Learning Objectives

-To understand pathophysiology and etiology of Morton's neuroma.

-To demonstrate usefulness of ultrasound as an alternative to magnetic resonance imaging for diagnosis of Morton's neuroma.

-To illustrate essential sonographic techniques employed in diagnosis and imaging-guided therapy of Morton's neuroma.

Background

Health care suffers from a pandemic disease - economic crisis. This "disease" will undoubtedly affect medicine practice around the world and will manifest itself, among other things, in necessity of cutting expenses. In radiology, the attention is being drawn toward less expensive (yet still highly sensitive and specific) diagnostic modalities such as ultrasound. Musculoskeletal ultrasound in particular gains prominence as an important diagnostic tool, which may serve as an alternative to magnetic resonance imaging (MRI) in a wide variety of cases, including Morton's neuroma.

Definition:

Morton's neuroma is a painful non-neoplastic lesion of the plantar digital nerve, most commonly found in the third or second intermetatarsal space.

Etiology, pathophysiology and patient's presentation:

"Morton's neuroma" is a misnomer, since the lesion is not a true nerve neoplasm. The nerve enlargement occurs as a reaction to repetitive trauma and/or entrapment of the nerve, resulting in ischemia, subsequent axonal degeneration, and attempted repair by means of perineural fibrosis and vascular proliferation [1]. The collection of fibrous and vascular tissue around the nerve manifests itself as a mass known as Morton's neuroma.

Among the predisposing factors, the most common are high-heeled and/or narrow-toed shoes [2]. For this reason, middle-aged females with history of wearing such footwear are the population most commonly presenting with Morton's neuroma. Patients usually
present with metatarsalgia (pain localized to the metatarsals, especially the heads, and intermetatarsal spaces). It may radiate distally to the toes or proximally to the midfoot. The pain is aggravated by motion and alleviated by rest, with occasional paraesthesia or burning sensation.

**Differential diagnosis:**

Differential possibilities for metatarsalgia include, apart from Morton's neuroma: intermetatarsal bursitis, stress fracture, arthritis, Freiberg's infraction (avascular necrosis of metatarsal head), tenosynovitis, tendinopathy, tendon rupture, ganglion cyst, foreign body with or without granuloma, plantar plate injury (turf toe), less commonly - bony or soft tissue neoplasms [3]. Combination of clinical history, physical examination and radiologic studies helps differentiate between these diagnoses.

For example, Morton's neuroma should be a main differential consideration in a middle-aged female with history of wearing high-heel and/or narrow-toed shoes, presenting with intermetatarsal pain, and a Mulder’s sign on physical examination (a palpable click when pressure is applied to the sole of the foot and the metatarsals are squeezed together). When presentation is atypical, however, imaging correlation should be considered.

**Imaging investigation:**

Imaging is frequently essential not only for confirmation of presence of a neuroma in the clinical cases with atypical presentation but also for precise localization of a neuroma, for evaluation of presence of additional neuromas, for differentiation between a neuroma and a wide variety of its mimics, for planning of imaging-guided intervention, and for guidance of intervention itself (injection of neuroma with corticosteroids, alcohol or other sclerosing agents). Best imaging options are ultrasound and MRI.

**Treatment:**

Multiple treatment options are available for Morton's neuroma, ranging from noninvasive (pain management, anti-inflammatory medications such as non-steroidal anti-inflammatory drugs (NSAIDs), shoes adjustment with supination or pronation insoles [4]), minimally invasive (ultrasound-guided injection of corticosteroids, alcohol or other sclerosing agents), to invasive (surgical excision or nerve transposition). There is no current consensus as to what is the optimal or definitive treatment option. Clinical evidence suggests that stepped treatment, starting with conservative low cost/less invasive options and, for cases that fail non-surgical measures, resorting to higher cost/more invasive therapy, as suggested by Schreiber et al. [5].
Advantages of ultrasound in diagnosis of Morton’s neuroma (compared to MRI):

1. Excellent sensitivity, especially for diagnosis of small neuromas (less than 5 mm) (as reported by Fazal et al., sensitivity of ultrasound is 96% vs. MRI - 88% [6]. Lee et al. report ultrasound sensitivity reaching 95-98% [7]).
2. Patient's comfort.
3. Financial benefits (ultrasound being considerably cheaper than MRI).
4. Time benefits (high quality ultrasound examination can be performed faster than MRI).
5. Possibility of dynamic imaging (sonographic Mulder's maneuver [8]) to increase visibility of a neuroma and to directly correlate sonographic findings with patient's symptoms.
6. Possibility to readily examine the contralateral foot to differentiate pathologic findings from normal anatomic variations or to detect concurrent contralateral neuromas.
7. Possibility to administer therapy (neuroma injection) in expedient fashion, at the same time as making the diagnosis.
8. No necessity to administer intravenous contrast.
9. Possibility to easily detect some of the other etiologies (mimics) of metatarsalgia (such as e.g. small foreign bodies - which may be overlooked on MRI, although sensitivity of detection of intermetatarsal bursitis by ultrasound and MRI is probably equal).

