71 Evaluation of Stress Fractures

Gustavo Vinagre, Flávio Cruz, and Pieter D'Hooghe

71.1 Introduction

A stress fracture is a partial or complete disruption of bone continuity, representing the inability of the skeleton to withstand repetitive submaximal loading, which results in structural fatigue, and resultant signs and symptoms of localized pain and tenderness [1].

Although stress fractures are rare, they can present as common overuse injuries, leading to fatigue fractures (gradual onset—overload injury; high recurrence) in physically active individuals like athletes and military recruits [2]. These injuries are associated with a prolonged absence from sports [3, 4] and can potentially be career-ending [5]. In addition, stress fractures have a high rate of recurrence (22%) and often present as a competition season-ending injury (20%) [6].

This chapter aims at outlining the most common stress fractures of the ankle and foot with focus on the initial management by means of clinical examination. It also provides diagnostic, therapeutical, and return-to-play guidelines for these types of injuries.

G. Vinagre · F. Cruz · P. D'Hooghe (✉)
Department of Orthopaedic Surgery, Aspetar Orthopaedic and Sports, Medicine Hospital, Doha, Qatar
e-mail: gustavovinagre@gustavovinagre.com; flavio.cruz@aspetar.com; pieter.dhooghe@aspetar.com

71.2 Epidemiology

Stress fractures are rare, but they most commonly occur in athletes who are usually exposed to highly repetitive weight-bearing activities and they can lead to long absences from sports.

There is a lack of evidence-based epidemiologic data among studies regarding the rate of stress fractures in recreational or competitive athletes, ranging from 0.5% to 4.8% of all injuries in multiple sports [7]. The incidence of stress fractures in military recruits is higher when comparing to athletes and varies from 5% to 30% per year, being higher in female recruits [8–11].

According to Ekstrand et al. [12], in elite male football (soccer) players, stress fractures represent only 0.5% of all injuries, giving an injury incidence of 0.04 injuries/1000 h (a team of 25 players can expect one stress fracture every third season), but the median absence from sports is high—80 days (3 months).

It seems that the injury rate among females is higher when compared to males due to the specific physiopathogenesis of the female athlete triad [13]. According to Rizzone et al.'s study [6] in collegiate student-athletes, the ratio of female/male was 2.5–3 to 1. There are some sports in which stress fractures are more common such as running, gymnastics, ballet, football (soccer), and figure skating [14].

It is also known that younger players are more likely to develop stress fractures in comparison to

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older players and they also have a higher reinjury rate (29%) [12].

Anatomically, all bones of the human body can be subjected to stress fractures, but there is a clear predominance over the lower limbs, especially over the weight-bearing bones [15].

The most common locations for stress fractures are the metatarsals (fifth and second), tibia (anterior cortical bone), femoral neck (superolateral), ribs, medial and lateral malleolus, talus, calcaneus, navicular, cuboid, patella, sesamoids (hallux), pelvis (ischiopubic rami), sacrum, and pars interarticularis. According to Matheson et al. [16] in a study of 320 athletes, the tibia (49.1%), tarsals (25.3%), and metatarsals (8.8%) were the most frequently involved bones affected by a stress fracture (Fig. 71.1). Certain anatomical sites are specific of certain sports [17].

71.3 Etiopathogenesis and Mechanism of Injury

The exact pathophysiology of stress fractures is unknown. Bone is a dynamic tissue, and its turnover cycle, remodeling, and mineralization phases generally require a period of 3–4 months.

The applied bony load during sports activities or weight-bearing activities results in external forces (strain) and internal forces (stress) [18], both of which are vital for the maintenance of the normal bony strength. Stress fractures occur when there is an imbalance between the bone that is formed and the bone that is remodeling. This will consequently result in a progressive discontinuity of the bone, and eventually, the bone becomes unable to resist repetitive (cyclic) loads. It can also be explained by an imbalance between the strength of the bone itself (bone resistance)

