

Ultrasound of Peripheral Nerve Entrapment

Jon A. Jacobson, M.D.

FACR, FAIUM, FSRU, RMSK

Musculoskeletal Radiologist
Ann Arbor, Michigan, USA

1

Disclosures

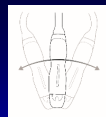
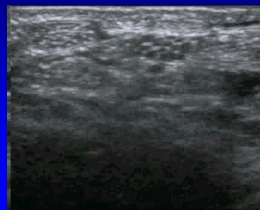
- Book Royalties: Elsevier
- Consultant: Bioclinica
- Medical Director: POCUSPRO
- Not relevant to this talk

Syllabus on line and other educational material:
www.jacobsonmskus.com

2

Normal Peripheral Nerve

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



Silvestri et al. Radiology 1995; 197:291

Median Nerve

3

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

4

Nerve Entrapment

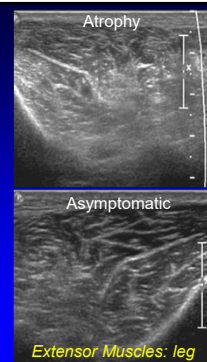
- US findings:
 - Nerve enlargement proximal to entrapment
 - Best appreciated transverse to nerve
 - Abnormally hypoechoic
 - Especially the connective tissue layers
 - Variable enlargement or flattening at entrapment site

5

Denervation

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

J Ultrasound Med 1993; 2:73



6

Nerve Entrapment Syndromes

- Median:
 - Carpal tunnel syndrome
 - Pronator teres syndrome
- Ulnar:
 - Ulnar tunnel syndrome
 - Cubital tunnel syndrome

7

Carpal Tunnel Syndrome:

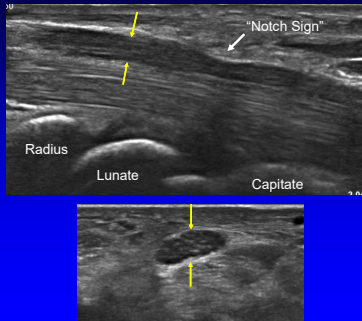
- Proximal median nerve swelling
 - Area: circumferential trace
 - Normal: $< 9 \text{ mm}^2$
 - Borderline: $9 - 12 \text{ mm}^2$
 - Abnormal: $> 12 \text{ mm}^2$
 - 12.8 mm^2 = moderate (83% sens, 95% spec)
 - 14.0 mm^2 = severe (77% sens, 100% spec)



Klauser AS et al. Sem Musculoskel Rad 2010; 14:487
Ooi et al. Skeletal Radiol 2014; 43:1387

8

Carpal Tunnel Syndrome



9

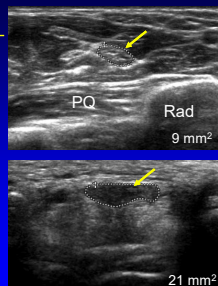
Median Nerve: how to measure

- Short axis
- Toggle transducer: defined borders
- Site of maximal enlargement
- Circumferential trace
- Inner border of hyperechoic epineurium

10

Carpal Tunnel Syndrome

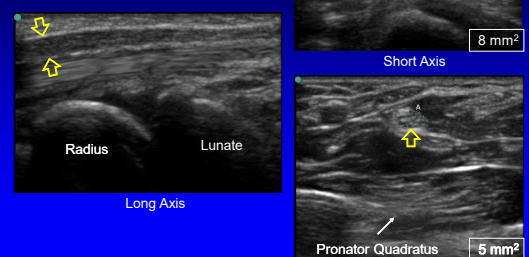
- Compare areas:
 - Proximal: pronator quadratus
 - Distal: carpal tunnel
- $\geq 2 \text{ mm}^2$ = carpal tunnel syndrome
- 99% sensitivity
- 100% specificity



