

Loosening of tibial component of knee arthroplasty with medial impression fracture defined by bone SPECT/CT

By Christian Waldherr, MD

Data and images courtesy of Engereid Hospital, Bern, Switzerland

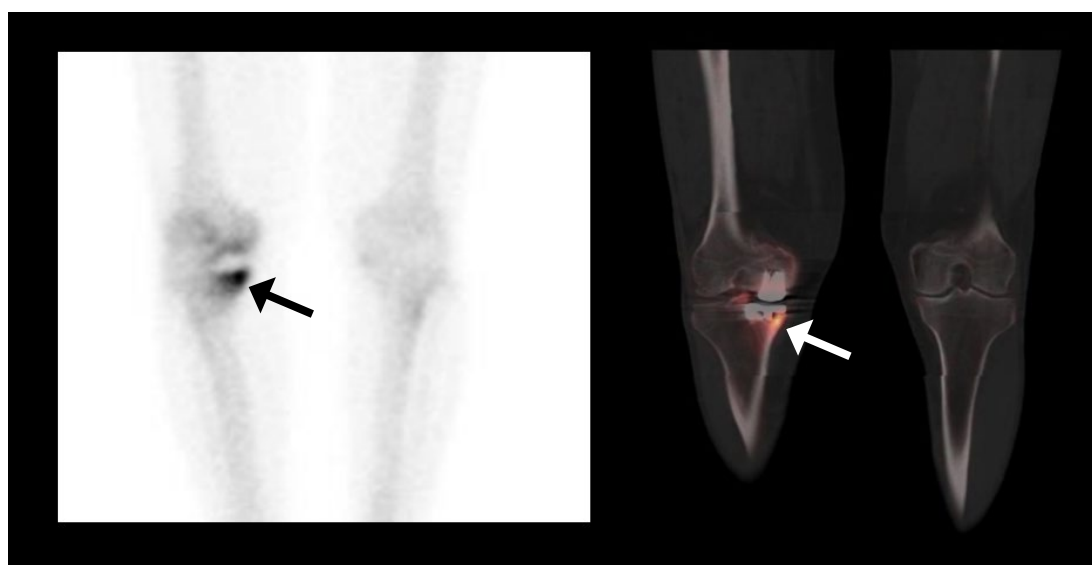
History

A 50-year-old man with a history of osteoarthritis of the right knee underwent medial hemi-arthroplasty of the right-knee joint. Following hemi-arthroplasty, the patient noted persistent pain in the joint for which he underwent a ^{99m}Tc -HDP SPECT/CT scan (Figure 1), which suggested loosening of the tibial component. The patient subsequently received a revision total knee arthroplasty (TKA).

