JACOBS PUBLISHERS

OPEN ACCESS

Jacobs Journal of Orthopedics and Rheumatology

Research Article

Tarsal Navicular Stress Fracture - A Challenging Injury in Athletes

Esa Liimatainen[1], Olli J. Heinonen[1], Lasse Lempainen[2*], Kristian Johansson[1], Janne Sarimo[2], David Lopez[3], Sakari Orava[2]

[1]*Paavo Nurmi Centre and Department of health and Physical activity, University of Turku, Turku, Finland*

[2]*Neo sports Medicine Hospital, Turku, Finland*

[3]*Clinica Cemtro, Madrid, Spain*

**Corresponding author: Dr. Lasse Lempainen, Hospital Neo, Joukahaisenkatu 6, FI-20520 Turku, Finland,*

Tel: +358 10 235 3535; Email: lasse.lempainen@sairaalaneo.fi

Received: 07-11-2016

Accepted: 11-01-2016

Published: 11-14-2016

Abstract

Background: Tarsal navicular stress fracture is a serious injury. Results from conservative treatment of early phase navicular stress fracture and surgical treatment of severe phase navicular stress fracture in athletes was evaluated.

Methods: 34 athletes were diagnosed to have a tarsal navicular stress fracture. Seventeen patients were treated conservatively. Seventeen patients had surgical treatment. The follow-up time was >2 years and return to pre-injury level of sports was evaluated in all patients using four categories: excellent, good, moderate or poor.

Results: The results from conservative treatment were excellent in all patients. Recovery from surgical treatment was excellent in 7 patients, good in 7, moderate in 2 and poor in 1 patient.

Conclusions: Early diagnosis is very important for successful treatment of tarsal navicular stress fracture. The treating physician must keep in mind the symptoms and use an appropriate imaging method in the early phase of forefoot pain.

Keywords: Stress Fracture; Running; Overtraining; MRI; Lower Extremity Injuries

Introduction

Stress fractures in the lower extremities are common, especially in athletes and military recruits [1–4]. In 1970 Towne and colleagues were the first to publish two cases of navicular stress fractures in humans while earlier navicular stress fractures had been reported e.g. in racing dogs [5,6].

Tarsal navicular stress fractures were thought to be rare overuse injuries. Early studies showed an incidence of 0.7 to 2.4 % in athletes [7]. In a 12-month prospective study the incidence of a navicular stress fracture in track and field athletes was 15 % [8]. An incidence as high as 35% has been reported also in track & field athletes [9].

Navicular stress fracture diagnosis is a challenge at the early stage, because symptoms are usually vague and early radiographs may be normal [10]. Early symptoms are activity-related local pain and swelling [11]. DeClercq et al. reported that 33% of initial radiographs showed a visible fracture line [12]. Usually x-ray findings become positive 4-6 weeks after the onset of symptoms [13].

Navicular stress fractures are often classified as “high risk” stress fractures, because the healing may be compromised by non-union and pseudoarthrosis [1,14]. Torg et al reported that non-weight bearing treatment with/without cast for 6 weeks is the treatment of choice [15]. However, operative treatment has been reported to be as successful as conservative treat-

ment [16]. Surgical treatment may be an option in high-risk stress fractures with complications like non-union or pseudoarthrosis and also when the conservative treatment fails.

The aim of this study was to investigate the conservative and operative treatment options for the challenging navicular stress fracture in 34 athletes.

Materials and Methods

There were 34 patients with navicular stress fracture between 1993 and 2011 in Sports Injury Clinic. The decision for conservative or operative treatment was made by the same surgeon from radiological findings as well as duration and severity of symptoms. An IRB approval was granted for this retrospective study.

Conservative treatment

Seventeen national level track & field athletes (10 females, 7 males) were diagnosed with an early phase unilateral navicular stress fracture between 2000 and 2010. The mean age of the patients was 18.5 years (range 16-25 years). Early stage MRI (within 1-2 months from the onset of symptoms) showed diffuse bone oedema in the navicular bone suggesting bony stress reaction and osteopathy (Figure 1). Three patients had a control MRI after three weeks showing markedly diminished oedema.