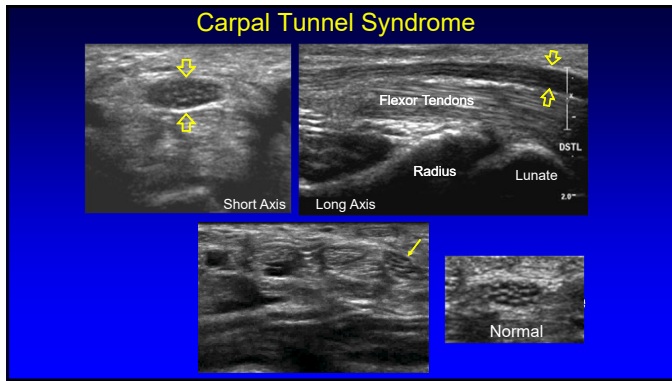
Klauser AS. Radiology 2009; 250:171

11

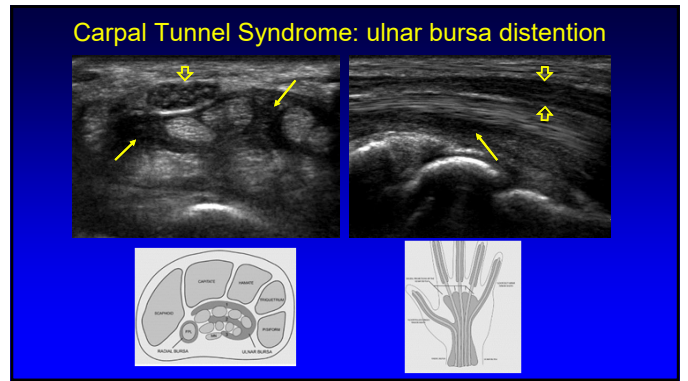
Carpal Tunnel Syndrome



12



13



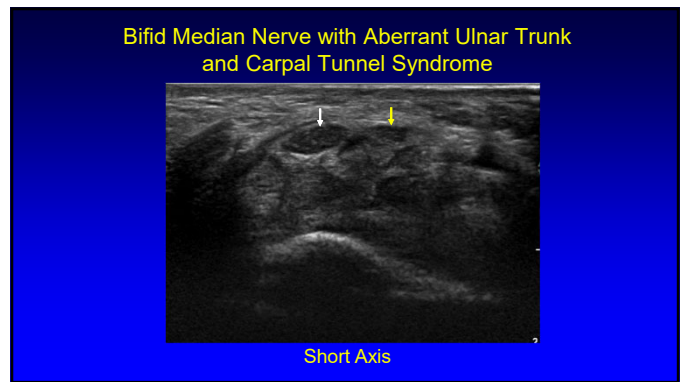
14

Bifid Median Nerve + CTS

- Carpal tunnel syndrome¹
 - Increase in cross-sectional area of $\geq 4 \text{ mm}^2$
- Intraneural hypervascularity: 95% accuracy in diagnosis of CTS²

¹Klauser et al. Radiology 2011; 259: 808
²Mallouhi et al. AJR 2006; 186:1240

15



16

Persistent Median Artery

- Incidence: 10 – 20%: most with bifid median nerve

Gassner EM *et al.* JUM 2002; 21:455c

17

Postoperative Carpal Tunnel

- Discontinuous or thickened transverse carpal ligament
- Anterior displacement of transverse carpal ligament¹
- Median nerve size:
 - May decrease²
 - Does not correlate with success³

¹Lee CH *et al.* Ann Plast Surg 2005; 54:143
²Abicalaf CA *et al.* Clin Radiol 2007; 62:891
³Naranjo A *et al.* Scand J Rheum 2010; 39:49

18

Failed Carpal Tunnel Release

Transverse

Sagittal

- Thickened transverse carpal ligament (white arrows)
- Persistent median nerve enlargement (yellow arrows)

19

Nerve Entrapment Syndromes

- Median:
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- Ulnar:
 - Ulnar tunnel syndrome
 - Cubital tunnel syndrome

20

Pronator Teres Syndrome

- Median nerve compression between humeral and ulnar heads
- Trauma, congenital, pronator teres hypertrophy
- Rare
- Forearm pain, numbness, weakness

Jacobson JA, et al. Semin Musculoskeletal Rad 2010; 14:473

PT-h

PT-u

21

Nerve Entrapment Syndromes

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 - Ulnar tunnel syndrome
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22

Guyon's Canal:

