Research Square

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The Anatomical Variations of the Posterolateral Tubercle of Talus in Patients with Posterior Ankle Impingement Syndrome

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Abstract

Background: The most important anatomical variations of the posterolateral talar tubercle that can predispose patients to development of posterior ankle impingement syndrome (PAIS) are an os trigonum and Stieda process. The aim of this study was to elucidate the prevalence of different anatomical variants of posterolateral talar tubercle on CT imaging, their prevalence in patients with PAIS, and to evaluate the risk posed by these anatomical variants to PAIS.

Methods: 1478 ankle CT scans were retrospectively reviewed for the different anatomical variants of the lateral talar tubercle, the type and size of os trigonum. In addition, these anatomical differences were assessed in a subgroup of patients with PAIS.

Results: Normal sized lateral tubercle was found in 46.1%, Stieda's process in 26.1%, os trigonum in 20.5% and almost absent tubercle in 7.3%. A statistically higher prevalence of Stieda's process was found in males while os trigonum was higher in females ($p<0.05$). In patients with PAIS, the most common variant was os trigonum (48.8%), followed by Stieda process (34.1%). Patients with Stieda process were 1.5 times more likely to have PAIS, and patients with os trigonum were 4.4 times more likely to have PAIS. PAIS was observed in 20.8% of patients with os trigonum. Fused forms of os trigonum (by cartilage) and sizes larger than 1cm were associated with a higher risk of occurrence of PAIS (OR 2.10 and OR 1.96 respectively)($p<0.05$).

Conclusion: Patients with os trigonum, followed by Stieda process were more likely to have PAIS compared to other anatomical variants of lateral talar tubercle.

Introduction

The posterior process of the talus is made up of two tubercles, the medial tubercle and the lateral tubercle. Between these tubercles is a groove that allows the passage of the flexor hallucis longus tendon from the posterior ankle to enter the tarsal tunnel (1). The lateral tubercle is generally larger and serves as an attachment point for the posterior talofibular ligament and the posterior talocalcaneal ligament (2). An accessory bone, the os trigonum can occur in continuity with the lateral tubercle of talus. It begins to appear between the ages of 8-11 years in boys and 8–10 years in girls as a secondary center of ossification for the posterior process of talus. Normally it fuses with talus within a year (3). If the ossicle fails to fuse, it is referred to as the os trigonum. Fusion results in the formation of a prominent lateral tubercle of the posterior talus, termed as a Stieda's process.

The frequency of occurrence of the os trigonum in normal feet varies from 2 to 50% (4, 5), while the frequency of the enlarged posterolateral talar tubercle (Stieda's process) is rarely reported. In a recent CT based study, Stieda's process was found in about one-third of the patients without os trigonum (6). In another CT based study of a Chinese population, Stieda's process was identified in 14.7% of patients (7).

A wide variation in the size of the lateral tubercle of talus and the os trigonum is present. Sarrafian and Kelikian classified the lateral tubercle of talus according to its size into: absent, moderate, medium and large (2). Medium and large lateral tubercles were identified in the study of Zwiers et al as an enlarged Stieda's process (6). For the variations of os trigonum, it can be fused with the lateral tubercle by a cartilaginous or fibrous articulation or be a separate fragment not articulating with the posterior talus (4, 8, 9).

Watson and Dobas described a classification scheme for the anatomical variations of the posterolateral tubercle of talus (10). Type 1 was identified as a normal appearance of the lateral tubercle without clinical consequence. Type 2 is the Stieda's process (an enlarged posterolateral process). Type 3 is the os trigonum, which may be the source of discomfort because of repetitive trauma. Type 4 is a fused os trigonum, which forms a synchondrosis or syndesmosis with the talus.

