Disclosures – None.
Tumors of the Foot & Ankle

Bone Tumors

- Bone-forming
  - Osteoid osteoma (OO)
  - Osteoblastoma
  - Osteosarcoma
- Cartilage-forming
  - Enchondroma
  - Osteochondroma
  - Chondrosarcoma
  - Chondroblastoma
  - Chondromyxoid F
- Vascular bone tumors
  - Hemangioendothelioma
  - Angiosarcoma
  - Fibrous and
  - NOT
  - FF
  - 4
  - 5

Soft Tissue Tumors

- Hemangioma
- Hemangioblastoma
- Angiosarcoma
- Fibrous and
- NOT
- FF
- N
- K

Tumor-like Lesions

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Goals

- Provide a brief image-based approach for the DDx of “Lumps & Bumps” of the foot & ankle.
- Use imaging features to formulate a limited DDx and, perhaps, suggest a Dx.
- Prevent delay and/or misdiagnosis of malignant lesions, and avoid tumor mimickers.

TABLE III

<table>
<thead>
<tr>
<th>Zone</th>
<th>Benign Lesions (n = 72)</th>
<th>Malignant Tumors (n = 10)</th>
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<tbody>
<tr>
<td>1</td>
<td>Ganglion cyst (10)</td>
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* The areas are outlined in the text and in Figure 1. The numbers of lesions in each zone are given in parentheses.

Foot & Ankle Lesion

- Radiographs
- US
- CT
- MRI

DDx & Clinical Hx*

Diagnosis → Guide Bx

* - Malignancy should **NOT** be ruled out on the basis of chronicity (Anderson and Wildermuth found average Sx duration of 35 mo)

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**Radiograph(s)**

- **Do NOT** discount them:
  - Important information may be present
    - “Big picture”
    - Ancillary findings:
      - Presence of calcifications or ossifications
      - Osseous remodeling
      - Foreign body
    - In some cases a Dx can be rendered
Value of Radiograph(s): Osteochondroma

- Most common bone tumor
- Misplaced epiphyseal plate tissue
- Multiple Hereditary Exostoses (MHE)
- Corticomedullary continuity
- Complications: deformity/cosmetic, neurovascular sequelae, bursa formation, fracture, and malignant transformation (cartilage cap > 1.5 to 2 cm, new pain, and lesion growth)

Value of Radiograph(s): Companion case of Osteochondroma
Value of Radiograph(s):
Subungual Exostosis/Dupuytren exostosis

- Uncommon exophytic lesion of distal phalanges especially the great toe, but any toe or finger may be involved
- 2nd to 4th decade, Male 2:1
- Reactive process to trauma, but t(X;6)
- Osseous protuberance, but NO corticomedullary continuity with native bone
- Tx – elective excision for pain or cosmesis; recurrence ~10 to 15%

Value of Radiograph(s):
“Big Picture” & Ancillary findings

- Rheumatoid Arthritis
- Synovial Osteochondromatosis
Ultrasound

- Cystic versus Non-cystic lesions
  - Cystic $\rightarrow$ **NO** worries
  - Non-cystic $\rightarrow$ location and Hx $\rightarrow$ focused DDx

MR Imaging

- **Nonspecific**
SOFT TISSUE TUMORS

- Adenomas
- Glandular tumors of tendon sheaths
- Lipomas
- Soft tissue chondroma
- Neurofibromas
- Neurofibromatosis, Neurofibromatosis type 1 (NF-1)
- Leiomyomas
- Intramusosal neuromas / Neurofibromatosis (NF-2)
- Lipomas
- Liposarcomas

TUMOR-LIKE LESIONS OF SOFT TISSUE

- Cystic lesions
  - Ganglia
  - Synovial cyst
  - Arteriovenous malformations

- Noncystic lesions
  - Intermittent neurofibromas
  - Neurofibromatosis
  - Calcified nodules
  - Xanthomas
  - Foreign body granulomas

