Lumbo-sacral transitional vertebrae are occasionally encountered, and may cause spine level labeling difficulties in the presence of metastatic disease. What is the frequency of a transitional vertebra in the general population?

- A. 0.1-1%
- B. 1-5%
- C. 5-10%
- D. 10-20%

Lumbo-sacral transitional vertebrae are occasionally encountered, and may cause spine level labeling difficulties in the presence of metastatic disease. What is the frequency of a transitional vertebra in the general population?

- D. 10-20%

Transitional Vertebrae

– Labeling issues
  • *Be descriptive*
  • Use cervical spine as relatively constant (almost always 7 vertebra)
  • Use iliolumbar ligaments
– Other
  • Can be a source of pain and low-grade uptake
  • Bertolotti's syndrome
Transitional Vertebrae

Amini, Behrang
Roentgen Ray reader, weblog
Cervical Rib

- Usually incidental, but should be mentioned
  - Neurovascular compression can result
Cervical Rib
Question 77

- Pars defects can progress to spondylolisthesis, and may become symptomatic. What is the frequency of pars defect in the general population?
  - A. 0.1-1%
  - B. >1-10%
  - C. >10-20%
  - D. >20%

Question 77

- Pars defects can progress to spondylolisthesis, and may become symptomatic. What is the frequency of pars defect in the general population?
  
  - B. >1-10%

Pars Defects

• Spondylolysis
  – 3-6% incidence
  – Congenital or acquired in youth
  – Can be a source of pain
  – Grade I-IV degree of anterolisthesis
  – 85% at L5
  – 14% at L4

  • May result in uptake on PET
  • 18F-NaF PET emerging as useful tool in children

In the case of mildly increased uptake on PET-CT at a vertebral body endplate, which modality could best distinguish a Schmorl’s node from a metastatic lesion in a difficult case?

- A. Radiography
- B. Bone scan
- C. MRI
- D. CT

MR imaging of enhancing intraosseous disk herniation (Schmorl’s nodes). A Stäbler, M Bellan, M Weiss, C Gärtner, J Brossmann and M F Reiser. AJR April 1997 vol. 168 no. 4 933-938
Question 78

- In the case of mildly increased uptake on PET-CT at a vertebral body endplate, which modality could best distinguish a Schmorl’s node from a metastatic lesion in a difficult case?
  - C. MRI

- MR imaging of enhancing intraosseous disk herniation (Schmorl's nodes). A Stäbler, M Bellan, M Weiss, C Gärtner, J Brossmann and M F Reiser. AJR April 1997 vol. 168 no. 4 933-938
Schmorl’s Node

- Herniation of disc material into the vertebral endplate
- Common (20-50%)
- Cluster around thoracolumbar junction
- Questionable association with back pain
  - Can be acute, and generally correlate with surrounding edema on MR
  - Can have uptake on PET
- Usually in continuity with endplate and have surrounding sclerosis
- Not highly associated with DJD

Vacuum Phenomenon

- Nitrogen out of solution
  - Most common in spine
    - Essentially excludes infection
  - Other joints usually positional
  - Can move from joint into adjacent structures:
    - Bone
    - Soft tissues
    - Spinal canal
Vacuum and Schmorl’s
Vacuum Phenomenon
Which disease is associated with the following complications: Acute cholecystitis, osteomyelitis, pulmonary hypertension, renal failure, and osteonecrosis?

- A. Cystic fibrosis
- B. Autosomal dominant polycystic kidney disease
- C. Sickle Cell anemia
- D. Down syndrome

Which disease is associated with the following complications: Acute cholecystitis, osteomyelitis, pulmonary hypertension, renal failure, and osteonecrosis?

- C. Sickle Cell anemia
Sickle Cell Disease

- Sickle cell disease
  - H-type or rounded vertebra
  - Osteonecrosis
    - Hips
    - Shoulders
    - Any joint
    - Findings:
      - Sclerosis
      - Subchondral collapse
      - Advanced DJD
  - Bone infarcts
  - Extra-medullary hematopoiesis
  - Osteomyelitis

- Extraskeletal
  - Cholelithiasis
  - Autoinfarcted spleen
  - PA hypertension
  - Renal failure

Which of the following skeletal manifestations of hyperparathyroidism can result in intense uptake on PET-CT?

- A. Rugger-jersey spine changes
- B. Osteosclerosis
- C. Osteopenia
- D. Brown tumor

Osteitis Fibrosa Cystica Mistaken for Malignant Disease.
Ja Hyun Lee, MD·Sung Min Chung, MD,·Han Su Kim, MD. Clinical and Experimental Otorhinolaryngology 2011 September 15
Which of the following skeletal manifestations of hyperparathyroidism can result in intense uptake on PET-CT?

