

Progress in the clinical imaging research of bone diseases on ankle and foot sesamoid bones and accessory ossicles

Xiaozhong Li*, Lenian Shi, Taiyun Liu, Lin Wang

Department of Radiology, Affiliated Hospital of Gansu College of Traditional Chinese Medicine, Lanzhou, China.

Summary

Sesamoid bones and accessory ossicles are research focuses of foot and ankle surgery. Pains of the foot and ankle are related to sesamoid bones and accessory ossicles. The specific anatomical and functional relationship of sesamoid bones and accessory ossicles can cause such bone diseases as the dislocation of sesamoid bones and accessory bones, infection, inflammation and necrosis of sesamoid bones, cartilage softening, tenosynovitis of sesamoid bones and the sesamoid bone syndrome. However, these bone diseases are often misdiagnosed or mistreated. In patients with trauma history, relevant diseases of sesamoid bones and accessory ossicles as above mentioned are highly probable to be misdiagnosed as avulsion fractures. In such cases, radiographic findings may provide a basis for clinical diagnosis.

Keywords: Ankle and foot, sesamoid and accessory bone, bone diseases, image

1. Introduction

Sesamoid bones and accessory ossicles of the foot and ankle, due to their large quantity and complex structure, play an important role in foot and ankle surgery and are attracting increasing and considerable attention of surgeons. Studies on such diseases as the dislocation of sesamoid bones and accessory bones, infection, inflammation and necrosis of sesamoid bones, cartilage softening, tenosynovitis of sesamoid bones and sesamoid bone syndrome are a few current areas of interest. Surgeons usually lack a reliable diagnostic basis for these diseases, and problems of misdiagnosis, mistreatment and missed diagnosis often occur. There are also the cases in which sesamoid bones and accessory ossicles are misdiagnosed as bone fractures. Particularly, with the accessory bones of the fibula and the bottom and accessory bones between the talus and the fibula, the rate of misdiagnosis of fractures is respectively 13.3% and 16.7%. Fracture of sesamoid bones can be misdiagnosed as bipartite

or multipartite sesamoid bones, thus causing spiritual and economic loss to patients. Our study finds that magnetic resonance imaging (MRI) and bone scanning can help early and accurate diagnosis of infection and inflammation of sesamoid bones and accessory ossicles, necrosis of sesamoid bones, sesamoid bone syndrome, etc. According to the predilection sites of diseases of sesamoid bones and accessory ossicles as well as X-ray findings, sesamoid bones and accessory ossicles can be distinguished from an avulsion fracture.

2. The mechanism of sesamoid bones and accessory ossicles

Sesamoid bones are embedded within tendons and ligaments. Accessory bones result from a non-combination of several ossification centers or development of extra and independent ossification centers. Such phenomena are usually found in the human foot and ankle with both sesamoid bones and accessory ossicles existing as ossicles. They have bone cortex and cancellous bone with a smooth and regular profile. In a tangential position, accessory bones and sesamoid bones are clearly separated from the surrounding bones.

3. Inspection methods of images

The ankle and foot joints were observed with

*Address correspondence to:

Dr. Xiaozhong Li, Department of Radiology, Affiliated Hospital of Gansu College of Traditional Chinese Medicine, No.732 Jiayuguan West Road, Lanzhou 730020, China.

E-mail: lixiaozhong925@sohu.com

anteroposterior and lateral X-rays, from patients suffering sesamoid bones and accessory ossicle lesions that could not be distinguished from fractures. Dislocation of the sesamoid bones and fracture of accessory ossicles were further examined by contralateral radiographs or even axial radiographs of the sesamoid bones and accessory ossicles. Computed tomography (CT): the patient sat down, with feet together and flat, KV:120 and mA:250, layer thickness 1mm, and layer distance 1 mm, the scanning area ranged from the top of the articular surface of the second metatarsal bone to the highest point of the articular surface of the calcaneus. MRI scanning plane: axial (vertical to the connecting line between from the highest point of the articular surface of the calcaneus and the top of the articular surface of the second metatarsal bone on the sagittal scout image), coronal (the section of the second metatarsophalangeal joints section on the axial image was parallel to the plane of the 5 metatarsuses or the lower edge of the metatarsuses), sagittal (the position on coronal image was parallel to the long axis of the second metatarsus), scanning sequence: SE T1WI, GRE T2WI and ST IR. Horizontal axis plane and sagittal plane radiograph were usually adopted. Layer thickness 1 mm, interval 0-1 mm, and matrix: 512 × 512.

