Applications of SPECT/CT in Orthopaedic Practice

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Introduction

- Increasing utility in Orthopaedic Practice
- Improved technology
  - Improved software resulting in better image fusion
  - High quality multislice CT
- Correlation with other cross sectional imaging
- Greater interest from MSK radiologists
- Major role in problem solving when other imaging inconclusive
- Important role to play in assessment of implanted devices and assessment of bony fusion
3 Phase Bone Scan

- Has been mainstay of orthopaedic nuclear imaging.
- Dynamic and blood pool phases useful physiologic information especially re inflammation/infection
- Inject 99mTc labelled with HMDP which is incorporated into bone at sites of osteoblastic activity.
- Delayed phase reflects level of osteoblastic activity
- Advantages:
  - Large anatomical coverage
  - Low cost
- Disadvantages:
  - Low resolution
  - Low sensitivity compared with SPECT
  - Poor anatomic localisation
  - Lack of specificity
3 Phase Bone Scan
SPECT Scanning

- Single Photon Emission Computed Tomography (SPECT)
- Obtain planar image (similar principle to CT) of anatomy which can be reconstructed in multiple planes.

Advantages:
- Improved sensitivity and anatomical localisation
- Relatively low resolution

Disadvantages:
- Poor specificity
- Difficult for referrers to interpret
- No compensation for body size (no attenuation correction) can result in spurious results
SPECT/CT: Background

- Hybrid system of a SPECT nuclear medicine scanner and a CT scanner
- Has until recently been hampered by poor quality of CT scanner
- The CT scanner allows for attenuation correction to compensate for body size/tissue density resulting in more accurate representation of uptake.
SPECT/CT
SPECT/CT Image Quality: Evolution
SPECT/CT: Evolution of Image
Pseudarthrosis
SPECT/CT: Spine Indications

- Stress response/ fractures
- Pars defects? Healed /symptomatic
- Tumours e.g. Osteoid osteoma
- Fracture healing
- Location of pain generator especially in widespread degenerative changes – Cervical spine axial pain
  - Endplate changes /Neurocentral joints
  - Facet joint disease
  - Osteophytes/DISH
- SI joint disease
- Post spinal surgery
SPECT/CT: Spine

- Important modality in assessment of source of spinal pain in pre and post operative patients.
- SPECT/CT allows detection of foci of inflammation/ increased osteoblastic activity and accurate anatomic localisation/lesion characterisation.
- Increased osteoblastic activity associated with osteoarthritis, implant loosening, failure of fusion, infection, fracture i.e. altered bone stress
- Usually performed after MRI assessment to confirm suspected cause of pain or if MRI inconclusive.
- Less susceptible to metal artefact
- Also useful in patients who cannot have an MRI.
- Unexpected causes of spine pain.
- Get a non contrast abdominal scan for free.
SPECT/CT: Spinal Fusion

- 10% of spinal fusion complicated by pain.
- 14% reintervention rate 4 yrs post surgery, 19% after 11 yrs
- SPECT/CT has been shown to have high sensitivity and specificity in detection of pseudoarthrosis and implant loosening.
- Also assessment of adjacent segment failure such as disc failure and facet joint degeneration.
- The combination of SPECT and high resolution CT allows one stop assessment with less total radiation dose.
- Must wait at least 1 year post surgery before scanning to allow activity to normalise.
- Cost effective compared with PET/CT
Instrumented Spinal Fusion

- Pseudarthrosis incidence 5-30% in various series
  - Up to 50% asymptomatic
  - Diagnosis difficult. Persistent cleft after 12-18/12 sign of pseudarthrosis.
  - In 8% CT falsely predicts pseudarthrosis.
  - Lack of SPECT uptake around cages showing subsidence or surrounding lucency on CT suggests false positive

- Pedicle screw loosening-
  - SPECT/CT signs of loosening-Markedly increased activity(compared with background) at typical sites of loosening around screws

- Facet joints
  - Morphologic changes on CT correlate poorly with symptoms. Fat supressed MRI better but metal artefact.
  - SPECT/CT useful in cases with metal or multilevel changes.
Pseudarthrosis
Fusion: Adjacent level failure
SPECT/CT: Instrumented Spinal Fusion

- Sensitivity of SPECT/CT for loosening: 100%
- Specificity: 87%
- Overall accuracy: 92%
- Alternative cause in SPECT/CT negative for loosening:
  - Facet joint disease
  - Disc degeneration
  - SI joint disease

>1yr post op activity has usually normalised
SPECT/CT: Spinal fusion

- False positive causes
  - Scanning too early
  - Fusion misregistration (facet jt vs screw)

- Hardware loosening can be ruled out if negative SPECT scan
- Gold standard surgical reintervention
- Clinical followup in negative scans is alternative
Facet joint osteoarthritis and DISH
Osteoid Osteoma vs LCH
Costo vertebral
Pseudarthrosis
Sacroiliitis: Buttock Pain
Sacroiliitis
SPECT/CT: Ankle and Foot

- Identification of pain generators can be problematic due to complex anatomy.
- Most cases sorted out with Xray and MRI.
- In case of normal/inconclusive Xray and MRI SPECT /CT can be helpful.
- Can help localise pain generator especially on background of widespread degenerative change.
- SPECT/CT very useful in presence of metalware eg status of arthrodesis union
- Multiple abnormalities
- Poorly localised pain
- Congenital abnormalities such as coalitions, synchondrooses
- Impingement
SPECT/CT vs MRI: Ankle and Foot

- Sensitivity: MRI and CT similar
- Specificity: High for SPECT/CT of 48% vs 24% for MRI
- MRI most effective diagnostic modality in assessing foot and ankle pain
  - Limitations: Subtle structural changes and when several coexistent lesions
  - MRI detects many asymptomatic lesions which impairs its diagnostic specificity.
- Increased uptake on SPECT closely associated with increased bone turnover
- Pathologic uptake on SPECT well correlated with symptoms
- Small joints of foot and ankle-uptake closely correlated with pain or pain relief post anesthetic injection
- Complimentary modalities: Markedly increased specificity and minimal reduced sensitivity when lesion positive on both
- Radiation dose not an issue due to extremities not being rad sensitive
- Ankle SPECT/CT 5.5mSv with diagnostic CT.
Anterolateral pain post Fusion
TMT Joint Osteoarthritis
SPECT/CT: TKJR

- Diagnosis of loosening complex
- On planar bone scans
SPECT/ CT: TKR Assessment

- Hot patella high association with pain
- Negative - patellofemoral problems unlikely

Component positioning:
- Coronal: Varus / valgus position of tibial component - increased uptake due to bone remodelling - early loosening or collapse
- Femoral malrotation: Internal rotation - patellar maltracking e.g. edge loading lateral patellar facet
- Tibial malrotation - internal rotation causes increased MCL forces and medial joint pain.

- Use of CT with metal artefact reduction software can help visualise osteolysis/fractures.
SPECT CT : TKR assessment

- Small percentage persistent pain post TKR
  - Infection
  - Aseptic loosening
  - Instability
  - Malposition of TKA
  - Arthrofibrosis
  - Patellofemoral

- Aseptic loosening
  - Micromotion and attempts to stabilise cause increase secretion of calcified bone matrix and increased uptake on bone scan and SPECT
  - Look for osteolysis / lucency on CT

- Patellofemoral problems
  - Progression of OA
  - Patellofemoral maltracking
  - Overstressing due to patella baja
  - Femoral component malpositioning
Unicompartment TKR
Unicomp TKR
SPECT/CT: THJR Aseptic Loosening
THJR Osteolysis
SPECT/CT: Heterotopic Bone