

The use of bloodpool SPECT/CT

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Introduction

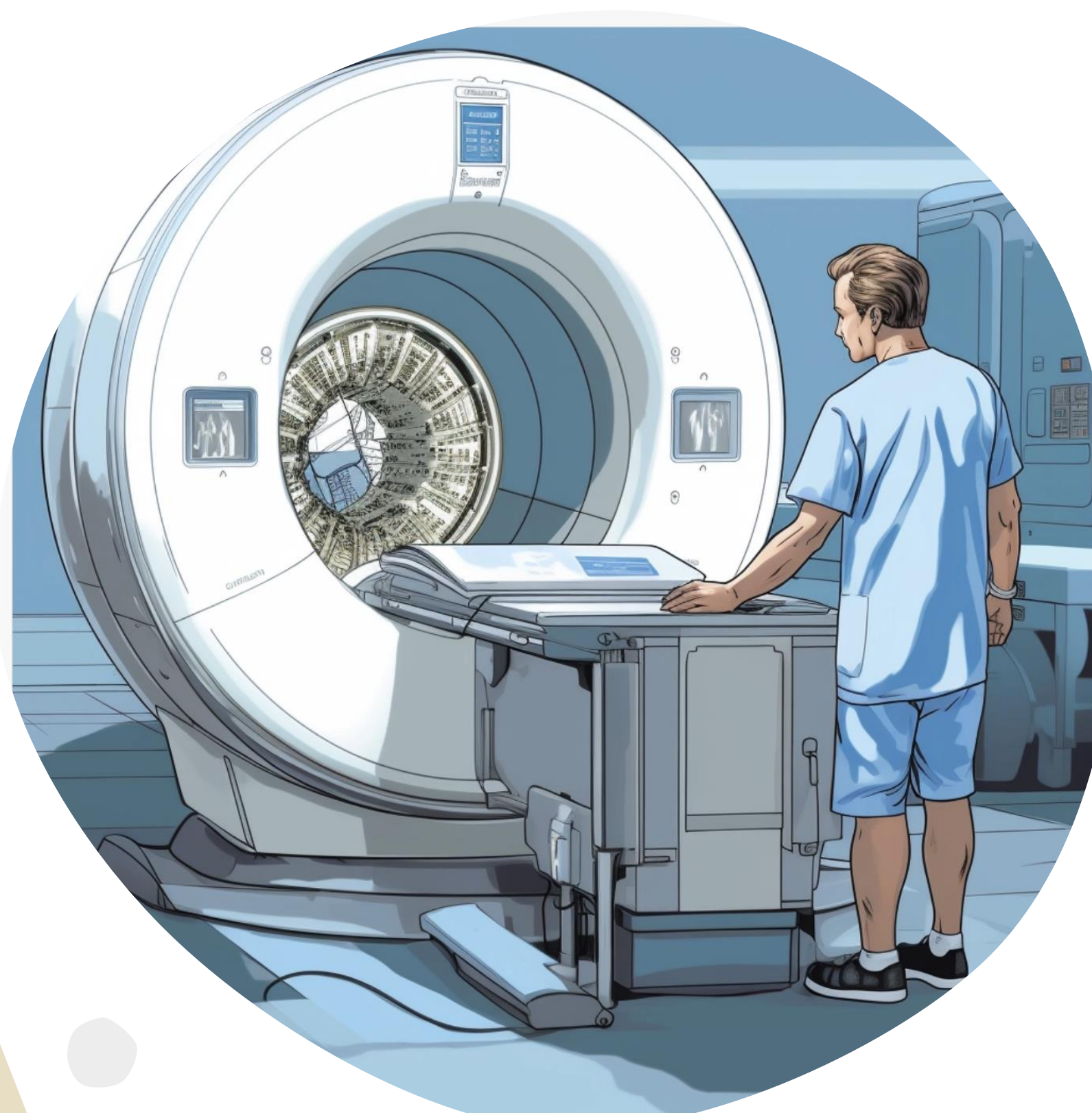
The radionuclide bone scan is the cornerstone of skeletal nuclear medicine imaging. Bone scintigraphy is a highly sensitive diagnostic nuclear medicine imaging technique that uses a radiotracer to evaluate the distribution of active bone formation in the skeleton related to malignant and benign disease, as well as physiological processes.

Eur J Nucl Med Mol Imaging (2016) 43:1723–1738
DOI 10.1007/s00259-016-3415-4

GUIDELINES

The EANM practice guidelines for bone scintigraphy

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R. Delgado-Bolton⁹ • W. A. Weber¹⁰ • M. Beheshti¹¹ •
W. Langsteger¹¹ • F. Giammarile¹² • F. M. Mottaghy^{13,14} • F. Paycha¹⁵ •
On behalf of the EANM Bone & Joint Committee and the Oncology Committee.



Bone imaging – ^{99m}Tc HMDP/HDP/DPD



- Uptake mechanism

Radiolabelled bisphosphonates are incorporated into the surface of hydroxyapatite crystals in proportion with local bone vascularization and osteoblastic activity

IV administration, after 4h: 60% fixed in the skeleton, 34% excreted in urine, 6% circulation

Maximum bone accumulation 1h after tracer injection – constant up to 72h

Optimal bone-soft tissue ratio between 2-3 h PI



Bone imaging - ^{99m}Tc HMDP/HDP/DPD

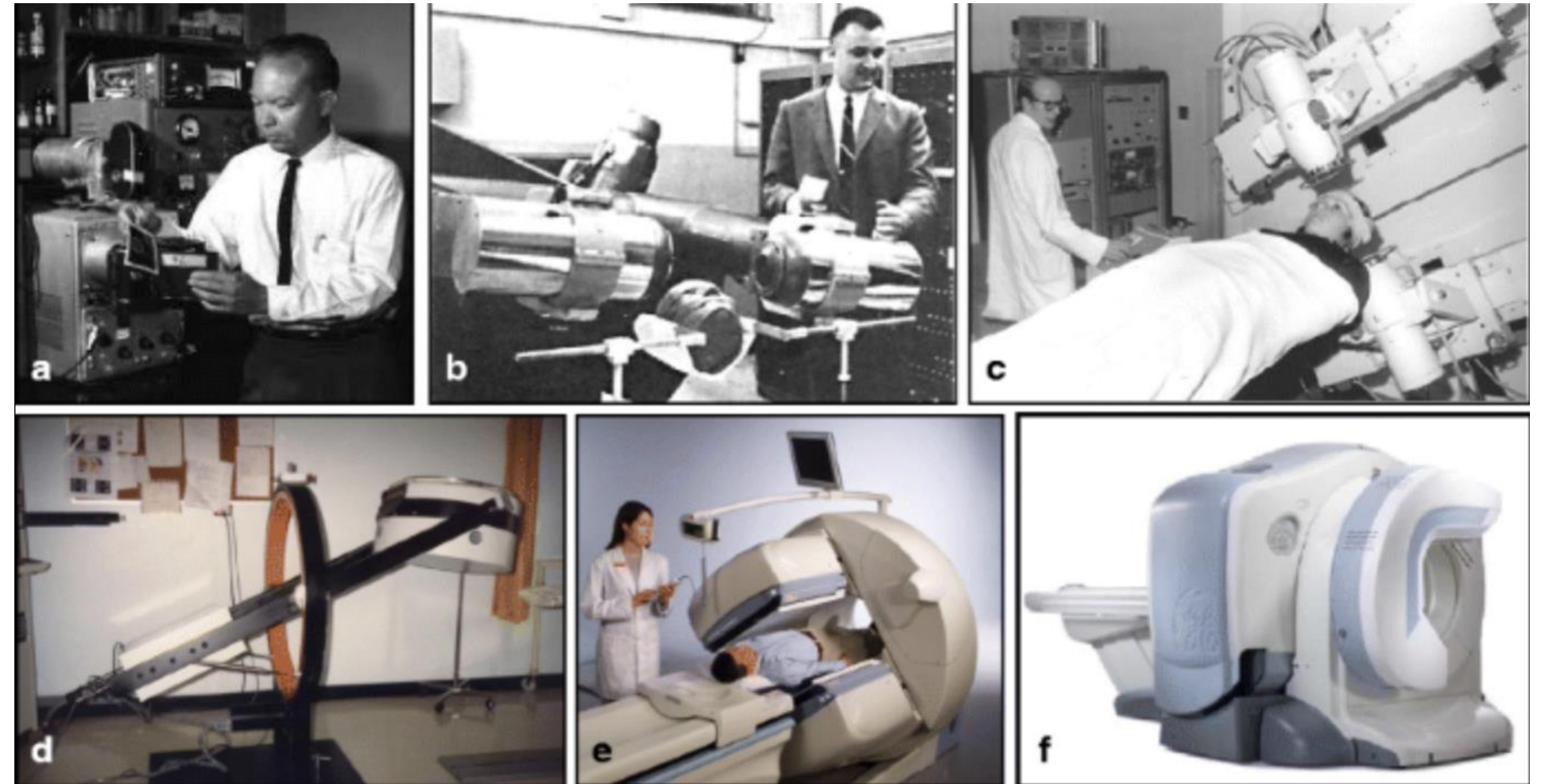


- Indications
 - Confirm/exclude specific bone disease (oncology/rheumatology/ orthopaedics/...)
 - Explore unexplained symptoms (musculoskeletal or bone pain)
 - Metabolic assessment of the skeleton prior to start of therapy (Xofigo)



