Clinical Meaning of Hot Uptake on Bone Scan in Symptomatic Accessory Navicular Bones

Ari Chong¹ · Jung-Min Ha¹ · Jun-Young Lee²

Received: 27 July 2016 / Revised: 6 September 2016 / Accepted: 13 September 2016 / Published online: 13 October 2016
© Korean Society of Nuclear Medicine 2016

Abstract

Introduction We analyzed clinical factors related to uptake on a Tc-99 m HDP bone scan of the accessory navicular (AN).

Materials and Methods We retrospectively reviewed patients who had been examined by an orthopedic surgeon and underwent bone scan due to suspected symptomatic AN. A three-point grading system was used to evaluate uptake on bone scan. Relationships between grade, symptoms, age, gender, symptom duration, and bone size were analyzed.

Results In total, 73 ANs (30 asymptomatic, 43 symptomatic) were enrolled. The majority of asymptomatic ANs had no uptake but some had grade 1 ($n = 8$) or 2 ($n = 2$) uptake. All asymptomatic ANs with uptake remained asymptomatic during follow-up. For the asymptomatic ANs, larger bones showed a higher grade. With a cut-off value of size ≤ 6.8 mm, there is no chance of uptake. All symptomatic ANs showed uptake on bone scan. For symptomatic ANs, larger size and shorter pain duration were related to a higher grade. Age, gender, and left-/right-sidedness were not related to grade. Multiple regressions revealed that only uptake grade, not size or symptom duration, was the significant risk factor for a symptomatic AN. With a cut-off value of grade <1 , a symptomatic AN could be ruled out with a negative predictive value of 100 %.

Conclusion Bone scanning is useful for symptomatic ANs with a high negative predictive value. Higher grade is related to larger size and shorter pain duration. For asymptomatic ANs, grade was related to size but did not predict symptom development.

Keywords Accessory navicular bone · Emission-computed · Radionuclide imaging · Tomography

Introduction

The accessory navicular (AN) is an accessory ossicle within the tibialis posterior tendon at its navicular insertion [1]. It is also called the os tibiale externum, prehallux, or navicular secundum [2]. It is relatively common and reported to be present in 4–21 % of the population [3–6]. Usually, it is asymptomatic and observed incidentally. However, in some patients, it can be a direct cause of medial foot pain in the navicular bone area [7]. This constitutes a so-called symptomatic AN.

The mechanism of pain might be due to overuse or traumatic or degenerative changes at the synchondrosis, or to inflammation related to fusion and the bony prominence [3, 8]. A chronic stress reaction has been suggested based on pathologic reports about micro-fractures, new bone formation and inflammation, and cellular proliferation through the cartilaginous synchondrosis [9]. There is also osteonecrosis, which creates bone marrow edema on magnetic resonance imaging [3]. Usually, the first line treatment is conservative [1]. Surgery is indicated for patients who do not respond to medical management [1]. The Kidner procedure and modified Kidner procedure both involve excision and reattachment of the tendon [1]. Simple excision of the AN from the tendon also can be

✉ Jung-Min Ha
jmha@chosun.ac.kr

¹ Department of Nuclear Medicine, Chosun University Hospital, 588 Seoseok-dong, Dong-gu Gwangju, Republic of Korea 501-757

² Department of Orthopaedic Surgery, Foot and Ankle Surgery, Chosun University Hospital, Gwangju, Republic of Korea

performed [1]. However, other causes such as plantar fasciitis, tendinitis, fractures, tarsal coalitions, or tumors should be ruled out [10]. Chiu et al. [11] reported that the absence of uptake on bone scintigraphy can exclude a symptomatic AN. However, there can be hot uptake with an asymptomatic AN as well [11]. Therefore, AN uptake should be interpreted cautiously in an asymptomatic patient. However, in spite of the high incidence of asymptomatic ANs, no study has evaluated the clinical factors related to asymptomatic AN uptake on a bone scan. Also, Chiu et al. [11] attempted to use a three-point scoring system to grade bone scan uptake. However, they found that the scoring system was of no value in differentiating degrees of uptake.

Therefore, we analyzed whether bone scan uptake on an AN is related to the risk of becoming symptomatic. We also analyzed whether clinical factors such as age, size of bone, or duration of symptoms are related to the grade of uptake on the

bone scan. In addition, we investigated the diagnostic value of the bone scan and single photon emission/computed tomography (SPECT/CT) using a grading system in patients with symptomatic ANs.