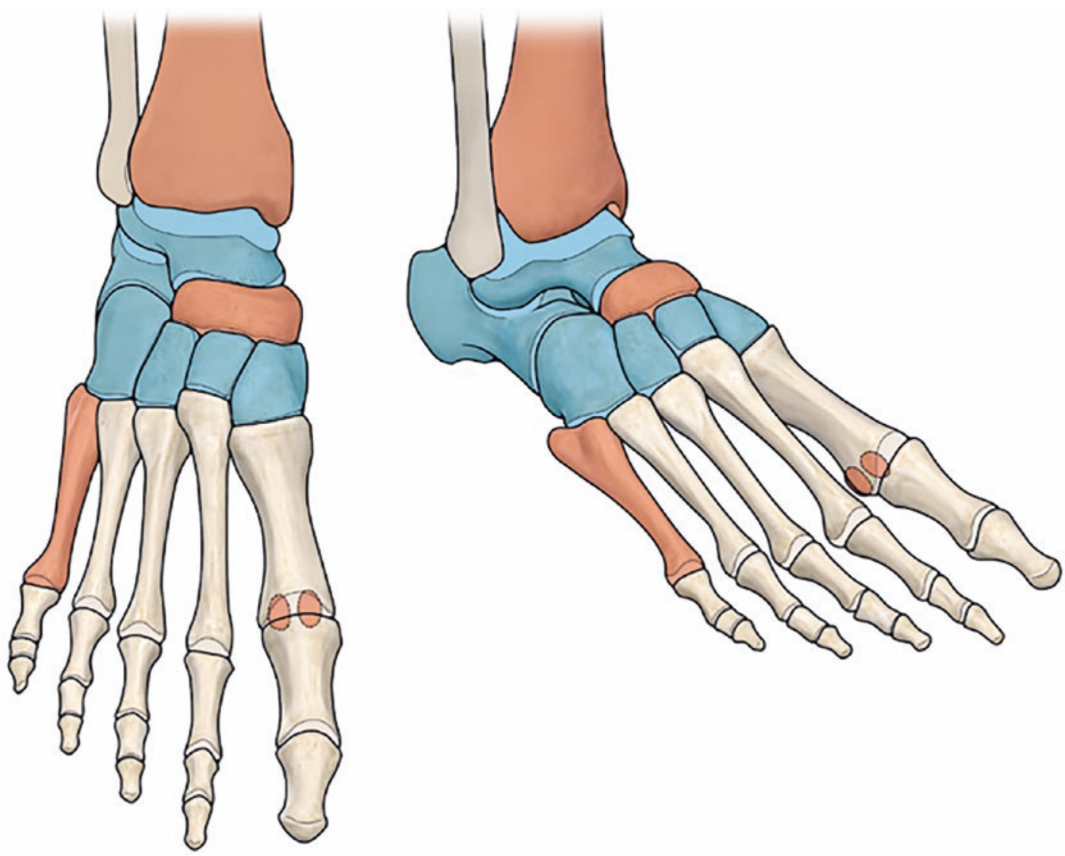

Fig. 71.1 "High-risk (brown)" and "low-risk (blue)" foot and ankle stress fractures' anatomical sites

Table 71.1 Intrinsic and extrinsic risk factors for stress fractures [19]

Intrinsic factors	Extrinsic factors
• Female gender (hypoestrogenic state/menstrual dysfunction/female athlete triad) • Younger age: In males, incidence decreases after 17 years of age; in females, it increases after menarche • Low body mass index (BMI <19) • Decrease muscle strength • Misalignment • Low physical activity • Bone geometry and bone turnover (osteopenia/osteoporosis) • Genetic predisposition • Hormonal factors • Nutritional aspects and eating disorders • Cavus feet • Forefoot varus • Leg-length discrepancies • Forefoot varus • Tarsal coalitions	• Training schedule changes • Inadequate/changing footwear (low-impact absorption) • High-volume and -intensity training (external load) • New training regimen/technical staff • Preseason training • Improper technique • Hard/rigid field surfaces • Long-distance runners • Alcohol • Smoking • Low vitamin D • Sleep deprivation

and chronic mechanical overload (forces of tension and compression/impact) on the bone that makes it unable for the bone to deform and absorb these forces (repetitive loading), exceeding the range of normal bone elasticity.

Stress fractures can be divided (according to the bone quality and load) into fatigue fractures (in those that result from an increase load/cyclic forces on a normal bone like a high volume of exercises in a short period of time) and insufficiency fractures, produced by normal load within weakened bones (i.e., osteoporosis/osteomalacia).

However, not only the bone pathophysiology and biomechanical factors are involved, but also hormonal, nutritional, and genetic factors. Other intrinsic and extrinsic risk factors are detailed in Table 71.1.

It is important to identify these risk factors and target these groups in order to prevent and anticipate the occurrence of stress fractures.

71.4 Diagnosis

71.4.1 Clinical Assessment and Physical Examination

A detailed clinical assessment and a focused physical examination with a presumptive clinical suspicion are key for a correct non-delayed diagnosis of a stress fracture.

