ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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Radiographic Evaluation of the Medial Part of Navicular Bone as Accessory Navicular or Prominent Navicular Tuberosity: Morphometrical Study

Os Naviculare'nin Medyal Kısmının Os Naviculare Accessorius ya da Tuberositas Ossis Naviculare Olarak Radyografik Değerlendirilmesi: Morfometrik Çalışma

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ABSTRACT Objective: Accessory navicular (AN) is one of the most common accessory bones of the foot. It is classified into three types according to radiologic appearance. Also these types are divided into subgroups. It was difficult to distinguish the prominent navicular tuberosity from the Type IIIb AN as there was no criterion in the literature. Therefore, it is aimed to ensure morphometric data for the medial extension of AN. **Material and Methods:** In the present study, radiographs of 77 subjects were investigated in terms of AN presence and types. Widths and anteroposterior lengths of both native navicular and its medial extension were measured and data were evaluated statistically. **Results:** Type I and Type II AN bones were detected in 6 and 11 sides, respectively. While Type IIIb could not be discernable, Type IIIa and c were found in 3 sides. The width and anteroposterior length of native navicular bone were found significantly higher in men than in women (p=0.0001, p=0.018). But there was no statistically significant difference between sexes for the parameters of the medial extension (p=0.776, p=0.137). Dimensions of the medial bony extension didn't show significant differences in the presence or absence of AN (Type I, II, IIIa, c). **Conclusion:** In all cases, navicular tuberosity was exceeding the surgical reference line medially more or less. Knowledge about the diversity in morphometry of the exceeding part could be helpful for surgical procedures. To clarify this issue and as the discrimination criteria is not found sufficient, it is proposed to describe Type IIIb AN as an enormous sized tuberosity of native navicular rather than being an accessory bone.

Keywords: Accessory navicular; flat foot; navicular bone; posterior tibial muscle; prominent navicular tuberosity

ÖZET Amaç: Aksesuar naviküler (AN) kemik, ayakta sık karşılaşılan aksesuar kemiklerden biridir. Radyolojik görünümüne göre 3 tipte sınıflandırılmıştır. Ayrıca bunlar da alt tiplere ayrılmıştır. Ancak literatürde net bir kriter bulunmadığı için Tip IIIb AN'nin, belirgin tuberositas ossis navicularede ayrımı tam olarak yapılamamıştır. Bu sebeple, bu çalışmada naviküler kemik ve medial uzantısına yönelik morfometrik veri sağlanması amaçlanmıştır. **Gereç ve Yöntemler:** Bu çalışmada, AN varlığını ve tiplerini belirlemek için 77 bireyin radyografileri incelendi. Normal naviküler kemiğin ve medial uzantısının genişlikleri ve ön-arka mesafeleri ölçüldü ve istatistiksel olarak değerlendirildi. **Bulgular:** Altı tarafta Tip I ve 11 tarafta Tip II AN tespit edilirken, Tip III (a ve c) ise 3 tarafta tespit edildi (Tip IIIb ayırt edilemedi). Normal naviküler kemiğin genişliği ve ön-arka uzunluğu, erkeklerde, kadınlara göre istatistiksel olarak daha yüksek bulundu (p=0,0001, p=0,018). Medial uzantı parametreleri için ise cinsiyetler arasında istatistiksel olarak anlamlı bir fark yoktu (p=0,776, p=0,137). Kemiğin medial uzantısının boyutları, AN (Tip I, II, IIIa, c) kemiğin var olup olmaması ile önemli bir değişim göstermiyordu. **Sonuç:** Tuberositas ossis naviculare, tüm olgularda az ya da çok cerrahi referans hattının medialinde yer alıyordu. Mediale taşan bu kısmın morfometrisi ile ilgili bilgilerin, cerrahi işlemler için faydalı olabileceği düşünüldü. Konuya açıklık kazandırmak için ve ayırt edici kriter yeterli görülmediği için Tip IIIb AN'nin, aksesuar bir kemik olmaktan ziyade, asıl kemiğin aşırı büyük bir uzantısı olarak tarif edilmesi önerildi.

