a ganglion cyst. The examination had been ordered by a foot surgeon. Standard radiographs and MRI performed prior to US were considered normal. The US examination was unrewarding, with the exception of a MBDFN neuroma located distal to where the nerve crosses the EHBt. The size of the neuroma was 3 × 5 mm. A US-guided Tinel's test was positive. After failing to improve with medical therapy, surgical exploration confirmed the US findings. Surgical neurolysis led to complete resolution of symptoms.

Case 4

A 70-year-old female was sent for US examination of the left foot by a foot surgeon who suspected Morton's neuroma of the second intermetatarsal space, associated with a possible lesion of the SFN. A previous X-ray was normal, and no MRI was performed for this patient. The US examination was unremarkable, except for signs of compression of the MBDFN by the EHBt at the level of the Lisfranc joint. The nerve showed a neuroma (2.6 × 5.4 mm) distal to the site of compression. Local pressure with the transducer was painful and elicited symptoms in the patient. After failure of medical treatment, surgical exploration confirmed the US findings. Subsequent surgical neurolysis achieved complete resolution of the patient's symptoms.

Discussion

The DFN, one of the two branches of the common fibular nerve, originates at the lateral face of the knee [3]. It descends with the anterior tibial artery inside the anterior compartment of the leg,

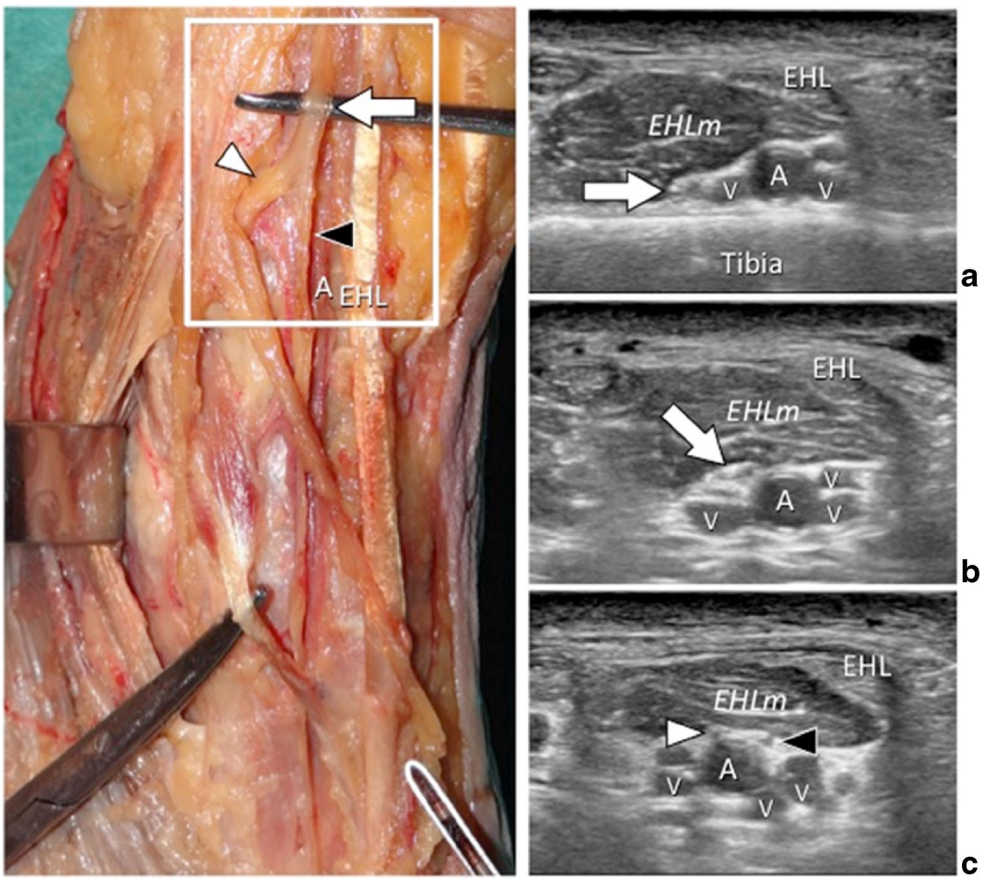

