

# Combined single-photon emission computerized tomography and conventional computerized tomography (SPECT/CT): clinical value for the knee surgeons?

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**Abstract** Single-photon emission computerized tomography in combination with conventional computer tomography (SPECT/CT) is an emerging technology that may hold great clinical value to the orthopaedic knee surgeon. Post-operative knee pain is a familiar condition seen in most orthopaedic clinics. Here, we present the value of SPECT/CT in three such cases of pain after surgical treatment of knee osteoarthritis (high tibial osteotomy, medial unicompartmental arthroplasty, total knee arthroplasty). In these patients with post-operative knee pain, SPECT/CT has proved to be beneficial in establishing the diagnosis and providing guidance for further treatment.

**Keywords** Knee · SPECT/CT · Total knee replacement · High tibial osteotomy · Unicompartmental knee arthroplasty

## Introduction

During the past decade the diagnosis of knee disorders has been significantly aided by improved imaging techniques. In contrast to radiographs, computer tomography and

magnetic resonance imaging bone scans not only provide information on structural and biomechanical characteristics, but also on osseous physiology and metabolism [3]. Thus, these are routinely used to rule out or confirm the suspicion of an infection, osteonecrosis, tumour or reflex sympathetic dystrophy [3]. With the introduction of single-photon emission tomography (SPECT), the localization of the tracer to anatomical structures has been improved. More recently, integrated hybrid systems (SPECT/CT) enable us to merge anatomical (computerized tomography CT) and functional (SPECT) imaging modalities accurately and may open a new horizon of diagnostic opportunities in orthopaedic surgery [1, 2, 5–7, 9–12]. Particularly in patients with post-operative knee pain, the sensitivity and the specificity of radiologic diagnostic modalities are currently limited. Thus SPECT/CT may offer a relevant improvement in diagnostics. However, to the best of our knowledge, so far there is no single study dealing with SPECT/CT in patients after knee surgery.

## Technical description and case reports

<sup>99m</sup>Tc-DPD-single-photon emission computerized tomography (SPECT/CT) was performed using a hybrid system, Symbia T16 (Siemens, Erlangen, Germany), equipped with a pair of low-energy, high-resolution collimators. This system incorporates a dual-head gamma camera with an integrated, 16, 0.75-mm slice thickness CT. All patients received a commercial 700 MBq Tc-99 m DPD injection (CIS Bio International Sur Yvette, France). At 2 h after injection, anterior and posterior views of both knees were obtained. SPECT/CT was performed with a matrix size of 128 × 128, an angle step of 32, and a time per frame of 25 s. Data were processed by interactive reconstruction and

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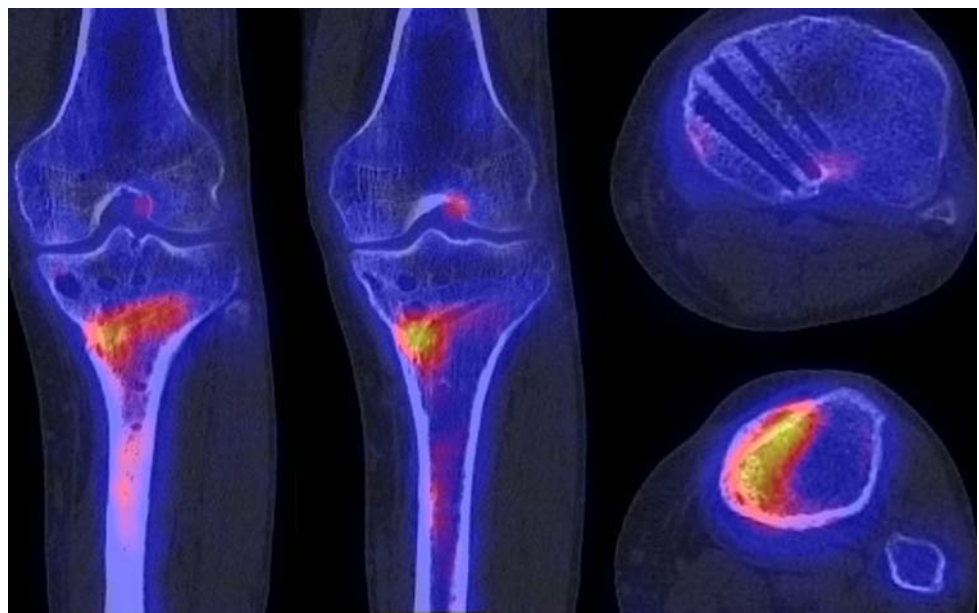
**Fig. 1** Anteroposterior and lateral radiographs of the left knee joint after removal of the high tibial osteotomy plate 12 months after initial surgery

images were displayed in transaxial, coronal and sagittal planes.

