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Stress Fractures of the Foot and Ankle in Athletes, an Overview

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Abstract

Stress fractures occur due to repetitive forces on the bones and develop over time. The etiology differs from a traumatic fracture and therefore stress fractures are more an overload injury. Stress fractures of the foot and ankle are frequently seen in athletes and can be a potentially career ending injury for these high demanding sportsmen. Some locations are considered as high-risk stress fractures due to slow healing and high rates of non-unions. This article discusses the most common sites for stress fractures of the foot and ankle, the risks and evidence on best treatment options.

Keywords: Stress fracture; Fatigue fracture; Foot; Ankle; Athletes

Introduction

A stress fracture develops over time and is the result of an overload of the bone. Therefore these fractures are also called fatigue fractures. The etiology differs from traumatic fractures, because the damage is caused when repeated forces on the bone outruns its remodelling capacity. This can eventually result in micro-fractures leading to a weak spot and when loading proceeds, a stress fracture can arise [1-3]. Another difference with a traumatic fracture is the stress fracture's healing process. It is described that stress fractures do not heal by callus formation, but more via direct remodelling of bone across the fracture line [1,4,5]. This is a slower process and more comparable to the healing pathways of non-unions [1,5].

Athletes belong to a very healthy but also demanding group of patients. They require much of their body with intensive workloads. They are at risk to create an overload injury, and studies reported an incidence of stress fractures among athletes of up to about 2% [6,7]. Different sites of the foot and ankle can be affected and in some, union problems and re-fractures are frequent and are considered high-risk [8]. This article focusses on the most common sites of stress fractures in the foot and ankle, discussing the epidemiology, diagnostic options, risks and best available treatment.

Diagnosis

Patients' history usually concerns prodromal symptoms, with insidious onset. These symptoms have a chronic character sometimes worsening gradually. In other cases pain eventually worsens after an acute moment of severe pain. People suddenly increasing their training intensity [9-11] and athletes of adolescent' age [12,13] are at risk to develop a stress fracture. Furthermore intrinsic factors like nutrition or hormonal deviations, both frequently seen in especially endurance athletes, and sex have been suggested to contribute to the misbalance of bone remodelling resulting in a stress fracture, although in conflicting directions [3,14,15].

After physical examination -where local tenderness, pain during axial forces and sometimes a palpable swelling are the most important signs- imaging is the next step. A stress reaction and sometimes even a stress fracture is not always seen on X- rays. In the early stage of the injury the fracture line could be too vague to distinguish. An MRI, bone- or CT-scan can be of help at this stage. When prodromal symptoms exist for a longer period of time, the fracture could have progressed into a complete (stress) fracture, well recognizable on an X-ray by a radiolucent fracture line and evidence of a sclerotic intramedullary cavity, with or without a thickening of the affected cortex.

Treatment

When deciding which treatment is best, the physician should bear in mind that in the developing stage, rest from activities can provide the bone some time to remodel and heal the micro-fractures before a definite stress fracture develops. After all, the origin of a stress fracture is a misbalance between load and rest resulting in an overload of the bone. In order to prevent this type of injury, trainings intensity should be deliberated, as well as the nutrition and hormonal state of the athlete. Unfortunately, this preventive approach is not always possible. Especially in professional athletes, match play or competition pressure is of great importance and the loads are high, this allows the stress reaction to turn into a stress fracture.

Conservative treatment is an option if the athlete can manage the pain while performing activities and is able to go on despite of it. According to the biology of a stress fracture, a possible theory would be that when continuing performing sports a total fracture could occur. This means: a fracture more like a traumatic fracture and thus with more potential to heal. It is important to consider the anatomical variations and locations, to classify the fracture into low- or high risk [8,16]. Another possible important factor to be at high risk of healing problems is the hypovascularity of the affected bone. Stress fractures localized in a hypovascular site or a so-called watershed area, are considered to be of a high-risk [17-21]. When untreated, healing problems could occur due to the lack of vascularization at these spots.

Common Sites

Medial Malleolus

A stress fracture of the medial malleolus usually occurs in long distance runners, but also high demand athletic individuals like jumpers and gymnastics [7,22]. The medial malleolus stress fracture is a high risk location and accounting for 0.6 - 4.1% of all lower limb stress fractures [7,8,22,23]. Repetitive loading or impingement of the talus on the medial malleolus during ankle dorsiflexion and tibial rotation may result in a medial malleolar stress fracture [24].