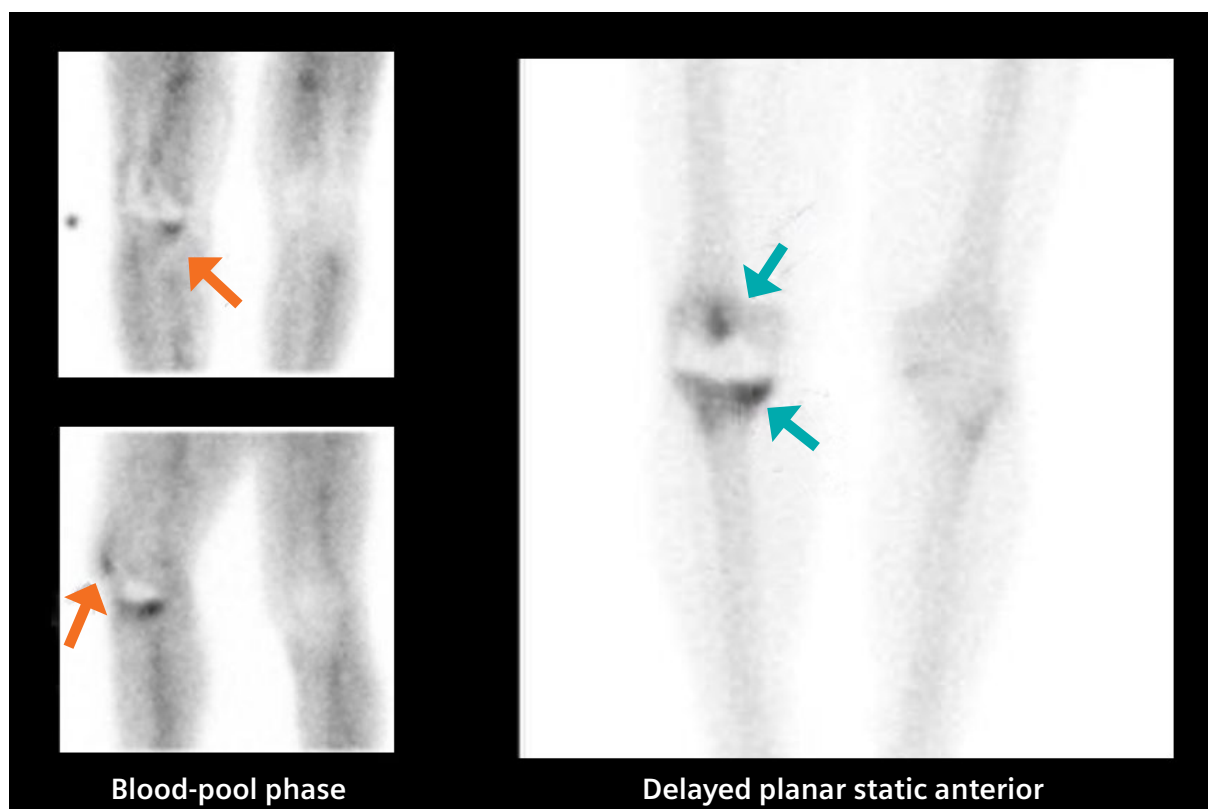
Three years following the revision, the patient presented again with persistent pain in the prosthetic right-knee joint. Routine radiographs were unremarkable. The patient was referred for a ^{99m}Tc -DPD bone scintigraphy to evaluate for prosthetic joint pathology.

The study was performed on a Symbia Intevo™ 16 SPECT/CT scanner.

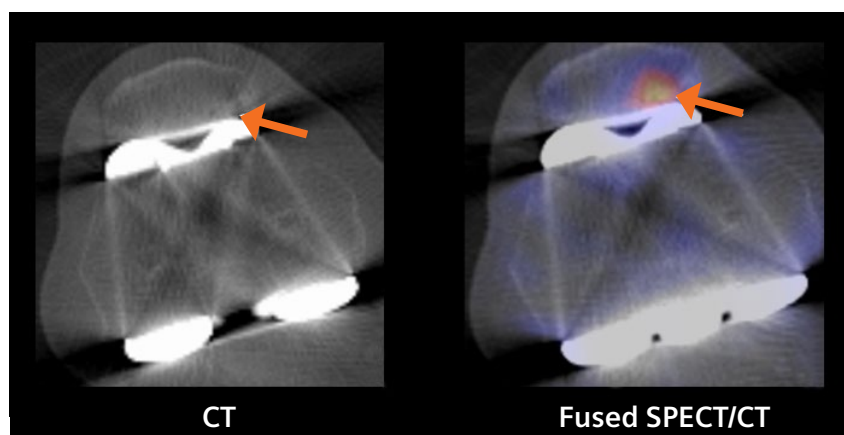
Following intravenous (IV) injection of 600 MBq of ^{99m}Tc -DPD, a 3-phase bone scan was completed. Initial dynamic planar perfusion images were followed by planar blood-pool images of both knee joints. Delayed-phased planar whole-body images were acquired 3 hours post injection, followed by SPECT/CT of both knees. CT and fused SPECT/CT images were reviewed together for final evaluation.



