Emergency Radiology (2019) 26:465–478
https://doi.org/10.1007/s10140-019-01688-x

PICTORIAL ESSAY

Accessory ossicles of the foot—an imaging conundrum

Shuyi Guo[1] · Yet Yen Yan[1] · Sonia Shu Yi Lee[1] · Tien Jin Tan[1]

Received: 31 January 2019 / Accepted: 21 March 2019 / Published online: 8 April 2019
© American Society of Emergency Radiology 2019

Abstract
Various anatomical variations can be found in the foot and ankle, including sesamoid bones and accessory ossicles. These are usually incidental findings and remain asymptomatic; however, they may cause complications resulting in painful syndromes or degenerative changes secondary to overuse or trauma. They can also lead to fractures or simulate fractures. These complications are challenging to diagnose on radiographs. Advanced imaging with US, CT, MRI, or Tc-99m bone scan is useful for definitive diagnosis. This study aims to illustrate how imaging modalities can be used to diagnose complications of common sesamoids and accessory ossicles of the ankle and foot (hallux sesamoids, os trigonum, accessory navicular, os supranaviculare, os peroneum, os intermetatarseum, and os calcaneus secundarius) and demonstrate the imaging differences between fractures and their mimics.

Keywords Sesamoids · Accessory ossicles · Radiography · Ultrasound · Computed tomography · Magnetic resonance imaging

Introduction

Various skeletal variations of the foot and ankle can be found, including sesamoid bones and accessory ossicles [1] (Fig. 1).

Sesamoids are bony structures that arise within a tendon. Their function is to protect the tendon and provide mechanical advantage to the tendon [1, 2]. The common sesamoids in the foot include the hallux sesamoids, lesser metatarsal sesamoids, and interphalangeal sesamoids [3].

Accessory ossicles usually derive from unfused accessory ossification centers [1, 4]. The most common accessory ossicles in the foot and ankle are os trigonum, accessory navicular, os supranaviculare, os peroneum, os intermetatarseum, and os calcaneus secundarius.

Sesamoids and accessory ossicles are frequently asymptomatic; however, they can cause degenerative changes, stress, and painful syndromes due to impingement of adjacent soft tissues. They can also suffer or simulate fractures [1–3].

Our purpose is to review the imaging findings of some of the more common sesamoids and accessory ossicles of the ankle and foot [1] (hallux sesamoids, os trigonum, accessory navicular, os supranaviculare, os peroneum, os intermetatarseum, and os calcaneus secundarius) (Table 1) and illustrate how different imaging modalities can be used to diagnose associated complications. We will also demonstrate the imaging differences between fractures of these sesamoids and accessory ossicles, and their imaging mimics. In general, fracture margins usually appear poorly corticated whereas accessory ossicles and their bipartite/multipartite variants are well-corticated. In cases of doubt, a comparison radiograph of the contralateral foot may be helpful, although this can be confounded by variability in bilateralism. Follow-up radiographs may also demonstrate callus formation in fractures. Ultrasound (US) can be used to identify non-ossified or cartilaginous accessory bones and to evaluate associated soft tissue inflammation or injury [3]. Advanced imaging with computed tomography (CT), magnetic resonance imaging (MRI), or Tc-99m bone scan can be used in equivocal cases. CT scans are useful for delineating fractures, especially in cases when early surgical management is crucial [13]. MRI shows additional information such as marrow edema and associated soft tissue injuries. Lastly, Tc-99m bone scan shows radioisotope uptake within 24 h of a fracture—this is highly sensitive but not specific.

✉ Shuyi Guo
shuyi.guo@mohh.com.sg

Yet Yen Yan
yanyetyen@gmail.com

Sonia Shu Yi Lee
sonia.lee@mohh.com.sg

Tien Jin Tan
tien_jin_tan@cgh.com.sg

[1] Department of Radiology, Changi General Hospital, 2 Simei Street 3, Singapore 529889, Singapore

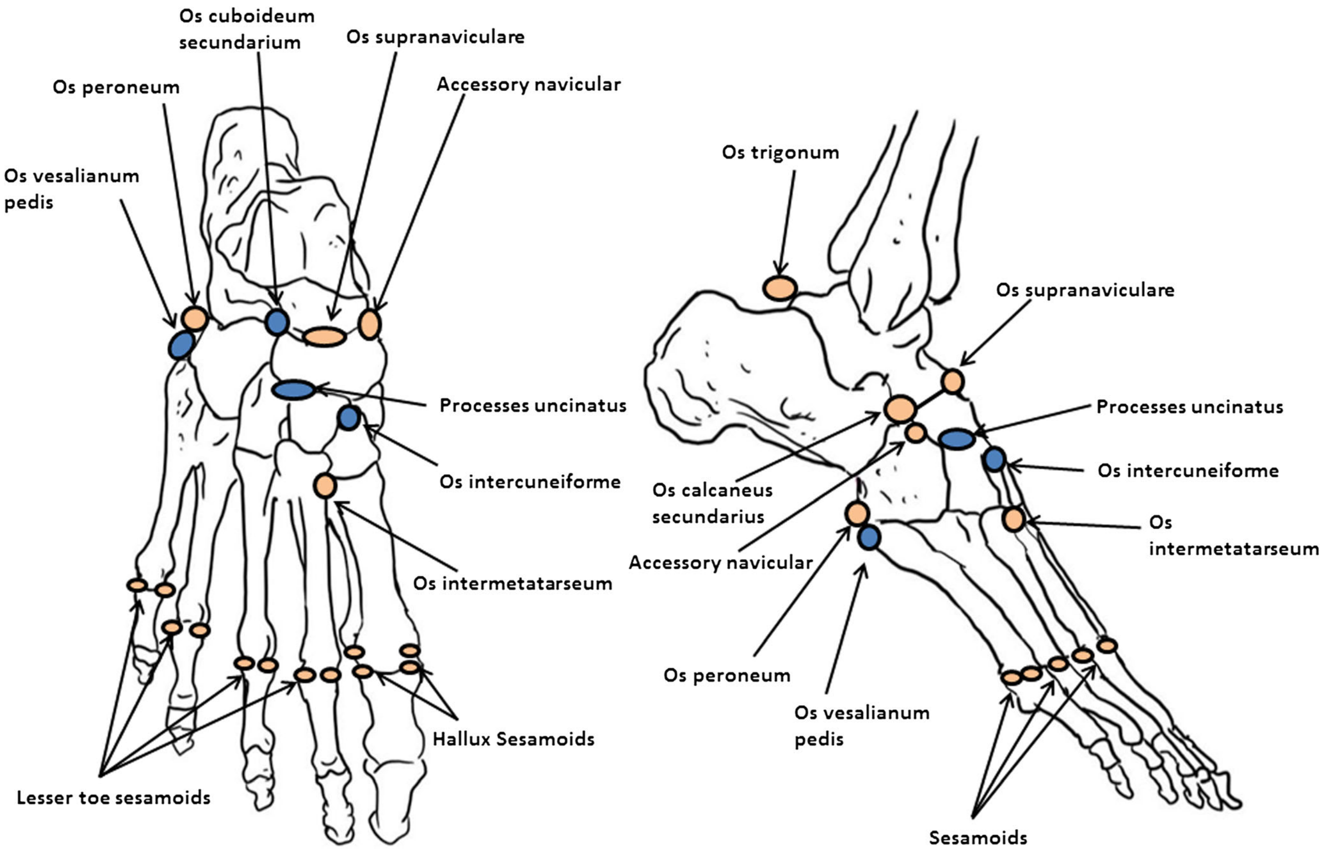


Fig. 1 Frontal and lateral views of sesamoids and accessory ossicles of the foot and ankle—the ossicles in orange are the more common accessory ossicles discussed in this article

