Radionuclide bone SPECT/CT in orthopaedics

Radionuclide 99mTc-MDP planar bone scan is the most commonly performed nuclear medicine procedure and may aid diagnosis of benign and malignant bone pathologies. 99mTc-MDP is injected intravenously and subsequently taken up by osteoblasts and incorporated into the bone matrix. In the process it acts as a marker for new bone formation, bone turnover and local vascularity.

The high sensitivity of the 99mTc-MDP bone scan for detection of skeletal metastases and the ability to image the entire skeleton has maintained its role in oncology imaging in combination with other imaging modalities. In contrast, the main limitation of planar 99mTc-MDP bone scan is its limited specificity. It can be a challenge with planar bone scans to accurately localise lesions due to overlying structures, and also to fully characterise the abnormality accurately on a single imaging modality. With the emergence of hybrid imaging such as SPECT/CT and PET/CT it is possible to obtain and provide both morphological/anatomical and metabolic functional data concurrently. SPECT/CT can harness the improved spatial resolution of SPECT and co-registration with CT to enable accurate localisation and the diagnostic features from the two tests can be used together to improve the diagnostic potential.

There is a developing body of evidence that supports the use of 99mTc-MDP SPECT/CT routinely in orthopaedics. In this article the authors share their experience, review the contemporary literature and summarise the role of SPECT/CT in orthopaedics.

SPECT/CT: wrist

The potential causes of wrist pain are varied. Complex anatomy with multiple articulating joint surfaces makes the assessment of wrist joint pain particularly challenging. Often several anatomic abnormalities coexist and it can be difficult to confidently localise the pain generator. SPECT/CT bone scan can improve localisation and characterisation of abnormalities.

With non-specific pain of the hand and wrist, Schleich et al (n=51) showed that while CT reveals a number of anatomical abnormalities sites in patients, SPECT/CT altered patient management in 19/51 patients by ‘identifying sites of active metabolism’ (figure 1).

Carpal bone fracture and especially scaphoid fractures benefit from early diagnosis and treatment due to the risk of avascular necrosis. Beeres et al confirmed in 100 consecutive patients with a suspected scaphoid fracture and normal initial plain radiographs, a planar bone scan had superior sensitivity to early MRI (100% vs 80%). Similarly, Querellou et al confirmed the added role of SPECT/CT in diagnosing occult carpal fractures and proposed that when there is high suspicion of an occult carpal fracture SPECT/CT should be considered as second line after a normal radiograph.

SPECT/CT: pelvis/hip

Hip pain is often characterised by non-specific symptoms and normal imaging findings. It may be due to local intra or extra articular hip pathology or referred from the spine or knee. Anatomical imaging often demonstrates multiple abnormalities. 99mTc-MDP SPECT/CT can help localise pain generators within the hip and in addition whole body images can be helpful in the assessment of referred pain (figure 2). In the authors’ experience SPECT/CT has been useful in assessment of the hip in cases of possible femoroacetabular impingement, insertional enthesisopathies, bursitis, avascular necrosis etc.

SPECT/CT: knee

MRI is commonly used for initial imaging of the knee. 99mTc-MDP bone SPECT/CT may have a complementary role in a subset of patients. Pre-arthroplasty SPECT/CT evaluation of osteoarthritic changes in the knee joint can help guide the surgeon in the choice of prosthesis and extent of surgery. SPECT/CT has been shown to be more sensitive than MRI in the diagnoses of mechanical bone overload in chronic medial knee pain without history of previous trauma and in a small cohort SPECT/CT generated a higher diagnostic confidence compared to conventional bone scan or CT alone in evaluation of knee pain. In the authors’ experience SPECT/CT has been particularly helpful in the characterisation of osteochondral defects, patellar maltracking/subluxation and patellofemoral arthritis.

SPECT/CT: post hip and knee arthroplasty

In the first eight years following arthroplasty up to 3.9% of patients develop complications, including aseptic loosening, infection, heterotopic ossification and peri-prosthetic fracture. Both CT and MRI are compromised due to local image degradation close to metallic prosthetic. Strobel et al eloquently described the role of bone SPECT/CT in discriminating different causes of post hip arthroplasty pain.

