

# Growth Arrest Line Mimicking Lymphoma Involvement: The Findings of $^{99m}\text{Tc}$ -MDP Bone SPECT/CT and Serial Bone Scan in a Child with Non-Hodgkin's Lymphoma

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**Abstract** Growth arrest lines appear as dense sclerotic lines parallel to the growth plate of long bones on radiography. We describe the case of a 9-year-old female with growth arrest lines initially masquerading as lymphoma involvement on  $^{99m}\text{Tc}$ -MDP bone scintigraphy who had been treated with chemotherapy for non-Hodgkin's lymphoma about 3 years previously. Subsequent regional bone SPECT/CT clearly diagnosed the growth arrest lines, and retrograde review of previous bone scintigraphy demonstrated line migration in this patient. Growth arrest lines should be considered a possible diagnosis on bone scintigraphy, especially in the surveillance of children who have experienced severe childhood infections, malnutrition, immobilization, or treatment with immunosuppressive or chemotherapeutic drugs that may inhibit bone growth.

**Keywords**  $^{99m}\text{Tc}$  MDP bone scintigraphy · SPECT/CT · Growth arrest lines · Migration · Chemotherapy

## Introduction

Growth arrest lines (also known as Harris lines) are usually found where there is a slowing of longitudinal bone growth, appearing as dense transverse sclerotic metaphyseal lines on radiography [1, 2]. These lines can be seen in patients with immature skeletal growth due to many different etiologies, including malnutrition, infection, prolonged immobilization, lead poisoning, bisphosphonate administration, and chemotherapy for malignancies [3–6]. To the best of our knowledge, only a few reports have described  $^{99m}\text{Tc}$ -MDP bone scintigraphy and  $^{18}\text{F}$ -FDG PET/CT findings of growth arrest lines [6, 7]. Here, we describe the accurate diagnosis of growth arrest lines on  $^{99m}\text{Tc}$ -MDP bone SPECT/CT that initially masqueraded as recurrent lymphoma involvement in a 9-year-old female patient who had been treated with chemotherapy for non-Hodgkin's lymphoma 3 years previously. We clearly demonstrate the migration of growth arrest lines in this patient by retrograde review of previous  $^{99m}\text{Tc}$ -MDP bone scintigraphy images.

## Case Report

A 9-year-old asymptomatic female received  $^{99m}\text{Tc}$ -MDP bone scintigraphy for a surveillance workup of non-Hodgkin's lymphoma (precursor B-cell lymphoblastic lymphoma) (NHL) treated with chemotherapy 3 years previously. The  $^{99m}\text{Tc}$ -MDP bone scintigraphy revealed symmetric transverse linear faintly increased uptakes (Fig. 1a, arrow) at the metaphysis above the growth plate of both distal femurs. There were several transverse increased uptakes along the growth plates of the long bones, and no other abnormal increased uptake was noted. The possibility of lymphoma involvement could not be excluded, even though there was no specific tenderness or pain at this area. Subsequent regional SPECT/CT (Symbia T6, Siemens)

