

Case Study

SPECT/CT delineation of proximal screw loosening and distal pseudoarthrosis following total hip replacement

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Data courtesy of Klinik Engered, Lindenhofgruppe, Bern, Switzerland

History

A 74-year-old female underwent right side total hip replacement in 2001. In 2006, the hip prosthesis was replaced due to low-grade infection. A periprosthetic fracture was delineated on routine radiography and CT in 2014. A pathological frac-

ture was suspected due to exaggerated bone loss in fracture area, but there was no evidence of tumor or histology of other bony pathology, such as Paget's disease. The patient complained of progressive pain and limitation of movement, as well as instability of the hip joint during

walking. Patient underwent a ^{99m}Tc MDP bone SPECT/CT to assess the complex post-arthroplasty situation.

SPECT/CT of the hip joint and proximal femur using a single 360-degree acquisition was performed on a Symbia IntevoTM1 scanner 3

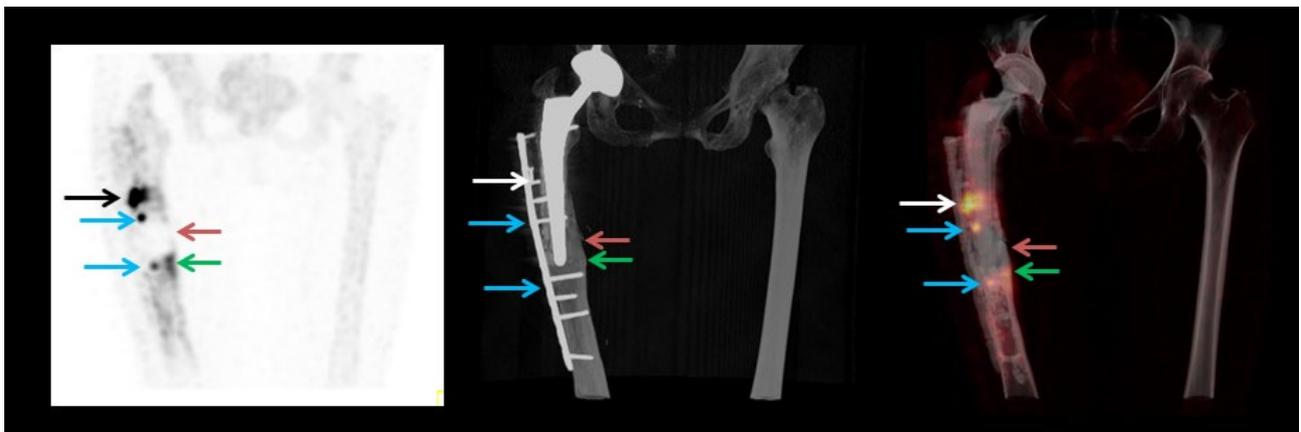


Figure 1: MIP image of SPECT and CT as well as volume-rendered SPECT/CT fused data show the focal areas of skeletal hypermetabolism and their correlation to prosthesis and bone in the right hip and femur. The most intense focal hypermetabolic area seen in SPECT (*black arrow*) corresponds to the loosened proximal screw (*white arrow*), which appears to be outside the bone on the CT images. Just below this region, a focal hot area seen on SPECT (*blue arrow*), which corresponds to the last fixed proximal screw (*blue arrow on CT*), reflects activated screw loosening. The region with absence of tracer uptake on SPECT below the last fixed screw (*red arrow*) suggests avascularity of the bone around the lower part of the shaft of the femoral prosthesis. Below the avascular region, focal cortical uptake (*green arrow*) reflects pseudoarthrosis. Adjacent focal uptake in the screw just distal to the femoral prosthesis shaft (*lower blue arrow*) also reflects loosening. Slightly increased uptake in the distal screws below, which are fixed to bone, reflect reactive stress secondary to pseudoarthrosis.

hours following an IV injection of 600 MBq (16.22 mCi) ^{99m}Tc MDP. Planar whole-body acquisition preceded SPECT/CT acquisition. Following a thin-slice diagnostic CT (130 kV, 72 eff mAs 16x0.6 mm collimation), SPECT was acquired with 32 stops per detector at 20 sec/stop. SPECT reconstruction was performed using 3DOSEM (Flash 3D). Reconstructed SPECT data was fused with the CT for a final evaluation.

