

# Peripheral Nerve Pathology: Lower Extremity

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## Disclosures

- Consultant: Bioclinica
- Book Royalties: Elsevier
- Not relevant to this lecture

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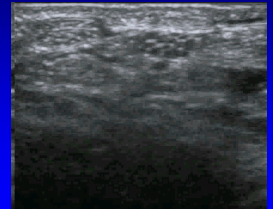
## Outline

- Peripheral nerve entrapment
  - Common and superficial peroneal
  - Tibial
  - Interdigital
- Peripheral nerve sheath tumors

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## Normal Peripheral Nerve

- Ultrasound appearance:
  - Hypoechoic nerve fascicles
  - Hyperechoic connective tissue
- Transverse:
  - Honeycomb appearance



Silvestri et al. Radiology 1995; 197:291

Median Nerve

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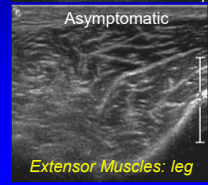
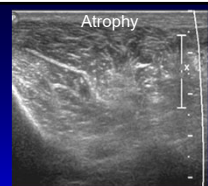
## Nerve Entrapment

- 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

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## Denervation

- Edema: hyperechoic
- Fatty degeneration:
  - Hyperechoic
  - Echogenic interfaces
- Atrophy:
  - Hyperechoic with decreased muscle size
- Compare to other side!



J Ultrasound Med 1993; 2:73

Extensor Muscles: leg

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## Nerve Entrapment Syndromes

- Peroneal:
  - Common peroneal
  - Superficial peroneal
- Tibial
- Interdigital

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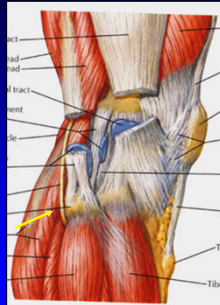
## Anatomy: common peroneal nerve

- 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)

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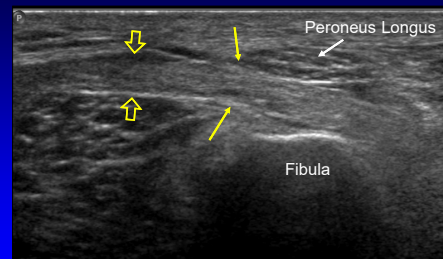
## Common Peroneal Nerve

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



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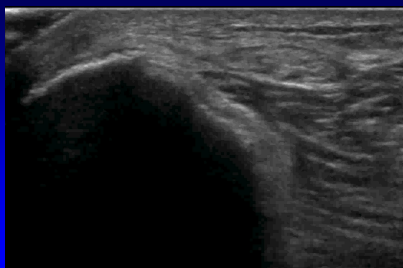
## Common Peroneal Nerve: entrapment



Long Axis

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## Common Peroneal Nerve: entrapment



Long Axis

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## Peroneal Intraneural Ganglion

- Pain: knee or peroneal nerve distribution
  - Possible palpable mass, fluctuating course
- 18% of those with foot drop<sup>1</sup>
- No identifiable etiology
  - Weight loss, trauma, leg crossing
- High body mass index<sup>2</sup>
  - Unlike other causes for peroneal neuropathy

<sup>1</sup>Visser et al. Neurology 2006; 67:1473  
<sup>2</sup>Young et al. Neurology 2009; 72:447

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### Peroneal Intraneural Ganglion

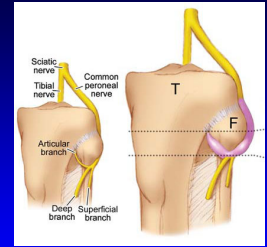
- Joint fluid from proximal tibiofibular joint
  - Enters peroneal nerve via articular nerve branches
  - Shown at MR arthrography after exercise
  - Extends proximal via epineurial sheath<sup>1</sup>
- May also form via tibial nerve<sup>2</sup>

<sup>1</sup>Spinner et al. Clin Anatomy 2007; 20:826  
<sup>2</sup>Spinner et al. Skeletal Radiol 2006; 35:172

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### Peroneal Intraneural Ganglion

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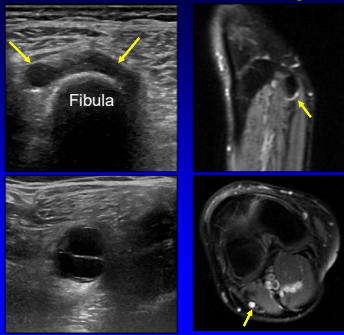