Fig. 2 Normal ultrasound anatomy of the deep fibular nerve (DFN) and distal branches in the anterior ankle. Anatomic dissection of the anterior ankle and foot and axial oblique sonograms obtained from proximal (**a**) to distal (**c**). Images show the DFN, the LBDFN (*white arrowhead*) and MBDFN (*black arrowhead*). In **a**-**c** note the nerves, the tibialis anterior artery (A) and veins (V) running below the extensor hallucis longus muscle (EHLm) and over the distal tibia and anterior capsule of the ankle joint. *EHL* extensor hallucis longus tendon

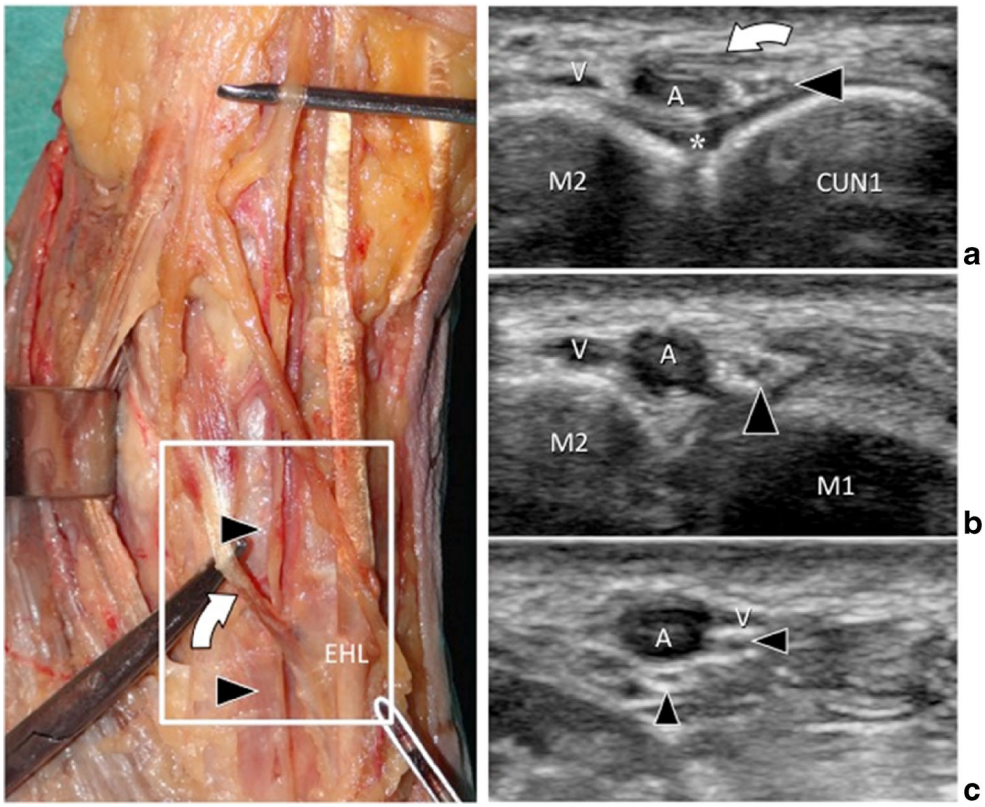

Fig. 3 Normal ultrasound anatomy of the MBDFN at the Lisfranc joint. Anatomic dissection of the anterior ankle and foot and axial oblique sonograms obtained from proximal (**a**) to distal (**c**). In **a**–**c** the MBDFN (*black arrowhead*) runs medial to the dorsalis pedis artery (A) and veins (V). **a** The nerve is located between the extensor hallucis brevis tendon (*curved arrow*) and the dorsal band of the Lisfranc ligament (*asterisk*). **b** More distally, the MBDFN runs between the first two metatarsals (M1 and M2). **c** At the anterior part of the first intermetatarsal space, note the two terminal branches (*small arrowheads*) of the MBDFN

where it is positioned between the tibialis anterior and the extensor hallucis longus muscles (Fig. 1). It then enters the ankle and foot region (Fig. 1) where it divides into two terminal branches [5, 11–15]. The level of the division varies, but is more frequently