Anahtar Kelimeler: Os naviculare accessoria; düz tabanlık; os naviculare; musculus tibialis posterior; tuberositas ossis naviculare

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The most common accessory bones in the foot are reported to be os trigonum, os peroneum and accessory navicular (AN).[1-4] The AN which is reported to be the most common one, is located at the instep of the foot and is encountered in 4-21% in asymptomatic population.[1,2,5-7] The navicular bone is the last tarsal element to chondrify and its onset of ossification is late than the other tarsal bones occurring at 2.7 to 4 years. Normally it has a single center of ossification. The AN comes into being when the tuberosity of the navicular develops from a secondary ossification center that fails to unite during childhood.[3,8-10]

AN bone was reported to be asymptomatic and found incidentally in radiographs.[7,8] It usually becomes symptomatic in childhood, early adulthood, or young athletes or dancers.[8,11] When it is symptomatic, it presents with pain and/or tenderness localized to the prominence at the medial aspect of the instep, distal to the medial malleolus due to pressure of the bony prominence.[5,6,12,13] In the currently used classification, AN bones are classified into three types according to radiologic appearance.[1,2,8,10,11] Type I AN (os tibiale externum) is a small sesamoid bone (2x3 mm) and embedded within the distal part of the posterior tibial tendon. Type II AN (prehallux) is a triangular or heart-shaped bone (max.12 mm), connected to the native navicular by fibrocartilage or hyaline cartilage. Type III AN is reported as a fused form of the accessory bone.[5,6,13] It is also referred as “prominent navicular tuberosity”, "prehallux", "os tibiale externum", “cornuate or gorilloid navicular.”[3,9,13-18] Each group was also divided into subgroups by Coughlin.[14] According to their schematic description, Type IIIa is fused to native navicular by a stalk that has a notch on one side. Type IIIb continues by native navicular without any notch (i.e. like a bony expansion of native bone). Type IIIc is fused to native navicular by a stalk that has notches on both sides. In this commonly used classification, there is not any morphometric data for discrimination of Type IIIb AN from the prominent navicular tuberosity. It seems that in this classification system based on radiological appearance, all types of AN could easily be identified, except for Type IIIb.

The purpose of the present study was to take attention to the lack of morphometric criteria in the literature to distinguish Type IIIb AN and the native navicular tuberosity and to ensure data about the morphometry of native navicular and navicular tuberosity. As the classification system is based on radiological appearance, we evaluated the navicular bone and its medial tuberosity on radiograms.

MATERIAL AND METHODS

During the routine dissection, encountering with a prominent tuberosity at the instep of a cadaver led us to evaluate AN bones. As it was found difficult to distinguish that prominent navicular tuberosity from the Type IIIb AN, a retrospective study was conducted on radiographs of 77 subjects (52 females and 25 males) (ages ranged between 20 and 78, mean: 45.43±15.77) obtained from the archive of radiology department of our faculty. The ethics committee of the faculty (Mersin University, Medical Faculty, Ethics Committee) has approved the study (date: 19.12.2008, decision number: 10/123). The study is also in compliance with Helsinki Declaration 2008 principles. The subjects who had fracture, luxation, osteomyelitis, malignancy or previous operation on foot and the cases below 20 years were not included in the evaluation. As the subjects were selected randomly from the archive, we had no more knowledge about their occupation.

Standard anteroposterior and lateral radiographs of 95 feet (29 right, 30 left side and 18 bilateral) were examined to evaluate the presence of an apparently distinguishable AN (completely or partially separate from native navicular), incidence and types of the AN.

Some certain measurements for navicular bone and its medial extension were carried out on the radiographs. The parameters were determined as below (Figure 1a, b):

The width of the navicular bone at the widest site (wN)

The anteroposterior length of the native navicular bone at the longest site (apN)

The width of the medial extension of navicular which lies medial to the reference line (wMP) (The mentioned reference line passes the head of talus and medial cuneiform medially)

