Ultrasound of Lower Extremity Entrapment Neuropathies

Jon A. Jacobson, M.D.
Professor of Radiology
Director, Division of Musculoskeletal Radiology
University of Michigan

Outline
- Normal ultrasound appearance
- Entrapment syndromes
- Nerve trauma and transection neuromas
- Peripheral nerve sheath tumors

Disclosures
- Consultant: Bioclinica
- Advisor: Philips
- Book Royalties: Elsevier
- Not relevant to this talk

Note: all images from the textbook Fundamentals of Musculoskeletal Ultrasound are copyrighted by Elsevier Inc.
Outline
• Normal ultrasound appearance
• Entrapment syndromes
• Nerve trauma and transection neuromas
• Peripheral nerve sheath tumors

Nerve Compression
• Experimental model (rat, sciatic nv):
  – Compression causes ischemia
  – First pathologic change: edema
    • Correlated with severity of axonal injury
  – Mild compression: demyelination
  – Severe compression: axonal damage
  Powell, Laboratory Investigation 1986; 55:91

Nerve Entrapment
• US findings:
  – Nerve enlargement proximal to entrapment
    • Best appreciated transverse to nerve
  – Abnormally hypoechoic
    • Especially the connective tissue layers
  – Variable enlargement or flattening at entrapment site

Denervation
• Edema: hyperechoic
• Fatty degeneration:
  – Hyperechoic
  – Echogenic interfaces
• Atrophy:
  – Hyperechoic with decreased muscle size
  – Compare to other side!
  J Ultrasound Med 1993; 2:73

Denervation:
• Decreased muscle mass
• Hyperechoic
  – From fat replacement, not fibrosis
• If muscle completely replaced by fat
  – Hypoechoic
  J Ultrasound Med 1993; 2:73

Common Peroneal Nerve: entrapment
Extensor Musculature (Short Axis)
Nerve Entrapment Syndromes

- Peroneal:
  - Common peroneal
  - Superficial peroneal
- Tibial
- Interdigital (Morton neuroma)

Anatomy: common peroneal nerve

- Forms at bifurcation of sciatic nerve with tibial nerve (L4, L5, S1, S2)
- Courses posterior to biceps femoris and fibula, wraps around fibular neck divides:
  - Superficial: peroneal muscles, sensory
  - Deep branch: anterior compartment muscles
- Gives off:
  - Lateral sural cutaneous nerve
  - Articular branches (3)

Anatomy: lateral

From: Netter’s Atlas of Human Anatomy

Common Peroneal Nerve

- Entrapment
  - Between fibula and peroneus longus
  - Swollen, hypoechoic nerve
- Injury:
  - Direct trauma, laceration
  - Fibular fracture

Common Peroneal Nerve: entrapment
Common Peroneal Nerve: entrapment

Peroneal Nerve: impingement by exostosis

Denervation

Peroneal Intraneural Ganglion

Peroneal Intraneural Ganglion
Peroneal Intraneural Ganglia

From: Spinner et al.
Skeletal Radiol 2008;37:1091

From: Spinner et al.
Clin Anatomy 2007;20:826

Note: “signet ring” appearance

Peroneal Intraneural Ganglion

Fibula

>15 cm

Atrophy

Asymptomatic

Nerve Entrapment Syndromes

• Peroneal:
  – Common peroneal
  – Superficial peroneal

• Tibial

• Interdigital (Morton neuroma)
Ankle and Foot: Sensory Innervation

- SPN = superficial peroneal
- DPN: deep peroneal
- SN = sural nerve
- MCN = medial calcaneal
- LCN = lateral calcaneal
- MPN = medial plantar
- LPN = lateral plantar

Dorsal Plantar

Superficial Peroneal Nerve
- Branch of common peroneal nerve
- Sensory: dorsolateral foot and ankle
- Motor: collateral branches to peroneal muscles

Delfaut, RadioGraphics 2003; 23:613

Superficial Peroneal Nerve
- Pierces crural fascia of leg:
  - 9.2 cm proximal to fibular tip
  - Range: 6 to 16 cm proximal
  - Potential entrapment site
- Terminal branches: 6 cm proximal to fibular tip
  - Superficial to inferior extensor retinaculum

Canella, AJR 2009; 193:174

Muscle Hernia (extensor digitorum): superficial peroneal nerve entrapment

From Canella, AJR 2009; 193:174
Sural Nerve

Note sural nerve (arrow) centered within fat pad adjacent to lesser saphenous vein (V) and half way between peroneal tendons (PL/PB) and Achilles tendon (AT).

Sural Nerve: transection neuromas

Longitudinal

Transverse

Nerve Entrapment Syndromes

- Peroneal:
  - Common peroneal
  - Superficial peroneal
- Tibial
- Interdigital (Morton neuroma)

Tibial Nerve (TN)

- Bifurcates in tarsal tunnel (distal tibia)
  - Medial plantar nerve (MPN)
  - Lateral plantar nerve (LPN)
- Plantar nerves divide into interdigital nerves
  - Motor branches: muscles of sole of foot
  - Sensory: digits (via common and proper plantar digital nerves)

Martinoli, RadioGraphics 2000; 20:S199

Tibial Nerve (TN)

