Ultrasound ability in early diagnosis of metatarsal stress fractures

Silva A[1,2], Fontes T[1,3], Fonseca JE[1,2], Saraiva F[1,2]

[1] Rheumatology and Metabolic Bone Diseases Department, Hospital de Santa Maria, Centro Hospitalar Universitário Lisboa Norte, Lisbon Academic Medical Center and European Reference Network on Rare Connective Tissue and Musculoskeletal Diseases Network (ERN-ReCONNET), Lisbon, Portugal.

[2] Instituto de Medicina Molecular João Lobo Antunes, Faculdade de Medicina da Universidade de Lisboa, Lisboa, Portugal.

[3] Rheumatology Department, Hospital do Divino Espírito Santo, Ponta Delgada

Correspondence to

Augusto Silva

E-mail: augusto.silva@chln.min-saude.pt

Submitted: 20/12/2023

Accepted: 24/02/2024

Abstract

Stress fractures are common in young and active individuals, associated with aggressive or repetitive physical activity and their early detection is fundamental to optimise patient care, decrease complications and avoid unnecessary exams. Currently, magnetic resonance imaging is the standard of care for detecting these lesions. Recently, ultrasound has been getting an increasing interest for the detection of stress fractures. In this article, we describe a clinical case that involved a second metatarsal stress fracture diagnosed by ultrasound and review the literature regarding the use of ultrasound in the diagnosis of stress fractures, particularly of the metatarsals.

Keywords: Stress fractures; Metatarsal; Ultrasound; Early detection.

Introduction

Bone stress injuries commonly cause lower extremity pain in young active individuals and may mature into stress fractures. Fractures can happen if local stress is maintained, which can increase periosteal and bone marrow oedema, ending in bone disruption[1,2,3]. Stress fractures are commonly associated with aggressive or repetitive physical activity and their early detection is fundamental to optimise patient care, decrease complications and avoid unnecessary exams[1,2].

The assessment of bone usually relies on standard radiographs, computerised tomography (CT), magnetic resonance imaging (MRI) and bone scintigraphy, since ultrasound (US) only allows the evaluation of bone surface. However, US can display early signs of bone stress injuries, providing early diagnosis after normal radiographs[4].

Clinical case

A 29-year-old female doctor presented with mechanical pain and mild soft tissue swelling over the dorsum of the right foot, starting 2 weeks earlier. There was no history of trauma or high physical activity recently. On examination, the area over the second metatarsal was painful and swollen. Plain radiographs were normal (*figure 1*). An US of the swollen area was performed, revealing soft tissue swelling over the second metatarsal, pushing away the extensor tendon, and a subtle periosteal thickening with localised hypoechoic fluid surrounding a tiny cortical break, suggestive of fracture (*figures 2 and 3*). An MRI was performed a week later, confirming the diagnosis, showing soft tissue and bone marrow oedema in the area of a clear fracture of the second metatarsal (*figure 4*). The patient started to use Barouk shoes and was referred to the Orthopaedic department. Six weeks later the pain disappeared and the patient returned to normal life activities.

Discussion

Stress fractures commonly occur in young and active individuals, especially in those who suddenly increase physical activity. Typical locations include the tibia (33%), tarsal bones (20%), metatarsals (20%), femur (11%), fibula (7%) and pelvis (7%). Risk factors include extrinsic factors, like footwear and types of sport's training surface, duration, load and type of sport, but also intrinsic factors, such as gender, age, race, nutrition, overall fitness level, structural biomechanical factors, muscular, and hormonal imbalance[2,4]. The aetiology of stress fractures tends to be multifactorial. Most studies concluded that females have a higher incidence of these fractures, with a prevalence of pelvis and metatarsal fractures being more commonly reported in this group[2].

When the injuries affect the foot and ankle, other potential contributing factors include malalignments (hyper/hypo-pronation, pes *planus/cavus*, forefoot or hindfoot *varus/valgus*, *tibia vara*, *genu valgus/varus*), limb length discrepancies, tarsal coalition, previous surgeries or trauma to the same or opposite limb, joint laxity or instability, and muscle weakness or imbalance. All these factors can alter the complex biomechanics and weight-bearing dynamics of the lower extremity and place undo stresses on one bone or set of bones to compensate for these alignment abnormalities or other deficiencies[1,2].

In most bone fractures, standard radiographs, CT, MRI and bone scintigraphy are sufficient to make the diagnosis[3,4]. However, in stress fractures, plain radiographs can be normal for several weeks before callus or fracture lines appear, with a sensitivity as low as 10%, which can lead to a delayed diagnosis and possible complications, such as bone remodelling, non-union injuries, and loss of function[1,4]. Currently, the standard of care for detecting bone stress injuries is MRI, which is a non-invasive method of detecting stress fractures with good sensitivity but has high cost and poor accessibility in some areas[1,2,4].