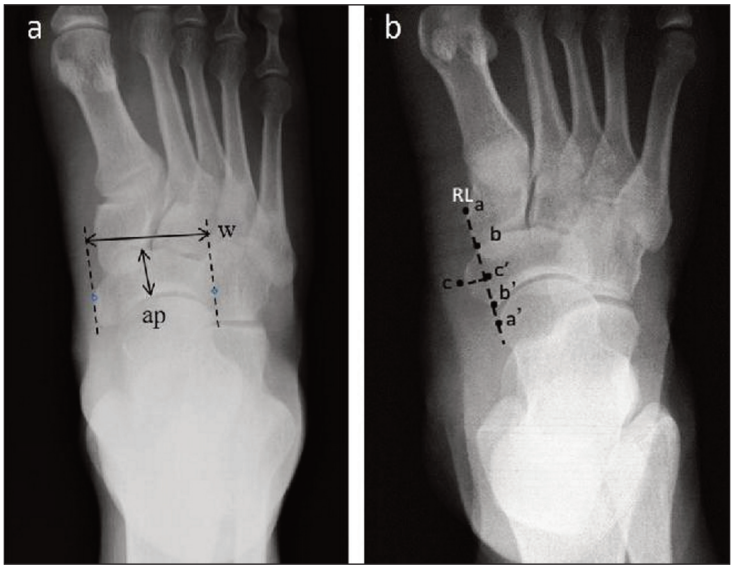

FIGURE 1: Measurements of parameters on anteroposterior radiograms, a) Width and anteroposterior length of native navicular, b) Width and anteroposterior length of medial extension of navicular bone. Figure legends: w: width; ap: anteroposterior length; a: medial side of medial cuneiform; a': medial side of the head of talus; RL: the reference line passing the a and a' points; b-b': anteroposterior length of the prominent part of the navicular bone; c-c': width of the prominent part of the navicular bone.

The anteroposterior length of the medial extension of navicular bone on the reference line (apMP).[19]

The investigator made the measurements of the parameters in two different times in the same standards. The mean values were taken as the agreement in the measurements were high.

Descriptive statistics of data were given in Table 1. The data were evaluated by using Kolmogorov-Smirnov test and determined to be normally distributed. The morphometric parameters were analyzed statistically in terms of sex and side differences by student t-test and paired t-test respectively. Relations between parameters were evaluated by using Pearson correlation test. Presence of apparently distinguishable AN was evaluated in terms of sides and gender with Chi-square test. The significance level was taken as 0.05.

RESULTS

An apparently distinguishable AN (completely or partially separate from native navicular) were found in 20 sides which of 11 were on the left and 7 were on the right (13 females, 6 males). In one female case, AN was found bilaterally.

When the presence of apparently distinguishable AN was evaluated with Chi-square test in terms of sides and gender, there was no statistically significant difference (p=0.802 and p=0.794 respectively).

In 6 sides the AN was Type I (6.3%), in 11 sides AN was Type II (11.5%). Apparently distinguishable AN Type III (a, c) that attached to the native navicular by a bony stalk at the medial side was encountered in 3 sides (3.2%) (Figure 2a-c). On the other hand, in 9 of 20 cases with apparently distinguishable AN (Type I, II, IIIa, c), the medial extension was also prominent (Figure 2a). In all cases, medial prominence of the navicular bone was more or less exceeding the reference line medially. According to paired t-test, there was no statistically significant difference (p>0.05) in terms of sides for all parameters in 18 bilateral cases.

The wN and apN were found significantly higher in men than in women (p=0.0001, p=0.012). But in terms of wMP and apMP, there was no statistically significant difference between sexes (p=0.781, p=0.058) (Table 1).

There were statistically significant correlations between the measurements of native navicular bone and medial prominence (for width p=0.0001, r=0.392, for anteroposterior length p=0.0001, r=0.357).

Regarding to all parameters, there was no statistically significant difference between groups that with