- Ulnar tunnel syndrome
 - Ulnar nerve compression
 - Accessory Abductor Digiti Minimi¹
 - Variant: up to 24% of wrists
- Hypothenar hammer syndrome²
 - Trauma
 - Ulnar artery thrombosis + distal emboli

¹AJR 1999; 172:1397

²J Vasc Surg 1987; 5:838

23

Accessory Abductor Digiti Minimi

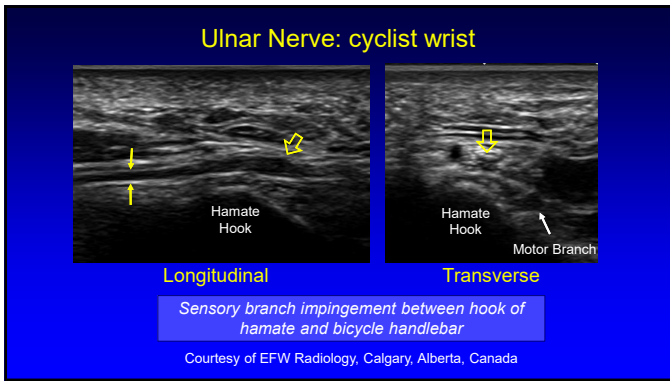
- Normal variant: 24%
- Origin: palmaris longus, flexor retinaculum, fascia
- Insertion: abductor digiti minimi
- Superficial to ulnar nerve:
 - Nerve compression
 - Uncommonly interposed

Ulnar Nerve

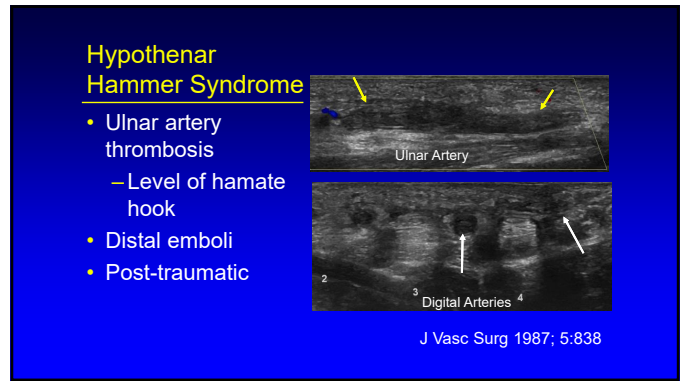
Ulnar Nerve

Timins et al. AJR 1999; 172:1397

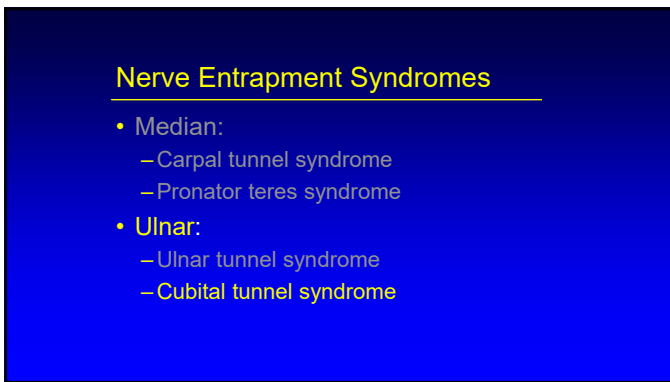
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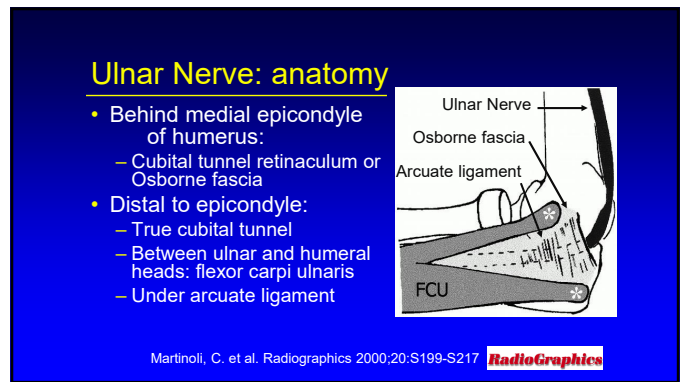
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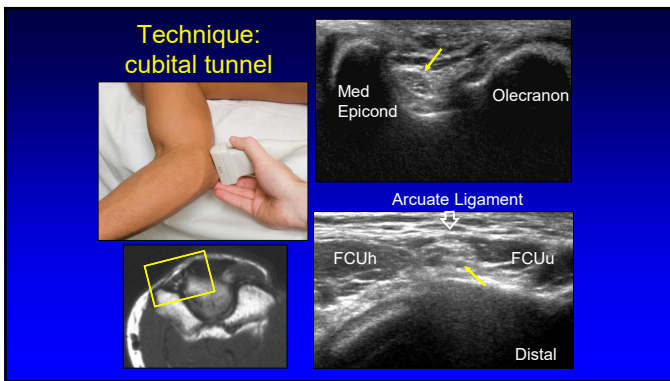
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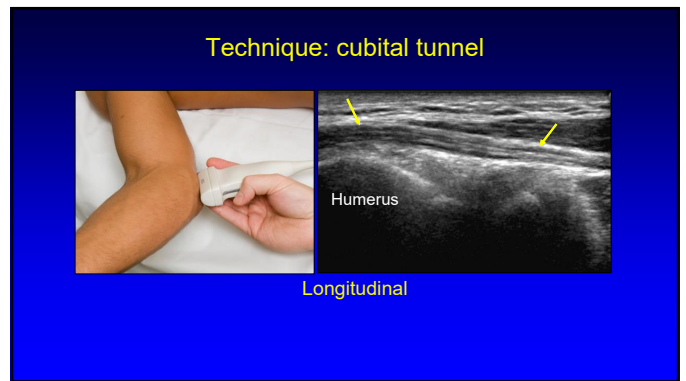
27