Diagnosis

The maximum intensity projection (MIP) images of SPECT and CT as well as volume rendering of the fused SPECT/CT data (Figures 1 and 2) demonstrate the skeletal stress related to the loosening of the proximal screws, especially the upper screws extruded from the bone as shown on CT. The loosening of the last fixed proximal screw attached to the distal end of the shaft of the femoral component of the hip prosthesis is

probably secondary to the shear stress following extrusion of the upper screws, which also reflects associated severe periprosthetic osteoporosis.

The periprosthetic fracture adjacent to the distal end of the femoral component of the hip prosthesis is associated with avascularity of the bony segment with distal pseudoarthrosis and reactive hypermetabolism, as evident in the SPECT/CT images.

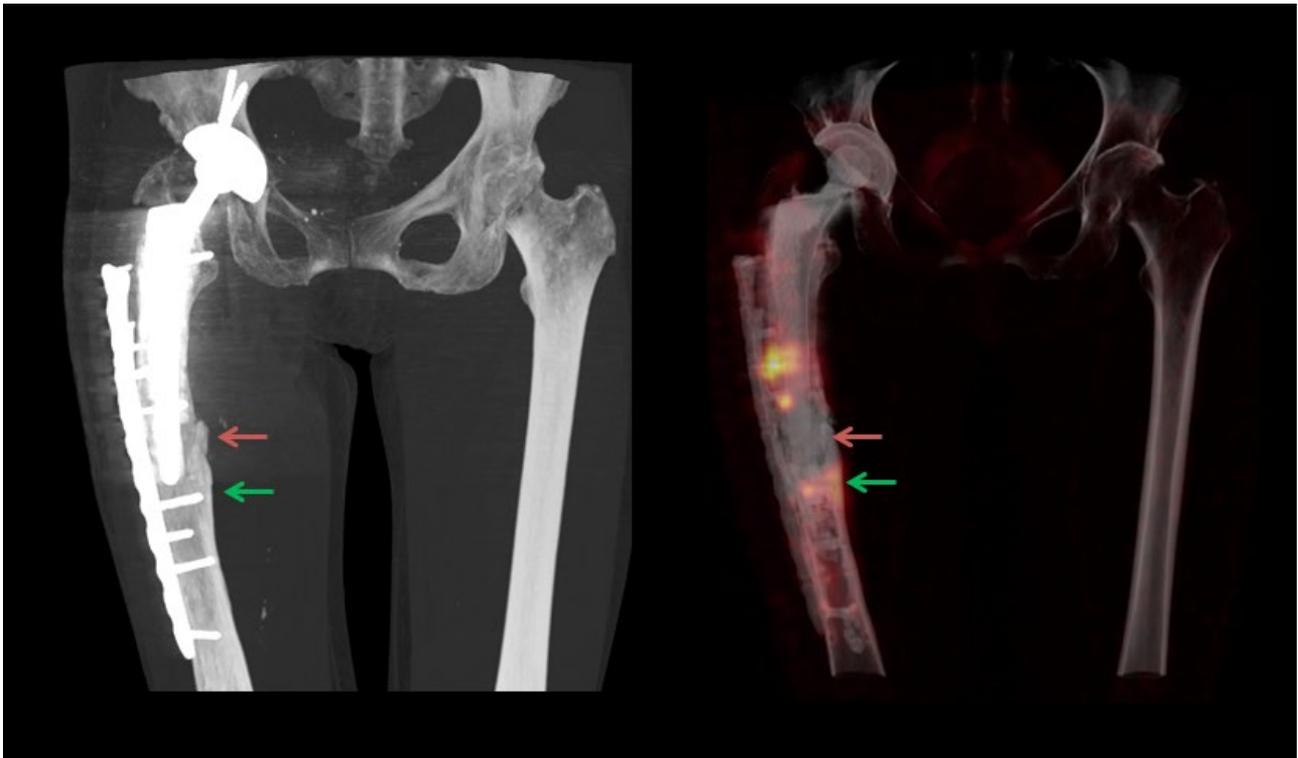


Figure 2: MIP of CT shows periprosthetic fracture (red arrow), which also corresponds to avascular area with absence of tracer uptake on the fused images (red arrow). The focal area of increased cortical uptake just below the fracture site (green arrow) reflects reactive hypermetabolism related to chronic pseudoarthrosis due to avascular bone segment just distal to the femoral component of the hip prosthesis. The acetabular component appears stable with no loosening or malalignment.

