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Prevalence and classification of accessory navicular bone: a medical record review

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BACKGROUND: The accessory navicular bone (ANB) is one of the most common accessory bones in the foot. Certain pathologies, such as posterior tibial tendon insufficiency are associated with ANB, and should be differentiated from midfoot and hindfoot fractures such as navicular tuberosity avulsion fractures. There are few studies addressing the prevalence and types of ANB in Saudi Arabia.

OBJECTIVES: Determine the prevalence and morphological variations of ANB and its relation with age and sex in patients visiting foot and ankle clinics.

DESIGN: Medical record review

SETTING: Orthopedic foot and ankle clinic at a university hospital.

PATIENTS AND METHODS: The presence of ANB was retrospectively analyzed in radiographs from patients who presented to the orthopedic foot and ankle at our university hospital from February 2010 to December 2020. The patients were stratified according to sex, age, and diagnosis. For each ANB, recorded information included site, size, classification, subtypes, and symptomatology. Purposive sampling was used to select the patients for the study (non-probability sampling).

MAIN OUTCOME MEASURES: Prevalence of ANB in patients attending a foot and ankle clinic.

SAMPLE SIZE: 117 patients and 194 feet.

RESULTS: ANB was analyzed in 1006 radiographs from 503 patients. ANB was detected in 117 (23.3%) patients and 194 (19.3%) feet Prevalence was significantly higher in females (67.5%) than in males (32.5%) ($Z=5.359$, $P<.001$). The ages ranged from 19 to 86 years, with a mean age of 48.26 (14.5) years. The most common site was bilateral (77 patients, 65.8 %). Type I was the most common type, with a prevalence of 42.1%. There were no significant differences in types in relation to sex, but all types and subtypes differed significantly from each other.

CONCLUSION: ANB was common among patients presenting to the foot and ankle clinic, with an overall prevalence of 23.3%. It should be considered among the differential diagnosis in chronic foot pain, and should be differentiated from midfoot and hindfoot fractures. Further studies with a larger, randomized sample are needed, for more accuracy and to confirm the reported results.

LIMITATIONS: Retrospective chart review, non-probability sampling, and use of plain radiographs.

CONFLICT OF INTEREST: None.

The accessory navicular bone (ANB) is one of the most common accessory ossicles in the foot and ankle.[1,2] It has been called os naviculare, os tibiale externum, navicular secundum, os naviculare secundarium, accessory scaphoid, accessory tarsal scaphoid, divided navicular and prehallux.[1,2] The accessory navicular is located on the medial aspect of the arch and is closely related to the tibialis posterior tendon and navicular bone.[1,2] ANB can be detected by X-ray and magnetic resonance imaging, among other imaging techniques.[2]

According to Coughlin et al ANB can be classified into three types.[1] Type I is a small, round, or oval-shaped accessory ossicle unattached to the navicular bone.[1] It is almost always asymptomatic and can be found on the plantar aspect of the tibialis posterior tendon at the level of the inferior calcaneonavicular ligament.[1] Type II is connected to the navicular body; however, a fibrocartilaginous plate with a width of less than 2 mm separates the tuberosity from the body.[1] Type II tends to be symptomatic, and it is sometimes misdiagnosed as a navicular tuberosity fracture.[1] Sella and Lawson differentiated type II ANB into two separate entities according to the angle of attachment.[3] A type IIA ANB attaches with the talar process by a less acute angle, while a type IIB ANB is located more inferiorly.[3] Type III ANB is fused with the navicular bone by a small bone, producing cornuate shaped bone.[4] A modified Coughlin classification uses subtypes a, b, and c according to their image appearance and has been used to further report the classification of ANB.[5]

ANB is usually an asymptomatic ossicle and detected incidentally on radiographs. However, pain has been reported especially in type II ANB.[5,6] The cause of symptomatic accessory navicular bone pain has always been controversial. Pain has recently been linked to local mechanical factors such as tension, shearing, or compression forces resulting from pressure against shoes, overuse, or twisting injuries.[7]

The incidence of accessory ossicles in the foot and ankle varies between 2% and 25% among the general population,[2,5-11] with an epidemiological rate of 21% in a study from Jordan, 20% in a study from China, 46.0% in a study from Asia, and 11% in a study from Turkey.[5,6,8,9] The differential diagnoses for symptomatic ANB are avulsion fractures of the tuberosity, tarsal stress fractures, arthritis, and posterior tibial tendon rupture.[2,12] Furthermore, certain pathologies, such as flatfoot or posterior tibial tendon (PTT) insufficiency are particularly associated with ANB types II and III.[1,3,7]

There are few studies assessing the prevalence and types of ANB, and no such studies have been conducted in Saudi Arabia.[5,6,8-11] It is one of the differential diagnoses for foot fractures; thus accurate identification and clinical significance of ANB should be recognized to decrease the rate of misdiagnosis and unnecessary orthopedic intervention when a patient presents to the emergency department with a traumatic/twisting foot injury. This study aimed to determine the prevalence and patterns of ANB and its relation with age and sex in patients visiting foot and ankle clinics in a University Hospital, Riyadh, Saudi Arabia.

