Localization of osteomyelitis lesions for operative eradication of chronic osteomyelitis of the lower extremities by bone SPECT/CT

Seung Hoo Lee[1], Min Bom Kim[2]

[1]Department of Department of Orthopedics, Chungnam National University Sejong Hospital, Sejong, Korea

[2]Department of Orthopedic Surgery, Seoul National University Hospital, Seoul National University College of Medicine, Korea

INTRODUCTION

Treatment of chronic osteomyelitis (COM) is challenging. It is important not only to use appropriate surgical technique and antibiotics, but also to determine the location and extent of osteomyelitis.

Various radiological methods are available for evaluation of COM. MRI can be used to determine the extent of bone infection and thus facilitate planning of surgical management. However, when a fracture or prior surgery is evident, MRI is less specific for the diagnosis of infection. In the presence of metallic implants, artefacts hamper the evaluation of areas of interest near the implant. In addition, MRI may lead to overestimation of the extent of infection due to detection of adjacent bone marrow edema.

Recently, combined single-photon emission tomography/computed tomography (SPECT/CT) is widely used in orthopaedics. By combining a dual-head gamma camera with a low-power X-ray system, sequential acquisition of SPECT and CT data has become possible, allowing the overlay and precise correlation of the two data sets. Bone SPECT/CT is useful not only for the diagnosis of chronic post-traumatic osteomyelitis but also for the localization of infective foci, enabling one-step surgical planning.

PURPOSE

This study was performed to investigate the feasibility of bone SPECT/CT for pre-operative planning in the case of COM of the lower extremities, by localization of osteomyelitis lesions. Here, we evaluated the clinical results of surgical treatment for COM in the long bones of the lower extremities after localization of osteomyelitis lesions and intra-operative eradication based on bone SPECT/CT.

Table 1 Cierny-Mader classification of adult osteomyelitis

Anatomical type	
Type 1	Medullary osteomyelitis (nidus is endosteal). No dead space management. Aetioloy often haematogenous, post-intramedullary rod
Type 2	Superficial osteomyelitis. Limited to surface of bone. No dead space management but requires soft tissue coverage
Type 3	Localized osteomyelitis. Full thickness of cortex. Complex dead space management, simple osseous stabilization
Type 4	Diffuse osteomyelitis. Circumference of cortex. Biomechanically unstable. Complex dead space and osseous management
Physiological host class	
Class A	Normal host. Normal immune system. Normal vascularity
Class B	Bs: systemic compromise Bl: local compromise Bsl: systemic and local compromise
Class C	Treatment morbidity worse than present condition with low prognosis for cure

MATERIALS & METHODS

From January 2016 to January 2020, we surgically treated ten adult patients with Cierny-Mader type III COM (Table 1) in the tibia or femur for a mean duration of 24.4 months (range, 7.0 – 70.0 months) (Table 2). We conducted preoperative planning by bone SPECT/CT and localization of osteomyelitis lesions. The treatment consisted of intra-operative eradication of the infective focus and antibiotic administration (Figure 1,2 and 3). The clinical and radiological outcomes were retrospectively analyzed after a minimum of one year follow-up.

Patient no	Age (years)	Sex	Location	Aetiology	Cierny-Mader classification (host status)*	Duration of osteomyelitis (months)
1	53	Male	Tibia	Post-traumatic (open fracture)	3 (Bl)	30
2	63	Male	Tibia	Post-traumatic (open fracture)	3 (Bl)	14
3	63	Male	Femur	Post-traumatic (open fracture)	3 (Bsl)	24
4	54	Female	Tibia	Bone puncture injury	3 (A)	9
5	62	Male	Tibia	Post-traumatic (open fracture)	3 (Bl)	70
6	56	Female	Femur	Post-traumatic (open fracture)	3 (A)	8
7	64	Male	Tibia	Post-traumatic (open fracture)	3 (Bsl)	8
8	79	Male	Femur	Post-traumatic (open fracture)	3 (Bsl)	24
9	60	Male	Femur	Post-traumatic (open fracture)	3 (Bsl)	50
10	49	Male	Femur	Post-traumatic (closed fracture)	3 (Bl)	7

*A: normal host; Bl: local compromise; Bsl: systemic and local compromise

Table 2. Patient demographics and characteristics

RESULTS

The patients were surgically treated by thorough debridement, dead space management, and appropriate antibiotics without bone transport or an external fixator (Figure 1, 2 and 3). The location of the hot uptake region on bone SPECT/CT coincided with that of the osteomyelitis lesion, which was confirmed intra-operatively in all patients. At an average of 16.5 ± 4.3 months (range, 13.0–25.0 months), clinical eradication of osteomyelitis was achieved in nine of the ten patients (Table 3). One patient required amputation due to recurrence of osteomyelitis.