Bone Tumors

- Bone-forming
  - Osteoid osteoma (OO)
  - Osteoblastoma
  - Osteosarcoma

- Cartilage-forming
  - Enchondromas
  - Osteochondromas
  - Chondrosarcoma
  - Chondroblastomas
  - Chondromyxoid fibromas
  - Neurofibrosarcoma
  - Osteosarcoma
  - Foci of chondroblastic bone tumors
  - Malignant fibrous histiocytoma (MFH)
  - Bone cysts

- Vascular bone tumors
  - Hemangiomas
  - Hemangiomas
  - Histiocytomas
  - Hemangioendotheliomas
  - Hemangiopericytomas
  - Angiosarcomas

- Fibrous and fibrohistiocytic bone tumors
  - Osteoid osteomas
  - Osteoclastomas
  - Osteosarcomas
  - Fibrous dysplasia
  - Malignant fibrous histiocytomas

TUMOR-LIKE LESIONS OF BONE

- Simple bone cysts
- Pseudocysts
- Angiomyolipomas
- Intratumoral ganglia

Miscellaneous

- Lipomas
- Intramusosal neuromas
- Arteriovenous malformations
- Accessory muscles

Tissue Types

- Fat
- Melanin
- Calcium
**MR Imaging**

<table>
<thead>
<tr>
<th>BONE TUMOR(S)</th>
<th>T1</th>
<th>T2</th>
<th>Non-Specific (dT1 &amp; bT2)</th>
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<tr>
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<tr>
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<td>Ewing Sarcoma</td>
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<td>PVNS</td>
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<td>Macrodystrophia</td>
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<td>Fibrolipomatous</td>
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<td>(osteo)chondromatosis</td>
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<td>Tumor (HFLT)</td>
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<td>Gout</td>
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<td>Neuroma</td>
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<td>Xanthoma</td>
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<td>RA nodule(s)</td>
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<tr>
<td>Accessory muscle</td>
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- Well defined lucent lesion w/ thin sclerotic rim +/- dystrophic calcs centrally (fat necrosis)
- Can have variegated appearance d/t differing amounts of fat, calcs, fibrous tissue, peripheral sclerosis, and cystic degeneration
- Fat can be higher T1 signal than adjacent yellow marrow b/c lack of hematopoietic tissue
- 4th to 5th decades, slight male predilection, often ASx and incidental
- 30% are found in calcaneus, typically in the body inferior to angle of Gissane
- Tx – None, but Sx lesions can be treated w/ curettage and bone grafting

**Intraosseous Lipoma**

- Well defined lucent lesion w/ thin sclerotic rim +/- dystrophic calcs centrally (fat necrosis)
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Simple/Solitary/Unicameral bone cyst (UBC)

- B9 fluid-containing lesion that may be multiloculated
- Classic “fallen fragment sign” has not been reported in calcaneal lesions
- ?reactive, developmental, obstruction of venous drainage?
- Calcaneus is 3rd most common site (4%) after humerus and femur.
- Tx – None, but if Sx then may try steroid or bone marrow injection in which case the # of septa may become important

Intraosseous Lipomas and Simple bone cysts

- Occur in similar locations
  - Thus, a potential relationship has been suggested
  
  Involution of cyst into lipoma
  
  OR
  
  Complete fat necrosis and cyst formation of an intraosseous lipoma
**Osteoid Osteoma (OO)**

- XR – lucent or mineralized nidus w/ surrounding sclerosis, but appearance depends on location: Intracortical, Intramedullary, and Subperiosteal
- CT - more sensitive; round or oval, smoothly margined lytic lesion w/ central mineralization present in 50% of cases; may also be used to guide ablation
- MR - less accurate but can evaluate extent of marrow and soft tissue edema
- Affects the foot in ~10% of cases and ~50% occur in the talus
  - Subperiosteal and at the superior aspect of talar neck
  - 2nd decade, Caucasian males; dull constant bone pain worst at night and relieved by salicylates
- Tx – conservative neglect, surgical excision, or ablation