Multimodality imaging: SPECT/CT

- Functional information + anatomical information
- First SPECT/CT in 1999 by GE, low dose 1 slice CT
- Today: high resolution and fast diagnostic CT systems



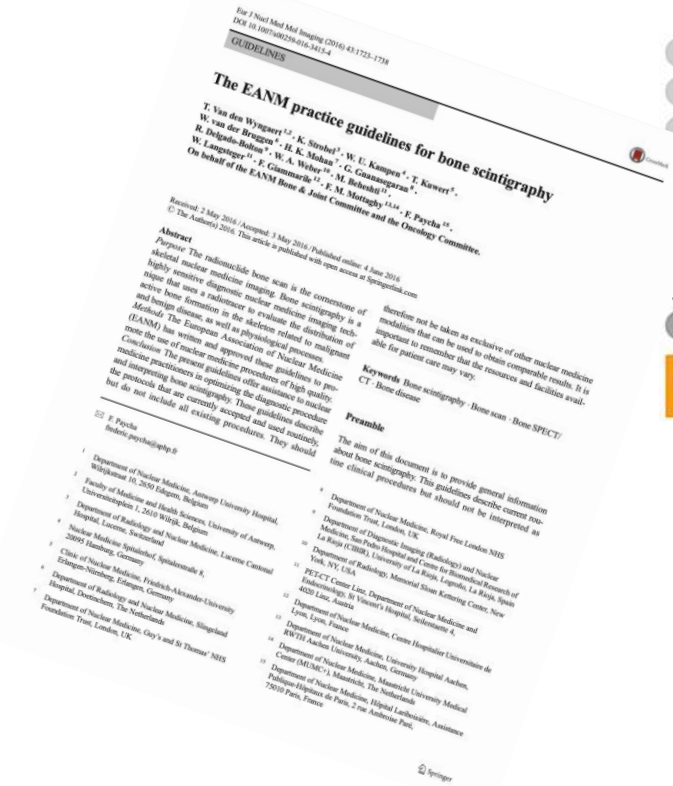
The origins of SPECT and SPECT/CT. EJNMMI 2013.

EANM Guidelines bone scintigraphy

Multiphase bone scan produces planar images of the vascular inflow and the soft tissue phase, and delayed phase images of the radiopharmaceutical over a given area of the skeleton. The vascular inflow images are acquired during intravenous injection. The study of the soft tissue distribution of the radiopharmaceutical in the region of interest is performed within the first 5–10 min after injection. Finally, delayed whole-body, focal views, and/or tomographic images are usually acquired between 2 and 4 h after injection of the radiopharmaceutical. In some patients, it may be useful to acquire late-phase images up to 24 h after tracer administration [11].

2016

For the vascular phase of the examination, the camera is positioned centred on the area of interest. The dynamic acquisition of 30 to 60 images with a duration of 1–2 s each and a matrix of 64×64 or 128×128 pixels is started simultaneously with the intravenous tracer injection. The early and late planar images are focused on one or more region(s). The early images are acquired between 1 min and 10 min after intravenous injection of $^{99\text{m}}\text{Tc}$ -labelled bisphosphonate, with an acquisition time of 3 min to 5 min and a matrix size of 128×128 or 256×256 .



EANM Guidelines

- KNEE: “ consider early-phase SPECT/CT: might be helpful in inflammation and infection”
- FOOT: ????

Region	Static blood pool	
	Indication	Acquisition
Wrist/hand	Routinely recommended Immediately following the injection of the radiotracer, place both hands (palms down) on the camera	Planar images 256 × 256 matrix LEHR or LEGP collimators 2 – 5 min per view
Hips	Routinely recommended Depending on the size of the replacement, two images may be required to ensure the whole area is covered LEHR or LEGP collimators	Anterior/posterior images 256 × 256 matrix 2 – 5 min per view
Knee	Routinely recommended Also consider early-phase SPECT/CT might be helpful in inflammation and/or infection	Anterior/posterior images 256 × 256 matrix LEHR or LEGP collimators 2 – 5 min per view
Spine	Radiologically inconclusive result for fracture with red flags Suspicion of infection, including spondylitis and spondylodiscitis In case of likely fractures to discriminate recent from old fracture In the postsurgery setting (with or without implants)	Anterior/posterior images 256 × 256 matrix LEHR or LEGP collimators 2 – 5 min per view



What about blood pool SPECT/CT?

The Added Value of Bloodpool SPECT/CT in Painful Non-Operated Foot and Ankle Undiagnosed With Standard Three-Phase Bone Scintigraphy.

Cuvilliers et al. Front. Med. 2021.

- **LITERATURE**

- 3 phase bone scintigraphy is imaging method of choice to establish the etiological diagnosis of painful lower extremities
- Bloodpool SPECT outperforms planar imaging in the assessment of total knee arthroplasty (Verschueren et al.)

- Prevalence of extra osseous pathologies
- Complex anatomy of feet and ankles

BLOOD POOL SPECT/CT:

- could be of interest in exploration of pain in lower extremities
- could detect extraosseous pathology

Methods

- 133 patients
- Tc-99m-HMDP
- Planar 2 min early dynamic and bloodpool feet/ankles
- Late phase planar WB and SPECT/CT feet/ankles
- + bloodpool SPECT/CT feet/ankles 7-14 min after injection

Characteristic	N (Proportion)	Median [Range]
Participants	113	
Age (years)		53 [37, 66]
Gender		
Male	71 (63%)	
Female	42 (37%)	
Pain		
Left only	63 (55.8%)	
Right only	45 (39.8%)	
Bilateral	5 (4.4%)	
Duration (weeks)		14 [7, 40]
Intensity (scale from 0 to 10)		5 [4, 7]
Mechanical type only	28 (24.7%)	
Inflammatory type only	10 (8.9%)	
Mixed type	75 (66.4%)	
Suspicion of complex regional pain syndrome	36 (31.9%)	
Reported trauma	59 (50.0%)	
Referred by		
General practitioner	63 (55.8%)	
Specialist	50 (44.2%)	

