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Original Article

Incidence and anatomical variability of accessory and sesamoid bones of the foot

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Abstract

Aim: We aimed to assess the incidence, mean size, patterns, and types of accessory and sesamoid bones of the foot using computed tomography.

Material and Methods: A total of 814 non-contrast-enhanced computed tomography images of the foot obtained from 717 patients between October 2015 and January 2018 were investigated retrospectively. Images acquired in the original axial plane were used to perform multiplanar reconstruction in the coronal or sagittal planes. Incidence, mean size, patterns, and types of accessory and sesamoid bones were evaluated in all images.

Results: Accessory bones were detected in 387 (47.5%) non-contrast-enhanced computed tomography scans from 326 patients (45.4%). Sixty-seven patients (9.3%) showed accessory bones on both sides; 133 patients (18.5%), only on the right side; and 126 patients (17.5%), only on the left side. The most common accessory bones of the foot were the os naviculare accessorium (24.8%), os trigonum, (20.3%), os peroneum (14.6%), os intermetatarseum (10.6%), os supranaviculare (3.1%), os supratalare (1.9%), and os vesalianum (1.5%). The hallucal sesamoid bone was observed in all patients, while the interphalangeal sesamoid bone was observed in 34.6% of the patients.

Conclusions: The computed tomography scans provided a detailed overview of the characteristics of accessory and sesamoid bones, and the incidence of these bones in our patients was higher than those reported in previous radiographic studies. Our findings can facilitate the diagnosis and management of disorders involving these bones.

Keywords: Accessory Bone; Sesamoid Bone; Computed Tomography.

INTRODUCTION

Accessory bones are developmental skeletal variations that originate from secondary ossification centers and remain apart from the parent bone (1). Although they are usually asymptomatic, these bones might occasionally be associated with local pain or might be separated, which may be misinterpreted as an avulsion fracture (2). These bones may also cause connective tissue diseases or infections (3, 4). Sesamoid bones are small round or ovoid bones that form from their own ossification center (2). They are embedded in the adjacent tendon to reduce friction and protect the tendon from injury (5).

Accessory and sesamoid bones may be detected in many different forms in imaging examinations. They are usually seen close to a bone or a joint and may be bipartite or multipartite (6). Thus, a thorough understanding of these bones and their clinical features is essential to prevent incorrect diagnosis and unnecessary interventions. However, the currently available literature on the incidence of accessory and sesamoid bones is inadequate, especially regarding rare accessory and sesamoid bones. Moreover, the mean sizes of accessory and sesamoid bones have not been well described in the existing literature. In this study, we aimed to present the incidence, mean size, patterns, and types of accessory and sesamoid bones of the foot in a detailed investigation using computed tomography images.

MATERIAL and METHODS

After obtaining approval from the local ethics board, 814 non-contrast-enhanced computed tomography (NECT) images of the foot from 717 patients (401 men, 316 women; age range, 15–74 years; mean age, 37.2 ± 13.8 years)

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obtained between October 2015 and January 2018 were retrospectively investigated. The requirement for informed consent was waived due to the retrospective design of the study. Patients were excluded if they had a history of multiple partite fractures, previous surgical treatment, and advanced-level osteoporotic and extensively osteophytic bones.

The CT examinations were performed using a multi-detector row CT scanner with a 64-detector row CT system (Brilliance CT system; Philips Healthcare, Cleveland, OH). For the scans, the rotation time was 0.5 s; beam collimation, 1 mm; section thickness and intervals, 1 mm; pitch, 53; 200 mAs, 120 kVp; and matrix, 512 × 512. Multiplanar reconstruction using images obtained in the original axial plane allowed the creation of images in the coronal or sagittal planes. Computed tomograms were reviewed on a CT workstation (Philips Extended Brilliance Workspace; Philips Healthcare) by a radiologist with at least 8 years' experience in musculoskeletal radiology. Axial, coronal, and sagittal images were evaluated separately. The incidence and types of accessory and sesamoid bones were evaluated in all images. The accessory and sesamoid bones were classified on the basis of the system proposed by Coughlin (1). Sizes of the accessory and sesamoid bones were calculated according to the highest axial measurements. In multipartite bones, such as bipartite and tripartite bones, each bone was measured separately.