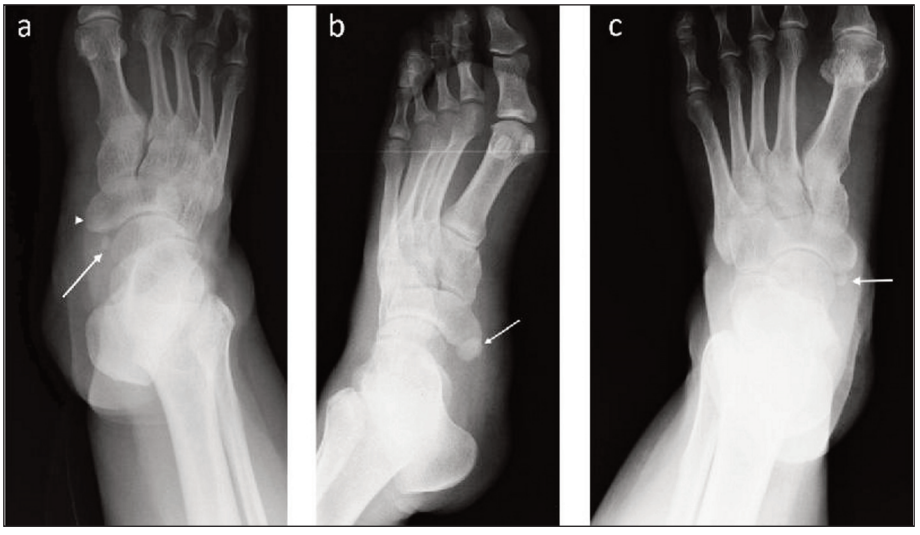

FIGURE 2: Radiographic images of accessory navicular bones a) Anteroposterior radiogram depicting Type I accessory navicular (apparently distinguishable AN) accompanying to a prominent navicular tuberosity on a right foot, b) Type II AN on anteromedial radiogram of left foot c) Type IIIc AN (attached to main navicular by a stalk) on anteroposterior radiogram on a left foot. Figure legends: Black arrow: accessory navicular bone; white arrowhead: prominent navicular tuberosity.

TABLE 1: Descriptive statistics of the parameters and statistical evaluation of each parameter regarding the gender difference.

		Gender	n	Minimum value	Maximum value	Mean	SD	p value
		M	31	33.50	54.80	41.64	4.29	
	w							0.0001
N		F	64	31.40	42.70	37.13	2.73	
		M	31	14.30	23.40	19.98	2.21	
	ap							0.012
		F	64	14.10	24.60	18.82	2.20	
		M	31	3.30	12.90	6.64	2.32	
	w							0.781
MP		F	64	2.70	12.00	6.77	2.00	
		M	31	4.30	24.28	10.37	3.67	
	ap							0.058
		F	64	5.60	13.10	9.31	1.74	

N: Main navicular bone; MP: Medial prominence of the navicular bone; w: width; ap: anteroposterior length; M: Male; F: Female; n: number; SD: Standard deviation.

apparently distinguishable AN and without AN as shown in Table 2.

DISCUSSION

Numerous studies have been published reporting the types and incidences of AN.[3,8,13,16] Prominent medial navicular tuberosity is similar with Type IIIb of Coughlin's classification, which has been currently used by almost all authors.[2,8,9,16,17] While Type I, II and Type III a, c could be determined easily on radiograms, it was difficult to distinguish Type IIIb (AN joined to the native navicular without any notch) from the prominent tuberosity of native navicular. Also there is no criterion in the literature about that issue.

The prevalence of AN is reported to be higher in females by some authors.[9,16] Coşkun et al. reported that the presence of AN did not show significant difference in terms of gender and sides similar to our study.[2] The most common one is Type I according to Huang et al., Type II according to Nwawka et al. similar to ours and Type III according to Keleş et al.[4,7,16] The ratios of these types are shown in Table 3. The in-

TABLE 2: Statistical comparison of each parameter regarding the presence or absence of an apparent accessory navicular.

Presence of AN	n	Mean (mm)	SD	p value
–	75	38.69	4.15	
wN				0.677
+	20	38.28	3.01	
–	75	19.22	2.30	
apN				0.903
+	20	19.15	2.16	
–	75	6.59	2.09	
wMP				0.237
+	20	7.22	2.11	
–	75	9.61	2.15	
apMP				0.750
+	20	9.82	3.82	

AN: Accessory navicular; SD: Standard deviation.

TABLE 3: Reported data about the ratios of the types among the cases with accessory navicular.

The author	Type I (%)	Type II (%)	Type III (%)
Coşkun et al.	35.6	22.9	41.4
Huang et al.	41.6	36.8	21.6
Nwawka et al.	30.0	50.0	20.0
Jason et al.	27.5	57.0	15.5
Kalbouneh et al.	25.4	42.4	20.0
Our series	6.3	11.5	3.2 (except for Type IIIb)

cidence of Type IIIb within the AN cases are given as 14% by Huang et al. and 9.1% by Coşkun et al. While in the study of Coşkun et al. the incidences of subtypes of Type III (a, b, c) are close to each other (1.5, 1.4, 1.7% respectively), Type IIIb (14%) is distinctly higher than Type IIIa (4.5%) and Type IIIc (3.0%) in the study of Huang et al.[2,16] Confliction in these ratios for Type IIIb might be due to the lack of discrimination criteria.