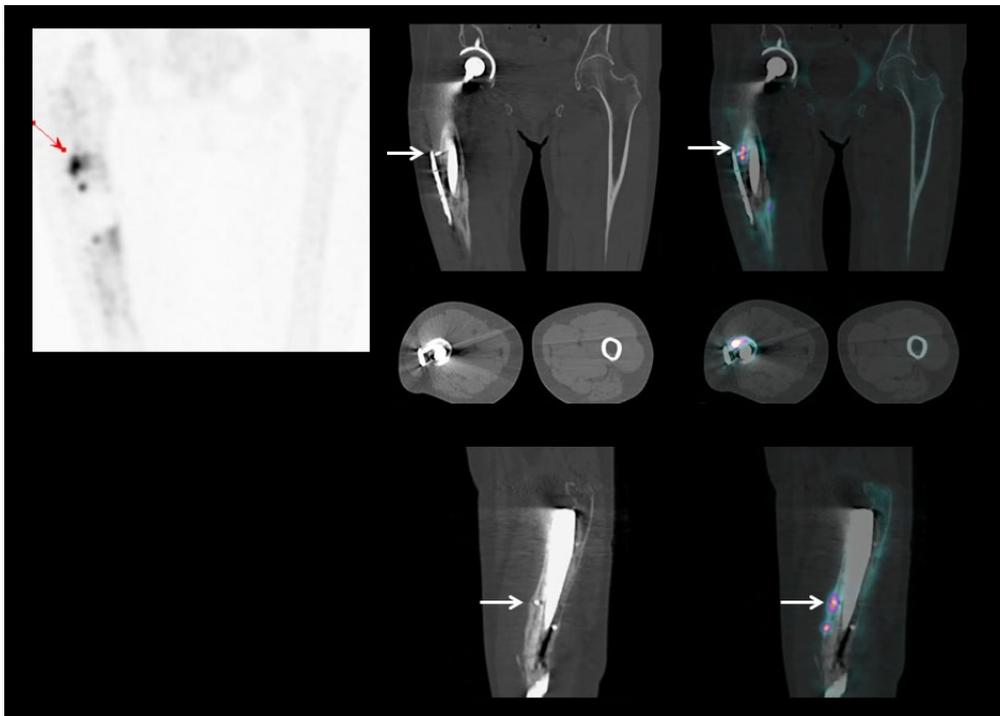


Figure 3: CT and fused SPECT/CT images highlight the extruded proximal screw with associated hypermetabolism related to shear stress secondary to screw loosening and extrusion (white arrows).

