16 Ankle Fractures and Return to Sports in Athletes: "Does Arthroscopy Add Value to the Treatment?"

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16.1 Introduction

The ankle is one of the most commonly injured joints in sports—ankle injuries constitute 12–23% of all injuries recorded during FIFA competitions. Although the incidence of ankle fractures in athletes is low, accounting for less than 3% of all ankle injuries [1, 2], the severity of this injury warrants meticulous treatment [1]. Throughout the past decades open reduction and internal fixation (ORIF) has established itself as standard of care for unstable ankle fractures. However, ORIF is associated with substantial surgical exposure and inherent complications, such as infection and skin necrosis. With the aim to minimize complications and further improve outcomes, arthroscopic reduction and internal fixation (ARIF) and arthroscopy-assisted open reduction internal fixation (AORIF) were introduced [3].

Potential advantages of arthroscopic treatment of ankle fractures include [4]:

- Limited surgical exposure and soft-tissue trauma
- Video-assisted fracture reduction
- Direct visualization of the joint articulation
- Evaluation of ligamentous injuries and associated intra-articular pathology (e.g., osteochondral injuries)

As ankle fractures constitute a major time-loss injury in athletes, treatment should address the demand for early and safe return to sports. Due to the minimal soft-tissue trauma associated with arthroscopic fracture treatment, it can facilitate early rehabilitation and may lead to improved return to sport [2]. In addition, the use of arthroscopy can aid in the diagnosis and treatment of concomitant pathology that is often found in acute ankle fractures.

Potential benefits of using arthroscopy for ankle fractures in athletes include the following:

- Concomitant treatment of cartilage lesions, which are observed in up to 63% of ankle fractures [2].
- Stability of the syndesmosis can be assessed (e.g., drive-through sign).
- Accurate tibial plafond reduction for complex intra-articular ankle fractures can best be achieved through arthroscopy.
- The minimally invasive nature of arthroscopy can facilitate early rehabilitation.

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Although arthroscopic surgery for posttraumatic pathology has been shown to have significant benefits, the evidence on its use in the treatment of ankle fractures is scarce. The aim of this chapter is to offer an evidence-based overview of the current literature regarding the indications for using arthroscopy in the treatment of acute ankle fractures and its associated injuries in athletes.

16.2 Materials

A Medline search using the keywords "ankle fracture, arthroscopy, and athlete" yielded a total of 55 articles, describing the surgical technique or the outcomes of arthroscopic reduction and internal fixation (ARIF) or arthroscopy-assisted open reduction internal fixation (AORIF) of various types of ankle fractures. Six of these papers focused on ARIF in elite athletes [2, 5–9]. Ligamentous injuries, except for syndesmosis injury, are not discussed in this chapter.

Current indications for ARIF/AORIF in sport-related ankle fracture management include:

- Malleolar fracture
- Intra-articular fracture
- (Osteo-)chondral injury
- Syndesmosis injury
- Talar body/neck fracture
- Talar process fractures

16.3 ARIF (Arthroscopic-Assisted Reduction and Internal Fixation)

Arthroscopic-assisted reduction and internal fixation of ankle fractures was first introduced in 1989 and has since gained acceptance [2]. The use of arthroscopy in the treatment of ankle fractures presents surgeons with the ability to directly visualize the articular surface and assess the presence of associated pathology (e.g., osteochondral lesions), all with minimal surgical exposure. The increased understanding of the pathophysiology of ankle fractures and its associated injuries, combined with a demand for rapid return to sport among athletes, has caused a surge in arthroscopic techniques for the treatment of various indications (Figs. 16.1 and 16.2).

A recent review on the indications of ARIF in ankle fractures concluded that the use of

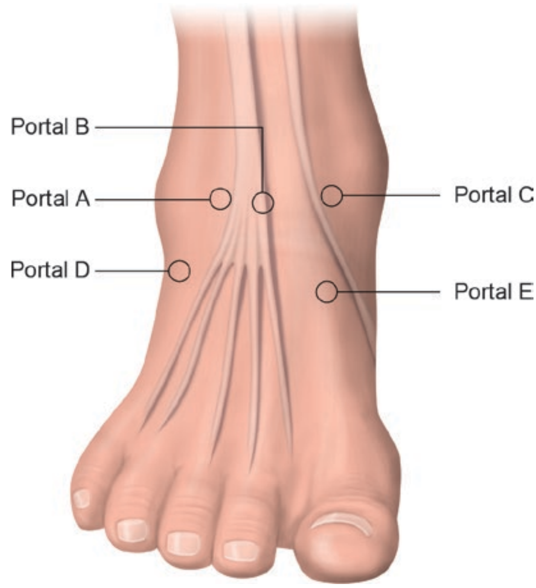

Fig. 16.1 The surge in arthroscopic techniques for ankle pathology has led to the development of different arthroscopic portals that can be chosen to treat the various (described) indications (image copyright: Pieter D'Hooghe)