- D. Brown tumor

Osteitis Fibrosa Cystica Mistaken for Malignant Disease.
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Renal Osteodystrophy/Hyperparathyroid

- Renal Osteodystrophy
  - Secondary hyperparathyroidism
    - Osteoporosis
    - Osteosclerosis
      - Rugger-Jersey
      - Dense bones
    - Soft tissue and vascular calcifications
    - Osteomalacia
      - Stress fractures
    - Rare
      - Periosteal reaction
      - Brown tumors
  - Tendon rupture
  - Amyloid deposition
  - Crystal deposition
  - Osteonecrosis

Renal Osteodystrophy/Hyperparathyroid

- Renal Osteodystrophy
  - Dense bones
  - Accentuates other lesions
    - Schmorl’s nodes
    - Hemangioma
Hemangioma

- **CT**
  - “polka dot”, “corduroy”, internal fat, vertical trabeculations

- **MR**
  - T1, T2 hyperintense

- **PET**
  - Often cold
Hemangioma

T1

T2
Fracture and metabolic dz

• **Stress fracture**
  – Can be chronic and show uptake
  – CT can identify sclerosis
  – Location helpful
    • Sacrum
    • Pubo-acetabular jx
    • Pubic rami
    • Tibia, hips, ribs

• Metabolic
  – Dense bones
    • Renal osteodystrophy common
    • Osteopetrosis, fluorosis, mastocytosis rare
    • Metastases should show uptake
Hyperparathyroid

- End stage or *Primary* hyperparathyroid can be severe:
  - Osteitis Fibrosis Cystica
    - Replacement with stroma composed of immature bone and osteoclasts
  - Called “brown tumor” when focal
  - Hot on PET and easily confused with metastases
Brown Tumor
Brown Tumor
Brown Tumor
Question 81

- Scattered small sclerotic foci seen in a peri-articular distribution most likely represent which of the following disorders?
  - A. Marfan syndrome.
  - B. Osteopoikilosis
  - C. Melorheostosis
  - D. Sickle cell disease

Question 81

• Scattered small sclerotic foci seen in a peri-articular distribution most likely represent which of the following disorders?

  – B. Osteopoikilosis

Bone Islands

• **Enostosis**
  – Usually solitary or few in number
  – Brush border or “thorny” spiculations
  – Normal adjacent bone
  – Almost always stable over time
  – No uptake on PET, none on bone scan unless very large
  – Incidence comparable to hemangioma
    • 10-15%

*July 2008 RadioGraphics, 28, 1019-1041*
Osteopoikilosis vs Tuberous Sclerosis

- **Osteopoikilosis**
  - Benign, congenital, sporadic
  - Periarticular, small enostoses

- **Tuberous sclerosis**
  - Autosomal dominant
  - Enostoses are usually axial
  - Presence of other lesions
    - Renal angiomyolipomas
    - Renal cysts
    - Brain lesions
      - Hamartomas
        » Subependymal giant cell astrocytomas

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Metastatic Disease
Dural Ectasia

- Spinal canal expansion
  - Neoplasms
    - Ependymoma
      - Myxopapillary
    - Arachnoid cyst
    - Lipoma, epidermoid and other tumors
  - Congenital
    - Neurofibromatosis
    - Marfan
    - Ehlers-Danlos
    - Ankylosing spondylitis
    - Osteogenesis Imperfecta
    - Mucopolysaccharidoses
Neurofibromatosis and malignancy

• Differentiating benign from malignant
  – Benign
    • Split fat sign (CT, MR)
    • Target sign (MR)
    • Localized to a peripheral nerve (CT, MR)
    • Homogenous enhancement (CT, MR)
  – Malignant
    • Larger (CT, MR)
      » Interval growth
    • Retroperitoneal (CT, MR)
      » Plexiform
    • Cysts, necrosis (CT, MR)
    • Peripheral enhancement (MR)
    • Perilesional edema (MR)
Peripheral Nerve Sheath Tumor
Spondylodiskitis can be a difficult diagnosis, particularly in the postoperative spine. Which modality is most specific for infection?

- A. Unenhanced CT.
- B. FDG-18 PET/CT.
- C. Radiography.
- D. Bone scan.

Spondylodiskitis can be a difficult diagnosis, particularly in the postoperative spine. Which modality is most specific for infection?

- B. FDG-18 PET/CT.

Vertebral Osteomyelitis / Spondylodiskitis

- **CT**
  - *End plate destruction*
    - Loss of cortical white line
  - Soft tissue thickening
  - Disc destruction
  - Vertebral body sclerosis
  - Paravertebral abscess

- **MR**
  - Edema in vertebral body
  - Fluid in disc space

- **PET**
  - Often increased uptake
Vertebral Osteomyelitis / Spondylodiskitis

- Infection
  - Hot on PET
  - Follow with MR
    - Best modality
    - Biopsy often performed
    - Pathogen identification
Question 83

- CT findings are helpful in vertebral osteomyelitis and spondylodiskitis. Which of the following is typical of benign, degenerative joint disease?
  - A. End plate destruction
  - B. Epidural low density collection
  - C. Gas within the disk space
  - D. Paraspinous muscle fluid collections

CT findings are helpful in vertebral osteomyelitis and spondylodiskitis. Which of the following is typical of benign, degenerative joint disease?