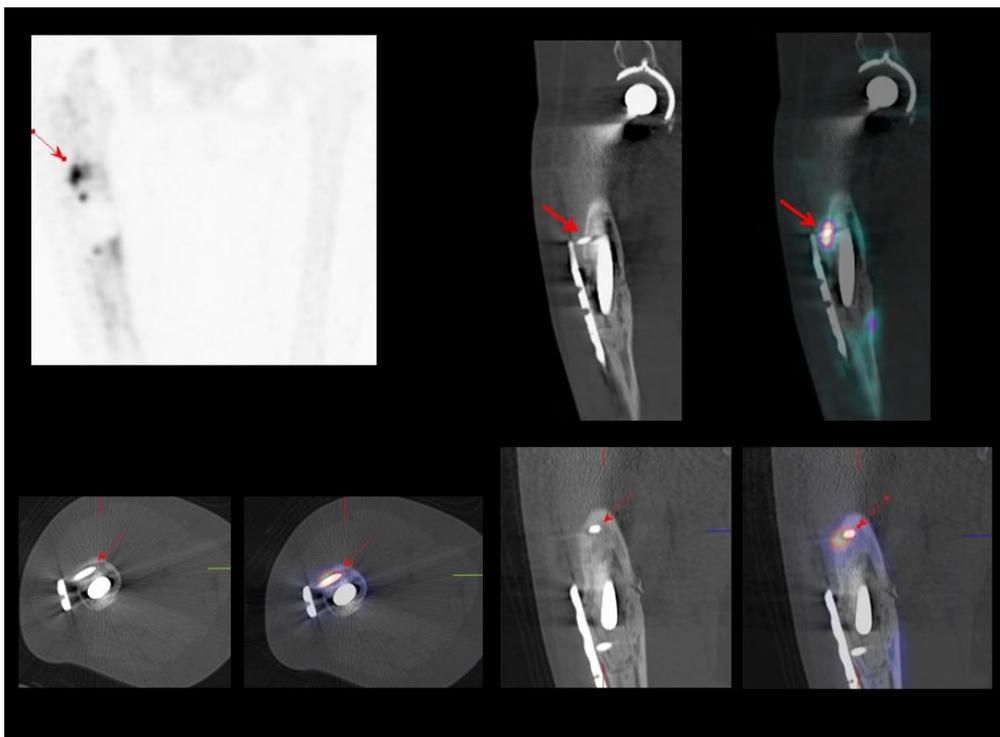


Figure 4: CT and fused SPECT/CT views delineate the extruded proximal screw separated from the shaft of the femoral component of the prosthesis with part of the screw and plate shifted away from the cortical margin. Focal uptake at the site of the extruded screw reflects the bony stress at the site of loosening.