28



29



30

Ulnar Nerve: cubital tunnel syndrome

- Hypoechoic and enlarged
 - > 9 mm² area¹
 - 2.8x area compared to proximal²
- Mild hypoechoogenicity alone: may be normal
- Causes:
 - Idiopathic, overuse, joint process
 - Anconeus epitrochlearis: compression
 - Normal variant accessory muscle

¹Thoirs K et al. J Ultrasound Med 2008; 27:737
²Yoon JS et al. Muscle Nerve 2008; 38:1231

31

Anconeus Epitrochlearis

32

Isolated Ulnar Nerve Dislocation

Okamoto, J Hand Surg 2000; 25B:85

*Asymptomatic finding in 20%

33

Snapping Triceps Syndrome

- Ulnar nerve and medial triceps dislocate over apex of medial epicondyle
- Ulnar nerve and medial triceps remain in contact with each other
- Palpable snap felt through transducer

Jacobson JA et al. Radiology 2001; 220:601

34

Nerve Entrapment Syndromes

- Radial:
 - Posterior interosseous nerve syndrome
 - Wartenberg syndrome
 - Superficial sensory branch radial nerve
- Suprascapular: paralabral cyst

35

Radial tunnel

- Radial nerve: deep branch
 - Originates from radial nerve between brachioradialis and brachialis
 - Passes between deep and superficial layers of supinator muscle
 - Exits as posterior interosseous nerve

Jacobson JA, et al. Sem Musculoskel Rad 2010; 14:473

36

Radial Nerve: deep branch

- Supinator syndrome:
 - Motor deficits (wrist, finger extension)
 - Abnormal electrodiagnostic studies
 - Nerve enlargement: entrapment
- Radial tunnel syndrome:
 - Pain, no motor deficits, normal EMG
 - Muscle denervation on MRI
 - No nerve enlargement

Ferdinand BD et al. Radiology 2006; 240:161

37

Nerve Entrapment Syndromes

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 - Wartenberg syndrome
 - Superficial sensory branch radial nerve
- Suprascapular: paralabral cyst

38

Wartenberg Syndrome

Superficial branch of radial nerve

Transverse

39

Wartenberg Syndrome

- Superficial branch of radial nerve
 - Sensory branch
 - Crosses over distal radius and first wrist compartment
- Entrapment
- Injury: direct trauma, iatrogenic

40

Nerve Entrapment Syndromes

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- Suprascapular: paralabral cyst