Patients and Methods

Patients

This was a retrospective study. We reviewed 58 patients (99 ANs) who underwent a Tc-99 m hydroxymethylene diphosphonate (HDP) bone scan (bone scan) between October 2012 and June 2014 to evaluate the AN due to typical foot pain suggesting a symptomatic AN (Fig. 1). We enrolled all patients who met all of the inclusion criteria, which were as follows: 1) patients with typical medial foot pain, 2) those with AN proven on X-ray, 3)

Fig. 1 Flow chart of enrollment and grades on bone scan. Footnote a) Among bilateral AN and unilateral foot pain, four patients had medical records only about original “symptomatic foot” area during follow-up. There was not any comment about other foot with asymptomatic AN about checking out development of pain follow-up. Therefore, 4 feet were excluded for analysis of asymptomatic AN. Their grades were three of uptake grade 1 and one of uptake grade 2. b) Fourteen ANs with uptake grade 1 and eight ANs with uptake grade 2. c-e) All of

these patients did not become symptomatic during follow-up period. f) No uptake on AN but hot uptake on the talonavicular joint. g) Symptoms of these patients were subsided after treatment (operation ($n=11$) or conservative treatment ($n=6$)). h) Twenty-five patients with grade 2 uptake underwent operation and became asymptomatic. The other patient had conservative treatment and did not become asymptomatic until 35 months of follow-up. *Abbreviation: R/O, rule out

those who were examined by an orthopedic surgeon and tentatively diagnosed with a “symptomatic AN”, 4) patients who underwent a bone scan to evaluate the foot, and 5) those whose clinical follow-up after the bone scan was performed and a final diagnosis was made by an orthopedic surgeon. The final diagnosis was made based on the clinical follow-up after the scan, and the surgeon then decided on the correct treatment. If typical pain was not reported from the time of enrollment until the last day of the follow-up period, that bone was confirmed as an asymptomatic AN. Figure 1 describes the process of enrollment. We excluded patients with pain in any other part of the foot besides the medial portion. We also excluded feet whose clinical follow-up was not done to rule out false positives or false negatives. This retrospective study was approved by the Institutional Review Board of our institution.

Bone Scan and Interpretation

Tc-99 m HDP 740 MBq (20 mCi) was injected intravenously. For pediatric dosing, we followed the European recommendations [12]. After 4 h, the whole body scan was done using a dual-head gamma camera (INFINIA GP3, GE, USA) with a low-energy, high-resolution collimator; the photo peak was 140 keV with a 20 % window (128 × 128 matrix). After whole-body scanning, plantar images of both feet were obtained. Then, SPECT/CT images were obtained on both feet (INFINIA HAWKEYE 4, GE).

All scans were read and analyzed retrospectively. Image readers were blinded to the final diagnosis and knew only whether the accessory bone was present or absent in each foot. The grade of HDP uptake on the accessory bone area (medial foot) was decided by two nuclear physicians via consensus. The three-point scale was scored as follows: grade 0, no uptake; grade 1, mild uptake; and grade 2, hot uptake [11]. Mild uptake (grade 1) was defined as activity similar or mildly greater than the adjacent cuneiform bone. Hot uptake (grade 2) was defined as markedly increased uptake compared to the adjacent bone (Fig. 2). Grades on all the planar images, fusion images, and maximum intensity projection images were recorded on the bone scan and SPECT/CT.

Clinical Factors

Age, gender, duration of symptoms, size of AN (longest, mm), and location of AN (right/left foot) were obtained by reviewing medical records.

Statistical Analysis

Data which were accepted based on a Kolmogorov-Smirnov normality test were analyzed using parametric tests such as the

Fig. 2 Grades on bone scan. Plantar images of bone scans (a–c) showed grade 0 (a), grade 1 (arrow, b), and grade 2 (arrow, c)

t-test, chi-square test, chi-square for trend, or simple correlation. Other data were analyzed by non-parametric tests such as the Mann–Whitney *U* test, Fisher’s exact test, or Wilcoxon’s test. Logistic regression and receiver-operator curve analysis was also done. Inter-rater agreement of the two image readers regarding the grade of uptake was analyzed. The MedCalc software package (ver. 13.3.3.0; MedCalc, Inc., Ostend, Belgium) was used for analyses. *P*-values < 0.05 were considered to be statistically significant.