From: Spinner et al. Skeletal Radiol 2008;37:1091

Spinner et al. Clin Anatomy 2007; 20:826

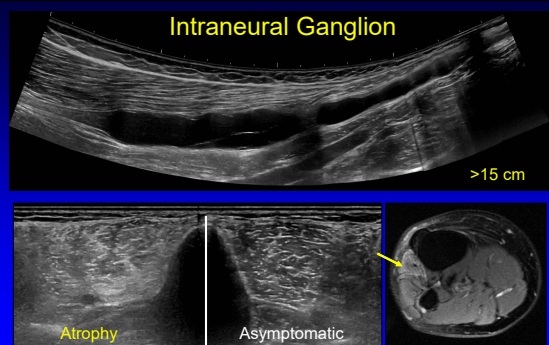
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### Peroneal Intraneural Ganglion



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### Intraneural Ganglion



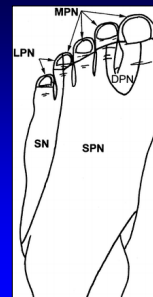
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### Nerve Entrapment Syndromes

- Peroneal:
  - Common peroneal
  - Superficial peroneal
- Tibial
- Interdigital

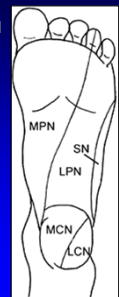
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### Ankle and Foot: Sensory Innervation



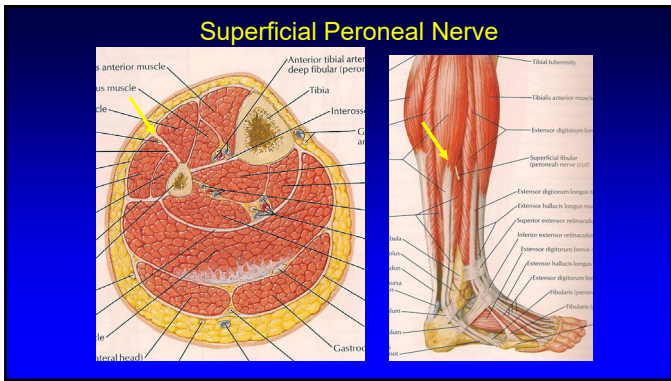
Dorsal

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



Plantar

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### 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

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### Muscle Hernia (extensor digitorum): superficial peroneal nerve entrapment

Longitudinal

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### Nerve Entrapment Syndromes

- Peroneal:
  - Common peroneal
  - Superficial peroneal
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### 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

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

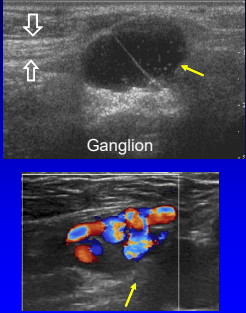
From: Louisia, Surgical and Radiologic Anatomy, 1999; 21:169.

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### Tarsal Tunnel Syndrome

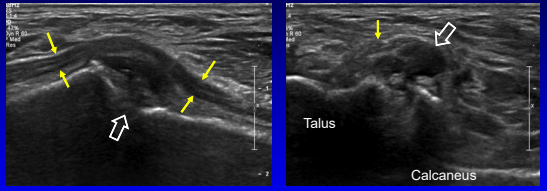
- Entrapment of tibial nerve
  - Ganglion cyst: most common
  - Varicose veins, tenosynovitis
  - Trauma, deformity, coalition, idiopathic
- Tibial nerve:
  - May appear normal
  - May be hypoechoic and swollen

Nagaoka, J Ultrasound Med 2005;24:1035



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### Ganglion: tarsal tunnel syndrome



Long Axis      Short Axis

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

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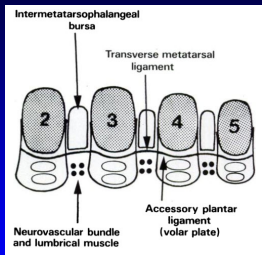
### Nerve Entrapment Syndromes

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### Anatomy

- At level of metatarsal heads:
  - Transverse metatarsal ligament
    - Attaches to plantar plates
  - Intermetatarsal bursa: dorsal
  - Neurovascular bundle: plantar




