



## Navicular stress fracture in high-performing twin brothers : A case report

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Navicular stress fractures mainly occur in sprinting and push-off athletes. Numerous predisposing factors have been implicated in their development. Within a six-week interval in the summer of 2009, twin brothers, both elite track and field athletes, presented to us with medial foot pain. Plain radiographs were negative but a radioisotope bone scan and CT scan revealed an incomplete navicular fracture in both of them. The fracture was typically located in the proximal dorsal cortex of the central portion of the navicular bone. The presence of such a stress fracture in high performing, monozygotic twins, has never been described. As extrinsic and intrinsic risk factors, their comparability of mechanical stresses and kinematics as well as a genetic predisposition can be put forward. This case report suggests that a complex interaction between mechanical and genetic risk factors exists in the development of navicular stress fractures.

**Keywords :** navicular bone ; stress fracture ; predisposing factors.

0.7% to 2.4% of all stress fractures (3). More recent studies reveal an incidence of 14% to 35% of all stress fractures (1,3,11,13). Navicular stress fractures mainly occur in sprinting and push-off athletes (13).

Numerous extrinsic and intrinsic predisposing factors have been implicated in the development of navicular stress fractures (8,16). Extrinsic factors include the training load, intensity, footwear and running surface. As intrinsic factors, several authors have mentioned pes cavus, pes planus, leg-length discrepancies, short first metatarsal, limited subtalar or ankle motion and medial narrowing of the talo-navicular joint. However, no study has yet demonstrated the statistical significance of any of these risk factors (8,10,13,14,15). Moreover, the interference of a genetic predisposition has been suggested (6).

In this case report, the simultaneous occurrence of a navicular stress fracture in high-performing, monozygotic twin brothers is described.

### INTRODUCTION

Stress fractures are common overuse injuries in athletes ; they result from intense and repetitive activity without adequate periods of rest. Growing awareness of stress fractures and improved diagnostic techniques have increased the reported incidence of navicular stress fractures. Stress fractures of the tarsal navicular bone are less common than stress fractures of the tibia and metatarsals. Studies in the 1980s projected a navicular fracture incidence of

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*Fig. 1.* — Twin brother 1. Plain radiographs of the right foot were normal

### CASE REPORT

A 21-year-old, high-performing track and field athlete (sprint) presented in the summer of 2009 with severe medial right foot pain since a few weeks. The pain increased dramatically after a race two days before the patient consulted us. Weight-bearing was very painful. Physical examination showed tenderness over the dorsal central portion of the navicular bone ('N-spot') (2). There was no swelling, discoloration or ecchymosis.

Plain radiographs were normal (fig 1). A radioisotope bone scan showed increased uptake in the navicular bone, suggesting a navicular stress fracture (fig 2). CT scan confirmed an incomplete, non-displaced navicular fracture at the proximal dorsal cortex (fig 3a-b).

A short-leg non-weight bearing cast was applied for six weeks. After removal of the cast, the patient was pain free and there was no tenderness over the navicular. Progressive weight bearing and physiotherapy were started.

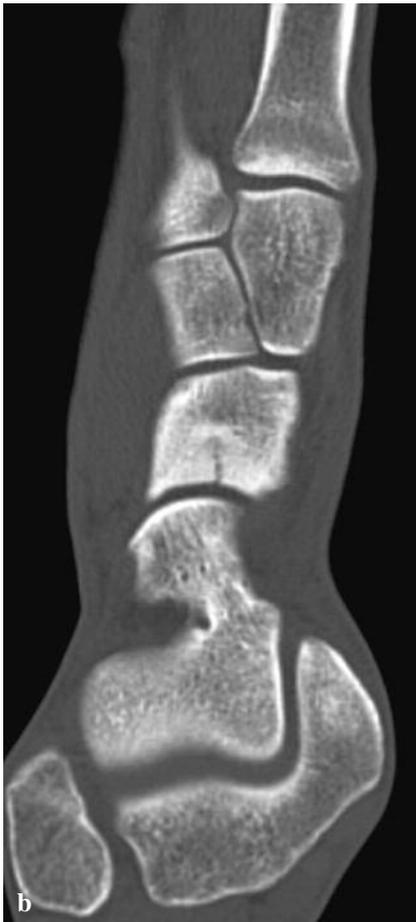
The day the cast of the previous athlete was removed, his monozygotic twin-brother, also a high-performing sprinting athlete, presented with medial left foot pain.

Plain radiographs were also normal (fig 4). A radioisotope bone scan showed bilaterally a slightly increased uptake over the tarsal navicular (fig 5). CT scan of the left (symptomatic) foot confirmed a small fracture line (fig 6a-b). After non-weight bearing cast immobilisation for 6 weeks, the patient was pain free, and progressive weight bearing was started.



*Fig. 2.* — Twin brother 1. The radiotope bone scan showed increased uptake over the navicular bone of the right foot.