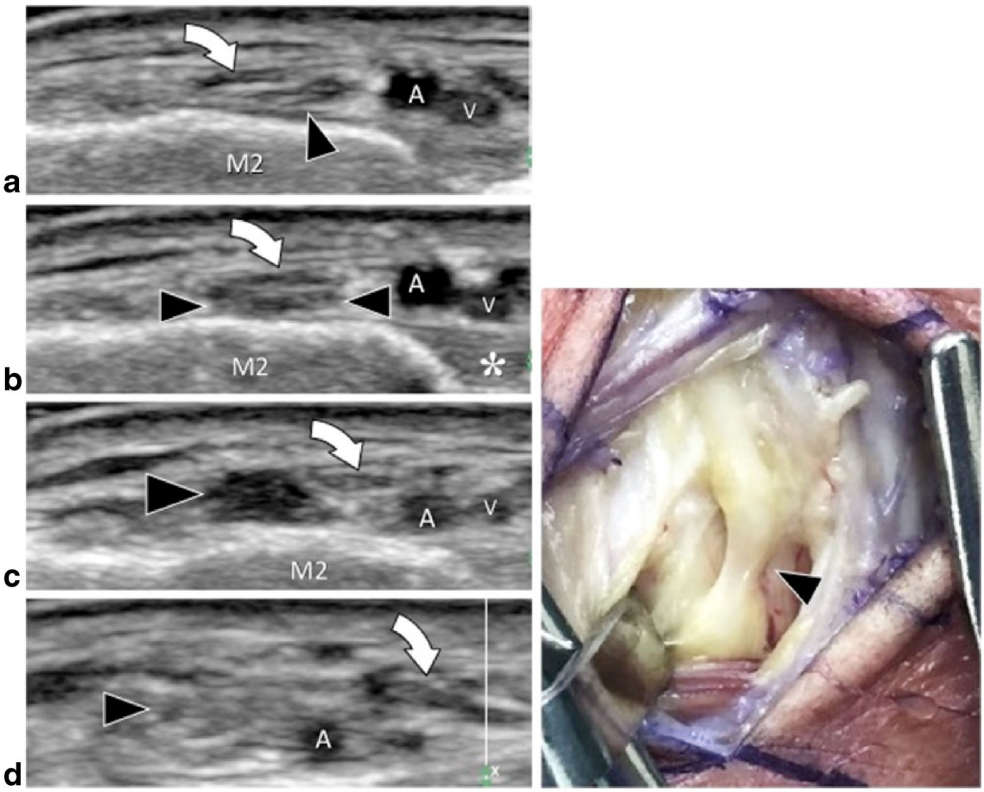

Fig. 4 A 23-year-old woman with compression of the MBDFN at the Lisfranc joint (patient 3). Ultrasound appearance with surgical correlation. Axial oblique sonograms were obtained from proximal (**a**) to distal (**d**). **a**–**c** Sequential sonograms showing crossing of the extensor hallucis brevis tendon (*curved arrow*) over the MBDFN (*black arrowhead*). The tendon runs from lateral to medial (*left to right in the sonograms*). In panel **c**, note a focal neuroma (*large arrowheads*) located immediately distal to the site of nerve compression. **d** In a more distal location, the MBDFN appears normal. Surgical correlation shows focal thinning of the nerve (*arrowhead*) at the site of compression