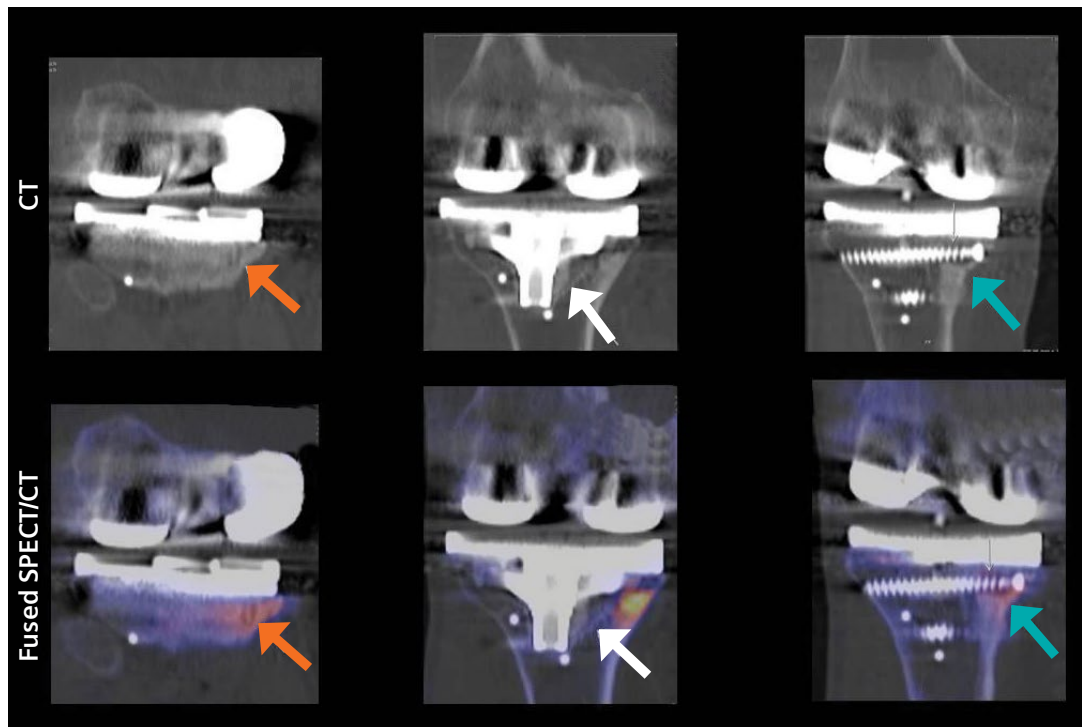
1 Anterior planar and coronal-fused SPECT/CT images show focal increased tracer uptake in the tibial component of the medial right-knee hemi-arthroplasty, suggesting medial tibial compartment overload with loosening of the tibial component.



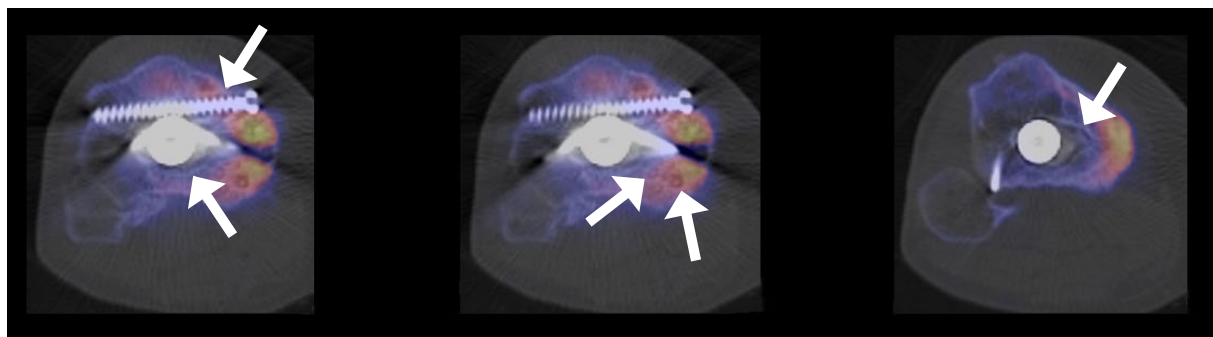
- 2** Planar static blood-pool images in the anterior and lateral views show focal increased blood-pool in the right medial tibial compartment as well as in the right patellar region (orange arrows). Delayed planar anterior images of both knees show increased uptake in the medial tibial compartment of the right-knee joint (blue arrow) along with focal hypermetabolism at the level of patella. The right-knee prosthesis is delineated as a photopenic area with mild hypermetabolism in the lateral tibial component as well, but without obvious hypermetabolism in the femoral component. The highest uptake intensity is in the medial tibial compartment, which appears to be the key focus of bone stress, with the patella showing a lower level of hypermetabolism.