Most of the patients have an insidious and progressive onset of mild pain with no history of trauma. The pain is aggravated with repeated weight-bearing activities and is relieved by rest. However, many athletes with stress fractures can present asymptomatic. It is critical to have a high index of suspicion on the presence of predisposing risk factors since many athletes with complaints may present with normal radiographs. A complete history should include detailed questions on diet, nutrition, medication, daily activities, training schedule, equipment/footwear, training surface, menstrual cycle, and external load. Ask if something has changed, regarding training load, coach and/or staff, footwear, or surface.

In females, it is mandatory to evaluate gender-specific risk factors such as menstrual disorders, eating disturbances, and recent weight loss.

The physical examination should assess limb alignment, length discrepancies, gait, muscular asymmetry, active and passive range of motion, abnormalities of the plantar arch, callosities (repetitive stress in a focal area), fixed or flexible deformities, and laxity or stiffness.

Usually, tenderness on palpation or percussion of the involved bone is found, and sometimes it is possible to palpate a periosteal thickening (sign of inadequate callus formation), especially in chronic stress fractures with delayed union. Swelling, erythema, ecchymosis, and warmth may also be apparent. If the pain increases with passive inversion stretch, you should look for a fifth metatarsal stress fracture. In the case of a calcaneus stress fracture, the pain should increase with a calcaneal squeeze test (Fig. 71.2).

The hop test (Fig. 71.3) should be performed to rule out foot and ankle stress fractures. This test consists of hop up and down on the affected limb several times barefoot. A large amount of pain in a localized area of the lower extremity is a positive test and may signify a fracture.

Cavovarus foot alignment and pain upon tiptoe standing can also be suspicious.

Fact Box 1
Always suspect a stress fracture in an athlete who presents with dull foot pain, localized to the bone, that increases on activity and is relieved with rest.

71.4.2 Imaging

Radiographic imaging is considered critical for the diagnosis, prognosis, and follow-up of stress fractures.

Fig. 71.2 Calcaneal squeeze test. The test is positive if the patient feels pain with the medial-lateral compression of the calcaneus

Fig. 71.3 Hop test. The patient should be asked to jump (**a**) and land in one foot. (**b**) The test is positive if the patient feels pain in the localized area of the stress fracture when landing (**b**)

71.4.2.1 Radiography

Radiographs are considered the initial imaging modality in stress fractures due to their easy access and relatively low cost. Plain weight-bearing anteroposterior, lateral, and oblique radiographic views are the current standard.

Although radiographs have a high specificity, they are not always reliable and can be missed (up to 87% false-negative rate), particularly during the initial 2–3 weeks after the onset of symptoms [20, 21]. Most fractures are incomplete, which makes them invisible on plain radiographs until bony osteoclastic resorption has taken place [22].

The earliest stress fracture sign on radiographs is a localized periosteal thickening or a subtle radiolucent area. Especially at later stages in the stress fracture development, periosteal reaction and callus formation will appear (Fig. 71.4). In the absence of positive radiographic findings and a high index of stress fracture suspicion, further imaging should be considered by means of magnetic resonance imaging (MRI), computed tomography (CT), or bone scan.

Fact Box 2
Do not rely on plain radiographs only for the diagnosis of foot stress fractures. MRI, CT scan, and/or bone scan are often required for diagnostic confirmation.

Fig. 71.4 Anteroposterior plain foot radiographic view with a periosteal reaction on the second metatarsal shaft (stress fracture) in a national team football player

71.4.2.2 Ultrasonography

Ultrasound is a sensitive diagnostic tool and easily accessible and can identify early bony stress reaction. In case of a normal radiograph, it is advised to ask for an ultrasound to identify periosteal reaction as a primary sign of the bony stress reaction. Although previously thought to have a poor sensitivity and specificity, a recent trial found increased pain to have a positive predictive value of 99% (sensitivity, 81.9%; specificity, 66.6.%) in the application of therapeutic ultrasound at the site of a bony stress injury [23].

71.4.2.3 CT Scan

Computed tomography (CT) scan can be helpful to highlight a small fracture line, can confirm the diagnosis of a complete stress fracture, and can also be used to monitor healing (Fig. 71.5). This modality can also be useful when there is a contraindication for the use of magnetic resonance imaging (MRI) or in chronic cases (where it is shown to be more useful than MRI or bone scan).