Results

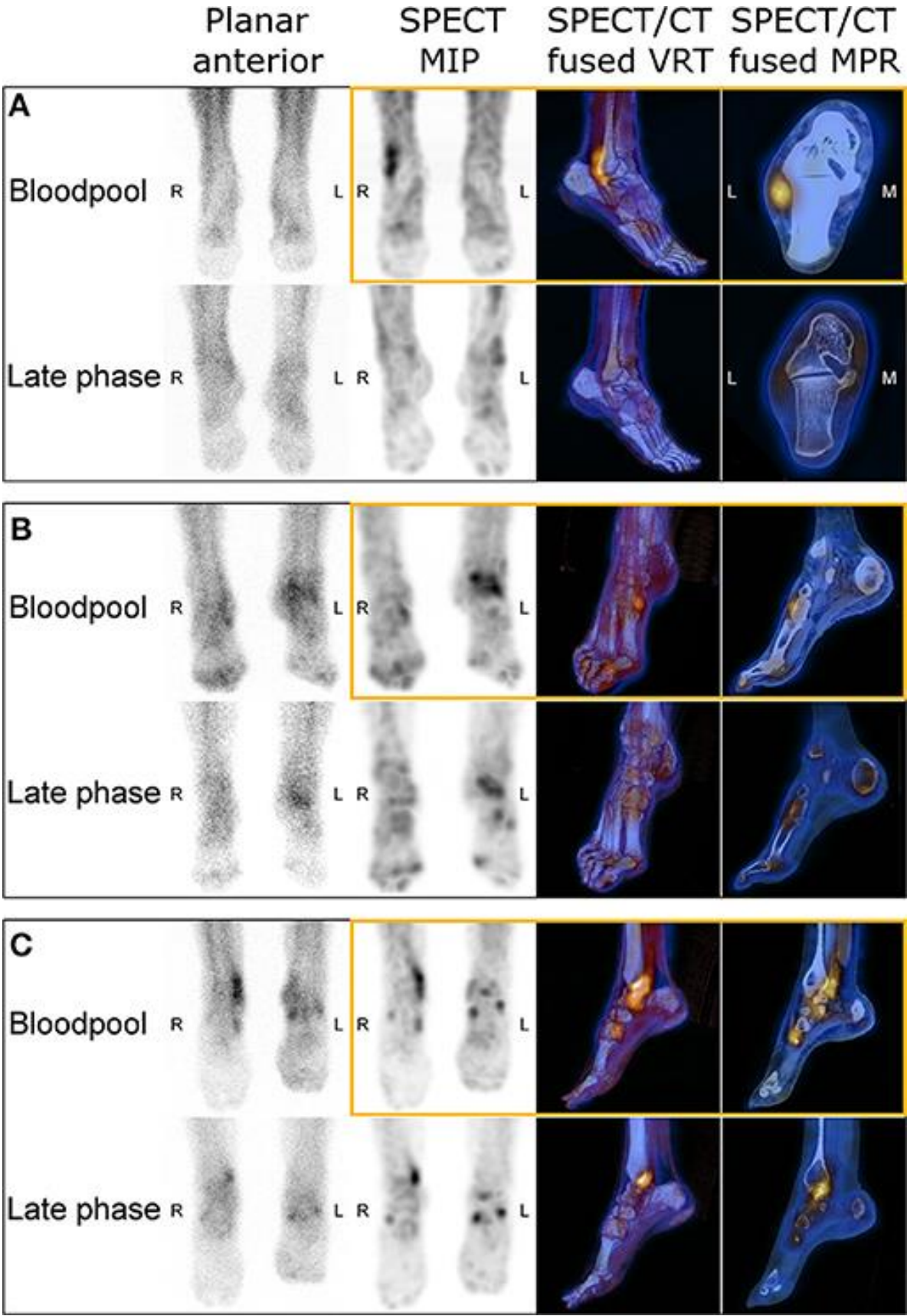


FIGURE 2 | Images of three-phase bone scintigraphy from three patients with right lower extremity pain, including images provided by bloodpool SPECT/CT (in orange boxes).

Patient **(A)** was a 62-year-old man referred for suspicion of right lateral malleolus stress fracture. Bloodpool SPECT/CT revealed intense uptake along peroneal tendons, highly suggesting the diagnosis of right peroneal tendonitis.

Patient **(B)** was an 81-year-old woman with pain of the right ankle and anterior tarsus, suspected with stress fracture. Bloodpool SPECT/CT revealed focal uptake at the insertion of the anterior tibial tendon, leading to set the diagnosis of right tibial anterior tendonitis.

Patient **(C)** was a 60-year-old woman, suffering from right medial ankle pain. Planar bloodpool and late phase SPECT/CT images were compatible with a posterior tibial tendonitis with a low diagnostic confidence. Bloodpool SPECT/CT substantially increased the diagnostic confidence for posterior tibial tendonitis and revealed intense focal uptake at the insertion of the anterior tibial tendon, evocative of associated right tibial anterior tendonitis.

Results

	Abnormalities <i>n</i> (%)
Total	165 (100%)
Detectable with both planar and SPECT ^a imaging	112 (67.9%)
<i>Identically localized</i>	79 (70.5%)
<i>Differently localized</i>	33 (29.5%)
Detectable with SPECT ^a only	44 (26.7%)
Detectable with planar imaging only	9 (5.4%)
<i>Related to physiological activity in plantar vessels</i>	5 (55.6%)

^aSPECT, single photon emission computed tomography.

Results / conclusions



- Extra osseous pathology: common cause of symptoms
- Addition of bloodpool SPECT/CT changed diagnostic conclusion in 24,6 % of lower extremities (tendonitis)



Conclusions



- Addition of bloodpool SPECT/CT to standard 3pBS for the exploration of painful lower extremities increased the diagnostic yield and enhanced the diagnostic confidence.
- Improve feasibility and comfort of patients: blood pool SPECT/CT instead of planar images



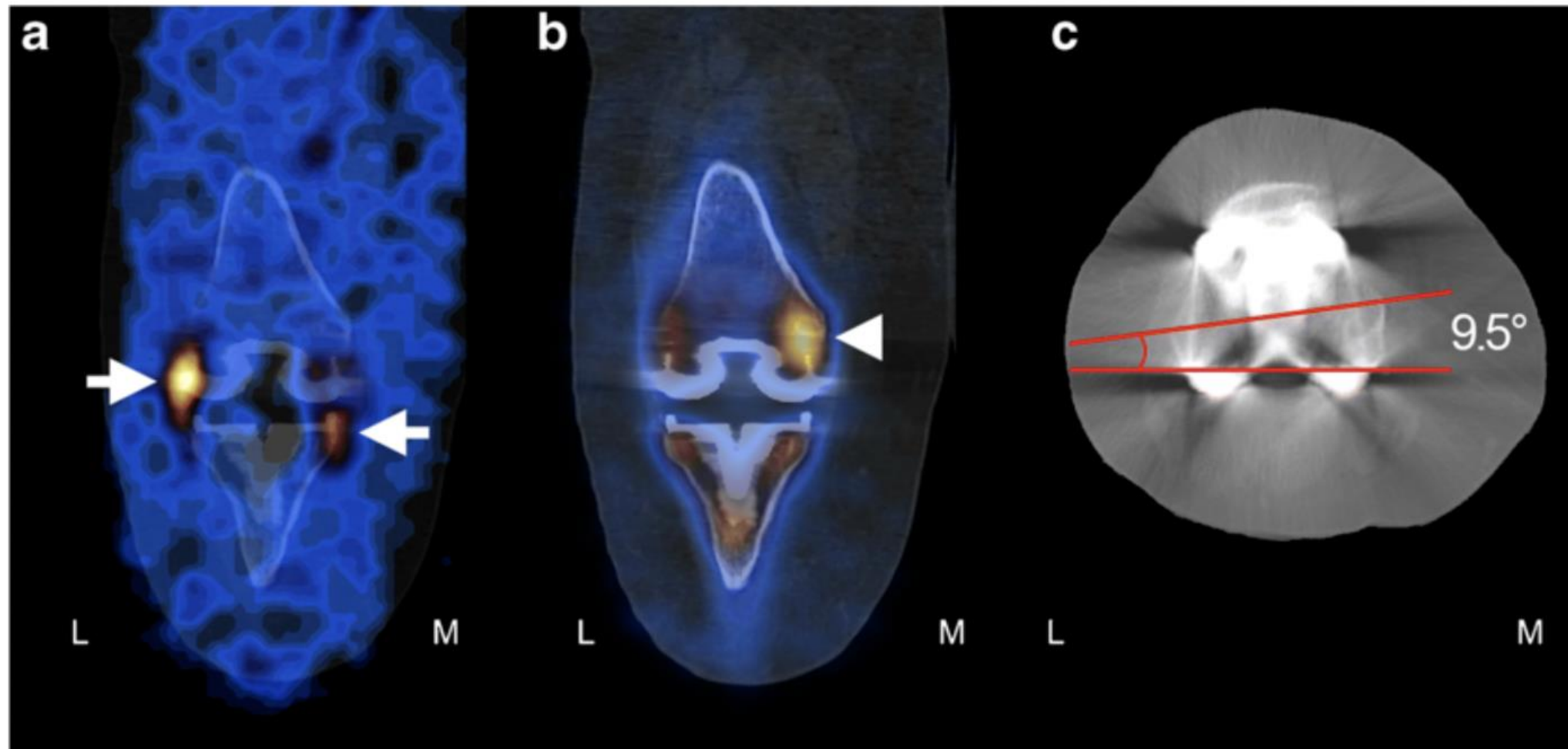
What about blood pool SPECT/CT?

- LITERATURE

Bloodpool SPECT as a part of bone SPECT/CT in painful total knee arthroplasty (TKA): validation and potential biomarker of prosthesis biomechanics. Verschueren et al. EJNMMI 2019.