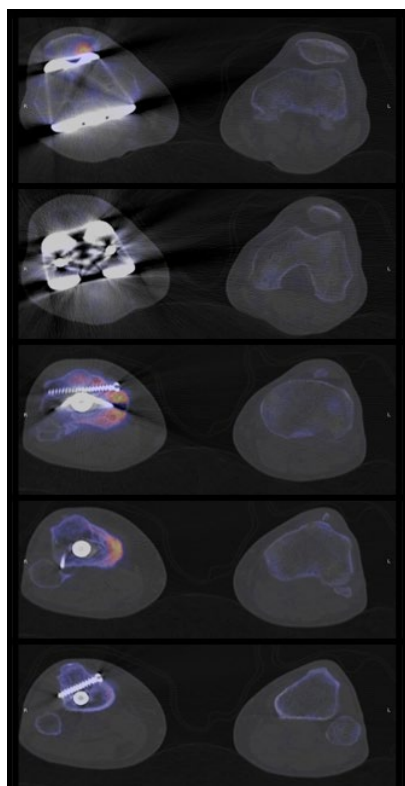
- 3** CT and fused SPECT/CT transverse slices through the mid patellar level of the right knee demonstrates focal increased uptake in the medial aspect of the posterior margin of the patella (orange arrow), reflecting medial patellar overload due to possible patellar maltracking and medial shift, secondary to TKA.



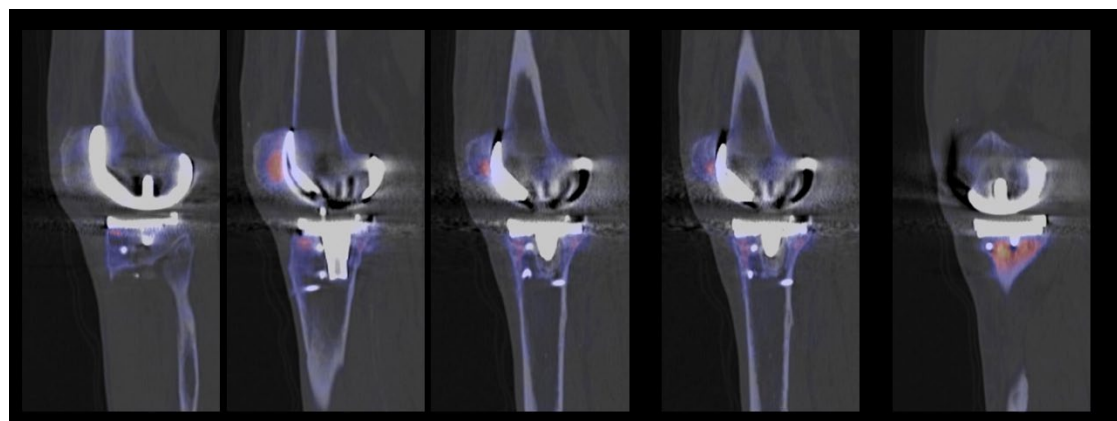
- 4 CT and fused SPECT/CT coronal images at different levels through the right-knee prosthesis show increased uptake in the medial tibial compartment adjacent to the medial end of the tibial component of the TKA prosthesis. Corresponding CT slices show sclerosis correlating with focal hypermetabolism seen on SPECT/CT (orange arrows). The CT image also shows a zone of lysis medial to the stem of the tibial component of the prosthesis with slight separation between the edge of the prosthesis and adjacent bony margin (white arrows), which suggests loosening of the tibial component. The focal hypermetabolism in the medial end of the tibial compartment (blue arrow) suggests a medial impression fracture, possibly related to the excessive varus deformity of the right knee, secondary to TKA.