Hallux sesamoids

The hallux sesamoids are present at the plantar aspect of the first metatarsal head. There is a wide range of normal variation of the hallux sesamoid complex, and the most common variant is the bipartite hallux sesamoid with a prevalence of 16.5% [14] (Fig. 2). The medial hallux sesamoid is more commonly injured due to its position directly under the first metatarsal head [15].

There are subtle differences in appearances of normal bipartite/multipartite variations and fractures of the hallux sesamoids (Fig. 3). Acute fractures usually have more jagged and irregular edges. Increased separation of the parts or comminution is also suggestive of fracture [16].

Table 1 Accessory bones and sesamoids of the foot and ankle

Accessory/sesamoid bone	Prevalence (%)	Clinical significance	Differential diagnoses
Hallux sesamoids	Close to 100 [1]	Fracture, stress fracture, osteonecrosis, osteochondritis, or osteochondrosis [4]	Bipartite/multipartite tibial sesamoid [1]
Os trigonum	1–25 [1]	Synchondrotic degeneration Posterior ankle impingement syndrome [5]	Posterior talar process fracture [1]
Type 2 accessory navicular	2–12 [1]	Synchondrotic degeneration Posterior tibial tendon dysfunction or tear [1, 6]	Navicular tuberosity avulsion fracture [1]
Os supranaviculare	1–3.5% [7]	Dorsal foot pain [1]	Avulsion fracture of the navicular or talar head [7]
Os peroneum	9 [1]	Fracture Painful peroneum syndrome [8, 9]	Bipartite os peroneum [1]
Os intermetatarseum	1.2–10 [1]	Painful syndrome [1, 4] Hallux valgus [10, 11]	Lisfranc injuries [3]
Os calcaneus secundarius	0.6–7 [1]	Pain after trauma [12]	Fracture of anterosuperior calcaneal process [1]

Fig. 2 Frontal radiograph of the toes (**a**) shows a bipartite medial hallux sesamoid, the most common variant, with a typical transverse cleft with smooth corticated edges separating the bony fragments (white arrow). Frontal radiograph of the toes (**b**) shows a tripartite medial hallux sesamoid (white arrow) with smooth corticated edges

In addition, the hallux sesamoids can give rise to acute pain from excessive axial loading or direct trauma. Chronic pain can also result from stress fracture, osteonecrosis, osteochondritis, or osteochondrosis from prolonged/repetitive plantar flexion (e.g., in ballet dancers, athletes, wearers of high-heel shoes) [4].

An axial projection through the hallux sesamoids or serial radiographic surveillance can be used to guide decision-making [4].

Os trigonum

Os trigonum is the most common accessory ossicle with a prevalence of 1–25% [17]. Os trigonum syndrome refers to pathology attributed to the os trigonum. Acute pain is usually caused by acute forced hyper-plantar flexion, whereas chronic pain can occur in individuals who participate in intense physical activities requiring ankle hyper-plantar flexion (ballet, soccer, and downhill running) [18]. On lateral radiographs of the ankle, swelling of the soft tissue shadows and stranding of the fat surrounding the os trigonum may be seen. There may also be bony hypertrophy of the os trigonum with repeated trauma [19]. CT is useful in demonstrating acute fractures of the os trigonum, as well as degeneration at the synchondrosis [5]. On MRI, marrow edema may be seen in the os trigonum and apposing posterior talar process, along with degenerative changes across the synchondrosis, adjacent synovitis, and flexor hallucis longus tenosynovitis [5] (Fig. 4). US may demonstrate a posterior tibiotalar joint synovitis or flexor hallucis longus tenosynovitis [20].

A bipartite os trigonum (Fig. 5), os trigonum fracture (Fig. 6), and posterior talar process fracture (Fig. 7) can have similar radiographic appearances. It is essential to differentiate an os

Fig. 3 Frontal radiograph (**a**) of the right foot shows an irregular oblique fracture line in the medial hallux sesamoid (white arrow). Follow-up axial radiograph (**b**) of the toes performed 2 weeks later showed interval callus formation (white arrow) at the fracture site. Proton density (**c**) and T2-weighted fat saturated (**d**) images from an MRI performed 2 months following the initial radiographs confirmed the presence of a fracture of the medial hallux sesamoid with mild marrow edema of the fracture fragments (white arrows)

trigonum fracture from a posterior talar process fracture as the latter may potentially require early surgical intervention [13].

Accessory navicular

Accessory navicular is the second most common accessory ossicle with a prevalence of 4–21% [1], and 50% of them are found bilaterally [3]. They can be categorized into types 1–3, based on the configuration [21] (Fig. 8).

The type I accessory navicular is a small round ossicle and is asymptomatic [4] (Fig. 9). The type 3 accessory navicular is a prominent tuberosity, thought to be a fused type 2 accessory navicular bone [3] (Fig. 9). Type 2 accessory navicular is the most common variant (50%) [3], and type 2 and 3 accessory navicular are associated with posterior tibialis tendon dysfunction [6]. The accessory navicular can simulate or suffer from fractures (Fig. 10). It can also cause os naviculare syndrome [1], which presents with pain and tenderness in the medial aspect of foot in middle-aged women. On radiographs and CT, os naviculare syndrome may manifest as degenerative changes at the synchondrosis, with or without abnormal osseous density. There is also usually increased radioisotope uptake on Tc-99m bone scan. On MRI, there is abnormal marrow edema within the accessory navicular and navicular tubercle (with increased fluid signal in the synchondrosis), the adjacent soft tissues, and in the distal posterior tibialis tendon [4, 22] (Fig. 11). Ultrasound can be used to demonstrate heterogeneous changes in the synchondrosis secondary to degeneration or separation, as well as diastasis or fluid around the synchondrosis and the posterior tibialis tendon [23] (Fig. 12).

