

Contribution of Bone Scintigraphy in Benign Bone Pathology: Illustrative Cases from the Nuclear Medicine Department at the University Hospital of Fez

Assia Seddouki^{1*}, Sofia Chkikar¹, Ezzo-Mada Kpekpeou¹, Mehdi Goudira¹, Nadia Ismaili Alaoui¹

¹Department of Nuclear Medicine, Hassan II University Hospital Center, Fez, Morocco

*Corresponding author: Dr. Assia Seddouki · assiased.as@gmail.com

Received: 11 April 2024 · Published: 14 April 2024 · Volume 7 · Issue 1 · Article 12

Swiss Journal of Radiology and Nuclear Medicine · www.sjoranm.com · SJORANM GmbH · Rosenweg 3 · CH-6340 Baar · Switzerland

Abstract

Bone scintigraphy is a sensitive whole-body technique for assessing osteoblastic activity and can support the evaluation of infectious, traumatic, metabolic, developmental, and benign neoplastic bone disorders. This educational review summarizes the principles and practical conduct of planar bone scintigraphy and hybrid SPECT/CT and presents 14 illustrative cases from the Nuclear Medicine Department of Hassan II University Hospital Center in Fez. The cases demonstrate the contribution of multiphase imaging and SPECT/CT to lesion localization and characterization in septic pseudarthrosis, osteochondritis, brown tumors, osteoblastoma, neurogenic para-osteoarthropathy, Langerhans cell histiocytosis, osteogenesis imperfecta, focal osteoarticular inflammation, polyostotic fibrous dysplasia, Paget disease, femoral-head osteonecrosis, osteoid osteoma, active condylar hyperplasia, and renal osteodystrophy. The examples are illustrative and do not define universal image-quality or equipment standards. Interpretation must integrate the clinical question, laboratory findings, anatomic imaging, and, when indicated, histopathology.

Keywords: bone scintigraphy; benign bone pathology; SPECT/CT; lesion localization; bone metabolism; case series

Introduction

Bone scintigraphy is one of the most frequently performed examinations in conventional nuclear medicine. It depicts the distribution of osteoblastic activity throughout the skeleton and is used in diagnostic pathways for infectious, traumatic, inflammatory, metabolic, developmental, and neoplastic bone disorders [1,4,5,6]. Planar images are assessed for the appearance, number, intensity, and distribution of areas of abnormal tracer uptake. Hybrid SPECT/CT can improve anatomic localization and specificity by correlating radiotracer uptake with morphologic findings [2,5].

The examination is highly sensitive to changes in perfusion and bone remodeling, which may precede findings on conventional radiographs. Its specificity is limited, however, and abnormal uptake must be interpreted in the context of the clinical history, laboratory data, and complementary imaging. CT, MRI, microbiology, serology, or biopsy may be required to establish the final diagnosis.

Principles of Bone Scintigraphy

Bone-seeking diphosphonates labeled with technetium-99m bind to the surface of hydroxyapatite crystals in relation to local blood flow and osteoblastic activity. Common agents include methylene diphosphonate, hydroxymethylene diphosphonate, hydroxyethylene diphosphonate, and 2,3-dicarboxypropane-1,1-diphosphonate. Technetium-99m emits a 140-keV gamma photon and has a physical half-life of approximately 6 hours [5,6].

Properties of bone scintigraphy
1. High sensitivity (80–95%) for detecting bone lesions
2. Assessment of bone remodelling (turnover)
3. Vascular and tissue information through dynamic or static imaging
4. Panoramic imaging of the skeleton
5. No artefacts caused by orthopaedic equipment
6. Quantification of bone damage
7. Easy to perform
8. No significant toxicity: 1 adverse event per 100,000 injections
9. Low radiation dose: 5 mSv plus 1.5–2 mSv per low-dose CT field of view
10. Relatively low cost

Table 1. Principal characteristics of bone scintigraphy.

Indications in benign bone pathology
1. Rheumatology
2. Osteoarticular infections
3. Traumatology
4. Metabolic osteopathies
5. Orthopaedics
6. Paediatrics

Table 2. Examples of indications in benign bone pathology.

Patient Preparation and Examination Protocol

The request should state the clinical question, relevant bone or joint history, symptoms, laboratory findings, prior imaging, recent surgery or trauma, and treatments that may influence tracer distribution. Pregnancy and breastfeeding status, renal function, and urinary-tract abnormalities require specific consideration. Patients should be well hydrated before and after tracer administration and should void frequently, including immediately before delayed imaging, to reduce bladder activity and radiation exposure [5,6].

For adults, an administered activity within 8-20 mCi (300-740 MBq) may be used, subject to national diagnostic reference levels, patient characteristics, equipment performance, and local protocol [5]. Pediatric activity must be weight-adjusted according to an accepted pediatric dosage card and local regulations; a fixed adult-derived MBq/kg rule should not be used without validation.

A multiphase examination may include dynamic perfusion images during injection, immediate blood-pool or soft-tissue images during the first minutes, and delayed skeletal images, usually acquired 2-4 hours after injection. Additional delayed imaging may be useful when soft-tissue clearance is slow or urinary activity obscures the pelvis. Whole-body planar images may be supplemented with focused views, pinhole imaging, SPECT, or SPECT/CT according to the clinical question [1,5].

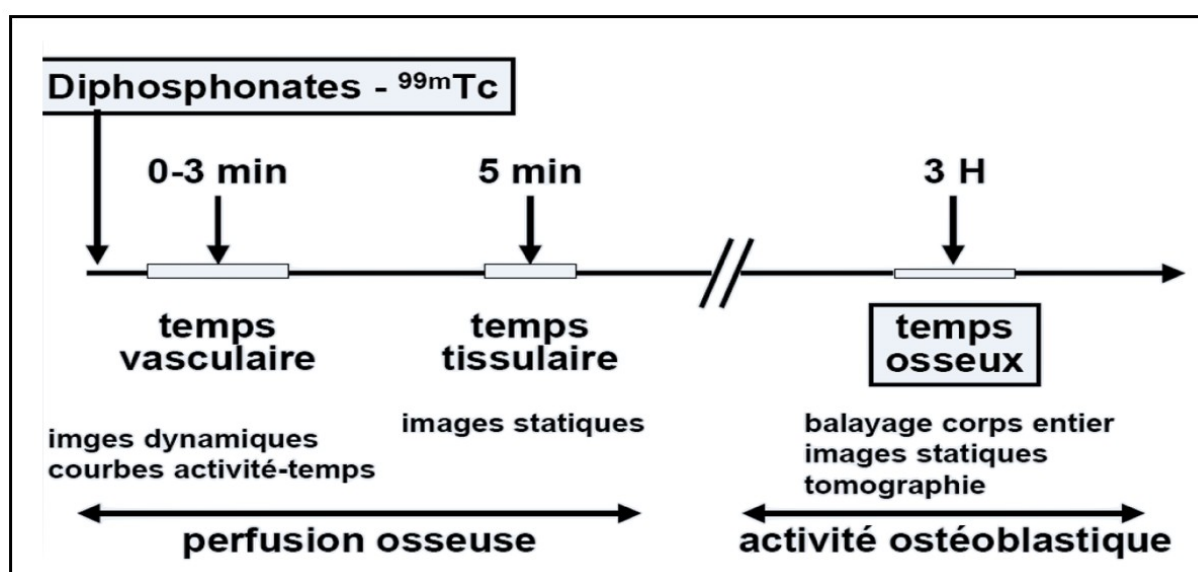


Figure 1. Schematic representation of vascular, soft-tissue, and delayed skeletal phases reproduced from the original article source.

For technetium-99m oxidronate, the French public product information reports an effective dose of approximately 4.0 mSv after administration of 700 MBq to a healthy 70-kg adult, with absorbed doses of approximately 44.1 mGy to bone and 33.6 mGy to the urinary-bladder wall [6]. These are total doses for the stated administered activity, not values per MBq. Patient-specific exposure varies with skeletal uptake, renal function, hydration, and voiding.

Image Interpretation

Interpretation begins with assessment of image quality and expected physiologic tracer distribution. Symmetry, intensity, homogeneity, shape, and anatomic location of uptake should be evaluated. Increased uptake is common but nonspecific; reduced uptake can occur in purely lytic lesions, infarction, avascular necrosis, or attenuation. Common pitfalls include injection extravasation, urinary contamination, patient motion, attenuation by metal, altered urinary drainage, and soft-tissue calcification. SPECT/CT is particularly helpful for anatomically complex regions such as the spine, pelvis, skull, and small joints [5].

Illustrative Clinical Cases

The following cases were selected as educational examples from examinations performed at Hassan II University Hospital Center in Fez. They illustrate potential contributions of multiphase bone scintigraphy and SPECT/CT. They do not constitute a consecutive cohort or a diagnostic-accuracy study.