- C. Gas within the disk space

Vertebral Osteomyelitis

- MR
  - Most sensitive
    - Best depiction of edema/fluid
  - Contrast MR
    - Increases sensitivity and specificity
Vertebral Osteomyelitis

- PET
  - Increased uptake
  - Promising adjunct to MR
    - Comparable sensitivities and specificities
  - Particularly useful in MR restricted patients (pacemaker)

Infection, symphysis pubis
Infection, spine
Infection, mycobacterial
• The “ivory vertebral body” sign seen on CT is associated with which of the following?
  – A. Hemivertebrae
  – B. Lymphoma
  – C. Multiple myeloma
  – D. Osteoporosis

The “ivory vertebral body” sign seen on CT is associated with which of the following?

- B. Lymphoma

Vertebral malignancy

- Differentiating malignancy from infection or fracture:
  - Malignancy
    - Less disc involvement
    - Multiple vertebrae involved
    - Skipped areas of normal vertebrae
    - More focal lysis/destruction
    - Paravertebral masses
    - Retropulsion of posterior cortex
    - Posterior element involvement
  - Infection
    - Disc involvement
    - Disc is epicenter
    - End plate destruction
    - More focal (usually 2 vertebrae)
Vertebral malignancy
Vertebral malignancy

- Adenocarcinoma metastases
  - Multilevel
  - Focal areas of lysis
  - End plates *relatively* spared
  - Collapse and retropulsion
    - Can be seen in late/aggressive infection
Multiple Myeloma

• Findings:
  – Multiple punched out, lytic lesions
  – No sclerosis
  – Diffuse distribution
  – Cold on Bone scan
  – Radiographs normal

• Can PET be helpful?
Multiple Myeloma

- MR reported most sensitive
  - Limitations:
    - Limited field of view
    - Can’t image pacemaker patients
- Bone scan insensitive
- Radiographs need large lesions
- CT alone can miss marrow involvement
- PET CT reported to be useful

Multiple Myeloma
Multiple Myeloma
• PET-CT can be very useful in planning a biopsy. What unique characteristic of PET-CT is unmatched by most other modalities?
  – A. Highest spatial resolution.
  – B. Best depiction of adjacent structures that could be injured.
  – C. Better soft tissue contrast than MRI.
  – D. Ability to depict areas of viable cells in necrotic tumors.

PET-CT can be very useful in planning a biopsy. What unique characteristic of PET-CT is unmatched by most other modalities?

- D. Ability to depict areas of viable cells in necrotic tumors.

FDG-PET/CT-guided biopsy of bone metastases sets a new course in patient management after extensive imaging and multiple futile biopsies.

Bone metastases

- **PET-CT**
  - Can detect bone metastasis before morphologic changes
  - Can identify areas of necrosis to avoid
  - Commonly only modality available to review prior to biopsy

Bone metastases
Cortical thickening, coarsened trabeculae, and bony expansion involving an entire bone is most suggestive of which of the following entities?

- A. Prostate metastases
- B. Fibrous dysplasia
- C. Paget disease
- D. Osteomyelitis

Question 86

- Cortical thickening, coarsened trabeculae, and bony expansion involving an entire bone is most suggestive of which of the following entities?

  - C. Paget disease

Paget’s Disease

- Common 3-4% >40 yrs old
- Skull, spine, pelvis, long bones
- Complications
  - Arthritis
  - Fracture
  - Neurovascular
  - Osteosarcoma
- Description
  - Expansile
  - Cortical and trabecular thickening
  - Mixed sclerosis and lucency
- CT and MR: look for spared fatty marrow
- PET-CT: Can be hot, but focal areas of uptake may signify sarcoma
Paget’s Disease

- Paget
  - Often involves multiple bones which can be helpful
Paget’s Disease

T1 non fat sat images
Paget’s Disease
Question 87

- Uptake about the shoulder joint can often be explained by an underlying musculoskeletal abnormality. Which of the following musculoskeletal disorders will most likely result in a true-positive PET/CT result in a patient with shoulder pain?
  - A. Acromioclavicular joint degenerative change
  - B. Active rheumatoid arthritis
  - C. Enthesophytes at the insertion of the rotator cuff tendons
  - D. Supraspinatus tear

• Uptake about the shoulder joint can often be explained by an underlying musculoskeletal abnormality. Which of the following musculoskeletal disorders will most likely result in a true-positive PET/CT result in a patient with shoulder pain?