71.4.2.4 MRI

Magnetic resonance imaging (MRI) is the most sensitive and specific imaging modality for the

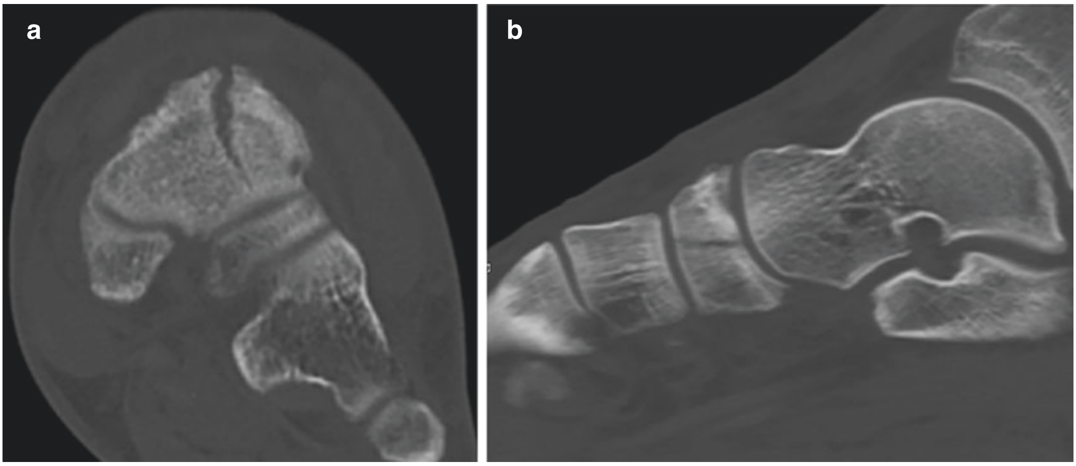

Fig. 71.5 CT scan of an elite football player with a navicular stress fracture. (**a**) Axial CT view, (**b**) sagittal CT view

Table 71.2 Generic MRI grading system of stress fractures. From Arendt EA, Griffiths HJ [29]

Low grade	Grade 1	STIR signal changes
	Grade 2	STIR and T2 changes
High grade	Grade 3	STIR, T1, and T2 changes No fracture line present
	Grade 4	STIR, T1, and T2 changes Fracture line present

diagnosis of stress fractures, and it is currently considered the golden standard [24].

The abnormalities caused by the fracture can usually be identified 1–2 days after the start of symptoms, with an early detection of bony edema [25–27].

MRI can differentiate medullary damage from the cortical, endosteal, and periosteal bone, allowing it to formulate a severity and prognosis staging (Table 71.2). MRI can also accurately delineate the exact anatomic location and the extent of the stress injury (by detecting bone edema and changes in cortical density), but it remains important to correlate the radiological images with the patient's clinical findings. In a study involving 21 asymptomatic runners [28], 43% presented with bone edema on MRI suggesting a potential stress fracture because athletes are subjected to repetitive microtrauma during endurance running.

It is important to highlight MRI as the imaging modality of choice in the detection of pre-fracture stages with bone edema (Fig. 71.6) and stress reac-

Fig. 71.6 Axial T2 MRI view of a navicular stress reaction over the typical "nutcracker effect" area in a young football player

tion, but MRI is shown to be inferior to CT scan in the identification of the stress fracture itself.

When a stress fracture is clinically suspected, the initial imaging modality should be CT scan in order to visualize the fracture line. If the CT scan does not demonstrate any signs of fracture, an MRI is the next appropriate imaging modality to determine whether a stress reaction is occurring.

71.4.2.5 Bone Scan (Scintigraphy)

A bone scan has a high sensitivity but low specificity and should not be used as a first-line imaging modality in bony stress fractures. However, a bone scan can be helpful when CT and/or MRI fail to demonstrate a clear diagnosis. In case of a stress fracture, the bone scan can present with positive signs in all three phases, in contrast to soft-tissue injuries where it can only hypercaptate during the first injury phase.

71.5 General Treatment Concepts

Although there are no evidence-based guidelines supported by literature regarding best treatment, below is a summary of the current treatment options.

71.5.1 Conservative Treatment

Most nonoperative treatment strategies should include decrease in physical activity and training load, avoidance of pain-related activities and relative weight-bearing restriction, or immobilization. Pain control with oral analgesic medications (NSAIDs should be avoided), cold therapy, proper rehabilitation, and a personalized conditioning alternative physical program is recommended (minimal impact aerobic activities to maintain flexibility and strength; consider using antigravity treadmill). Other modalities of nonoperative treatment can be described below:

- *Biomechanical therapy*

  The major components in the treatment of any stress fracture are “rest” and “activity modification.” Especially during in-season, a team approach (medical staff, coach, agent, director) is key in the management of setting up treatment goals and return-to-play criteria. Although this sometimes means to temporarily unload and immobilize a player/athlete, cycling, rowing, swimming, and even specific running (to maintain cardiovascular fitness and lower limb strength) can be continued. The focus should be on altering the nature of the training, individualizing the program, and type of surface and shoe. Hydrotherapy and antigravity treadmill are useful in this stage to keep the player’s fitness while allowing the stress fracture to heal. Careful evaluation of malalignment, muscular imbalance, and abnormal loading patterns need to be assessed and corrected meanwhile.
- *Biological therapies*

  Several adjuvant treatment strategies, such as bone morphogenic protein (BMP), bisphosphonates, teriparatide, and hyperbaric oxygen, have been recommended in literature to enhance stress fracture healing. Controversy remains due to the heterogeneity of patient populations, the interventions offered, as well as the different outcome measures considered. In addition, most of the published reports are case series. We did not find any evidence regarding platelet-rich plasma (PRP) injections for stress fracture treatment.
- *Extracxorporal Shock-wave therapy (ESWT)*

  ESWT can have a role in the upregulation of local angiogenesis and concentration of growth factors. Although quality research is lacking, ESWT has shown improved healing potential and earlier return to play in chronic and nonunion cases [30, 31].
- *Low-intensity pulsed ultrasound therapy (LIPUS)*

  LIPUS has been introduced as a promising alternative to treat nonunion or delayed union. A recent systematic review however concluded that LIPUS does not reduce the time to return to activity for conservatively treated stress fractures [32].
- *Electrical stimulation (ES)*

  There is laboratory evidence that endochondral bone formation and growth factor expression may be appropriately stimulated by the application of an electromagnetic field. Electrical stimulation (ES) therapy can be provided via several modes: direct current, capacitative coupling, inductive coupling, and pulsed electromagnetic field. Although in football for example the pressure can be high to try out these “new tools,” there is little evidence for the use of ES in the management of stress fractures [33].

- *Bone morphogenic proteins (BMPs)*
  BMPs belong to “transforming growth factor b superfamily proteins” and act as osteoinductive agents to enhance fracture healing. Several BMPs have been isolated like BMP-2 and BMP-7 that are subjected to clinical trials. In stress fractures, there is no evidence to support the use of BMPs [33].
- *Teriparatide*
  Teriparatide is a bone anabolic agent (recombinant human parathyroid hormone analogue) used in the treatment of osteoporosis by stimulating osteoblasts. A recent RCT showed that it can shorten the time to fracture healing compared to placebo, but no credible data in stress fractures is available yet [34].
- *Vitamin D*
  In football, there is a growing awareness of the importance of the role of vitamin D levels, particularly in Northern Europe (even the elite players), with several studies showing hypovitaminosis (some among the lowest levels), especially in wintertime [35].

71.5.2 Surgical Treatment

Stress fractures can be classified as “low risk” or “high risk,” and this can influence the proper decision-making (Table 71.3). High-risk fractures are prone to displacement, delayed union, and nonunion. In case of nonoperative treatment, they require a prolonged period of healing and can potentially become career-ending.

In patients with “high-risk” stress fracture sites or displaced fractures (especially in athletes), early surgical fixation is preferred due to a high rate of biological failure, extended healing time, nonunion, and possibility of refracture [36–38].

Table 71.3 Foot and ankle “high-risk” and “low-risk” stress fractures

“High-risk” stress fractures	“Low-risk” stress fractures
Medial malleolar fractures	Calcaneus
Talar neck fractures	Cuboid
Central-dorsal navicular fractures	Cuneiform
Hallux sesamoid fractures	Lateral malleolus
Fifth metatarsal fractures	

71.6 Site-Specific Stress Fractures

According to a stress fracture study in 2379 elite male football players [12], all fractures (51) were noted in the lower extremities: the most common site was the fifth metatarsal (78%); 12% were in tibia and 6% in the pelvis. Twenty-nine percent of those stress fractures were reinjuries.

Additionally, it is important to be aware of “high-risk” stress fracture sites such as fifth metatarsal (zone 3—metaphysio-diaphyseal junction); talar neck; femoral neck; patella; anterior tibial diaphysis; medial malleolus; navicular; sesamoids of the hallux; and neck of the second to fourth metatarsals. These site-specific stress fractures are prone to complications such as displacement, delayed and nonunion, or prolonged specific treatment management requirements. “Low-risk” stress fracture sites are the posteromedial tibial shaft, metatarsal shaft, distal fibula, medial femoral neck, femoral shaft, and calcaneus and often heal with a proper diagnosis and treatment (Table 71.3).