Imaging Findings OR Procedure Details

Examination technique:

Figures 1-6 (choice of probe, patient’s position, probe orientation, sonographic Mulder’s maneuver)

Typical sonographic appearance of Morton's neuroma:

Figures 7-9 (transverse image, transverse image with sonographic Mulder's maneuver, sagittal image)

Other pathologic entities that may mimic presentation of Morton's neuroma and can be detected on ultrasound examination:
Figures 10-16 (intermetatarsal bursitis, plantar fibroma, plantar wart, flexor tenosynovitis, MTP synovitis/ capsulitis, foreign body, adventitious bursitis)

**Example of MR-occult neuroma detected on ultrasound:**

Figures 17-19 (ultrasound and MR images)

**Ultrasound-guided treatment of Morton's neuroma:**

Figures 20-21

**Images for this section:**
Fig. 1: Sonographic examination of the forefoot is preferrably performed with the small footprint linear array ("hockey stick") transducer probe (frequency 10-15 MHz).
**Fig. 2:** Patient is placed on the examination table in prone position. A wedge is placed under the patient's ankle.
Fig. 3: Ultrasound examination is usually performed from the plantar aspect of the foot. Dorsal examination can be performed for larger lesions or during intervention (neuroma injection).
**Fig. 4:** The area of interest (symptomatic intermetatarsal space) is initially examined in transverse plane, with the probe perpendicular to the long axis of metatarsals.
**Fig. 5:** Sonographer can use the nonimaging hand to perform the sonographic Mulder's maneuver by firmly grasping the dorsal aspect of patient's foot and squeezing the metatarsals together, while applying pressure with the ultrasound probe from the plantar aspect of the foot.
Fig. 6: Examination in sagittal plane (without and with sonographic Mulder's maneuver), with the probe oriented along the long axis of the metatarsals, is then performed for confirmation of the findings detected in transverse plane and to measure the longitudinal extent of the neuroma.
**Fig. 7:** Morton's neuroma. 71-year-old female with foot plantar pain. Ultrasound examination of the plantar aspect of the right 3rd intermetatarsal space in transverse plane demonstrates a solid hypoechoic mass protruding between the heads of the 3rd and 4th metatarsals (arrow).
**Fig. 8:** Morton's neuroma for the same patient in figure 7. Transverse plane examination. Utilization of sonographic Mulder's maneuver (MM) allows the Morton's neuroma to protrude further towards the probe and increases its conspicuity (arrow). Emergence of neuroma from between the metatarsal heads during the maneuver is frequently associated with a palpable or audible "click".
**Fig. 9:** Morton's neuroma. Sagittal plane examination of the plantar aspect of the right 3rd intermetatarsal space is performed by slowly moving the probe between the heads of the 3rd and 4th metatarsals (arrow). It confirms presence of a solid hypoechoic mass (Morton's neuroma), allows better delineation and measurement of its longitudinal extent.
Fig. 10: Intermetatarsal bursitis. 48-year-old female with foot plantar pain. Ultrasound examination of the plantar aspect of the left 2nd intermetatarsal space in transverse plane demonstrates hypoechoic material with mobile internal echoes (thus fluid rather than solid material) protruding between the heads of the 2nd and 3rd metatarsals during application of sonographic Mulder’s maneuver (arrow).
**Fig. 11:** Plantar fibroma. 27-year-old female with plantar foot pain. Ultrasound examination of the plantar aspect of the right 3rd intermetatarsal space in transverse plane demonstrates solid superficial hypoechoic- to - isoechoic mass (long thin arrow) contiguous with plantar aponeurosis (short thick arrow).
Fig. 12: Plantar wart (verruca). 41-year-old male with plantar foot pain and skin induration. Ultrasound examination of the plantar aspect of the right 1st intermetatarsal space in transverse plane demonstrates superficial fusiform lesion with posterior through-transmission broadly based against the skin (arrow).
**Fig. 13:** Plantar flexor tenosynovitis. 76-year-old female with plantar and dorsal forefoot pain. Ultrasound examination of the plantar aspect of the 2nd intermetatarsal space in transverse plane demonstrates fluid in the tendon sheath of the 2nd flexor tendon (arrow).
Fig. 14: Dorsal 2nd MTP synovitis/ capsulitis. Same patient in figure 13. Ultrasound examination of the dorsal aspect of the 2nd MTP joint in sagittal plane demonstrates 2nd MTP capsular thickening, heterogeneity and hypervascularity on power Doppler imaging (arrow), suggestive of capsulitis and synovitis, concerning for inflammatory arthritis, particularly in the setting of concurrent flexor tenosynovitis (see figure 13).
Fig. 15: Wooden foreign body (splinter). 63 year-old female status post removal of a splinter from the left foot, with persistent focal plantar pain and no radio-opaque foreign body seen on radiograph. Ultrasound examination demonstrates linear hyperechoic structure in the subcutaneous tissues (arrow) consistent with a retained foreign body.