  - B. Active rheumatoid arthritis

Shoulder Uptake

- Shoulder uptake at PET
  - Glenohumeral DJD
  - Acromioclavicular DJD
  - Inflammatory arthropathy
    - RA most common
    - CPPD
    - Amyloid
  - Calcific tendinitis (HADD)
  - Rotator cuff tear
  - Heterotopic ossification
  - Bursitis
  - Fracture/Hardware
  - Tumor
  - Infection
Shoulder DJD

- **Degenerative change**
  - Joint space narrowing
  - Subchondral sclerosis
  - Subchondral cysts
  - Marginal osteophytes
  - Variable uptake on PET
Rotator Cuff

Rotator cuff
  - Tears can show uptake
  - CT signs of tear:
    • Acromio-humeral interval narrowing
    • Fatty atrophy of RC muscle
    • Uptake within muscle
    • Uptake around joint w/o DJD
      - *DJD often present, however*
Inflammatory Arthritis

- Rheumatoid
  - When active, almost always increased PET uptake
  - Joint space narrowing
  - Effusion/pannus/synovial thickening
  - Erosions
  - Peri-articular osteopenia
  - In early cases, OA features absent
    - No subchondral sclerosis
    - No subchondral cysts
    - No osteophytes
  - Pet CT can assess response
    - Activity decreases as synovitis decreases
PET-CT low intensity uptake at the acromion with CT findings of a transverse lucency with sclerotic borders suggests which of the following?

- A. Fracture
- B. Os acromiale with degenerative change
- C. Metastasis
- D. Osteoid osteoma

• PET-CT low intensity uptake at the acromion with CT findings of a transverse lucency with sclerotic borders suggests which of the following?
  
  – B. Os acromiale with degenerative change

Os Acromiale

- **CT**
  - Transverse lucency at acromion
  - Sclerotic borders
  - Often painful
  - May have secondary DJD
  - Low grade PET uptake
  - Treatable
    - Inject
    - Surgery
Enthesopathy vs Ankylosing Spondylitis

- **Osteoarthritis**
  - Joint space narrowing and osteophytes
    - Bony spurs at joint margins
    - May show significant uptake
  - Enthesophytes
    - Bony spurs along tendon insertions
    - Can be secondary to OA or inflammatory arthritis
    - Often show uptake

- **Ankylosing spondylitis**
  - Variable uptake with some correlation to disease activity
  - Sacroiliac joint fusion late, erosions early
  - Thin enthesophytes at disc margins known as syndesmophytes
    - Bamboo spine
    - Easily traumatized ‘chalk stick’ fracture
Ankylosing Spondylitis
Question 89

- PET-CT uptake within an extra-osseus lesion that shows zonal morphology, with peripheral cortical bone and central medullary bone most likely represents?
  - A. Heterotopic ossification
  - B. Metastatic osteosarcoma
  - C. Primary periosteal osteosarcoma
  - D. Displaced, healed, fracture fragment

• PET-CT uptake within an extra-osseus lesion that shows zonal morphology, with peripheral cortical bone and central medullary bone most likely represents?

  – A. Heterotopic ossification

Heterotopic Ossification

• Myositis ossificans (older term)
  – Benign ossification
    • Usually within muscle
      – Post-traumatic
      – Post surgical
        » Idiopathic
    • Characteristic zonal pattern
      – Morphous
    • Peripheral cortex
    • Central medullary cavity
    • Can show increased uptake on PET
      – Particularly when acute
  – Differential:
    • Osteosarcoma
      – No zonal pattern
      – Amorphous calcification
Heterotopic Ossification

- **Symptoms**
  - Usually none
  - Periarticular
    - Can restrict motion

- **Injection Granulomas**
  - Characteristic location
  - Fat necrosis
    - Dystrophic calc’s.
  - Similar to H.O.
Osteosarcoma

- Conventional
  - Arises from bone, metaphyseal
- Surface-types
  - Amorphous calcification
  - Adjacent bone(+/− involved)
    - Periosteal reaction
    - Cortical destruction
  - Soft tissue mass
  - Absence of zonal pattern
Osteosarcoma

- Lack of zonal pattern
- Subtle periosteal rxn
- Peripheral lucencies
Question 90

- Which is the most useful finding to determine chance of malignancy when encountering an osteochondroma (exostosis) on PET-CT?
  - A. Location of the lesion
  - B. Lesion is contiguous with medullary cavity
  - C. Number of lesions
  - D. Thickness of the cartilage cap

Question 90

- Which is the most useful finding to determine chance of malignancy when encountering an osteochondroma (exostosis) on PET-CT?

  - D. Thickness of the cartilage cap


Osteochondroma

**Exostosis**
- Benign, common tumor of cartilage and bone
- Developmental abnormality
- Continuity with underlying medullary bone
- Cartilage cap

**Significance:**
- Rarely turn malignant (1%)
  - Cartilage cap
    - Thickness > 1.5 cm
    - Growth after skeletal maturity
- Local neurovascular effects
- Mechanical effects
Osteochondroma Mimic

- **Location**
  - Solitary
    - Most common in long bones
    - Lower extremities
    - Usually point AWAY from joint
    - Metaphyseal
  - Mimics:
    - H.O. can occasionally adhere to bone
    - NO medullary continuity
Osteochondroma Mimic
Hereditary Multiple Exostoses

