Ultrasound in the forefoot

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**Introduction**

Foot pain is one of the most common musculoskeletal complaints encountered. It affects nearly one in five of people in the community, is associated with increased age, female sex, obesity and pain in other body regions. It has a significant detrimental impact on health-related quality of life.

The majority of scans that we are asked to perform are to aid in the differential diagnosis and management of metatarsalgia. Metatarsalgia is pain in the ball of the foot. It is usually felt in the sole of the foot and is often described as being like “walking on pebbles”. Other people feel a more diffuse vague pain, ache or burning. Some people experience symptoms around only one or two toes, others have it throughout one or both feet.

Ultrasound is the imaging modality of choice in our institution. We take referrals from a combination of GPs, MSK triage pathways and dedicated foot and ankle surgeons. Scans are then performed by either MSK radiologists or MSK sonographers.

Several pathologic conditions produce pain in the region of the metatarsal bones and the cause may be difficult to establish based solely on clinical findings. Although conventional radiography is still useful in detecting bone lesions and showing the underlying foot architecture, it typically does not help the diagnosis of early joint abnormalities or soft-tissue disease causing forefoot pain.

**What causes metatarsalgia?**

As clinical sonographers and radiologists our role includes taking a clinical history and performing a clinical examination. Although the orthopaedic foot and ankle surgical department will have their established management pathways that we, as diagnosticians, should be familiar with, many referrals will come directly from primary care and general practitioners who will welcome onward management advice. We should not shy away from giving patients and their referring clinical colleagues advice, even if a management plan is limited to a referral to physiotherapy. In our institution we have several one-stop clinics and these are a valuable learning opportunity, helping us to better understand the management options for patients. This type of knowledge sharing should be actively encouraged.

Anything which puts extra stress on the front of the foot, resulting in forefoot overload, can lead to metatarsalgia. Common examples are:

- obesity
- a tight calf due to a gastrocnemius contracture
- hallux valgus or rigidus that can weaken the big toe and throw extra stress onto the ball of the foot. This can also happen after an operation on the big toe, such as a bunion correction
- certain foot shapes, particularly cavus foot, claw or hammer toes
- a stiff ankle
- a stretched or irritated nerve in the ball of the foot (interdigital neuroma) or behind the ankle (tarsal tunnel syndrome) can produce pain in the ball of the foot
- diabetes can produce problems with the small nerves in the foot leading to a burning pain
- athletes or walkers occasionally get stress fractures of the metatarsal bones
- systemic inflammatory diseases affecting the forefoot cover a wide range of pathologic conditions, including rheumatoid arthritis, gout, Reiter’s disease and psoriasis
- high-heeled shoes

**Extended ultrasound**

Generally in musculoskeletal ultrasound, but specifically in the forefoot, sonographers and radiologists should rise to the diagnostic challenge and take on greater clinical responsibility. It is not sufficient to simply say “no abnormality found”. We should understand the clinical possibilities and diagnostic pathways involved in assessing the forefoot. This article outlines our protocol for the forefoot. The main advantage diagnostic ultrasound has over other imaging modalities is the ability to dynamically evaluate the patient while scanning (figure 1). We would also encourage you to offer a plan by suggesting the best diagnostic pathway when a specific ultrasound diagnosis cannot be made.

In order to evaluate the patient with a musculoskeletal problem you can take either a targeted approach, eg look for a neuroma, or a more systematic (anatomical or clinical) approach, eg evaluate the structures in the region of interest. The latter requires an understanding of ultrasound anatomy and the clinical differential diagnosis. Understanding all the clinical possibilities (not just those identified on ultrasound) not only enhances the scanning process but gives us the opportunity to suggest an alternative diagnosis by a process of exclusion.

The recommendations of this article are to undertake a systematic approach as even the most experienced clinicians can be misled by symptoms. Every experienced radiologist will have encountered synovitis or stress fracture mimicking the presentation of a Morton’s neuroma.

**Protocolled scanning**

- Always use a high resolution transducer, preferably with a frequency of at least 15MHz, and if you are performing injections then a hockey stick probe is often helpful
- The patient should initially be supine with the knee bent and the foot flat on the couch
- Scan the metatarsal bones longitudinally looking for evidence of callus formation or periosteal reaction to exclude a stress fracture
- Scan the metatarsophalangeal (MTP) joints looking for synovitis or erosive changes
- Straighten the knee and look at the plantar skin and scan the distal plantar fascia
- Examine the plantar plates, sesamoids and flexor tendons while passively hyperextending and flexing the toes
- Look between the metatarsals heads at the interdigital nerves and the intermetatarsal bursae. This is easiest if done longitudinally balloting the interdigital space between the transducer and a finger on the dorsum of the forefoot
- Consider scanning the tarsal tunnel and the contralateral foot.
**Metatarsal fracture**

Insufficiency fractures occur when a weak bone fails as a result of loading. This typically occurs in postmenopausal women and most commonly involves the shafts of the second and third metatarsals. Stress fractures are common in those whose sporting or occupational activities result in repetitive loading of the foot, with the normal bone eventually failing through “fatigue”. Athletes, dancers, gymnasts and military recruits after long marches (march fracture) are more vulnerable to metatarsal stress fractures, as are those with anatomical variants leading to biomechanical overload (e.g., tight gastrocnemius, long lesser metatarsals).