Os supranaviculare

The os supranaviculare is an accessory ossicle located at the proximal dorsal cortex of the navicular [24]. The estimated prevalence is about 1 to 3.5% [7]. The os supranaviculare is usually asymptomatic but can be misdiagnosed as an avulsion fracture of the navicular or talar head in the context of trauma [7]. The os has also been hypothesized to be associated with navicular stress fractures [24]. In rare cases, the os supranaviculare can become symptomatic and cause dorsal

Fig. 4 Lateral radiograph of the ankle (**a**) shows the presence of an os trigonum with no definite fracture (white arrow). Sagittal (**b**) and axial (**c**) CT images shows a well-corticated, sclerotic osseous body closely apposed to the lateral tubercle of the posterior talar process confirming the presence of an os trigonum, associated with degenerative subcortical cystic change of the posterior talar process (white arrows). Sagittal T2-weighted fat-suppressed (**d**), sagittal proton density (**e**), and axial proton density (**f**) MR images show marrow edema of the os trigonum and posterior talar process (white arrows), with adjacent synovitis and inflammatory changes but no fracture line, in keeping with imaging findings seen with os trigonum syndrome

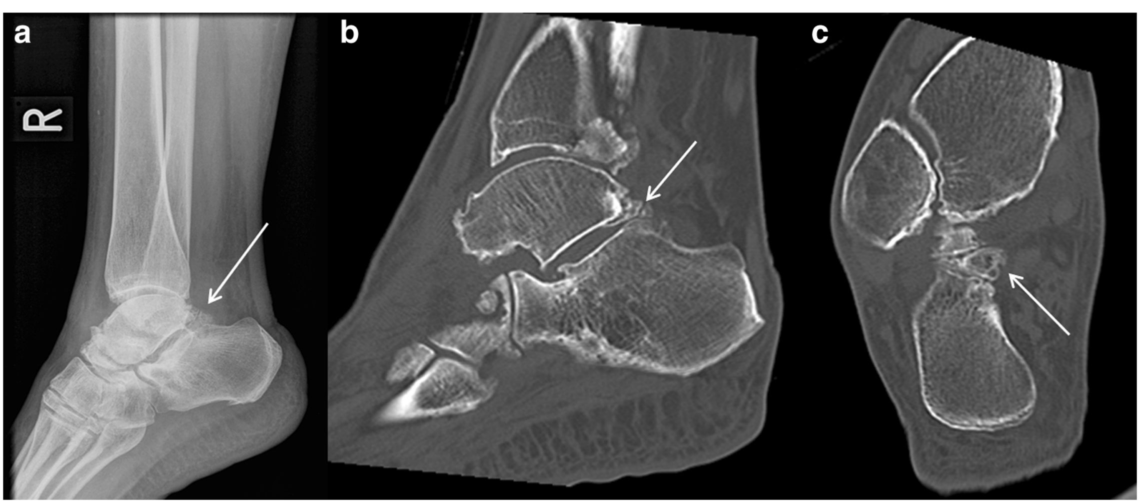


Fig. 5 Lateral radiograph of the right ankle (**a**) shows a bipartite os trigonum with well-corticated margins (arrows). Sagittal (**b**) and axial (**c**) CT images of the ankle confirm the bipartite variant (arrow)

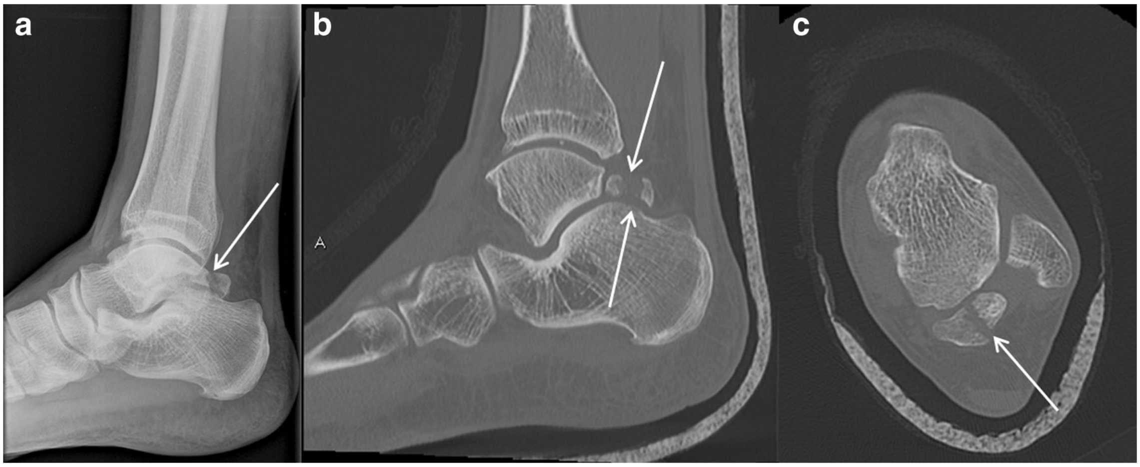


Fig. 6 Lateral radiograph (**a**) of the ankle shows a fractured os trigonum with poorly corticated margins (arrow). CT of the ankle in the sagittal (**b**) and axial (**c**) planes show distraction of the fracture fragments (arrow) [13]