- Multiple osteochondromas
  - Autosomal dominant
  - Majority are *sessile*
  - Risk of malignancy 3-5%
    - Chondrosarcoma
  - Results in short stature
- Metaphyseal lesions
  - Cause widening of metaphysis
  - Disturb growth
Hereditary Multiple Exostoses

- Signs of malignancy
  - Pain
  - Growth after skeletal maturity
  - Indistinct lesion margin
  - Radiolucency centrally within lesion
  - Soft tissue mass w scattered calcs
  - Erosion of adjacent bone
Hereditary Multiple Exostoses
Hereditary Multiple Exostoses
• Apparently cystic masses can be malignant, and a cyst in the popliteal fossa is a common finding. How can you be sure a lesion is a benign Baker’s cyst?
  – A. It passes between the medial head of the gastrocnemius and the semimembranosus tendon.
  – B. It is lateral to the lateral gastrocnemius tendon.
  – C. It follows the neurovascular bundle.
  – D. The lesion has many thick septations.

Question 91

• Apparently cystic masses can be malignant, and a cyst in the popliteal fossa is a common finding. How can you be sure a lesion is a benign Baker’s cyst?

  – A. It passes between the medial head of the gastrocnemius and the semimembranosus tendon.

Knee PET-CT

• Anatomy
  – Compartments
    • Medial
    • Lateral
    • Patello-femoral
    • Femoro-tibial
      – Communicates w knee jt 15%
  – Soft tissues
    • Ligaments
      – ACL, PCL, MCL, LCL
    • Tendons
      – Quad, pes anserinus, IT band, biceps
    • Menisci
      – Lateral and medial
Knee PET-CT

- **DJD**
  - Any compartment
    - Typical - medial > lateral
    - Post traumatic
  - Cysts
    - Popliteal (Baker’s) cyst
    - Paramensical cyst
    - Suprapatellar pouch effusion
    - Bursae

- **Inflammatory**
  - RA
  - PVNS
  - GOUT
  - CPPD
    - Patellofemoral and lateral
Knee PET-CT

- Popliteal cyst most common
  - B/w med head gastrocnemius and semimembranosus
- Paramensical cysts
  - Adjacent to menisci
- Tumor
  - Synovial sarcoma
    - NOT in classic location
    - Expect PET uptake
    - Rare
Knee PET-CT

- RA
- Gout
  - Both show increased uptake and erosions
  - Gout may have crystals
    - Amorphous calcium
    - Tophi
    - Check great toe
- Synovial sarcoma
  - Cyst mimic
Question 92

• Low grade uptake on PET-CT at a single joint with large erosions, and peri-articular soft tissue masses suggests which diagnosis?
  – A. Metastasis
  – B. Gouty arthropathy
  – C. DJD
  – D. Synovial chondromatosis

• Costelloe, et al. Musculoskeletal Pitfalls in 18F-FDG PET/CT: Pictorial Review. AJR September 2009 vol. 193 no. 3 Supplement WS1-WS13
Question 92

- Low grade uptake on PET-CT at a single joint with large erosions, and peri-articular soft tissue masses suggests which diagnosis?
  - B. Gouty arthropathy

GOUT

- Sodium Urate deposition
  - Erosions
    - Can be away from joint
  - Tophi
  - Calcification
  - Joint spaces preserved early
  - Often hot on PET
  - “when in doubt, think gout”
GOUT
GOUT
Question 93

• Which modality is most sensitive for osteonecrosis of the hip?
  – A. PET-CT
  – B. MRI
  – C. Radiography
  – D. Ultrasound

• Role of 18F-Fluoride PET-CT scan in the diagnosis of avascular necrosis (AVN) of femoral head. Shankaramurthy Gayana1, Anish Bhattacharya, Ramesh Sen, Manohar Kuruva, Kanhaiyalal Agrawal, Raghava Kashyap and Bhagwant Mittal. SJ Nucl Med. 2012; 53 (Supplement 1):536e
• Which modality is most sensitive for osteonecrosis of the hip?

  – B. MRI

Osteonecrosis

- Bone death
  - Synonyms: Avascular necrosis, aseptic necrosis, bone infarct
  - Associated conditions
    - Sickle cell
    - Steroids
    - ETOH
    - Pancreatitis
    - Collagen vascular, RA
    - Trauma
    - Radiation
    - Others

Osteonecrosis

- **Location**
  - Weight bearing convex joints
  - Severe disease results in diaphyseal and metaphyseal infarcts

- **Appearance**
  - PET
    - Increased uptake
    - Can mimic mets
  - CT
    - Sclerosis/lucency
    - Serpiginous sclerotic line and central lucency
    - Collapse/fracture
  - MR
    - Edema early
    - Dark line, serpiginous
Hip Osteonecrosis

- Radiography
  - Classic staging FICAT
    - 0 – Normal
    - 1 – Normal
    - 2 – Sclerosis/lucency
    - 3 – Loss of round contour
    - 4 – Degenerative changes

- Similar
  - Transient osteoporosis
  - Regional migratory osteoporosis
  - Reflex sympathetic dystrophy
  - “Bone marrow edema syndrome”
  - Hip appearance of edema mimics early osteonecrosis but does not progress
Hip Osteonecrosis

T2 fat sat

T1 non fat sat
Bone infarcts

T2 fat sat

T1 non fat sat
Degenerative change can be managed conservatively, with joint replacement often being the end result. What is the treatment for synovial osteochondromatosis?