Posterior ankle impingement (PAIS) is a condition characterized by posterior ankle pain in plantarflexion. It is usually aggravated by repetitive plantarflexion and can result from either an acute injury or simple overuse (11-13). PAIS pathology can be due to osseous, soft tissue lesions and variations in anatomy (14). The most important anatomical variations that can predispose patients to the development of PAIS are an os trigonum and Stieda process (15). With repetitive plantarflexion, the posterior lip of the tibia may displace over the back of the talus and causes impingement on these anatomical variants. Other described causes of PAIS are flexor hallucis longus tendinopathy, osteophytes, intra-articular loose bodies, osteochondral lesion, avulsion fracture of posterior distal tibia, retrocalcaneal bursitis, subtalar coalition, impingement of the joint capsule, and impingement of the anomalous muscles (11, 14, 16). There is a paucity of work upon the prevalence of various conditions contributing to PAIS (11). The aim of this study was to elucidate the prevalence of the different anatomical variants of the posterolateral tubercle of talus on CT imaging, their prevalence in patients diagnosed clinically and radiologically (by MRI) with PAIS, and to evaluate the risk posed by different anatomical variants of the posterolateral talar tubercle to PAIS.

Methods

Ankle CT scans of adolescent and adult patients made between March 2018 and March 2020 were retrospectively reviewed for the different anatomical variants of the lateral talar tubercle.

Excluded from the study were patients aged less than 14 years, patients with ankle fracture, instability, avulsion fractures of the tibia, fibula, or lateral tubercle of talus (Shepherd fracture), patients who underwent hindfoot surgery, patients with pathologies including osteolysis, severe arthritis, osteochondritis dissecans, avascular necrosis, and congenital deformations of the ankle joint. This study was approved by the Academic Research Council and the Ethics Committee.

CT scans of 1,478 patients (860 men and 618 women) with 701 left and 777 right feet were included. The anatomical variations of the lateral tubercle of talus were assessed by two researchers independently. Four variants for the lateral tubercle of talus were distinguished (Fig. 1): 1: almost absent, 2: normal tubercle, 3: Stieda's process (enlarged posterolateral tubercle) and 4: os trigonum. Similar to the study of Zwiers et al, we defined medium and large lateral tubercles according to Sarrafian and Kelikian classification as an enlarged Stieda's process (2, 6).

According to the articulation of os trigonum with the lateral tubercle, two types were distinguished using multiplanar reformatted images (MPR): separate bone located posterior to the lateral tubercle of talus and os trigonum fused to the lateral tubercle by synchondrosis or syndesmosis. The axial CT images were reconstructed with a slice thickness of 3 mm with reconstruction at 1 and 0.4 mm, and multiplanar reformatted images were obtained with reconstruction. Based on its relation with the lateral tubercle in the axial plane, three types of os trigonum were distinguished according to Zwier et al classification (6): Type A: os trigonum with intact lateral tubercle, Type B: os trigonum as part of the lateral tubercle and Type C: os trigonum without lateral tubercle (Fig. 2). Based on the os trigonum size (measured in the axial plane), three groups were distinguished: smaller than 0.5 cm, between 0.5 and 1cm, and larger than 1 cm (6).

Age, gender, clinical findings, MRIs (if present) and provisional diagnoses of the patients were reviewed from hospital records. Furthermore, the prevalence of PAIS was evaluated among these patients. Afterwards, the anatomical variations of the lateral tubercle of talus and the differences in os trigonum in terms of size and type were evaluated in patients with PAIS in comparison with patients without PAIS. Positive MRI findings for PAIS were considered as capsular and synovial thickening, bone marrow edema, and fluid increase around the flexor hallucis longus tendon.

Statistical Analysis

GraphPad Prism version 6.04 for Windows (GraphPad Software, La Jolla, CA) was used. The anatomical variations of the lateral tubercle of talus was compared between genders (male vs. female) and sides (right vs. left) using Chi Squared test.

Odds ratio with 95% confidence intervals (CIs) were calculated with logistic regression models to determine whether a particular anatomical variant of the lateral tubercle is a risk factor for PAIS.

Inter-rater reliability was analyzed using the *Cohen's* kappa to assess the consistency between two investigators. A third investigator was consulted in case of disagreement in identifying different variants of the lateral tubercle and the type of os trigonum. The significance threshold was set at the value of $p \leq .05$.

Results

The average age was 33.7 (range, 14–63) years. Of the patients, 58.2% were males. The prevalence of different anatomical variants of the lateral tubercle of talus was identified as: almost absent (7.3%), normal tubercle (46.1%), Stieda's process (26.1%), and os trigonum (20.5%). The prevalence of Stieda's process was statistically higher in males while os trigonum was statistically higher in females (*p*<0.05). No significant difference was found between sides (Table 1).

