Ultrasound evaluation of focal neuromas in athletes: a clinically-focused review

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ABSTRACT

Focal neurethrapies represent a rare but clinically important and potentially challenging aetiology of pain in athletes. Diagnostic ultrasound is commonly used in the evaluation of nerve entrapments, and has several advantages over other imaging modalities, including high resolution, portability, lack of ionising radiation, low cost, point-of-care access, ease of contralateral comparison and capability of Doppler and dynamic imaging techniques. In this review, we discuss the use of ultrasound for the evaluation of injuries to the brachial plexus including ‘stingers,’ suprascapular nerve, ulnar nerve, radial nerve, common fibular nerve, tibial nerve and interdigital nerves of the foot at selected common sites of entrapment.

INTRODUCTION

Focal neuropathies are an uncommon but clinically important aetiology of pain in athletes. Specific aetologies include blunt trauma, instability, compression or stretch injury, and can be related to biomechanics, equipment, technique, training errors or collisions. Sport participation can produce forceful and repetitive compression, stretch, dislocation or subluxation of nerves.

The advantages of ultrasound over other forms of imaging include high resolution, portability, lack of ionising radiation, low cost, point-of-care access and ease of contralateral comparison. Ultrasound also has Doppler imaging capability, which allows assessment of vascular flow, as well as dynamic imaging capability to assess moving tissue. These features provide advantages for assessing peripheral nerves.

In this review, we discuss the use of ultrasound for the evaluation of selected focal neuropathies in athletes: (1) brachial plexus injuries and ‘stingers;’ (2) suprascapular neuropathies at the suprascapular and spinoglenoid notches; (3) ulnar neuropathies at the elbow, wrist and hand; (4) radial neuropathy at the supinator; (5) common fibular neuropathy; (6) tibial neuropathy at the ankle; and (7) interdigital nerves of the foot.

BRACHIAL PLEXUS INJURIES AND ‘STINGERS’

Injury location and mechanism

Brachial plexus injuries and ‘stingers’ are encountered most frequently in collision sports such as football and rugby.3 They occur most frequently at the C5 and C6 roots as a result of simultaneous force on the shoulder and neck in a contralateral direction. Less commonly, forced shoulder abduction can result in lower root (C8 and T1) injury, or from direct trauma.4 Fractures and shoulder dislocations can also result in brachial plexus injuries.3

Clinical presentation

Most ‘stingers’ are transient injuries that last for a few seconds, but may last weeks. They typically present as a ‘burning sensation’ between the neck and shoulder, with a feeling of heaviness in the affected limb. Persistent neurological deficits can occur in some ‘stingers.’4 Electrodiagnosis can provide more precise localisation and prognostic information (ie, neuapraxic vs axonal lesions), although this information may not be reliable until 10 days postinjury.4 6 MRI is useful for visualising root avulsions inside the bony canal.7-9 However, ultrasound has better spatial resolution than MRI and can assess the integrity of adjacent vascular structures with Doppler imaging.10 11 With persistent neurological deficit following brachial plexus injury, MRI and ultrasound are both indicated due to complementary strengths and weaknesses.11

Ultrasound scanning technique

The athlete is seated or supine, and the root levels are identified using characteristic bony landmarks of the transverse processes (figures 1A–C).12 The anatomic landmarks of the anterior and middle scalenes as well as the carotid artery, internal jugular vein, and sternocleidomastoid aid localisation (figure 1D). The cord and branch level of the brachial plexus are identified with the transducer in the infraclavicular and axillary positions, respectively.13 The nerve fascicles in these locations are identified by their positions in relation to the axillary artery.14 15

Normal and pathological sonographic appearance

Nerves at the root and trunk levels typically appear as hypoechoic dots, whereas a differentiated fascicular pattern is more evident at the cord and branch levels (figure 1E–G).16 Both focal and fusiform enlargement of neural tissue can be seen after injury. Comparison with the unaffected side can be valuable. Ultrasound can also be used to assess for tethering of nerves with movement, discontinuity, scarring and infiltration of bone fragments after fracture, and can aid clinical decision-making.9 17 Enlargement of the affected root can be seen (figure 1H).