Case 1 Septic Pseudarthrosis

A 29-year-old woman had a post-traumatic comminuted fracture of the left femur that was initially treated with plate-and-screw osteosynthesis. The hardware was removed after local infection, and an external fixator was placed. CT showed ongoing consolidation of the femoral-shaft fracture without a definite intraosseous or soft-

tissue abscess. Early scintigraphic images demonstrated focal hyperemia at the junction of the upper and middle thirds of the left femoral shaft. Delayed imaging and SPECT/CT showed focal osseous uptake at the same site, heterogeneous uptake related to healing, and reactive uptake adjacent to the upper fixation pin. The overall appearance supported septic pseudarthrosis with a focal infectious component.

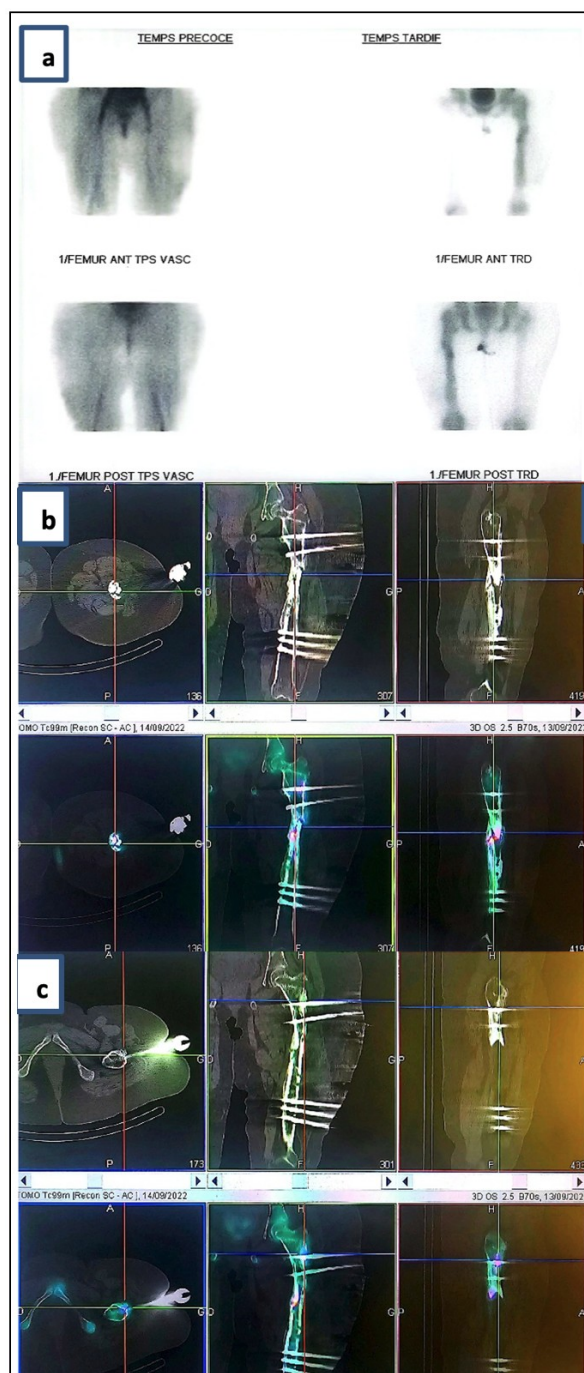


Figure 2. Case 1. Early and delayed planar images and SPECT/CT centered on the left femur.

Case 2 Primary Osteochondritis

A 10-year-old child presented with a one-year history of an afebrile left-sided limp. Pelvic CT demonstrated an osteolytic lesion of the left acetabulum adjacent to the hip joint, associated with soft-tissue infiltration and a small joint effusion. Early scintigraphic images showed no marked perfusion or blood-pool asymmetry. Delayed pinhole imaging demonstrated intense linear uptake involving the left femoral epiphysis with loss of normal sphericity, while whole-body images showed reactive uptake at the left acetabulum and greater trochanter. The findings were interpreted as primary osteochondritis; the diagnostic terminology and stated Conway stage should be confirmed against the clinical record before final publication.

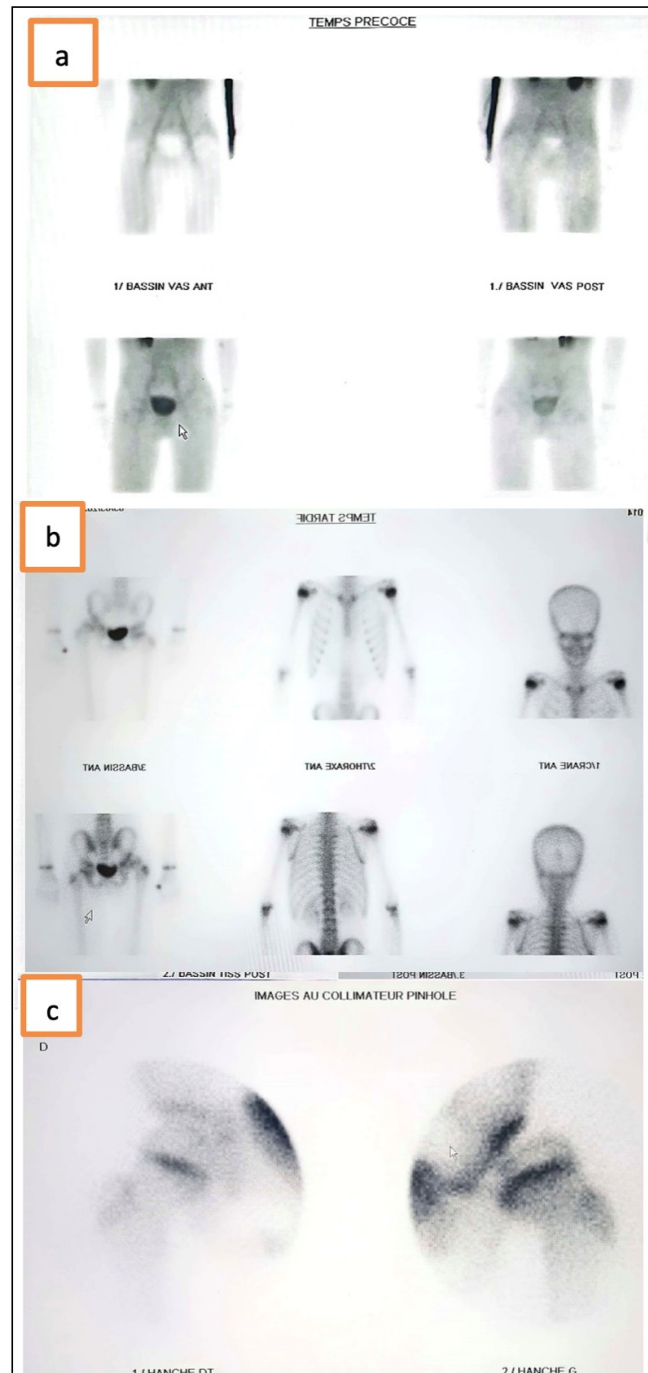


Figure 3. Case 2. Early and delayed images centered on the pelvis with pinhole and whole-body views.

Case 3 Multiple Brown Tumors

A 46-year-old patient receiving chronic hemodialysis had a parathyroid hormone concentration approximately ten times the upper reference limit. CT demonstrated osteolytic lesions involving the right sacral ala and the left sixth rib, with sacral cortical destruction and extension toward the epidural space and sacral foramina. Bone scintigraphy showed marked hyperemia and intense delayed uptake in the right sacrum, additional uptake in the left sixth rib, and a less intense focus in the distal right femur corresponding to an enchondroma. In the clinical context, the sacral and rib lesions were interpreted as brown tumors. Biopsy showed an immature reparative bone reaction without tumor in the sampled cores.