- A. Hip replacement.
- B. Wide resection of entire joint.
- C. Radiation.
- D. Resection of loose bodies and/or partial synovectomy.

Degenerative change can be managed conservatively, with joint replacement often being the end result. What is the treatment for synovial osteochondromatosis?

- D. Resection of loose bodies and/or partial synovectomy.

Synovial Chondromatosis

- Synovial metaplasia
  - Synovial *osteochondromatosis*
    - When ossification of chondral bodies occurs
      - Primary
        » Numerous, similar size
        » Erosions
      - Secondary
        » Different sizes
        » Fewer
        » DJD, post-traumatic
  - Can differentiate from PVNS
  - Treatable
  - ~ increased PET activity
Synovial Chondromatosis
Question 95

• Which of the following shows consistent increased PET radiotracer uptake?
  – A. Degenerative change
  – B. Pigmented villonodular synovitis
  – C. Active rheumatoid arthritis
  – D. An os acetabula

• Which of the following shows consistent increased PET radiotracer uptake?

  – C. Active rheumatoid arthritis

Pigmented Villonodular Synovitis

• Synovial Proliferation
  – PVNS joints
  – PVNTS tendon
    • “Giant cell tumor tendon sheath”
  – Occurs where there is synovium
    • CT
      – Erosions
      – Effusion
      – Mass-like
    • MR
      – Low signal from hemosiderin
      – Anatomic localization
    • PET
      – Often increase uptake
• DIFF: RA, other synovial proliferation
Pigmented Villonodular Synovitis
Pigmented Villonodular Synovitis
• Amorphous calcification within a tendon that also shows increased uptake on PET-CT is most suggestive of which process?
  – A. Heterotopic ossification
  – B. Pigmented villonodular synovitis
  – C. Hydroxyapatite deposition disease
  – D. Calcium pyrophosphate disease

Question 96

• Amorphous calcification within a tendon that also shows increased uptake on PET-CT is most suggestive of which process?
  
  – C. Hydroxyapatite deposition disease

Calcific Tendinitis

- **Hydroxyapatite deposition disease**
  - Any tendon in the body, but commonly the rotator cuff
  - Often detected incidentally on radiography
  - *Amorphous* calcific density
  - “Tooth=paste”-like
  - Can be extremely painful
  - May cause increased uptake on PET-CT, particularly in the acute phase
  - Radiography characterizes better than CT due to small size
  - MR shows low signal and can show edema during acute inflammation
  - Treatment can be conservative, but we have success with Ultrasound guided aspiration
Calcific Tendinitis
Calcific Tendinitis
Calcific Tendinitis
Calcific Tendinitis
Question 97

• Significant radiotracer uptake can be seen in several benign bone lesions on PET-CT. What does the following description MOST suggest?
  • Metaphyseal lesion, well circumscribed with expansion of overlying cortex, ground-glass matrix, narrow zone of transition, and absence of periosteal reaction or soft tissue mass.

  – A. Fibrous dysplasia
  – B. Osteoid osteoma
  – C. Enchondroma
  – D. Osteochondroma

• Fitzpatrick, et al. Imaging Findings of Fibrous Dysplasia with Histopathologic and Intraoperative Correlation. AJR June 2004 vol. 182 no. 6 1389-1398
Question 97

- Significant radiotracer uptake can be seen in several benign bone lesions on PET-CT. What does the following description MOST suggest?
  - Metaphyseal lesion, well circumscribed with expansion of overlying cortex, ground-glass matrix, narrow zone of transition, and absence of periosteal reaction or soft tissue mass.

  - A. Fibrous dysplasia

  - Fitzpatrick, et al. Imaging Findings of Fibrous Dysplasia with Histopathologic and Intraoperative Correlation. AJR June 2004 vol. 182 no. 6 1389-1398
Fibrous Dysplasia

- Monostotic most common
  - Developmental lesion
  - Bone marrow replaced by fibrous tissue
  - Often hot on PET
  - Radiographs:
    - Medullary lesion
    - Lucent to dense
      - “ground glass”
    - Cortical scalloping and expansion
    - Deformity “shepherd’s crook”
    - Absence of periosteal reaction or cortical destruction
    - Lesions are geographic
    - Often involves skull base
  - CT
    - Normal marrow fat within lesion
    - Absence of aggressive features
Fibrous Dysplasia

Sagittal T1

Axial FLAIR
Fibrous Dysplasia
Fibrous Dysplasia

- Sarcoma <0.5%
- Polyostotic
  - McCune Albright
    - Precocious puberty
    - Often unilateral
  - Mazabraud
    - Unilateral fibrous dyplasia
    - Soft tissue myxoma
    - Higher rate of sarcomas

Osteosarcoma in a patient with McCune-Albright syndrome and Mazabraud’s syndrome.
Fibrous Dysplasia
Fibrous Dysplasia
Fibrous Dysplasia

• **Mimic**
  - Melorheostosis
    • Mesenchymal dysplasia
    • Osteopoikilosis spectrum
    • Looks like FD
    • “dripping candle wax”
    • Unilateral or monostotic
Fibrous Dysplasia
A solitary enchondroma encountered on PET-CT is likely to be benign. If multiple lesions are encountered (Ollier’s disease), what is the lifetime risk of malignant transformation?