On a plain X-ray only 30% of the fractures are seen [25]. Other reported findings are regional osteopenia, sclerosis, callus or cysts [23]. Bone scan and MRI are sensitive to demonstrate a stress reaction, but MRI has more specificity as diagnostic imaging [23,26].

Because the rarity of this stress fractures location, there is lack of firm evidence supporting either surgical or conservative treatment. Conservative treatment of the medial malleolus consists of 4-8 weeks non-weight bearing cast, with reported time to return to sports from 6 weeks to six months [23,27-29]. Surgery is advocated by complete or displaced fractures and in athletes. The reported return to play is 5 weeks to 4 months [27,30]. Most advocated surgical technique is internal fixation with compression screws (Figure 1). In case of a delayed union additional drilling of the fracture site or bone graft is recommended [27,31].

Figure 1: AP and lateral view after surgical treatment with compression screws of a medial malleolar stress fracture.

Distal Fibula

Up to 30% of all stress fractures are fibular stress fractures [22,32] located in distal part of the fibula, or mostly in the shaft or proximal [33,34]. Distal fibular stress fractures are seen in runners and soccer players.

The fracture line is hard to see the first 4 weeks on X-ray. When not treated, symptoms may persist longer, which calls for an early diagnosis. This fracture does have an excellent prognosis when treated with a 3 to 6 week-period of rest, after local tenderness is resolved the athlete can return to his athletic activities [16]. Surgery is not indicated as primary treatment, but can be of value in case of union problems (Figures 2 and 3).

Figure 2: CT scan of the right ankle showing a non-union of a fibular stress fracture.

Figure 3: Intramedullairy screw for a non-union of a fibular stress fracture on the right side.

Talar bone

Stress fractures of the talar bone are very rare, incidence is reported to be 4.4 per 10000 persons a year in military recruits [35] and they found the talar stress fracture associated with stress reactions of the other tarsal bones. The body of the talus or, even less often reported, the lateral talar process is affected [35,36] and pain is located into the subtalar joint or in the lateral ankle and sinus tarsi.

The suggested cause is excessive subtalar pronation and plantar flexion [37,38].

Figure 4: a) CT scan of the left ankle with a stress fracture of the lateral proces of the talus b) MRI of the same fracture.

The fracture line is seldom visible on plain radiographs, so a CT-scan (Figure 5), bone scan or MRI (Figure 4) is advocated in case of suspicion. Probably due to its rarity, there is often a long period before final diagnosis. Healing of this fracture site is also a slow process [8,39] and most patients do not return to their previous level of sports [38]. Therefore a non-weight bearing cast of at least 6 weeks is advocated [8]. Surgically described treatment is drilling, combined with immobilization of 6 weeks, but still healing remains arduously with a long time to return to sports and not always to previous level of achievement [8,35-43]. In athletes we recommend surgical treatment by using compression osteosynthesis (Figure 5) in both body and lateral stress fractures.

Figure 5: AP and Lateral view of the status after surgical treatment with compression screws of the left sided stress fracture of the lateral process of the talus.

Calcaneal bone

This location is mainly seen in long distance runners and recruits, but is also a rare location with an incidence in recruits of 2.6 per 10.000 person-years [44]. Most of the time, the fracture is located at the postero-superior calcaneus just anterior to the apophysial plate, but also one case of a stress fracture of the anterior process is reported [42]. When considering a calcaneal stress fracture it is important to differentiate from other injuries as achilles tendinosis, retrocalcaneal bursitis or plantar fasciitis. On plain radiographs only 15% of the fractures were seen, MRI can be of important additional information [44].

Preferred treatment of this low-risk stress fracture is conservative with limitation of activity for 3 weeks and potential use of a soft heel pad [16]; in recruits the mean time to return to activities was 70 days [44]. During rehabilitation calf and plantar fascia stretching is recommended to prevent recurrence. All reported cases returned to sport.

Figure 6: MRI of the left ankle showing a navicular stress fracture.

Navicular bone

Navicular stress fractures are reported to be 25% of all stress fractures, most in runners and basketball players [45,46]. These stress fractures can present as partial up to complete fractures and severity of the fracture is believed to correlate with the outcome [47] The fracture is located in central third of the bone or at the junction of the central and lateral thirds of the navicular (Figure 6). This is where a hypovascular watershed area is present [17] what makes it a high-risk stress fracture. Sometimes the stress fracture is seen on X-ray but mostly a sagittal CT or MRI is needed [48,49]. No strong evidence supporting surgical treatment is available [50], but reviewing current literature reveals an return to sports of 16 weeks where conservative treatment takes 21 weeks, with a higher complication rate. Recommended conservative treatment is 6 weeks non-weight bearing cast. The most performed surgery consists of screw fixation (Figure 7), sometimes with additional bone graft [50].