Results

Enrolled Subjects

A total of 73 ANs (28 asymptomatic ANs and 45 suspected symptomatic ANs before the scan) were enrolled (Fig. 1 and Table 1). After clinical follow-up, the diagnosis was changed in two patients (from symptomatic AN to arthritis). Therefore, based on the final diagnosis, there were 30 confirmed cases of asymptomatic ANs and 43 confirmed symptomatic ANs.

Bone Scan Findings and Follow-Up

Among asymptomatic cases of AN, more than half of the patients did not show any uptake on AN (Fig. 1). However, there were eight asymptomatic AN with grade 1 uptake and two asymptomatic AN with grade 2 uptake.

All of them remained asymptomatic until the last day of clinical follow up (6.25 ± 9.5 months; range: 1–35 months). Therefore, they were all confirmed as asymptomatic ANs.

Among the symptomatic ANs, 17 had grade 1 uptake and 26 had grade 2 uptake (Fig. 1g and h). Among the ANs suspicious for being symptomatic, two of them were proven to

Table 1 Patients' characteristics

A. Asymptomatic AN				
Grade on bone scan	All	Grade 0	Grade 1	Grade 2
Number of AN	28	18	8	2
Age, range (year)	10–66	10–66	13–49	28 & 19
(median, average)	(20.5, 23.46)	(20.5, 23.78)	(21, 22.75)	
Gender (M:F)	12:16	7:11	5:3	0:2
Size, range (mm)	2.1–16.4	2.1–14.1	7–16.4	15.6&14.6
(median, average)	(9.2, 9.56)	(7.5, 7.77)	(12.6, 12.21)	
Laterality (right: left)	13:15	9:9	4:4	0:2
B. Symptomatic AN				
Grade on bone scan	All	Grade 0	Grade 1	Grade 2
Number of AN	45	2	17	26
Age, range (year)	10–51	37 & 20	10–51	13–49
(median, average)	(20, 22.91)		(19.0, 21.0)	(20.5, 23.73)
Gender (M:F)	17:28	1:1	6:11	10:16
Size, range (mm)	5.2–18.3	8.7& 9.0	5.2–15.7	9.1–18.3
(median, average)	(12.7, 12.0)		(11.6, 10.71)	(13.2, 13.09)
Laterality (right: left)	26:19	1:1	7:10	18:8
Duration of symptom, range (month)		13.0 & 54.0	0.5–82.33	0.46–43.47
(median, average)			(24.67, 28.91)	(9.73, 12.64)

not be the source of pain (Fig. 1f). Talonavicular arthritis was identified as the cause of pain in both of these cases and the bone scan showed hot uptake on that joint and not on ANs (Figs. 1f and 3). For symptomatic ANs with grade 2 uptake, all patients underwent surgery except one because he refused the operation but still complained about foot pain on clinical follow-up after 35 months. Follow-up bone scan of that patient showed decreased uptake compared to the previous scan. For symptomatic ANs with grade 1 uptake, 11 patients underwent the operation and six were treated conservatively. All of them were asymptomatic at the last follow-up as assessed by the orthopedic surgeon (19.49 ± 12.31 months; range: 6.3–36.1 months).

Asymptomatic Accessory Navicular: Factors Related to Bone Scan Uptake

In asymptomatic ANs, larger bones showed a higher uptake grade (correlation coefficient $r = 0.6317$, $p = 0.0003$ on simple correlation). The size of the bones of the group with bone scan uptake was significantly larger than that of the bones without uptake ($p = 0.0005$, t -test). For predicting grade 2 uptake, receiver operating characteristic (ROC) curve analysis showed that a cut-off value > 14.2 mm had a sensitivity of 100 %, a specificity of 92.31 %, positive predictive value of 50 %, and negative predictive value of 100 %. For predicting grade 1 and 2 uptake, ROC curve analysis showed that a cut-off value > 6.8 mm had a sensitivity of 100 %, a specificity of 44.44 %, positive predictive value of 50 %, and negative predictive value of 100 %. Therefore, when the size of the

asymptomatic AN is ≤ 14.2 mm, there is no chance of grade 2 uptake. Also, when the size of the asymptomatic AN is ≤ 6.8 mm, there is no chance of grade 1 or 2 uptake. Other clinical factors, such as age, gender, and the side of the AN (left/right) were not related to bone scan uptake on an asymptomatic AN.