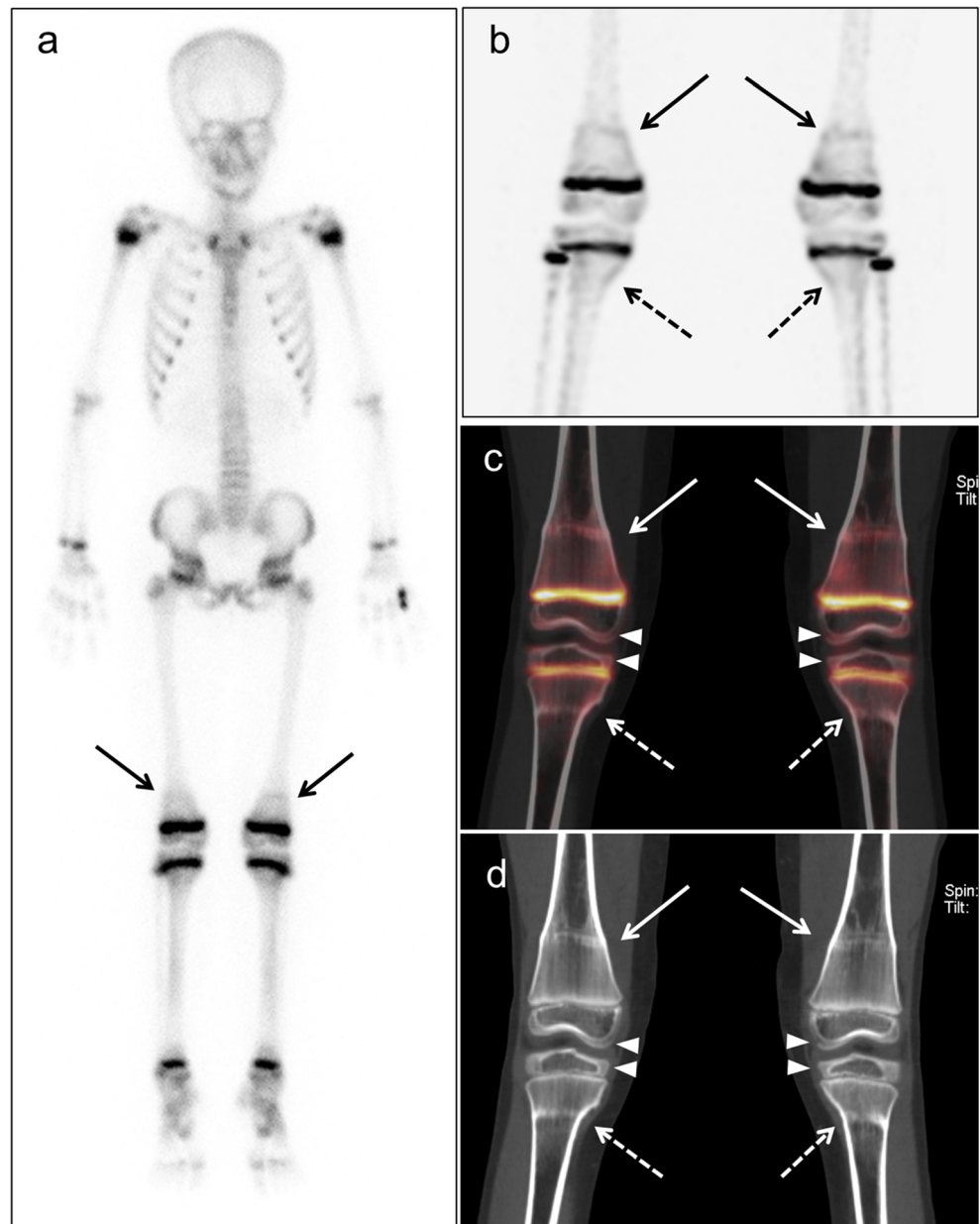
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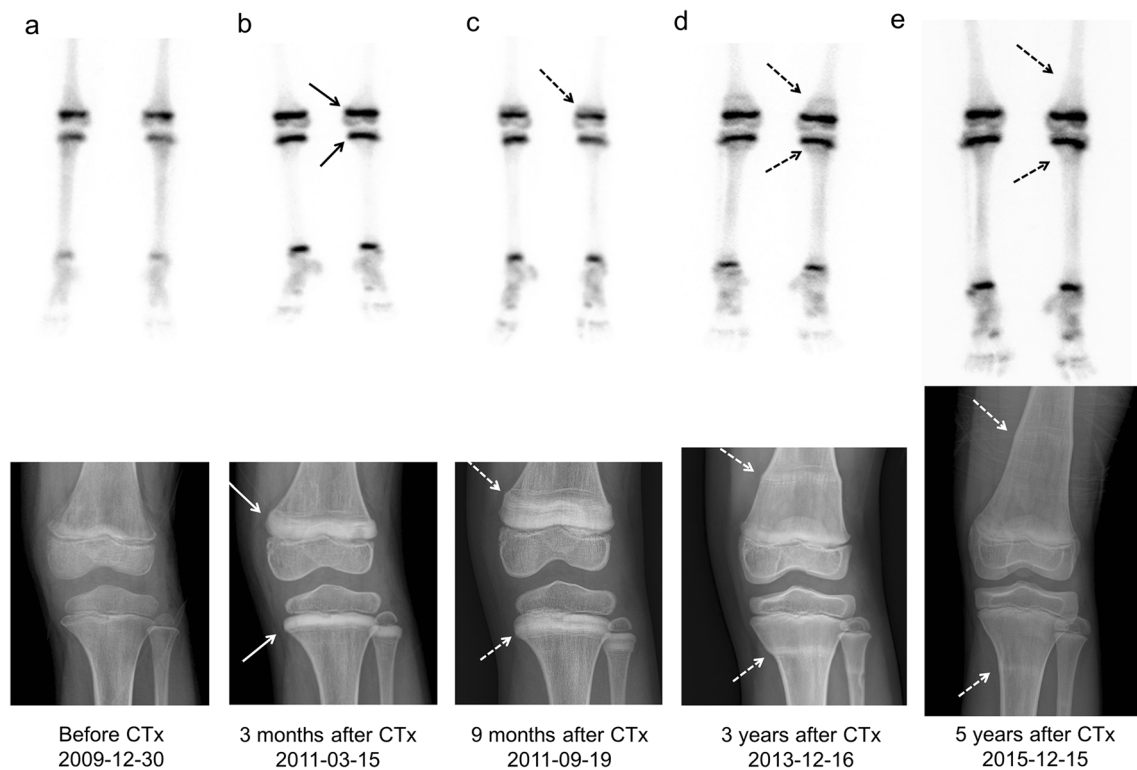
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**Fig. 1**  $^{99m}\text{Tc}$ -MDP bone scintigraphy (a) revealed symmetric transverse increased uptakes at the metaphysis of both distal femurs (arrows). The lines corresponded with transverse sclerotic lines at the metaphysis of both distal femurs (arrows) on regional SPECT/CT images (b, coronal SPECT only image; c, coronal SPECT/CT fusion image; d, coronal CT image) and were finally diagnosed as growth arrest lines. SPECT/CT also demonstrated additional growth arrest lines at the metaphysis of both proximal tibias (dashed arrows, b–d) and the epiphysis of both distal femurs and proximal tibias (arrowheads, c and d). Focal intense uptake was seen at the tracer injection site on the left hand on bone scintigraphy (a) and the other symmetric intense transverse increased uptakes at the bilateral proximal humerus, distal radius and ulna, proximal and distal femur and tibia were determined to be normal growth plate activities at that age