Stress fractures are recognised by cortical disruption, periosteal reaction, abnormal local vascularity (within and around bone) and callus formation (figure 2).

**Metatarsophalangeal joint**

Inflammatory diseases affecting the forefoot include rheumatoid arthritis, gout and psoriasis. Ultrasound findings include joint effusion, thickened synovium, bursitis and erosive changes. A small amount of fluid in the dorsal and plantar recesses of the MTP joints should be regarded as physiological. Pannus is demonstrated as a hypoechoic hypertrophy of the synovium that is usually hyperaemic on power Doppler imaging in the acute phases of disease. In rheumatoid arthritis, bone erosions appear as intra-articular irregular cortical defects visible in two perpendicular planes located in the marginal area. Erosions in gout are larger, also irregular but lie further away from the joint.

The first MTP joint is the most common site of degenerative osteoarthritis in the foot. Gout is the most common inflammatory arthritis in adult men and the first MTP is again the most frequently involved joint. Hallux rigidus is much more common than crystal arthropathy although the two conditions may co-exist. Ultrasound may demonstrate crystals in the synovial fluid and around the joints as small hyper-echoic foci. Ultrasound guidance may assist in the aspiration of fluid from a gouty joint to reveal negatively birefringent monosodium urate crystals. Calcium pyrophosphate crystals (pseudo gout), in contrast, will show weak positive birefringence.

**The plantar plate**

Similar to the volar plate in the hand, the plantar plate is a fibrocartilaginous structure extending from the distal fascicles of the plantar fascia at the metatarsal necks to the proximal phalanges. Turf toe relates to partial or complete tear of the plantar plate of the hallux, probably related to a hard push off from a rigid surface most commonly in athletes who accelerate rapidly. The involvement of the lesser MTP joints is often seen in women with increased load and forefoot overload due to hallux valgus. High heels may aggravate the symptoms. On ultrasound the normal plantar plate appears as a uniformly hyperechoic structure that reinforces the plantar aspect of the joint capsule. Plantar plate tears are often best demonstrated as a discontinuity during dynamic flexion and extension during scanning and should always be actively excluded in the presence of fluid in the tissues beneath the metatarsal heads (figure 3). If in doubt an ultrasound arthrogram following the injection of a small volume of fluid into the dorsal aspect of the joint is often helpful. This will allow small tears to be more clearly defined as the fluid distends the cleft.

**Morton’s neuroma and intermetatarsal bursitis**

These two are best looked at together and in our experience it is uncommon to find a symptomatic Morton’s neuroma without some fluid in the associated bursa. Technically, as we all know, neuroma is a common misnomer since histologically the neuropathy is actually caused by a perineural fibrotic mass. Morton’s neuromata tend to affect 3/4 and to a lesser extent the 2/3 interosseous and their associated interdigital nerves as they pass through to the plantar side of the intermetatarsal ligament with the intermetatarsal bursa.
situated just dorsal to it.

Scanning techniques vary between users but since an US-guided injection is often performed at the time of the scan we prefer to scan longitudinally from the plantar surface with a hockey stick probe. This allows easyballoting from above and makes single-handed scanning and injecting through the webspace very easy to perform (figure 4).

US-guided injection of steroid in the forefoot is best performed with a premixed formulation so that volume of injectate is minimal in order to reduce pain.

Bursitis is compressible, deformable and more heterogeneous in echogenicity. It has a variety of shapes, sizes and locations and often has a close relationship with one of the MTP joints (and may communicate with it though this is often difficult to prove with images). As already mentioned, beware that neuromas and bursitis often coexist and appear to occur together much more frequently than expected by chance alone – suggesting common aetiological factors.

Morton’s neuromata are incompressible, less hypoechoic and it is often possible to visualise the normal afferent interdigital nerve with fusiform expansion around and inseparable from it at the point of maximal tenderness.

**Summary**

Ultrasound of the forefoot is a quick and rewarding test but a variety of differential diagnoses should always be considered. We recommend that you develop relationships with your referrers to fully understand their requirements and avoid inconclusive reports without a suggestion of any additional appropriate imaging.

**Figure 4**

Single handed technique for scanning the intermetatarsal space using a 15MHz hockey stick probe.