PATIENTS AND METHODS

We reviewed the medical records of patients aged 18 years and older who presented to the orthopedic foot and ankle clinic at King Saud University Medical City between February 2010 and December 2020 and had a minimum of two radiographs (standard anterior-posterior (AP), standard lateral, and/or oblique X-ray) of both feet. Purposive sampling was used to select the patients for the study (non-probability sampling) until an adequate sample size was reached. Patients were excluded if they had previous foot and/or ankle surgeries, a diagnosis of rheumatoid arthritis, or incomplete documentation. The primary outcome measure was prevalence of ANB in patients attending a foot and ankle clinic. Secondary outcome measures were classifications and subtypes of ANB. Ethics approval was granted by the King Saud University Institutional Review Board, (reference number E-19-4359) to review patient medical records. Informed consent was not required for the enrollment of patients in the study. To preserve anonymity, each patient was assigned a unique identification. Confidentiality of the collected data was maintained during all the phases of the study.

A standardized data collection sheet was used to collect the demographic data, clinical presentations, and radiological diagnoses. All X-ray images were independently and anonymously analyzed by two experienced specialists in foot and ankle surgery for the presence or absence of ANB in patients presenting with various complaints. In cases of disagreement, a third specialist was consulted. When ANB was identified, it was classified into different subtypes. The modified Coughlin classification was used to categorize ANB (**Figure 1**); ANB was classified into types I, II, and III and subtyped into a, b, and c.[1,5] Type II was further classified into subtypes IIA and IIB according to Sella and Lawson.[3,4] The size of each ANB was calculated by taking its highest axial measurements (highest reading recorded when drawing a straight line from the bone edges) in a standard AP X-ray view. In multipartite bones such as bi-

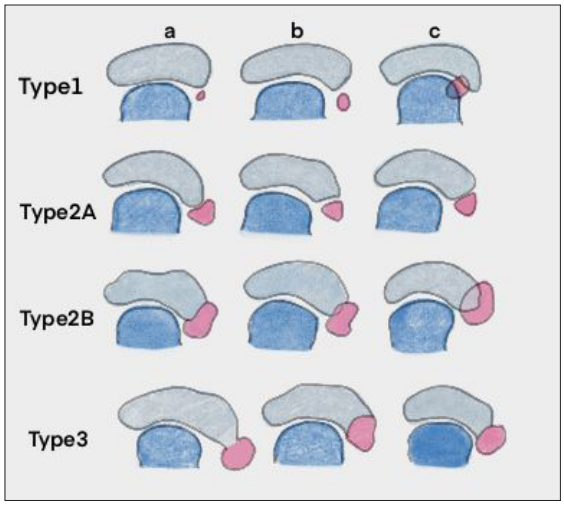

Figure 1. Classification of accessory navicular bones by the modified Coughlin classification.

partite and tripartite bones, each bone was measured separately.[13] Classification of multipartite bones were based on the largest bone. The following information was recorded for each ANB: site (left, right, or bilateral), size (highest axial measurements), classification (Type I, IIA, IIB, III), subtypes (a, b, c), and whether they were symptomatic. Patients were stratified by age (greater than 75, 65-74, 55-64, 45-54, 35-44, 25-34, and less than 24 years), sex , and reasons for visiting and obtaining radiographs (chronic foot pain, pes planus, trauma, big toe pathology, ankle pain, foot deformity, twisting injury, and others, which included screening, knee pain, extra digit, ingrown toenail, biopsy and leg swelling).

The proportion of people with ANB for a single proportion was estimated using the following formula: n=N*X / (X + N – 1) with a 95% confidence interval, and 5% margin of error. In a similar study, researchers assessed the radiographs of 650 patients at Akdeniz University Hospital in Turkey,[9] and a proportion of 11% was detected. Using the above-mentioned formula, the estimated minimum sample size was 242 patients.

Differences between groups were assessed using the chi-squared statistic for categorical data and *t* tests and analysis of variance (ANOVA) for continuous variables. Microsoft Office Excel 2018 (Microsoft Corporation Redmond, Washington, U.S.) was used for the data entry. Data were exported to IBM SPSS (Version 28.0. Armonk, NY: IBM Corp) for data analysis. The Z-test for two proportions was performed manually.