Based on their medical records and MRI findings, 8.7% of patients (129/1478) were diagnosed clinically and radiographically with PAIS.

The prevalence of different anatomical variants of the lateral tubercle of talus in PAIS(+) patients was identified as almost absent (2.3%), normal tubercle (14.7%), Stieda's process (34.1%), and os trigonum (48.8%). No significant difference in different anatomical variants was found between sexes in PAIS (+) patients (Table 2).

The first two anatomical variants (almost absent and normal tubercles) were associated with a lower rate of occurrence of PAIS (OR 0.28, 95% CI 0.09 to 0.90; and OR 0.18, 95% CI 0.11 to 0.30 respectively *p*<0.05).

Patients with Stieda's process were 1.5 times more likely to have PAIS (CI 1.04 to 2.24), and patients with os trigonum were 4.4 times more likely to have PAIS (CI 3.04 to 6.40) (*p*<0.05)(Table 2).

Prevalence of type and size of os trigonum in PAIS(+) patients was shown in Table 3.

Among 303 feet with os trigonum, 25.7% (78/303) were nonarticulating and identified as a separate bone located posterior to the lateral tubercle of talus and 74.3% (225/303) of os trigonum were identified as fused to the lateral tubercle by synchondrosis or syndesmosis. Additionally, Type A was identified in 17.5% (53/303), Type B in 53.5% (162/303) and Type C in 29.0% (88/303).

Regarding the size of os trigonum, 22.8% (69/303) was smaller than 0.5 cm, 55.4% (168/303) was between 0.5 and 1cm, and 21.8% (66/303) was larger than 1 cm.

PAIS was observed in 20.8% (63/303) of patients with os trigonum. Among 63 feet with PAIS, a separate bone was identified in 15.9% (10/63) and a fused form in 84.1% (53/63). Additionally, Type A was identified in 17.4% (11/63), Type B in 52.4% (33/63) and Type C in 30.2% (19/63).

Regarding the size of os trigonum in PAIS (+) patients, 11.2% (7/63) was smaller than 0.5 cm, 57.1% (36/63) was between 0.5 and 1cm, and 31.7% (20/63) was larger than 1 cm.

Compared to PAIS (-) patients with os trigonum, the fused form of os trigonum had a higher risk of occurrence of PAIS (OR 2.10, 95% CI 1.01 to 4.36). Os trigonum larger than 1cm was also associated with a higher risk of occurrence of PAIS (OR 1.96; 95% CI 1.05 to 3.65)(*p*<0.05). There was no significant association between different relations of os trigonum with the lateral tubercle and PAIS occurrence (*p*>0.05).

Inter-rater agreement (kappa statistics) over identification of the different anatomical variants of the lateral tubercle (except for Stieda's process) and types of os trigonum was perfect (kappa > 0.9). Inter-rater agreement for defining an enlarged Stieda's process was *substantial* with a kappa of 0.79.

Discussion

In our study, we examined the prevalence of different anatomical variants of the lateral talar tubercle in a general population and in a specific PAIS (+) patient group. Previous studies have almost exclusively focused on the prevalence of os trigonum as the most common cause of PAIS (6, 17). Although Stieda's process is also reported as one of the common osseous causes of PAIS, little knowledge on the exact occurrence of Stieda's process in PAIS patients is available. This may be attributed to the lack of a standard definition for the enlarged lateral talar tubercle. As far as we know, no previous research has investigated the prevalence of different variants of the lateral talar tubercle in PAIS patients and evaluated the risk posed by these anatomical variants to PAIS compared to patients without PAIS.

In the 1478 CT scans examined in our study, normal sized lateral tubercle was found in 46.1%, Stieda's process in 26.1%, os trigonum 20.5% and almost absent tubercle in 7.3%. A higher prevalence of Stieda's process was found in males while os trigonum was higher in females suggesting that bony union with the posterior talus is more likely to occur in males.

In our study population, PAIS was found in 8.7% of patients. Considering that most of our patients are nonatheletic, the frequency of PAIS occurrence found in our study is considerably high. Albisetti et al followed 186 trainee ballet dancers and identified a 6.5% prevalence of PAIS during a one-year period of observation (18). The higher prevalence of PAIS in our population can be explained by the repetitive trauma occurring during the physical movement in Muslim prayer (19). Repetitive plantarflexion/dorsiflexion is a continuous requirement during Muslim prayer which may cause disruption of the synchondrosis between the os and the talus or causing compression of the ossicle/ Stieda's process against the tibia.