71.6.1 Metatarsal Stress Fractures

The metatarsal area is a common site for developing stress fractures [5]. Stress fractures of the fifth and the second metatarsals (MT) are more common than the rest. Because of its unique anatomy and function, it is conventional to group MT fractures into fractures of the medial column (first MT), central column (second–third MT), and lateral column (fourth–fifth MT).

Fact Box 3
Always enquire about changes in the training schedule and playing surface since these are important risk factors in football particularly.

71.6.1.1 Fifth Metatarsal Stress Fractures

Fractures of the base of the fifth metatarsal have been classified into three zones according to Lawrence and Botte [39], with each zone representing a different mechanism of injury, treatment strategy, and prognosis (Fig. 71.7). Zone 1 (tuberosity area) is associated with avulsion fractures; zone 2 (tuberosity—metaphyseal area) is the so-called Jones fracture; and zone 3 (metaphyseal-diaphyseal area) represents true stress fractures and involves the junction of the metaphysis and diaphysis of the fifth metatarsal. Zones 2 and 3 are predisposed to delayed healing due to a vascular watershed zone between the insertion of peroneus brevis and the diaphyseal blood supply.

Surgical strategies include percutaneous, mini-open, and open reduction and internal fixation techniques with intramedullary screw fixation, bone grafting, and tension band wiring (by means of a metal cerclage or a novel high-resistance suturing method) (Fig. 71.8) [40]. In

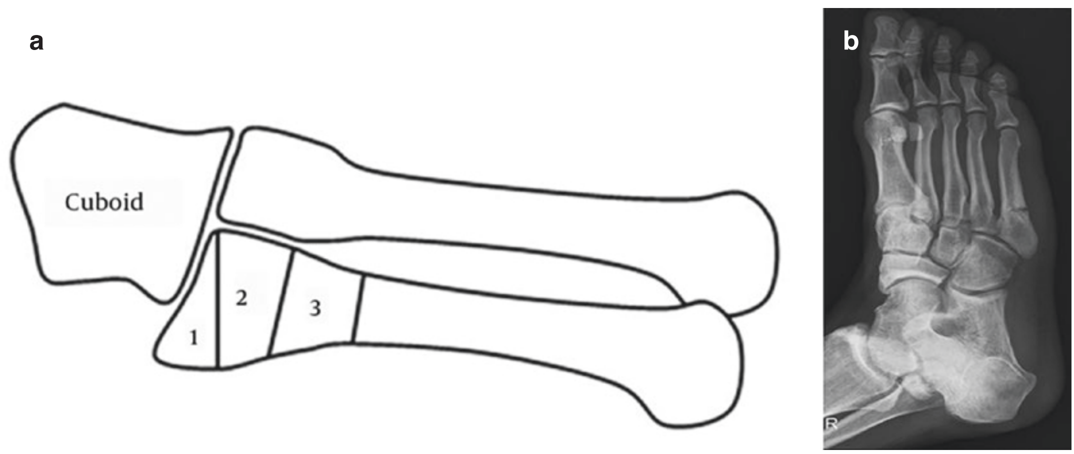

Fig. 71.7 (**a**) Lawrence and Botte's classification of proximal fifth metatarsal fractures: zone 1 (avulsion fractures), zone 2 (Jones fracture), and zone 3 (stress fractures). (**b**) Typical fifth metatarsal stress fracture (zone 3)

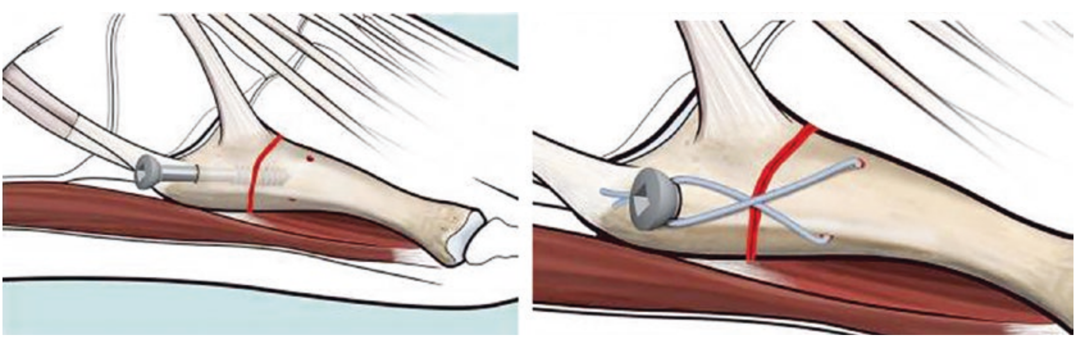

Fig. 71.8 High-resistance suture cerclage technique [40]

addition, some authors have advocated adding bone marrow aspirate concentrate (BMAC) to improve the biological environment and healing potential of the fracture.