RESULTS

Overall, 1006 foot radiographs of 503 patients were reviewed and ANB was detected in 117 (23.3%) patients and 194 (19.3%) feet. The prevalence of ANB was significantly higher in females (n=79, 67.5%) than that in males (n=38, 32.5%) (Z=5.359, *P*<.001). The patients' ages ranged from 19 to 86 years, with a mean age of 48.3 (14.5) years. However, there was no difference in the prevalence of ANB according to age group stratified by sex [χ^2 (6)=7.017, *P*=.319] (**Table 1**). The most common reason for consultation at the foot and ankle clinic and obtaining foot radiographs was chronic foot pain (29 patients, 25.7%), followed by pes planus (28 patients, 24.8%). No significant differences were found in the reason for consultation according to sex [χ^2(7)=5.084, *P*=.650] (**Table 1**).

According to the Coughlin classification,[1] accessory navicular bones were bilateral in 77 (65.8%) patients, on the right foot in 19 (16.2%) patients, and on the left foot in 21 (17.9%) patients (**Table 2**). The ANB site did not differ by sex [χ^2 (2)=0.311, *P*=.856]. All three types of ANB were noted in this study; type I was the predominant variant with an overall prevalence of 41.1%. The percentages of the other types of ANB were as follows: type IIA, 13.9% (27 feet); type IIB, 19.6% (38 feet); and type III, 24.7% (48 feet). One patient had both type III and type I (0.5%). No significant differences were found in type according to sex for either the right foot [χ^2(3)=2.0424, *P*=.658] or left foot χ^2(4)=5.453, *P*=.244]. Type III ANB had the largest average size [left=1.95 cm (0.37 cm); right=1.91 cm (0.36 cm)], while type I ANB had the smallest average size [Left=0.57 cm (0.25); right=0.48 cm (0.24 cm]). The ANOVA results indicated that the four types were significantly different for the right foot (F=10.055, *P*<.001), with post-hoc tests indicating that all types differed significantly from each other. Similarly, the ANOVA results showed significant differences in the size of the various types for the left foot (F=121.436, *P*<.001), although in this instance, post-hoc tests showed that types I and III ANB differed from each other and from types IIA and IIB ANB. However, type IIA and IIB ANB were not significantly different from each other. No significant differences were found in the mean ANB sizes in either foot according to sex (**Table 2**).

The proportion of subtypes (a, b, c) within each type (I, IIA, IIB, III, III and I) were compared for right and left feet (**Table 3**). The chi-squared tests showed that the proportions of the subtypes differed significantly across types for both the right [χ^2(12)=159.443, *P*<.001] and the left feet [χ^2(12)=36.026, *P*<.001]; post-hoc tests, with Bonferroni correction, revealed the proportions of subtypes that were significantly different across types.

Rare anatomical variants of ANB, such as bipartite and tripartite bones, were observed in 4.1% of the pa-

Table 1. Demographic characteristics of patients with accessory navicular bones by sex

Characteristic	Males (n=38)	Females (n=79)	Statistic	*P* value
Age (years)	46.9 (17.2), 19-86	48.9 (13.2), 22-79	-0.719	.474
Age group (years)				
≤24	6 (15.8)	4 (5.1)		
25-34	5 (13.2)	7 (8.9)		
35-44	5 (13.2)	16 (20.3)		
45-54	8 (21.1)	24 (30.4)	7.017	.319
55-64	8 (21.1)	21 (26.6)		
65-74	4 (10.5)	4 (5.1)		
≥75	2 (5.3)	3 (3.8)		
Reason for consultation[a]				
Chronic foot pain	7 (18.4)	22 (29.3)		
Pes planus	11 (28.9)	17 (22.7)		
Trauma	7 (18.4)	7 (9.3)		
Big toe pathology	3 (7.9)	4 (5.3)	5.084	.650
Ankle pain	1 (2.6)	5 (6.7)		
Foot deformity	1 (2.6)	5 (6.7)		
Twisting injury	1 (2.6)	2 (2.7)		
Other[b]	7 (18.4)	13 (17.3		
Side affected				
Left	6 (15.8)	15 (19.0)		
Right	7 (18.4)	12 (15.2)	0.311	.856
Bilateral	25 (65.8)	52 (65.8)		

Data are n (%) and mean (standard deviation) and range for age. [a]Reason for consultation was missing for four patients; [b]Includes screening, knee pain, extra digit, ingrown toenail, biopsy, and leg swelling.

tients (n=8). In 185 (95.9%) feet, the ANB was single, whereas in 7 feet (3.6%), it was bipartite; only 1 foot (0.5%) was tripartite. Most cases of ANB in the current study were incidental. Of the 117 patients presenting to the foot and ankle clinic, only 4 patients complained of a painful ANB (3.4%), 3 of which presented after traumatic twisting injuries of the left foot, with mild to severe pain in the medial arch. Radiographs revealed type IIB ANB in two patients and type III in one patient. All of the three had bilateral ANB.