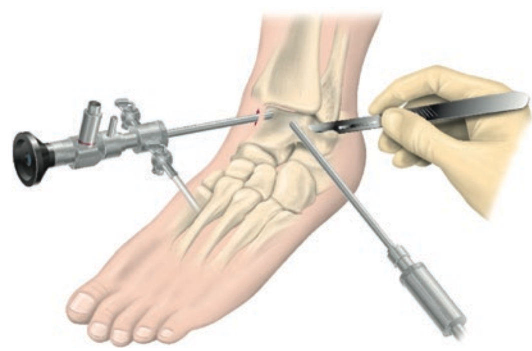

Fig. 16.2 The use of arthroscopy in the treatment of ankle fractures presents surgeons with the ability to directly visualize the articular surface and assess the presence of associated pathology (e.g., osteochondral lesions), all with minimal surgical exposure (image copyright: Pieter D'Hooghe)

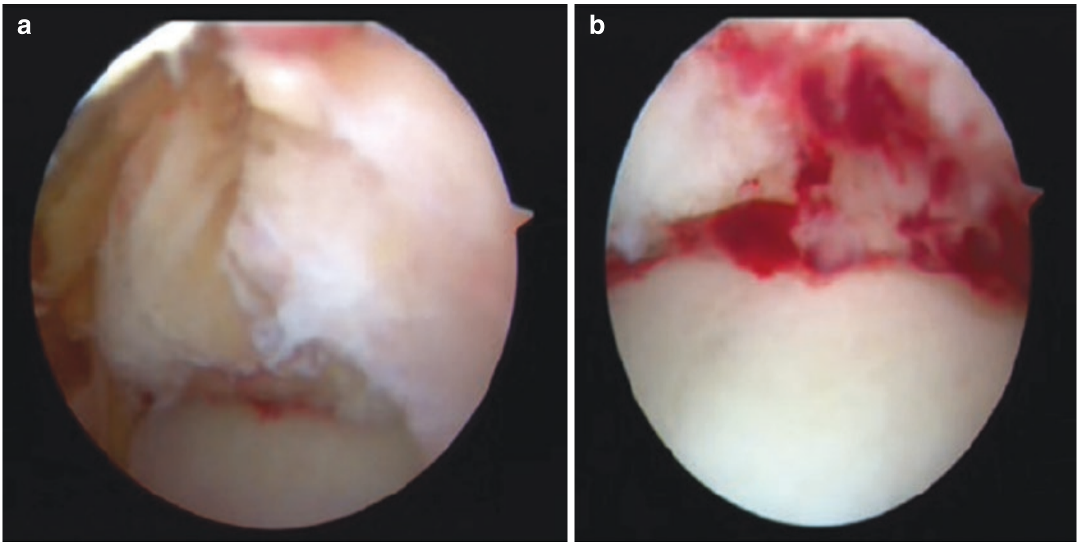

Fig. 16.3 (**a**) Intraoperative anterior arthroscopic view of a distal tibial fracture with intra-articular extension. (**b**) Intraoperative anterior arthroscopic view of a distal tibial fracture after intra-articular reduction (image copyright: Pieter D'Hooghe)

arthroscopy can be advantageous in the treatment of [4]:

- Acute ankle fracture dislocations
- High-energy ankle fractures requiring reduction
- Suspected loose bodies and chondral lesions

The use of arthroscopic reduction and internal fixation (ARIF) has been described for a wide variety of fractures, including fractures of the talus and talar processes, the distal tibia, and fractures of the medial and lateral malleolus [10–13]. Furthermore, using arthroscopic techniques, symptomatic fractures of the medial and lateral posterior process of the talus can be fixed or excised [14]. For most of these indications a classic two-portal anterior/posterior arthroscopic technique is utilized (Fig. 16.3a, b) [2, 5, 6].

In addition to fracture fixation, arthroscopy may facilitate immediate treatment of concomitant ligamentous injuries, tendon pathology, and osteochondral lesions, potentially enabling early rehabilitation and faster return to sports [5].

No absolute contraindications for using arthroscopy in the treatment of acute ankle fractures and its associated injuries have been formulated. However, concerns regarding increased surgical time, soft-tissue swelling, and surgeon-dependent ability to successfully utilize arthroscopic techniques have been stated [2]. Despite these concerns, only one case report describing an acute anterior compartment syndrome following ankle arthroscopy in the treatment of a Maisonneuve fracture in a football player has been published [15].

Relative contraindications for arthroscopy in the treatment of ankle fractures include [4]:

- Low-energy fracture mechanism
- Open fractures
- Degloving injuries with severe soft-tissue compromise

16.4 Indications for Combined Ankle Arthroscopy in Acute Athlete Ankle Fractures

16.4.1 Malleolar Fractures

Malleolar fractures are generally evaluated by physical examination and radiographs—they are then classified according to either the AO or the Weber classification systems. In case of dislocation, immediate reduction is mandatory to prevent skin necrosis and possible nerve damage. The treatment strategy is chosen based on:

- Mechanism of injury
- Classification/injury severity
- Associated soft-tissue damage

Weber A fractures are usually treated conservatively, while Weber B and C fractures frequently require surgery. Specific attention should be given to the intraoperative evaluation of syndesmotic joint stability, as up to 66% of Weber B and C ankle fractures have some degree of syndesmotic ligamentous injury [5, 16–22]. A recent retrospective review by Chan et al. on a series of 254 ankle fracture patients showed associated syndesmosis disruption in 52% of Weber B fractures, 92% of Weber C fractures, and 20% of isolated medial malleolus fractures [23]. The most frequently encountered complications of open reduction and internal fixation of these fractures are formation of wound hematoma and wound necrosis with a postoperative infection rate of around 2%.