Figure 5: CT and fused images at the level of the last fixed proximal screw with cortical erosion and remodeling secondary to abnormal prosthetic motion due to loosening seen on CT, which corresponds to focal increase in uptake (blue arrows), reflecting shear stress.

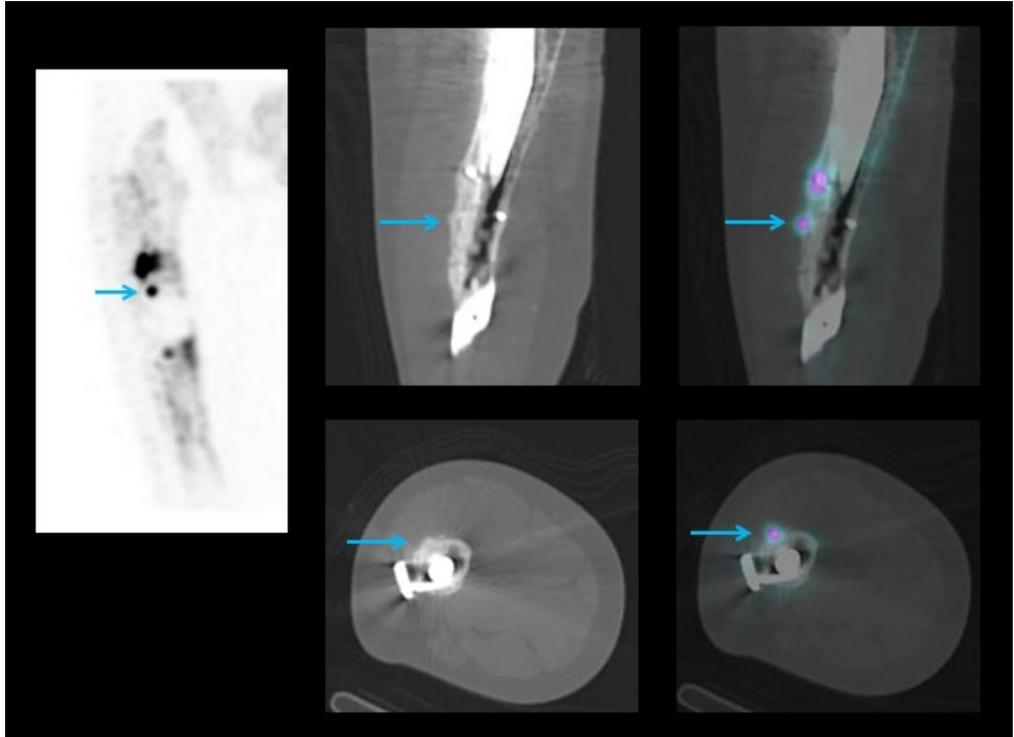
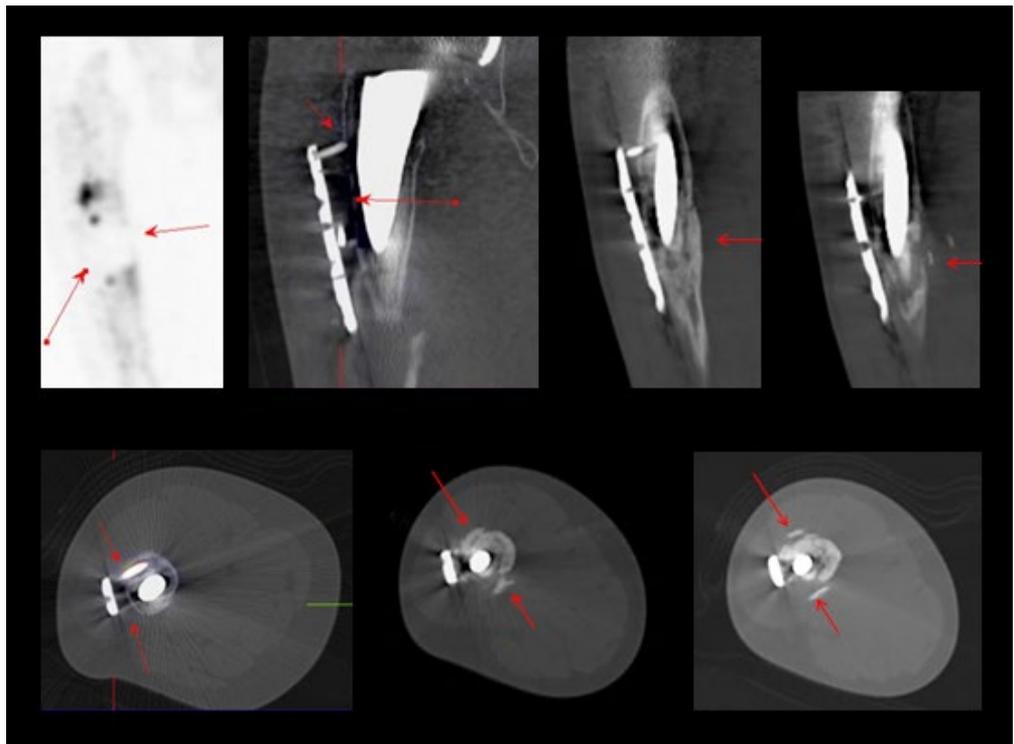