SUPRASCAPULAR NEUROPATHY

Injury location and mechanism

The suprascapular nerve can be injured by traction, compression or direct trauma.18 Contact sports as well as overhead sports such as tennis and volleyball are at risk.19 It is also associated with compression from paralabral cysts at the spinoglenoid and suprascapular notches.20 Branches of the suprascapular
nerve can also be injured with large supraspinatus or infraspinatus tears, which can complicate the mechanical disruption with muscle denervation.21

Clinical presentation
Suprascapular neuropathies typically present with supraspinatus and infraspinatus weakness, and sometimes atrophy.22 Sensory

Figure 1  (A) Sonogram of a short-axis view of the C5 root. The bony landmarks of the posterior and anterior tubercles of the transverse process of the spine are noted. The landmarks of the carotid artery and sternocleidomastoid (SCM) are also seen. Left=posterior; right=anterior; top=superficial; bottom=deep. (B) Sonogram of a short-axis view of the C6 root (unlabelled arrow). The bony landmarks of the posterior and anterior tubercles of the transverse process of the spine are noted. Note the distinct pattern of the wider shelf created by the tubercles at C6 in contrast to the narrow shelf seen with the C5 root (figure 1A). The landmarks of the carotid artery and SCM are also seen. Left=posterior; right=anterior; top=superficial; bottom=deep. (C) Sonogram of a short-axis view of the C7 root. The bony landmark of the posterior tubercle of the transverse process of the spine is shown. Note that, unlike the C5 and C6 roots, there is no anterior tubercle at the C7 level creating a bony shelf that resembles a chair. Left=posterior; right=anterior; top=superficial; bottom=deep. (D) Sonogram demonstrating a short-axis view of the interscalene portion of the brachial plexus. The anatomic landmarks of the anterior and middle scalene muscles are noted. The jugular vein is collapsed from transducer pressure in this picture. These anatomic landmarks are particularly helpful in regions where the neural tissue appears less distinct. Left=posterior; right=anterior; top=superficial; bottom=deep. (E) Sonogram demonstrating a short-axis view of the interscalene portion of the brachial plexus. The anterior and middle scalene muscles are noted. Note that the root levels of the brachial plexus appear as hypo echoic dots (arrows). Left=posteri
or; right=anterior; top=superficial; bottom=deep. (F) Sonogram demonstrating a short-axis view of the C6 root (arrow—figure on the left) on the affected side of a football player with an acute stinger and neurological deficit. The unaffected C6 root (arrow—figure on the right) is also shown. Left=posteri
or; right=anterior; top=superficial; bottom=deep.
loss is unexpected. Isolated infraspinatus involvement is seen with spinoglenoid notch lesions. Electrodiagnosis can confirm neurological injury and provide prognostic information. Ultrasound scanning technique

The suprascapular nerve should be scanned at the supraclavicular region as it branches from the superior trunk of the brachial plexus (figure 2A), the suprascapular notch, and the spinoglenoid notch (figures 2B, C). It is identified in the supraclavicular region in short axis by placing the transducer in transverse position to the neck and identifying the roots and trunks of the brachial plexus between the anterior and middle scalenes. As the transducer is translated caudally, the suprascapular nerve is identified as a hypoechoic dot that emerges immediately after the C5 and C6 root coalesce to become the superior trunk. With continued caudal translation, the nerve traverses posteriorly from the superior trunk. The transducer is then placed in long axis to the scapular spine. It is translated superiorly to the suprascapular notch and beneath the spine of the scapula to the spinoglenoid notch.

Normal and pathological sonographic appearance

In the supraclavicular region, the suprascapular nerve normally appears as a hypoechoic dot. Suprascapular nerve injury at that level is often accompanied by brachial plexus injury. Contralateral comparisons should be performed to distinguish focal enlargement. The region should be scanned for masses and other potential compressive aetiologies.
Suprascapular artery flow is often not visualised by Doppler imaging in the suprascapular artery, so it can be difficult to distinguish from the suprascapular nerve at the suprascapular and spinoglenoid notches. The accompanying vein is generally hypoechoic. It can be distinguished from a cyst with internal and external humeral rotation, which will collapse the vein. Potentially compressive paralabral cysts may be seen (figure 2C). Ultrasound is also helpful for identifying neurogenic atrophy of the involved muscles, which can aid injury localisation (figure 2D).