A successful clinical outcome was achieved in eight patients; one suffered persistent ankle pain due to a destructive change in the ankle joint despite eradication of the infection.

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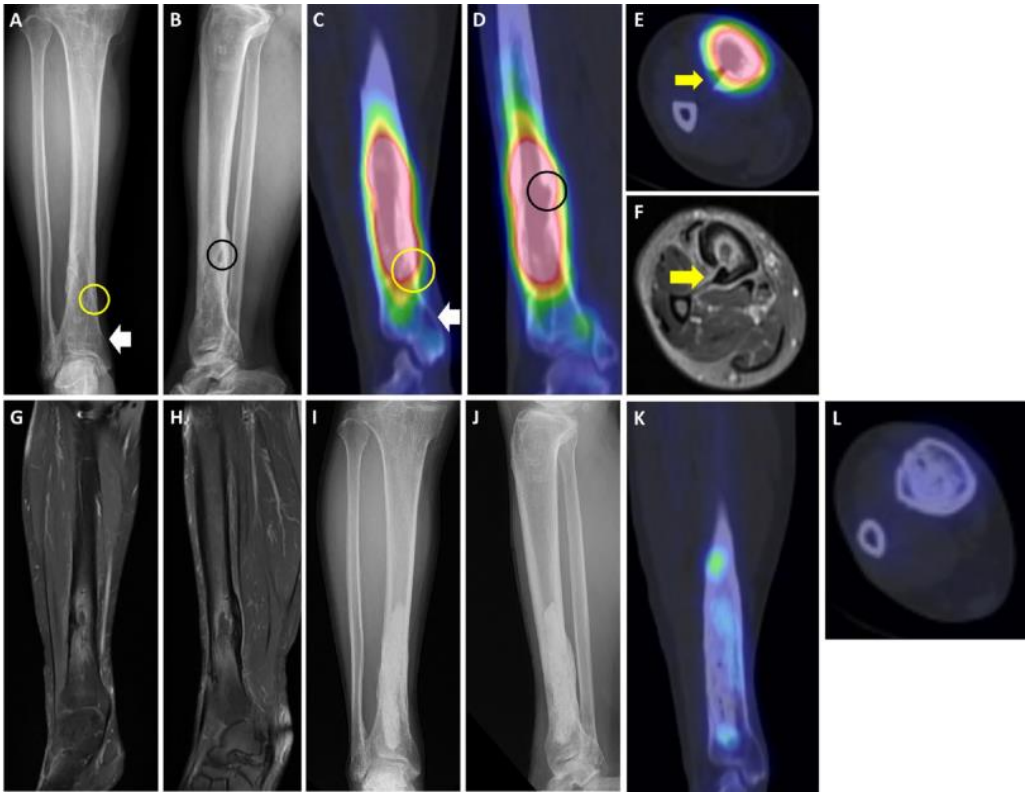

Fig. 1 A 53-year-old man with chronic osteomyelitis of the tibia due to an open fracture (case no. 1)

A,B Anteroposterior and lateral radiographs of the lower leg. There were characteristic radiological and anatomical landmarks, which corresponded to C and D. Yellow circle: the location where the thickened cortical bone became thinner; this corresponded to the yellow circle in C. White arrow: medial malleolus as an anatomical landmark, which corresponded to C. Black circle: the location of the defect in thickened cortical bone, corresponding to the black circle of D.

C–E Preoperative bone SPECT/CT. We determined the extent of intraosseous debridement by matching the hot uptake region to simple radiographs using characteristic radiological and anatomical landmarks (yellow and black circles, white arrow). As the sinus tract was on the lateral side of the tibia (yellow arrow), we approached via the sinus tract on the lateral side of the tibia and created a cortical window for extensive debridement of the proximal and distal margins of the involved bone.

F–H MRI of the lower leg. Although MRI could localize the sinus tract (yellow arrow), it could not determine the extent of osteomyelitis because of artefacts and abnormal signal changes caused by previous metal implants.

I–L Simple radiographs and bone SPECT/CT at the 1-year follow-up. There was no evidence of osteomyelitis, and the hot uptake region was absent