RESULTS

Accessory bones were detected in 393 (48.2%) NECT foot images from 326 patients (45.4%). Of the 814 NECT images, 411 (50.5%) and 403 (49.5%) were of the right and left feet, respectively. Accessory bones were noted on both sides in 67 patients (9.3%), only on the right side in 133 patients (18.5%), and only on the left side in 126 patients (17.5%). The os naviculare accessorium (24.8%) and os trigonum (20.3%) were the most frequently observed accessory bones (Figure 1).

Figure 1. Sagittal non-contrast-enhanced computed tomography image shows the os trigonum at the posterior of the talus and the os talotibiale at the anterior of the tibiotalar joint (white arrows)

Among the navicular bone types, the type 1 os naviculare accessorium was most frequently observed (10.3%). The accessory bone with the largest mean size was the type 3 os naviculare accessorium (12.9 ± 3.3 mm). Some of the very rare accessory bones such as os talotibiale, os retinaculi, os sustentaculi were detected in only one patient (Figure 2).

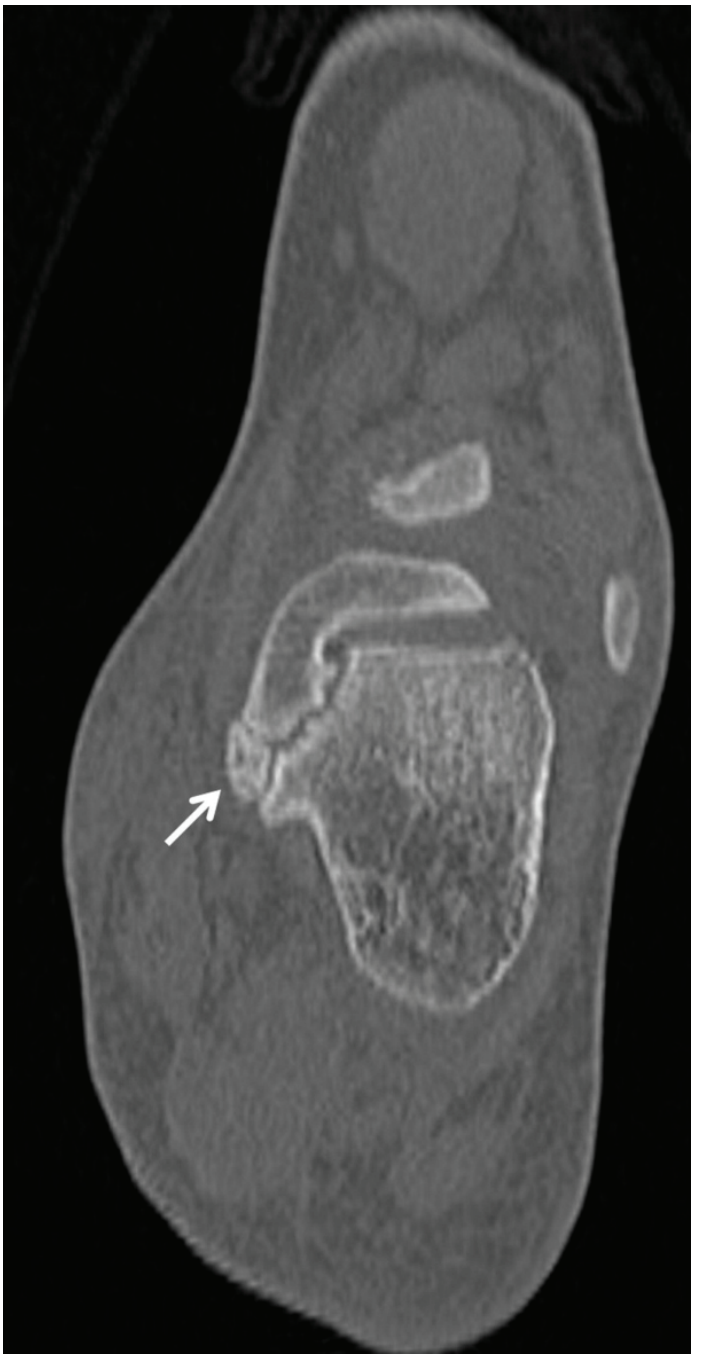

Figure 2. Coronal non-contrast-enhanced computed tomography image shows the Os sustentaculi at the anteromedial portion of the calcaneus and articulates with the middle calcaneal surface of the talus (white arrow)

The incidence and mean sizes of the frequent and rare accessory bones are summarized in Table 1 and Table 2.