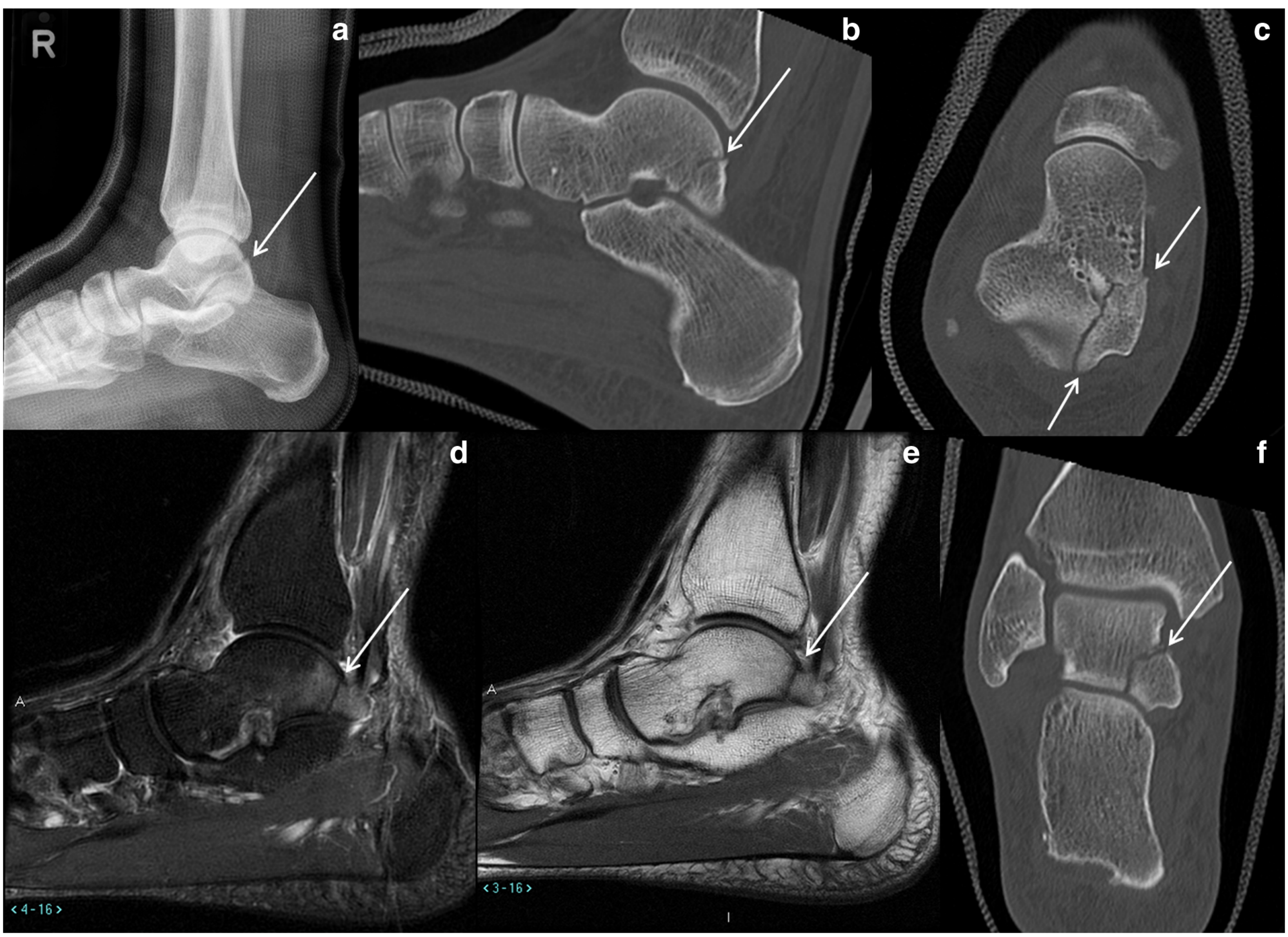
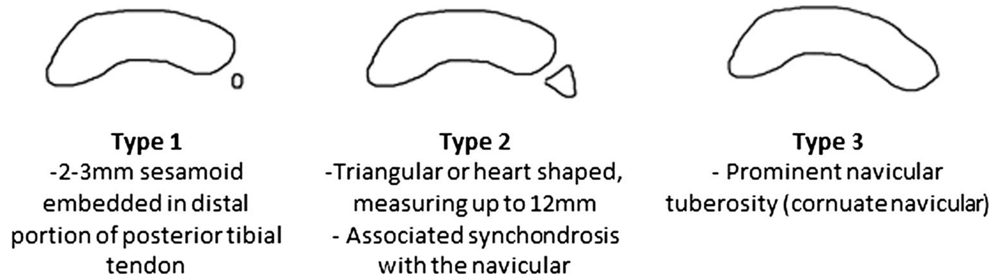


Fig. 7 Lateral radiograph (**a**) of the ankle shows a curvilinear lucency at the posterior talus with poorly corticated margins (arrow) suspicious for a posterior talar process fracture. CT of the ankle in the sagittal (**b**), axial (**c**), and coronal (**f**) planes confirm the presence of a fracture of the lateral tubercle of the posterior talar process (arrow). Sagittal T2-weighted fat-suppressed (**d**) and proton density (**e**) MRI images demonstrate a discrete fracture line through the posterior talar process (arrow) with surrounding marrow edema

Fig. 8 Types 1–3 accessory navicular



foot pain, requiring surgical resection [1]. On radiographs, the os supranaviculare appears as a well-corticated bony fragment at the dorsal aspect of the navicular (Fig. 13), while an avulsion fracture of the navicular would appear as a thin flake of bone with adjacent soft tissue swelling (Fig. 14).

Os peroneum

The os peroneum is omnipresent in a cartilaginous or fibrocartilaginous form but is ossified only in about 9% of the population within the peroneus longus tendon as it arches around the cuboid, making it radiographically evident [1, 3, 4]. Thirty percent of os peroneum are bipartite and 60% of os peroneum are present bilaterally [25]. A bipartite os peroneum can appear fragmented, simulating a fracture. Complications include os peroneum syndrome, which presents with lateral pain and tenderness along the course of peroneus longus tendon, especially with resisted plantar flexion of the foot [8]. Acute pain can be due to rupture of the peroneus longus tendon or os peroneum fracture. Chronic pain can be attributed to attrition of the peroneus longus tendon, diastasis of a multipartite os peroneum, or healing of an os peroneum fracture [9]. On radiographs and CT, there may be displacement of the os from its normal location, indicative of a rupture of the peroneus longus tendon (Fig. 15), or fracture or distraction of a bipartite sesamoid (Fig. 16). On MRI, peroneus longus tendinosis as well as abnormal bone marrow signal within the ossicle and the adjacent osseous structures may be seen [25]. On ultrasound, there may be irregularity of the os peroneum with edema and increased vascularity in the adjacent soft tissues as well as peroneus longus tendinopathy [9].

Fifth metatarsal tuberosity apophysis

The apophysis of the fifth metatarsal tuberosity develops at about age 12 and usually fuses by age 16, but can remain ununited in adulthood when it is then known as a persistent apophysis or os vesalianum. It is frequently bilateral and symmetrical and may be confused for a base of fifth metatarsal fracture [26]. A key feature of the

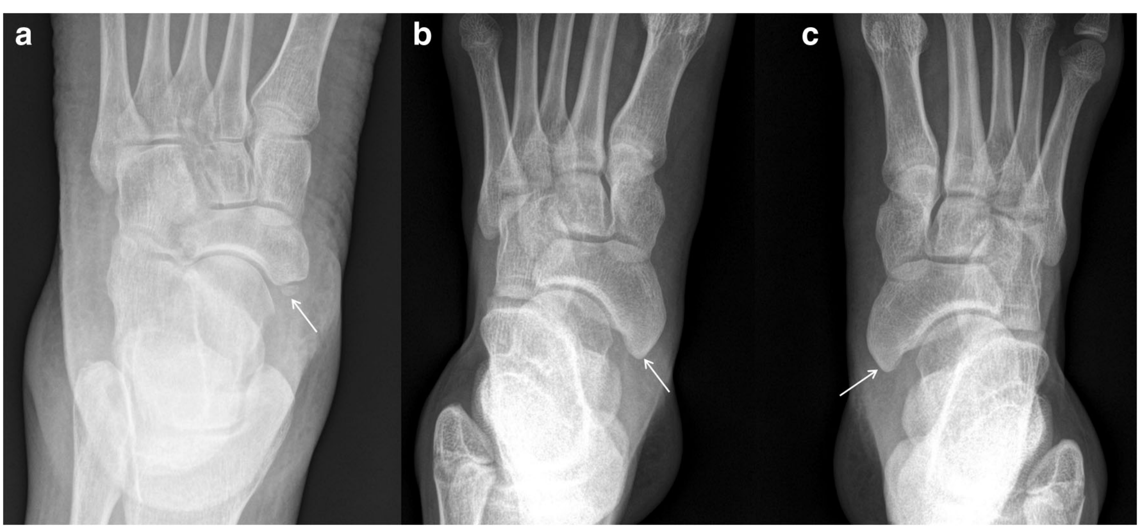


Fig. 9 Frontal radiograph of the left foot (**a**) shows a 3-mm well-corticated bony density compatible with normal type 1 accessory navicular (arrow). Frontal radiographs of the left (**b**) and right foot (**c**) of a different patient show bilateral cornuate navicular in keeping with normal type 3 accessory navicular (arrows)