- TKA is accepted as a successful intervention for end-stage osteoarthritis, it is estimated that 20—30% of patients are not pain free or satisfied after TKA
- Recurrent pain: septic loosening, aseptic mechanical intra-articular or extra-articular complications
- Bloodpool SPECT: more accurate localisation – easier comparison to late SPECT/CT images

Results



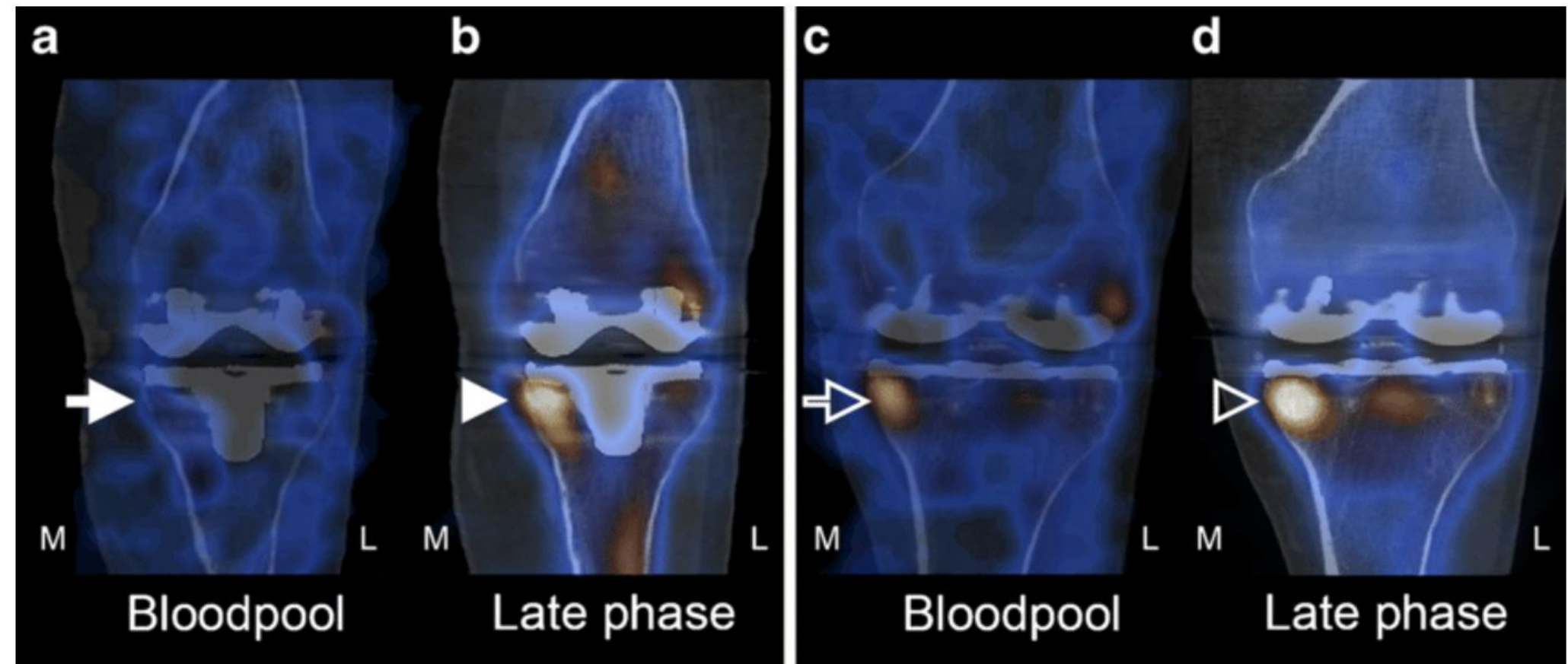
Lateral femoral uptake:
important marker of
biomechanical
prosthesis failure

Illustration of increased focal bloodpool SPECT uptake at the lateral femoral and medial tibial prosthesis components (a: arrows), without corresponding late-phase SPECT/CT uptake (b: arrowhead showing increased medial femoral uptake without prosthesis–bone interface contact) in a patient with severe internally rotated femoral component (9.5°) (c: summed axial CT images with measurement of angle between anatomic transepicondylar axis and posterior bicondylar axis). Revision surgery was performed. Abbreviations: M = medial; L = lateral. Note: for illustrative purposes, fused bloodpool SPECT images are shown after rigid registration with the CT performed during late-phase SPECT/CT, but during the study only non-fused bloodpool SPECT images were assessed

Results / conclusions



Superior for assessment of tibial and patellar regions: differentiate between local stress and loosening of the tibial component



Example of complementary information provided by bloodpool SPECT in a patient imaged 9 months after left TKA without uptake on bloodpool SPECT (a: arrow) but increased focal uptake on late phase SPECT/CT below the tibial component on the medial side reflecting bone stress (b: arrowhead). Resolution of symptoms was seen with conservative management. Another patient imaged 14 months after left TKA showing increased uptake on the medial side below the tibial component on bloodpool SPECT (a: arrow outline) and late phase SPECT/CT (b: arrowhead outline). Loosening of the tibial component was confirmed during revision arthroplasty. Abbreviations: M = medial; L = lateral. Note: For illustrative purposes, fused bloodpool SPECT images are shown after rigid registration with the CT performed during late-phase SPECT/CT, but during the study only non-fused bloodpool SPECT images were assessed



Conclusions



- SPECT/CT outperforms planar bone imaging (patients with and without arthroplasty)
- Bloodpool SPECT: higher inter rater agreement and higher rater confidence
- True imaging biomarker of prosthesis biomechanics
- Identifying uptake patterns → particular clinical/surgical diagnoses



What about blood pool SPECT/CT?

- Our indications?

- **EXPLORATION OF UNEXPLAINED SYMPTOMS: polyarthrititis**

- **BONE DISEASE**
Rheumatology

RA, SAPHO, SI-itis, enthesopathy (e.g. fasciitis plantaris), CRPS

Bone and joint infections

Osteomyelitis, septic arthritis, septic loosening/mechanical complication of arthroplasty

Orthopaedics

Periostitis, enthesopathy, radiological occult stress related fractures

Paediatrics

Osteoid osteoma, osteochondritis of the hip

What about blood pool SPECT/CT?

- Technique/ Acquisition parameters

- Matrix size: 128x128
 - Zoom: 1,00
 - Both detectors
 - Orientation: Head Out
 - Patient position: Supine
 - Degrees of rotation: 180
 - Number of views: 30
 - Time per view: 9 sec
 - Detector configuration: 180
- } 4,5 min

What about blood pool SPECT/CT?