(77%) located distal to the ankle mortise [16]. Within the tarsal region, the nerve runs inside the anterior tarsal tunnel consisting of the retinaculum of the extensor tendons, the tendons, and the joint capsule. The LBDFN is directed laterally, running deep to the extensor tendons and the extensor digitorum brevis muscle (EDB). It provides sensitive innervation to the lateral joints of the tarsal region and innervates the EDB. The MBDFN continues toward the anterior region of the foot, together with the DPA, where it crosses the talonavicular joint and the other tarsal joints. At this level, the MBDFN and DPA run medial to the extensor hallucis longus (EHL) tendon. When crossing the Lisfranc joint, the MBDFN can be found over the base of the second metatarsal, first cuneiform, or dorsal band of the Lisfranc ligament. It is located below the EHBt that, covered by the superficial fascia, crosses over the nerve. At approximately the middle of the first intermetatarsal space, the MBDFN splits into the two terminal sensitive branches for the skin of the first commissural space.

Small high-frequency transducers allow optimal assessment of the distal DFB and its terminal branches (Figs. 2 and 3). Transverse sonograms are most useful due to the small size of the nerves, while longitudinal images are more helpful in the assessment of adjacent structures. Color Doppler allows evaluation of the flow of the DPA and hyperhemia in the adjacent soft tissues (Figs. 4, 5, and 6).

Anterior tarsal tunnel syndrome was first described by Marinacci in 1968 to differentiate it from the more common entrapment neuropathy of the tibial nerve at the ankle [17]. Complete anterior tarsal tunnel syndrome presents sensitive symptoms and denervation of the EDB at the ENMG due to compression of the DFN, or simultaneous compression of its two branches. It can be caused by local chronic microtrauma,

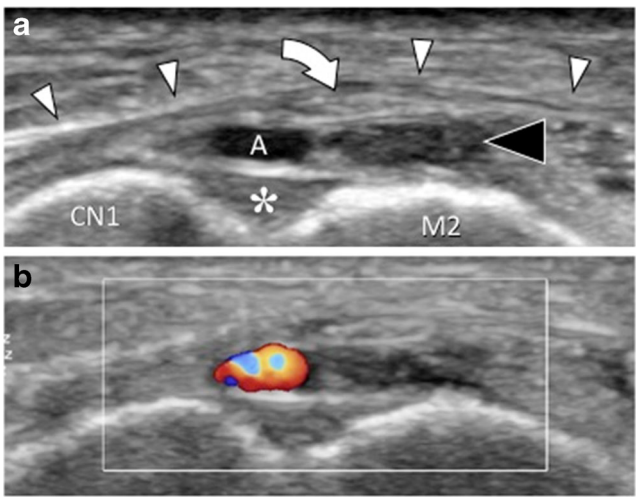

Fig. 5 A 70-year-old woman with compression of the MBDFN at the Lisfranc joint (patient 4). Color Doppler appearance. Greyscale (**a**) and color Doppler (**b**) axial oblique sonograms were obtained over the site of compression of the MBDFN. **a** The neuroma superiorly displaces the extensor hallucis brevis tendon (*curved arrow*) and the superficial fascia (*white arrowheads*). **b** The dorsalis pedis artery (A) shows a normal size and internal flow