4. Imaging of bone diseases on ankle and foot sesamoid bones and accessory ossicles

4.1. The dislocation of sesamoid bones and accessory ossicles

Sesamoid bones and accessory ossicles dislocations often occurred after ankle and foot joint trauma, which was most commonly seen in the first metatarsophalangeal joints of the foot. Hyperextension of the first metatarsophalangeal joint often results in dislocation of the proximal phalanx on the head of the metatarsal bone (1). Thus adjacent sesamoid bones are dislocated to the outward lateral side, or the sesamoid bones might also dislocate to the proximal head of the metatarsal bone. Different degrees of sesamoid bone dislocations were seen in valgus, and they were significantly correlated with each other, the sesamoid bone dislocations became more significant as the HVA (hallux valgus angle) and MA (the angle between the first and second metatarsus) increased (1). The clinical symptoms were local soft tissue distention and positive tenderness. The imaging findings were significant distention of adjacent soft tissue, translocations of the sesamoid bones and accessory ossicles, which were usually accompanied by the rupture of tendons and ligaments, and the fracture of adjacent skeleton, *etc.* The patients would have a radiograph of the contralateral part for contrast diagnosis.

4.2. Fracture of the sesamoid bones and accessory ossicles

The sesamoid bones and accessory ossicles are prone to be misdiagnosed as an avulsion fracture in the case of trauma, however, fracture indeed sometimes occurs in the sesamoid bones and accessory ossicles. The diagnosis is mainly based on radiographs, while the sesamoid bones lesions are generally unclear in conventional radiographs (2). Additional axial radiographs of the sesamoid bones and accessory ossicles are necessary in which the broken ends of the fractured bone are sharp and irregular. Callus is seen forming surrounding broken ends in a follow-up examination, and the adjacent soft tissue is obviously swollen and accompanied with severe pain. Those suspect patients need to have a radiograph of the contralateral part for contrast analysis (Figure 1), and they should be differentiated from bipartite sesamoid bones and tripartite sesamoid bones. Bipartite sesamoid bones and tripartite sesamoid bones are normal skeletal variations in which the edges are round, blunt and regular with a smooth and intact adjacent bone cortex; furthermore, the shape, size and position of



Figure 1. Fracture of the sesamoid bones. (A) Radiograph after trauma of the right foot fracture of the sesamoid bones on the outward lateral side of the first caput of metatarsal bone which is broken into 2 fragments, the broken end is sharp; (B) Sesamoid bone of the first caput metatarsal of the left foot of the same patient is normal.



Figure 2. Multipartite sesamoid bones. (A) Bipartite sesamoid bones of the first metatarsus of right foot; (B) Multipartite sesamoid bones of the first metatarsus of right foot, the edge of each sesamoid bone is round, blunt and regular, and the adjacent bone cortex is smooth and intact.

the sesamoid bones in follow-up examination are unchanged (Figure 2).

4.3. Inflammation of sesamoid bones and accessory ossicles

Trauma is the primary cause of pathogenesis and most of the inflammations are induced by repetitive injuries, while once acute severe impingement can also cause fracture or inflammation of sesamoid bones or accessory ossicles. They mainly occur in the outward lateral side of the first metatarsophalangeal joints. Clinical symptoms include redness and distention of local soft tissue accompanied by significant tenderness. There is generally no characteristic change in radiographs, and MRI imaging shows distention and a fluid effusion shadow in the adjacent soft tissue. There is usually no significant abnormality in the sclerotin of sesamoid bones, and bone scanning shows the radionuclide concentration in the local sesamoid bones. Thus the diagnosis is primarily based on clinical symptoms and physical symptoms, and eventually confirmed by pathological examination (Figure 3).