Zanetti M et al. Radiology 2014; 203:516

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### Interdigital Neuroma

- Common plantar digital nerve entrapment
- Edema, fibrosis, necrosis
- 3<sup>rd</sup> intermetatarsal space > 2<sup>nd</sup>
- Sharp, burning pain to toes
- Females: pliable foot, high-heeled, narrow-toed shoes
- Asymptomatic neuromas in up to 33%
- Neuromas < 5 mm mediolateral: **often asymptomatic**



Zanetti M et al. Radiology 1997; 203:516

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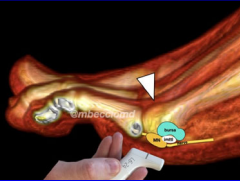
### Neuromas: eponyms

- Medial to first metatarsal: Joplin
- 1<sup>st</sup> webspace: Heuter
- 2<sup>nd</sup> webspace: Hauser
- 3<sup>rd</sup> webspace: **Morton**
- 4<sup>th</sup> webspace: Iselin

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### Interdigital Nerve

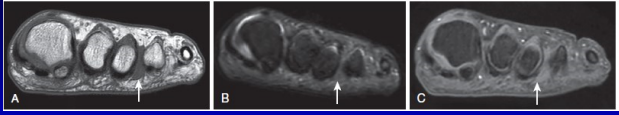
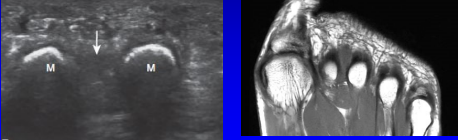
- Pathophysiology:
  - Neuroma forms where common plantar digital nerve passes distal around transverse metatarsal ligament at distal metatarsal heads
  - Note: intermetatarsal bursa is more dorsal and more proximal at level of intermetatarsal ligament



From: youtube @mbecciomd

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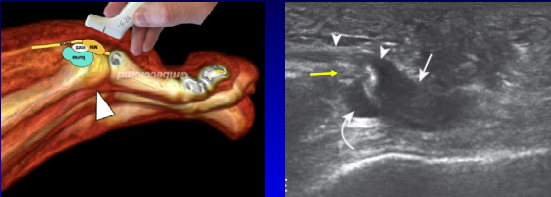
### Intermetatarsal Neuroma

Note: location of neuroma located plantar extending beyond metatarsal heads

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### Intermetatarsal Neuroma




Note: neuroma is at distal edge of intermetatarsal ligament  
 White arrow: neuroma  
 Arrowheads: interdigital nerve  
 Curved arrow: intermetatarsal bursa  
 Yellow arrow: intermetatarsal ligament

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### Ultrasound Evaluation

- #1: plantar, short axis
  - With dorsal compression
- #2: plantar, long axis
  - With dorsal compression
- #3: Mulder maneuver
  - With side-to-side compression

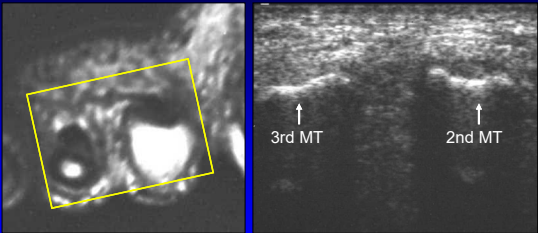


\*Neuroma of 5 mm or larger: 100% sensitivity, 83% specificity

Redd et al. Radiology 1989; 171:415  
 Quinn et al. AJR 2000; 174:1723

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### Interdigital Space: normal

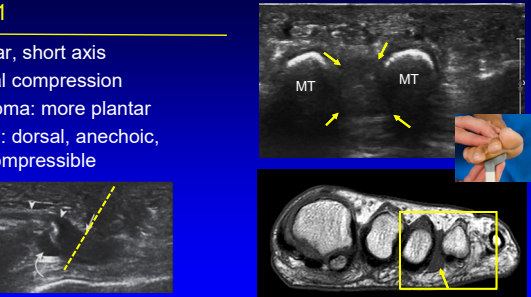


Short Axis to Metatarsals

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### Step #1

- Plantar, short axis
- Dorsal compression
- Neuroma: more plantar
- Bursa: dorsal, anechoic, compressible