ULNAR NERVE AT THE ELBOW, WRIST AND HAND

Injury location and mechanism

Ulnar neuropathy at the elbow is the second most common focal neuropathy of the upper limb in athletes or non-athletes. Neuropathy at the elbow is far more common than other locations. The nerve can be chronically compressed at the cubital tunnel, injured by repetitive motion or acutely injured with elbow trauma. Subluxation or dislocation of the nerve can occur with flexion or resisted elbow extension while in a flexed position. This may predispose to neuropathy. Other predispositions to ulnar neuropathy include mechanical alterations of the elbow joint from prior fracture (‘tardy ulnar palsy’) or congenital deformity. Abnormal motion from ligamentous injuries, such as the ulnar collateral ligament, can predispose to neuropathy in throwing athletes. Ulnar neuropathy at the wrist or hand is less common than at the elbow, and is often related to an identifiable anatomic abnormality such as hamate fracture, carpal instability, ganglion cysts, other masses, ulnar artery thrombosis or prolonged pressure, such as against the handlebars in cycling.

Clinical presentation

Ulnar neuropathy typically presents with sensory disturbance in the ulnar aspect of the hand, small finger and ulnar aspect of the ring finger. The dorsal branch of the ulnar nerve (ie, dorsal ulnar cutaneous nerve) bifurcates from the main branch of the ulnar nerve proximal to the wrist. Therefore, a sensory deficit that involves that dorsal-ulnar aspect of the hand is related to a neuropathy proximal to the wrist. The first dorsal interosseus is the most distal ulnar-innervated muscle and is affected in virtually all ulnar neuropathies associated with weakness. Sparing of the muscles of the hypothenar eminence but weakness of the interossei suggests injury in the hand, distal to the ulnar tunnel. Sparing of the flexor carpi ulnaris (FCU) and medial portion of the flexor digitorum profundus (FDP) with weakness of the hypothenar muscles suggests injury at the level of the mid-forearm to wrist. Weakness that includes the ulnar portion of the FDP and FCU suggests injury at the elbow or more proximally. Caution should be exercised with a clinical diagnosis of a more distal ulnar neuropathy because of the potential for relative fascicle sparing in a more proximal lesion. Additionally, there are no sensory or motor branches from the ulnar nerve until it courses below the elbow, so a lesion in the axilla, arm or elbow cannot be reliably distinguished clinically without external signs of trauma. Electrodiagnosis may aid with defining severity as well as refining localisation, although limitations exist. Pain is infrequent with non-traumatic ulnar neuropathies, although increased sensitivity of the nerve can occur at the entrapment site. Subluxation of the ulnar nerve from the ulnar groove can be palpated with elbow flexion, and is often associated with a palpable click. Two palpable clicks in rapid succession often represent the subluxation of both the ulnar nerve and the medial head of the triceps brachii.

Ultrasound scanning technique

The patient is generally supine, where the ulnar nerve can be scanned from its departure at the medial cord of the brachial plexus distally to the digital branches in the hand. Ulnar nerve evaluation at the elbow should include inspection in the arm above the elbow, retrocondylar groove, medial epicondyle, cubital tunnel and forearm. Short-axis views should include cross-sectional area measurements at these levels to assess for enlargement. As with all nerve measurements, the transducer should be orthogonal to the nerve to obtain the correct cross-sectional area. An oblique angle will create an artifactually increased area. The posterior recurrent ulnar artery should be identified to avoid mistakenly including it in the cross-sectional area (figure 3A). Long-axis views are helpful to visualise focal enlargement and to correlate with identified short axis abnormalities. It is generally helpful to scan with the elbow in extension. Owing to the curvature of the nerve around the ulnar groove, using a split screen or multiple images is often needed to eliminate anisotropic artefact. Dynamic assessment should be performed to assess for subluxation or dislocation over the medial epicondyle. The transducer is positioned between the medial epicondyle and the olecranon, and the nerve is visualised while the examiner passively flexes the elbow. In some circumstances, subluxation is only seen with resisted elbow extension with the elbow in flexion, often due to pressure from the medial head of the triceps brachii. In the setting of persistent ulnar dysfunction following surgical release and transposition, the nerve should be assessed for kinking, recurrent dislocation, undesired superficial position, encroaching scar or other sources of entrapment.

