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# Ultrasonography Can Be Early Diagnostic Modality for Pediatric Calcaneus Fractures: A Case Report

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## CASE REPORT

# Ultrasonography can be Early Diagnostic Modality for Pediatric Calcaneus Fractures: A Case Report

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### Abstract

Although calcaneus fractures may be the most common pediatric tarsal bone fracture, most occult calcaneus fractures are not visible on plain radiography, resulting in delayed diagnosis. However, ultrasonography can aid early diagnosis of this fracture with an unspecified mechanism of injury and unremarkable radiographic findings. In a pediatric patient with progressive ankle swelling and pain, initial plain radiography was unremarkable, and antibiotics were administered for suspected infective arthritis. After limping developed, ultrasonography showed symmetric growth plates of bilateral distal tibia, fibula, and tarsal bone; a step-off calcaneus cortex with periosteal reaction; increased power Doppler flow; and probe tenderness, indicating a fractured calcaneus. This case shows the value of ultrasonography and supports this modality as a promising alternative for early diagnosis of pediatric calcaneus fracture.

**Keywords:** Ultrasound, Pediatrics, Calcaneus fracture

## 1. Introduction

The calcaneus is the largest tarsal bone and plays an essential role to support and stabilize the body.<sup>1</sup> Pediatric tarsal fractures are incredibly uncommon, with less than 1% of all fractures in childhood,<sup>2</sup> and calcaneus fractures may be the most common pediatric tarsal bone fracture. Due to the larger cartilage component and lower body weight in children, most pediatric calcaneus fractures are non- or minimally displaced.<sup>2,3</sup> Moreover, the incidence may be underestimated because of misdiagnosis or occult fractures.<sup>3</sup> Diagnosis is delayed in 27%–55% of calcaneus fractures, possibly because the fracture line cannot be seen on plain radiography at the time of diagnosis.<sup>2,4</sup>

Nevertheless, to diagnose pediatric calcaneus fracture, axial and lateral views on plain radiography are often ordered. For children with hindfoot pain, limping gait, and unremarkable radiographic findings, computed tomography (CT) is needed to rule out a high suspicion of occult calcaneus fracture or even magnetic resonance imaging (MRI) may be needed for the evaluation of growth plate injury.

Ultrasonography (US) has become an increasingly common approach to evaluate soft tissue or musculoskeletal injuries. Because the cortex bone may appear as the brightest and most detailed when the transducer is perpendicular to the bone, US is particularly suited for linear fractures, such as diaphyseal and metaphyseal regions

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of long bones, appearing as an interruption of the smooth cortical surface, which may indicate a cortical gap, bulging, or deviation.<sup>5,6</sup> Other associated findings related to periosteal thickening, hyperemia, and edema of the adjacent muscle and soft tissues are visualized with increased power Doppler flow.<sup>6</sup> For pediatric patients, US is also useful in cases with a high suspicion of growth plate injury but normal findings on plain radiography. A non-displaced growth plate injury is visualized on US as widening of the physis, cortical interruption, a bony fragment at the physis, and perichondral ring thickening.<sup>5</sup> Recent reports show a high sensitivity and specificity of bedside US to detect calcaneus fractures in adults evaluated in the emergency department.<sup>1</sup> This case report details how ultrasonography aided the early detection and diagnosis of pediatric calcaneus fracture with an unspecific mechanism of injury and unremarkable finding of plain radiography.

## 2. Case report

A 10-year-old boy was evaluated for a 4-day history of progressive right ankle swelling and pain in the pediatric emergency department. He had no underlying disease and typically enjoyed riding his bike daily. However, his bike riding had become increasingly difficult because of ankle swelling and pain, and his grandmother observed his fear of single right leg weight bearing, which resulted in his emergency presentation. The patient denied any trauma episode, fall, or injury during the previous month. A detailed physical examination by a pediatrician showed a limited range of motion for the right hindfoot associated with lateral calcaneal swelling and pain. Limping was also observed. No skin laceration or open wounds were noted, and no hematoma was present. The remainder of physical examination was unremarkable. The family reported that the patient has had no episodes of fever over the previous week. Initial anteroposterior and lateral radiographic views of bilateral feet showed no significant abnormality (Fig. 1). The patient was admitted to the pediatric ward with the suspicion of ankle arthritis.