4.4. Sesamoid bones infection

Sesamoid bones infection are usually disseminated from

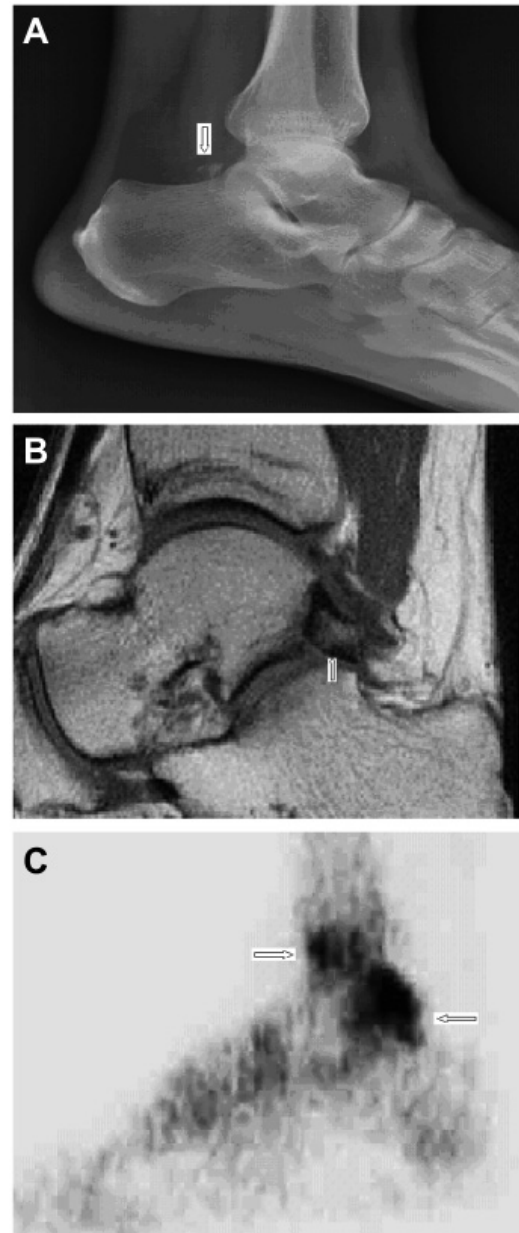


Figure 3. Inflammation of the sesamoid bones and accessory ossicles. (A) The accessory ossicle (OS trigonum) behind the talus of left foot and the sclerotin of accessory ossicle are normal; (B) T1W1: the small sesamoid bones over the calcaneus and behind the talus, low signal liquid shadow can be seen in the adjacent area, there is edema in the sesamoid bones and adjacent bone marrow is distended, and effusion is in the surrounding intervals; (C) Bone scanning: two radionuclide concentration areas can be seen in the lower end of shinbone and behind the talus.

adjacent tissue or by blood, and the latter situations are often seen in children and youth. Clinical symptoms include local soft tissue distention, increasing skin surface temperature and apparent tenderness. Radiographs show that the edge of the sesamoid bones is coarse, the density is inhomogeneous, and a low density destruction area of sclerotin can be seen. CT imaging shows distention of adjacent soft tissue and arthroedema. The early stage diagnosis can be made by MRI. MRI imaging shows scattered or irregular

strip sesamoid bones, a mixed signal of low, middle and high degree, and adjacent soft tissue distention and liquid effusion shadow. Bone scanning indicates radionuclide concentration in the local sesamoid bones (Figure 4).