Stufkens et al. analyzed the long-term outcome after surgical treatment of malleolar fractures and noted that over 10% of patients eventually go on to develop ankle arthrosis [16]. The evidence regarding optimal treatment strategies, and in particular regarding the return to sports, for these types of fracture is scarce.

ARIF is shown to be effective in discovering undetected osteochondral defects in the ankle and enabling the surgeon to evaluate the quality of anatomical reduction [3, 5, 17, 22–26]. Up to 60–75% of ankle fractures (that require surgical fixation) have demonstrated evidence of articular cartilage damage—previously undiagnosed prior to surgery [16]. Such injuries are mostly cartilaginous in nature and therefore not radiographically visible (Fig. 16.4a–c).

These lesions usually occur at locations not accessible through traditional fracture surgery incisions. Therefore, simultaneous arthroscopic assessment and management of these lesions are required to improve the rate and quality of recovery after fracture surgery. Since radiographs are

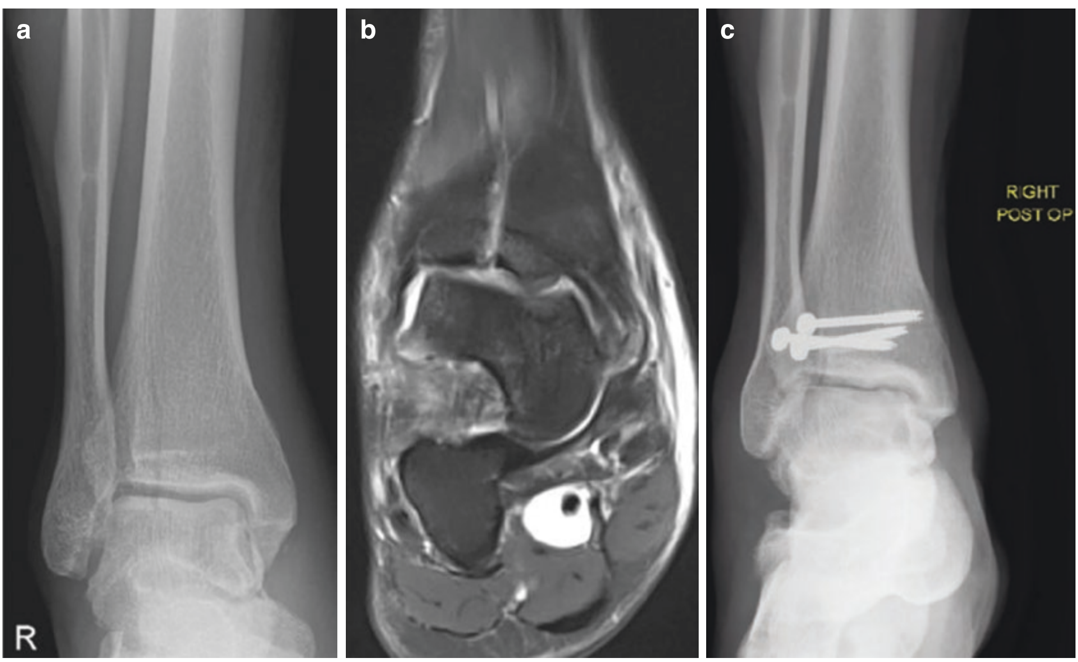

Fig. 16.4 (**a**) Anteroposterior (AP) X-ray of an elite athlete with a centro-lateral distal tibial stress fracture with intra-articular excursion. (**b**) Coronal T2 MRI image of the centro-lateral distal tibial stress fracture with intra-articular excursion. (**c**) After arthroscopic-assisted percutaneous reduction and fixation with control over the anatomical reduction and articular cartilage status (image copyright: Pieter D'Hooghe)

commonly used as the preferred diagnostic tool in acute ankle fractures, the very low sensitivity of plain radiography leads to underdiagnosis of osteochondral lesions [5, 16, 17, 27–29]. In a prospective randomized trial comparing arthroscopic-assisted with traditional non-assisted lateral malleolar fracture fixation, Takao et al. showed a very high rate of secondary pathology. This was mostly chondral damage and syndesmotic injury [17]. At an average follow-up of 40 months, there was a small but significantly greater AOFAS outcome score in the arthroscopically assisted group compared to the traditional group [17].

16.4.2 Intra-articular Fractures

Intra-articular fractures like triplane and Chaput-Tillaux fractures clearly benefit from an arthroscopic-assisted approach as fracture site clearance and intra-articular realignment can be visualized intraoperatively with minimal surgical exposure. Some authors claim that the treatment of triplane fracture should be performed in two steps. The first step is closed reduction under fluoroscopic view. If the displacement is less than 2 mm after closed reduction, it is regarded acceptable and conservative treatment with a short-leg cast is recommended. If the displacement is more than 2 mm after closed reduction, open reduction and internal fixation should be performed [30]. However, a long-term follow-up study of triplane fractures found that in patients treated conservatively, despite there being less than 2 mm of displacement after closed reduction, complications such as decreased ankle mobility, early osteoarthritis, and pain were present at 5-year follow-up [30].