Figure 6: CT images demonstrate the gap between the fixation plate and edge of the femoral component of the prosthesis are secondary to loosening and extrusion as well as the bony sclerosis and periprosthetic fracture fragments at the level of the lower part of the femoral component shaft, which appears avascular on SPECT.



Figures 3 through 7 delineate the degree of loosening of the proximal screws with extrusion of the uppermost screws and resulting shear stress at the level of the proximal screws and

plate, especially the last fixed proximal screw, reflecting the abnormal prosthetic motion secondary to loosening. CT also shows severe periprosthetic osteoporosis. The bone around the lower part of

the shaft of the femoral component of the prosthesis appears completely avascular with sclerosis and multiple periprosthetic fractures with absence of tracer uptake, indicating necrosis.

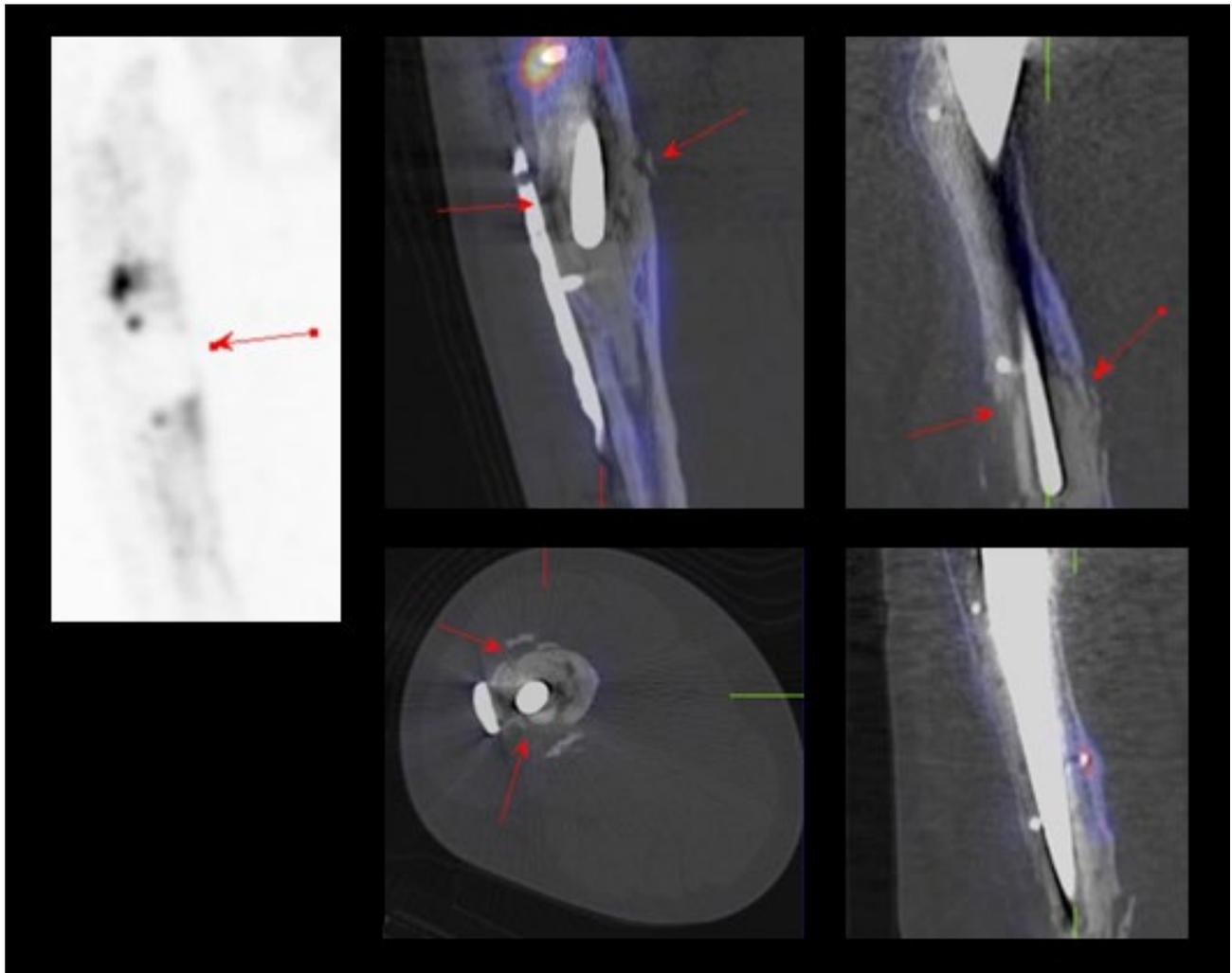


Figure 7: Fused images at the level of the avascular segment around the lower part of the shaft of the femoral component of the prosthesis show absence of significant tracer uptake within the sclerotic cortical bone around the prosthetic shaft as well as in the periprosthetic fracture fragments (red arrows), reflecting the avascularity and osteonecrosis.

Figure 8 demonstrates the secondary impact of the loss of vascularity and related bone necrosis and periprosthetic fractures to the normal bone of the femoral shaft below the avascular zone and the lower part of the shaft of the femoral component of the prosthesis, which developed a pseudoarthrosis,

throsis between the necrotic segment and the normal segment below at the medial end. This shows a significant hypermetabolism due to shear stress secondary to abnormal movement caused by the pseudoarthrosis. Although the plate and screws attached to the normal mid femoral

shaft are properly fixed without any CT or SPECT evidence of loosening, the mild increase in uptake in the lateral cortex reflects the added shear stress secondary to abnormal movement at the level of the pseudoarthrosis.