4.5. Necrosis of sesamoid bones and accessory ossicles

Necrosis of sesamoid bones and accessory ossicles is

more often seen in females, and usually is related to trauma. The clinical manifestations include apparent local tenderness. Radiographs show that the shape and outline of the sesamoid bones are irregular with inhomogeneous density (Figure 5). CT imaging shows that the sesamoid bones edge is coarse, density increases, and a linear and cystic translucent area can be seen within the sesamoid bones. MRI imaging has a diagnostic value for necrosis of sesamoid bones in

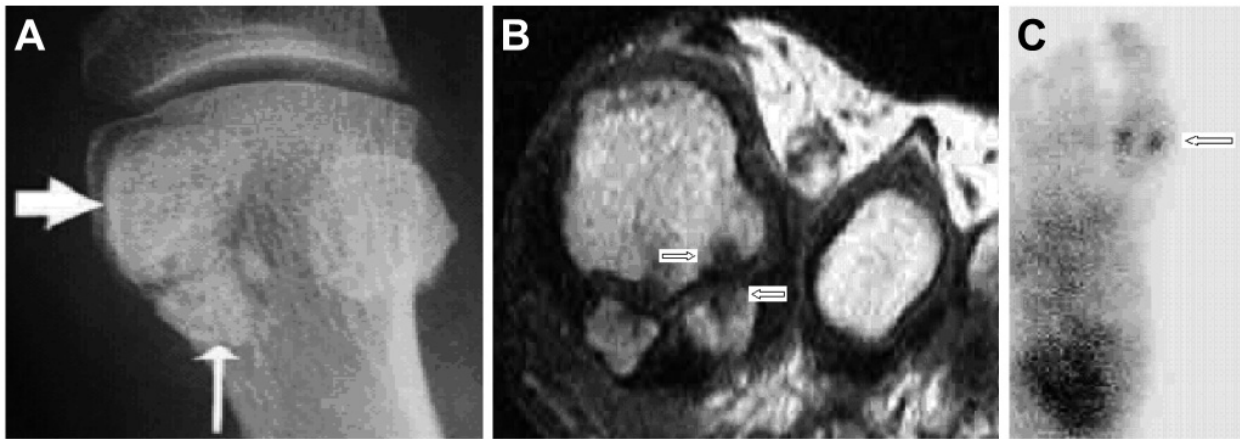


Figure 4. Sesamoid bones infection. (A) The edge of the sesamoid bones of first caput of metatarsal bone is coarse with inhomogeneous density; (B) T1WI: irregular low signal of first caput of metatarsal bone and sesamoid bones, joint chondromalacia, thickened flexor tendon of second metatarsus; (C) Bone scanning: radionuclide concentration in the first caput metatarsal of the feet.