In a case report by *Imade* et al. they applied ankle arthroscopy for the treatment of an ankle triplane fracture for the first time [15]. The use of arthroscopy allowed for a minimally invasive treatment strategy and accurate anatomical reduction. The patient was able to walk without discomfort 2 months after surgery and was able to fully participate in athletic activities with no pain at 3 months postoperatively. A second-look arthroscopy at 1-year follow up showed an articular surface over the previous fracture area that was smooth and congruous. They noted that the fracture line was filled with fibrocartilage-like tissue and concluded that this technique had provided satisfactory results [15]. Various other case reports reporting similar outcomes have been published since [2].

In a recent study by Feng et al. [31], a series of 19 patients with a Chaput-Tillaux fracture (treated with ARIF) were retrospectively followed up after a mean of 19.0 months [2]. Good to excellent results were reported in all patients. The Visual Analogue Scores for pain scores improved from a mean preoperative 8.1 (±0.8 SD) to a postoperative 0.1 (±0.3 SD), at 6-month follow-up. Furthermore, the AOFAS score improved from a mean 52.8 (±6.4) preoperatively to a mean 91.7 (±4.3) at final follow-up.

The use of arthroscopy for isolated malleolar or distal tibial stress fractures with an intra-articular fracture line extension can be equally beneficial, as in Chaput-Tillaux fractures complete cartilage assessment can be performed with arthroscopy without the need for large exposures. Any step-off into the joint line, comminution, or depressed fragment can be recognized and realigned (Fig. 16.5a–d).

Percutaneous temporary K-wires can be used to manipulate and aid in fracture reduction before definitive osteosynthesis is performed [32, 33] (Fig. 16.6a–d).

However, the technique can be technically demanding and no quality comparative studies are available [5, 25].

16.4.3 Osteochondral Lesions

Although open reduction and internal fixation of ankle fractures leads to good result in most patients, poor functional outcome is observed in a subset of patients. It has been hypothesized that these lesser results can be attributed to undiagnosed osteochondral lesions, present in up to 63% of the patients [18, 26].

Acute osteochondral defects associated with ankle fractures are commonly amenable to arthroscopic treatment. Arthroscopic diagnosis of the defect location, defect size, and condition of

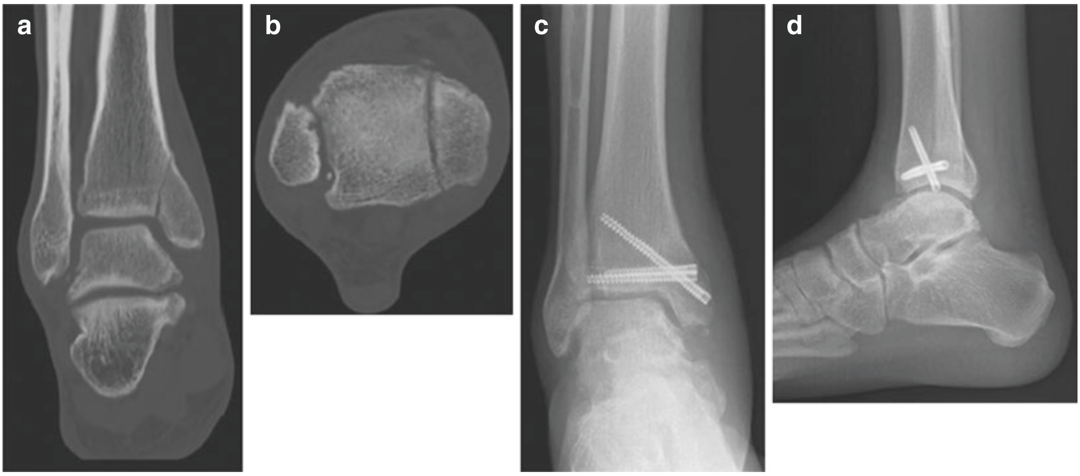

Fig. 16.5 (**a**) Coronal CT image of a medial malleolar stress fracture in the ankle of an elite athlete. Note the talar varus deformity alignment. (**b**) Axial CT image of a medial malleolar stress fracture in the ankle of an elite athlete. Note the anterior small fragment. (**c**) Postoperative AP X-ray after arthroscopic-assisted percutaneous fracture reduction and fixation. (**d**) Postoperative lateral X-ray after arthroscopic-assisted percutaneous fracture reduction and fixation (image copyright: Pieter D'Hooghe)