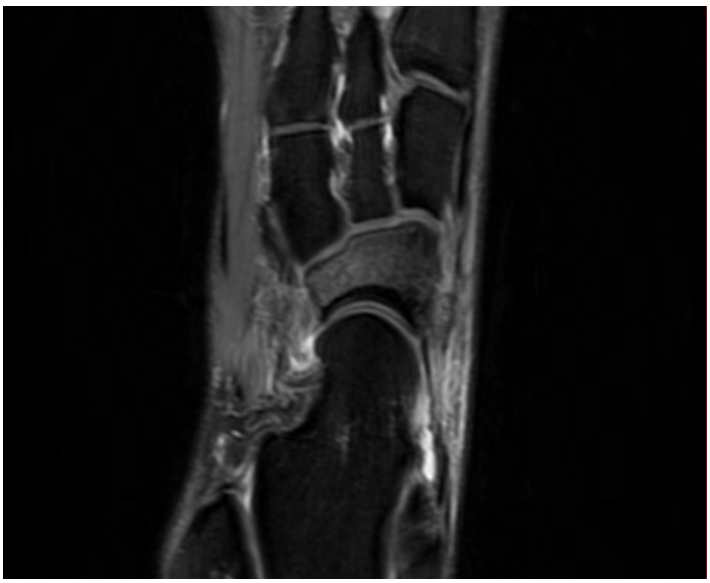

Figure 1.

Conservative treatment was initiated by a cessation of all training activities. Crutches with limited weight bearing (10-20 kg) were used during the first 4 weeks in all patients. Thereafter, normal full weight bearing was allowed, and swimming and water running exercises were allowed. After two months the patients gradually returned to their normal training and sports activities. For heavy athletes (body weight >100 kg), a third month was used for rehabilitation before normal training was allowed.

Operative treatment

Seventeen athletes engaged in running related sports (Table 1) were diagnosed with a severe phase navicular stress fracture between 1993 and 2011. The competing and training intensity level was national/high intensity in 14 patients and recreational/low intensity in three patients. The mean age of the patients was 21.4 years (range 15-34 years). There were 8 males and 9 females. The mean duration of symptoms before the operation was 5.5 months (range 3-12 months). The typical symptom was local pain during sports and a typical sign was palpable tenderness over the navicular bone. MRI showed a fracture line and bone oedema in all patients. Three patients went through CT imaging to show the exact orientation of the fracture line. All patients had also X-ray taken. Only two patients failed to show a clear fracture line through both cortexes in initial X-rays.

Sports and events	Operated patients (N)
Running events total	13
Sprint	4
Endurance	5
Orienteering	1
Soccer	2
Rhytmic gymnastics	1
Heptathlon	1
Taekwondo	1
Figure skating	1
Total	17

Table 1. Typical sports in operatively treated patients with severe phase navicular stress fracture

Surgical procedure

The left navicular bone was operated in 7 patients and the right one in 10 patients. An incision was made to the medial side of the navicular bone. The fracture was reduced under x-ray control using a Kirchner wire, and the fracture was fixed with two parallel AO-screws using a lag screw technique (Figure 2). After healing was verified, the lag screws were removed, normally 6 months postoperatively. One patient had developed pseudoarthrosis in the fracture line and despite two screws and bioorganic absorbable rods a delayed healing was observed. In one patient an additional avulsion fragment was found later. It was removed one year after the initial operation.

Figure 2.

Post-operative rehabilitation

The patients used crutches for four weeks (from non-weight bearing to half-weight bearing) followed by walking with hard-soled shoe for four weeks with full weight-bearing. Swimming and deep-water running were begun within 2-3 weeks after the operation. The rehabilitation training included treadmill exercises with hard-soled shoes. After two months the patients were permitted to move freely, and leg presses, barbell exercises and gym training were gradually allowed. Walking was limited to moderate level until three months from the surgery. In lean patients endurance type exercises (cycling/treadmill exercises, rowing, cross-country skiing) were allowed 3-4 months post-operatively and in heavy patients 4-6 months post-operatively.

Assessment of result

The follow-up time was >2 years. Recovery to pre-injury level of sports was evaluated using four categories (excellent, good, moderate or poor). An excellent result was defined with no symptoms in sports or normal life. A good result was achieved when there were only minor symptoms during sports, but not in activities of daily living (ADL). A moderate result was assessed when the patient was not able to perform maximally in sports but was asymptomatic in ADL. A poor result was defined when it was impossible to participate in sports due to pain and symptoms also in ADL occurred.

Results

All conservatively treated patients had excellent results and were able to gradually return to full sporting activities after 2-3 months from the diagnosis. None of these patients had navicular pain during sports during 2-year follow-up.

Operative treatment caused excellent results in 7 patients, good in 7 and moderate results in 2 patients. A 27-year-old female recreational runner had a poor result despite surgical treatment and had to give up sports (Table 2.). Her preoperative symptoms had lasted over 12 months and a pseudoarthrosis was diagnosed in the operation. Later, when the two lag screws were taken out, biofix rods were inserted into the screw canals to give additional stiffness to the fracture line. The healing process was slow but the patient became asymptomatic also in ADL.