DISCUSSION

The incidence of ANB in the general population is reported to be between 2% and 25% among the general population.[2,5-11] Out of the 503 patients screened in our study, 117 (23.3%) patients and 194 (19.3%) feet exhibited ANB. According to studies by Huang et al,[6] and Keles et al,[9] females exhibited a slightly higher prevalence of ANB than males, with frequencies of 56.5% and 55.6%, respectively.[6,9] By comparison, we found the rate to be 67.5% in females. Most patients visited the foot and ankle clinic because of chronic foot pain (25.7%); however, only four patients in our study had pain related to ANB. These findings support previous studies where most cases are asymptomatic, with a reported incidence of painful ANB to be less than 1%.[1,5,9]

All three types of Coughlin classification of ANB were observed in this study, with type I having the highest prevalence (41.2%) and occurring in 71.2% of females. This finding is similar to a study by Huang et al, in which 41.6% of patients had type I ANB, with 57.7% occurring in females.[6] In contrast, Keles et al reported the incidence

of type I ANB to be 30.5%, ranking it as the second most common type after type III ANB.[9] Kalbouneh et al similarly reported that type I ANB was the second most common type, with a prevalence of 25.4%.[5] According to Stacy et al, the prevalence of type I ANB and type IIB ANB was 19.6% and 24.6%, respectively.[8]

Type IIA ANB was found in 13.9% of the cases and the least common type in our study. Similarly, Keles et al,[9] Kalbouneh et al,[5] and Stacy et al,[8] reported type IIA ANB as the least common type, occurring in 11.1%, 20.0%, and 3.6% of cases, respectively. Type IIB ANB was the third most common type in our study, with a prevalence of 19.6%. Kalbouneh et al found similar results, with the prevalence of type IIB ANB to be 22.4%, making it the third most common ANB type in their study.[5] Keles et al reported a prevalence of type IIB ANB of 16.6%, making it the third most common type in their study.[9] Finally, type III ANB was observed in 24.7% of the cases and ranked as the second most common type in our study. Huang et al reported a similar incidence of 21.6%, with type III ANB as the second most common type in their study.[6] However, higher percentages were reported by Keles et al (42.6%) and Kalbouneh et al (32.0%); both studies reported type III ANB as the most common type.[5,9] The variation in the number of the predominant type results in our study compared to other studies could be due to differences in the predominant sex or the inclusion of a higher age group. We could not determine the actual cause as there is no other study reported in the Middle East.

Of 194 feet, ANB was bilateral in 77 patients (65.8%). By comparison, Keles et al reported bilateral ANB in 37.5% of patients,[9] while Stacy et al reported bilateral ANB in 76.7% of patients.[8] In contrast, Huang et al reported bilateral ANB in only 18.8% of patients.[6] In our study, the second most common site was in the left foot (17.9%). These findings are similar to those reported by Huang et al and Stacy et al, who reported a frequency of 47.0% and 53.2% in the left foot, respectively.[6,8] In our study, the least common site was the right foot (16.2%). Huang et al and Keles et al similarly reported that 36.7% and 30.6% of cases were in the right foot, respectively.[6,9] Stacy et al reported that type IIBa had the highest prevalence of 16.6% out of 439 patients.[8] While we found type IIIb to have the highest prevalence of 81.3%.

In our study type I ANB had the smallest average size of 0.54 cm (0.24 cm); type IIA was 0.87 cm (0.32 cm); type IIB was 1.20 cm (0.25 cm); and type III had the largest average size of 1.95 cm (0.36 cm). Another study by Arslan et al[13] noted the size range from 814 foot x-rays were as follows: type I (0.09-0.97 cm),

Table 2. Accessory navicular bones according to Coughlin classification (right and left foot) by sex.