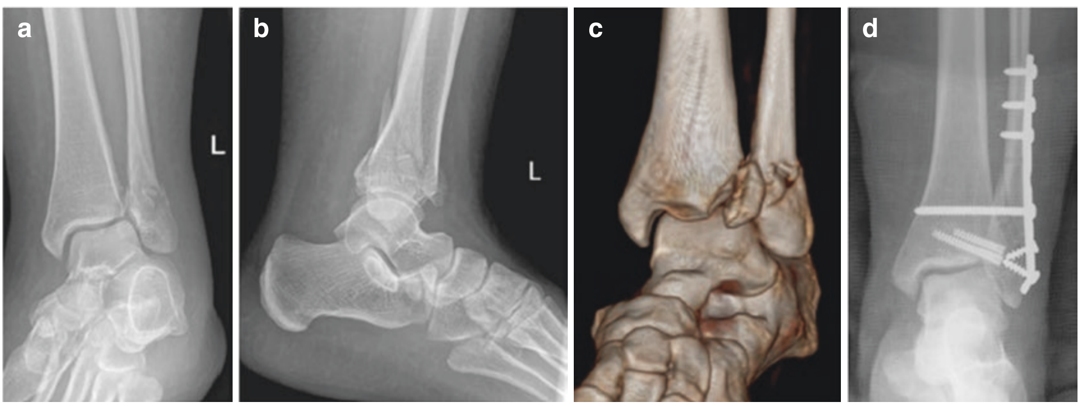

Fig. 16.6 (**a**) AP X-ray of a Weber B distal fibular fracture in an athlete. (**b**) Lateral X-ray reveals the combined bony anterior syndesmotic fracture. (**c**) Coronal 3D CT image of the intra-articular ankle fracture. (**d**) AP X-ray image after arthroscopic-assisted fracture reduction and fixation (image copyright: Pieter D'Hooghe)

the osteochondral fragment can guide the selection of appropriate treatment [2, 17, 18, 28]. Based upon the talar dome/tibial plafond osteochondral defect size, bone marrow stimulation techniques (e.g., drilling, abrasion, or microfracture) or transplantation techniques (autograft/allograft) can be used instantaneously [34–38].

Furthermore, as cartilage-regenerative procedures (autologous chondrocyte implantation [ACI], matrix-induced autologous chondrocyte implantation [MACI]) gain popularity in the treatment of athletes with a chronic osteochondral defect of the talus [39, 40], ARIF in the acute setting can provide cartilage biopsies for cell culture and cartilage implantation in a later stage (ACI). The same treatment strategy is applicable for the less common tibial plafond osteochondral lesions [32].

Currently there is sufficient evidence that arthroscopy can be successfully employed in the treatment of fracture-associated intra-articular injuries. However, despite the obvious potential of arthroscopy, evidence comparing functional outcome and complication rates of ARIF to ORIF is lacking [41].

16.4.4 Syndesmosis

Fracture-related injury to the syndesmosis is observed in 47–66% of patients and is associated with the development of chronic ankle complaints [19]. Intraoperative stress views are more reliable—when compared to plain radiographs—at detecting definitive instability [20]. Nevertheless, borderline instability or partial injury to the syndesmotic complex without instability is difficult to detect. Magnetic resonance imaging (MRI) has been shown to provide accurate information when documenting a syndesmotic injury, but has a significant false-positive rate, whereas arthroscopic assessment has been shown to be more sensitive and specific and an accurate guide for anatomical reduction of the syndesmosis because it provides 3-dimensional assessment and reduces the chance of having malreduction [2, 5, 20, 21, 23, 42].

In addition, arthroscopy can debride the extra-syndesmotic fibers of the most commonly ruptured anteroinferior tibiofibular ligament that may otherwise produce chronic pain due to anterior impingement [43–45]. Good to excellent results have been reported in a few studies where arthroscopic assessment (with fixation) and/or debridement were used to manage such injuries [17, 18, 27, 29]. Arthroscopic evaluation may also detect sagittal and rotational ankle instability, which may not always be visualized on intra-operative stress radiography [2, 46].

Arthroscopy is also useful in detecting the relationship between malleolar fractures and syndesmotic injury [2, 23] where they found a statistical significance association between Weber B fractures and syndesmotic injuries but no statistical significant association between posterior malleolus fracture and syndesmotic injury [23]. Another important role of arthroscopy can be to monitor residual syndesmosis instability after removal of the syndesmotic screw where they found a low number of residual syndesmosis instability of 3% after screw removal [23]. Finally, damage to the medial area of the talocrural joint, which is an indirect finding commonly associated with syndesmotic injury, can be visualized using the arthroscope.

16.4.5 Talar Body and Neck Fractures

Fractures of the talar neck and body (Fig. 16.7a–e) are rare injuries that can cause significant morbidity and complications.

For the athlete, these injuries can have a deleterious effect on their long-term functional outcome. Treatment efforts are aimed at the quality of fracture reduction and the preservation of talar blood supply. Arthroscopic-assisted surgery has been shown to be of value in both aspects but the technique is demanding, prolongs operative time, and increases soft-tissue swelling. However, case reports and small case series provide some evidence to recommend this technique [16, 47–49]. The underlying principle in managing a talar fracture is to achieve an anatomical reduction and stable fixation with minimal disturbance to the soft tissue—for the abovementioned reasons [47, 48]. Skin necrosis, infection, malunion, and posttraumatic arthritis are well-recognized complications of talar fractures, and management should be designed to minimize these. *Subairy* et al. have shown that arthroscopic-assisted surgical stabilization of these fractures is advantageous and reduces the time to union [48]. Stress fractures are the most common overuse bony injuries in sports but stress fractures of the talar body are extremely rare and have only rarely been reported [6, 10, 50]. More common—but still rare—are stress fractures of the talar neck or lateral talar process [6, 11, 12]. Due to their minor displacement, most stress fractures of the talar body are treated nonsurgically [6, 10, 13]. Stress fractures in sports are the result of excessive, repetitive cyclic loads traumatizing bones with normal form and structure [51]. Predisposing factors may be both intrinsic and extrinsic and include malalignment, lack of flexibility, increase in training, training of excessive volume and intensity, hard or soft activity