Result	N	Operative	Conservative
Excellent	24	7	17
Good	7	7	0
Moderate	2	2	0
Poor	1	1	0
Total	34	17	17

Table 2. Results of operative treatment (severe phase fractures) and conservative (early phase fractures) treatment

Discussion

The aim of this study was to focus on the navicular stress fracture in athletes with special reference to early phase fracture with conservative treatment and severe phase fracture with operative treatment. Direct comparisons between these two treatment options are not possible because the phases of the stress fractures were different in our case series. However, it is important to get more detailed information on this interesting stress fracture which is challenging for both treating physicians and also athletes. The diagnosis is often difficult and the fracture is classified as high-risk fracture with possibly serious complications.

Stress fractures occur, when a healthy bone is subjected to continuous cyclical stress exceeding normal limits [1,17,18]. The bone exposed to repetitive loading does not have adequate time to recover from the mechanical stress, and may fracture [11]. In running events the foot must absorb up to three times the body weight in every step taken [19]. The navicular bone becomes impinged between talus and cuneiforms and the middle part of the bone forms a fulcrum between forces [20,21]. The relatively avascular middle third of the navicular bone is especially vulnerable for stress fracture [22]. If the blood supply is poor, a dislocated fracture may lead to avascular necrosis. McKeon et al. recently showed that 12 percent of individuals have diminished vascular supply to the central part of the navicular bone [23].

Most of the patients in our study were training on a national level. This training is often of high intensity in order to improve physical performance. Training including a lot of running and jumping exercises seems to increase the risk for stress [2]. These, and especially jumping exercises, are often performed with nearly maximal effort resulting in remarkable forces acting upon the navicular bone. This may first lead to stress reaction of the bone, and eventually to stress fracture.

When a stress fracture is suspected, a bone scan is usually positive 72 hours after the onset of symptoms. Both MRI and scintigraphy may show local bone oedema or osteopathia, but MRI is more specific to bone stress reactions. In early stages a radiograph has limited value, but is still suggested as the first line examination when a stress fracture is suspected, to rule out other problems [24]. To identify the location, and the direction of the fracture line a CT scan after a few weeks is useful [12]. In our series of operated patients only two did not show a clear fracture line through both cortexes of the navicular bone in x-rays. In these patients the symptoms persisted for an extended period of time, and a clear fracture line was seen in MRI. In all patients with early phase fracture and conservative treatment, MRI was taken within 1-2 months from the onset of the symptoms confirming the diagnosis.

All conservatively treated patients (four weeks of non-weight bearing) had an excellent outcome in our study, mainly due to the early phase diagnosis. According to our observations a delayed diagnosis could lead into a more serious outcome, highlighting the importance of achieving the right diagnosis after the onset of symptoms. The longer the symptoms persist, the more difficult the treatment becomes and an optimal recovery is also more difficult to reach.

Pseudoarthrosis may result from failed conservative treatment, and in such cases surgical treatment may be an option. In a recent case-study Toren et al reported good results using vascularized scapular bone graft when treating avascular necrosis of the tarsal navicular stress fracture [25]. We chose the surgical treatment when a clear fracture line in navicular bone was seen in radiographs. In these cases the symptoms had been present for an extended period of time prior to the diagnosis - on average 5.5 months, and one patient had symptoms for over 12 months before surgery.

The longer the symptoms persist, the more difficult the treatment becomes, and the optimal result is also threatened. A combination of tensile forces and poor vascularity at the fracture site lead to poor healing even with appropriate treatment. This means that high-risk stress fractures in athletes may require more aggressive treatment [14]. Even if there is a longer delay between the onset of the symptoms and the diagnosis, surgical treatment may provide the athlete with good results and low risks.

We speculate, that the diminished vascular supply to central part of the navicular bone may cause delayed healing and eventually lead to surgical treatment because in such case conservative treatment would be prone to fail, and serious complications might occur without surgical intervention [23,26]. On the other hand, patients who have adequate blood supply may not be in high danger of fracture complications and the conservative treatment would most probably lead to complete healing. However, studying the blood flow and vasculature in the central part of the navicular bone is challenging in a clinical setting.

A limitation of the study is that the patient case series was collected retrospectively. However, it would be ethically unsound to randomize patients into the conservatively or surgically treated groups and not considering the phase of the fracture. The strength of the study is the relatively high number of well documented cases of this rare injury, representing typical athletes in both conservatively and surgically treated group.

Conclusions

High-risk stress fracture of tarsal navicular bone in athletes may be potentially career-threatening if left untreated. A clinician should look for a tarsal navicular stress fracture in sports-related, vague but persistent forefoot pain because an early diagnosis reduces the risk of serious complications. Our recommendation is that confirmation of the diagnosis with MRI should be considered when plain radiographs are negative. An important early phase symptom is bone oedema. However, the decision making between conservative and surgical treatment requires experience. Excellent recovery results can be achieved in the early phase with adequate, conservative treatment. If symptoms have been persisted over four months and a fracture line is visible in radiographs, surgical treatment is an option.