	Total feet	Male Feet	Female feet	χ^2	*P* value	Overall mean size (cm)	Males (cm)	Females (cm)	t test	*P* value
Right foot	(n=95)	(n=32)	(n=63)							
Type I	40 (42.1)	14 (45.2)	25 (40.9)			0.48 (0.24)	0.44 (0.15)	0.49 (0.27)	-0.604	.549
Type IIA	12 (12.6)	3 (9.7)	9 (14.8)	2.424	.658	0.81 (0.39)	0.95 (0.30)	0.75 (0.43)	0.828	.427
Type IIB	21 (22.1)	5 (16.1)	14 (22.9)			1.23 (0.32)	1.32 (0.42)	1.18 (0.26)	0.942	.358
Type III	22 (23.2)	10 (29.0)	13 (21.3)			1.91 (0.36)	1.89 (0.41)	1.92 (0.34)	-0.161	.874
Left foot	(n=99)	(n=32)	(n=67)							
Type I	40 (40.4)	8 (25.0)	32 (47.8)			0.57 (0.25)	0.56 (0.18)	0.57 (0.29)	-0.130	.897
Type IIA	15 (15.2)	6 (18.8)	9 (13.4)			0.93 (0.31)	1.04 (0.39)	0.86 (0.25)	1.039	.318
Type IIB	17 (17.2)	7 (21.9)	10 (14.9)	5.453	.244	1.17 (0.19)	1.12 (0.11)	1.28 (0.24)	-0.925	.370
Type III	26 (26.3)	11 (34.4)	15 (22.4)			1.95 (0.37)	2.08 (0.52)	1.86 (0.19)	1.582	.063
Type III & Type I	1 (0.5)	0	1 (1.5)					0.70		

Data are n (%) and mean (standard deviation) for bone size. Comparisons are males versus females.

Table 3. Subtypes for right and left feet according to the modified Coughlin classification.

Right foot	**a**	**b**	**c**	
Type I	14 (35.0)[b]	8 (20.0)[a,c]	18 (45.0)[b,c]	
Type IIA	5 (41.7)[a]	5 (41.7)[a]	2 (16.7)[a]	
Type IIB	3 (14.3)[a,b]	4 (19.0)[a]	14 (66.7)[b]	
Type III	2 (9.1)[a]	18 (81.8)[b]	2 (9.1)[a]	
Left foot	**a**	**b**	**c**	**c and b**
Type I	10 (25.0)[a]	12 (30.0)[a]	17 (42.5)[a]	1 (2.5)[a]
Type IIA	8 (53.3)[a]	3 (20.0)[b]	4 (26.7)[a,b]	0
Type IIB	2 (11.8)[a]	4 (23.5)[a]	11 (64.7)[a]	0
Type III	2 (7.7)[a]	21 (80.8)[b]	3 (11.5)[a]	0
Type III & Type I	0	1 (100.0)[a]	0	0

Data are n (%). Superscripts identify statistically significant comparisons with other subtypes. Chi-square statistic for right foot: 159.443; left foot: 36.026 (P<.001).

type II (0.26-1.3 cm), and type III (0.5-2.28 cm); these measurements were similar to those in our study.

The clinical importance of this study is in differentiating symptomatic ANB from other pathologies that are related or considered among the following differential diagnoses: navicular tuberosity avulsion, tarsal stress fractures, arthritis, posterior tibial tendon rupture, flatfoot, or PTT insufficiency.[1-3,7,12] To differentiate between ANB and navicular/tarsal fractures, physicians must recognize the natural history of ANB, as symptomatic ANB is frequently reported in young athletes with symptoms manifesting during exercise or walking, affecting their athletic performance.[9] ANB might manifest itself in childhood or early adulthood. In children, the pressure of the accessory bone against the shoe is the most common cause of symptoms. Adults are more likely to develop symptoms following a foot trauma, which commonly occurs as a result of a twisting injury.[9]

In an acute setting upon presentation to the emergency department, physical examination will be most helpful to differentiate between the two entities, with ANB presenting with tenderness over the prominence on the medial aspect of the instep,[9] while fracture tenderness will be more diffuse and usually accompanied by ecchymoses on the medial aspect of the foot.[5,9] Radiograph imaging will aid further in differentiation between the two. Specialized views are not required as the signs can be differentiated from standard AP, lateral, and/or oblique x-rays.[5] Fractures are usually sharp, with irregular borders, while ANB will have smooth, regular edges.[5]

In conclusion, the prevalence of ANB in patients examined at the foot and ankle clinic was 23.3% (of which 3.4% were symptomatic), which is consistent with the literature. ANB should be considered as a differential diagnosis for patients who present with medial midfoot pain or pes planus deformity and should be differentiated from navicular/tarsal fractures. Further studies with a randomized sampling and with larger sample size are needed for more accuracy and to confirm the reported results. This study was limited by its chart review design and sampling technique. Additionally, advanced imaging would have provided more accurate results for the size and classification of ANB.

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