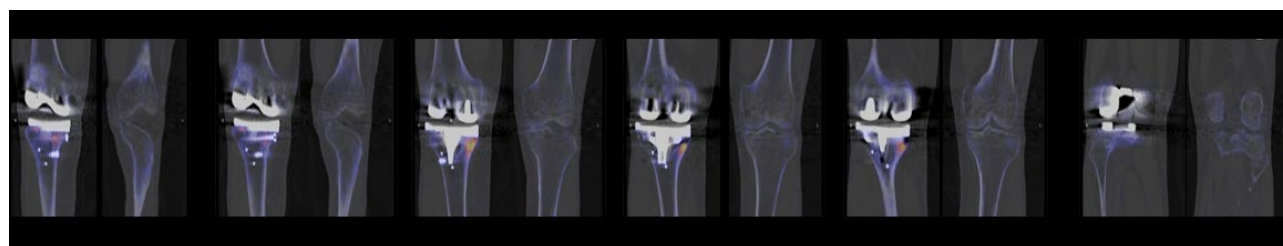
- 5 Axial-fused SPECT/CT images, at the level of the stem of the tibial component of the TKA prosthesis, show focal hypermetabolism in the medial part of the tibial compartment as well as around the stabilizing screw, which suggests a medial impression fracture caused by the slight varus deformity of the right-knee joint after TKA. There are gaps between the prosthetic stem and stabilization screw margins and the margins of adjacent bones (white arrows), which reflect loosening of the tibial component.



- 6** Axial-fused SPECT/CT slices from the mid patellar level to upper tibial shaft of both knee joints demonstrate focal hypermetabolism in the medial aspect of the patella as well as in the medial tibial compartment, which reflects patellar overload as well as a medial impression fracture of the tibial compartment along with tibial component loosening. The normal skeletal metabolism in the other knee highlights the intensity of the tibial compartment hypermetabolism, which reflects severe bone stress due to an impression fracture rather than mild varus-related instability.



- 7** Coronal-fused SPECT/CT slices through the knee joint, from lateral to medial, show posterior patellar-margin hypermetabolism secondary to patellar overload, along with medial tibial compartment hypermetabolism adjacent to the medial end of the tibial component of the TKA. The femoral component of TKA shows normal position without any periprosthetic hypermetabolism, which reflects the absence of any femoral component-related loosening or instability.



- 8** Coronal sections of fused SPECT/CT for both knee joints, from the anterior to the posterior aspect, demonstrate the position and intensity of the tibial compartmental hypermetabolism. The typical position of the hypermetabolism at the medial edge of the tibial compartment clearly reflects the bone stress as secondary to varus deformity of the prosthetic right-knee joint.

Findings

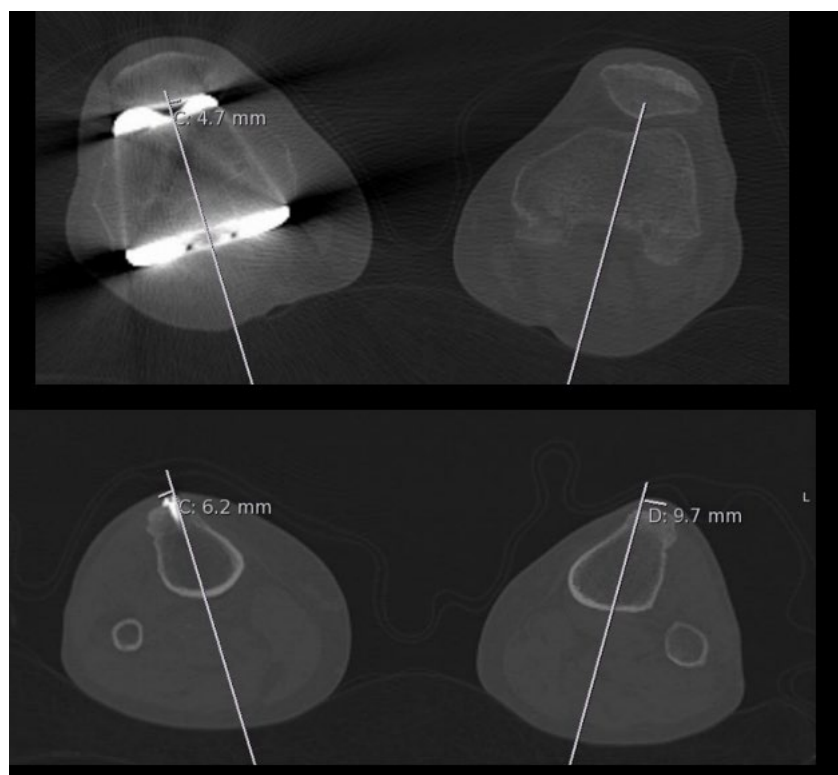
The planar blood-pool and delayed images (Figure 2) suggest medial tibial compartment overload, with possible loosening of the tibial component of the TKA prosthesis. As evident from the SPECT/CT images (Figures 2-8), the primary site of stress overload is localized to the edge of the medial tibial compartment and clearly reflects overload stress with an impression fracture secondary to the chronic varus deformity of the right-knee joint after TKA.