**Aneurysmal bone cyst (ABC)**

- Expansile lytic multiseptate lesion w/ fluid-fluid levels
  - Decreased signal intensity in the dependent portion reflecting met-Hb (Kransdorf MJ et al. AJR 1995)
- Bg reactive lesion w/ cyst-like walls of predominantly fibrous tissue filled w/ blood
- Solid nodular C+ raises suspicion for an underlying neoplasm
- Metaphyseal regions of long bones>spine>pelvis>foot and ankle (w/ distal tibia and fibula ~70% and calcaneus ~1%)
- Slight female predilection
- Tx – intralesional excision techniques
Lesions associated with Secondary ABC’s

- GCT (19-39%)
- Chondroblastoma
- Osteoblastoma
- Telangiectatic osteosarcoma
- Angioma
- Fibrous dysplasia (FD)
- Fibroxantoma/Nonossifying fibroma
- Chondromyxoid fibroma
- Solitary bone cyst
- Fibrous histiocytoma
- Eosinophilic granuloma (EG)

Ewing Sarcoma

Non-Specific
(dT1 & bT2)

- Lytic permeative appearance
- Reactive osteoid causing sclerosis in the medullary canal can mimic Bg entities such as stress Fx or AVN
- Aggressive primary round blue cell tumor
- Male 1:5:1
- Distal tibia and fibula and, to a lesser extent, calcaneus and MT’s
- Tx – chemo followed by wide local tumor resection
Metastasis: Prostate

- RARE (<1% of mets) owing to decreased red marrow
  - Diffuse metastatic involvement
  - Venous insufficiency
  - Lung, renal, colon, uterine, bladder, breast, prostate
  - Occur late in disease and indicates poor prognosis
  - Lytic lesion and may mimic enchondroma

Soft Tissue Tumor & Tumor-like Lesions

**SOFT TISSUE TUMORS**
- Plantar fibromatosis
- Giant cell tumor of tendon sheath
- Lipoma
- Soft tissue chondroma
- Synovial sarcoma
- Undifferentiated Pleomorphic Sarcoma (UPS)
- Leiomyosarcoma
- Leukemic arthritis

**TUMOR-LIKE LESIONS OF SOFT TISSUE**
- Cystic lesions
  - Ganglia
  - Synovial cyst
  - Adventitial bursa
- Noncystic lesions
  - Interdigital neuroma
  - Rheumatoid nodule
  - Callus
  - Xanthoma
  - Foreign body granuloma
  - Calcium hydroxyapatite (CHA)
- Synovial-based process
  - Synovial (osteochondromatosis
  - Pigmented villonodular synovitis (PVNS)
  - Gout
- Miscellaneous
  - Tendon tear
  - Macrodystrophia lipomatosa
  - Accessory muscles
Vascular Lesions

- ISSVA classification
  - Hemangioma
    - Most frequent B9 foot tumor of vascular origin
    - Phleboliths
    - Low to IT1 v-/fat, smooth muscle, fibrous tissue, hemosiderin or thrombus
    - IT2 multilobulated and septated v/slow blood flow
  - Vascular Malformations
    - Low flow
      - Capillary-venous-lymphatic
    - High flow
      - AVM and AVF’s

- Maffucci, KTW, OWR syndrome

Macrodystrophia Lipomatosa

- Painless enlargement of digits of hand or feet in median or plantar n. distribution
  - Marked increase in mesenchymal tissue
  - Fat deposition w/o discernable capsule

- Rare form of congenital, but non-hereditary, localized gigantism
- DDx – NF1 and vascular malformations
Tenosynovial giant cell tumor, Intraarticular, Diffuse type