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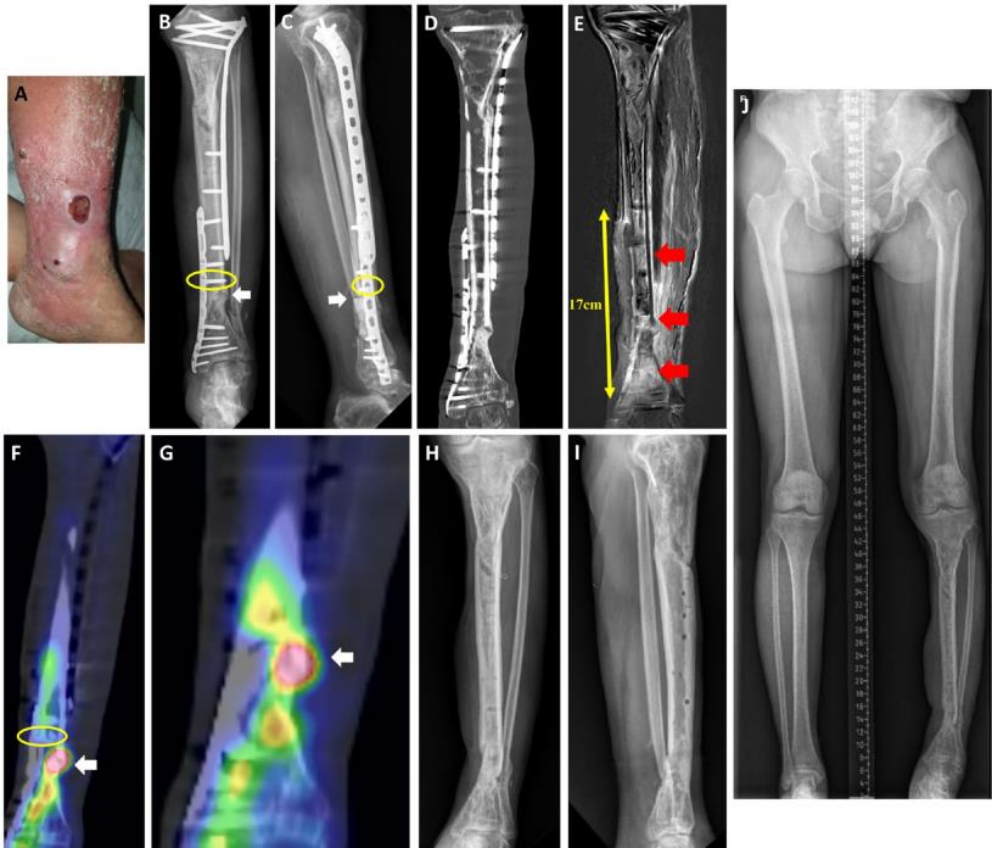

Fig. 2 A 63-year-old man with chronic osteomyelitis of the tibial shaft after an open fracture (case no. 2).

A Photographs showing persistent pus drainage from the sinus tract.

B–E Pre-operative simple radiographs, CT, and MRI scans. Although partial union was noted on pre-operative CT, there was a diffuse intramedullary bone marrow signal change (red arrows) with contrast enhancement at the tibial shaft about ~ 17 cm in length (yellow line), which was identified as osteomyelitis by a musculoskeletal radiologist, suggesting the need for additional reconstructive surgery, such as bone transport. The yellow circle and white arrow denote the screw and bony defect, as indicators for localization.

F,G An osteomyelitis lesion localized by bone SPECT/CT, which was observed as a hot uptake area in the dis- tal tibia consistent with the site of pus drainage (white arrow). There were characteristic radiological landmarks, corresponding to B and C (yellow circle and white arrow). After implant removal, we used an anterolateral approach and created a cortical window that included the sinus tract and performed extensive debridement of the involved area. Yellow circle: the location of the locking screw near the osteomyelitis lesion, which corresponded to the yellow circle in B. White arrow: the location of the osteomyelitis lesion showing the cortical defect, which corresponded to the white circle in C.

H–J Simple radiographs obtained at the 2-year follow-up examination. There was no evidence of infection recurrence, and the patient could perform normal activities of daily living.

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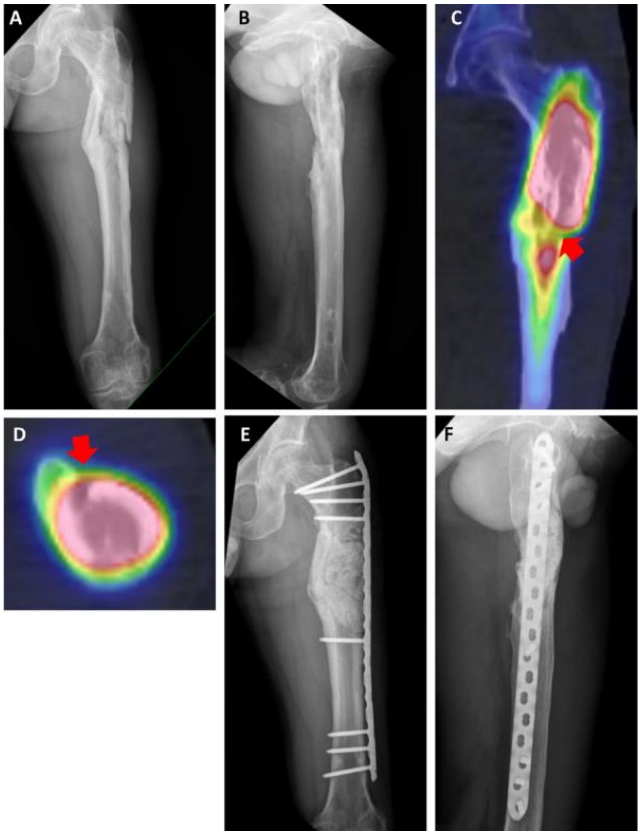