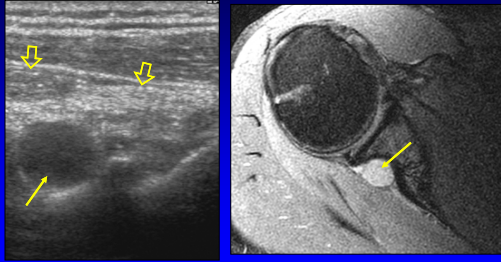
41

Labral Cyst:

- Most associated with labral tear
- Suprascapular notch:
 - Supraspinatus and infraspinatus atrophy
- Spinglenoid notch:
 - Infraspinatus atrophy
- US guided aspiration

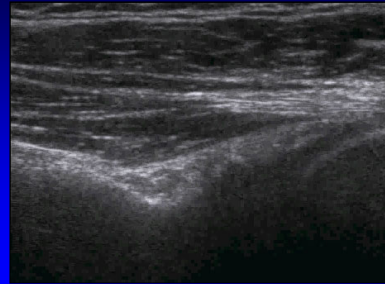
42

Paralabral Cyst: infraspinatus atrophy



43

Pitfall: suprascapular vein dilation



44

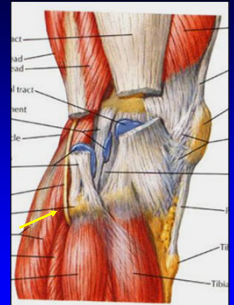
Nerve Entrapment Syndromes

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

45

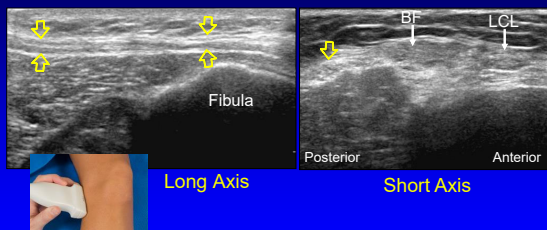
Common Peroneal Nerve

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



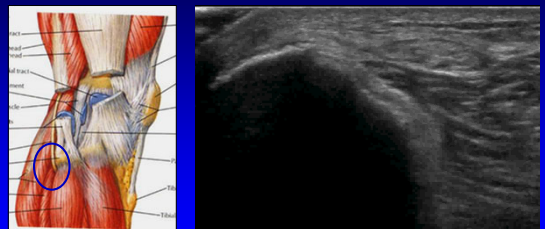
46

Common Peroneal Nerve



47

Common Peroneal Nerve: entrapment



48

Peroneal Intraneural Ganglion

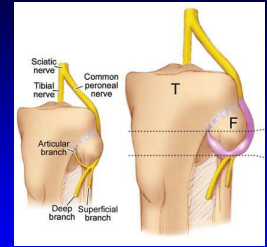
- Pain: knee or peroneal nerve distribution
 - Possible palpable mass, fluctuating course
- 18% of those with foot drop¹
- No identifiable etiology
 - Weight loss, trauma, leg crossing
- High body mass index²
 - Unlike other causes for peroneal neuropathy