- XR - Dense joint effusion, erosions on both sides of joint with relative preservation of joint space
- Calcs are RARE, and if present, then synovial (osteo)chondromatosis, and synovial sarcoma should be considered
- MR - Hemosiderin deposition (paramagnetic effect) → blooming artifact on GRE d/t increased magnetic susceptibility
- Synovial proliferation resembling a shaggy red beard
- Knee>hip>shoulder>ankle and foot (Hindfoot>mid- and forefoot)
- Tx w/ complete excision but recurrence ~15%

Tenosynovial giant cell tumor, Extraarticular, Focal type

- Typically dT1 and T2 owing to paramagnetic effect of hemosiderin content
- Homogenous C+ d/t extensive capillary network in collagenous stroma
- Erosion may be seen in 15%
- Extraarticular form of PVNS arising from tendon sheaths, bursae or ligaments
- 3rd to 5th decades, women
- Commonest B9 tumor of the foot
- Tx is excision w/ local recurrence from 0 to 30%
Nodules or cords involving plantar fascia, variable signal and C+
Mature/involutional phase vs immature/Cellular proliferative phase
One or more nodules may be present, infiltrative

Most common Bg ST tumor of the foot and ankle, type of superficial fibromatosis
Posttraumatic nodular fibrous proliferation arising from plantar aponeurosis
Men 2:1, bilateral in up to 40 to 50%
- 50% of pts may have Dupuytren and Peyronie disease

Infiltrative growth and high recurrence rate
- ~75% of pts and often with 2 yrs
Synovial (osteochondromatosis)

- Signal characteristics dependent on degree of mineralization
- Monotonous bodies
- B9 disorder in which multiple hyaline cartilage nodules are formed within a joint, tendon, sheath, or bursa
- Metaplastic transformation of synovium → cartilage?
- Ch. 6 abnormalities (Buddingh EP. Cancer Genet Cytogenet 2003)
- Knee > elbow > hip > shoulder

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Synovial Sarcoma

- Inhomogenous juxta-articular mass; often mistaken for cysts especially when small
- "Triple" signal intensity due to blood, cystic, and solid components
- Can invade multiple compartments of foot and erode into bone, 1/3 will be mineralized
- Tumor of uncertain differentiation by WHO
- t(X;18)
- Young adult males
- ½ recur, and ~40% mets to lungs, bones, or regional nodes
### Neurogenic/Nerve Sheath Tumors

- Schwannoma – displace nerve fibers **eccentrically**
- Neurofibroma – nonencapsulated infiltrative lesions causing **fusiform enlargement**
- Target, dural tail, split fat, fascicular, and rat tail signs
-Usu present w/ painless mass < 5 cm in size
- Vast majority are solitary and **NOT** a/w NF1/von Recklinghausen disease

### Leukemic Arthritis

**RARE** complication of chronic or acute leukemia, but more common with acute forms and in children
- Joint manifestations in leukemia include synovial infiltration, joint or periarticular hemorrhage, synovial reaction to periarticular disease, crystal induced synovitis
- Sx may mimic an inflammatory arthropathy
  - May see mild leukocytosis and elevated ESR or CRP making differentiation from infection difficult
  - Synovial fluid analysis is nonspecific and **Synovial Bx remains the gold standard**
**Tendon tear (Anterior Tibialis t.)**

- Dx is often delayed and unable to recall precipitating event
  - Preserved f(x) owing to other tendons
  - Mdx as NEOPLASM
- Rare event, 44 cases (as of 1996)
- Usual site - 0.5 to 3 cm proximal to insertion (i.e. M1 and C1)
- Classically – men > 45 yoa w/ closed spontaneous rupture after mod forceful plantar flexion stress
  - Can occur in younger pts – laceration/penetrating injury

**Gout**

- Dense deposits on XR and well-margined erosions
- Typically involve MTP and IP of great toe
- Can see extensive, multiple, soft tissue masses with destruction of multiple bones of foot
- iT1, vT2, and heterogenous C+
- Jt effusion, synovial thickening
- Sodium urate crystal deposition
- Tophaceous gout is chronic form of disease
  - Can occur intra- or periarticular, or at a distance from a joint as a soft tissue mass
Gout: a companion case