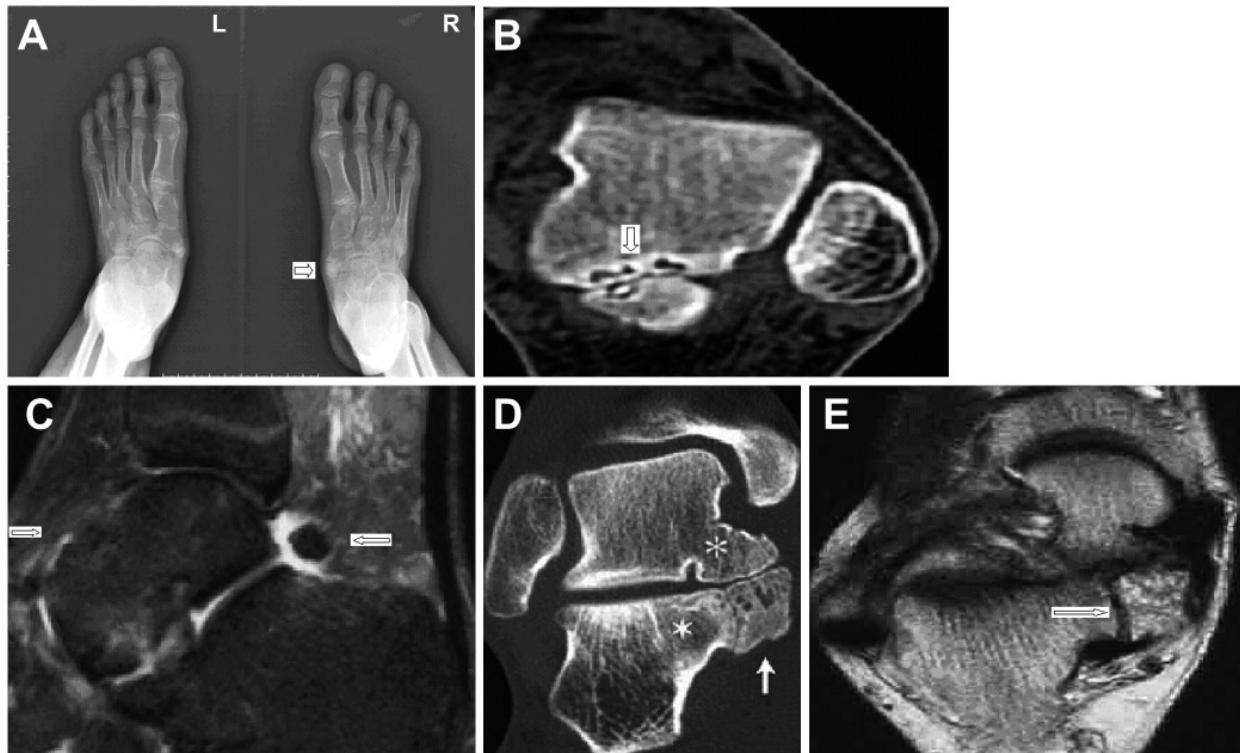


Figure 5. Necrosis of sesamoid bones and accessory ossicles. (A) The density of the articular surface formed by the navicular and accessory navicular of the right foot increases, the density of accessory navicular increases, small sacular translucent area can be seen at the edge of accessory navicular, there is no significant abnormality in the navicular and accessory navicular of left foot; (B) CT scanning of the posterior margin of the talus of another patient, there are several small sacular translucent areas in the margin of the OS trigonum and talus, the shape of the accessory ossicle is irregular; (C) MRI of OS trigonum, effusion signal shadow can be seen in adjacent soft tissue and can also be seen in the interval space of the talonavicular joint; (D) The accessory ossicle in the medial margin of the calcaneus of another patient, there are several cystic lesions; (E) Accessory ossicle marrow edema.

the early stage, sesamoid bone marrow edema can be seen in the early stage which manifests as long T1 and T2 signals, and a long T1 and short T2 cystic necrosis area might appear within the sesamoid bones following development of illness.

4.6. Sesamoid bones chondromalacia

It is often seen in the articular surface of the first metatarsophalangeal joint, and most of them result from sesamoid bones degeneration induced by repetitive strain, and the clinical symptoms include local pain, while there is no distention in the adjacent skin area. Radiograph examination: radiographs show that the shape and edge of the sesamoid bones are irregular with an inhomogeneous density, a linear and cystic translucent area can be seen within the sesamoid bones area, and axial images show that the sesamoid bones surface is coarse and there are some bone fragments. MRI imaging shows scattered, or irregular strip sesamoid bones, a mixed signal of low, middle and high degree, bone marrow edema is visible under the sesamoid bones cartilages, and the dissociative bone fragments can also be seen in the adjacent area of the sesamoid bones (Figure 6).