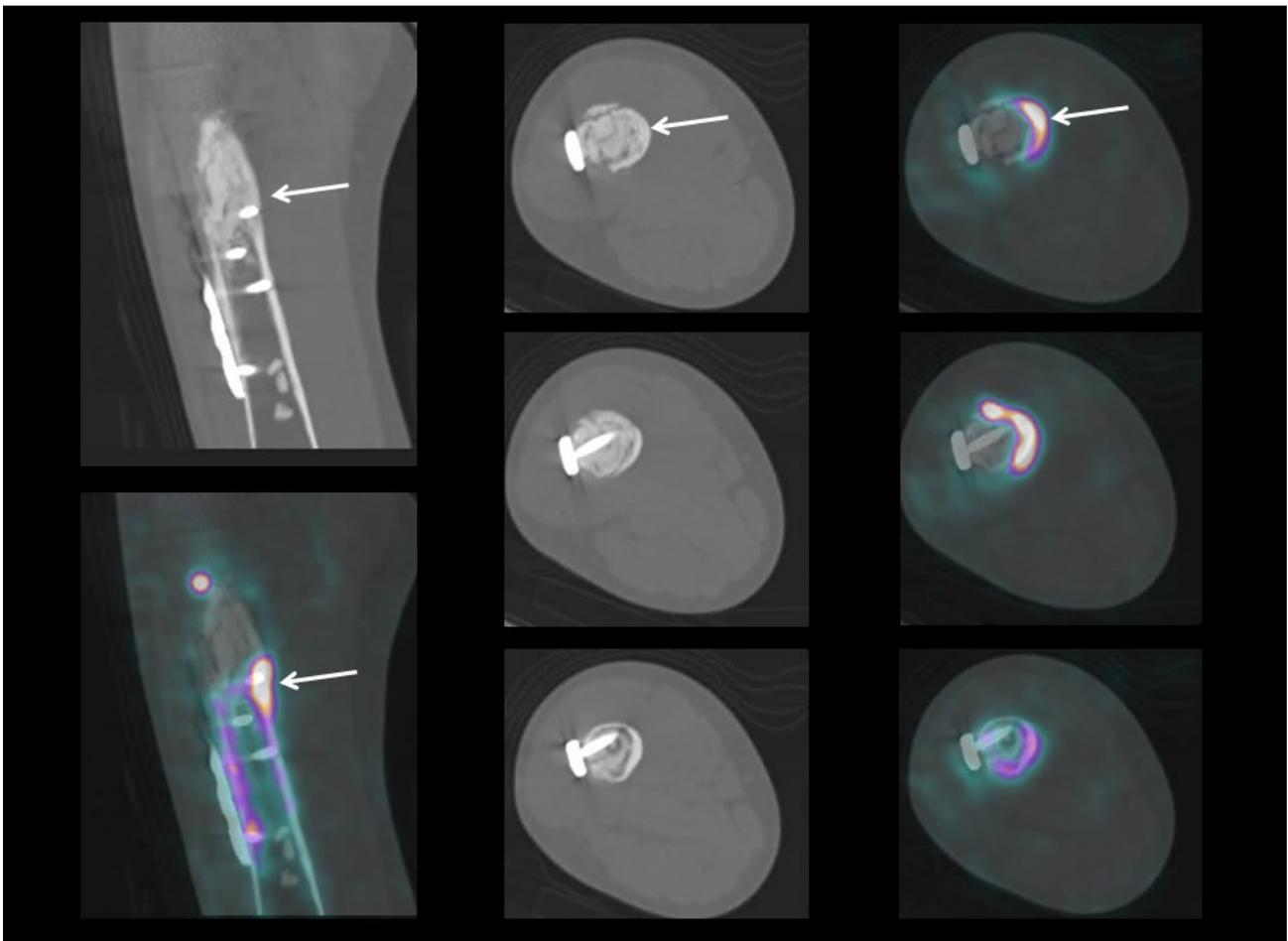


Figure 8: Coronal and axial slices through the middle of the femoral shaft just below the tip of the lower end of the shaft of the femoral component of the prosthesis show sclerotic bone in the cortex as well as medulla with hypermetabolism predominantly in the medial cortex (*white arrow*) at the level of the junction of the avascular part of the femoral shaft and the metabolically active lower part. This suggests pseudoarthrosis with abnormal motion between the avascular necrotic component and the normal cortex below. The lateral cortex below the site of pseudoarthrosis (aligned to the plate) shows slightly increased uptake, which is probably related to shear stress secondary to pseudoarthrosis.