- Medial calcaneal nerve (MCN)
  - From TN 62%, trifurcation 18%, LPN 18%
  - Sensory: medial heel
- Inferior calcaneal branch
  - From LPN 81%, TN 12%, 6% TN + MCN
  - Motor: FDB, quadratus plantae, abductor digiti quinti
  - Sensory: long plantar ligament, ant calcaneal tubercle

Delfaut, RadioGraphics 2003; 23:613

TN = tibial nerve
MPN = medial plantar nerve
LPN: lateral plantar nerve
MCN = medial calcaneal nerve
ICN = inferior calcaneal nerve

**Inferior Calcaneal (Baxter) Nerve**

Location (green arrows) is plantar to the lateral plantar branch of the tibial nerve (LPN) in between abductor hallucis muscle (AH) and quadratus plantae (QP)


---

**Tarsal Tunnel Syndrome**

- Entrapment of tibial nerve
  - Ganglion cyst: most common
  - Varicose veins, tenosynovitis
  - Trauma, deformity, coalition, idiopathic
- Tibial nerve:
  - May appear normal
  - May be hypoechoic and swollen

Nagaoka, J Ultrasound Med 2005;24:1035

---

**Tarsal Tunnel: tibial nerve**

- Medial, lateral plantar nerve and medial calcaneal nerve branches

---

**Tibial Nerve:**

Axial

Sagittal

Nagaoka, J Ultrasound Med 2005;24:1035
Ganglion Cyst

Ganglion Cyst: tarsal tunnel syndrome

Medial plantar nerve impingement from ganglion cyst originating from middle facet of anterior subtalar joint

Tarsal Tunnel Syndrome: Varices

Nerve Entrapment Syndromes

- Peroneal:
  - Common peroneal
  - Superficial peroneal
- Tibial
- Interdigital (Morton neuroma)

Morton Neuroma:

- Interdigital nerve entrapment
- Edema, fibrosis, necrosis
- 3rd intermetatarsal space > 2nd
- Sharp, burning pain from metatarsal head to toes
- Females: pliable foot, high-heeled narrow-toed shoes


Morton Neuroma

- Hypoechoic 5 mm mass
  - Sensitivity: 100% ; Specificity: 83%
  - Accuracy equal to MRI
  - Nerve continuity: sagittal plane
- Intermetatarsal bursa
  - Associated with neuroma
  - "Neuroma-bursal complex"

Quinn T et al. AJR 2000; 174:1723
Technique:
• Interdigital space
  – Transducer:
    • Plantar
    • Dorsal
  – Normal digital nerve difficult to visualize
  – Correlate with symptoms

Interdigital Space

Morton Neuroma

Morton Neuroma: nerve continuity

Morton Neuroma

Courtesy of Mark Murphy, MD
Dynamic Evaluation

- Compression
  - Between transducer and palpation
  - Bursae (dorsal) compress, neuromas (plantar) do not
- Sonographic Mulder Sign
  - Scan plantar: coronal plane
  - Neuroma displaces: plantar
  - Palpable click

Torlani M et al. AJR 2003; 180:1121
Zanetti M et al. Radiology 1997; 203:516

Dynamic imaging: Mulder's Maneuver

Dynamic: Morton Neuroma + Bursa

Morton Neuroma + Bursa

Outline

- Normal ultrasound appearance
- Entrapment syndromes
- Nerve trauma and transection neuromas
- Peripheral nerve sheath tumors
**Outline**
- Normal ultrasound appearance
- Entrapment syndromes
- Nerve trauma and transection neuromas
- Peripheral nerve sheath tumors

**Peripheral Nerve Sheath Tumor**
- **Benign:**
  - Schwannoma (neurilemoma)
  - Solitary, <5 cm, flexor surfaces
  - Neurofibroma: 3 forms
    - Localized: 90%, painless, < 5 cm
    - Diffuse: subcutaneous, 90% associated with NF1
    - Plexiform: associated with neurofibromatosis
- **Malignant**

Murphy MD, RadioGraphics 1999; 19:1253

**Peripheral Nerve Sheath Tumor**
- Hypoechoic mass
- Nerve continuity (most important)
- Posterior acoustic enhancement
  - Possible pseudocyst appearance
- Neurofibroma
  - Central, fusiform, lobular, and avascular
- Schwannoma
  - Eccentric, possible calcifications, cystic

Reynolds D et al. AJR 2004; 182:741

---

**Schwannoma: radial nerve branch**

Humerus

Longitudinal
Schwannoma

Note: increased through-transmission

Schwannoma: deep peroneal nerve branch

Longitudinal

color Doppler

Ancient Schwannoma

Neurofibroma: deep branch of radial nerve

Transverse

Longitudinal

Neurofibroma: deep branch of radial nerve

Peripheral Nerve Sheath Tumors

Schwannoma: Tibial Nerve

Plexiform Neurofibroma: Tibial Nerve
Neurofibromatosis

Localized Plexiform

Neurofibroma: diffuse

Subcutaneous, hyperechoic, interconnecting hypoechoic tubular or nodular structures, vascular

Chen W, J Ultrasound Med 2007; 26:513

Malignant Peripheral Nerve Sheath Tumor

- Hypoechoic
- Heterogeneous
- Variable blood flow
- 25 -70%: NF 1 or prior radiation
- Rapid growth or increased pain

Take Home Points

- Each nerve has select locations
- Fibro-osseous canals
- Common locations for entrapment
- Image entire limb regardless

See www.jacobsonmskus.com for syllabus and other educational material