from the mid shaft of the femur to the mid shaft of the tibia was performed for further characterization of the suspicious areas noted on bone scintigraphy. The corresponding area on SPECT/CT images revealed symmetric transverse sclerotic lines at the metaphysis parallel to the growth plates of both distal femurs (Fig. 1b–d, arrows) as well as the metaphysis of the proximal tibias (Fig. 1b–d, dashed arrows) and the epiphysis of distal femurs and proximal tibias (Fig. 1c and d, arrowheads). Based on these findings and the past clinical history, we finally diagnosed them as growth arrest lines. After carefully reviewing previous bone scintigraphy and radiography, we could clearly see the migration of growth arrest lines that we had overlooked before. The initial plain radiography (Fig. 2a) before the start of

chemotherapy showed irregular sclerosis at the metaphysis adjacent to the growth plates of the distal femur and proximal tibia, suggesting that growth disturbance already existed in this child. Three months after completion of chemotherapy (Fig. 2b), the uptakes of the growth plates on bone scintigraphy became more intense (black arrows), and dense metaphyseal sclerotic bands were noted on plain radiography (white arrows). Follow-up images 6 months later (Fig. 2c) showed faint transverse increased uptakes on bone scintigraphy (dashed black arrow) and linear sclerotic lines on radiography (dashed white arrows) just above the growth plates of the distal femurs. Three (Fig. 2d) and 5 (Fig. 2e) years after completion of chemotherapy, these faint transverse increased tracer uptakes (dashed black arrows)



**Fig. 2** The migration of growth arrest lines was clearly demonstrated by retrograde review of previous bone scintigraphy (upper row) and radiography (lower row) images taken before the start of chemotherapy (a) and 3 months (b), 9 months (c), 3 years (d), and 5 years (e) after

completion of chemotherapy. Over time, growth arrest lines moved toward the diaphysis, and the intensity of tracer uptake as well as the density of sclerosis declined and had nearly disappeared on the last follow-up study

parallel to the growth plates at the metaphysis of the distal femurs and proximal tibias moved toward the diaphysis and decreased in intensity. The density of the sclerotic lines (dashed white arrows) also decreased over time.