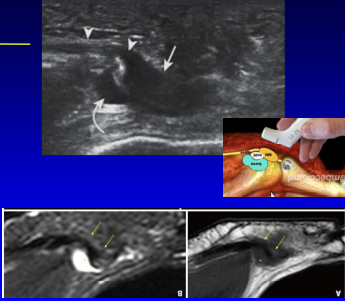
Note: coronal-oblique plane moving distal to metatarsal heads

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### Step #2

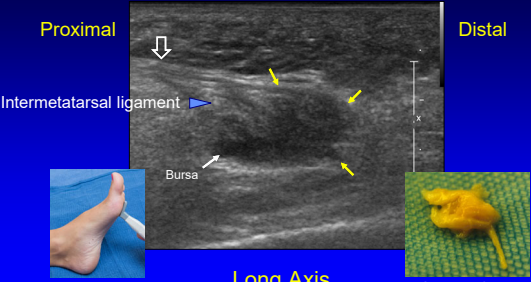
- Plantar, long axis
  - Follow MT head curvature
- Dorsal compression
  - Move finger distal, proximal
  - See neuroma sliding over intermetatarsal ligament
- Neuroma: plantar, distal
- Bursa: curved arrow
  - Dorsal, proximal
  - Anechoic, compressible



MRI flipped upside down to simulate US

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### Neuroma: nerve continuity (white open arrow)



Proximal Distal

Intermetatarsal ligament

Bursa

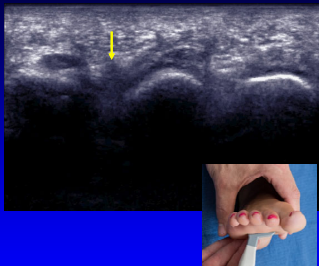
Long Axis

Courtesy of Mark Murphey, MD

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### Step #3: Mulder's maneuver

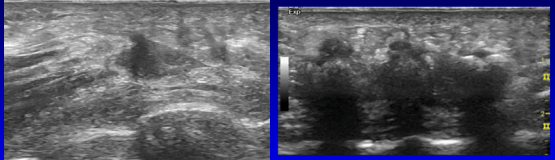
- Transducer: plantar, short axis
- Squeeze foot side-to-side
- Neuroma moves plantar
  - Palpable click, elicits symptoms
  - Important to document
  - Improved accuracy, measurements
- Make sure to perform distal to intermetatarsal ligament
- Bursa: remains dorsal



Torriani M et al. AJR 2003; 180:1121

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### Dynamic: Interdigital Neuroma + Bursa

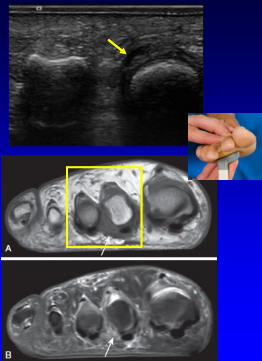


Dorsal Mulder's Maneuver

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### Differential Diagnosis

- Pericapsular fibrosis
- Associated with capsule injury
- Hypoechoic
- Eccentric
- Not truly intermetatarsal
- Negative Mulder's maneuver



Umans H et al. Skeletal Radiol 2014

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### Neural Tumors

- Peripheral nerve sheath tumors
- Benign:
  - Schwannoma (or neurilemmoma)
  - Neurofibroma
- Malignant peripheral nerve sheath tumor

Murphey et al. Radiographics 1999; 19:1253

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### Peripheral Nerve Sheath Tumors

- Schwannomas and neurofibromas appear similar at ultrasound
- Well-defined fusiform mass
- Hypochoic, internal low level echoes
- Peripheral nerve: entering and exiting
  - Split fat sign
  - Schwannoma: may be eccentric to nerve

Reynolds et al. AJR 2004; 182:741

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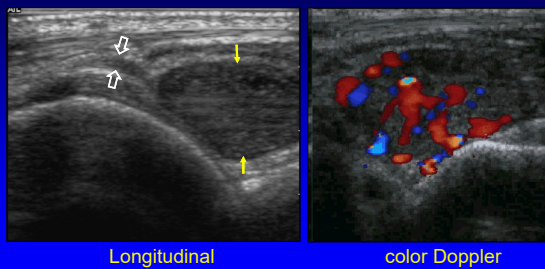
### Schwannoma