In patients with PAIS, the most common anatomical variant was os trigonum (48.8%), followed by Stieda's process (34.1%), while the other morphologic variants were found in 17% of PAIS patients (almost absent (2.3%), normal tubercle (14.7%)). Patients with os trigonum were 4.4 times more likely to have PAIS while patients with Stieda's process were 1.5 times more likely to have PAIS. As has been previously *reported in the literature*, patients with PAIS are more likely to have an os trigonum (6, 17). Eighty- one percent of the pathologies causing PAIS were reported to be osseous in origin and os trigonum accounted for 47% of these cases while Stieda's process accounted for only 4% (11). Zwiers et al reported 46.4% prevalence of os trigonum in patients with posterior impingement complaints using CT images (6). In a recent study evaluating the prevalence of os trigonum using ankle MRI, os trigonum was found in 63.3% in patients with PAIS (17). The higher prevalence of Stieda's process in PAIS patients in our study compared to the 4% reported in a review by Ribbans et al could be attributed to the use of conventional radiographs which have lower sensitivity to CT imaging in evaluating the size of the lateral tubercle of talus (11).

The most important dataset of this study was the evaluation of os trigonum size and type in PAIS patients. PAIS was observed in 20.8% (63/303) of patients with os trigonum. Most of os trigona in PAIS patients were of a fused type (84.1%). These results suggest that a fused os trigonum has a higher incidence of symptoms compared to a separate ossicle.

Usually the os trigonum is asymptomatic; however, symptoms such as pain and swelling can occur particularly during sporting activities requiring repetitive forced plantarflexion of the foot (11, 20). Repetitive plantarflexion/dorsiflexion may result in degeneration or tear of the synchondrosis posing the fused type of os trigonum at higher risk for developing symptoms. Compared to PAIS (-) patients with os trigonum, the fused type of os trigonum was associated with higher risk for PAIS occurrence (OR 2.10, $p<0.05$). Although 57.1% of os trigonum in PAIS (+) patients sized between 0.5 and 1cm, odds ratio statistics, compared to PAIS (-) patients with os trigonum, showed that sizes larger than 1cm were associated with higher risk for PAIS occurrence (OR 1.96, $p<0.05$).

Our study has some limitations. We did not include information on the activity levels of patients with PAIS, duration and severity of clinical symptoms. In addition, the contralateral ankle was not assessed in our study. Furthermore, since a difference in incidence between populations was reported for os trigonum, future studies with a greater geographic area or a multi-country analysis should be performed. Further studies are also recommended to assess other anatomical variants like a prominent posterior downward sloping of tibia, posteromedial and posterolateral accessory ossicles that might contribute to PAIS.

Conclusion

The anatomy of the posterolateral talar tubercle is variable. An understanding of this anatomy is fundamental for recognizing the mechanisms of PAIS occurrence and the prevalence of anatomical variants contributing to PAIS. Our study showed that os trigonum was present in 48.8% of patients with PAIS and Stieda's process was found in 34.1%. PAIS is more likely to occur in patients with a fused type of os trigonum, and with sizes larger than 1cm.

Declarations

Ethical approval and consent to participate:

This study was approved by the Academic Research Council and the Ethics Committee of Jordanian Royal Medical Services and The University of Jordan.

Availability of data and materials:

Please contact authors for data requests (Heba Kalbouneh PhD –email address: heba.kalbouneh@ju.edu.jo).

Competing interests:

The authors declare that they have no competing interests.

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Author's contribution:

HK: Manuscript writing, design of the work, supervision and project development. MA: Manuscript editing and data analysis design. MBH: Acquisition of data and interpretation. HA: Acquisition of data and interpretation. YM: Data analysis and literature review. TM: Data analysis and literature review. TB: Data analysis and literature review. OA: Project development, validation and management. All authors drafted the work, approved the version to be published; and agreed to be accountable for all aspects of the work.

