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CASE REPORT

The os supranaviculare and navicular stress fractures

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Abstract Tarsal navicular stress fractures are injuries more commonly observed in athletes involved in sprinting and jumping sports. Known risk factors for the development of navicular stress fractures include pes cavus, metatarsus adductus, limited subtalar or ankle motion, medial narrowing of the talonavicular joint, as well as a short first metatarsal. The presence of an os supranaviculare has yet to be described as a predisposing factor in the occurrence of navicular stress fractures. We present two cases of navicular stress fractures in patients with an os supranaviculare and discuss possible reasons for such an association.

Keywords Navicular · Stress fracture · Os supranaviculare

Introduction

The tarsal navicular is a roughly pear-shaped bone that makes up a portion of the medial column of the foot. Its blood supply is organized in such a way that a relatively hypovascular zone exists within the central third of the bone [1–3]. This partly explains why stress fractures occur in this region. Navicular stress fractures typically are sagittally orientated and originate in the proximal dorsal cortex. They are more often seen in athletes, classically in track and field participants.

The os supranaviculare, also referred to as os talonaviculare dorsale or Pirie's bone, is an accessory ossicle located at the proximal dorsal cortex of the navicular at its mid-point. It is reported to occur in 1% of individuals [4]. There has been no reported association between an os supranaviculare and navicular stress fractures.

The following cases involved two individuals who sustained navicular stress fractures and also had an os supranaviculare. We hypothesize that there is an association between the os supranaviculare and navicular stress fractures and propose a possible mechanism.

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Case report

Case 1

Case 1 involved an 18-year-old woman with left foot pain. Initial radiographs demonstrated an os supranaviculare without identifying the stress fracture (Fig. 1a). A subsequent CT ordered to rule out ankle impingement confirmed the presence of a navicular stress fracture and os supranaviculare (Fig. 1b, c).

Case 2

Case 2 involved a 14-year-old female soccer player with dorsal foot pain. An initial bone scan demonstrated focal uptake within the mid-foot over the region of the navicular; however, this was not appreciated at that time (Fig. 2). A subsequent bone scan 2 years later (not shown) confirmed the diagnosis. CT of the mid-foot 5 years after the initial bone scan was performed because of recurrent symptoms and demonstrated an os supranaviculare with an accompanying navicular stress fracture (Fig. 3). MR imaging around the same time revealed marrow edema within the navicular (Fig. 4).

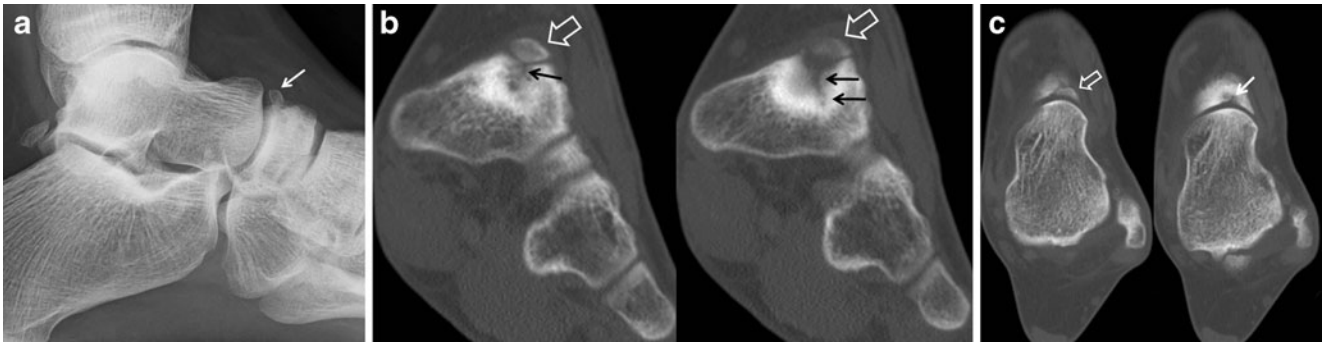

Fig. 1 **a** Lateral radiograph of the foot demonstrates a well-corticated ossicle dorsal to the proximal aspect of the navicular bone, consistent with an os supranaviculare. No convincing findings of a navicular stress fracture were identified. **b** Successive coronal CT images of the mid-foot in the same patient show a well-corticated ossicle (*open white arrow*) at the dorsal margin of the proximal navicular bone situated within an osseous depression. A sagittally oriented fracture line (*solid black arrows*) extends from the dorsal cortex to the mid-portion of the navicular body. Surrounding sclerosis suggests that this might be chronic in nature. **c** Successive axial CT images through the superior aspect of the navicular demonstrates the os supranaviculare (*open white arrow*). The sagittally orientated fracture lucency (*white arrow*) involving the subchondral plate is noted. Surrounding sclerosis is again evident