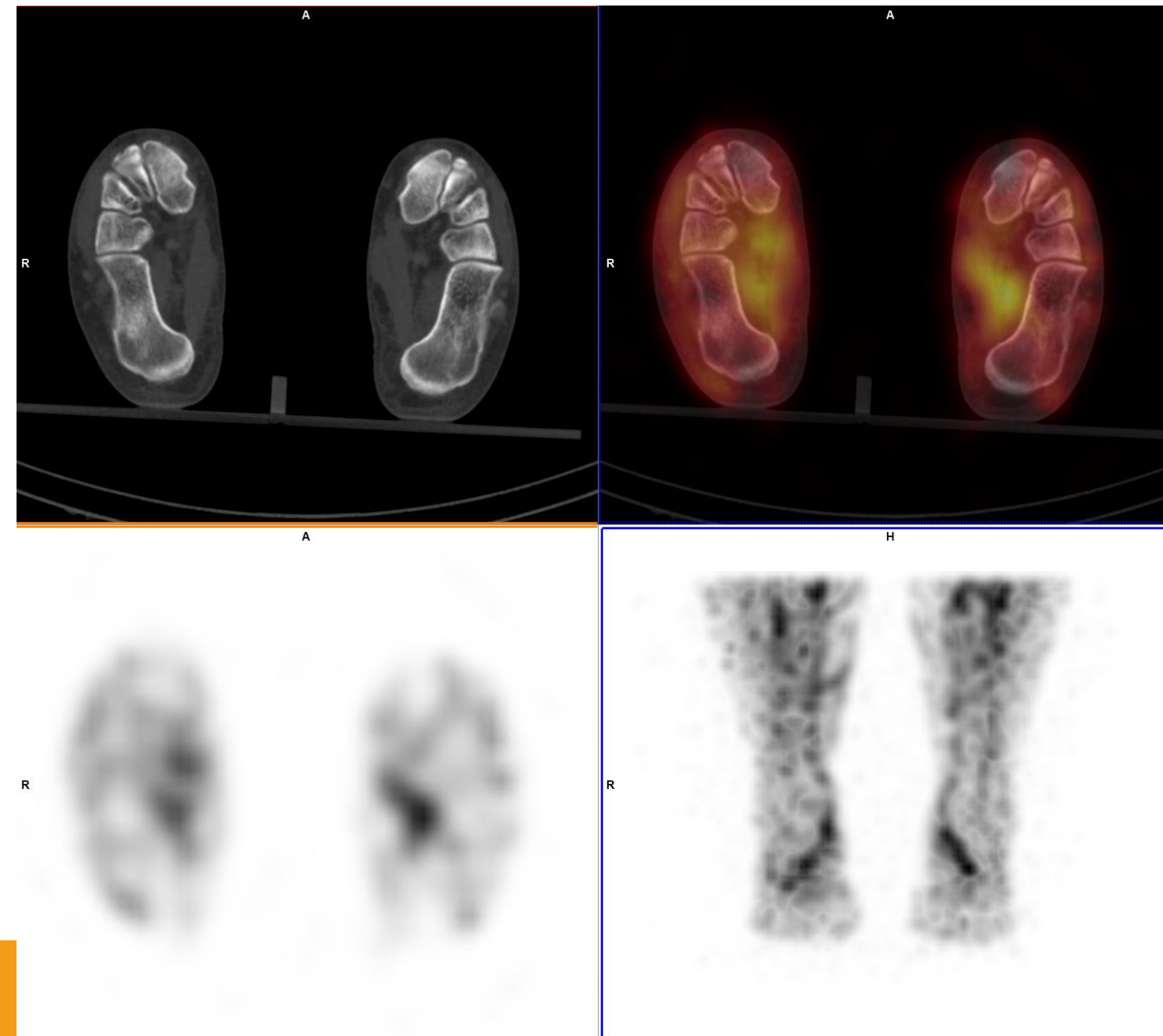


- What to keep in mind
 - use in lower extremities
 - movement!
- Radiation dose?
 - Low dose CT



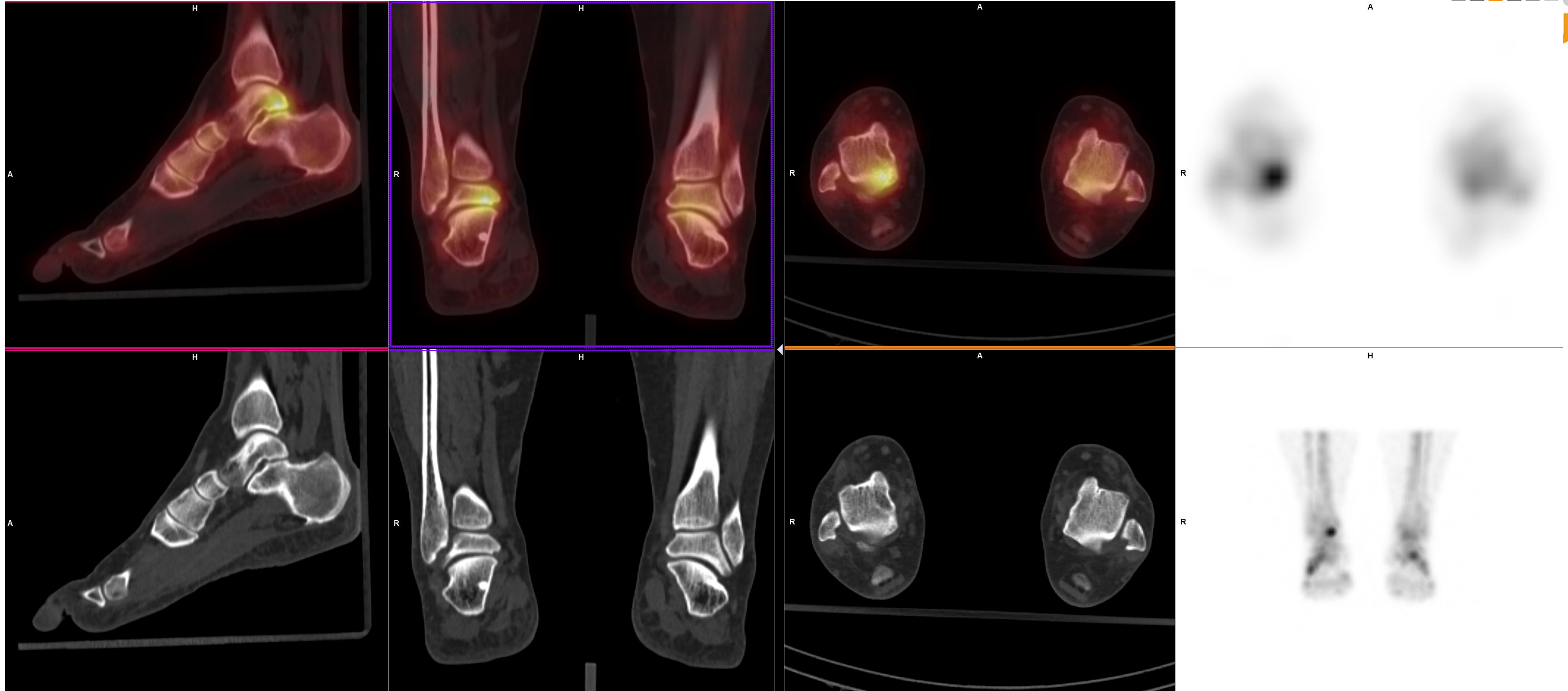
Examples

- Woman, 47 years old, pain right foot and ankle: normal blood pool SPECT



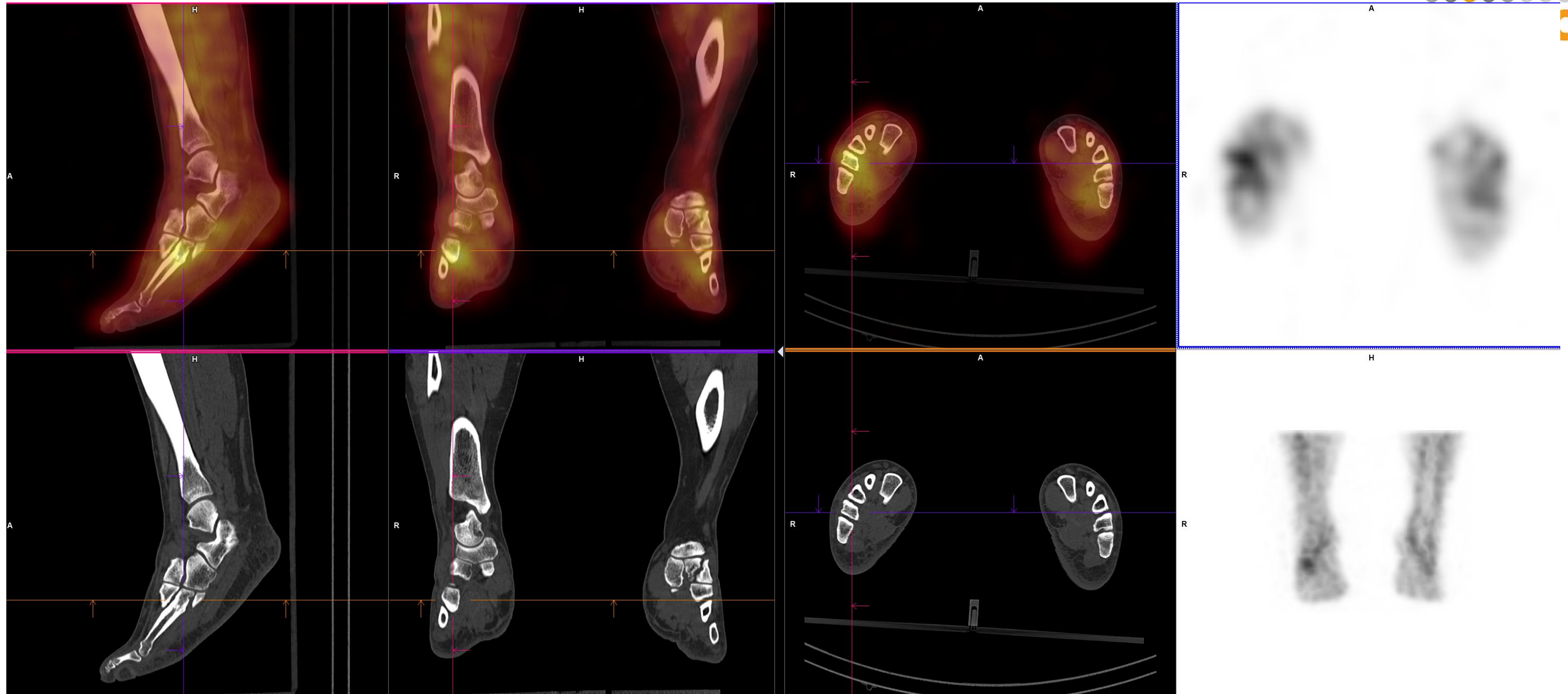
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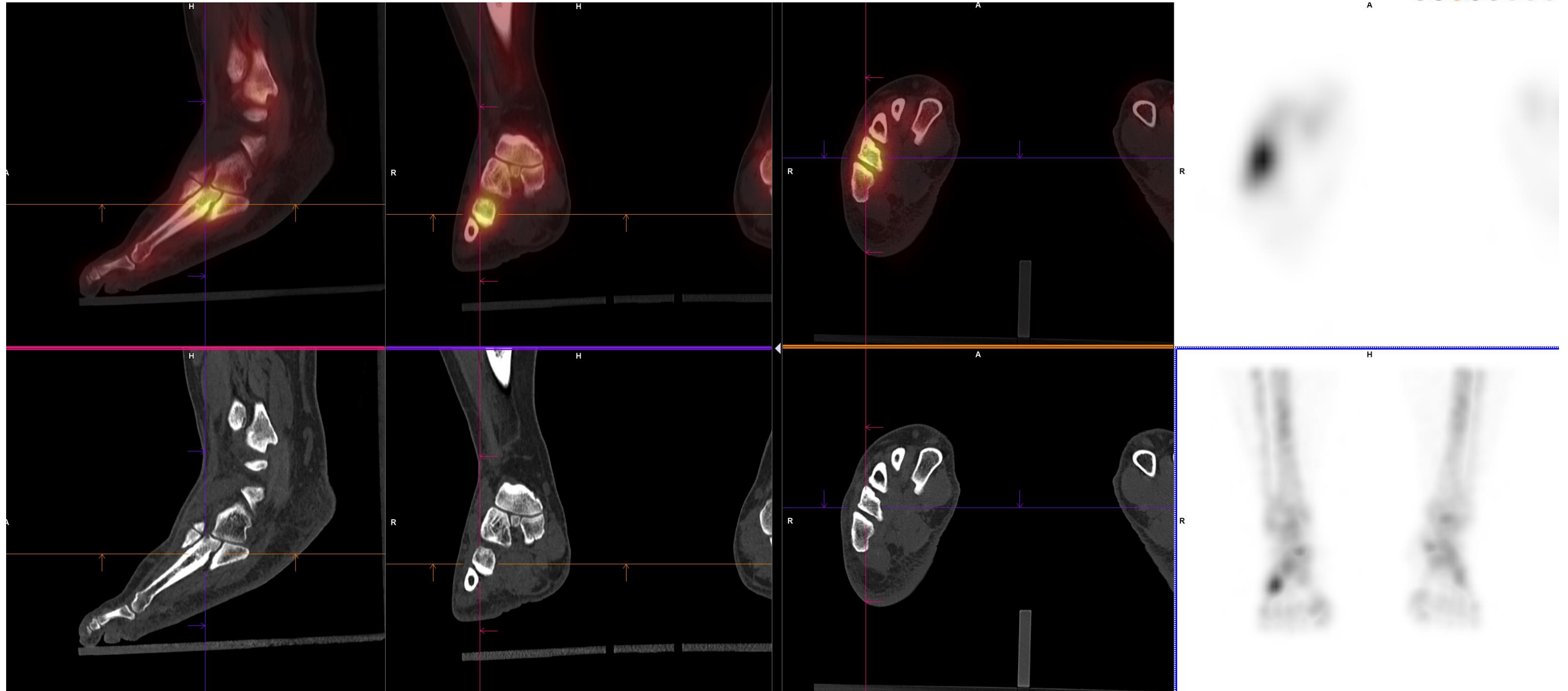
Examples