Fig. 3 A 63-year-old man developed chronic osteomyelitis of the femur after open fracture (case no. 3).
A, B Preoperative simple radiographs. The implant was removed at another hospital, and partial union was achieved.
C, D Pre-operative bone SPECT/ CT. Pre-operative localization of osteomyelitis was performed based on the extent of the hot uptake region using characteristic radiological findings and anatomical landmarks, such as the cortical defect and greater trochanter. As the sinus tract was located on the anterolateral side of the femur (red arrow), the anterolateral approach was used.
E, F Simple radiographs at 2 years after surgery. The locking plate was positioned a few millimetres away from the bone. There was no evidence of infection recurrence or cement related complications, and he could perform normal activities of daily living

Table 3 Clinical details and outcomes of all patients*

Patient no	Prior treatment	Organism	Dead space management	Skeletal stabilization	Clinical outcome	Recurrence	Follow-up (months)
1	Metal removal, debridement, cement bead insertion, IV antibiotics	MRSA	Cementing	None	Successful	No	24
2	Metal removal, debridement, VAC dressing, cement bead insertion, IV antibiotics	MSSA	No	None	Successful	No	25
3	Metal removal, debridement, IV antibiotics	MRSA	Cementing	Plate fixation	Successful	No	14
4	IV antibiotics	Not identified	Cementing	None	Successful	No	14
5	Partial implant removal, debridement, IV antibiotics	*Streptococcus dysgalactiae*	No	None	Successful	No	16
6	IV antibiotics	MRSA	Cementing	Plate fixation	Successful	No	15
7	Metal removal, debridement, IV antibiotics, failed ankle fusion operation	*Corynebacterium*	No	None	Chronic pain	No	16
8	Debridement, IV antibiotics	*S. anginosus/E. faecalis*	No	Plate fixation	Successful	No	14
9	Debridement, iliac bone graft, IV antibiotics	MRSA/*P. aeruginosa*	Cementing	Plate fixation	Amputation	Recur	13
10	IV antibiotics	MRSE	No	None	Successful	No	14

**E. faecalis*, Enterococcus faecalis; *IV*, intravenous, *MRSA*, methicillin-resistant *Staphylococcus aureus*; *MRSE*, methicillin-resistant *Staphylococcus epidermidis*; *P. aeruginosa*, *Pseudomonas aeruginosa*; *S. anginosus*, *Streptococcus anginosus*; *VAC*, vacuum-assisted closure

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CONCLUSION

Bone SPECT/CT is a feasible method for the localization and eradication of osteomyelitis lesions in COM of the lower extremities and has favourable clinical outcomes. It can also be applied in cases of distorted bony structures caused by previous trauma or surgery, or in the presence of implants.

REFERENCES

1. Parsons B, Strauss E (2004) Surgical management of chronic osteomyelitis. Am J Sur 188:57–66.
2. Heckman JD, McKee M, McQueen MM, Ricci W, Tornetta P III (2014) Rockwood and Green's fractures in adults. Lippincott Williams & Wilkins
3. Pineda C, Vargas A, Rodriguez AV (2006) Imaging of osteomyelitis: current concepts. Infect Dis Clin North Am 20:789–825.
4. Arıcan P, Okudan B, Şefizade R, Naldöken S (2019) Diagnostic value of bone SPECT/CT in patients with suspected osteomyelitis. Mol Imaging Radionucl Ther 28:89–95.
5. Horger M, Eschmann SM, Pfannenberg C, Storek D, Dammann F, Vonthein R, Claussen CD, Bares R (2003) The value of SPET/CT in chronic osteomyelitis. Eur J Nucl Med Mol Imaging 30:1665–1673.
6. Song Q, Long L, Cui S, Shu H, Wan C, Wu B, Ma X (2019) Utility of technetium-99m-methylene diphosphonate single-photon emission computed tomography/computed tomography fusion in detecting post-traumatic chronic-infected nonunion in the lower limb. Nucl Med Commun 40:778–785. 13.
7. van der Bruggen W, Bleeker-Rovers CP, Boerman OC, Gotthardt M, Oyen WJ (2010) PET and SPECT in osteomyelitis and prosthetic bone and joint infections: a systematic review. Semin Nucl Med 40:3–15.
8. Madsen JL (2008) Bone SPECT/CT detection of a sequestrum in chronic-infected nonunion of the tibia. Clin Nucl Med 33:700–701.

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