- Tendon enlargement w/ hetero T1 and T2
- Focal collections of histiocytes containing lipids
- Found in subcutaneous tissues and less commonly tendons
- Hyperlipidemia

Xanthoma

- T2

- Tendon enlargement w/ hetero T1 and T2
- Focal collections of histiocytes containing lipids
- Found in subcutaneous tissues and less commonly tendons
- Hyperlipidemia
Accessory Muscles

- **Peroneus quartus**
  - 13 to 22% of pts
  -Usu incidental but may give rise to lateral ankle pain and instability, or predispose to subluxation of the peroneal tendons

- **Accessory soleus**
  - 10% of pts
  - Flexor digitorum accessorius longus

Infection

- **Maduromycosis (left)**
  - Localized chronic granulomatous infection w/ granulation tissue, discharging sinuses, and late bone involvement
  - Madurai, India (1842)
  - Fungi or Actinomyces
  - “Dot-in-circle” on MRI
    - Grains-granulation-fibrosis

- **Coccidioidomycosis (right)**
  - Fungal infection endemic to Southwest US, Mexico, Central and South America
  - Often multicentric and can involve any bone
    - Multiple lytic lesions
    - Punched-out lesions
    - Arthropathy
    - Spine involvement
  - May have pulmonary Sx
"Exclude infection, please biopsy."

**Calcium Hydroxyapatite (CHA)**

- $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ is the most common type of Ca$^{2+}$ in bone and pathologic calcifications.
- Common disorder exemplified by periarticular deposition of calcium hydroxyapatite and an associated inflammatory process.
- **ANY** joint can be involved—SHOULDER being the most common.
**Calcium Hydroxyapatite (CHA)**

- Well defined, cystic structure that is hyperintense on fluid-sensitive sequences
- Most common soft tissue mass in the foot and ankle
  - > 40% of suspected soft tissue masses
  - Myxoid lesion caused by coalescence of small cysts formed by myxomatous degeneration of periarticular connective tissue related to joint capsules or tendon sheaths
  - Often Dx’d clinically, but MR may be helpful if palpable or Sx d/t extension along a nerve or tendon
- Recurrence can occur d/t failure of id and removal of satellite mass

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**Ganglia/Ganglion cysts**

- Non-Specific
  - (dT1 & bT2)

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- Most common soft tissue mass in the foot and ankle
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### Interdigital neuroma

- **Coronal short-axis T1** is most important for Dx (Zanetti AJR 1997)
  - C+ study may help detect lesions that are poorly defined on noncontrast MR (Terk MR et al. Radiology 1993)
  - May be a/w fluid in IM bursa
- Nonneoplastic neural degeneration and perineural fibrosis entrapping a plantar digital nerve
- Most often located w/in 3rd interspaces
- ?High heeled shoes with narrow toe box?, women in ~80% of cases; Toe/forefoot burning/electric pain and numbness, but 2/3 are Asx, multiple in 26% and bilateral in 13%
- Tx – surgical excision

### Rheumatoid nodule

- Nonspecific ill defined mass...but listen for h/o RA and look for active inflammatory marrow changes, jt eff, and synovitis
- Granulomatous foci w/ areas of central fibrinoid necrosis
- Occur **along superficial sq tissues**, but frequently in sites of repeated minor trauma
- ~25% of rheumatoid pts, more commonly in women with advanced dz
- Can also be seen in rheumatic fever, SLE, and ankylosing spondylitis
Percutaneous Biopsy

- Discuss with Orthopedic Oncologist
- Shortest distance is the best course
- Avoid passing through multiple compartments, neurovascular bundles, and tendon sheaths

Conclusion

- Knowledge of imaging features, disease behavior, and location can help narrow DDx of foot & ankle lesions
- If a lesion remains indeterminate → consider Bx
- Think of the tumor-like lesions and mimicks
References