- 49 year old woman, pain MT4, right foot



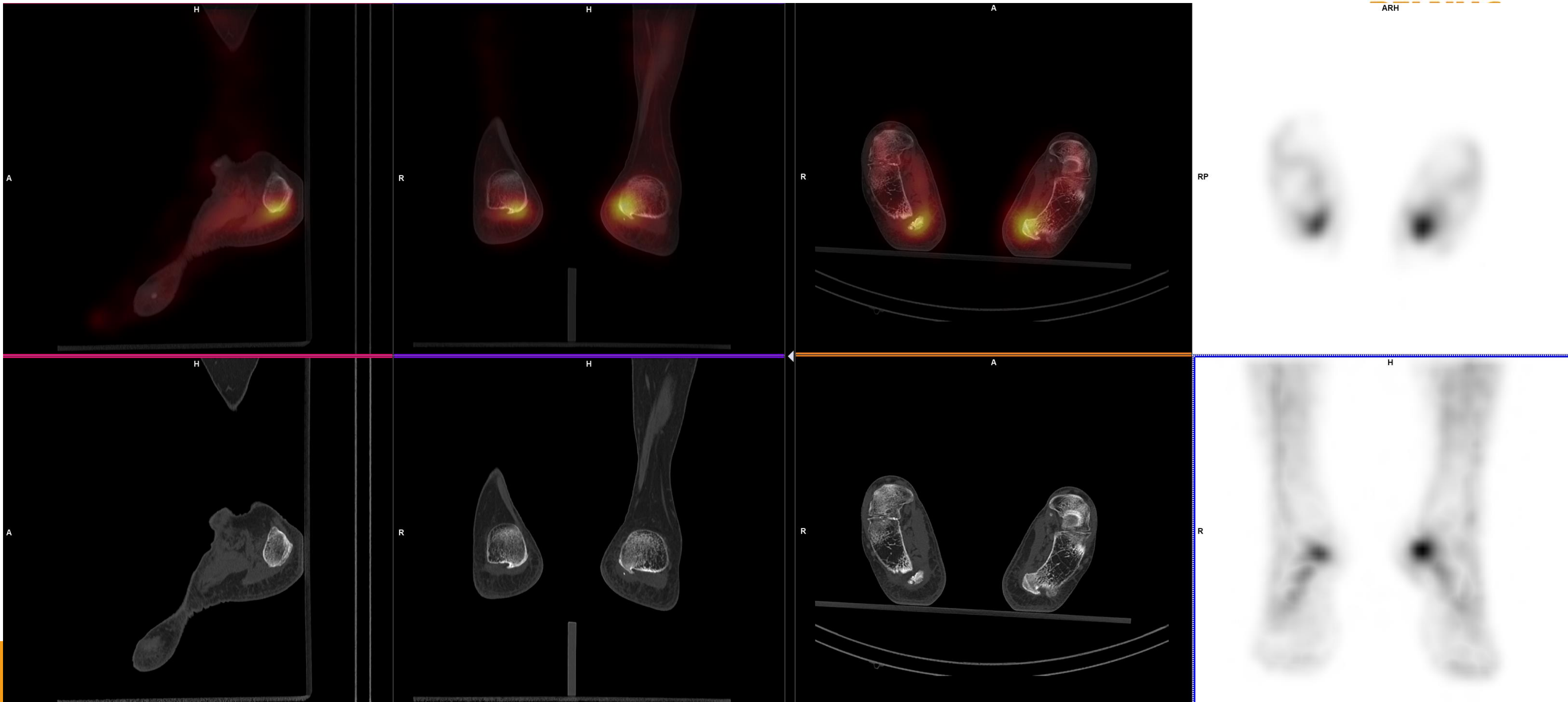
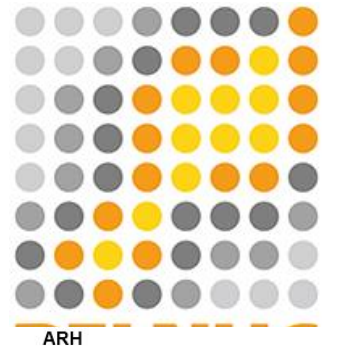
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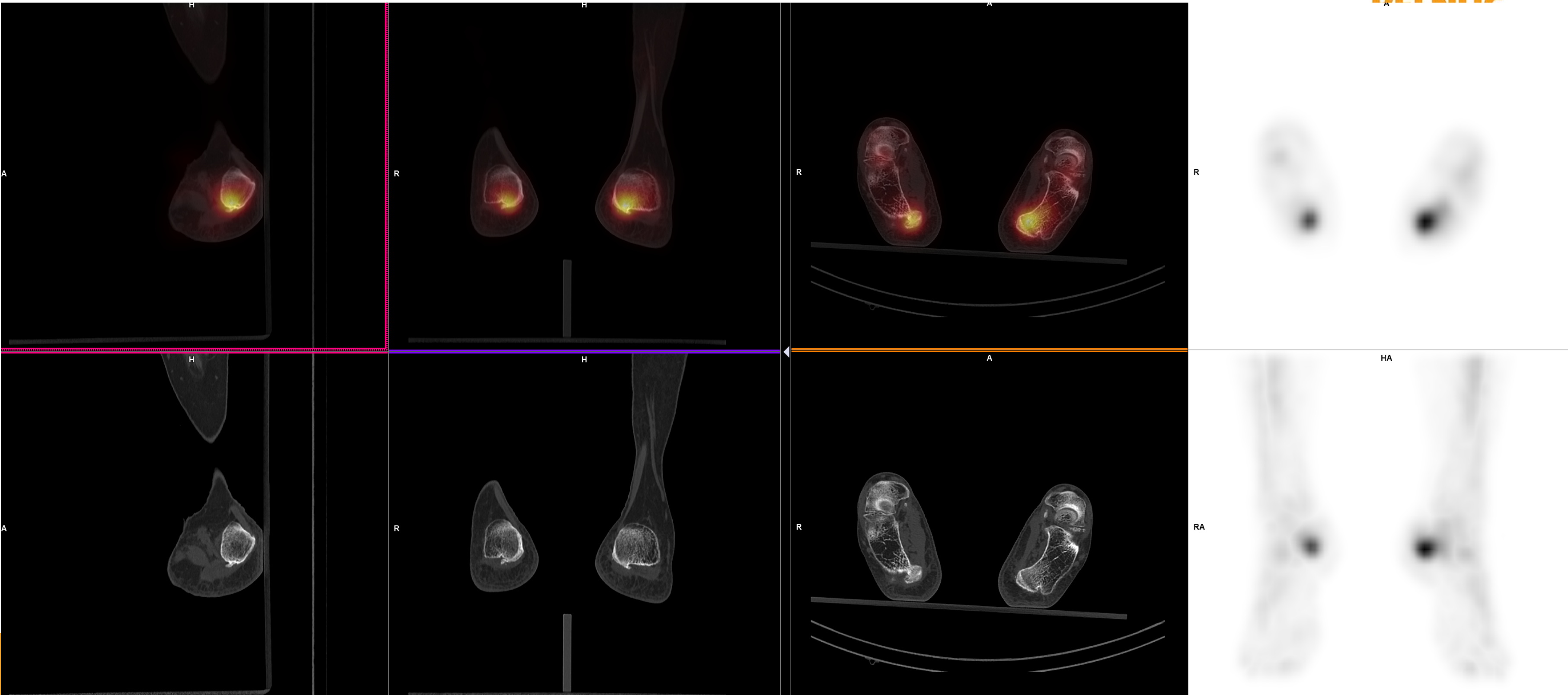
Examples