On admission, blood tests were normal for white blood count, hemoglobin, platelets,

liver, renal function, erythrocyte sedimentation rate, and C-reactive protein; however, the tenderness over the right ankle joint persisted. Progressive general malaise with decreased activity was noted by the grandmother after admission. Based on the unremarkable findings of the ankle and foot radiography, the pediatrician seriously considered the possibility of a single joint infection. Based on the pediatrician's high suspicion of infective arthritis, the patient was placed on antibiotic treatment with oxacillin 750 mg every 6 h.

During the first week of admission, the patient exhibited an improving spirit and appetite. Another blood test series was performed on admission day 5 to rule out juvenile idiopathic arthritis, based on his clinical pattern of unusual worsening of a single joint, which showed rheumatoid factor and antinuclear antibody both within the normal limit. However, he still had an uneven gait pattern associated with limping, despite the encouragement to ambulate provided by the pediatrician. The few ecchymoses that had developed over the right lateral ankle increased daily. The pediatrician then consulted our Rehabilitation Department for further evaluation of this patient. Our physical examination showed tenderness near the right lateral ankle, with scattered ecchymoses. Based on a platelet count within the normal limit, we considered a further need to evaluate and clarify the scattered ecchymoses. Because the patient's grandmother denied any family history of inherited disease, the probability of inherited homozygous protein C or protein S deficiency was low. Clinically, the extending ecchymosis was the first episode in his life and was locally present over a single foot, significantly raising the suspicion of a possible trauma history. Although the radiologist reported that the initial plain radiography revealed an anatomical structure within the normal limit, we could not rule out a tiny cortical irregularity found over the calcaneus, which was observed on the upper part of the posterior surface. Therefore, ultrasonography was performed with a 13-MHz linear array transducer (Ultrasound imaging system LOGIQ e R7; GE, Wauwatosa, Wisconsin, USA) under the clinical diagnosis of occult fracture of the calcaneus. A comparable widening of non-closed

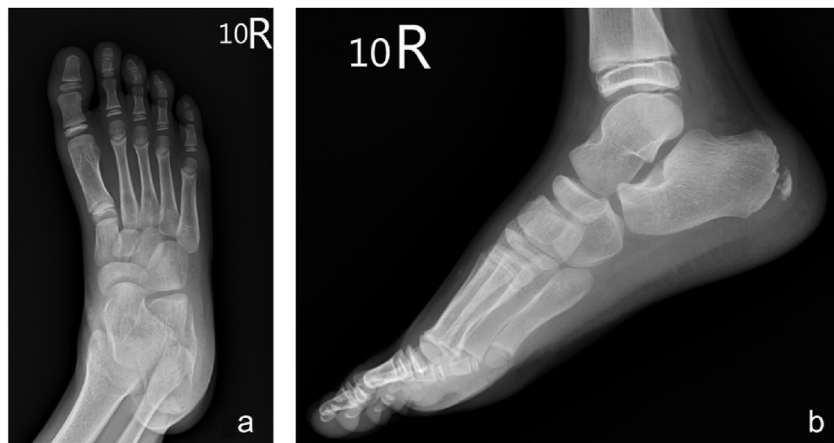


Fig. 1. Initial radiography of a 10-year-old boy with progressive right ankle swelling and pain. Both (a) anteroposterior and (b) lateral views were reported as revealing a normal anatomical structure by the radiologist.

growth plates at bilateral distal tibia, fibula, calcaneus, tarsal bones, and metatarsal bones was observed. The structure of anterior talofibular ligament, calcaneofibular ligament, and the peroneus tendons were within the normal limit. No significant effusion was noted at the anterior ankle recess, talocrural joint, and subtalar joints. The right side showed a cortical irregularity with a step-off lesion at the posterolateral calcaneus near the calcaneofibular ligament attachment, with probe tenderness at this area (Fig. 2a, c, 2e), which was compatible with the painful area clinically, compared with the left side (Fig. 2f and g). A periosteal reaction and increased power Doppler flow were also noted (Fig. 2b and d). Calcaneal body fracture was detected.

For comparison with US results showing a fractured right calcaneus with swollen surrounding soft tissue, radiography was performed with axial and lateral views (Fig. 3). The boy underwent conservative treatment and received a final diagnosis of a minimally displaced extra-articular calcaneal fracture with slight stretching of the calcaneofibular ligament (grade I ankle sprain). A 4-week immobilization was considered, with subsequent progressive weight bearing. The patient was discharged with his grandparents after a 2-week admission. At the 2-week follow-up in the outpatient department, they reported that the pain and limping were significantly improved. Although deambulation had not been recommended, the boy tried walking smoothly after being discharged from our hospital.