Ulnar nerve evaluation at the wrist should include inspection of the nerve at the distal forearm, throughout the ulnar tunnel and the bifurcation into the superficial and deep ulnar branches at or distal to that level. The ulnar canal is bordered by the transverse carpal ligament on its deep aspect and the palmar carpal ligament superiorly. Medially, the proximal portion of the ulnar canal is bordered by the pisiform and the distal portion by the hamate (figures 3B-C). The ulnar nerve lies medial to the ulnar artery within the canal. Although there is variation, the bifurcation into the superficial and deep branches occurs (with their associated arteries) at the level of the hamate.

Normal and pathological sonographic appearance

The ulnar nerve at the level of the arm, forearm and cubital tunnel has well-defined fascicular architecture that typically appears more hypoechoic when between the medial epicondyle and olecranon (figure 3D). Dramatic changes in the fascicular pattern and focal enlargement of the nerve are consistent with ulnar neuropathy at this location (figures 3E, F). The literature is disparate with respect to normal cross-sectional area, although greater than 10 mm² or more than 2 mm² greater than the contralateral ulnar nerve is generally considered abnormally enlarged. ‘A notch’ sign can sometimes be seen in long-axis views, which can occur from compression by the arcuate ligament, scarring or other tissue infiltration. The nerve may be swollen in a more diffuse pattern across the ulnar groove. Potentially predisposing factors for nerve compression should be noted, such as encroaching osteophytes and anatomic variants such as anconeus epitrochlears (accessory anconeus).
The ulnar nerve at the wrist should be carefully assessed, and not confused with the FCU tendon. There is variation of expected normal size in the literature, however focal swelling can often be demonstrated in neuropathy. Contralateral comparisons are helpful. Neuropathy at the ulnar tunnel is rare and in the absence of known activity causing external compression, the area should be inspected thoroughly for an anatomic predisposition, such as carpal bone abnormalities, post-traumatic scarring, ganglion cysts, other tumours and ulnar artery abnormalities.

**RADIAL NEUROPATHY AT THE SUPINATOR**

**Injury location and mechanism**

The radial nerve branches from the posterior cord of the brachial plexus, through the axilla and along the humeral spiral groove near the deep brachial artery. It then courses between the brachialis and brachioradialis at the elbow where it divides into the deep radial and superficial sensory branches. The superficial sensory branch travels in the volar-lateral forearm, then to the dorsal wrist to provide cutaneous sensation to the radial-dorsal hand. The deep radial nerve passes between the superficial and deep heads of the supinator, where it becomes the posterior interosseus nerve and travels in the forearm, where it innervates the extensor digitorum, extensor digiti quinti, extensor carpi ulnaris, abductor pollicis longus, extensor pollicis longus, extensor pollicis brevis and extensor indicis.

The radial nerve is the most frequently-injured nerve in the upper limb due to trauma, but is infrequently injured without trauma. Among athletes, radial neuropathy occurs most often to the deep radial nerve as it enters the supinator at the Arcade of Frohse, and is likely related to repeated pronation and supination. Racquet, throwing, strength and wheelchair athletes are most at risk.

**Clinical presentation**

Radial neuropathies at the supinator muscle typically present insidiously. The athlete may present with weakness, particularly...
in the finger and wrist extensor musculature, which can compromise performance. Elbow extension weakness suggests a more proximal injury. Pain may be present in the dorsal forearm.\textsuperscript{67} Although the posterior interosseous nerve transmits sensory information from the posterior wrist capsule and the muscles it innervates, it does not provide cutaneous sensory innervation, so sensory deficits are not expected.\textsuperscript{68}

**Figure 4** (A) Sonogram demonstrating a short-axis view of the bifurcation of the superficial radial sensory branch and deep radial branch from the main trunk of the radial nerve. Left=medial; right=lateral; top=superficial; bottom=deep. (B) Sonogram demonstrating a short-axis view of the posterior interosseous nerve (three fascicles indicated by arrows) as it traverses between the deep and superficial heads of the supinator. Left=medial; right=lateral; top=superficial; bottom=deep. (C) Sonogram demonstrating a short-axis view of an abnormal posterior interosseous nerve on the left half of the figure, characterised by abnormal swelling, with a sonogram of a short-axis view of the contralateral normal posterior interosseous nerve for comparison on the right half of the figure. Left=medial; right=lateral; top=superficial; bottom=deep.