Neuromuscular and strength training together with individual adaptation of footwear, allowed both athletes to return to normal training regimen after 4 months.



*Fig. 3a & b.* — Twin brother 1. Computed tomography of the right foot confirmed a fracture line in the proximal dorsal cortex of the navicular bone.



*Fig. 4.* — Twin brother 2. Plain radiographs of the left foot were normal.

### DISCUSSION

This case report describes the presence of a navicular stress fracture in high-performing twin brothers. In both athletes computed tomography was used to demonstrate the exact location and extent of the fracture.

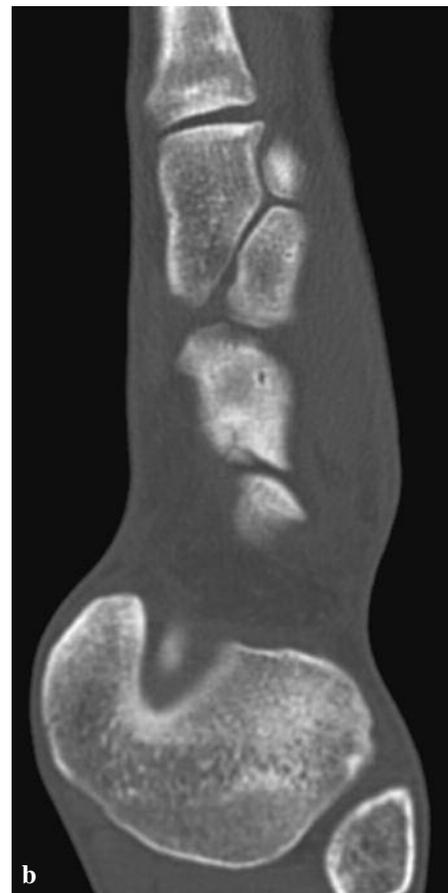
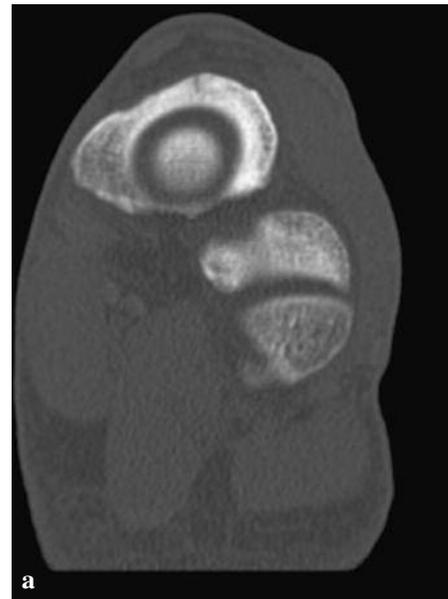
The stress fracture developed in both athletes in the central third of the navicular bone, which is the most commonly affected region of the navicular bone (11,13). An important aspect that may contribute to this characteristic location is the unique vascular anatomy of the navicular bone. There is an adequate blood supply to the medial and lateral surfaces of the navicular bone, but the central portion of the bone shows a lower level of vascularisation (9,13).



**Fig. 5.** — Twin brother 2. The radioisotope bone scan showed bilaterally a slightly increased uptake over the navicular bone.

On top of this unique vascular anatomy, the kinematics of the tarsal joints may also contribute to this characteristic location. During weight bearing, the navicular is subjected to shear stresses, on the one hand due to torsion between the first and second metatarsals transmitted via rigid naviculocuneiform articulations and on the other hand due to talar impingement on the medial proximal pole (4). Analysis of the stresses across the navicular during weight-bearing showed that these were greatest in the dorsal central zone of the navicular (12).

In both athletes the stress fracture originated from the proximal dorsal cortex of the navicular bone. This is the typical location of navicular stress fractures. The fracture line develops in the sagittal plane and courses from the proximal dorsal cortex to the distal plantar aspect of the navicular. In the first athlete, the fracture line was more advanced (length of 8 mm versus 2.5 mm and depth of 12 mm versus 3 mm).



**Fig. 6a & b.** — Twin brother 2. Computed tomography of the (symptomatic) left foot showed a small fracture line in the proximal dorsal cortex of the navicular bone.

Because of this typical location of a navicular stress fracture at the proximal dorsal cortex and if talar impingement plays a role, one may assume that dorsiflexion of the navicular bone with respect to the talus causes compression at the proximal dorsal cortex of the navicular bone. An *in vitro* study of motion of the tarsal bones of cadaver specimens using a gait simulator (Division of Biomechanics and Engineering Design and Faculty of Kinesiology and Rehabilitation Science, KU Leuven, Belgium) showed that dorsiflexion of the navicular bone with respect to the talus is mainly induced by the pretibial muscles (tibialis anterior, extensor digitorum longus and extensor hallucis longus) and in mid-stance position (unpublished data). Hypothetically, one might conclude that a better support of the longitudinal foot arch during maximal load and strengthening of the other muscle groups of the lower leg (triceps surae, tibialis posterior, flexor hallucis longus, peronei and flexor digitorum) could reduce the risk of impingement.