## Discussion

Normal bone growth can be compromised by exposure to conditions such as malnutrition, infection, prolonged immobilization, or chemotherapy for malignancies [1–5]. If stresses persist, a slowdown of bone growth leads to decreased cell column height in the growth plates, and these narrowed chondrocytes undergo secondary endochondral ossifications, resulting in condensation of trabecular bone [2, 8]. Bisphosphonates, used to treat osteoporotic patients, can also cause disturbance of normal bone growth due to an imbalance between osteoblastic and osteoclastic activity. Normal bone growth maintains a balance between bone formation and remodeling. However, bisphosphonates increase bone mineral density by suppressing osteoclastic bone resorption. This imbalance leads to sclerotic changes that can be seen as dense metaphyseal bands [6, 9]. When normal bone growth resumes, these bands can present later as growth arrest lines, especially

at skeletal regions of rapid longitudinal bone growth, such as the proximal tibias and distal femurs. These growth arrest lines also can be seen in the epiphysis of long bones, where they present with a bone-in-bone appearance and an orientation consistent with the known hemispherical pattern of epiphyseal growth parallel to the surface of the articular cartilage [10]. Recent histological examination has demonstrated that the key anatomical change is a deviation in the trabecular orientation from longitudinal to transverse, according to a reduced rate of ossification rather than abnormal ossification [2]. As bone growth continues at the growth plate, growth arrest lines migrate to the diaphysis. Such lines change with bone remodeling and can disappear completely with time [11].

In our case, a 9-year-old female treated with chemotherapy showed growth arrest lines at the bilateral metaphysis and epiphysis of her long bones, and her bone growth was likely compromised by chemotherapy. Immediately after chemotherapy had been completed, there were no noticeable growth arrest lines. At that time, the observed condensed sclerotic bands were presumed to still be attached to the growth plates. After bone growth resumed, those dense bands separated from the growth plates toward the diaphysis, and growth arrest lines were visible radiographically. Serial follow-up bone scintigraphy clearly demonstrated migration and disappearance of the

lines as well as longitudinal bone growth as the child got older. Over time, the growth arrest lines moved toward the epiphysis, and the intensity of tracer uptake declined. Sclerotic density was similar between the growth arrest lines at the distal femur and proximal tibia, but the intensity of tracer uptake by the growth arrest lines at the distal femur was higher than at the proximal tibia. We posit that the intensity of tracer uptake might reflect not only sclerosis but also the difference in bone remodeling activity at the growth arrest lines. The distal femur has more potential for rapid growth than the proximal tibia, so the bone remodeling activity of both growth arrest lines and growth plates could be higher there. Regional SPECT/CT visualized growth arrest lines in the epiphysis of the distal femurs and proximal tibia, as well as the metaphysis of the proximal tibia, which were not evident on planar bone scintigraphy, thus confirming the diagnosis of growth arrest lines rather than lymphoma involvement.

There have only been a few case reports detailing scintigraphic findings of growth arrest lines. Hong et al. [6] described scintigraphic and radiographic findings of multiple symmetric growth arrest lines in the long bones after bisphosphonate administration in a 14-year-old male with steroid-induced osteoporosis at one time point. Lim et al. [7] described the bone scintigraphy findings of a 7-year-old male with osteosarcoma 2 years after treatment with adjuvant chemotherapy and bisphosphonates and the  $^{18}\text{F}$ -FDG PET/CT findings 6 years after treatment. This report demonstrated the migration of growth arrest lines with two different imaging modalities (bone scintigraphy and  $^{18}\text{F}$ -FDG PET/CT) but failed to capture the disappearance of the lines. However, our report clearly demonstrated the migration of growth arrest lines by serial bone scintigraphy images as well as the disappearance of these lines at the last follow-up study.

This is the first case report of a growth arrest line imaged by bone SPECT/CT with subsequent migration and disappearance on follow-up scintigraphy images in a child with a past history of chemotherapy for NHL. Careful recording of the medical history with familiar image findings can guide

nuclear medicine physicians to a correct diagnosis of growth arrest lines.

#### Compliance with ethical standards

**Conflict of interest** Chanwoo Kim, Ji Young Kim, Yun Young Choi, Seunghun Lee, and Young-Ho Lee declare that they have no conflict of interest and no source of funding.

**Ethical statement** All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2000. The study design and exemption of informed consent were approved by the Institutional Review Board of Hanyang University Seoul Hospital.

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