The hallucal sesamoid bone was detected in all patients. The second-most frequently detected sesamoid bone

was the interphalangeal joint bone (34.6%). The rarest sesamoid bone was the third lesser metatarsal bone, with an incidence of 0.7%. The incidence and mean sizes of sesamoid bones are summarized in Table 3. Some of the accessory and sesamoid bones were bipartite, tripartite, and even tetrapartite (Figure 3).

Table 1. Location, incidence and mean sizes of the frequent accessory bones

Frequent Accessory Bones	Location	Incidence	Mean Size mm (Range)
Type 1 accessory navicular	Embedded within the distal portion of the posterior tibial tendon	10.3%	4.3 ± 2.4 (0.9-9.7)
Type 2 accessory navicular	Adjacent to the navicular tuberosity	8.8%	7 ± 3.1 (2.6 - 13)
Type 3 accessory navicular	Adjacent to the medial aspect of the par-ent navicular	5.6%	12.9 ± 3.3 (5-22.8)
Os trigonum	Posterior of the talus	20.3%	8.4 ± 3.3 (2.5-18)
Stieda process	Elongated lateral tubercle of the posterior process of the talus	6.6%	8.2 ± 2.3 (4.9-19.3)
Os peroneum	At the lateral plantar aspect of the cuboid within the substance of the peroneus longus tendon	14.6%	5.2 ± 2.7 (1.2-5.3)
Os intermetatarseum	At the intermetatarsal space of the first and second metatarsals.	10.6%	4.4 ± 1.8 (1.4-9.7)

Table 2. Location, incidence and mean sizes of the rare accessory bones

Frequent Accessory Bones	Location	Incidence	Mean Size mm (Range)
Os subfibulare	At the tip of the lateral malleolus	5.5%	
Os calcaneus secundarium	Between the calcaneus, the cuboid, the talus andthe navicular bone	5.5%	5.5 ± 2.6 (1-11)
Os supranaviculare	Above the talonavicular joint	3.1%	5.1 ± 3.2 (2-13.8)
Os supratalare	Above the neck of the talus	1.9%	3.9 ± 1.6 (2-8.7)
Os subtibiale	Adjacent to the posterior colliculus of the medial malleolus	1.7%	4.9 ± 2.4 (1.7-10.8)
Os vesalianum	At the base of the fifth metatarsal in the peroneus brevis tendon	1.5%	3.9 ± 0.8 (2.5 – 5.3)
Os intercuneiforme	On the dorsum of the mid-foot in an interval between the first and second cuneiforms	1.3%	3.2 ± 0.8 (2.2 – 5)
Os talotibiale	Anterior to the tibiotalar joint	0.9%	5.6 ± 2.5 (2.7-9.9)
Os infranaviculare	Between the intermediate and medial cuneiform bones and the navicular	0.7%	3.6 ± 1.6 (1.5 – 6.1)
Talus secundarius	At the lateral aspect of the talus	0.6%	5.4 ± 3.4 (2.4 - 11.2)
Cuboides secundarium	At the proximal-medial aspect of cuboid	0.4%	3.6 ± 0.9 (2.9 - 5)
Os trochleare calcanei	On the lateral side of the ligamentum calcaneonaviculare plantare	0.4%	3 ± 2.1 (1.8 – 6.2)
Os accessorium supracalcaneum	At the superior surface of the posterior calcaneus	0.3%	4.8 ± 1.6 (3.2 – 6.4)
Os subcalcis	At the inferior aspect of calcaneus	0.2%	4.5 ± 1.6 (3.3 – 5.7)
Os talotibiale	Anterior to the tibiotalar joint	0.1%	5.3
Os retinaculi	At the bursa of the malleolus lateralis	0.1%	5.2
Os sustentaculi	At the anteromedial portion of the calcaneus and articulates with the middle calcaneal surface of the talus.	0.1%	17.8