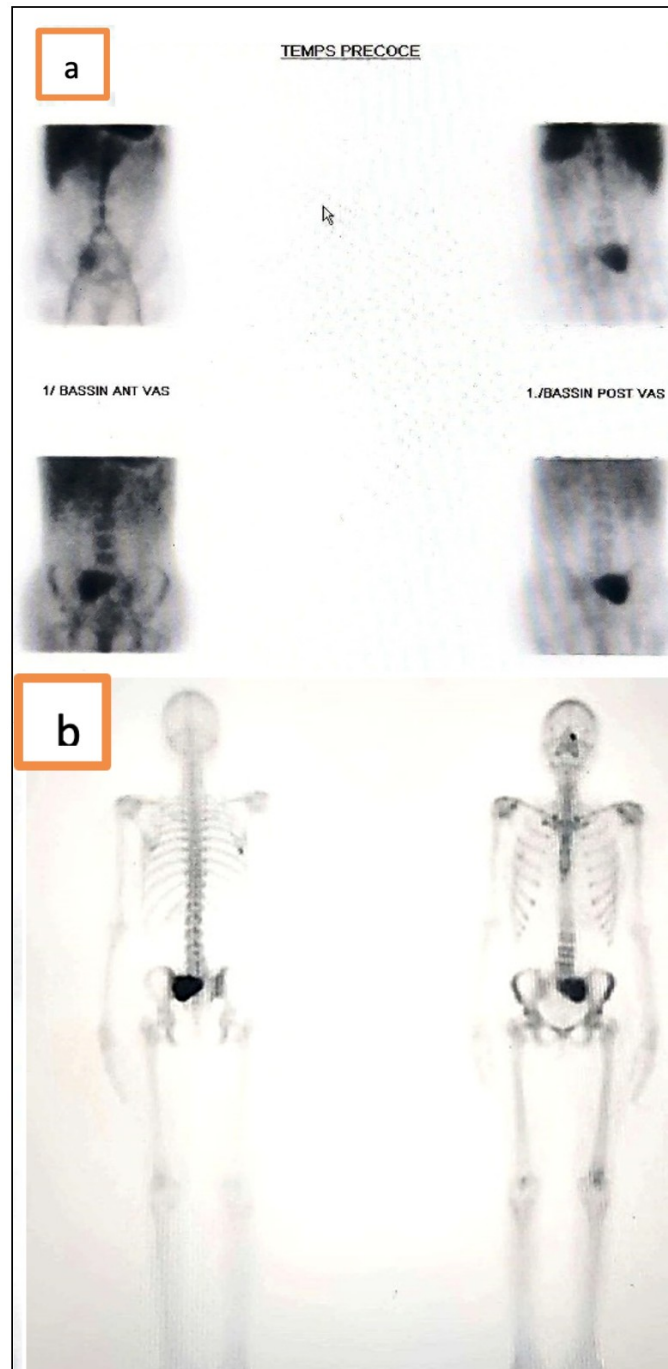


Figure 4A. Case 3. Early and delayed whole-body images in a patient with multiple brown tumors.

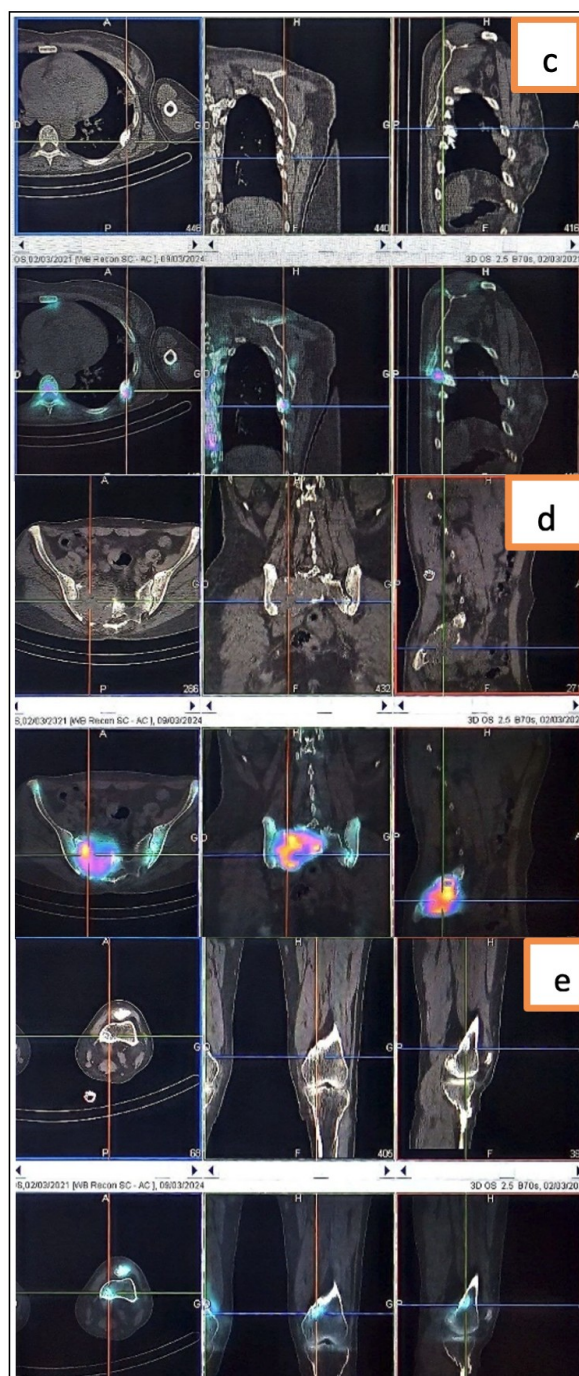


Figure 4B. Case 3. CT and SPECT/CT localization of the sacral, rib, and femoral lesions.

Case 4 Osteoblastoma

An 11-year-old boy presented with pelvic pain without lameness; palpation and mobilization were painless. Early bone scintigraphy showed increased soft-tissue-phase activity over the left hip. Delayed imaging demonstrated intense uptake in the left ischiopubic ramus. SPECT/CT localized the focus to a well-defined expansile osteolytic lesion with peripheral sclerosis and focal cortical disruption. The scintigraphic and morphologic findings supported osteoblastoma. No additional definite skeletal focus was identified.

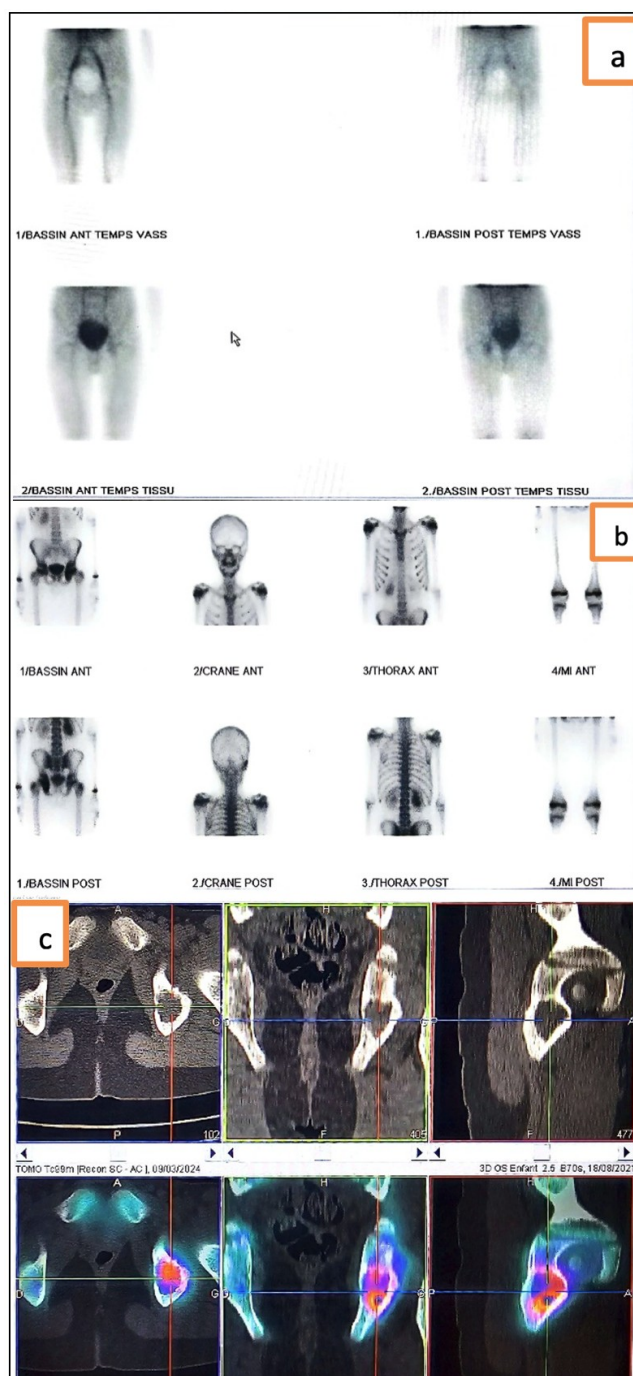


Figure 5. Case 4. Whole-body and SPECT/CT images centered on the left ischiopubic ramus.

Case 5 Active Neurogenic Para osteoarthritis

A 10-year-old child had previously required intensive-care treatment after polytrauma and subsequently developed neurogenic para-osteoarthritis involving both hips and the right knee. Early images showed increased tracer delivery to the right hip, knee, and ankle. Delayed images demonstrated increased uptake in both hips and in the right knee and ankle. No other definite osseous uptake abnormality was identified. The distribution was considered consistent with active neurogenic para-osteoarthritis.