References

1. Brockwell J, Yeung Y, Griffith JF. Stress fractures of the foot and ankle. Sports Med Arthrosc. 2009, 17: 149-159.

2. Hulkko A, Orava S. Stress fractures in athletes. Int J Sports Med. 1987, 8: 221-226.

3. Niva MH, Sormaala MJ, Kiuru MJ, Haataja R, Ahovuo JA, Pihlajamaki HK. Bone stress injuries of the ankle and foot: an 86-month magnetic resonance imaging-based study of physically active young adults. Am J Sports Med. 2007, 35: 643-649.

4. Sormaala MJ, Niva MH, Kiuru MJ, Mattila VM, Pihlajamäki HK. Stress injuries of the calcaneus detected with magnetic resonance imaging in military recruits. J Bone Joint Surg Am. 2006, 88: 2237-2242.

5. Towne LC, Blazina ME, Cozen LN. Fatigue fracture of the tarsal navicular. J Bone Joint Surg Am. 1970, 52: 376-378.

6. Baterman J. Broken hock in the greyhound. Repair methods and the plastic scaphoids. Vet Res. 1958, 70: 621-623.

7. Khan KM, Brukner PD, Kearney C, Fuller PJ, Bradshaw CJ, Kiss ZS. Tarsal navicular stress fracture in athletes. Sports Med. 1994, 17: 65-76.

8. Bennell KL, Malcolm SA, Thomas SA, Wark JD, Brukner PD. The Incidence and Distribution of Stress Fractures in Competitive Track and Field Athletes: A Twelve-Month Prospective Study. Am J Sports Med. 1996, 24: 211-217.

9. Brukner P, Bradshaw C, Khan KM, White S, Crossley K. Stress fractures: a review of 180 cases. Clin J Sport Med. 1996, 6: 85-89.

10. Mann JA, Pedowitz DI. Evaluation and treatment of navicular stress fractures, including nonunions, revision surgery, and persistent pain after treatment. Foot Ankle Clin. 2009, 14: 187-204.

11. Anderson MW, Greenspan A. Stress fractures. Radiology. 1996, 199: 1–12.

12. deClercq PF, Bevernage BD LT. Stress fracture of the navicular bone. Acta Orthop Belg. 2008, 74: 725-734.

13. Rossi F, Dragoni S. Talar body fatigue stress fractures: three cases observed in elite female gymnasts. Skeletal Radiol. 2005, 34: 389-394.

14. Boden BP, Osbahr DC. High-risk stress fractures: evaluation and treatment. J Am Acad Orthop Surg. 2000, 8: 344-353.

15. 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: 1048-1053.

16. Potter NJ, Brukner PD, Makdissi M, Crossley K, Kiss ZS, Bradshaw C. Navicular stress fractures: outcomes of surgical and conservative management. Br J Sports Med. 2006, 40: 692-695.

17. Hulkko A. Stress fractures in athletes. A clinical study of 368 cases. Dissertation. University of Oulu. 1988.

18. Matheson GO, Clement DB, McKenzie DC, Taunton JE, Lloyd-Smith DR et al. Stress fractures in athletes. A study of 320 cases. Am J Sports Med. 1987, 15: 46-58.

19. Novacheck T. The biomechanics of running. Gait Posture. 1998, 7: 77-95.

20. Orava S, Karpakka J, Hulkko A, Takala T. Stress avulsion fracture of the tarsal navicular. An uncommon sports-related overuse injury. Am J Sports Med. 1991, 19: 392-395.

21. van Langelaan EJ. A kinematical analysis of the tarsal joints. An X-ray photogrammetric study. Acta Orthop Scand Suppl. 1983, 204: 1-269.

22. Coris EE, Lombardo JA. Tarsal navicular stress fractures. Am Fam Physician. 2003, 67: 85-90.

23. McKeon KE, McCormick JJ, Johnson JE, Klein SE. Intraosseous and Extraosseous Arterial Anatomy of the Adult Navicular. Foot Ankle Int. 2012, 33:8570-8581.

24. Patel DS, Roth M, Kapil N. Stress fractures: diagnosis, treatment, and prevention. Am Fam Physician. 2011, 83: 39-46.

25. Toren AJ, Hahn DB, Brown WC, Stone PA, Ng A. Vascularized scapular free bone graft after nonunion of a tarsal navicular stress fracture: a case report. J Foot Ankle Surg. 2013, 52: 221-226.

26. McCormack JR. The management of bilateral high hamstring tendinopathy with ASTYM® treatment and eccentric exercise: a case report. J Man Manip Ther. 2012, 20: 142-146.