Symptomatic Accessory Navicular: Factors Related to Uptake

In symptomatic ANs, the larger bones showed a higher uptake grade (correlation coefficient $r = 0.3950$, $p = 0.0088$, simple correlation). Also, a shorter duration of symptoms was related to a higher uptake grade (correlation coefficient $r = -0.3926$, $p = 0.0076$, simple correlation).

Other clinical factors, such as age, gender, and the side of the AN (left/right) were not related to uptake on the AN regardless of pain.

Diagnosis of Symptomatic Accessory Navicular

For the final diagnosis of symptomatic AN, logistic regression revealed that both size (odds ratio = 1.26, $p = 0.0035$) and grade (odds ratio = 22.94, $p < 0.0001$) were significant factors. However, multiple regressions revealed that only the grade was a significant risk factor for diagnosis of a symptomatic AN.

To overcome the confounding factors of size and symptom duration, we analyzed the partial correlation which revealed that there was also a significant correlation between grade and

Fig. 3 A case of talonavicular joint arthritis. A 20-year-old male complained of left medial foot pain of 2 months' duration. On plain X-ray images of the foot (**a**), there was an accessory navicular bone (arrow). An orthopedic surgeon detected tenderness of the medial foot, suggesting a symptomatic accessory navicular bone. A Tc-99 m hydroxymethylene diphosphonate (HDP) bone scan (**b** & **c**) and single photon emission/computed tomography (SPECT/CT) (**d–f**) were done to evaluate the accessory navicular bone. There was no specific HDP uptake on the medial foot area of the accessory navicular bone (**b**, plantar image of left foot; **c**, medial view), but there was hot uptake in the mid foot area. On SPECT/CT (**d**, sagittal view of CT portion; **e**, sagittal view of SPECT; and **f**, fusion sagittal image), the hot uptake was on the talonavicular joint. Sclerotic changes of the talonavicular joint are shown (**d**, sagittal CT portion of SPECT/CT)

diagnosis of a symptomatic AN (correlation coefficient $r = 0.5343$, $p = 0.0002$).

The ROC analysis revealed that uptake on the bone scan is an excellent means of diagnosing a symptomatic AN (area under the curve = 0.901, standard error = 0.0360, 95 % confidence interval: 0.808, 0.958; $p < 0.0001$). Diagnostic performances are described in Table 1 with each cut-off value (grade ≥ 1 or grade 2). By using a cut-off value of grade < 1 on the bone scan uptake, a symptomatic AN can be ruled out with a negative predictive value of 100 % (Table 2).

Grade on Planar Image vs. SPECT/CT vs. Maximum Intensity Projection (MIP)

Inter-rater agreement of grades between the two readers was very good (weighted Kappa = 0.868). Uptake grade of AN also showed good agreement between the planar image, SPECT/CT, and MIP (inter-rater agreement). Furthermore,

Table 2 Diagnostic performance of symptomatic accessory navicular bone by uptake grade on Tc-99 m HDP bone scintigraphy

	Value	95 % Confidence interval
Diagnostic criteria: grade ≥ 1 (mild uptake)		
Sensitivity	100.00 %	91.78 to 100.00 %
Specificity	66.67 %	47.19 to 82.71 %
Positive likelihood ratio	3.00	1.81 to 4.98
Negative likelihood ratio	0.00	
Disease prevalence	58.90 %	46.77 to 70.29 %
Positive predictive value	81.13 %	68.03 to 90.56 %
Negative predictive value	100.00 %	83.16 to 100.00 %
Diagnostic criteria: grade ≥ 2 (hot uptake)		
Sensitivity	60.47 %	44.41 to 75.02 %
Specificity	93.33 %	77.93 to 99.18 %
Positive likelihood ratio	9.07	2.33 to 35.36
Negative likelihood ratio	0.42	0.29 to 0.62
Disease prevalence	58.90 %	46.77 to 70.29 %
Positive predictive value	92.86 %	76.50 to 99.12 %
Negative predictive value	62.22 %	46.54 to 76.23 %

comparison of the ROC curves revealed that there was no difference between planar images, SPECT/CT, and MIP in the diagnosis of symptomatic AN with the uptake grade. However, SPECT/CT can show anatomic information (Fig. 3).