Recently, there has been an increasing interest in US for the diagnosis of stress fractures [1,2]. The first case, reported in 1980, took advantage of US to diagnose tibial stress fractures in young military males earlier than radiographs. Since then, other publications have reported the importance of US in the early diagnosis of stress fractures, characterising typical findings. In 2018, Bianchi and Luong described the five hallmarks of bone stress injuries in US: periosteal thickening, a calcified bone callus, cortical irregularities, hypoechogenicity of the surrounding soft tissue which indicates oedema and inflammatory reaction, and hypervascular changes seen on colour/power Doppler[1,4].

The potential diagnostic accuracy of US for bone stress injury remains of interest, and in the last decade, several studies compared US accuracy with MRI and bone scintigraphy, concluding that US might be a useful tool for early diagnosis, since cortical irregularities and hypertrophic changes may be visualised before they are seen on plain radiographs or MRI[1,4]. Some of the potential advantages of US in this setting include low cost, being innocuous, dynamic images, fast execution and easy access[1,4]. The US has 81.8% sensitivity and 66.6% specificity in the diagnosis of metatarsal stress fractures[4], but in some studies, both can reach 100%, while other studies show positive and negative predictive values superior to 90%, in both paediatric and adult populations[5]. This is why US may become the preferred method, over MRI and scintigraphy, for the early diagnosis of stress fractures of superficial bones.

Major disadvantages of US in stress fracture identification are operator dependency and inability to depict bone beyond its surface. However, this imaging method when used by skilled technicians can provide real-time unparalleled images and high diagnostic accuracy to detect metatarsal stress fractures in a safe and portable manner, which is supported by the systematic review of Champagne *et al*. Nevertheless, current recommendations do not include yet US as an initial diagnostic method[6,7].

This case reveals the importance of US in early diagnosis of metatarsal stress fractures, when radiographs show no signs of it, minimising overall cost and complications, and avoiding exams like MRI.

In the future, it is expected that US can be implemented in the early detection of stress fractures. Further studies must be implemented to show the real role of US, comparing it to other imaging methods.

Tables and Figures

Figure 1. Plain anteroposterior radiograph of the feet showing no asymmetries or signs of metatarsal bone fractures.

Figure 2. Ultrasound images in longitudinal view of the symptomatic right foot, displaying a cortical brake (arrow) of the second right metatarsus with hypoechoic surrounding soft tissue oedema and periosteal thickening, bulging the extensor digitorum longus tendon (asterisk).

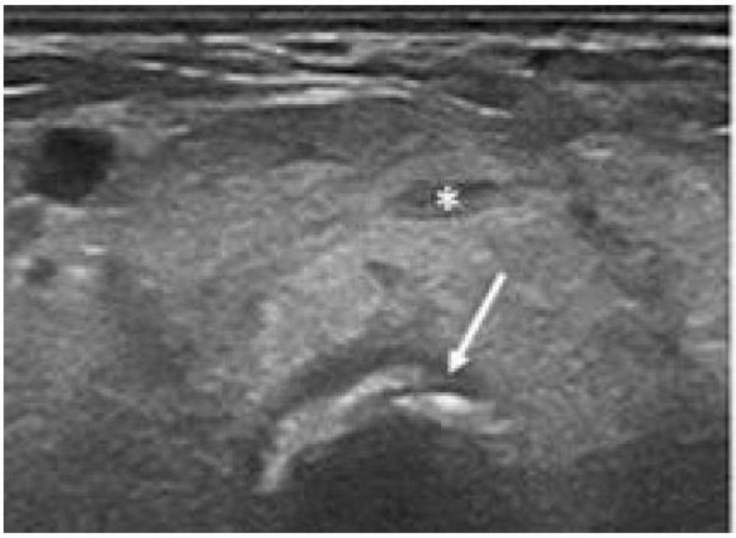

Figure 3. Ultrasound images in short axis view of the symptomatic right foot, displaying a cortical break (arrow) of the second right metatarsus, with hypoechoic surrounding soft tissue oedema and periosteal thickening, bulging the extensor digitorum longus tendon (asterisk).