4.7. Tenosynovitis induced by sesamoid bones

The formation of stenosal tenosynovitis is closely related to the sesamoid bones, the skeletal structures adjacent to the tendons. In particular, the sesamoid bones can cause or promote formation and development of stenosal tenosynovitis to some extent. The clinical symptoms of stenosal tenosynovitis include local distention, pain and a snap sound (3-5), radiographs show that bone spurs form in the joints adjacent to sesamoid bones (6), and MRI imaging shows that there is effusion adjacent to sesamoid bones and visible liquid signal shadows

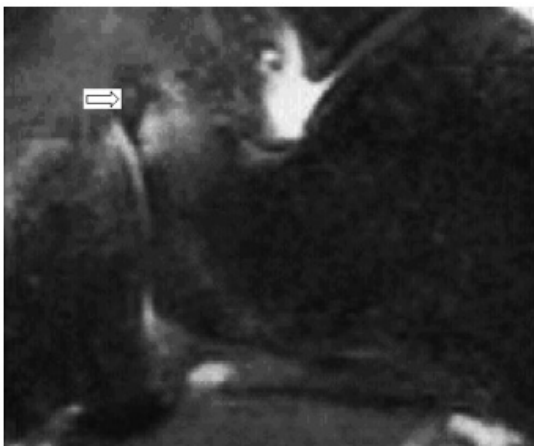


Figure 6. Sesamoid bones chondromalacia. STIR sesamoid bones chondromalacia patient. There are some small dissociative bone fragments in the adjacent area of the sesamoid bones.

within the tendons (Figure 7).

4.8. Sesamoid bones syndrome

Sesamoid bones syndrome refers to the deformation, crush, cystic change and proliferation of the sesamoid bones induced by repetitive impingement on sesamoid bones. The impingement will also increase pressure in the capsule of adjacent synovial joints, which might result in the repression of local soft tissue and a following inflammatory reaction, and then tenosynovitis of the flexor tendon, thickening and fibrosis of the joint capsule will be induced (7). The primary clinical symptom is acute joint impingement, which mainly includes local soft tissue distention, tenderness, asymmetric buckling of joints and stiff joints. Howse (8) has reported a relatively specific method to test the excitability which reproduces the corresponding symptoms by buckling as well as simultaneous rotating and impingement of the joints.



Figure 7. The tenosynovitis induced by sesamoid bones. T2WI: long T2 liquid signal shadow can be seen in the accessory ossicle (OS trigonum) above the calcaneus and behind the accessory ossicles and the flexor pollicis longus muscle tendon; there is pyema in the flexor pollicis longus muscle tendon.

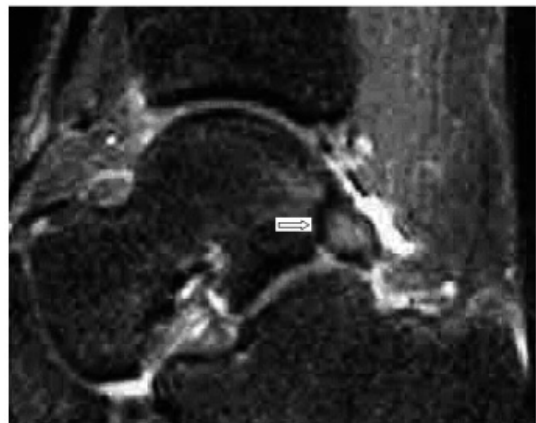


Figure 8. Sesamoid bones syndrome. STIR Low liquid signal shadow can be seen in the surrounding area of the accessory ossicles behind the talus (OS trigonum) and above the calcaneus; there is edema in the sesamoid bones and adjacent bone marrow, and effusion in the adjacent interval.

Radiographs only show distention of the soft tissue adjacent to sesamoid bones, while the distention of the adjacent soft tissue and effusion in the articular cavity can be seen in CT imaging. Bone scanning shows the radionuclide concentration in the local sesamoid bones, and the sesamoid bones syndrome can be diagnosed by MRI imaging, in which the radiographs of the horizontal plane and vertical plane are usually adopted, and the vertical plane is particularly important (9).