A recent systematic review from Mallee et al. [41] showed proven benefit of surgical management, in terms of return to sport. Conservative management varies from limitations of activities to non-weight-bearing cast immobilization and remains a valid option for the recreational athlete.

Especially for fifth metatarsal Torg type II and III fractures (Table 71.4) and for stress fractures displaced more than 2 mm, surgery is recommended [42, 43]. A 5.5 mm partially threaded cannulated screw is the current golden standard for fixation although good results are reported with headless compression screws also [44]. It is recommended to use the largest diameter screw that fits the width of the intramedullary canal with a minimum diameter of 4 mm, and with sufficient screw length, covering the fracture (Fig. 71.9) with threads jutting beyond the fracture site in order to generate maximum compression [45, 46].

Refractures after the surgical treatment of fifth metatarsal stress fractures can be as high as 10–30% in some series. They are found to be associated with increased body weight and zone 2–3 Torg-type fractures in the hypo-vascularized metatarsal stress fracture zone.

Postoperatively, a non-weight-bearing short leg cast or plaster splint for 1–2 weeks is started, followed by a controlled ankle movement walker boot for 2 more weeks [47]. After 6–8 weeks postoperatively, full weight-bearing is allowed and normal activities can be resumed.

Table 71.4 Torg classification of fifth metatarsal stress fracture

Torg 1	Torg 2	Torg 3
• Acute fracture • No periosteal reaction • No intra-medullary sclerosis	• Delayed union • Periosteal reaction • Intramedullary sclerosis • Widened fracture line	• Nonunion Periosteal reaction Intramedullary narrowing • Widened fracture line

71.6.1.2 Second Metatarsal Stress Fractures

Among the metatarsal bones, the second is known to be the most commonly injured, followed by the third, base of the fifth, fourth, and first metatarsal [3, 48]. Stress fractures of the proximal second metatarsal are most commonly observed in female ballet dancers, due to the "en pointe" position. They are also frequently encountered in runners, due to the high-force vector that is transmitted through the meta-diaphyseal region, leading to a

Fig. 71.9 Anteroposterior and lateral plain radiograph view of fifth MT stress fractures in a national team football treated with a mini-open fixation technique. (**a**) Double-stress fracture line, (**b**, **c**) 2.5 months postoperative

high metatarsal bending stress. Although no direct link with a specific forefoot morphology has been reported, a shorter and hypermobile first metatarsal or a longer second metatarsal is hypothesized to be a risk factor for these stress fracture types [3, 49, 50]. Clinically, these second metatarsal base fractures can be very difficult to differentiate from Lisfranc joint synovitis. They are also at high risk for delayed union and may significantly affect the athlete's ability to return to elite level.

Distal fractures have a good prognosis and a relatively fast recovery through nonoperative management. In these patients, relative rest and partial to full weight-bearing in a CAM boot are recommended.

71.6.2 Navicular Stress Fractures

Stress fractures of the tarsal navicular account for up to 35% of all foot and ankle stress fractures [51]. Navicular fractures are typically seen in track and field athletes, especially sprinting athletes, professional tennis players, jumpers, and athletes engaging in explosive push-off activities [52].

Navicular stress fractures are considered at high risk for delayed union or nonunion, due to the relatively poor vascular supply in the central third of the bone [53]. However, nonoperative treatment in a non-weight-bearing plaster cast or boot for 5 weeks followed by 4–6 weeks of rehabilitation is still recommended for the general population [54–58]. In case of displaced fractures, delayed union, or nonunion, surgery can be indicated [24, 59].

Currently, there is no evidence-based consensus on best therapeutic strategies in the athletic population.

According to Saxena's classification [58], nonoperative treatment should be advised in type 1 fractures (dorsal cortex-only involvement) and surgery in type 2 (propagation of the fracture into the navicular body) and type 3 (bicortical disruption) fractures.

Usually, surgical internal fixation involves the use of two partial-threaded cannulated screws placed lateral to medial in a parallel or cross configuration.

71.6.3 Medial Malleolus Stress Fractures

Medial malleolus stress fractures are relatively uncommon. They account for 0.6–4.1% of all stress fractures [51, 60]. They typically occur in high-level runners and jumpers. Stress fractures of this anatomical site seem to be due to repetitive impingement of the talus on the medial aspect of the distal tibia during forced dorsiflexion of the ankle [48].