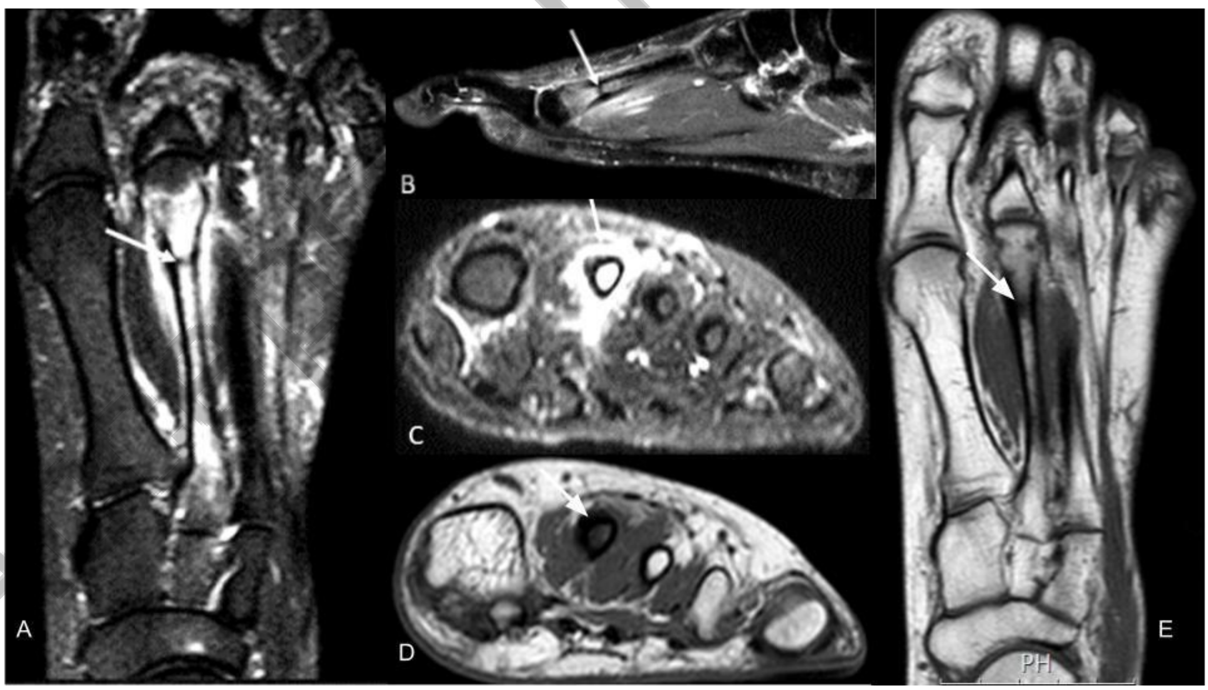

Figure 4. Magnetic resonance images of the right foot in transverse (A), parasagittal (B) and coronal (C) planes, acquired in short tau inversion recovery (STIR) sequence; in coronal (D) and transverse (E) planes, acquired in T1 sequence, displaying soft tissue and bone marrow oedema in the surroundings of a cortical brake of the second metatarsal bone, compatible with a fracture (arrows).

References

1. Fukushima Y, Ray J, Kraus E, Syrop IP, Fredericson M. A Review and Proposed Rationale for the use of Ultrasonography as a Diagnostic Modality in the Identification of Bone Stress Injuries. J Ultrasound Med. 2018 Oct;37(10):2297-2307. https://doi: 10.1002/jum.14588.

2. Matcuk GR Jr, Mahanty SR, Skalski MR, Patel DB, White EA, Gottsegen CJ. Stress fractures: pathophysiology, clinical presentation, imaging features, and treatment options. Emerg Radiol. 2016 Aug;23(4):365-75. https://doi: 10.1007/s10140-016-1390-5.

3. Amoako A, Abid A, Shadiack A, Monaco R. Ultrasound-Diagnosed Tibia Stress Fracture: A Case Report. Clin Med Insights Arthritis Musculoskelet Disord. 2017 Apr 10;10:1179544117702866. https://doi: 10.1177/1179544117702866.

4. Bianchi S. Ultrasound and bone: a pictorial review. J Ultrasound. 2020 Sep;23(3):227-257. https://doi: 10.1007/s40477-020-00477-4.

5. Champagne N, Eadie L, Regan L, Wilson P. The effectiveness of ultrasound in the detection of fractures in adults with suspected upper or lower limb injury: a systematic review and subgroup meta-analysis. BMC Emerg Med. 2019 Jan 28;19(1):17. https://doi: 10.1186/s12873-019-0226-5.

6. Kahanov L, Eberman LE, Games KE, Wasik M. Diagnosis, treatment, and rehabilitation of stress fractures in the lower extremity in runners. Open Access J Sports Med. 2015 Mar 27;6:87-95. doi: 10.2147/OAJSM.S39512.

7. Astur DC, Zanatta F, Arliani GG, Moraes ER, Pochini AC, Ejnisman B. Stress fractures: definition, diagnosis and treatment. Revista Brasileira de Ortopedia (English Edition). 2016 51(1):3-10. https://doi.org/10.1016/j.rboe.2015.12.008.