Follow-up imaging showed callus formation and consolidation of the fractured calcaneus (Fig. 4).

### 3. Discussion

Ultrasonography was not previously the method of choice for diagnosis of calcaneus fracture. Damir et al. (2013) measured the diameters of wedge defect of calcaneus fracture using US and concluded a possible use for US to diagnose fracture and monitor bone healing.<sup>7</sup> Today, US is a standard modality for physicians to approach musculoskeletal problems. For diagnosis of adult calcaneus fracture, US has been reported to have a high sensitivity, high specificity, and an acceptable efficacy, which may be attributed to its availability, ease of bedside use, portability, low cost, and avoidance of exposure to radiation.<sup>1</sup>

However, studies of calcaneus fractures in children are primarily case reports or case series. In this case report, we present how ultrasonography allowed early detection and diagnosis of pediatric calcaneus fracture. For this case, the specific time and mechanism of injury could not be clearly documented when taking a history from the patient and his grandmother; in addition, initial findings on plain radiography were unremarkable. All of these conditions may lead to an increased risk of delayed diagnosis or misdiagnosis of the occult fracture. In these circumstances, the value of US is to provide an immediate assessment of not only the bone injury but also the soft tissue

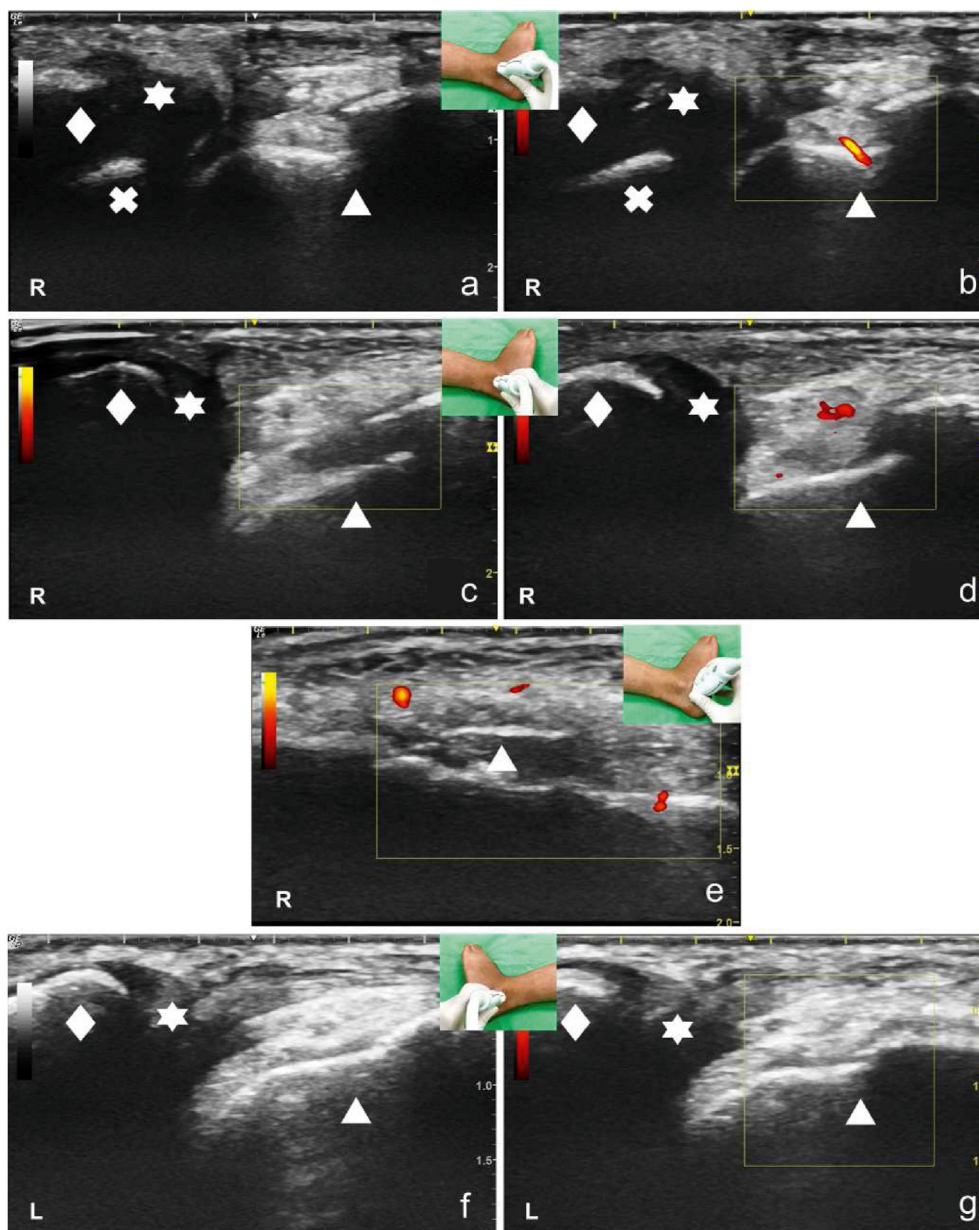


Fig. 2. Ultrasonography shows the fibula (diamond), unossified epiphysis (star), talus (cross), and calcaneus (triangle). We placed the probe below lateral malleolus, parallel to the Achilles tendon, which shows: (a) cortical irregularity with a step-off lesion at the right posterolateral calcaneus (triangle); and (b) some periosteal reaction and increased power Doppler flow at the right posterolateral calcaneus (triangle). Then, we moved the probe more posteriorly of the foot and found (c) a cortical irregularity with a step-off lesion at the right posterolateral calcaneus (triangle); and (d) increased power Doppler flow at the right calcaneofibular ligament; and we rotated the probe 90° and showed (e) a thin avulsed bone fragment located above the right posterolateral calcaneus (triangle), with increased power Doppler flow surrounding it. Finally, we placed the probe on the left ankle, which showed (f) a normal structure of the left calcaneus (triangle) and (g) no power Doppler flow evidence at the left posterolateral calcaneus (triangle) compared with (c) and (d).