#### Case 1

A 57-year-old male patient underwent uncomplicated medial open wedge high tibial osteotomy (Tomofix<sup>®</sup> plate,

**Fig. 2** SPECT/CT images of the left knee. Atrophic non-union clearly visible due to focal increased activity around the medial entrance of the osteotomy in combination with still visible osteotomy gap and screw holes



Synthes, Oberdorf, Switzerland) for isolated medial compartment knee arthritis. One year post-surgery, the patient continued to complain of pain to the medial aspect of the knee resulting in plate removal. Nevertheless, the antero-medial pain continued, particularly with weight bearing. Anteroposterior and lateral radiographs post-plate removal revealed a visible gap at the osteotomy site. This is a common appearance found post-HTO (Fig. 1).

A SPECT/CT was performed and this clearly localized the nature of the problem: non-union of osteotomy and no bone ingrowth at the site of the proximal screw holes (Fig. 2). During revision surgery, it was noted that although the medial tibial cortex (site of osteotomy) had healed, a large bone cavity existed underneath the proximal tibia. This was filled with cancellous bone graft. The patient made an uneventful recovery with resolution of symptoms.

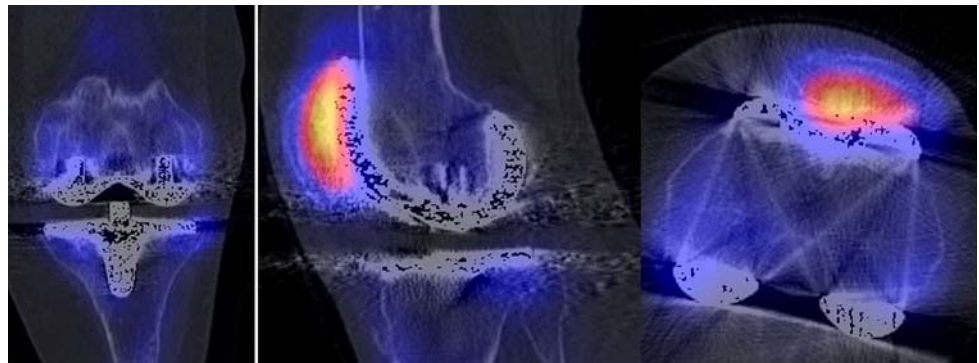
#### Case 2

A 65-year-old female patient underwent a primary patella sparing total knee arthroplasty (Balansys<sup>®</sup>, Mathys Ltd, Bettlach, Switzerland) for bicompartamental osteoarthritis of the left knee joint. Although not resurfaced, the patella was denervated with electrocautery. Initial post-operative recovery was uneventful, until 2 years post-surgery when the patient presented with activity-related anterior pain to the operated knee. Clinical examination, blood tests and plain radiographs were unremarkable and did not reveal an obvious cause for the symptoms. The radiographs showed an unchanged position of the total knee prosthesis, however, with a slightly flexed femoral component (Fig. 3). Suspecting sub-acute infection or component loosening,

**Fig. 3** Anteroposterior and lateral radiographs of the left knee joint after total knee arthroplasty 24 months after the initial surgery



**Fig. 4** SPECT/CT images of the left knee. Focal increased activity at the retro patellar patella with otherwise unsuspecting knee after total knee arthroplasty



a SPECT/CT was performed. In fact, the SPECT exam demonstrated unspecific tracer uptake around the knee joint. The hybrid SPECT/CT then demonstrated tracer uptake specifically to the retro patellar surface. There was no evidence of loosening of the prosthesis or infection. The SPECT/CT suggested the progression of patellofemoral osteoarthritis as the source of the pain (Fig. 4). The patella was resurfaced accordingly with an immediate improvement in the patient's symptoms.

### Case 3

Four months following uncomplicated medial unicompartmental knee arthroplasty (HLS<sup>®</sup>, Tornier AG, Cham, Switzerland), a 50-year-old patient presented with new onset activity-related pain. Clinical examination and blood tests were unremarkable, whilst radiographs demonstrated

a satisfactory component position (Fig. 5). The bone scan showed increased uptake around the operated knee joint. The SPECT/CT (Fig. 6) clearly showed an increased uptake below the anterior and central aspects of the tibial base plate, which was then revised with a successful outcome. Intraoperatively, the tibial base plate was found to be loose and lifted anteriorly.