Alignment measurements obtained from dedicated third-party 3D orthopedic software, using CT data generated from SPECT/CT, show excessive (9 degrees) varus deformity of the right knee along with slightly increased flexion, which explains the medial tibial compartment overload stress (Figures 9-11). Medial compartment stress is the cause of the impression fracture of the medial edge of the tibial condyle adjacent to the edge of the tibial component of the TKA prosthesis, defined as focal hypermetabolism on SPECT/CT. This is accompanied by loosening of the tibial component, as shown

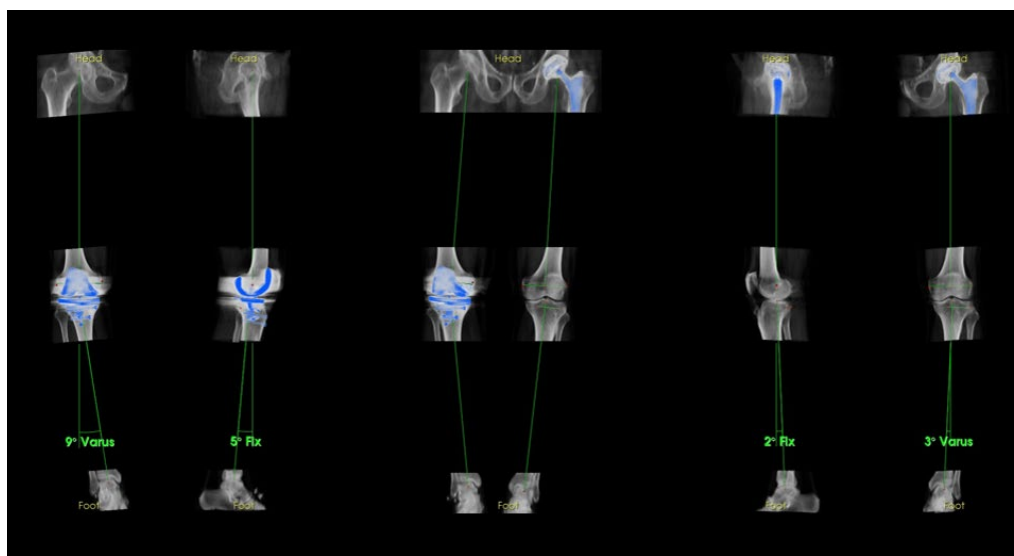
by the gap between the prosthetic edge and adjacent bone, as well as reactive bony stress around the stabilization screw as seen on SPECT/CT. The medial aspect of the posterior margin of the right patella shows patellar-overload-related hypermetabolism, possibly related to a medial shift of the patella or patellar maltracking. Thus the overall impression of tibial component loosening with medial tibial compartment overload, along with medial patellar overload—all caused by excessive varus deformity of the right knee following TKA—is clearly evident from the SPECT/CT findings.



9 Sagittal CT slices of the left (normal) and right (TKA) knee joints for determination of Insall-Salvati (IS) ratio of both knee joints (ratio of patellar tendon length or length of the posterior surface of the tendon from the lower pole of the patella to its insertion on the tibia (TL), to the patellar length or greatest pole-to-pole length of the patella (PL)). The right knee shows an IS ratio of 0.83, which is at the lower limit of normal, while left knee shows an IS ratio of 0.73, which is considered patella baja.



- 10** Axial CT slices through both knee joints at the level of the trochlear groove of the femur and the tibial tuberosity, with lines drawn through the trochlear groove and tibial tuberosity perpendicular to and bisecting the line joining the posterior edges of both femoral condyles (TG and TT lines). The distance between these lines (TT-TG distance) is 6.2 mm and 9.7 mm for the right and left knee respectively—both of which are within normal limits.