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

49

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 sheath¹

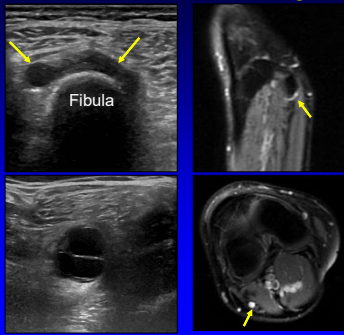


From: Spinner et al. Skeletal Radiol 2008;37:1091

Spinner et al. Clin Anatomy 2007; 20:826

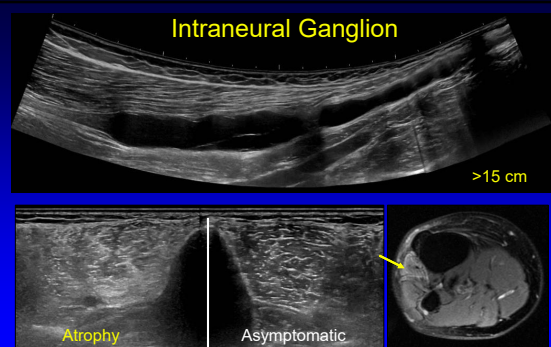
50

Peroneal Intraneural Ganglion



51

Intraneural Ganglion



52

Nerve Entrapment Syndromes

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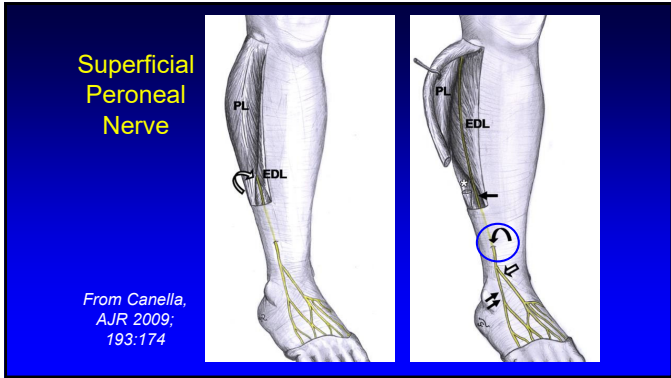
53

Superficial Peroneal Nerve

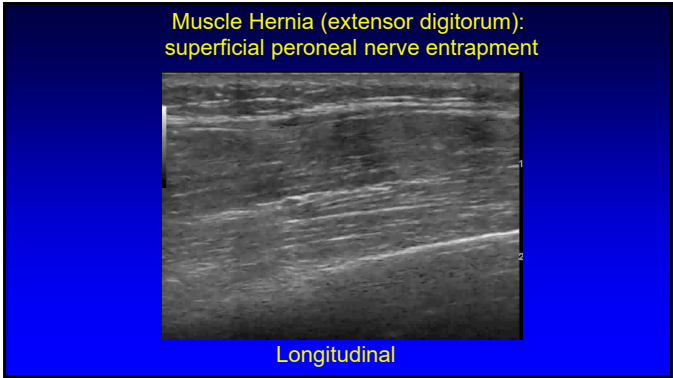
- Pierces crural fascia of leg:
 - 9.2 cm proximal to fibular tip
 - Range: 6 to 16 cm proximal
 - Potential entrapment site
- Terminal branches: 6 cm proximal to fibular tip
 - Superficial to inferior extensor retinaculum

Canella, AJR 2009; 193:174

54



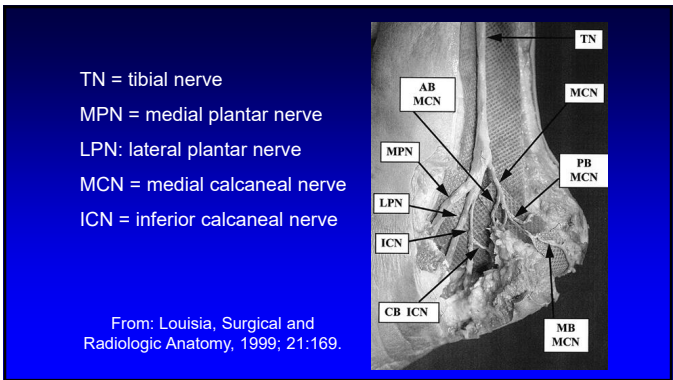
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56

- ### Nerve Entrapment Syndromes
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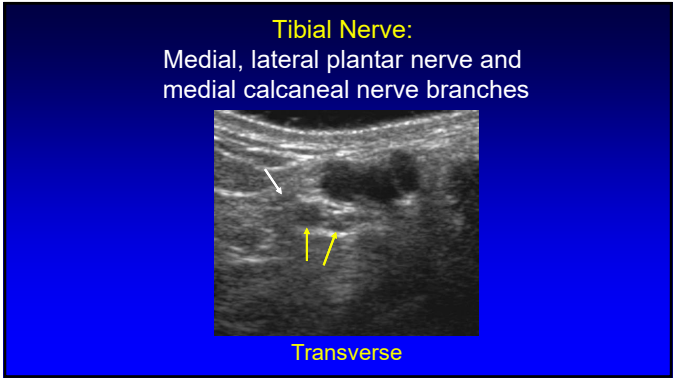
57



58

- ### Tarsal Tunnel:
- Osteofibrous tunnel: medial ankle
 - Tibial nerve
 - Tendons: tibialis posterior, flexor digitorum longus, flexor hallucis longus
 - Entrapment: mass, ganglion
-
- From: Martinoli, RadioGraphics 2000; 20:S199