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Tables

Table 1: The anatomical variations of the posterolateral tubercle of talus According to Gender and Side

	All; N=1478; N (%)	Male; N=860; N (%)	Female; N=618; N (%)	Right; N=777; N (%)	Left; N=701; N (%)
Type 1	108 (7.3)	65 (7.6)	43 (7.0)	60 (7.7)	48 (6.8)
Chi-square		0.191		0.416	
P value		0.662^{ns}		0.519^{ns}	
Type 2	681 (46.1)	392 (45.6)	289 (46.8)	354 (45.6)	327 (46.6)
Chi-square		0.202		0.176	
P value		0.653^{ns}		0.675^{ns}	
Type 3	386 (26.1)	248 (28.8)	138 (22.3)	201 (25.9)	185 (26.4)
Chi-square		7.891		0.052	
P value		0.005*		0.819^{ns}	
Type 4	303 (20.5)	155 (18.0)	148 (23.9)	162 (20.8)	141 (20.1)
Chi-square		7.746		0.122	
P value		0.005*		0.727^{ns}	
*significant, ^{ns}not significant.					

Table 2: The anatomical variations of the posterolateral tubercle of talus in posterior ankle impingement syndrome

	All; N=129; N (%)	Male; N=89; N (%)	Female; N=40; N (%)	Odds Ratio	Confidence interval	P value
Type 1	3 (2.3)	2 (2.2)	1 (2.5)	0.28	0.09 to 0.90	0.023*
Type 2	19 (14.7)	13 (14.6)	6 (15.0)	0.18	0.11 to 0.30	0.000*
Type 3	44 (34.1)	31 (34.8)	13 (32.5)	1.52	1.04 to 2.24	0.031*
Type 4	63 (48.8)	43 (48.3)	20 (50.0)	4.41	3.04 to 6.40	0.000*
Chi-square		0.071				
P value		0.995^{ns}				
*significant, ns not significant.						

Table 3: The anatomical variations of the posterolateral tubercle of talus in posterior ankle impingement syndrome

	All; N=129; N (%)	Male; N=89; N (%)	Female; N=40; N (%)	Odds Ratio	Confidence interval	P value
Type 1	3 (2.3)	2 (2.2)	1 (2.5)	0.28	0.09 to 0.90	0.023*
Type 2	19 (14.7)	13 (14.6)	6 (15.0)	0.18	0.11 to 0.30	0.000*
Type 3	44 (34.1)	31 (34.8)	13 (32.5)	1.52	1.04 to 2.24	0.031*
Type 4	63 (48.8)	43 (48.3)	20 (50.0)	4.41	3.04 to 6.40	0.000*
Chi-square		0.071				
P value		0.995^{ns}				
*significant, ns not significant.						