- 11** CT data from the left (normal) and right (TKA) knee joints were processed in dedicated third-party 3D orthopedic software and used to define various knee-joint alignment angles, as well as to define the prosthesis in a surface-shaded display in order to clearly ascertain the positioning of the prosthesis and the instability or absence of it. Analysis of varus and flexion angles of the right and left knee joint considering the appropriate positioning of the femoral head and ankle joint using the dedicated third-party 3D orthopedic software clearly shows excessive varus and flexion deformity of the right-prosthetic knee joint. The right knee shows a 9-degree varus and a 5-degree flexion deformity while the same for the normal left knee is a 3-degree varus and a 2-degree flexion. Such excessive varus deformity of the right-knee joint following TKA suggests that the medial tibial compartment overload and medial impression fracture is possibly related to the varus deformity, which leads to altered biomechanics of the right knee with excess bone stress to the medial tibial margin.

Discussion

This case illustrates how bone SPECT/CT, in combination with bone-alignment analysis using CT performed by dedicated third-party 3D orthopedic software, can correctly identify the site of excess bone stress and accurately explain the causative malalignment or post-operative deformity. The primary cause of pain in this revision TKA was the significant (9 degrees) varus deformity, which developed following surgery. This varus deformity led to chronic stress on the medial tibial compartment as well as the medial aspect of the tibial component of the TKA prosthesis. This leads to loosening of the tibial component, excessive overload stress on the medial tibial compartment, which in turn lead to an impression fracture. A ^{99m}Tc-HDP bone SPECT/CT was instrumental in accurately defining the focal point of excessive bony stress as well as in defining the impression fracture and prosthetic loosening. The CT images from the SPECT/CT study were used by third-party 3D orthopedic software to measure mechanical alignment of the femoral and tibial components and measure the deviation from the femoral axis to compare it to the normal side, thereby demonstrating the excessive varus deformity of the right-knee joint following the prosthesis insertion.

In a similar study involving 37 patients with TKA who underwent bone SPECT/CT, the location, pattern, and intensity of uptake were compared between symptomatic and asymptomatic prosthetic knee joints.¹ Intensity and location of skeletal hypermetabolism correlated with abnormal joint alignment, particularly excess varus and flexion deformities. Symptomatic TKAs were more flexed with greater internal rotation and showed higher intensity of tracer uptake as compared to asymptomatic knees. The highest bony hypermetabolism was found around the tibial stem with significantly higher intensity in symptomatic knees. The intensity of tracer uptake in the medial compartment correlated with the mechanical varus alignment of the knee. This clinical case has a similar finding where the medial compartment overload is associated with excess varus deformity. Excess varus may lead to medial shift of the patella, which is reflected by the medial patellar overload with hypermetabolism in the medial part of the posterior patellar surface. Tibial internal rotation accompanying the varus may also cause patellar maltracking, resulting in patellar overload stress.

Conclusion

Bone SPECT/CT can be used to accurately define bone stress in symptomatic prosthetic knee joints. In this case, SPECT/CT helped to confirm absence of any other significant bony stress in the femoral component within the periprosthetic region. Since accurate fusion of the focal hypermetabolism and bony morphology is key to SPECT/CT evaluation, the high-resolution SPECT imaging and high CT quality—with absence of displacement between CT and SPECT acquisition planes, provided by Symbia Intevo—was instrumental in the proper evaluation of this case. High-quality CT was also a key requirement for the evaluation of mechanical alignment of the femoral and tibial components and measurement of the prosthetic component’s relationship with the femoral axis by dedicated third-party 3D orthopedic software. This provided accurate varus/valgus, flexion/extension, and internal/external rotation for evaluation of the true varus deformity and correlation with the location and intensity of tracer uptake on SPECT/CT for correct assessment of the pathology and focal points of overload stress. ●

Examination protocol

Scanner: Symbia Intevo 16

SPECT		CT	
Injected dose	^{99m} Tc-DPD 600 MBq	Tube voltage	130 kV
Acquisition	30 frames, 20 seconds/frame with Flash 3D reconstruction	Tube current	25 mAs
		Slice thickness	3 mm

References

- ^[1] Awengen R, Rasch H, Amsler F, Hirschmann MT. Symptomatic versus asymptomatic knees after bilateral total knee arthroplasty: what is the difference in SPECT/CT? *Eur J Nucl Med Mol Imaging*. 2016 April;43(4):762–772. doi:10.1007/s00259-015-3278-0.

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