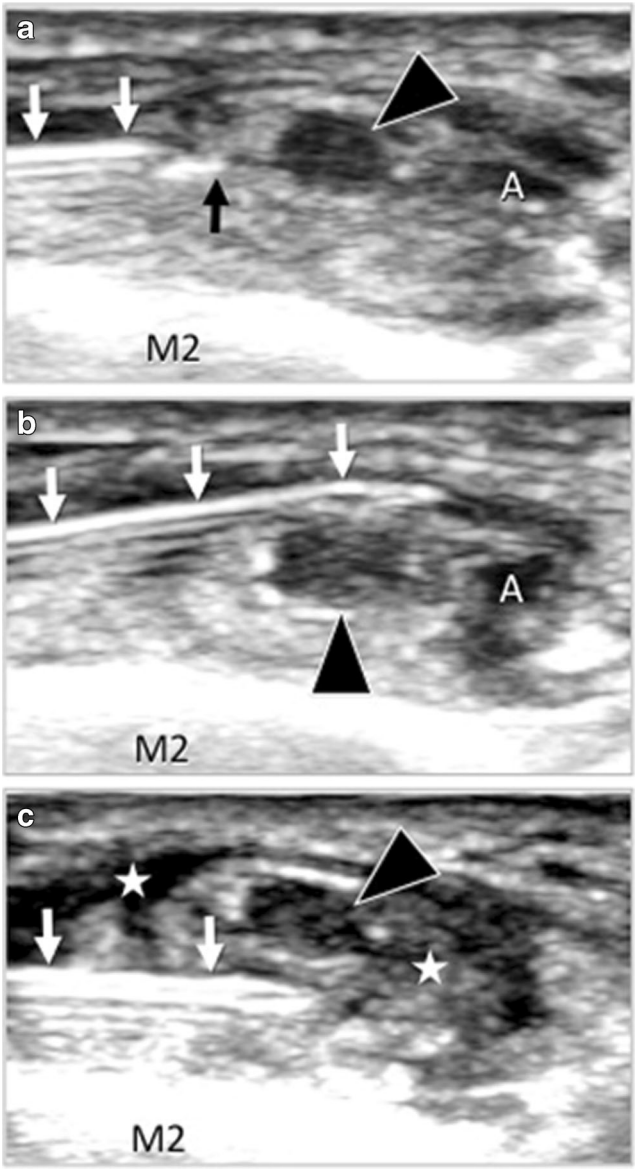

Fig. 6 A 51-year-old woman with compression of the MBDFN at the Lisfranc joint (patient 2). Ultrasound guided local injection. Sequential sonograms were obtained during ultrasound (US)-guided perineurioma injection. **a** The needle (*white arrows*) was maneuvered under US guidance until the tip (*black arrow*) was close to the neuroma (*arrowheads*). **b** and **c** Note the sequential injection (**b**) over and (**c**) under the neuroma. *Stars* indicate the injected fluid surrounding the neuroma

osteophytes, iatrogenic trauma during ankle arthroscopy, or an intratunnel or intranervous ganglion [18]. PATS can be motor or sensitive depending on whether the LBDFN or MBDFN are affected. The motor syndrome seems to be rare, and can occur secondary to nerve compression caused by local masses or hypertrophy of the EHB muscle [19]. Sensitive PATS [20] is most commonly caused by compression of the nerve by the EHBt, dorsal osteophytes of the Lisfranc joint, impingement on an os intermetatarseum [21], repetitive mechanical irritation

(potentially resulting from the tight-fitting footwear worn by skiers [22], hypertrophy of the EHB muscle in dancers [23] or a thrombosed DPA [24].

In all of the patients described here, the compression was caused by the EHBt at the level of the medial Lisfranc joint, a condition first described by Kanbe [25]. In all patients, the pathologic MBDFN presented a notch at the level of the compression and a neuroma immediately distal to it. A positive Tinel's sign corroborated the diagnosis in all patients. The adjacent soft tissues were normal. To the best of our knowledge, our series is the first to describe the US appearance of sensitive PATS.

The limitations of our study include the small number of patients and the retrospective nature of the analysis. We were unable to find articles that specifically provided an MRI description of this specific nerve entrapment. Diagnosis of PATS is difficult, and premature surgical exploration of the peroneal nerve at the fibular head and muscle and nerve biopsies has been reported in patients prior to diagnosis, in addition to psychiatric admission for "psychogenic" foot pain [10, 11]. In our series, no patients were suspected to have PATS, with all having received other diagnoses including SFN compression, Morton's neuroma, other musculoskeletal disorders and a psychiatric origin. Our small series show that US can be successfully used to assess the MBDFN in the ankle region and diagnose its local compression by the EHB.

Sonologists must be aware of the possibility of MBDFN compression in the Lisfranc region, and should include an examination of this area in all patients presenting with forefoot pain. Ultrasound can detect compression of the medial branch of the DFN by the EBHt.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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