59



60

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)

From: Presley JC et al. J Ultrasound Med 2013; 32:1643

61

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

62

Ganglion Cyst: tarsal tunnel syndrome

Labels: FHL, FHL, FHL, FHL

Axial Sagittal

63

Ganglion Cyst: tarsal tunnel syndrome

Long Axis Short Axis

Labels: Talus, Calcaneus

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

64

Tarsal Tunnel Syndrome: Varices

65

Nerve Entrapment Syndromes

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66

Morton Neuroma:

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



From: Martinoli, RadioGraphics 2000; 20:S199

67

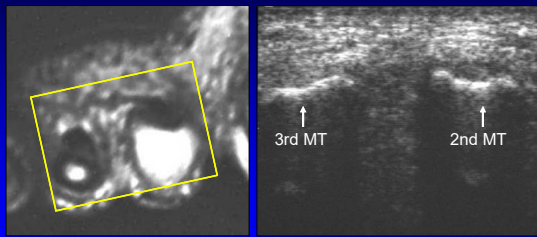
Technique:

- Interdigital space
 - Transducer:
 - Plantar
 - Dorsal
 - Normal digital nerve difficult to visualize
 - Correlate with symptoms



68

Interdigital Space



Axial

69

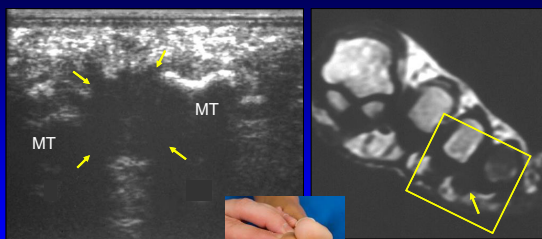
Morton Neuroma:

- Hypoechoic 5 mm mass
 - Sensitivity: 100% ; Specificity: 83%
- Digital nerve continuity*
 - Excludes other causes for mass
- Compression:
 - Produces symptoms
 - Bursa (compressible) vs. neuroma (not compressible)

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

70

Morton Neuroma

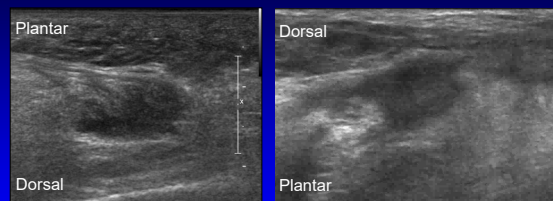


Transverse

Coronal T1w

71

Morton Neuroma



Plantar

Dorsal

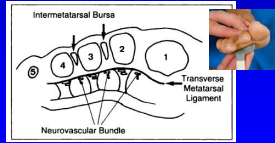
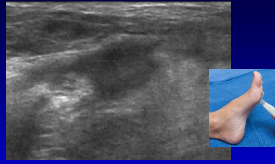
Dorsal

Plantar

72

Dynamic Evaluation

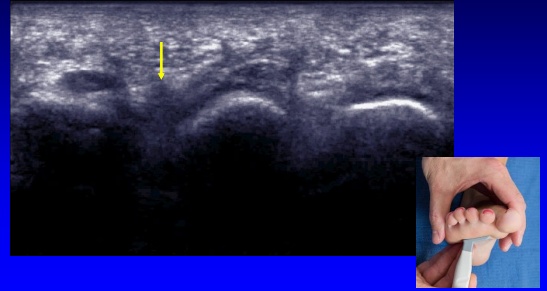
- Compression
 - Between transducer and palpation
 - Bursae (dorsal) compress, neuromas (plantar) do not
- Sonographic Mulder Sign
 - Scan plantar: coronal plane
 - Neuroma displaces: plantar
 - Palpable click



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

73

Dynamic imaging: Mulder's Maneuver



74

Summary: peripheral nerve US

- Evaluate entire limb efficiently
- Easy comparison to contralateral side
- Direct correlation: signs and symptoms
- Complements electrodiagnostic testing
- Dynamic imaging

75

Thank you!

Syllabus on line and other educational material:
www.jacobsonmksus.com

Twitter handle: @jjacobsn

76