Discussion

The tarsal navicular is a roughly pear-shaped bone that articulates with the talus proximally and the three cuneiforms distally. It has a concave proximal articular surface and a convex distal articular surface. Functionally, it contributes to the medial column of the foot and its medial tuberosity serves as the attachment site for the anterior component of the posterior tibial tendon. The navicular derives its blood supply from branches of the dorsalis pedis and medial plantar arteries. This configuration renders the central third of the navicular relatively hypovascular and is thought to partly explain why stress fractures occur in this region [3].

Initially considered a rare entity, tarsal navicular stress fractures account for up to 35% of stress fractures in recent series [5]. Navicular stress fractures are observed in athletes involved in sprinting and jumping activities. One series looking at stress fractures in athletes reported 59% of injuries occurring in track and field participants [6]. It is thought that during foot strike, shear stresses across the relatively hypovascular central navicular are accentuated by the plantarflexed position of the foot [7]. Navicular stress fractures are typically sagittally orientated and located within the central third of the bone.

Navicular stress fractures often present as vague mid-foot pain, but symptoms eventually evolve into focal pain over the dorsum of the navicular [8]. Thus, diagnosis is often made 7 months following the onset of symptoms in one series [3]. Radiographic evaluation of the weight-bearing foot is the first line imaging modality; however,

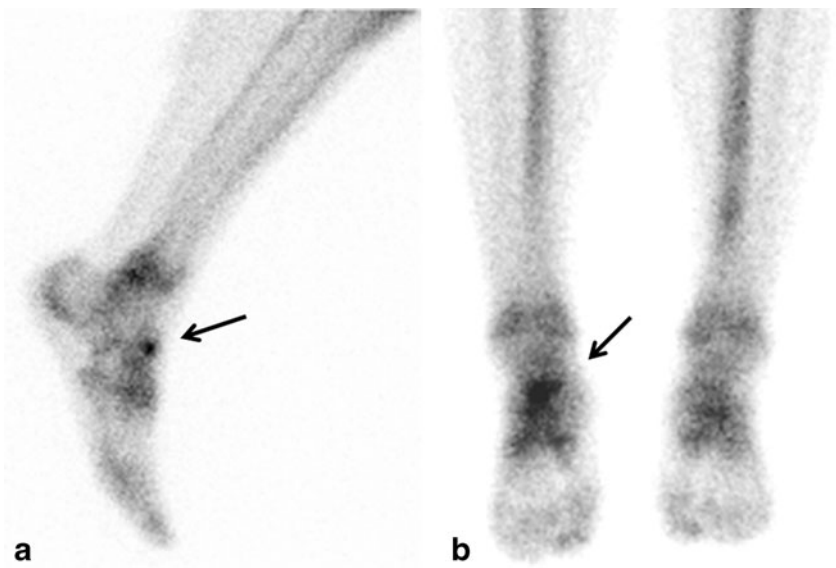

Fig. 2 **a** Lateral view of the right foot from a delayed phase bone scan. There is focal uptake within the dorsal aspect of the mid-foot (*black arrow*) in the region of the navicular bone. **b** Anterior views of both feet demonstrate asymmetric uptake within the right mid-foot (*black arrow*) in the region of the navicular bone