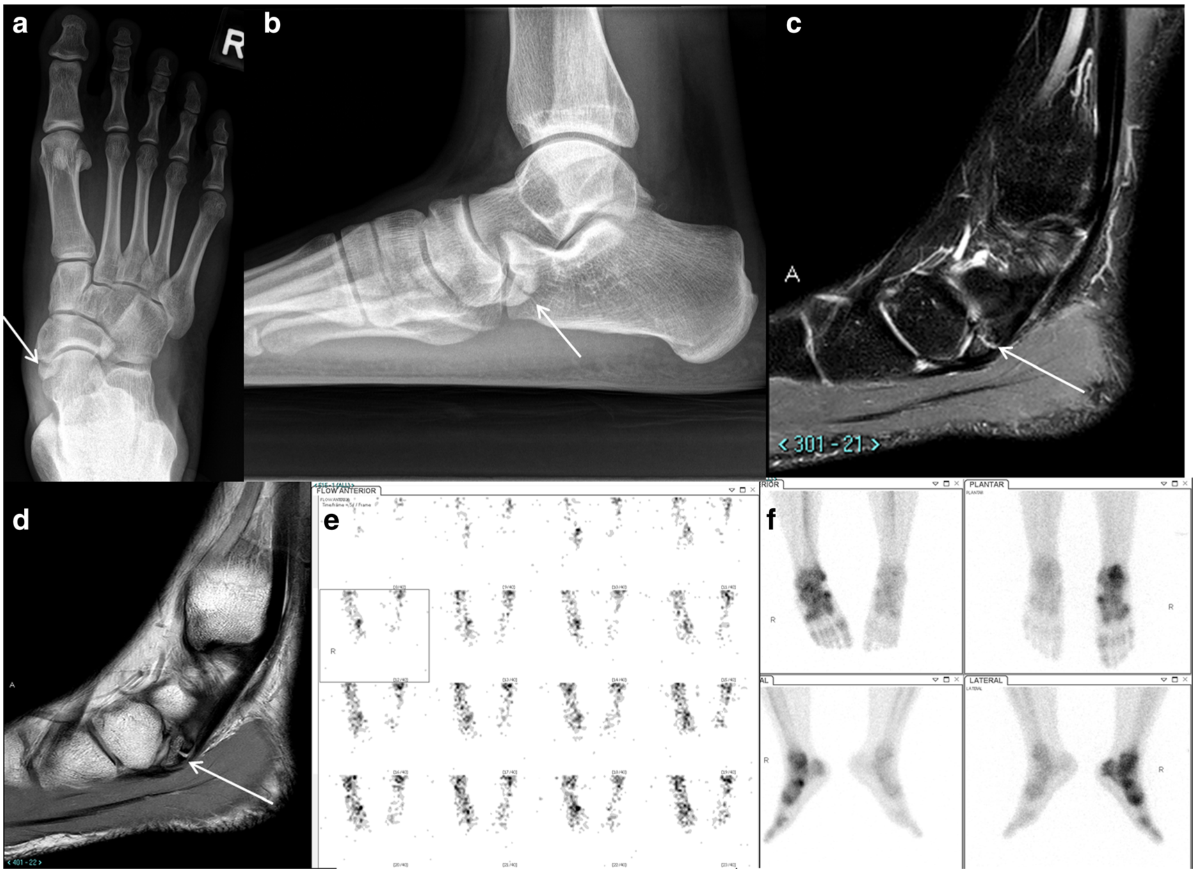


Fig. 10 Frontal (**a**) and lateral (**b**) radiographs of the foot show a split type 2 accessory navicular with poorly corticated margins (arrow). Sagittal T2-weighted fat-suppressed (**c**) and proton density (**d**) MR images confirms the presence of a fluid-filled fracture cleft within the accessory navicular (arrow) with adjacent marrow edema. Blood flow (**e**) and delayed (**f**) phases of the Tc-99m bone scan images of bilateral feet and ankles show persistent increased radioisotope uptake in the region of the right accessory navicular, consistent with a fracture of the accessory navicular. Incidental radioisotope uptake in the right ankle and subtalar joints is probably degenerative in nature

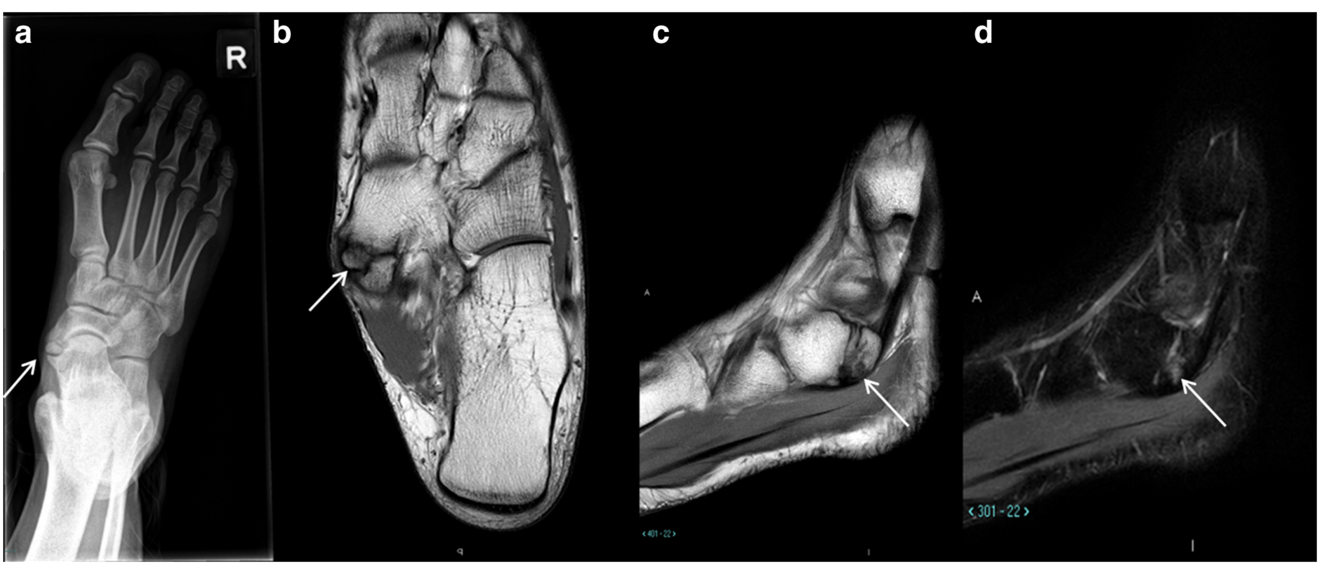


Fig. 11 Frontal radiograph of the foot in a patient who presented with os naviculare syndrome (**a**) shows a type 2 accessory navicular with well-corticated margins (arrow). Proton density axial (**b**) and sagittal (**c**) and T2-weighted fat-suppressed (**d**) MRI images show bipartite accessory navicular with bone marrow edema within the smaller ossicle (arrows)