injury. For the best of our knowledge, US can also evaluate the bone cortex in consecutive cross-section with multiple planes. With the high acoustic impedance of the bone cortex, US could better discriminate the bone cortex from surrounding soft

tissues, which is not accessible with plain radiography. When detecting soft tissue abnormalities and unossified structures, US and MRI are more sensitive than plain radiography. However, MRI is less desirable for children, for two key reasons: 1)





Fig. 3. Follow-up radiography after ultrasonography. The (a) axial and (b) lateral views both show a fractured calcaneus (arrows) with swollen surrounding soft tissue.

possibility of anesthesia for the lengthy process to prevent motion artifact, and 2) higher cost.<sup>6</sup> For the differential diagnosis of pediatric calcaneus fracture, US is helpful in cases of high suspicion of growth plate injury but unremarkable findings on plain radiography, with the possible findings of widening physis, cortical interruption, a bony fragment at the physis, and thickening of the perichondral ring,<sup>5</sup> which shows the superiority over plain radiography and CT in detecting pediatric occult fractures. In our case, the image of growth plates of bilateral calcaneus in longitudinal view shows a comparable incompletely ossified epiphysis.<sup>8</sup> The metaphysis can be seen with comparable widening of non-closed growth plates at bilateral calcaneus (Fig. 5).

In addition, US can allow real-time comparison with the contralateral side, which is essential to help to differentiate a normal structure variant, such as growth plate or unossified epiphysis, from a fracture. Moreover, clinicians can also perform dynamic testing with sonopalpation over a suspected injury site to determine whether probe tenderness exists during the US examination, which is not possible with the use of CT and MRI. If significant pain results from pressure on the examination site with the US transducer, this finding can help determine whether the changes in the bone surface represent a bone injury.<sup>5</sup> US

can also access the integrity of surrounding ligaments and tendons, as well as diagnose the concurrent disorders that may need further intervention.