Similarly, post arthroplasty pain in the knee is a common clinical problem. Bone SPECT/CT study of knee prosthesis has demonstrated added value in the planar study by accurately localising altered bone metabolism (figure 3). Hirschmann et al described the potential role of SPECT/CT as a valuable modality in differentiating causes of painful knee in patients with post arthroplasty knee pain.

SPECT/CT: ankle and foot

The complex anatomy of ankle and foot make localisation on planar imaging difficult. SPECT/CT has shown excellent intra and interobserver reliability for the assessment of degenerative disease of foot and ankle, which was also significantly better than CT and bone scan performed consecutively (figure 4). Precise anatomical localisation of symptomatic osteoarthritis with SPECT/CT can guide surgical intervention. SPECT/CT can also be used in the evaluation of pain in patients after joint arthrodesis to assess non-union or the development of osteoarthritis in adjacent joints. It may differentiate osseous and some soft tissue pathologies such as Achilles tendinitis, bursitis, plantar fasciitis, talar osteochondral defect, painful accessory bones.
and tarsal coalition as the cause of pain. This may help in targeting guided injections.

Suspected osteomyelitis in the diabetic foot often warrants urgent investigation with the aim of avoiding amputation. A three or two phase bone scan is a useful modality in assessing bony infection in such cases, however, again it is limited by spatial resolution. SPECT/CT can differentiate soft tissue and bone involvement. The labelled white cell SPECT/CT is reported to improve diagnostic capability over planar studies. Its utility is particularly evident when contrast enhanced MRI is not possible due to contraindications such as renal impairment in this cohort.

Summary

SPECT/CT may provide unique information and can help localise and characterise abnormalities in patients with orthopaedic pathology. There is a developing evidence base, but this is limited by the wide spectrum of disease and presentation. Multidisciplinary reporting and integrated diagnostic and imaging algorithms will help clinicians use it effectively and as a complement to other imaging tests.

References


Figure 1

Patient with history of fall three months prior. MRI of right wrist showed mild triangular fibro cartilage complex (TFCC) degeneration, however clinically the pain was worse than usually anticipated in TFCC degeneration. 99mTc-MDP bone SPECT/CT was performed to rule out other causes of pain. (A, B) Two-phase bone scan showed diffuse low-grade increased uptake in the right wrist with no associated hypervascularity on the (A) early blood pool images. (C-H) SPECT/CT was helpful in specifying the site of increased tracer uptake in the right wrist to the articular aspect of the distal ulna with no underlying bony abnormality on CT component, which supports MRI findings of TFCC injury.

Figure 2

Patient with hip pain and low back pain. (A,B) 99mTc-MDP bone scan showed subtle asymmetrical uptake of tracer at the left sacroiliac joint and a left sided hydrenephrosis. SPECT/CT (C-D) showed metabolically active bridging osteophyte at inferior aspect of left sacroiliac joint, which is likely to be the pain generator. (E, F) Metabolically inactive degenerative changes shown at the pubic symphysis, which is unlikely to be the pain generator. This example demonstrates the role of SPECT/CT in differentiating pain generators among multiple anatomical abnormalities.
**Figure 3**
Patient with bilateral knee replacement, presented with left knee pain two years after surgery. Two-phase 99mTc-MDP bone scan showed increased vascularity and increased tracer uptake at the tibial component of the left knee on the (A) early blood pool and (B) delayed images respectively. On SPECT/CT, the uptake at the left tibia was localised to stress remodelling changes at the medial part of proximal tibia with an oblique fracture, which is likely to be the pain generator and there were no features of infection.

**Figure 4**
Patient with left lateral foot pain. (A, B) 99mTc-MDP planar bone scan showed focal increased tracer uptake in the left ankle posterior to the talus and at right first metatarsophalangeal (MTP) joint. SPECT/CT demonstrated metabolically active (C, D) bipartite sesamoid bone at the right first MTP joint in keeping with sesamoiditis and (E-H) synchondrosis of the os trigonum and talus in the left hind foot.