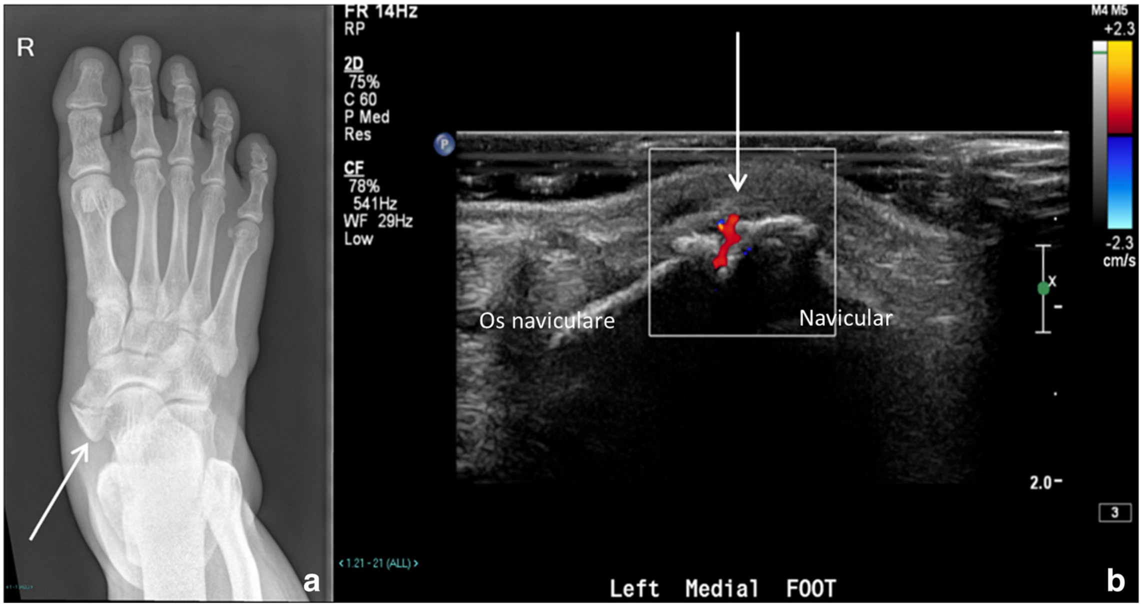


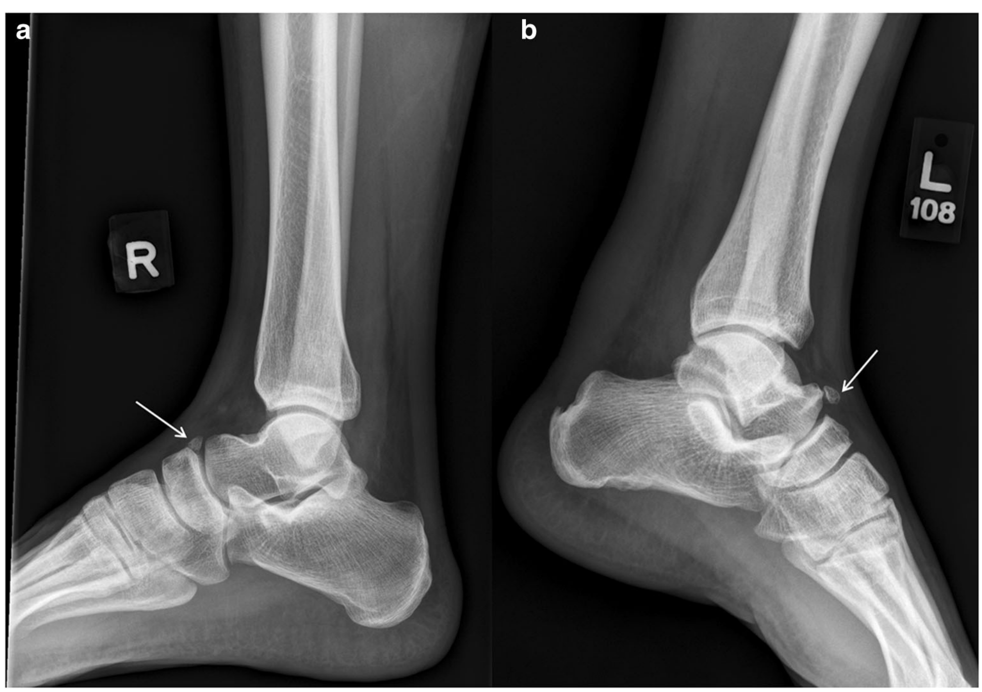
Fig. 12 **a**, **b** Frontal radiograph of the right foot showed a type 2 accessory navicular and marginal osteophytic lipping across its synchondrosis. Targeted ultrasound over the medial aspect of the midfoot showed increased vascularity around the accessory navicular and at its synchondrosis (white arrow) with the navicular tubercle. These findings together with tenderness on palpation with the transducer were compatible with the patient's symptoms of an os naviculare syndrome

apophysis or os vesalianum is that it is always aligned longitudinally with respect to the axis of the metatarsal [27], whereas most fractures are transverse or oblique (Fig. 17). If there remains uncertainty about whether the finding represents a persistent apophysis or fracture, a radiograph of the other foot will be useful to identify the contralateral apophysis.

Os intermetatarseum

The os intermetatarseum is most commonly found between the first and second metatarsal [3]. It has an estimated prevalence of 1.2–10% [1]. It may appear as an independent ossicle (Fig. 18), articulating by a synovial joint, or fused with adjacent bones (first metatarsal base, second metatarsal base,

Fig. 13 Lateral radiograph of the right ankle (**a**) demonstrates a well-corticated bony density at the dorsal aspect of the proximal navicular consistent with a normal os supranaviculare (arrow). Lateral radiograph of the left ankle (**b**) of a different patient also demonstrates a normal os supranaviculare (arrow)



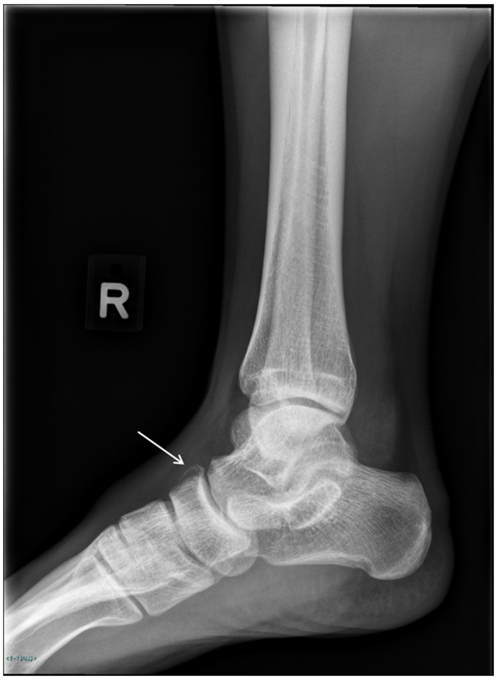


Fig. 14 Lateral radiograph of the right ankle demonstrates a curvilinear bony fleck adjacent to the proximal dorsal cortex of the navicular consistent with an avulsion fracture of the navicular (arrow)

medial cuneiform) to form a spur-like projection [1, 4]. It appears oval or round but can also be spindle-shaped [1, 3].