Pediatric calcaneal fractures are rare and challenging to diagnose in children because it is not always possible to obtain an accurate history.<sup>9,10</sup> The treatment of pediatric calcaneal fractures is usually conservative.<sup>11</sup> For non-displaced or minimally displaced extra-articular calcaneal fractures (minimally displaced fractures are those with 1–2 mm of deviation between the fragments),<sup>12</sup> a conservative treatment is the preferred approach.<sup>3,12</sup> Generally, cast immobilization for 4–6 weeks is considered,<sup>3</sup> as seen in our case, and subsequently, progressive weight bearing should be employed. For children who have calcaneal fracture with concomitant ligament injuries, preventive treatment of ankle sprain is important in avoiding recurrent injuries, which causes ligamentous laxity and chronic pain.<sup>13</sup> Activity modification is encouraged to temporarily reduced the recurrent sprain risk.<sup>14</sup> Ankle bracing and taping could provide additional mechanical stability by compensating the laxity of the lateral ankle ligament.<sup>14,15</sup> Strengthening and range of motion should be initiated simultaneously. Furthermore, physical therapy focused on proprioception, single-leg balance training and neuromuscular

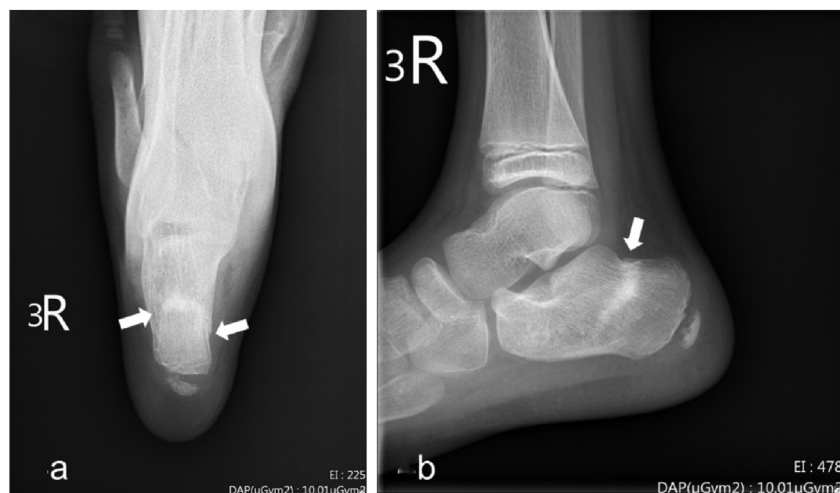


Fig. 4. Follow-up images acquired at 2 weeks after discharge. The (a) axial and (b) lateral views both show callus formation and consolidation (arrows) of the fractured calcaneus.

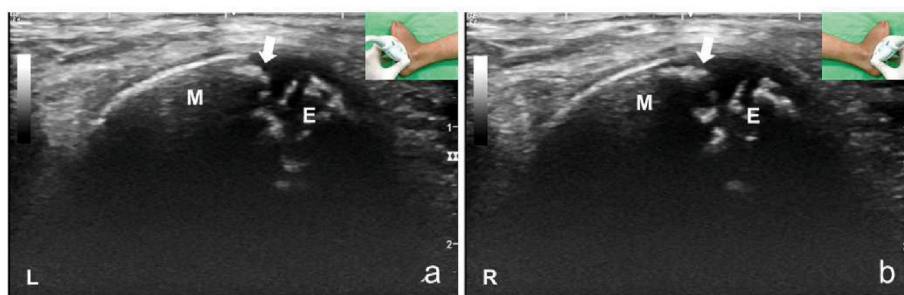


Fig. 5. Ultrasonographic image of the growth plates of the (a) left and (b) right calcanei in a longitudinal view of the foot of the 10-year-old boy. This image shows the hyperechoic outline of the meta-epiphyseal regions of the bones (arrows), with an incompletely ossified epiphysis (E). The metaphysis (M) can be observed, with comparable widening of the non-closed growth plates at bilateral calcanei.

control have shown to be the most effective in preventing ankle sprains.<sup>15</sup> Overall, the long-term treatment goal is to minimize angular deformities and leg-length discrepancies, avoid post-traumatic arthritis, and achieve normal ankle function.<sup>16</sup> Because of a tendency for misdiagnosis, a routine ultrasound approach to limping children with hindfoot pain has the benefits of helping the early diagnosis of pediatric calcaneus fractures and preventing the consequences of a delayed diagnosis, misdiagnosis, or improper treatment.

#### 4. Conclusion

In summary, our case demonstrates the usefulness of US in obtaining a diagnosis of calcaneus fracture and illustrates that US should be considered as a better modality

and promising alternative for the early diagnosis and detection of pediatric calcaneus fracture.

#### Informed consent statement

Informed consent was obtained from all subjects involved in the study.

#### Conflicts of interest

The authors declare no conflict of interest.

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