- 66 year old woman, exclude stress fracture



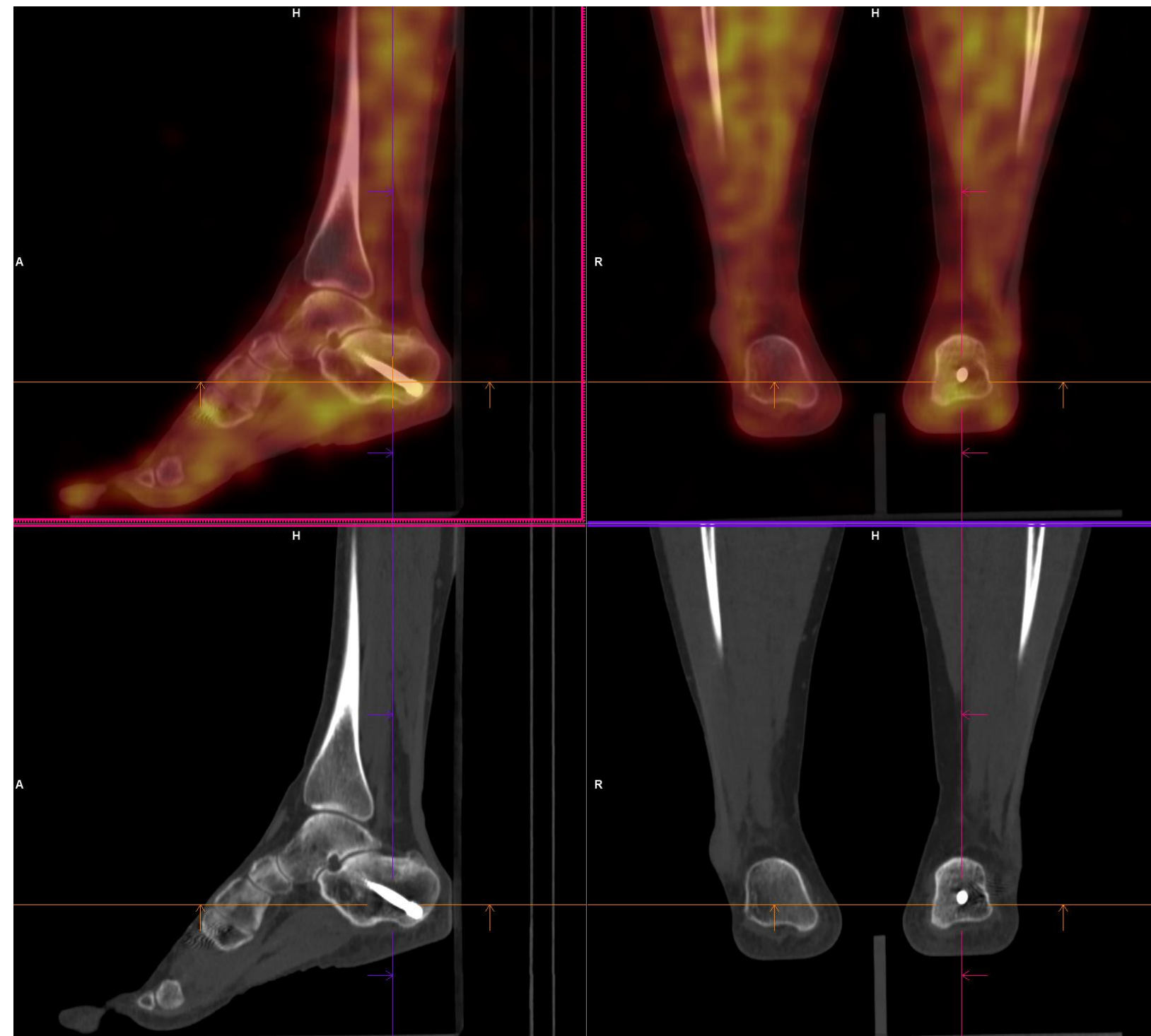
Examples

- 66 year old woman, exclude stress fracture



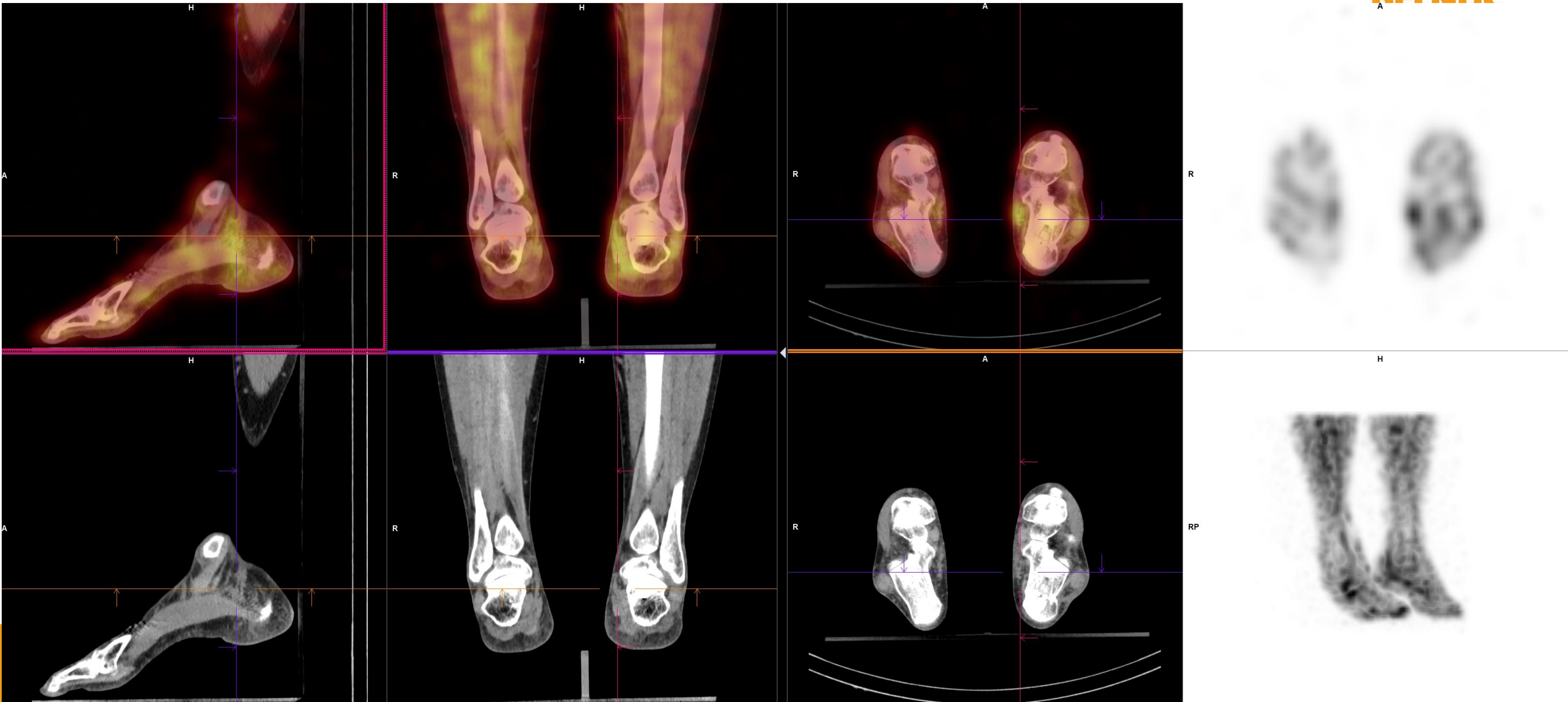
Examples

- 46 year old man, osteotomy left calcaneus 1 year ago, pain, loosening?