Fig. 16.7 (**a**) Sagittal CT image of an athlete with sudden ankle pain after a preseason training camp. (**b**) Sagittal T1 MRI image of a talar body stress fracture. Note the Hawkins sign. (**c**) Coronal T2 MRI image of the progressive diastasis of the talar body stress fracture during conservative treatment. (**d**) Axial T2 MRI image of the progressive diastasis of the talar body stress fracture during conservative treatment. (**e**) Lateral X-ray of the arthroscopic-assisted talar body fracture compression screw fixation (image copyright: Pieter D'Hooghe)

surfaces, inappropriate shoes, and inadequate coaching [6, 10]. Additional factors to be considered include age, ethnicity, gender, fitness, skill level, and menstrual history [6, 52]. Mechanical factors that may lead to a stress fatigue fracture remain unclear but may result from repeated loading or repetitive prolonged muscular action on bone not yet conditioned to such heavy and novel action. In athletes, significant pathogenetic movements predisposing to a talar stress fracture can be identified in repetitive, restricted axial loading while sprinting, kicking a ball, or landing after heading. The load that has to be absorbed during these actions (the extremes in plantar/dorsiflexion of the foot while kicking the ball and other traumatic actions) should be considered as an important pathogenetic factor in repetitive strain injuries. Moreover, when playing toward the end of a match or tournament, coordination is less precise as athletes are often fatigued [6, 52].

The diagnosis of a stress fracture is based on clinical suspicion, a detailed history, and a physical examination, followed by appropriate imaging investigations. The role of conventional radiography is important, although initial findings are often minimal or absent (Fig. 16.7a). The earliest sign—often delayed until after the onset of symptoms—may be a lucent linear image (more often a sclerotic band, periosteal reaction, or callus formation) seen on X-ray [6, 10, 13]. MRI has a high sensitivity for the detection of stress fractures (Fig. 16.7b). In addition, MRI signs are evident several weeks before radiographic signs appear.

Conservative treatment is preferred if there is no (or only minor) displacement at the fracture site. There is only limited literature on adequate healing times for stress fractures of the talar body but overall stress fractures are known for their prolonged time to heal [6, 53]. Generally, treatment of stress fractures is immobilization for 4–8 weeks [10, 50, 52, 53]. Avascular necrosis remains a relatively high risk—given the suboptimal talar vascular status—even after an adequate immobilization period [53, 54]. Hawkins classified (non-stress) fractures of the talus in an attempt to predict the risk of avascular necrosis [55]. A Hawkins type 1 fracture has a good prognosis as the risk of avascular necrosis is less than 15% [56]. If significant diastasis/displacement (Hawkins type 2) occurs, the risk of avascular necrosis rises to 50%, and surgical repositioning and fixation is indicated [56] (Fig. 16.7c–e). If adequate measures—with rapid intervention to reposition the displaced fracture—are taken, it is possible to achieve a positive outcome without ongoing problems [6] (Fig. 16.7e). *d'Hooghe* et al. described the management of progressive talar body stress fractures in professional football players through posterior arthroscopy-assisted compression screw fixation with excellent healing results [6] (Fig. 16.7a–e). No other articles were found that combine arthroscopy with talar stress fracture fixation management.

16.4.6 Talar Process Fractures

16.4.6.1 Lateral Tubercle Fractures and Os Trigonum Complex

Posterior impingement in the ankle refers to a mechanical conflict on the posterior side of the ankle. In athletes, it accounts for about 4% of all ankle injuries and can present either acutely or chronically [2]. Posterior ankle impingement syndrome is a clinical pain syndrome reflecting the most common cause of posterior ankle pain. It can be provoked by a forced hyperplantar flexion movement of the ankle [14, 17, 57, 58]. In the event of bony posterior impingement of the ankle, plantar flexion induces a conflict between the posterior malleolus of the distal tibia and the posterosuperior calcaneal bone. A hypertrophic posterior talar process or an os trigonum is present in almost 7% of the sports population [2]. Not every apparent posterior bone—caused by acute or repetitive overload (micro)trauma—induces posterior ankle pain and is not necessarily associated with the posterior ankle impingement syndrome.

Acute forced hyperplantar flexion movement of the ankle can induce a bony conflict in the posterior ankle joint as is frequently seen in sports like football and ballet. The mechanism of injury is a repetitive forced plantar flexion or an acute blocked kicking action. Compression of the os trigonum between the distal tibia and calcaneal bone can also cause this lesion, thus potentially leading to displacement of an os trigonum or fracture of the processus posterior tali or distal tibia (Fig. 16.8).

Over the last three decades, posterior arthroscopy of the ankle joint has become a standardized procedure, with numerous indications for treating posterior (intra-articular) ankle pathology. Lack of direct access and nature and deep location of its hindfoot structures are reasons why posterior ankle problems still pose a diagnostic and therapeutic challenge today.