Fig. 16: Adventitious bursitis. 67-year-old female with left foot plantar pain. Ultrasound examination of the plantar aspect of head of the 2nd metatarsal in transverse plane (arrows) demonstrates complex subcutaneous fluid collection with thick capsule, and no abnormal vascularity seen on Doppler imaging, consistent with chronic, partially fibrosed, adventitious bursitis.
Fig. 17: MR-occult Morton's neuroma. 65-year-old male with left foot plantar pain. MRI demonstrated intermetatarsal bursitis but no neuroma. Ultrasound examination of the 2nd intermetatarsal space in transverse and sagittal planes reveals, apart from compressible anechoic intermetatarsal fluid (known bursitis), a small solid noncompressible lesion, best seen with Mulder’s maneuver and associated with a palpable click, consistent with Morton’s neuroma (arrow).
Fig. 18: Short axis T2 weighted fat suppressed images of the left forefoot of the same patient in figure 17. Mild-to-moderate intermetatarsal bursitis, somewhat atypically extending between plantar aspects of metatarsal heads (arrow) with no definite neuroma.
**Fig. 19:** Same patient in figures 17 and 18. Retrospective review of sagittal T1 weighted (left), short axis T1-weighted (middle) and post-contrast short axis T1 weighted fat suppressed (right) MR images demonstrates a very small and subtle T1 hypointense enhancing lesion between the plantar aspects of the 2nd and 3rd metatarsal heads (arrows), corresponding to Morton's neuroma seen on ultrasound. Morton's neuroma was obvious on ultrasound examination, especially with utilization of sonographic Mulder's maneuver, but was easily overlooked on MRI.

![Image](image1.png)

**Fig. 20:** Morton's neuroma injection. 66 year old female with severe pain in the plantar aspect of the right foot. Preliminary ultrasound examination of the 2nd intermetatarsal space confirms presence of a clinically suspected, very large Morton's neuroma, seen from both plantar (not pictured) and dorsal aspect (pictured) (arrows) of the forefoot, in transverse (left) and sagittal (right) planes.
Fig. 21: Morton’s neuroma injection for the same patient in figure 20. Dorsal approach is chosen for injection due to large size of neuroma and relatively easy access for needle placement between the toes. (Plantar approach can also be used but would require needle passage through a much thicker layer of the skin and callus). Sagittal plane is chosen for easier visualization of the long axis of the needle as it is advanced towards the neuroma. (Left) Using sterile technique, and after administration of local skin anesthesia, 25 gauge 3.5 inches long needle is advanced into of the center of neuroma under direct ultrasound guidance (arrows). (Right) Neuroma can be usually injected with a combination of corticosteroid (triamcinolone acetonide injectable suspension) and anesthetic (2% Lidocaine or 0.2% Ropivacaine), mixed 1:1. Sclerosing agents such as alcohol can also be utilized. The total volume of the injected agent(s) is usually 1-2 cc. Injection of the central portion of the neuroma is confirmed by appearance of echogenic air bubbles (with “dirty shadowing”) within the neuroma at the endpoint of injection (arrow).
Conclusion

Ultrasound is a highly accurate and easily utilized imaging modality for diagnosis of Morton's neuroma. Compared to MRI, it is a more sensitive, especially for smaller lesions, cheaper, less time-consuming and therefore more patient-friendly examination. Ultrasound has an important value in differential diagnosis of metatatarsalgia etiologies and in providing guidance for minimally invasive and effective therapy of Morton's neuromas.

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References