Fig. 3 **a** Coronal CT image of the mid-foot demonstrates a well-corticated ossicle (*open white arrow*) at the dorsal margin of the proximal navicular bone situated within an osseous depression. A sagittally orientated fracture line (*solid black arrow*) extends from the dorsal cortex to the mid-portion of the navicular body. **b** Axial CT image of the mid-foot in the same patient shows a well-corticated ossicle (*white arrow*) at the dorsal margin of the proximal navicular bone situated within an osseous depression. **c** Axial CT image inferior to that in **b** demonstrates the fracture lucency (*solid white arrow*) involving the subchondral plate, which is consistent with a stress fracture. Surrounding sclerosis suggests that this might be chronic

radiographs are frequently negative [1]. CT, MRI, or nuclear scintigraphy may be necessary for further evaluation. Because of its high spatial resolution and availability, CT is a common choice for subsequent assessment and follow-up of stress fractures. A CT classification scheme for navicular stress fractures has been established by Saxena et al. [9]. According to this system, type I is a break in the dorsal cortex, type II is a break in the dorsal cortex with extension into the navicular body, and type III is a fracture into another cortex. Discriminating between complete and incomplete, or partial, stress fractures has important implications for determining therapy. A complete fracture corresponds to Saxena's type III fracture in which the fracture extends to another cortex, thus cleaving the navicular into two fragments. An incomplete fracture fails to do this, with the fracture line terminating in the navicular cortex or body. While there is some debate, in general, displaced complete fractures are treated surgically and incomplete fractures in non-athletes are managed conservatively [10].

There are numerous accessory ossicles of the foot and their clinical significance varies considerably. A type 2 accessory navicular occurs in 2–12% of individuals and is associated with posterior tibial tendon dysfunction [11]. An os peroneum is present in 9% of the general population and is responsible for the painful os peroneum syndrome [11, 12]. Interphalangeal ossicles of the great toe vary significantly in incidence and may become symptomatic with formation of a hyperkeratotic lesion [13, 14]. The os supranaviculare is estimated to occur in 1% of individuals [4]. Rarely, it may become symptomatic [15]. It is located at the proximal dorsal margin of the tarsal navicular bone near its mid-point. Of the few CT cases of an os supranaviculare in our file, we have observed an associated dorsal cortical notch in each navicular bone. An example is provided (Fig. 5). This examination was obtained in the setting of acute trauma in which there was no clinical suspicion of a navicular stress fracture.

While an os supranaviculare occurs in 1% of the population, Pavlov et al. reported a series of 23 navicular

Fig. 4 Axial T2 fat-saturated MR image demonstrates marrow edema within the navicular bone (*white arrow*)

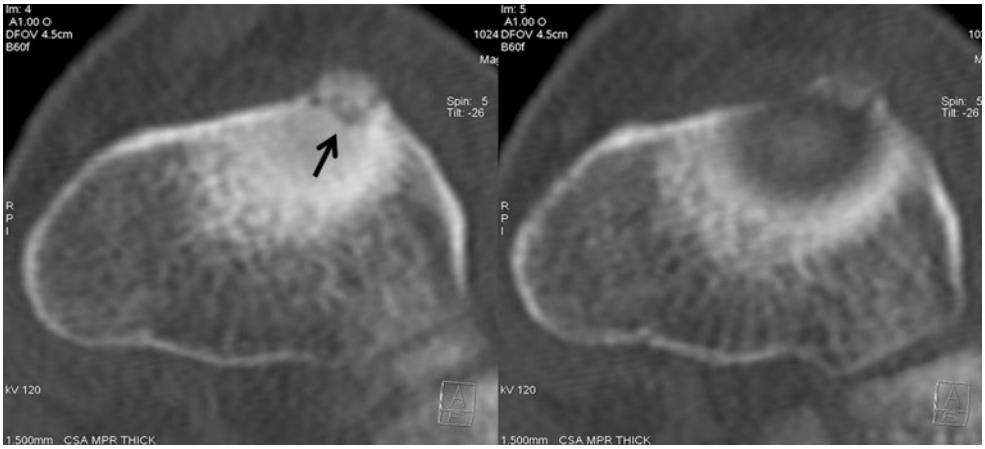

Fig. 5 Two successive coronal oblique CT images through the proximal navicular show an os supranaviculare situated within a dorsal navicular depression (*black arrow*). No additional findings were noted within the navicular

stress fractures, 22% of which involved an os supranaviculare [1, 4]. The exact cause of this association is not clear, but it is plausible that a pre-existing dorsal cortical notch accompanying an os supranaviculare may contribute. Our two cases of navicular stress fractures demonstrate dorsal cortical notches; however, this phenomenon is reported with healed stress fractures [3]. Anecdotally, we have observed a notch accompanying the os supranaviculare in patients without navicular stress fractures. A larger sample size would be necessary to confirm this association.