It can mimic a fracture of the second metatarsal base such as in Lisfranc injuries [3]. Bony malalignment and soft tissue swelling are however expected in cases of Lisfranc injuries, and their presence will be useful in differentiating this injury from the presence of an os intermetatarseum [3].

The os intermetatarseum itself may fracture or cause pain at the dorsum of the midfoot at the first intermetatarsal space by compressing the superficial or deep peroneal nerves [1, 4]. These complications may manifest on a bone scan by showing increased radiotracer uptake.

There is a possible association of os intermetatarseum with varus deformity of the first metatarsal and hallux valgus [10, 11]. This may be related to the ossicle acting as a wedge, which widens the interval between the first and second metatarsal bases [10].

Os calcaneus secundarius

The os calcaneus secundarius is located between the anteromedial aspect of the calcaneus, the cuboid, the talar

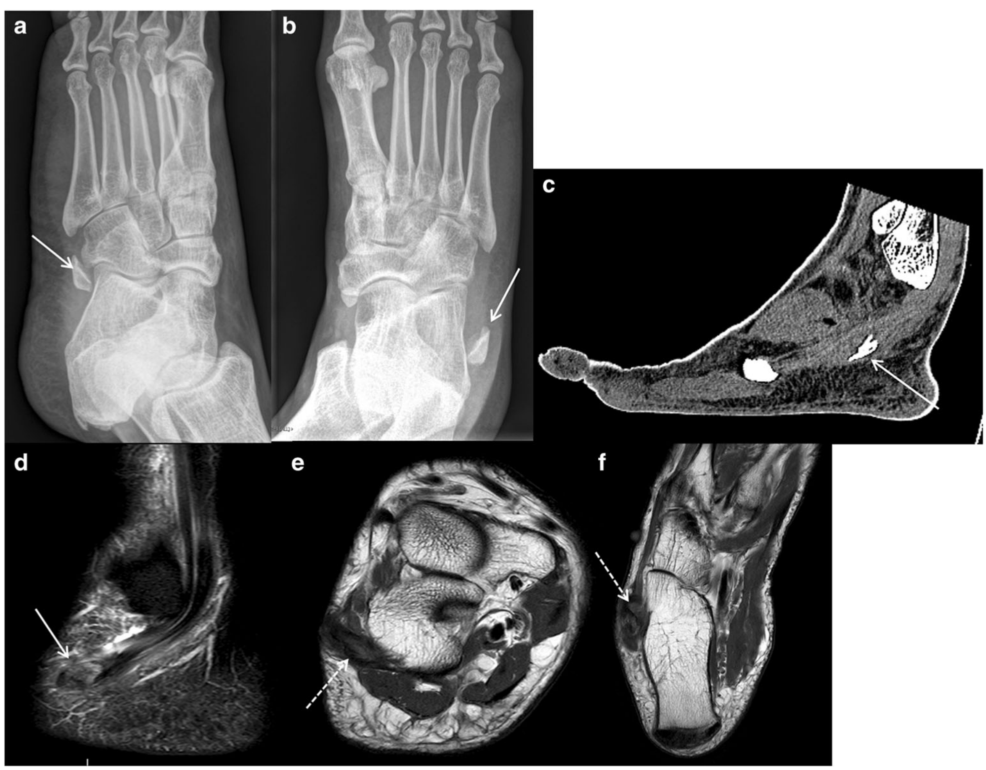


Fig. 15 Frontal radiograph of the left foot (**a**) shows normal appearance and location of the os peroneum (arrow). Frontal radiograph of the right foot (**b**) shows retraction of the os peroneum (arrow). Sagittal CT (**c**) of the right foot confirms a well-corticated bony fragment embedded within a thickened peroneus longus tendon compatible with an os peroneum (arrow). T2-weighted fat saturated sagittal (**d**), proton density axial (**e**) and coronal (**f**) images from an MRI show marrow edema within the os peroneum (white arrow) likely related to avulsion. Raised signal within the thickened peroneus longus tendon distal to the retracted os peroneum is in keeping with a complete avulsion tear (white dotted arrow)

Fig. 16 Frontal radiograph of the left foot (**a**) shows an apparent bipartite appearance of os peroneum (arrow). Interval follow-up frontal radiograph (**b**) shows distraction of the os peroneum fragments which are poorly corticated (arrow), representing a fracture of the os peroneum rather than a bipartite variant

Fig. 17 Frontal (**a**) and oblique (**b**) radiographs of the left foot demonstrate fracture of the base of the fifth metatarsal extending into the apophysis (arrow)

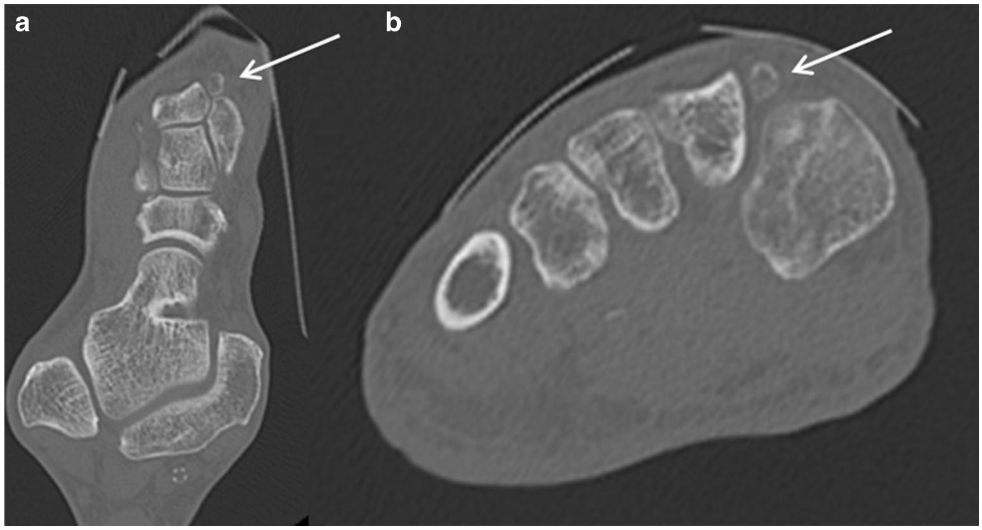


Fig. 18 Axial (**a**) and coronal (**b**) CT of the left foot shows a well-corticated ovoid bony fragment (arrow) with smooth edges articulating with the medial cuneiform at the dorsum consistent with a normal os intermetatarseum

head, and the tarsal navicular [1, 3]. It has a prevalence of 0.6–7% [1, 3].