In literature there are not many case reports that describe a stress fracture in twins. As far as we know this is the first case report describing a navicular stress fracture in monozygotic twins. The occurrence of a navicular stress fracture in monozygotic twins may underline the presence of a genetic predisposition.

Some studies have shown that military recruits with femoral and calcaneal stress fractures had 10% lower bone mineral density (measured by dual photon absorptiometry) than uninjured male recruits who followed the same training program (6). It is known that genetic factors play a major role in the determination of bone mineral density and osteoporosis risk. Seventy per cent of the variability in human bone mineral density has been attributed to genetics. Linkage studies have identified several quantitative trait loci that regulate bone mineral density but most causal genes remain to be identified (6).

Beside a possible genetic predisposition, there are also several mechanical risk factors.

Intrinsic risk factors include anatomic variations and kinematics of the tarsal joints. These identical twin brothers have a similar foot arch morphology (Djian Annonier angle < 115° : pes cavus) and

probably also the same biomechanical characteristics during running.

Training intensity, training load, footwear and training surface are some of the extrinsic risk factors. There are no clinical or mechanical studies that have investigated the effects of footwear on the occurrence of navicular or other tarsal stress fractures in athletes (8). There are however some Israeli and American studies on the effect of footwear on stress fractures in military recruits (6). Some Israeli studies demonstrated substantial reductions in stress fracture rates using soft biomechanical orthoses (5). Although a simple sorbothane insole was not beneficial in a US study of 3000 marine recruits, there was a trend toward higher rates of stress fractures for individuals with the oldest running shoes (> 6 months), highlighting the importance of foot cushioning in prevention of stress fracture (7).

In this case, many extrinsic risk factors were comparable in both athletes. They have the same sponsor and thus the same running shoes. They studied at the same university in Belgium and in the United States of America, so they trained on the same running surface, they followed the same training program and they participated in the same races. The first athlete consulted us in July 2009 while preparing for the August 2009 World Championships in Athletics, and his twin-brother consulted us right after participating in this competition.

## REFERENCES

1. **Brukner PD, Bradshaw CJ, Khan KM, White S, Crossley K.** Stress fractures : a review of 180 cases. *Clin J Sports Med* 1996 ; 6 : 85-89.
2. **Brukner PD, Kahn KM.** *Clinical Sports Medicine*. 3<sup>rd</sup> ed, McGraw-Hill, Sydney, 2006, pp 652-655.
3. **Coris EE, Lombardo JA.** Tarsal navicular stress fractures. *Am Fam Physician* 2003 ; 67 : 85-90.
4. **de Clercq PF, Bevernage BD, Leemrijse T.** Stress fracture of the navicular bone. *Acta Orthop Belg* 2008 ; 74 : 725-734.
5. **Finestone A, Giladi M, Elad H.** Prevention of stress fractures using custom biomechanical shoe orthoses. *Clin Orthop Relat Res* 1999 ; 360 : 182-190.
6. **Friedl KE, Evans RK, Moran DS.** Stress fracture and military medical readiness : bridging basic and applied research. *Med Sci Sports Exerc* 2008 ; 40 (11 Suppl) : S609-622.

7. **Gardner LI Jr, Dziados JE, Jones BH.** Prevention of lower extremity stress fractures : a controlled trial of a shock absorbent insole. *Am J Public Health* 1988 ; 78 : 1563-1567.
8. **Gehrmann RM, Renard RL.** Current concepts review : stress fractures of the foot. *Foot Ankle Int* 2006 ; 27 : 750-757.
9. **Golano P, Fariñas O, Sáenz I.** The anatomy of the navicular and periarticular structures. *Foot Ankle Clin North Am* 2004 ; 9 : 1-23.
10. **Jones MH, Amendola AS.** Navicular stress fractures. *Clin Sports Med* 2006 ; 25 : 151-158.
11. **Khan KM, Brukner PD, Kearney C et al.** Tarsal navicular stress fractures in athletes. *Sports Med* 1994 ; 17 : 65-76.
12. **Kitaoka HB, Luo ZP, An K.** Contact features of the talonavicular joint of the foot. *Clin Orthop Relat Res* 1996 ; 325 : 290-295.
13. **Lee S, Anderson RB.** Stress fractures of the tarsal navicular. *Foot Ankle Clin North Am* 2004 ; 9 : 85-104.
14. **Pavlov H, Torg JS, Freiburger RH.** Tarsal navicular stress fractures : radiographic evaluation. *Radiology* 1983 ; 148 : 641-645.
15. **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* 1982 ; 64-A : 700-712.
16. **Tuan K, Wu S, Sennet B.** Stress fractures in athletes : risk factors, diagnosis and management. *Orthopedics* 2004 ; 27 : 583-591.