Table 3. Location, incidence and mean sizes of the sesamoid bones

Sesamoid Bones	Location	Incidence	Mean Size mm (Range)
Hallucal	Plantar aspect of the first metatarsal head	100%	10.2 ± 2.2 (1.8 – 22)
Interphalangeal joint	Plantar aspect of the interphalangeal joint of the first digit of the foot	34.6%	4.9 ± 1.7 (0.7 - 11.5)
2nd Lesser metatarsal	Plantar aspect of the between the first and second metatarsal	2%	3.8 ± 1.5 (0.8 – 6)
3th Lesser metatarsal	Plantar aspect of the between the second and third metatarsal	0.7%	3 ± 0.6 (1.9 – 3.7)
4th Lesser metatarsal	Plantar aspect of the between third and fourth metatarsal	1.1%	3.6 ± 1.6 (1.8 - 6.9)
5th Lesser metatarsal	Plantar aspect of the between fourth and fifth metatarsal	14.6 %	3.4 ± 1.2 (1.1 – 8.1)

Figure 3. Coronal non-contrast-enhanced computed tomography image shows bipartite os subfibulare at the tip of the lateral malleolus (white arrows)

The accessory bone showing the bipartite pattern most frequently was the os peroneum (2.08%). Among sesamoid bones, the hallucal bone was bipartite in 731 images (89.8%).

A single medial hallucal bone was seen in only one patient. In three patients (0.36%), the hallucal bone showed a tetrapartite pattern (Figure 4).

The patterns of accessory and sesamoid bones are summarized in Table 4.

Figure 4. Axial non-contrast-enhanced computed tomography images show patterns of the hallucal sesamoid bone

Table 4. Patterns of accessory and sesamoid bones

	Single	Bipartite	Tripartite	Tetrapartite
Accessorry Bones				
Type 1 accessory navicular	75 (%)	7 (0.85%)	2 (0.24%)	0 (0%)
Type 2 accessory navicular	60 (%)	10 (1.47%)	2 (0.24%)	0 (0%)
Os peroneum	110 (13.5%)	17 (2.08%)	2 (0.24%)	0 (0%)
Os vesalianum	11 (1.47%)	1 (0.12%)	1 (0.12%)	0 (0%)
Os calcaneus secundarium	42 (5.15%)	2 (0.24%)	1 (0.12%)	0 (0%)
Os trigonum	160 (19.6%)	4 (0.49%)	2 (0.24%)	0 (0%)
Os subfibulare	43 (5.28%)	2 (0.24%)	0 (0%)	0 (0%)
Sesamoid Bones				
Hallucal	1 (0.12%)	731 (89.8%)	79 (9.7%)	3 (0.36%)
Interphalangeal joint	270 (33.1%)	12 (0.49%)	0 (0%)	0 (0%)
4th Lesser metatarsal	8 (0.98%)	1 (0.12%)	0 (0%)	0 (0%)
5th Lesser metatarsal	92 (11.3%)	26 (3.19%)	1 (0.12%)	0 (0%)

DISCUSSION

Accessory and sesamoid bones show wide variations in routine radiologic examinations (7). However, most of these bones are asymptomatic and do not cause any complaints. The incidence of accessory bones was reported to be between 18% and 36.3% in the literature (2). In our study, which was conducted using computed tomography scans, this incidence was 48.2%. The os naviculare accessorium was the most frequently detected accessory bone in a large number of studies and its incidence was reported to be between 2% and 21% in different studies (3, 6). This bone has three subtypes; type 3 was most frequently detected in the study by Coskun et al., while type 1 was most frequently detected in a study conducted by Huang et al. (3, 8). The os naviculare accessorium was the most frequently detected accessory bone in our study as well (24.8%), and type 1 was the most frequently detected subtype (10.3%).

The os trigonum is one of the largest accessory bones in the foot and the ankle region, and its incidence was reported to be 7% to 25% (3). This bone can cause posterior ankle impingement syndrome and may be misinterpreted as a fracture of the posterior process of the talus (9). The ossification center of this bone occasionally fuses with the talus and leads to the formation of a large posterior process named the "Stieda's process." In our study, with respect to mean size, the os trigonum was the second-largest accessory bone, and its incidence was 20.3%.