The size of AN, shape and size of the native navicular bone are reported to be important factors in decision of surgical procedure in addition to foot malalignment.[8] In our study, the size of medial tuberosity was found to be getting larger with the increasing size of native navicular. It was also remarkable that dimensions of the medial tuberosity did not show any difference between the sexes although dimensions of the native navicular were higher in men than in women. These findings would provide guidance to surgeons.

Painful AN is reported to be treated by simple excision or Kidner procedure when conservative treatments fail. In these operations, in addition to excision of apparent AN, navicular prominence could be trimmed by taking into account the line passing from the medial side of the medial cuneiform.[17,18] Kiter et al. reported that patients are satisfied after the removal of the medial prominence.[12] However, none of these authors mentioned about an exact definition for the limit of trimming.[12,17,19] Type IIIb AN (or prominent medial tuberosity). This issue was stated as a problem for orthopedic surgeons because the medial border of main navicular has not been determined.[17] In the present study, in all cases, medial extension of navicular was observed to pass that line more or less.

When the literature is reviewed, it seems that solely prominent navicular tuberosity referred as Type IIIb was ignored when an apparently distinguishable AN (Type I, II, IIIa) accompanies it. On the other hand, Kalbouneh et al. presented the cases of prominent medial tuberosity with an additional AN as "more than one AN bone in the same foot."[10] Leonard and Fortin stated that there may be cases which have symptomatic AN with large cornuate shaped native navicular. These cases are reported to require partial excision of the prominence of the cornuate shaped native navicular besides excising the AN.[8] Likewise, an apparently distinguishable AN (Type I, II, IIIa, c) accompanied a prominent medial tuberosity in 9 cases in our study (Figure 2a). It is also remarkable that there was no statistically significant difference in the measurements of medial extension between the cases with apparently distinguishable AN and without AN. We assume that this prominent bony extension cannot be interpreted as Type IIIb AN. Instead, it should be commented as dimensional variation of the native navicular bone.

Besides being a risk factor for posterior tibial tendinopathy, presence of AN has been associated with pes planus and based on biomechanical reasons

in which AN alters the insertion of the posterior tibial tendon.[5,8,19,20,21] Thereby the functional and anatomical balances of the longitudinal plantar arch changes.[8,13,21] But some authors reported that they did not find any association of AN and flat foot deformity.[2,22]

CONCLUSION

Consequently, findings of the present study revealed that in all cases, navicular tuberosity was exceeding the surgical reference line medially more or less. Dimensions of this tuberosity did not show significant differences in the presence or absence of apparently distinguishable AN. The cases similar to ours were determined as Type IIIb in the literature. In our opinion, to accept a structure as an accessory pattern, certain criteria are needed. It is not thought to be sufficient criteria to define a tuberosity as an accessory structure only for its enormous size. In many other structures, there may also be personal or sexual size differentiations. We believe that, definition of AN bone should be re-evaluated in larger series to determine a morphometric criterion. Our final conclution is to define Type IIIb AN as an enormous sized tuberosity of native navicular rather than being an accessory bone.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Alev Bobuş Örs, Zeliha Kurtoğlu Olgunus;* ***Design:*** *Volkan Öztuna;* ***Control/Supervision:*** *Alev Bobuş Örs;* ***Data Collection and/or Processing:*** *Alev Bobuş Örs, Volkan Öztuna;* ***Analysis and/or Interpretation:*** *Volkan Öztuna;* ***Literature Review:*** *Alev Bobuş Örs;* ***Writing the Article:*** *Alev Bobuş Örs, Zeliha Kurtoğlu Olgunus;* ***Critical Review:*** *Alev Bobuş Örs, Zeliha Kurtoğlu Olgunus;* ***References and Fundings:*** *Volkan Öztuna;* ***Materials:*** *Volkan Öztuna.*

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