**Ultrasound scanning technique**

The athlete’s forearm is placed in supination and the radial nerve is located in short axis as it passes between the brachioradialis and brachialis, and followed to its bifurcation into the superficial sensory and deep radial nerves (figure 4A). The deep radial nerve is then followed until it enters the Arcade of Frohse, passing between the superficial and deep heads of the
supinator. Dynamic supination and pronation may promote visualisation, as the nerve is more superficial during pronation. The nerve should also be observed in long axis (figure 4B).

**Normal and pathological sonographic appearance**

The normal radial nerve at the supinator will have fascicular architecture and is often seen as three distinct fascicles. Surrounding hyperechoic connective tissue can decrease the nerve’s echogenicity, and should not be confused with pathology. Sweeping the transducer proximally and distally while visualising the nerve in short axis can improve visualisation.

With radial neuropathy at the supinator muscle, focal hyperechoic swelling is often noted proximal to the entrapment site (figure 4C). The nerve is usually flattened at the entrapment site. A perpendicular transducer orientation is important to avoid misinterpretation of obliquity for a change in shape. Contralateral comparison can be helpful. The region should be assessed for constrictive bands or masses, including lipomas, ganglion cysts and intrinsic nerve tumours.

**COMMON FIBULAR NEUROPATHY**

**Injury location and mechanism**

The common fibular nerve fascicles originate from the L4, L5, S1 and S2 roots, and travel with tibial nerve fascicles as the sciatic nerve in the posterior hip and thigh. At the proximal popliteal fossa, the sciatic nerve bifurcates into the tibial nerve and common fibular nerve, which travels laterally and posterior-medial to the biceps femoris tendon. It courses anterolaterally around the fibular neck and through the lateral intramuscular septum. It then enters the fibular tunnel, composed of the apex-neuroses of the fibularis longus and soleus muscles. At the fibular neck, the common fibular nerve branches into the deep fibular nerve, superficial fibular nerve and an articular branch.

The deep fibular nerve innervates the tibialis anterior, extensor digitorum longus, extensor hallucis longus, fibularis tertius and extensor digitorum brevis, and transmits cutaneous sensation from the first web space. The superficial fibular nerve innervates the fibularis longus and fibularis brevis, and transmits cutaneous sensation from the anterolateral leg and dorsal foot, excepting the first web space.

The common fibular nerve is the most frequently injured nerve in the lower limb. It is most frequently injured at the lateral fibular neck due to stretch or direct trauma, but may occur due to proximal fibular fractures, knee derangement or direct ice or compression. Among athletes, it is most common among runners and football and soccer players. Rapid weight loss, as in weight-class sports, can cause common fibular neuropathy due to external compression.

**Clinical presentation**

Common fibular neuropathy will typically present with weakness or poor coordination of the ankle dorsiflexors, evertors and toe extensors. Paresthesias over the anterolateral leg and dorsal foot are often present. Athletes may also note early fatigue during running or cutting activities. A ‘steppage gait’ may occur, characterised by increased hip flexion during swing phase. Clinicians should assess for potential inciting aetiologies, such as knee or fibular head injuries or rapid weight loss.

**Ultrasound scanning technique**

The athlete is prone, and scanning begins with short-axis views of the common fibular nerve at the superior popliteal fossa (figure 5A). It is then followed inferolaterally, where it courses...
posteromedial to the biceps femoris tendon. Then, it may be followed distally around the fibular neck (figure 5B). It should also be assessed in long axis (figure 5C).