- A. 0-5%
- B. 5-10%
- C. 10-20%
- D. 20-30%

A solitary enchondroma encountered on PET-CT is likely to be benign. If multiple lesions are encountered (Ollier’s disease), what is the lifetime risk of malignant transformation?

- D. 20-30%

**Enchondroma**

- Solitary, benign cartilage tumor
  - Most common in hands
  -Usu. medullary and
diametaphyseal in long bones
    - Lucent
    - Expansile
    - Cortical scalloping
    - Rings/arcs of cartilage calcs
    - “popcorn” appearance
  - Rarely malignant
  - Diff: bone infarct
    - Sclerotic border, central lucency
  - Multiple- bizarre appearance
    - Ollier disease
    - Maffucci
      » Higher rate of malignancy
Bone Infarct

Henk Jan van der Woude and Robin Smithuis

The radiology assistant
Enchondroma

- PET
  - Benign
    - SUV’s <2.0 typical
  - Malignant
    - Pain
    - Growth outside of bone
    - Irregular calcification
    - Areas of lucency
    - Soft tissue mass
    - Bone destruction
    - More common when multiple
    - Maffucci’s has highest risk
      - Soft tissue hemangiomas
Enchondromatosis (Ollier’s disease)
Benign Bone Lesions

- Variable PET uptake
  - Usually lower than malignancy
    - However, significant overlap
  - CT characteristics helpful
    - Sclerotic rim
    - No periosteal reaction
    - No soft tissue mass
    - No cortical destruction
- Non-ossifying fibroma
  - Metaphysis, sclerotic rim, young adults
Non-Ossifying Fibroma
Expansile Rib Lesion

• FAME
  – Fibrous dysplasia
  – Aneurysmal Bone Cyst (ABC)
  – Mets, myeloma
  – Enchondroma, EG

• ALL +/- PET uptake
  – ABC, enchondroma less likely
Aneurysmal Bone Cyst

- **ABC**
  - Benign
  - Cystic expansile bone lesion
  - Fluid-fluid levels
    - Can be seen in aggressive lesions
      - Telangiectatic osteosarcoma
  - 1/3 associated with other lesion
    - GCT most common
Aneurysmal Bone Cyst
Fatty lesions seen in the soft tissues of the extremities are often seen. Which of the following features is usually benign?

- A. Thick, nodular septations within the lesion
- B. Areas of focal soft tissue attenuation in an otherwise fatty lesion (>25% non-adipose tissue)
- C. Homogenous fat attenuation and size less than 5 cm
- D. Low-grade uptake on PET-CT

Fatty lesions seen in the soft tissues of the extremities are often seen. Which of the following features is usually benign?

- C. Homogenous fat attenuation and size less than 5 cm

Liposarcoma

- **PET**
  - Can be false negative
    - Chondrosarcoma is another
  - High uptake = aggressive, dedifferentiated

- **CT**
  - Benign
    - Entirely fat
    - Superficial, extremity
    - A few thin septations
    - Encapsulated
    - <5cm
  - Malignant
    - Soft tissue density
    - Nodular septae
    - Invasive
    - Retroperitoneal
Liposarcoma
Lipoma
Lipoma
Lipomatosis
Soft tissue masses

- PET
  - MOST malignant are hot
  - MOST benign show minimal uptake
  - Overlap lesions:
    - Aggressive fibromatosis
      - Often HOT, but needs to be treated anyway.
        » MR or biopsy to characterize
    - Myositis ossificans
      - Characteristic zonal pattern on CT
    - Low grade sarcoma, particularly liposarcomas
      - CT helpful in demonstrating soft tissue density in the lesion
    - Chondrosarcoma
Aggressive Fibromatosis

- **Desmoid tumor**
  - Locally aggressive
  - Does not metastasize
  - Hard to cure
    - Therapy is surgery, chemo or radiation
    - PET can assess for tumor response
  - CT: Soft tissue mass, non-specific
  - MR: Areas of low signal on T2
  - PET: Often increased uptake
Primary soft tissue lymphoma
A focal, cortically based lesion with increased uptake is seen in a long bone. There is a central round calcification within the soft tissue of the lesion, with overlying thickened cortex. What is the likely diagnosis?

A. Brodies abscess
B. Osteoid Osteoma
C. Renal cell metastatasis
D. Non-Ossifying Fibroma

A focal, cortically based lesion with increased uptake is seen in a long bone. There is a central round calcification within the soft tissue of the lesion, with overlying thickened cortex. What is the likely diagnosis?