The two-portal endoscopic technique by *van Dijk* et al. allows for excellent access to the posterior ankle compartment and also to the surrounding extra-articular posterior ankle structures [57]. This technique, using modified classic arthroscopic tools and skills, has introduced a broad spectrum of new indications in posterior ankle pathology [57–59]. The most influential indication to perform posterior ankle arthroscopy remains the treatment of os trigonum. This is an attractive alternative to open surgery for experienced arthroscopic surgeons. Improved functional outcomes after surgery, lower morbidity, and more rapid rehabilitation time make this technique a beneficial technique in athletes [56–59].

Fig. 16.8 Lateral X-ray of an os trigonum in an athlete's ankle (image copyright: Pieter D'Hooghe)

16.4.6.2 Medial Tubercle Fractures

Fractures of the medial tubercle are rare but can occur due to [2]:

- Avulsion of the posterior tibiotalar ligament
- Dorsiflexion and eversion (Cedell fracture)
- Direct compression of the process as above
- Impingement of the sustentaculum tali in supination

In contrast to lateral tubercle injuries, pain and swelling are usually present between the Achilles tendon and the medial malleolus. However, there may be limited pain on walking or movement of the ankle. It is difficult to visualize fractures of the medial tubercle on plain AP and lateral radiographs, and it has been suggested that the addition of two oblique views at 45° and 70° of external rotation may significantly aid in the detection prior to resorting to a CT or MRI [2] (Fig. 16.9a, b).

These fractures can be approached through the posterior arthroscopic technique—their extent can be visualized and the necessary treatment can be performed in a one-stage procedure.

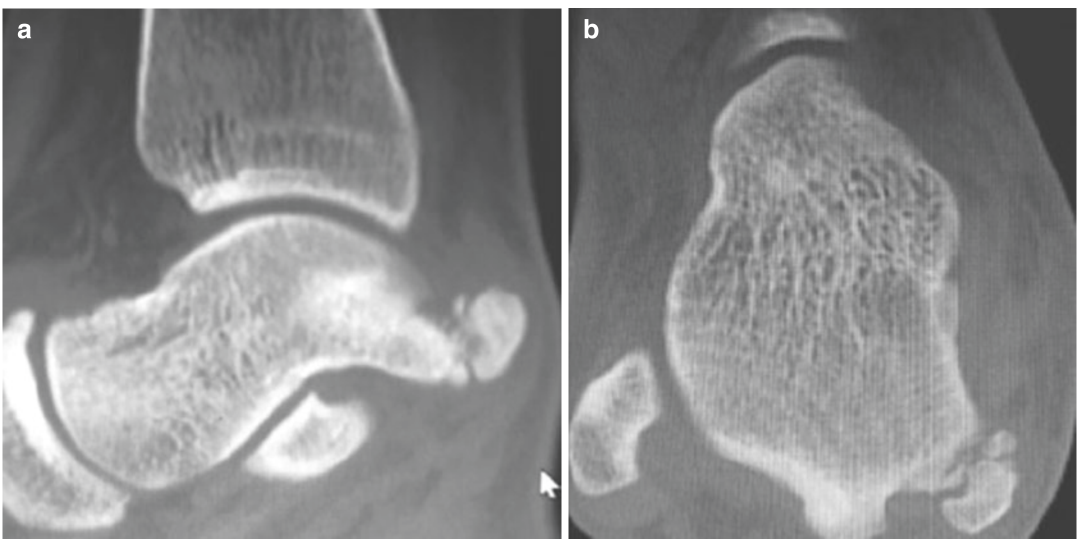

Fig. 16.9 (**a**) Sagittal CT image of a Cedell fracture in an athlete's ankle. (**b**) Axial CT image of a Cedell fracture in an athlete's ankle (image copyright: Pieter D'Hooghe)

16.4.6.3 Entire Posterior Process Fractures

These injuries are usually fractures of the lateral or posterior process and comprise some of the most commonly missed fractures in acute ankle injuries. Routine AP and lateral radiographs do not often show acute fractures and may be incorrectly interpreted. CT scan remains the mainstay of diagnosis, but there also needs to be a high index of suspicion by the assessing physician [2, 5]. Lateral process fractures in sports often present with signs and symptoms of a simple ankle sprain. Undiagnosed and untreated fractures often lead to persistent lateral ankle pain and late subtalar joint arthritis. Outcomes are suboptimal when diagnosis and treatment are delayed for more than 2 weeks [5, 60]. Type 1 fractures benefit from stable fixation usually via an open surgical technique. Type 3 fractures respond well to conservative treatment. Type 2 fractures, however, appear to respond best to early removal of the fracture fragments as opposed to delayed surgery. Removal of these fracture fragments by arthroscopy would reduce the surrounding soft-tissue dissection and potentially accelerate return to normal activity. However, at present, there is no study available that supports this theory. Further studies are therefore necessary in this area. Posterior process fractures usually occur as a result of forced plantar flexion injuries and are even less common than lateral process fractures. Most of these injuries are initially treated with conservative management, but a small number of cases with significant comminution may be appropriately treated by early arthroscopic debridement [5].

16.5 Rehabilitation

Rehabilitation is an essential aspect in the management of the athlete ankle fracture. The aim of arthroscopy is to improve functional outcome and reduce morbidity and shorten rehabilitation time. Therefore, it is commonly used as a valuable tool in sports-related ankle injuries. Initial elevation after injury or operation, as well as early range of motion exercises as soon as safely possible, is encouraged in the early postoperative phase [2] (Table 16.1).