Figures

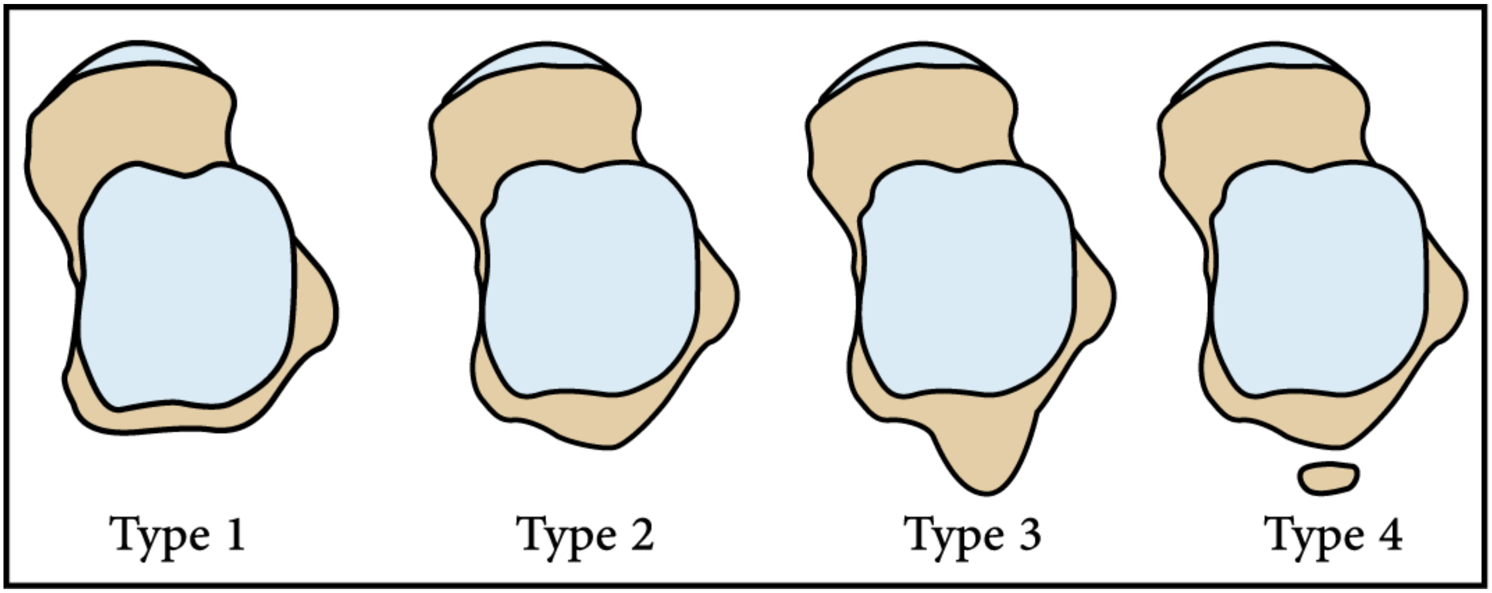

Figure 1

Variations in the lateral tubercle of the posterior talar process. 1: Almost absent, 2: Normal, 3: Enlarged (Stieda's process), and 4: Os trigonum.

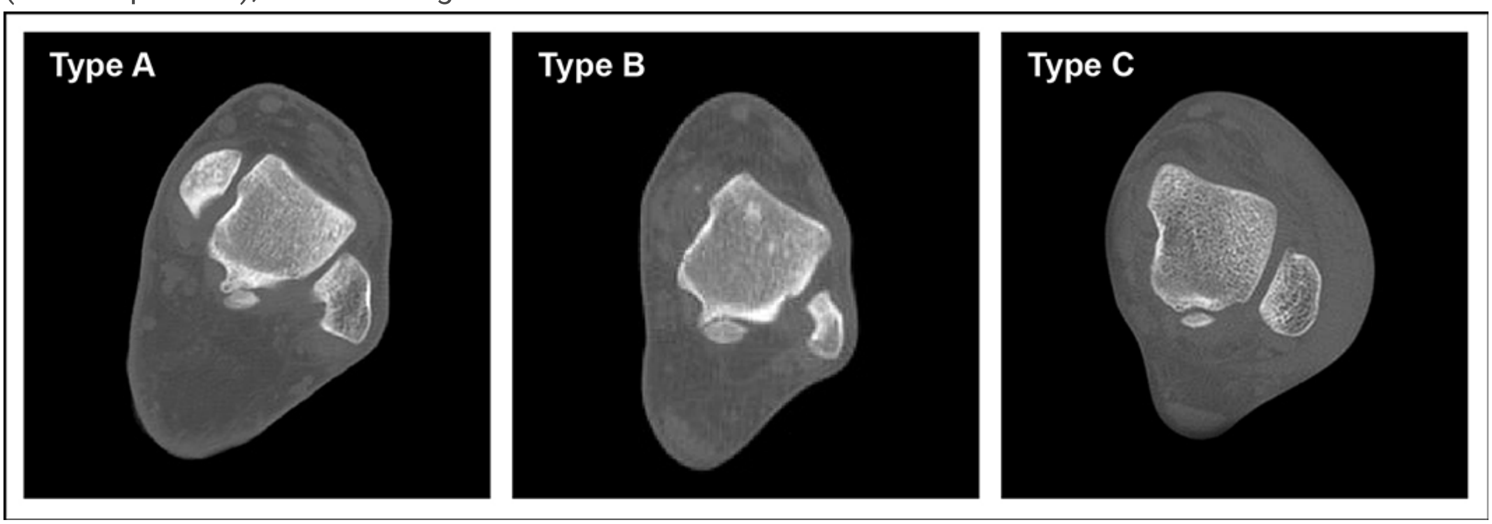

Figure 2

Axial multiplanar reformatted images of ankle computed tomography showing different types of os trigonum according to Zwier et al classification(6): Type A: os trigonum with intact lateral tubercle, Type B: os trigonum as part of the lateral tubercle and Type C: os trigonum without lateral tubercle.