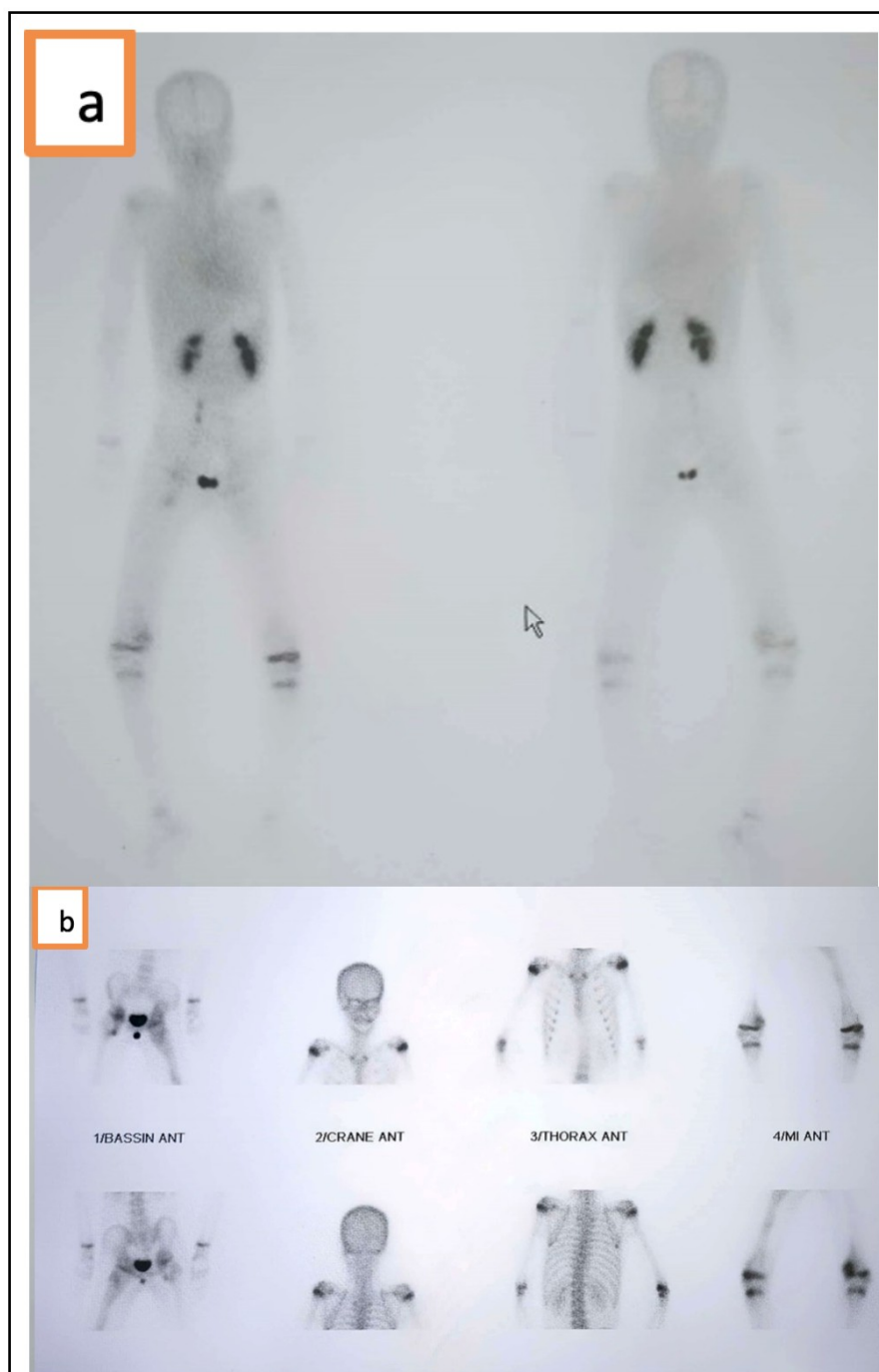


Figure 6. Case 5. Early and delayed whole-body images showing multifocal active para-osteoarthropathy.

Case 6 Unifocal Langerhans Cell Histiocytosis

A 15-year-old adolescent presented with left hip pain. Radiographs and MRI showed a lacunar lesion of the left greater trochanter with a surrounding inflammatory reaction. Early scintigraphy demonstrated mild hyperemia over the left hip. Delayed planar images showed asymmetric uptake, greater on the left, and SPECT/CT localized the abnormality to the greater-trochanter lesion. The imaging findings favored unifocal Langerhans cell histiocytosis. Histologic and immunohistochemical examination after biopsy confirmed the diagnosis.

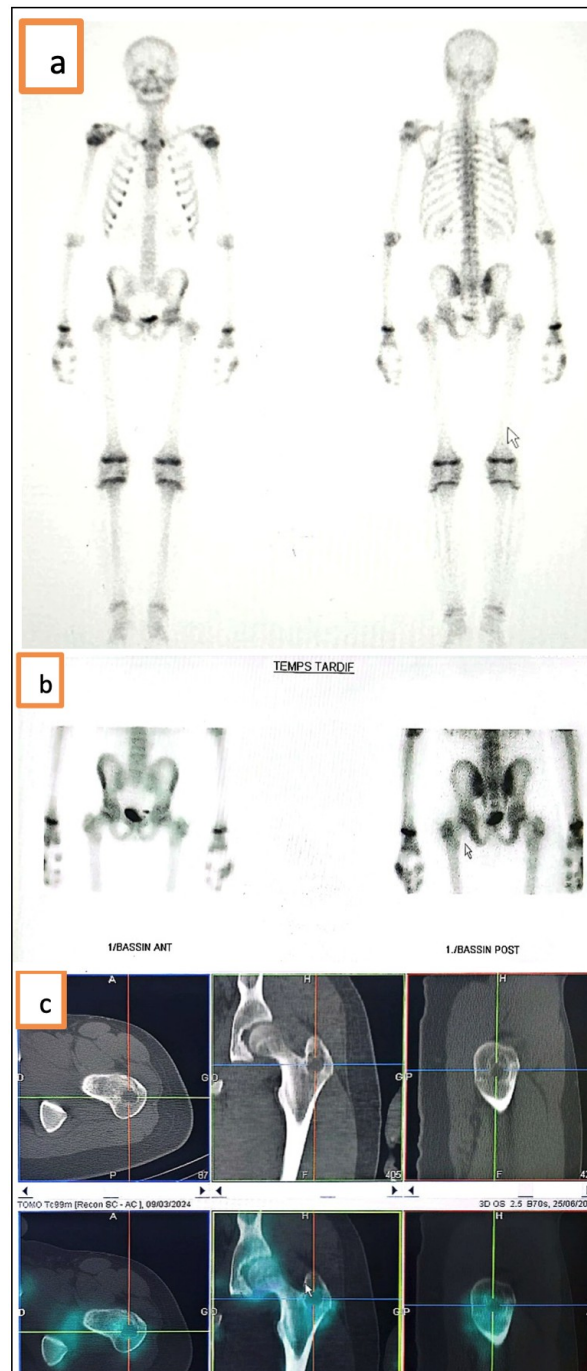


Figure 7. Case 6. Early, delayed, and SPECT/CT images of a left greater-trochanter lesion.

Case 7 Osteogenesis Imperfecta Type IV

A 40-year-old patient of short stature had a history of a spontaneous right femoral fracture. Fibrous dysplasia of the right arm was initially suspected. Radiography demonstrated an osteolytic lesion without surrounding sclerosis in the right femoral shaft. Early scintigraphy showed no abnormal perfusion or blood-pool activity. Delayed imaging showed linear uptake in the upper left femur related to previous trauma and deformities of the long bones, including bowing and cortical thinning. Additional findings included a heterogeneous enlarged sternum, a straightened spinal contour, and bilateral renal calculi. The overall pattern was interpreted as osteogenesis imperfecta type IV according to the Silience classification.