- Benign peripheral nerve sheath tumor
- Presents: ages of 20 – 30 years
- Usually solitary
- Multiple: schwannomatosis
- Associated with neurofibromatosis Type I
- Histology: Antoni A and B regions

Murphey et al. Radiographics 1999; 19:1253

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### Schwannoma: deep peroneal nerve branch



Longitudinal

color Doppler

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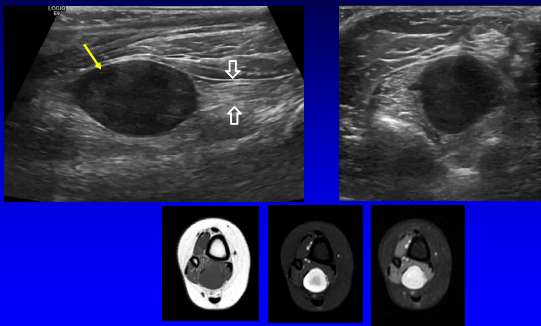
### Neurofibroma: 3 forms

- Localized:
  - Less than 5 cm, painless
- Plexiform:
  - Diffuse nerve trunk involvement
- Diffuse:
  - Dermal and subcutaneous thickening
- Neurofibromatosis Type I:
  - Dermal neurofibromas, café-au-lait spots

Murphey et al. Radiographics 1999; 19:1253

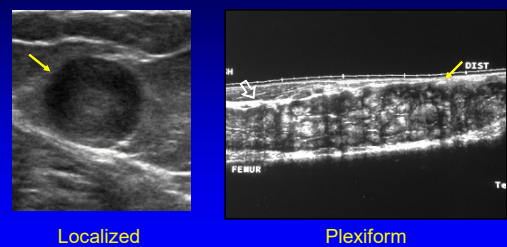
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### Neurofibroma: tibial nerve



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### Neurofibromatosis

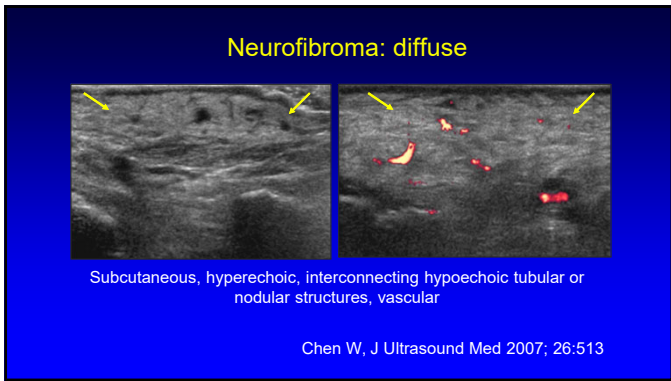


Localized

Plexiform

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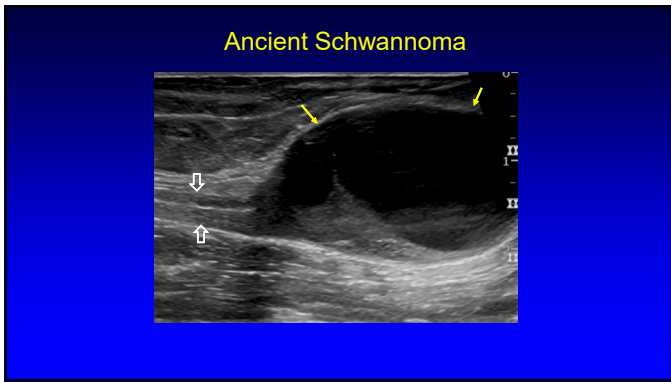
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### Peripheral Nerve Sheath Tumors

- Increased posterior through-transmission:
  - Simulate a complex cyst
- Hyperemia (unlike a cyst)
- Schwannomas may be heterogeneous:
  - Cystic: “ancient schwannoma”
- Target appearance:
  - Echogenic fibrous center
  - Peripheral hypoechoic mucinous rim

Reynolds et al. AJR 2004; 182:741

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### Malignant Peripheral Nerve Sheath Tumor

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

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### Take Home Points

- Resolution better than MRI
- Evaluate entire limb efficiently
- Easy comparison to contralateral side
- Direct correlation: signs and symptoms
- Dynamic imaging

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Thank you!

Syllabus on line and other educational material:  
[www.jacobsonmskus.com](http://www.jacobsonmskus.com)

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