Discussion

In this study, we found that a larger size of asymptomatic AN is related to a higher grade of uptake on bone scans. To the best of our knowledge, this is the first report to focus on the size and the uptake grade of asymptomatic ANs. We found that with a cut-off value of size ≤ 6.8 mm, there is no chance of grade 1 or 2 uptake.

The reason for increased uptake on an asymptomatic AN is not clear. None of the asymptomatic ANs with increased uptake on the bone scan became symptomatic during follow-up. This means that uptake on the bone scan was not a predictor of future symptoms. As in our study, Chisin et al. [13] reported that there was increased uptake on the great toe sesamoids in 29 % of asymptomatic subjects undergoing demanding physical training and in 26 % of subjects who were sedentary. They concluded that increased uptake may represent normal physiology [13]. Chiu et al. [11] also stated that increased bony uptake in asymptomatic subjects may not be a risk factor because none of their asymptomatic patients became symptomatic.

We found that uptake on asymptomatic bones was not a predictor of becoming symptomatic. Therefore, assessing the

value of scoring on the bone scan should not be used for diagnosis and differentiation. Furthermore, using a grading system in asymptomatic patients seems to be illogical. The grading system should only be used for ANs suspicious for becoming symptomatic. Among patients suspicious for having a symptomatic AN, a lack of uptake (grade 0) on the bone scan can rule out the possibility of a symptomatic AN with a negative predictive value of 100 % (Table 2). A diagnostic criterion of grade ≥ 1 is apparently more helpful in ruling out symptomatic ANs in the evaluation of foot pain due to its higher negative predictive value than a criterion of grade ≥ 2 (Table 2). Also, considering that the size and symptom duration are related to the grade, the grading system can also be used for additional information.

We used grading system in analysis. Chiu et al. [11] conducted a similar study with a small population (13 symptomatic and ten asymptomatic ANs) and reported that the uptake grade of the bone scan was of no value in differentiating symptoms. However, the clinical diagnosis of AN is not completely based on imaging, as the physical examination and patient history are also essential to diagnosis. Uptake grade of bone scan should not be used to detect disease but rather to rule it out.

Based on our study, larger size of AN and shorter duration of symptoms are related to a higher uptake grade of symptomatic ANs. Previously, a group analyzed three phase bone scans of ten patients with symptomatic AN and they reported that hyperemia was shown in all symptomatic ANs [14] (they did not conducted analysis based on grading system). Another group analyzed 24 ft of 16 patients who underwent SPECT/CT for symptomatic accessory bone and classified patients into high and low uptake groups [15]. In their study, the high uptake group had a higher pain score [15] (we could not conducted pain score analysis due to lack of information on medical record). The information about pain duration was not shown but all patients of the low uptake group improved after non-operative treatment [15]. Like we mentioned earlier, the exact reason of symptom of AN is not clear. However when we consider that trauma related to stress on pre-existing AN may produce pain [14], we authors suggested that bone scan uptake of symptomatic AN may be similar to that of fracture. That may cause shorter duration of pain to be related to higher grade on bone scan of AN.

In our study, the grades on planar images and fusion SPECT/CT images were not different. Also, the SPECT/CT in our study did not provide much additional information except to help localize arthritis (Fig. 3). In contrast to our study, a previous study by Mohan et al. [16] that used SPECT/CT in foot and ankle diseases reported that SPECT/CT could provide additional information in 80.6 % of patients and changed the method of management in 61.3 % of cases. This is probably due to differences in enrolled patients. In our study, all patients had a clinical impression of a symptomatic AN based

on X-rays of the foot and physical examinations by orthopedic surgeons. Other diagnoses such as foot fractures had been ruled out before referral for the bone scan. Therefore, our study suggested that in this limited population of patients with highly suspected AN pathology, SPECT/CT would only provide limited information.

Our study had several limitations. First, this was a retrospective study. The relationship between uptake grade and clinical factors such as responsiveness to treatment (conservative treatment or surgery), pain degree, and amount of physical activity could not be analyzed due to lack of information. Also, orthopedic surgeons exclusively selected the method of treatment for each patient regardless of grading on the bone scan. We found that only a larger size and shorter duration of pain are related to a higher grade. Further studies regarding the grade and other clinical factors such as the severity of pain, prediction of treatment response, and choice of treatment method are needed. In addition, the disease prevalence of our patients was almost near 50 %. Therefore, the cut-off value from this study should only be used for patients with foot pain with accessory bone and not for patients without foot pain.