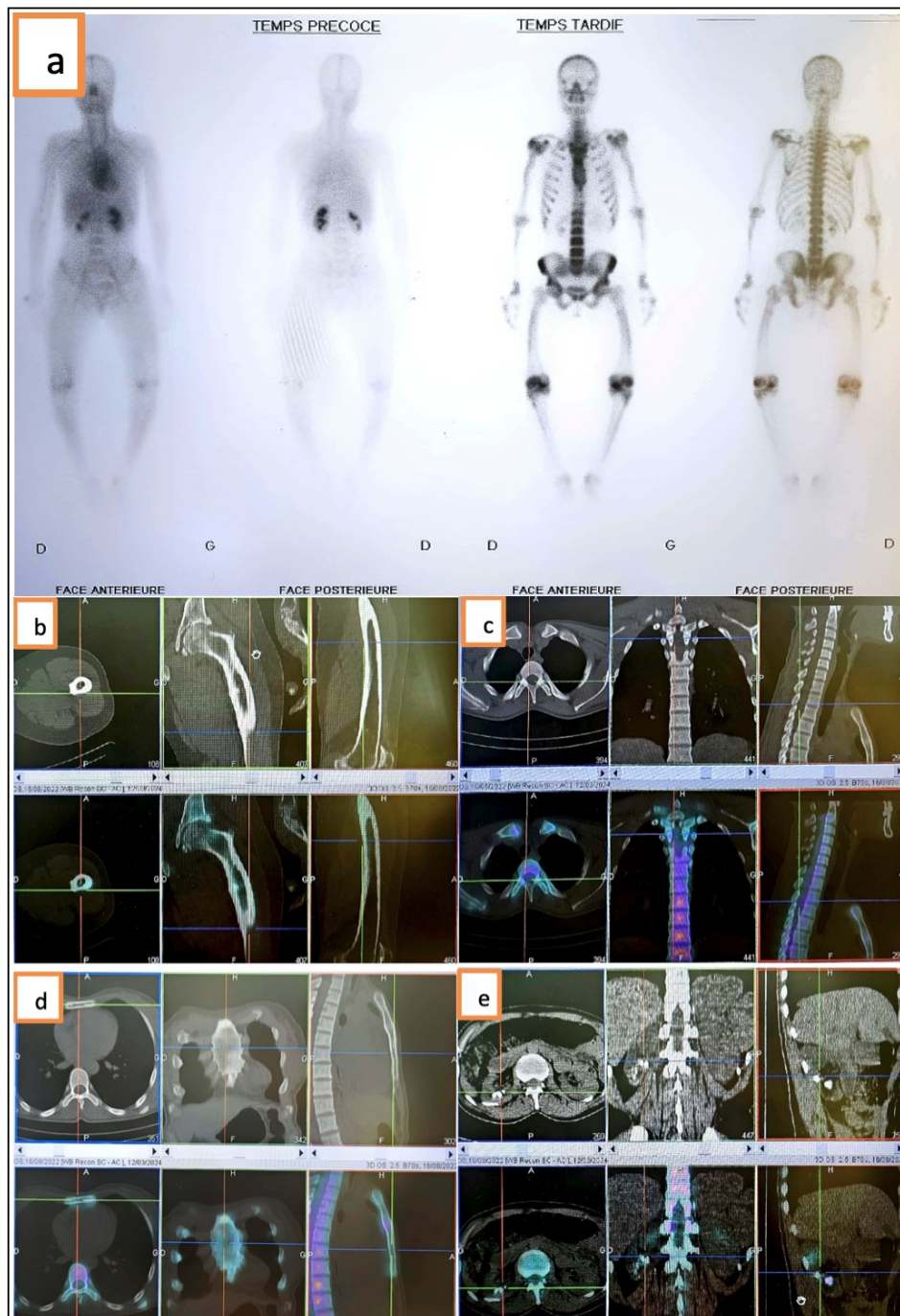


Figure 8. Case 7. Whole-body, regional, and SPECT/CT images in osteogenesis imperfecta.

Case 8 Focal Osteoarticular Inflammation

A 9-year-old boy with a history of surgically drained septic arthritis of the ankles and hip presented with painful swelling of the left ankle. The fever had initially been classified as fever of unknown origin. Early scintigraphy demonstrated asymmetric perfusion and blood-pool activity at the ankles, greater on the left. Delayed images showed increased periarticular uptake around the left ankle, without another definite skeletal focus. Because the clinical picture included fever and previous septic arthritis, the diagnosis should be stated as focal osteoarticular inflammation pending confirmation from the clinical and microbiological record rather than as uncomplicated osteoarthritis [3].

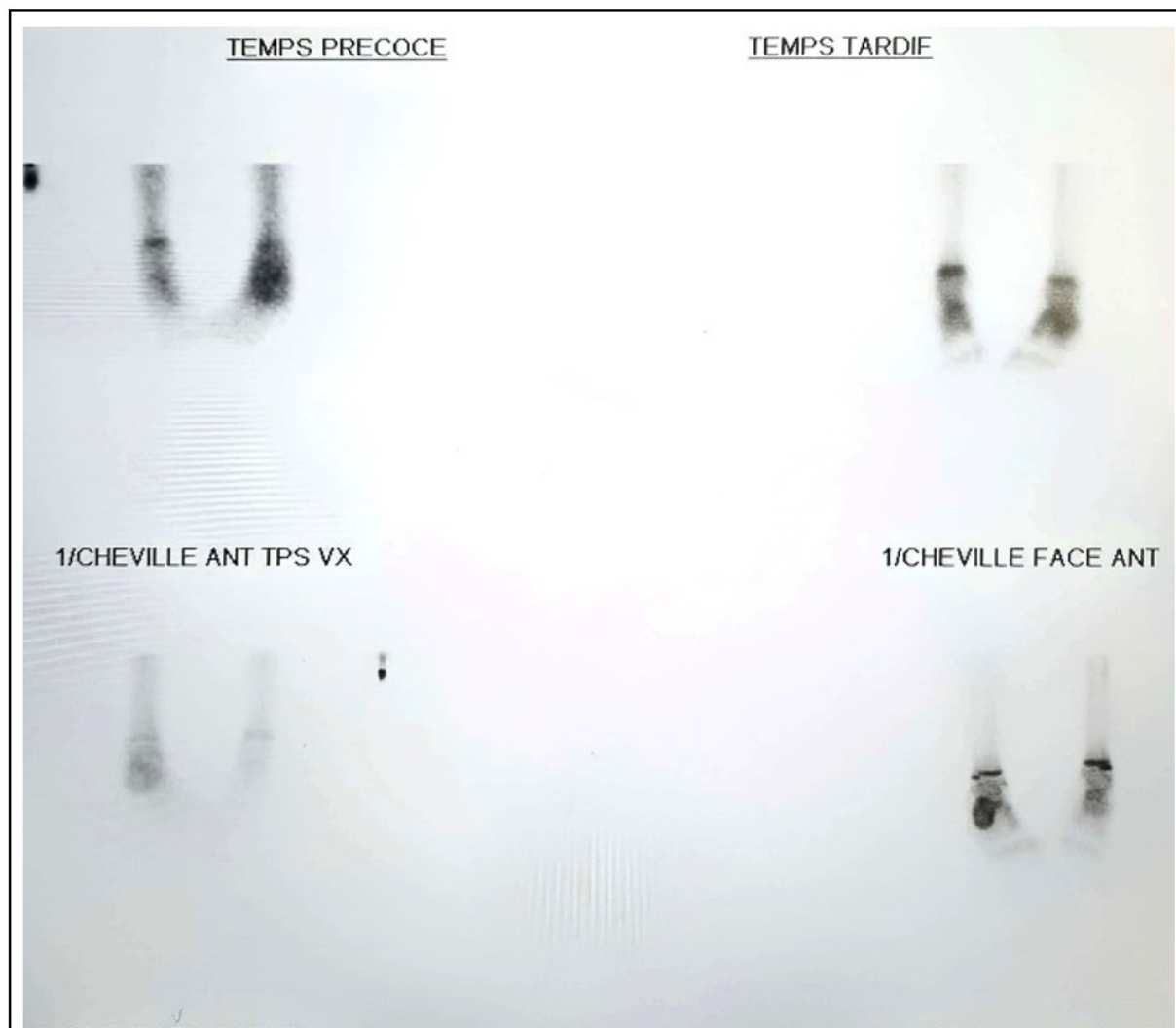


Figure 9. Case 8. Early and delayed images centered on the feet and ankles.

Case 9 Polyostotic Fibrous Dysplasia

A 46-year-old patient was evaluated for suspected fibrous dysplasia. CT showed multiple benign-appearing lytic lesions of the axial and appendicular skeleton, with a differential diagnosis including polyostotic fibrous dysplasia and multiple enchondromatosis. Bone scintigraphy demonstrated heterogeneous multifocal uptake involving the left seventh rib, right ninth rib, sacrum, iliac bones, left pubic rami, both femora, and both tibiae. The distribution was considered most compatible with polyostotic fibrous dysplasia.