- B. Osteoid Osteoma

Osteoid Osteoma

- **Osteoid osteoma**
  - Benign tumor of cortical bone
  - M>F
  - Peak age 7-25 y.o.
  - Central nidus of either soft tissue or dense bone
  - Painful, irritating
    - Often hot on PET
  - Causes cortical thickening with mature periosteal reaction
- **Osteoblastoma**
  - >2cm
Osteoid Osteoma

- Osteoid osteoma
  - Thick periosteal reaction
  - Edema on MR
- Mimics
  - Brodie’s abscess
    - Central lucency
    - Occasional central bone fragment, but usually less round
    - Sinus tract
  - Stress fracture
    - More linear
Intracortical (Brodie’s) abscess

- Classically in pediatrics at the physis
- Subacute hematogenous spread
- Name can be applied to small focus of infection in cortical bone in adult
- Can be confused with osteoid osteoma
  - Irregular margins
  - Sinus tract
  - Irregular sequestrum
  - Center does not enhance
Intracortical (Brodie’s) abscess
Osteomyelitis

• Pathogenesis
  – Hematogenous
    • Child - Metaphyseal
    • Adult – Diaphyseal
  – Direct inoculation
  – Diabetic/vascular insufficiency

• Description
  – Lytic(acute)
  – Reactive sclerosis
  – Thick periosteal reaction(chronic)
  – Soft tissue abscess
  – Sinus tract
  – Sequestrum
  – Involucrum
Osteomyelitis
Osteomyelitis

- **PET-CT**
  - Vertebral osteomyelitis
    - MRI alternative
    - Hardware present
    - MRI equivocal
  - Skeletal osteomyelitis
    - Fever of unknown origin
    - Adjunct to other modalities

- **CT:**
  - Sinus tract
  - Periosteal reaction
  - Involucrum/Sequestrum
  - Abscesses
Osteomyelitis

- PET-CT
  - Vertebral osteomyelitis
    - MRI alternative
    - Hardware present
    - MRI equivocal
  - Skeletal osteomyelitis
    - Fever of unknown origin
    - Adjunct to other modalities

- CT:
  - Sinus tract
  - Periosteal reaction
  - Involucrum/Sequestrum
  - Abscesses
Sacroiliac joint infection

• Infection
  – Usually unilateral
  – Adjacent abscesses

• Inflammatory
  – Ankylosing spondylitis
  – Reactive arthritis (Reiter)
  – Psoriatic
  – Inflammatory bowel
  – RA, DJD
  – Gout

• Stress fracture
Sacroiliac joint inflammatory changes
BONUS CASE 1 – Lymphoma of bone

- Primary Lymphoma of bone
  - Rare
    - < 5% of malignant bone tumors
    - Radiographically occult at times
    - MRI specific
  - Bone involvement in traditional lymphoma common
  - Aggressive, permeative appearance
  - Soft tissue mass
  - Less new bone than osteosarcoma
Primary bone tumor

- Utility of PET
  - Chemotherapy response
  - Recurrence
  - Less useful in staging
  - Problems with distinguishing benign and malignant
    - SUV’s overlap
      - CT appearance emphasized
        » MR is most sensitive modality

Osteosarcoma
Malignant bone tumor

• CT characteristics
  – Wide zone of transition
    • “moth eaten”
    • “permeative”
  – Cortical destruction
  – Aggressive periosteal reaction
    • “sunburst”
    • “onion-skin”
    • Codman triangle
  – Extrasosseus soft tissue mass
Benign bone tumor

- CT characteristics
  - Narrow zone of transition
    - Sclerotic border
    - “geographic”
  - No periosteal reaction
    - If present, solid and mature
  - No extraosseus mass
  - No cortical destruction
Periosteal reaction
Periosteal reaction

- **Aggressive**-
  - Focal, related to lesion
    - Infection
    - Mass
  - Sunburst
  - Discontinuous
  - Lamellated
  - Codman’s triangle

- **Benign**
  - Solid, thick
  - Uninterrupted

- **HPO**
  - Related to lung process (CA)
  - Diffuse, long bones
  - Diff:
    - Lung process
    - Primary- pachydermoperiostitis
    - Thyroid acropachy
BONUS CASE 2 - Neurofibromatosis

- Differentiating benign from malignant
  - Benign
    - Split fat sign(CT, MR)
    - Target sign(MR)
    - Localized to a peripheral nerve(CT, MR)
    - Homogenous enhancement(CT, MR)
  - Malignant
    - Larger(CT, MR)
      - Interval growth
    - Retroperitoneal (CT, MR)
      - Plexiform
    - Cysts, necrosis(CT, MR)
    - Peripheral enhancement(MR)
    - Perilesional edema(MR)
Neurofibromatosis
Neurofibromatosis
Neurofibromatosis
THANK YOU FOR YOUR ATTENTION