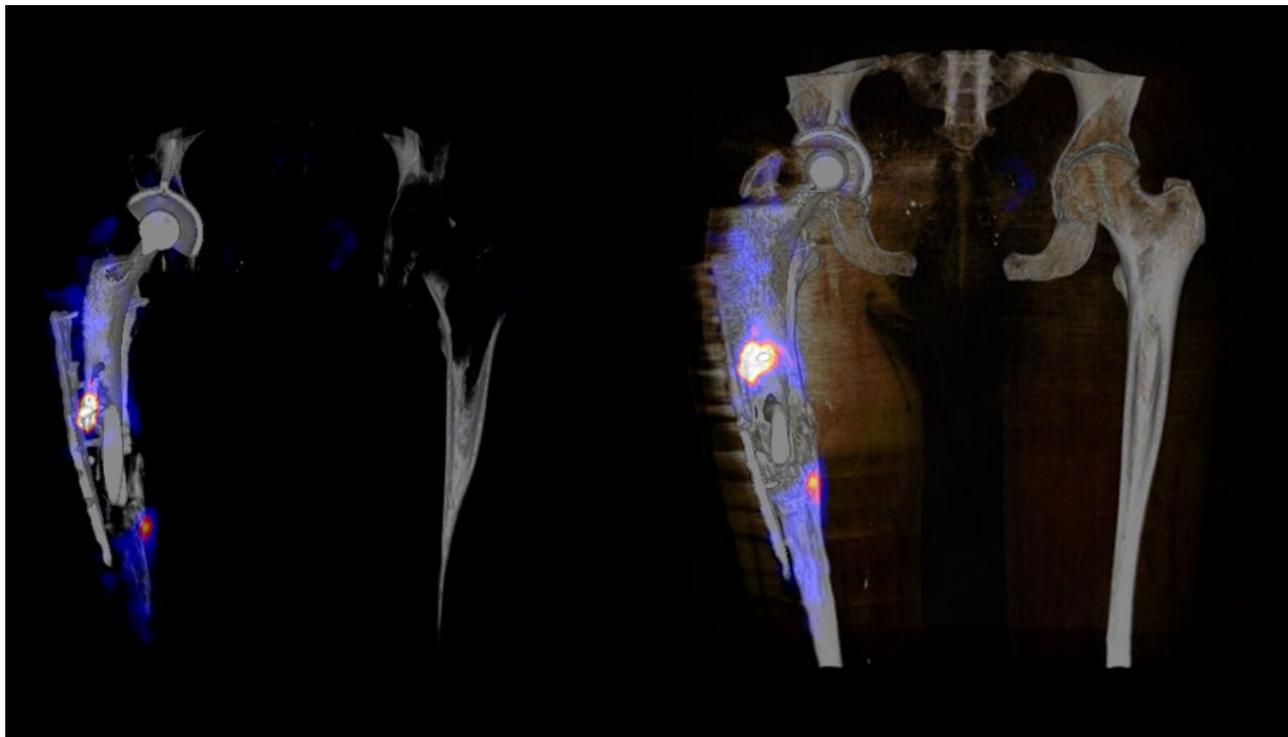


Figure 9: Volume rendering of fused images show the hypermetabolism at the level of proximal screws secondary to shear stress due to extruded upper screw and plate, as well as the focal uptake at the medial cortex below the avascular segment due to pseudoarthrosis.

Comments

This case illustrates the value of combining SPECT and CT for assessment of such complex post-prosthetic surgery situations. CT in isolation demonstrates the extruded proximal screws and periprosthetic fractures while addition of ^{99m}Tc MDP SPECT highlights the degree of shear stress at the proximal screws and delineates the avascular segment of the femoral shaft around the lower end of the prosthetic shaft, as well as the pseudo-arthrosis between the avascular segment and the normal lower femoral shaft. The acetabular component shows no loosening. A comprehensive understanding of the morphological and functional status of the femoral prosthetic component, the screws and plates, as well as that of the impacted femoral bone, including delineation of the avascular segment and pseudoarthrosis helps define the surgical management of this patient, especially the amount of avascular bone to be resected and the degree of bone graft placement, along with replacement of the femoral prosthesis. ■

Examination Protocol

Scanner: Symbia Intevo 16

SPECT

<i>Injected Dose (representative scan)</i>	600 MBq (16.22 mCi) ^{99m}Tc MDP
<i>Scan Delay</i>	3 hr
<i>Acquisition</i>	Planar whole-body SPECT/CT

CT

<i>Tube voltage</i>	130 kV
<i>Tube current</i>	72 eff mAs
<i>Slice Collimation</i>	16x0.6 mm

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