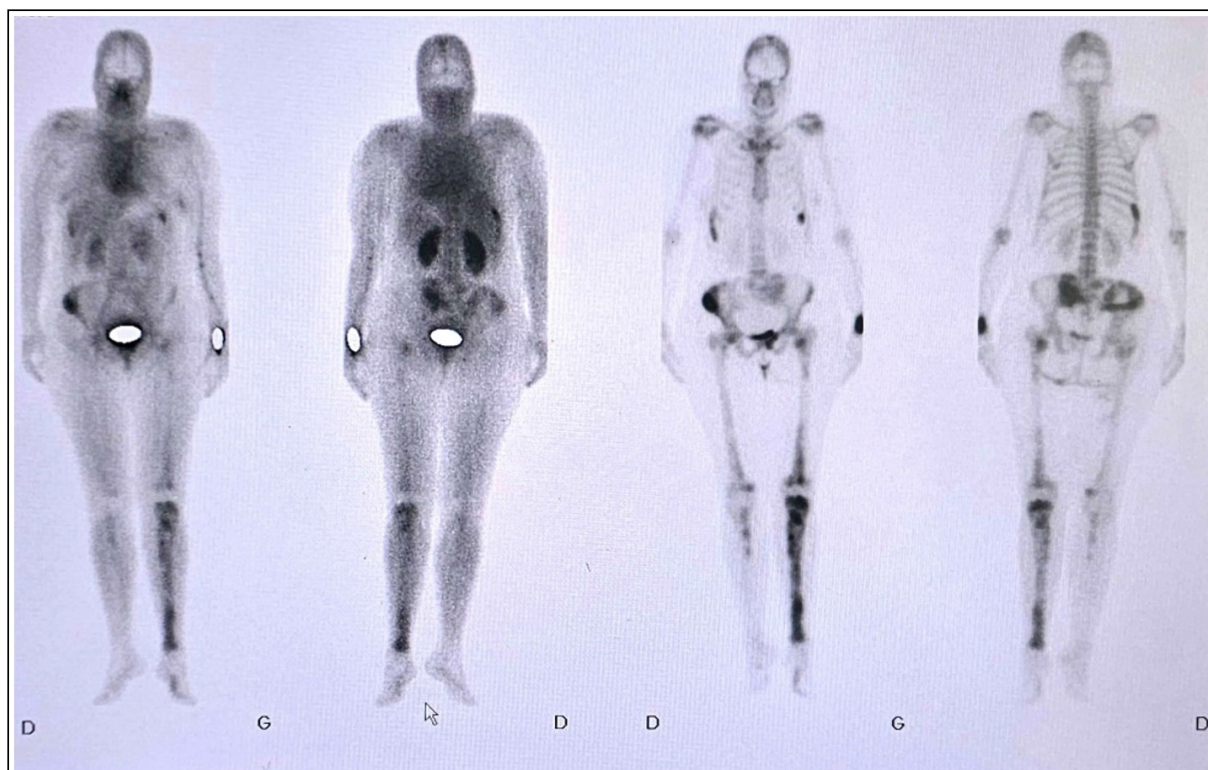


Figure 10. Case 9. Early and delayed whole-body images in polyostotic fibrous dysplasia.

Case 10 Paget Disease

A 75-year-old patient with prostate adenocarcinoma, Gleason score 7 (4 + 3) and prostate-specific antigen 17.25 ng/mL, underwent bone scintigraphy for staging. Delayed images demonstrated intense, relatively homogeneous uptake involving the left hemipelvis, the upper half of the right femur, and the entire left femur. The distribution was interpreted as suggestive of Paget disease, and serum alkaline phosphatase was elevated. Correlation with anatomic imaging is necessary to distinguish Paget disease from skeletal metastases in this oncologic setting.

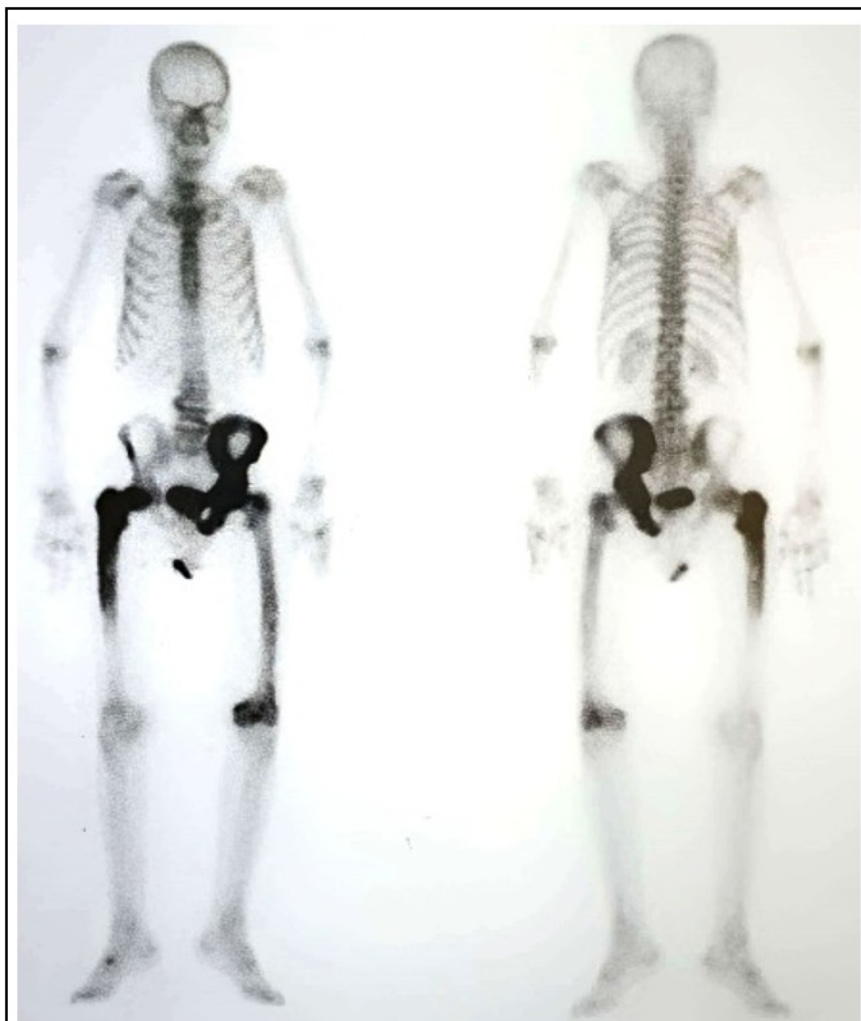


Figure 11. Case 10. Delayed whole-body bone scintigraphy showing the distribution interpreted as Paget disease.

Case 11 Osteonecrosis of the Right Femoral Head

A 15-year-old patient was evaluated after right hip dislocation because of suspected femoral-head osteonecrosis. CT performed four months earlier had been reported as unremarkable. Early scintigraphy showed greater tracer delivery to the right hip. Delayed imaging demonstrated diffuse increased uptake of the right femoral head, with subtle heterogeneity on the CT component. The findings were interpreted as osteonecrosis of the right femoral head. The classification system underlying the original designation of stage III should be confirmed before that stage is retained.