The treatment of medial malleolus stress fractures varies depending on fracture propagation, displacement, athletic level, and seasonal timing. In case of a clear fracture line or displacement (especially in elite and "in-season" athletes), surgical internal fixation is recommended [61–65].

71.6.4 Other Stress Fractures of the Foot

71.6.4.1 Calcaneus

Calcaneal stress fractures are rare, and most studies report on the occurrence of these fractures in army recruits rather than in athletes. The diagnosis is often delayed due to similarity of symptoms with plantar fasciitis, retrocalcaneal bursitis, Achilles tendinitis, Baxter's nerve disorder, and Sever's disease. The typical presentation is localized tenderness at the heel and/or with positive calcaneal compression test, which increases with activity and is relieved with rest/immobilization. At radiographic evaluation, a thin radiolucent or sclerotic line can become apparent, 2–3 weeks after the onset of symptoms. MRI can be a useful tool to identify early bone edema and fracture lines. In most cases, calcaneal stress fractures can be managed with nonoperative treatment and activity modification.

71.6.4.2 Talus

A talar stress fracture is a relatively rare injury but may present in athletes due to repetitive cycles of axial loading activities. The possibility of secondary displacement should be considered. MRI is often required as conventional radiographs are often unable to reveal talar stress fractures (Fig. 71.10).

Despite the lack of a general consensus, undisplaced fractures are often managed nonopera-

Fig. 71.10 Sagittal T1 MRI view of a talar body stress fracture in a young football player

Fig. 71.11 Sagittal T1 MRI view of a cuboid stress fracture in a national league female football player

tively by means of 6-week non-weight-bearing cast or boot immobilization. Surgical fixation is indicated in case of secondary displacement, in order to reduce the risk of avascular necrosis [66].

71.6.4.3 Cuboid

Cuboid stress fractures (Fig. 71.11) are usually treated conservatively with non-weight-bearing with crutches for the initial 2 weeks. Then, when the patient is pain-free, move into protected weight-bearing and then progress into a CAM boot and staged rehabilitation.

The role of podiatry and tailored orthotics is key in treatment and prevention.

71.6.4.4 Sesamoid

Typically, the medial sesamoid is the most affected by stress fractures. Plain radiographs can be difficult to interpret, and the use of a CT scan is advised in case of clinical suspicion. A bipartite sesamoid may be confused with a fracture but is frequently bilateral (up to 75% of cases) and has smooth edges [66]. Normally, conservative management with rest, boot, orthotics, and progressive loading is standard. In the case where surgery is required, a partial sesamoidectomy is the treatment of choice.

71.7 Return to Play

The return-to-play decision depends on multiple factors such as the stress fracture localization and pattern, sports activity, severity of the injury, and risk factor modification/control.

Stress fractures can lead to prolonged absences from sports, and the return-to-play process is key to reincorporate the athlete as soon as possible, respecting the biology and healing process.

In case of fifth metatarsal stress fractures, according to Ekstrand and Torstveit [12], the mean absence from football was 3 months and the average time to return to sports is reported to be 24 weeks if conservative treatment is done, and 12 weeks (average time) in case of surgery [67].

For navicular stress fractures, according to Saxena et al., in general population, patients treated conservatively with non-weight-bearing cast last 5.6 months to return to activity while patients treated surgically last 3.8 months to return to activity [58].

In case of medial malleolus stress fractures, 7.6 weeks' mean time to return to sport has been reported [68], although resolution of symptoms may take 4–5 months [48].

The criteria for allowing an athlete to return to his/her practice can include:

- Absence of pain 10–14 days before starting to do sports activities, during sports movements, and on physical exam
- Formation of bony callus and obliteration of the fracture line on simple radiographs or CT scan imaging support if necessary

In summary, it is important to have clinical and imaging evidence of healing before the athlete fully returns to play.

71.8 Prevention

Prevention of stress fractures is essential. Gradual training load and monitoring through different training principles/methods, as well as injury prevention programs and risk factor identification and adaptation, are crucial to prevent these injuries. For example, injury prevention programs such as the FIFA 11+ are very important, specially in low-skill-level youth teams [69, 70].

There is limited evidence at present for biological treatment of stress fractures, but biological agents may be useful adjuncts.

Susceptible individuals and risk factors should be identified, modified, and addressed to avoid unnecessary stress fractures. In addition, realistic return-to-play strategies should be implemented from the start.

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