**Normal and pathological sonographic appearance**

The normal common fibular nerve will have an ovoid shape with fascicular architecture. Focal common fibular neuropathy is characterised by nerve enlargement and hypoechogenicity (figure 5D). Contralateral comparison is often useful. Care should be taken that oblique views of the nerve are not mistaken for focal enlargements. The region should be assessed for adjacent compressive lesions.

**TIBIAL NEUROPATHY AT THE TARSAL TUNNEL**

**Injury location and mechanism**

The tibial nerve fascicles originate at the L4, L5, S1, S2 and S3 roots, and travel with common fibular nerve fascicles as the sciatic nerve in the posterior hip and thigh. At the proximal aspect popliteal fossa, the sciatic nerve bifurcates as noted above, with the tibial nerve continuing through the popliteal fossa and between the heads of the gastrocnemius muscle. Approximately 15 cm proximal to the medial malleolus, the tibial nerve courses posteromedially and enters the tarsal tunnel. 11

The upper tarsal tunnel is bordered by crural fascia posteromedially and by the tibia and talus anterolaterally. The lower component is bordered by the flexor retinaculum.

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**Figure 6** (A) Sonogram demonstrating a short-axis view of the tibial nerve at the tarsal tunnel. The calcaneal branch, lateral plantar branch and medial plantar branch are all identified at this level. Also shown are anatomic landmarks including the medial malleolus, tibialis posterior tendon, flexor digitorum longus tendon (FDL), flexor hallucis longus tendon (FHL), the retinaculum of the tarsal tunnel and the posterior tibial artery and veins. Left=posterior; right=anterior; top=superficial; bottom=deep. (B) Sonogram demonstrating a long-axis view of the tibial nerve at the tarsal tunnel. The flexor hallucis longus tendon is incompletely visualised in long-axis deep to the tibial nerve. Left=proximal; right=distal; top=superficial; bottom=deep. (C) Sonogram demonstrating a traumatic focal neuropathy of the medial plantar branch of the tibial nerve. The longitudinal view of the nerve is shown on the left and the transverse view is shown on the right. The area of injury is illustrated by the disruption of the normal fascicular architecture and focal area of swelling. Left side of figure: Left=proximal; right=distal; top=superficial; bottom=deep. Right side of figure: Left=medial; right=lateral; top=superficial; bottom=deep.
posteromedially and by the talus and calcaneus anterolaterally, including the sustentaculum tali. Tarsal tunnel contents include the tibialis posterior and flexor digitorum longus tendons, posterior tibial artery and veins, tibial nerve and the flexor hallucis longus musculotendinous junction. The medial calcaneal nerve exits the tibial nerve prior to its bifurcation into the medial and lateral plantar nerves, which typically occurs at the level of the tarsal tunnel. The medial plantar nerve innervates the abductor hallucis, flexor digitorum brevis, flexor hallucis brevis and the first lumbrical. The lateral plantar nerve innervates the quadratus plantae, flexor digiti minimi, adductor hallucis, interossei, lumbricals two through four and the abductor digiti minimi. Sensation to the majority of the plantar foot, as well as the posterior heel, is received from the three final branches of the tibial nerve.

An accessory soleus or flexor digitorum longus can fill the tarsal tunnel and predispose to focal tibial neuropathy, as can osteophytes or a talocalcaneal coalition. Tarsal tunnel neuropathy at the tarsal tunnel may occur with repeated inversion and eversion activities, such as running, jumping or cutting, and may be related to biomechanical factors such as overpronation and poor ankle stability. It can also occur due to compression, such as from footwear.

**Clinical presentation**

The most frequent symptoms are medial ankle pain as well as plantar foot paresthesias and sensory loss. Since the medial calcaneal branch typically exits the tibial nerve prior to the tarsal tunnel, entrapment at this level often spares this branch. The medial plantar nerve is more frequently affected than the lateral plantar nerve. Intrinsic foot muscle weakness and atrophy is infrequent. The athlete should be assessed for inciting aetiologies, such as poor ankle stability, gait mechanics and fit of footwear.