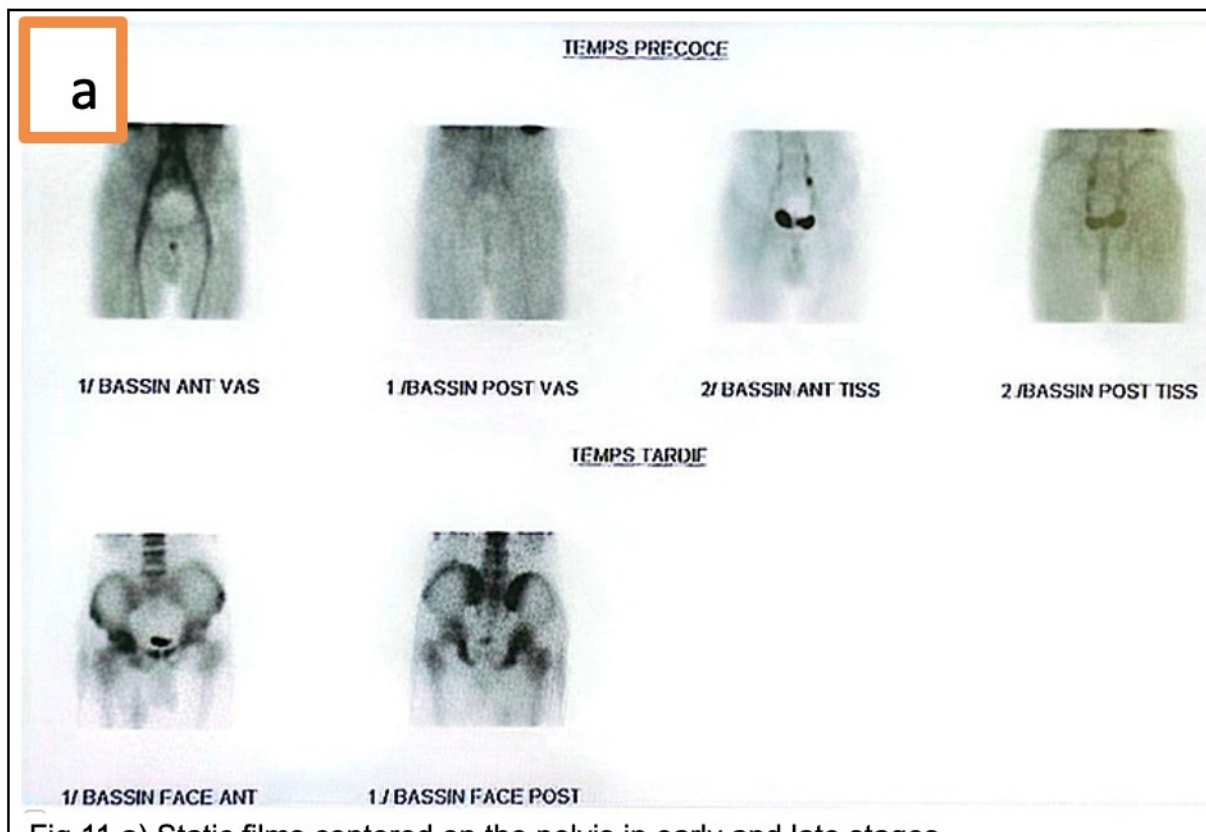


Fig 11 a) Static films centered on the pelvis in early and late stages

Figure 12A. Case 11. Early and delayed planar images of the hips.

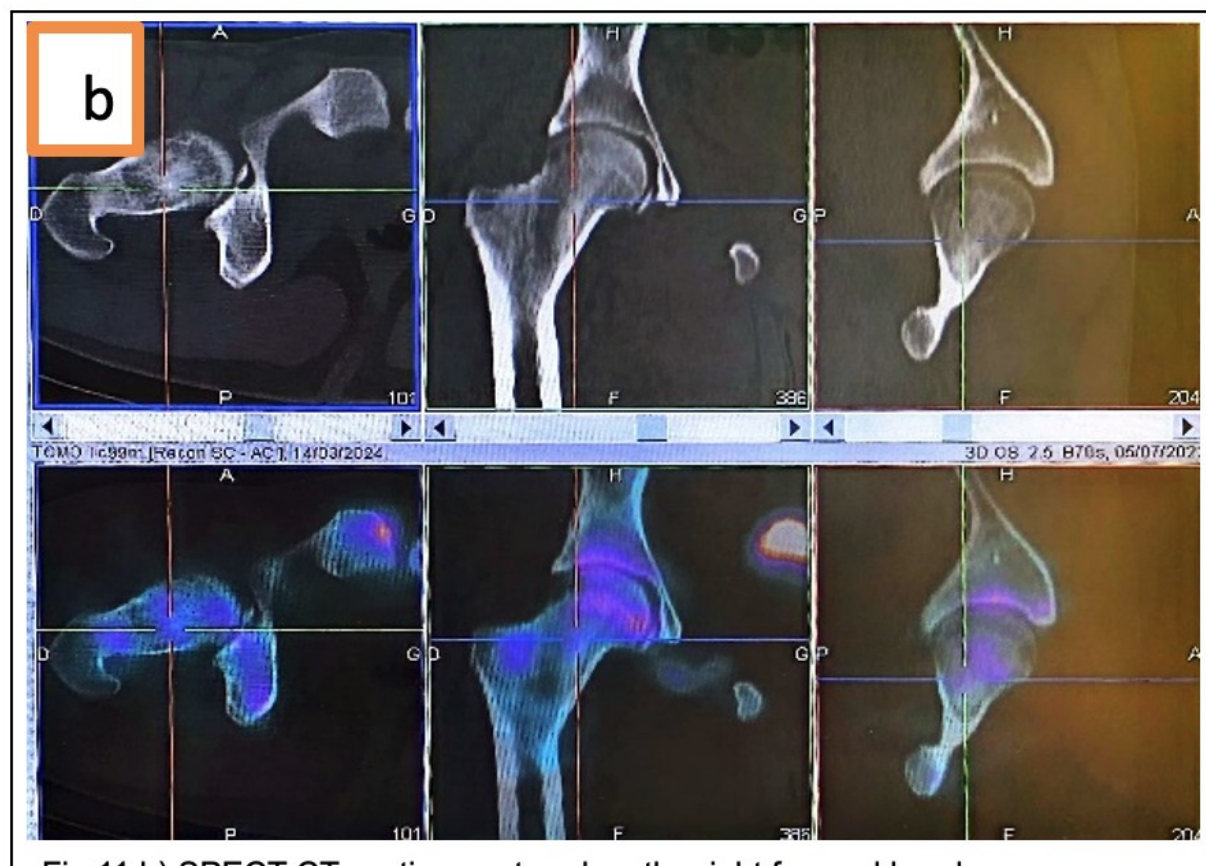


Fig 11 b) SPECT/CT section centered on the right femoral head

Figure 12B. Case 11. SPECT/CT images centered on the right femoral head.

Case 12 Osteoid Osteoma

A 15-year-old girl had experienced chronic right ankle pain for two years. Early bone scintigraphy showed moderately increased perfusion and blood-pool activity at the lateral right ankle. Delayed images demonstrated asymmetric uptake with a focal hotspot projected over the lateral malleolus. SPECT/CT localized the focus to a

small lucent cortical lesion with surrounding thickening and a central nidus. The combined findings supported osteoid osteoma.

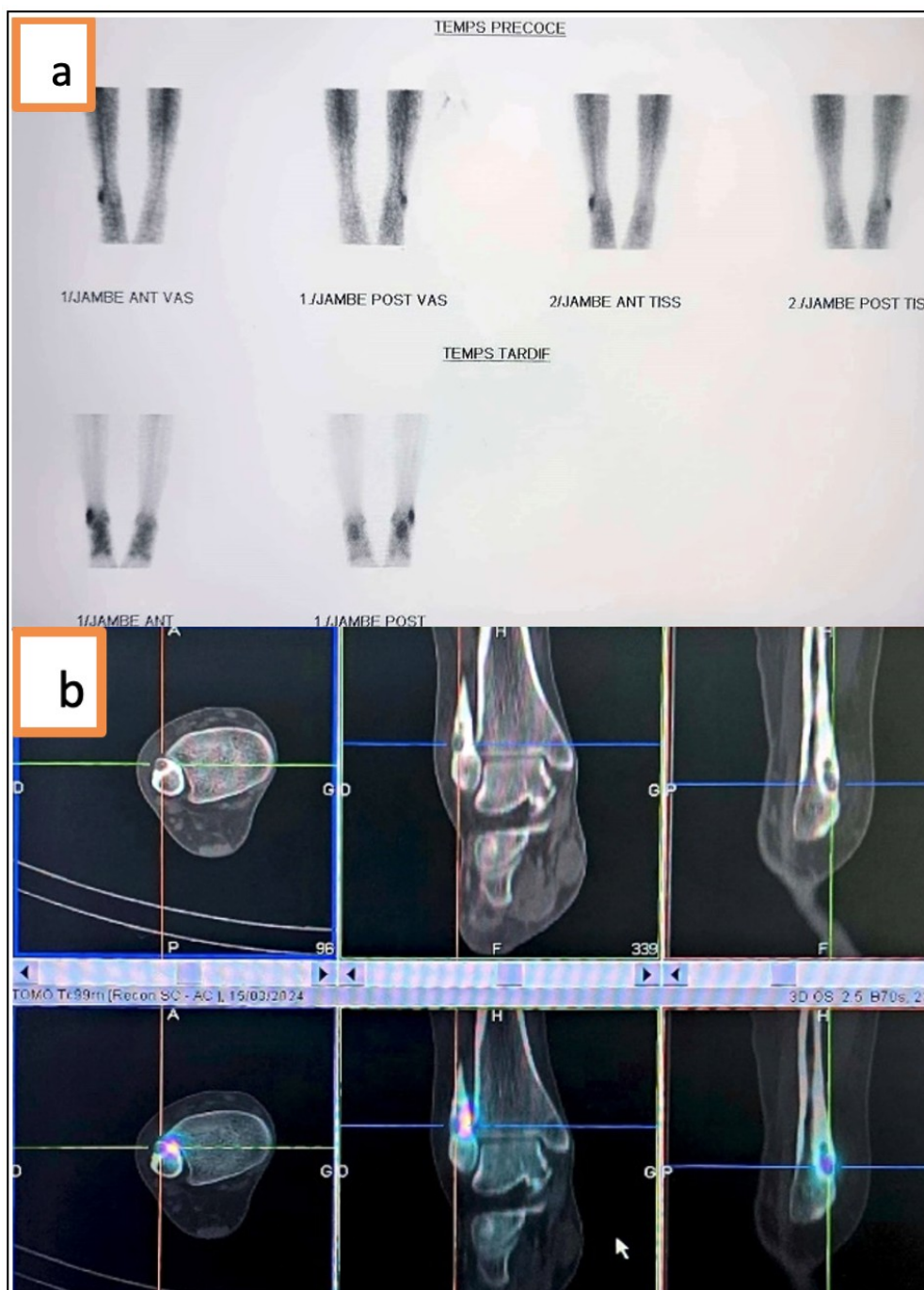


Figure 13. Case 12. Early, delayed, and SPECT/CT images centered on the right ankle.