It can be confused for a fracture of the anterosuperior calcaneal process, which is an avulsion injury of the bifurcate ligament during inversion and forced plantar flexion (Fig. 19) [28]. It is essential to differentiate the ossicle from a fracture to avoid unnecessary surgery [1]. Further imaging with CT or MRI may be helpful [29]. An ovoid, well-

Fig. 19 Radiograph of the right foot (**a**) shows a fracture across the anterosuperior process of the calcaneum (arrow). (**b**) Follow-up radiograph 2 weeks later shows interval new callus formation at the fracture site indicating interval healing

Fig. 20 Radiographs of the right foot (**a**) and (**b**) show os calcaneus secundarius. This was seen on axial (**c**), sagittal (**d**) and coronal (**e**) CT demonstrating the well-corticated margins, confirming the anatomical variant

corticated appearance favors an os calcaneus secundarius over the presence of a fracture (Fig. 20).

A traumatized os calcaneus secundarius can also present as persistent pain after a supination injury to the ankle [12]. In these cases, surgical resection of the ossicle may be considered if conservative treatment fails.

Conclusion

There is a wide variety of sesamoids and accessory ossicles in the ankle and foot. While they are usually asymptomatic, complications may arise and the diagnosis of these require a high degree of clinical suspicion. Being familiar with subtle imaging differences between anatomical variations and true pathology, as well as the use of follow-up imaging or advanced modalities such as CT, MR, and Tc-99m bone scan, will be helpful to the reporting radiologist or managing clinician in establishing a definitive diagnosis.

Authors' contributions All authors have made substantial contributions to the conception and design of the study, or acquisition of data, or analysis and interpretation of data, drafting the article or revising it critically for important intellectual content, and final approval of the version to be submitted.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Mellado JM, Ramos A, Salvado E et al (2003) Accessory ossicles and sesamoid bones of the ankle and foot: imaging findings, clinical significance and differential diagnosis. Eur Radiol 13(Suppl. 6): L164–L177
2. Sarin VK, Erickson GM, Giori NJ, Bergman AG, Carter DR (1999) Coincident development of sesamoid bones and clues to their evolution. Anat Rec 257(5):174–180
3. Nwawka OK, Hayashi D, Diaz LE, Goud AR, Arndt WF, Roemer FW, Malguria N, Guermazi A (2013) Sesamoids and accessory

ossicles of the foot: anatomical variability and related pathology. Insights Imaging 4(5):581–593
4. Miller TT (2002) Painful accessory bones of the foot. Semin Musculoskelet Radiol 6(2):153–161
5. Wong GNL, Tan TJ (2016) MR imaging as a problem solving tool in posterior ankle pain: a review. Eur J Radiol 85(12):2238–2256
6. Abourazzak FE, Shimi M, Azzouzi H, Mansouri S, El Mrini A, Harzy T (2015) An unusual cause of medial foot pain: the cornuate navicular. Eur J Rheumatol 2(1):33–34
7. Yalawar RS, Bhuyan D, Desai RS, Goswami G (2014) A rare case of symptomatic os supranaviculare in a sportsman. IOSR J Appl Phys 6(4):15–17
8. Oh SJ, Kim YH, Kim SK, Kim M-W (2012) Painful os peroneum syndrome presenting as lateral plantar foot pain. Ann Rehabil Med 36(1):163–166
9. Chagas-Neto FA, de Souza BNC, Nogueira-Barbosa MH (2016) Painful os peroneum syndrome: underdiagnosed condition in the lateral midfoot pain. Case Rep Radiol 2016:8739362
10. Henderson RS (1963) Os intermetatarseum and a possible relationship to hallux valgus. J Bone Joint Surg Br 45B(1):117–121
11. Lawson JP (1994) International skeletal society lecture in honor of Howard D. Dorfman. Clinically significant radiologic anatomic variants of the skeleton. Am J Roentgenol 163(2):249–255
12. Krapf D, Krapf S, Wyss C (2015) Calcaneus secundarius – a relevant differential diagnosis in ankle pain: a case report and review of the literature. J Med Case Rep 9:127
13. Yan YY, Mehta KV, Tan TJ (2016) Fracture of the os trigonum: a report of two cases and review of the literature. Foot Ankle Surg 22(4):e21–e24
14. Karadaglis D, Grace D (2003) Morphology of the hallux sesamoids. Foot Ankle Surg 9(3):165–167
15. Biedert R, Hintermann B (2003) Stress fractures of the medial great toe sesamoids in athletes. Foot Ankle Int 24(2):137–141
16. Boike A, Schnirring-Judge M, McMillin S (2001) Sesamoid disorders of the first metatarsophalangeal joint. Clin Podiatr Med Surg 28(2):269–285
17. Kose O, Okan AN, Durakbasa MO, Emrem K, Islam NC (2006) Fracture of the os trigonum: a case report. J Orthop Surg (Hong Kong) 14(3):354–356
18. Escobedo EM, MacDonald TL, Hunter JC (2006) Acute fracture of the os trigonum. Emerg Radiol 13(3):139–141
19. Karasick D, Schweitzer ME (1996) The os trigonum syndrome: imaging features. Am J Roentgenol 166(1):125–129
20. Pesquer L, Guillo S, Meyer P, Hauger O (2014) US in ankle impingement syndrome. J Ultrasound 17(2):89–97 PMC. Web. 22 Oct. 2018
21. Miller TT, Staron RB, Feldman F, Parisien M, Glucksman WJ, Gandolfo LH (1995) The symptomatic accessory tarsal navicular bone: assessment with MR imaging. Radiology 195(3):849–853
22. Mosel LD, Kat E, Voyvodic F (2004) Imaging of the symptomatic type II accessory navicular bone. Australas Radiol 48(2):267–271
23. Chuang Y-W, Tsai W-S, Chen K-H, Hsu H-C (2012) Clinical use of high-resolution ultrasonography for the diagnosis of type II accessory navicular bone. Am J Phys Med Rehab 91(2):177–181
24. Ingalls J, Wissman R (2011) The os supranaviculare and navicular stress fractures. Skelet Radiol 40(7):937–941
25. Bianchi S, Bortolotto C, Draghi F (2017) Os peroneum imaging: normal appearance and pathological findings. Insights Imaging 8(1):59–68
26. McLenna MK, Margolis M (1991) Radiology rounds. Can Fam Physician 37:1372–1375
27. Strayer SM, Reece SG, Petrizzi MJ (1999) Fractures of the proximal fifth metatarsal. Am Fam Physician 59(9):2516–2522
28. Hodge JC (1999) Anterior process fracture or calcaneus secundarius: a case report. J Emerg Med 17(2):305–309
29. Ersen O, Akyıldız F, Ozyurek S, Sivrioglu AK (2013) Os calcaneus secundarius mimicking fracture. BMJ Case Rep 2013: bcr2013009954

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.