The os peroneum is located within the peroneus longus tendon near the calcaneocuboid joint. Its incidence is reported to be between 4.7% and 31.7% (10). In one report, it was bipartite in almost 30% of the cases, and was present bilaterally in almost 60% of the cases (11). It may lead to conditions such as the painful os peroneum syndrome, fracture, or diastasis (10, 11). This bone may also easily be misdiagnosed as an avulsion fracture (2). In our study, the detection rate for the os peroneum was 14.6%, with 13.1% and 1.5% of the cases respectively showing bipartite and tripartite morphology. In the literature, the os naviculare accessorium, os trigonum, and os peroneum are the most frequently detected accessory bones in the foot and the ankle region (12). Consistent with these findings, the incidence of these three accessory bones was among the highest in our study using computed tomography.

Some of accessory bones incidence such as os intermetatarseum (10.6%), os supranaviculare (3.1%), os vesalianum (1.5%), os subfibulare (5.5%), os subtibiale (1.7%), os calcaneus secundarius (5.5%), os supratalare (1.9%), os talotibiale (0.9%), os intercuneiforme (1.3%) were lower than the other accessory bones. The os intermetatarseum may be oval, round, or linear and resemble a rudimentary metatarsal, and its estimated incidence is between 1% and 13% (3). This accessory bone is usually asymptomatic. The os supranaviculare is a rare accessory bone with an estimated incidence between 1% and 3.5% (12). It may be misinterpreted as a cortical avulsion fracture of the tarsal navicular bone. The os vesalianum is another rare accessory bone with a reported incidence of 0.1%-1% (13). It may cause lateral foot pain and may be misinterpreted as an acute avulsion fracture of the fifth metatarsal bone (14). The os subfibulare and os subtibiale have oval and well-defined cortical margins and reported incidences of 0.2%-2.1% and 0.2%-1.2%, respectively (15). Thorough knowledge of these bones is essential to distinguish them from acute avulsion fractures. Os calcaneus secundarius is another rare accessory bone of the foot, with an estimated incidence of 0.6%-7% (2). It can limit the range of motion in the subtalar joint, clinically resembling a fracture of the anterior process of the calcaneus.

Sesamoid bones can vary greatly among individuals. The hallucal bone is considered a normal part of the skeleton. Congenital absence of the hallucal sesamoid bone is a very rare variation (16). In our study, hallucal sesamoid bones were present in all the patients, while the medial unilateral hallucal sesamoid bone was detected in only one patient. However, the incidence of partite sesamoids varies in the literature. Medial division and the lateral division have been reported in 7.2%-30.6% and 0.6%-2.5% of the cases, respectively (17). In our study, a tripartite hallucal sesamoid bone was detected in 79 patients (9.7%), of which 66 (8.1%) showed medial division and 13 (1.59%) showed lateral division. In three patients, bilateral medial and lateral divisions were detected. The interphalangeal sesamoid has a harmful effect on the biomechanical functions of the first metacarpophalangeal and hallucal interphalangeal joints. It may cause painful callosities plantar to the joint or may become incarcerated in a dislocated joint (17). Its incidence has been reported to be between 2% and 13% (3). The interphalangeal sesamoid was detected in 34.6% of the patients in our study, and 12 cases (0.49%) showed a bipartite structure. Lesser toe sesamoids are usually more predominant in the second and fifth toes than in the other lesser toes (6). Metatarsophalangeal sesamoid bones have been reported in the second, third, fourth and fifth digits in 0.4%, 0.2%, 0.1%, and 4.3% of the cases, respectively (3). In our study, the corresponding values were 2%, 0.7%, 1.1%, and 14.6%, respectively.

CONCLUSION

In conclusion, in this study based on computed tomography scans, the incidences of particularly small-sized accessory bones and sesamoid bones were found to be higher than those reported previously in radiographic studies. The findings obtained in this study may facilitate the diagnosis and management of disorders involving the accessory and sesamoid bones.

Competing interests: The authors declare that they have no competing interest.

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Ethical approval: Ethical Approval for Research was taken and indicated in the method section

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