Bone scanning is a useful imaging tool for cases of symptomatic ANs and has a high negative predictive value. For symptomatic ANs, a higher uptake grade on the bone scan is related to a larger size and shorter duration of pain. For asymptomatic ANs, uptake on the bone scan was related to size but was not a predictor of the development of symptoms.

Acknowledgments This study was supported by research fund from Chosun University, 2013

Compliance with Ethical Standards

Conflict of Interest Ari Chong, Jung-Min Ha and Jun-Young Lee declare that they have no conflict of interests.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent The institutional review board of our institute approved this retrospective study, and the requirement to obtain informed consent was waived.

References

1. Kim JR, Park CI, Moon YJ, Wang SI, Kwon KS. Concomitant calcaneo-cuboid-cuneiform osteotomies and the modified Kidner procedure for severe flatfoot associated with symptomatic accessory navicular in children and adolescents. *J Orthop Surg Res.* 2014;9:131.

2. Fredrick LA, Beall DP, Ly JQ, Fish JR. The symptomatic accessory navicular bone: a report and discussion of the clinical presentation. *Curr Probl Diagn Radiol*. 2005;34:47–50.
3. Mellado JM, Ramos A, Salvado E, Camins A, Danus M, Sauri A. Accessory ossicles and sesamoid bones of the ankle and foot: imaging findings, clinical significance and differential diagnosis. *Eur Radiol*. 2003;13 Suppl 4:L164–77.
4. Miller TT. Painful accessory bones of the foot. *Semin Musculoskelet Radiol*. 2002;6:153–61.
5. Sarrafian SK, Kelikian AS. Osteology. In: Sarrafian SK, editor. *Anatomy of the foot and ankle*. Philadelphia: Lippincott; 1993. p. 89–112.
6. Keats TE. The foot. In: Keats TE, editor. *Atlas of normal roentgen variants that may simulate disease*. St. Louis: Mosby-Year Book; 1992. p. 615–704.
7. Romanowski CA, Barrington NA. The accessory navicular—an important cause of medial foot pain. *Clin Radiol*. 1992;46:261–4.
8. Jain S, Karunanithi S, Agarwal KK, Kumar G, Roy SG, Tripathi M. Incremental value of single photon emission tomography/computed tomography in 3-phase bone scintigraphy of an accessory navicular bone. *Indian J Nucl Med*. 2014;29:191–2.
9. Grogan DP, Gasser SI, Ogden JA. The painful accessory navicular: a clinical and histopathological study. *Foot Ankle*. 1989;10:164–9.
10. Tsuruta T, Shiokawa Y, Kato A, Matsumoto T, Yamazoe Y, Oike T, et al. Radiological study of the accessory skeletal elements in the foot and ankle (author's transl). *Nihon Seikeigeka Gakkai Zasshi*. 1981;55:357–70.
11. Chiu NT, Jou IM, Lee BF, Yao WJ, Tu DG, Wu PS. Symptomatic and asymptomatic accessory navicular bones: findings of Tc-99m MDP bone scintigraphy. *Clin Radiol*. 2000;55:353–5.
12. Lassmann M, Biassoni L, Monsieurs M, Franzius C, Jacobs F. The new EANM paediatric dosage card. *Eur J Nucl Med Mol Imaging*. 2007;34:796–8.
13. Chisin R, Peyser A, Milgrom C. Bone scintigraphy in the assessment of the hallucal sesamoids. *Foot Ankle Int*. 1995;16:291–4.
14. Sudhakar P, Sharma AR, Narsimhulu G, Prabhakar V. Diagnostic utility and clinical significance of three phase bone scan in symptomatic accessory navicular bone. *Indian J Nucl Med*. 2006;21:18–22.
15. Kim RS, Kang JS, Kim YT, Kim BS. Diagnosing symptomatic accessory tarsal bones using SPECT/CT. *J Korean Foot Ankle Soc*. 2011;15:212–6.
16. Mohan H, Holker P, Gnanasegaran G, Vijayanathan S, Sharp D, Langroudi B, et al. The applicability of SPECT-CT in directing the management of bony foot and ankle pathology. *Eur J Nucl Med Mol Imaging*. 2007;34 suppl 2:S166.