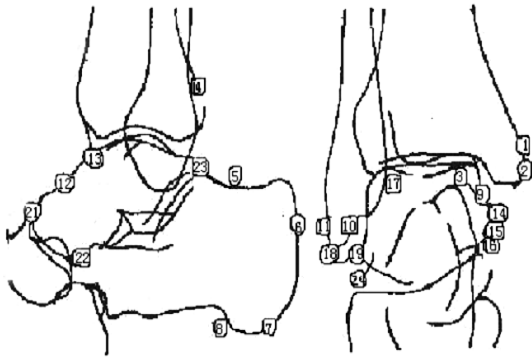


Figure 9. Site where accessory bone is existent. Generally, 1-8 are sites having no accessory bones. If bone fragments are existent at these sites, they are probable calcified or detached sclerites. Generally, 9-13 are the rarest sites where accessory bones are found. If there are bone fragments, they resulted from bone fracture in most cases. Generally, 14-23 are occasional sites where accessory bones are found. If there are bone fragments, the probability of bone fracture should be first excluded. Generally, 24 is the site where accessory bone is existent. However, bone fracture is also possible at this site.

Bone marrow edema, soft tissue distention and tendon laceration (10,11), and arthroedema (12,13) can be seen in ST IR sequence. T2WI shows mild thickening of aponeurosis adjacent to the sesamoid bones and degenerative cystic change signals at the connection area between sesamoid bones and cartilages, as well as myotenositis of the long flexor muscle of the thumb and effusion within its tendon sheath (Figure 8). Conservative treatment is the first choice, the sesamoid bones and accessory bones should be resected only when necessary (14-16).

4.9. Identification of key points of sesamoid bones, accessory ossicles and avulsion fracture

The edge of sesamoid bones and accessory ossicles is smooth, the density of adjacent cortical bone is high, the cortex is intact, the adjacent bone structures are intact and symmetrical, the shape and position of these structures in follow-up radiographs are unchanged, and generally there is nearly no pain (Figure 9). However, fracture usually has a definite history of trauma, adjacent soft tissue distention is significant with apparent pain, the cortex is broken, the broken ends are sharp and asymmetrical, and the shape and position of these structures might change in follow-up radiographs (Figures 10A-10F).

5. Conclusion

Many skeletal variations in the ankle and foot may



Figure 10. The identification of sesamoid bones, accessory ossicles, and avulsion fracture. (A) Os subfibulare in the lower end of extramalleolus: the soft tissue of os subfibulare distends, while the bone edge is smooth, the density of the surrounding bone cortex increases, the shape and position of the bone mass is unchanged in the follow-up examination; (B) The fracture in the lower end of os subfibulare: the fracture line is clear and sharp, the broken end is separated, and the adjacent soft tissue distends slightly; (C) Accessory navicular: the edge of the bone mass is smooth and the edge of navicular is regular; (D) Navicular fracture: the edge of the navicular is irregular and sharp; (E) and (F) are respectively bipartite patella and patella cubitus: the edge of the bone mass is smooth, the adjacent bone structures are intact.

be found, including different accessory ossicles and sesamoid bones, bipartitions and coalitions (17,18). Most accessory ossicles and sesamoid bones do not cause any complaints and remain asymptomatic. Generally, they are detected by routine radiologic examinations after trauma or overuse leading to degenerative changes or pain. They may also suffer or stimulate fractures and restrict the range of motion (19-23). In the literature reported, incidence of the accessory ossicles in the foot and ankle is 18-36.3% in the general population (24).

Sesamoid bones and accessory ossicles are research focuses of foot and ankle surgery (25). Pains of the foot and ankle are related to sesamoid bones and accessory ossicles (26). Clinical disease of the sesamoid bones and accessory ossicles of the ankle and foot joints is common in clinical practice, while the clinical symptoms and physical signs are not specific. Thus they are difficult to diagnose, and these bone diseases are often misdiagnosed or mistreated (27-30). The pathogenesis correlates with their anatomy and function, the comprehensive understanding of their imaging findings has important significance on the accurate diagnosis and treatment of these diseases.

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(Received July 20, 2012; Revised July 30, 2012; Accepted July 31, 2012)