**Ultrasound scanning technique**

The patient is positioned prone or in the lateral decubitus position. The tibial nerve is followed in short-axis planes from the leg to the tarsal tunnel (figure 6A). Both the upper and lower compartments of the tarsal tunnel should be assessed. The nerve should be assessed in long-axis for focal swelling and changes in architecture (figure 6B).

**Normal and pathological sonographic appearance**

Abnormal enlargement or echogenic changes of the nerve at the tarsal tunnel suggest pathology (figure 6C). A tibial nerve cross-sectional area at the tarsal tunnel of 1.8 mm² greater than the contralateral side is significant. The region should be inspected for masses and vascular abnormalities.

**INTERDIGITAL NEUROMA OF THE FOOT**

**Injury location and mechanism**

The plantar nerves originate from the tibial nerve, and innervate the sole of the foot. Among the interdigital nerves, the first and second are innervated by the medial plantar nerve, the third by communicating branches of both the medial and lateral plantar nerves and the fourth by the lateral plantar nerve. The third interdigital nerve is most frequently affected by a neuroma, and this is eponymously referred to as Morton’s neuroma. The second interdigital nerve is the next most frequently affected, and the first and fourth interdigital nerves are rarely affected.

The interdigital nerves pass inferior to the intermetatarsal ligaments at the level of the metatarsal heads. Forceful toe dorsiflexion, as during running or jumping, can compress and stretch the nerves. This may lead to a perineural fibrotic mass which is frequently termed a neuroma but is likely not a tumour. Athletes frequently affected by interdigital neuroma include runners and dancers. Poorly-fitting footwear can be a contributing aetiology.

**Clinical presentation**

Intermittent pain, numbness and paresthesias in the affected nerve distribution are typically noted, with symptoms worsened during activity. Night pain is uncommon and should prompt consideration of an alternate diagnosis. There may be loss of sensation in the affected web space. The metatarsal squeeze test may reproduce pain or a palpable click, referred to as Mulder’s sign. Passive dorsiflexion of the toes can also reproduce symptoms. No motor signs or symptoms should occur.

**Ultrasound scanning technique**

With the athlete supine, the knee is flexed and the foot is placed flat. Visualisation of the interdigital nerve is usually better from the dorsal aspect, at the level of the metatarsal heads (figure 7A). The normal nerve is usually isoechoic with surrounding tissue and may be difficult to identify. The nerve should be scanned in both short-axis and long-axis planes proximally and distally from this location.

**Figure 7** (A) Sonogram demonstrating a short-axis view of a normal interdigital nerve in the second intermetatarsal space. Left=lateral; right=medial; top=dorsal; bottom=plantar. (B) Sonogram demonstrating a short-axis view of an interdigital neuroma in the second intermetatarsal space, represented by an enlarged hypoechoic mass seen in the web space. Left=lateral; right=medial; top=dorsal; bottom=plantar.
neuroma will not be compressible to transducer pressure, unlike intermetatarsal bursitis.83 The average size of a symptomatic neuroma is 5 mm² in cross-sectional area when measured at the level of the metatarsal heads.86 Mulder’s sign can also be reproduced with ultrasound visualisation.

**SUMMARY**

Although rare, focal nerve entrapments in the athlete are an important clinical entity. Diagnostic ultrasound is increasing in availability. Clinicians are progressively recognising its utility in a range of sports medicine settings. At the London Olympic Games, ultrasound provided 20% of over 1700 imaging visits.87 The appropriate clinical scenario, the sports medicine clinician should consider sonographic evaluation of suspected focal nerve entrapment syndromes. Awareness of pertinent anatomy, mechanisms of potential entrapment, clinical presentation, normal sonographic nerve appearance and pathological sonographic appearance of nerve entrapment syndromes will allow the clinician to detect nerve disorders with ultrasound and improve care of the athlete.

**Summary box**

- Ultrasound is a powerful diagnostic imaging modality useful for the evaluation of focal neuropathies in athletes.
- Ultrasound can provide diagnostic information not readily available with other nerve imaging modalities, due to such features as dynamic imaging capability and ease of contralateral comparison.
- Sports medicine clinicians should consider diagnostic ultrasound evaluation when athletes present with persistent focal pain with neurogenic characteristics, guided by a careful clinical evaluation.

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**REFERENCES**