Normal morphological features of bone often concentrate stress [16]. Instances include sharp notches and surface discontinuities, a vascular channel being a common example. A dorsal navicular depression accompanying an os supranaviculare would demonstrate the same biomechanical principles, increasing stress over the dorsal aspect of the navicular bone. An insult to the dorsal cortex, which might otherwise not progress in the absence of a navicular depression, would more likely propagate in the presence of such a stress riser. Furthermore, with this depression localized to the site of maximal shear stress, the likelihood of failure increases. Therefore, we hypothesize that a depression accompanying an os supranaviculare might contribute to the development of navicular stress fractures. Additional characteristics noted by Pavlov et al. [1] on foot radiographs are provided in Table 1.

Our hypothesis in part relies upon reports of the incidence of an os supranaviculare in the general population as well as in a cohort with navicular stress fractures [1, 4]. Only a single study describing the incidence in the general population was available for review; however, the sample size was rather large [4]. Additionally, while there are many reports of navicular stress fractures, not all described the presence or absence of an accompanying os supranaviculare.

Table 1 Common foot characteristics in tarsal navicular stress fractures demonstrated on radiographs

Characteristic	Number
Anteroposterior view	
Sclerosis of the proximal articular border of the navicular	22
Short first metatarsal	19
Metatarsal adductus primus or 1st to 3rd digits	17
Metatarsal hyperostosis or stress fractures of the 2nd to 4th digits	17
Narrowing of the medial aspect of the talonavicular joint	9
Lateral view	
Plantarward displacement of the talus and the navicular with the cuneiforms	17
Juxta-articular ossicles	16
Os trigonum	10
Os calcaneus secondarias	2
Os supratalare	4
Os supranaviculare	5
Os tibia talare	3
Os tibiale externa	2

Conflicts of interest None.

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References

1. Pavlov H, Torg JS, Freiberger RH. Tarsal navicular stress fractures: radiographic evaluation. Radiology. 1983;148:641–5.
2. Ting A, King W, Yocum L, et al. Stress fractures of the tarsal navicular in long-distance runners. Clin Sports Med. 1988;7: 89–101.
3. Torg JS, Pavlov H, Cooley LH, et al. Stress fractures of the tarsal navicular: a retrospective review of twenty-one cases. J Bone Joint Surg Am. 1982;64A:700–12.
4. 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 (abstract). Nippon Seikeigeka Gakkai Zasshi. 1981;55(4):357–70.
5. Brukner P, Bradshaw C, Khan KM, et al. Stress fractures: a review of 180 cases. Clin J Sport Med. 1996;6:85–9.
6. Khan KM, Brukner PD, Kearney C, Fuller PJ, Bradshaw CJ, Kiss ZS. Tarsal navicular stress fracture in athletes. Sports Med. 1994;17:65–76.
7. Fitch KD, Blackwell JB, Gilmour WN. Operation for nonunion of stress fracture of the tarsal navicular. J Bone Joint Surg. 1989;71 B:105–10.
8. Jones MH, Amendola AS. Navicular stress fractures. Clin Sports Med. 2006;25(1):151–8.
9. Saxena A, Fullem B, Hannaford D. Results of treatment of 22 navicular stress fractures and a new proposed radiographic classification system. J Foot Ankle Surg. 2000;39:96–103.
10. Torg JS, Moyer J, Gaughan JP, Boden BP. Management of tarsal navicular stress fractures: conservative versus surgical treatment: a meta-analysis. Am J Sports Med. 2010;38(5):1048–53.
11. 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:L164–77.
12. Sobel M, Pavlov H, Geppert MJ, Thompson FM, DiCarlo EF, Davis WH. Painful os peroneum syndrome: a spectrum of conditions responsible for plantar lateral foot pain. Foot Ankle Int. 1994;15(3):112–24.
13. Davies MB, Dalal S. Gross anatomy of the interphalangeal joint of the great toe: implications for excision of plantar capsular accessory ossicles. Clin Anat. 2005;18:239–44.
14. Roukis T, Hurless MS. The hallucal interphalangeal sesamoid. J Foot Ankle Surg. 1996;35(4):303–8.
15. Miller GA, Black JR. Symptomatic os supranaviculare: a case report. J Am Podiatr Med Assoc. 1990;80:248–50.
16. Currey J. The mechanical adaptations of bones. Princeton, NJ: Princeton University Press, 1984.