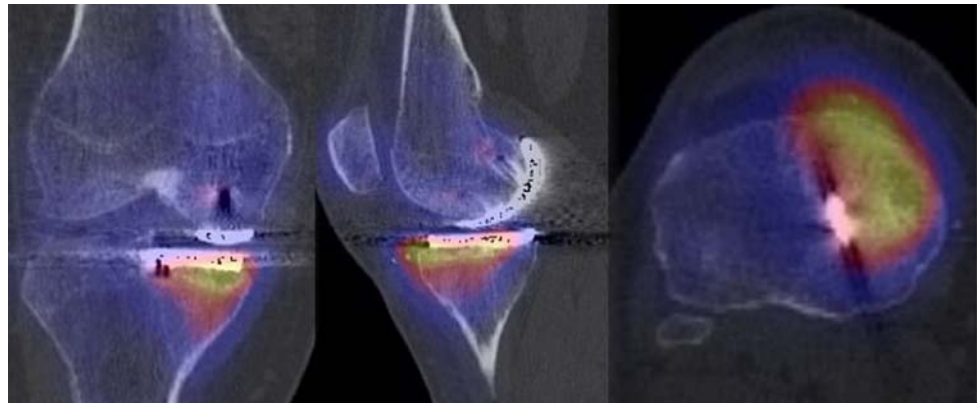
### Discussion

The most important finding of the present study was that SPECT/CT proved to be beneficial in establishing the diagnosis and providing guidance for further treatment in these patients with post-operative knee pain. However, this was only a pilot study on three patients and conclusions should be drawn with caution.

**Fig. 5** Anteroposterior and lateral radiographs of the right knee joint after medial unicompartmental knee arthroplasty



**Fig. 6** SPECT/CT images of the right knee. Focal increased activity below the tibial unicompartmental knee arthroplasty component and slight posterior tilt of the tibial component



Hybrid SPECT/CT combines images from a dual-head SPECT with images from conventional CT. Unlike SPECT, the scan clearly displays not only the region of interest, but the specific anatomical location [1, 2, 4, 7, 9]. Combining the characteristics of SPECT and CT, it offers increased sensitivity and specificity [7]. It also allows the joint in question to be viewed in three orthogonal planes [7]. Several joints can be evaluated at the same sitting [2]. Due to the combination of SPECT and CT data, the effect of metal artefact ‘splatter’ is considerably less than in MRI and conventional CT. It may be useful to use it early in the post-operative phase, as areas adjacent to implants seem to be better assessable.

The use of SPECT/CT has been limited due to the lack of its availability in most European hospitals. This may be

due to a lack of understanding, interest or appreciation of its value by the orthopaedic and, indeed, the radiology fraternity. The diagnostic possibilities, as well as the clinical value, of simultaneously co-registered anatomic and functional data are being increasingly recognized [1, 4–6, 8, 12, 13]. Along with this and with improved availability the use of SPECT/CT seems likely to expand in the next years.

To the best of our knowledge, there is no study in literature regarding the use of SPECT/CT in patients with knee disorders. With the three cases described above, we endeavour to introduce SPECT/CT to a broader group of orthopaedic surgeons and illustrate the possible clinical value it may offer as a new diagnostic radiologic modality. From early detection of osteoarthritis to investigating the



cause of post-operative pain, this non-invasive modality may assist the surgeon in diagnosing clinical problems anywhere in the treatment cycle. We highlight some of these advantages in cases that are not unfamiliar in most orthopaedic clinics.

In case one, if SPECT/CT had been used as a preliminary investigation, the cause of pain arising from the non-union of the proximal tibia would have been identified early. This would have allowed both plate removal and bone grafting of the non-union to be carried out under one procedure.

The second case illustrates a common diagnostic challenge post-patella sparing knee arthroplasty: is the native patella or implanted prosthesis the cause of anterior knee pain in this group? Identifying the patella as the true cause of symptoms without surgical means of investigation may be difficult and requires accurate clinical judgment. Whilst plain radiographs demonstrate the retro patellar arthritis, it does provide evidence to substantiate the cause of pain. The high specificity and sensitivity of SPECT/CT is demonstrated in Fig. 4b.

This is further highlighted by the third case where SPECT/CT revealed the tibial base plate as the specific cause of anterior knee pain. In comparison to bone scans, SPECT/CT was able to precisely localize the tibial component as cause of the pain and, even more, show the slight lifting of the component (Fig. 6b). However, there was also a tracer uptake around the femoral component, which was considered to be normal in this post-operative phase.

The radiation dosage is equivalent to two to three times that of the long leg radiograph. This may be considered unacceptable; however, patients with post-operative knee pain often require several radiological investigations before a firm diagnosis can be made.

The cost-effectiveness of SPECT/CT compared to other imaging modalities is an unanswered question, which, along with its wider clinical value in orthopaedic patients, needs to be addressed with further research and large-scale prospective studies.

## Conclusion

SPECT/CT provides knee surgeons with a promising diagnostic tool, which may be particularly helpful in

patients with post-operative knee pain, in which radiological diagnostic possibilities are currently limited.

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