Case 13 Active Condylar Hyperplasia

A 43-year-old patient was evaluated for suspected left condylar hyperplasia. Early images showed no relevant asymmetry of perfusion or blood-pool activity between the temporomandibular joints. Delayed images demonstrated mildly asymmetric uptake, greater on the left. SPECT/CT showed focal increased uptake in the left condylar process with associated osseous enlargement, supporting an active condylar growth process.

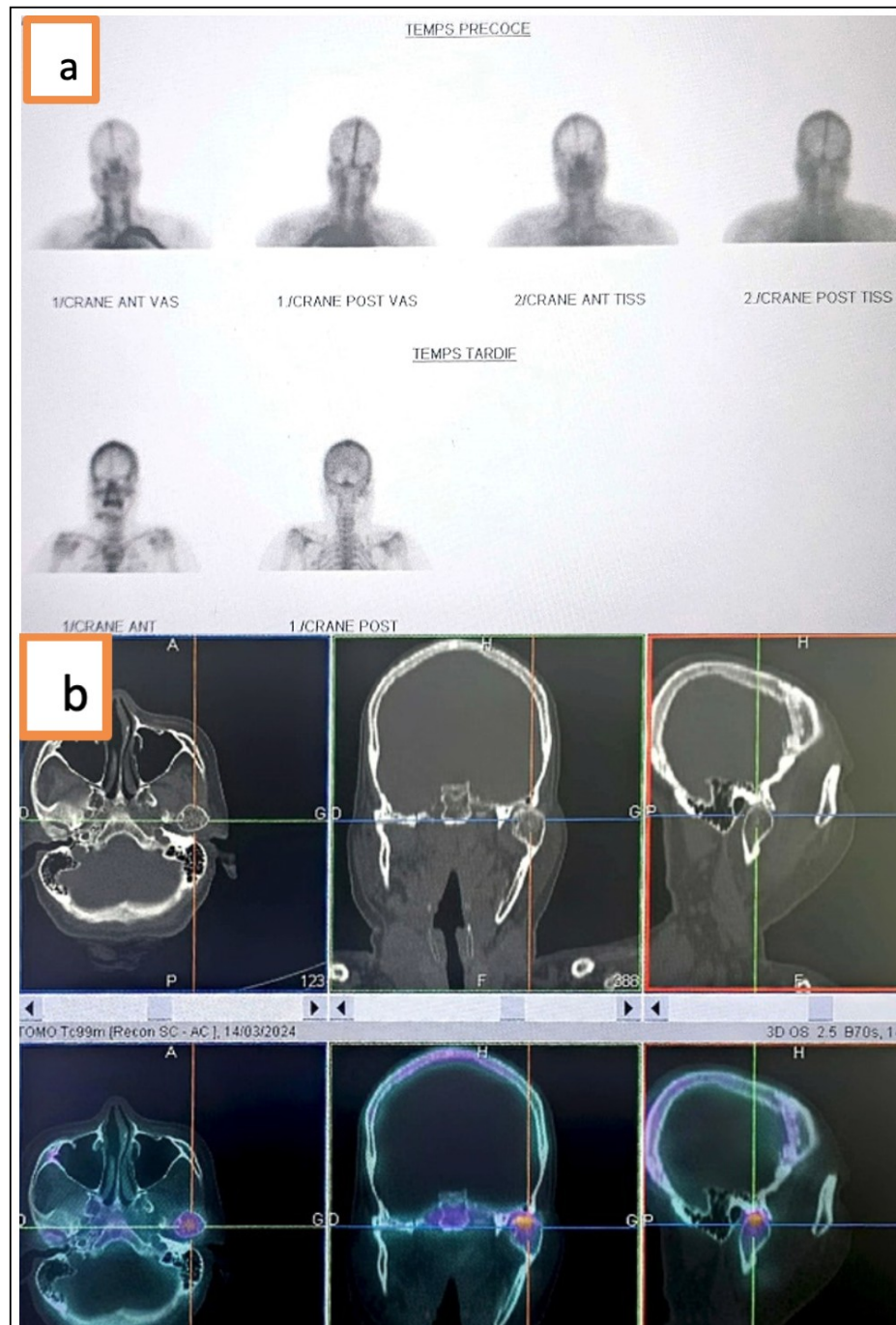


Figure 14. Case 13. Early, delayed, and SPECT/CT images centered on the mandibular condyles.

Case 14 Renal Osteodystrophy

A 48-year-old patient receiving chronic hemodialysis presented with eight months of spinal pain and increasing difficulty walking, without fever. MRI showed multiple vertebral compression deformities in osteoporotic bone. Bone scintigraphy demonstrated intense, relatively homogeneous uptake throughout the skeleton, particularly in the skull and facial bones, with increased uptake along the long bones and absent visualization of the urinary tract, producing a metabolic superscan pattern. Additional focal uptake involved the posterior left eleventh rib and the proximal femora, raising concern for insufficiency fractures. The overall appearance supported renal osteodystrophy with multiple vertebral compression fractures.



Figure 15. Case 14. Delayed whole-body bone scintigraphy demonstrating a metabolic superscan pattern in renal osteodystrophy.

Discussion

These cases illustrate the breadth of benign and nonmetastatic conditions that can alter skeletal perfusion and osteoblastic activity. Multiphase imaging adds information about perfusion and soft-tissue activity, while SPECT/CT improves localization and characterization in anatomically complex regions. Nevertheless, scintigraphic patterns are rarely disease-specific. Diagnostic conclusions should therefore be framed as imaging interpretations and correlated with clinical findings, laboratory data, cross-sectional imaging, microbiology, and histopathology where appropriate.

The article has important limitations. The cases are illustrative rather than consecutive, and no predefined inclusion criteria, accuracy analysis, blinded reading process, or standardized reference standard was reported. Equipment and reconstruction parameters were not available for every examination. The findings should not be interpreted as estimates of diagnostic performance or as universal acquisition standards.

Conclusion

Bone scintigraphy provides a sensitive whole-body assessment of skeletal perfusion and remodeling. Hybrid SPECT/CT can improve anatomic localization and specificity, but interpretation remains dependent on the clinical question and complementary evidence. The 14 cases demonstrate potential applications in infection, trauma, metabolic bone disease, developmental disorders, and benign tumors while also emphasizing the need for cautious, multidisciplinary interpretation.

Declarations

Ethics approval: The work was approved by the ethics committee of the authors' university.

Consent for publication and anonymization: Patient information and images were anonymized. Written informed consent for publication was obtained for all presented cases.

Conflict of interest: The authors declare that they have no competing interests.

Funding: No funding information was reported in the source material.

Data availability: All data presented in this educational case series are contained within the article. No separate research dataset was reported.

References

1. Dumont M, Côté C. La scintigraphie osseuse en trois phases pancorporelles. Médecine Nucléaire. 2012;36(11):678-686. <https://doi.org/10.1016/j.mednuc.2012.09.002>
2. Granier P, Mourad M. Exploration des polyalgies par la scintigraphie osseuse planaire couplée à la TEMP-TDM. Médecine Nucléaire. 2011;35(2):71-82. <https://doi.org/10.1016/j.mednuc.2010.12.003>
3. Parisi MT, Otjen JP, Stanescu AL, Shulkin BL. Radionuclide imaging of infection and inflammation in children: a review. Semin Nucl Med. 2018;48(2):148-165. <https://doi.org/10.1053/j.semnuclmed.2017.11.002>
4. Paycha F, Girma A, Granier P, et al. Guide pour la rédaction de protocole pour la scintigraphie osseuse. Médecine Nucléaire. 2012;36(11):687-697. <https://doi.org/10.1016/j.mednuc.2012.09.003>
5. Van den Wyngaert T, Strobel K, Kampen WU, et al. The EANM practice guidelines for bone scintigraphy. Eur J Nucl Med Mol Imaging. 2016;43:1723-1738. <https://doi.org/10.1007/s00259-016-3415-4>
6. Agence nationale de sécurité du médicament et des produits de santé. OSTEOCIS 3 mg, trousse pour préparation radiopharmaceutique: Résumé des caractéristiques du produit. Updated 8 September 2022. <https://base-donnees-publique.medicaments.gouv.fr/medicament/63521034/extrait>