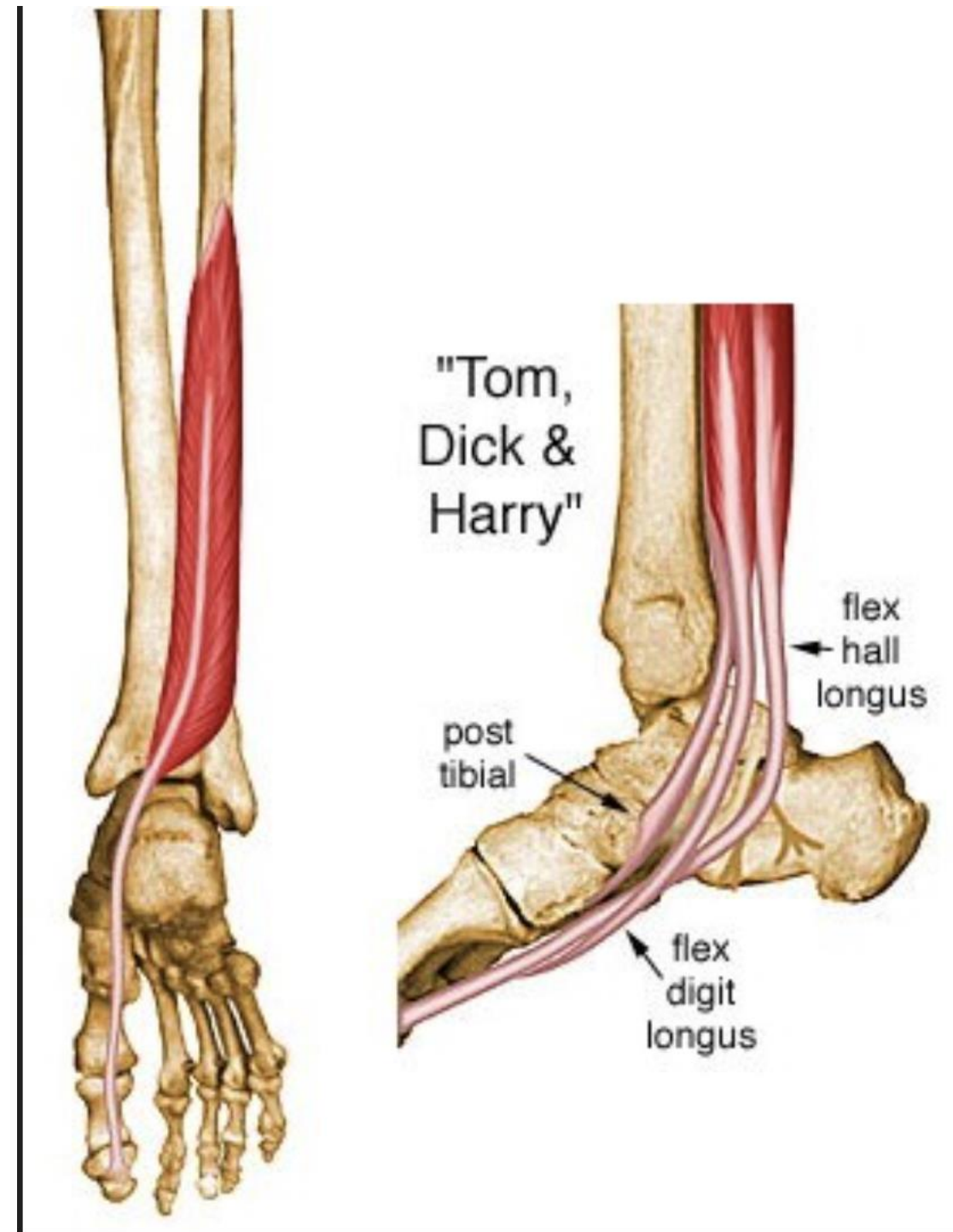
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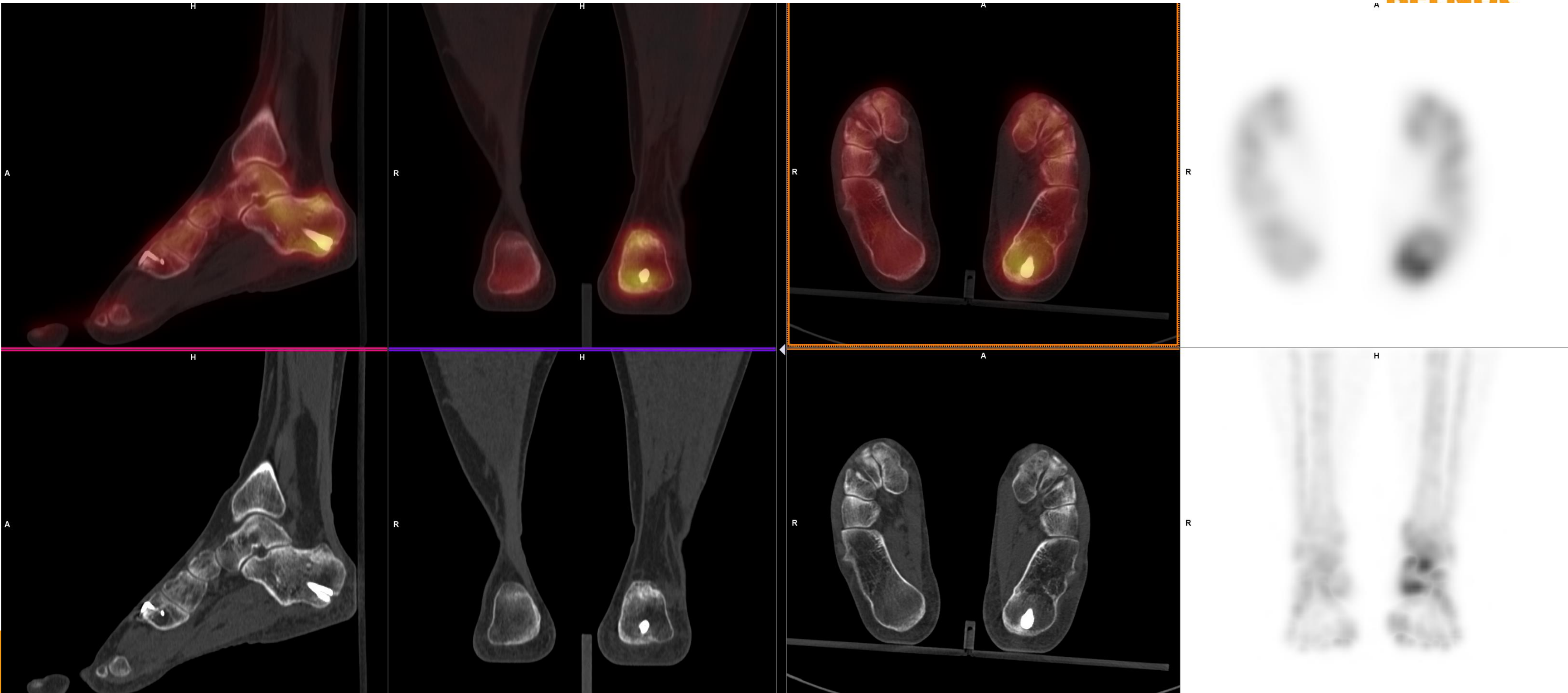
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Examples

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Thank you! Questions?