Figure 7: Left navicular stress fracture after surgical treatment with compression screws.

Fifth metatarsal

This stress fracture is mainly seen among soccer, football and basketball players [12,51,52]. The fractures are typically located in the proximal methaphysic of the bone, right where the watershed area is present [18-20]. Patients usually have prodromal symptoms of swelling and tenderness around. In early state, radiographs (Figure 8) don't always show a lucent fracture line or callus formation [2], and then a CT-scan can be performed. Most recommended evidence points in the direction of surgical treatment, especially in athletes [53,54] with a return to sports of 24-26 weeks versus 14-15 weeks in conservative treated patient. Surgery can be performed with a Zuggurtung- or screw fixation [12,52,55]. Recommended conservative treatment is a non-weight bearing cast for at least 6 weeks.

Figure 8: Oblique view of fifth metatarsal stress fracture of the left foot.

Metatarsal stress fractures

Stress fractures of the metatarsals were referred to as march fractures, they frequently occur with a change in running intensity [56,57]. They are accounting for 9% of all stress fractures in athletes, in a study of 320 stress fractures in athletes by Matheson et al. [32]. Approximately 80% of the stress fractures of the metatarsals occur in the medial and distal part of the second and third metatarsal [58-61]. Most patients are able to localize a delicate pain point during physical examination.

The evaluation of clinical suspicion of a stress fracture should include plain radiographs with MRI or bone scan [62]. In early state radiographic studies are usually normal, whereas after 3–4 weeks periostitis, fracture callus or increased bone density may be seen. Scintigraphy shows an increase in uptake at the level of fracture [58].

Traditionally treatment is conservatively by using a walker boot or a short-leg cast non-weight bearing for 4-8 weeks, after removal of the cast gradual resuming of the activities is recommended [63-66]. The reported time for gradual recovery and return to activity of non-critical stress fractures is approximately 6-8 weeks [67]. If conservative treatment fails, surgery seems to be a good option. Drilling around and through the fracture line, open reduction and internal fixation is possible, if needed combined with bone grafting. This surgery is followed by a non-weight bearing period with a cast or a hard sole shoe for 2-6 weeks [68-70]. Reported time from surgery to return to sport and activities was 10-20 weeks with an average of 12 weeks [70].

Great toe sesamoids

Sesamoid stress fractures of the hallux represent approximately 1%-3% of stress fractures in athletes, especially in runners [7,32]. These stress fractures have been described after repetitive loading by jumping and long walks, and occur more often at the medial sesamoid [71]. The sesamoid bones of the first metatarsophalangeal (MTP) joint absorb the majority of weight of the first ray and therefore play an important role in force transmission. The sesamoids also function as a pulley for the flexor hallucis longus- and brevis tendons and provide stabilization of the MTP joint.

Symptoms of having a sesamoid stress fracture during physical examination include local tenderness and pain on direct palpation and decreased plantar or dorsiflexion strength.

Conventional radiology is recommended by a X-ray of the axial sesamoid, however the X-ray can be misdiagnosed for a bipartite sesamoid. Scintigraphy and CT-scan are more reliable in confirming the diagnosis [71,72]. Initially a conservative treatment based on rest or partial weight baring, application of a short-leg walking cast with specific prevention of dorsiflexion for at least 6 weeks is recommended by most authors, and operative treatment is advised if non-operative treatment fails. Be aware that this side is also of high risk due to tenuous blood supply [8,73]. Percutaneous cannulated screw fixation appears to be a successful alternative to open procedures for acute fractures and nonunion. Total sesamoidectomy is rarely recommended as it causes a mechanical defect and reduces the flexion movement [71,74-76].

Conclusions

Stress fractures in the foot and ankle are common injuries in athletes. They can be classified as overuse injuries, and often seen in the younger athletes or military recruits. In order to prevent this type of injury, trainings intensity should be deliberated, which is hard to achieve in professional athletes. When low-risk stress fractures are still in early stage, it is an option to continue sports if the athlete can stand the pain during activities. High-risk stress fractures can develop more easily into a chronic problem, with career-ending properties. It is necessary to pay attention to diagnose these fractures in an early state and treat these more aggressive.

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