During the healing process of operatively treated ankle fractures, adequate follow-up is advised, as chronic ankle pain may occur. Chronic pain after fracture consolidation may arise as a result of soft-tissue impingement, bony impingement, or loose bodies. Arthroscopy has been shown to improve the outcome of chronic pain after fracture surgery. As demonstrated by *Kim* et al., pain scores improved when hardware removal after ORIF of ankle fractures was combined with arthroscopy, compared to hardware removal alone [61].

16.6 General Outcomes and Time to Return to Competition (Table 16.1)

Outcomes from the general population cannot be directly extrapolated to athletes, who usually receive better and more intense rehabilitation. Their safe and prompt return to a highly demanding level of activity is paramount. Evidence on outcomes on the rare fractures around the ankle (i.e., process and talar fractures) in sports is scarce as discussed earlier. Some evidence on the more common malleolar type fractures has been

Table 16.1 Time (in weeks) athletes required the use of rehabilitative devices and time when athletes were able to resume activities [2]

Classification	N	Crutches	Boot	Brace	Daily living	Practice	Competition
Lateral malleolus fracture	6	1.3 ± 0.5	3.0 ± 0.9	4.3 ± 3.8	1.2 ± 0.8	5.0 ± 0.9	6.8 ± 2.4
Medial malleolus fracture	2	2.0 ± 1.4	2.0 ± 1.4	7.0 ± 1.4	2.0 ± 0.0	12.0 ± 5.7	17.0 ± 9.9
Bimalleolar fracture	10	3.7 ± 1.6	3.7 ± 2.0	4.2. ± 2.2	1.0 ± 0.5	10.9 ± 4.0	12.7 ± 4.0
Syndesmosis disruption injury	4	3.3 ± 1.0	2.3 ± 1.3	6.8 ± 6.1	0.8 ± 0.5	13.5 ± 2.5	15.8 ± 1.7
Salter-Harris-type fracture	4	2.0 ± 0.8	3.5 ± 1.7	9.0 ± 1.2	1.0 ± 0.0	6.3 ± 1.3	8.5 ± 1.0
Pilon fracture	1	4.0	2.0	2.0	1.0	8.0	16.0

documented and allows for conclusions to be made [2]. It has to be noted that a number of studies reporting time-loss ankle injuries provide limited information. These studies often group ankle injuries together, with the severity of injury often being defined by the time to return to sport (rather than the type of injury) [2].

Surgical treatment may allow a more rapid recovery, with earlier weight bearing and functional rehabilitation providing a speedier return to normal daily living and work. However, a recent systematic review by *Donken* et al. looked at surgical versus conservative intervention for treating ankle fractures in adults [62]. They concluded that there is insufficient evidence to determine which type of treatment provided better long-term outcomes. The review only identified four controlled trials (292 adults with displaced ankle fractures) from the general population. Also, there were significant variations and limitations in the types of patients, the surgical and rehabilitation protocols applied, the outcomes reported, and the duration of follow-up. Another study by *Colvin* et al. looked at the functional ability of 243 patients who underwent operative fixation of unstable ankle fractures to return to "vigorous activity" and sport [7].

In their study, young and healthy male patients were more likely to return to sport. At 1-year follow-up—although 88% of recreational athletes were able to return to sport—only 11.6% of competitive athletes were able to do so. Specifically, those with bimalleolar fractures were more likely to return to sport, compared with those with unimalleolar fractures. However, this retrospective study analyzed self-reported outcomes from a general trauma population only [7]. Nevertheless, it has been suggested that surgical management (by open reduction and internal fixation of unstable ankle fractures) in athletes may provide a number of advantages. Firstly, it would avoid the issues of secondary fracture displacement which delay recovery. Secondly, it would ensure anatomic fracture reduction and articular surface restoration. Finally, it allows for early range-of-movement exercises and early weight bearing (within 1–2 weeks of fixation) and a more rapid recovery and return to sport [8].

Studies specifically looking at ankle fractures in elite athletes are limited [2, 8, 9, 63], but appear to demonstrate that a successful return to high-level competition can be expected. A study by *Dunley* et al. on three professional American football players showed that all three returned to their pre-injury level [9]. Walsh et al. reported similar findings in a study on the surgical treatment of ankle fractures in three American football players and one soccer player [63]. Another study by *Oztekin* et al. looked at the time-loss from play in ankle injuries of Turkish professional football players. In this study, all patients that were surgically treated for their ankle fracture were able to return to their previous level of play [64]. A layoff of 150 days in this study was reported for two football players (one with a Maisonneuve fracture and one with a lateral malleolar fracture with deltoid rupture), while a patient that was treated for a lateral malleolus pseudarthrosis took 200 days. Another study by *Porter* documented the management, rehabilitation, and outcomes in 27 athletes with ankle fractures that underwent ORIF (including repair of any injured ligaments). The indication for surgery was either displacement of ≥3 mm or if the athlete was "especially enthusiastic" for an early return to sports [8]. The most common sport injuries were in American football (ten athletes) and baseball (three athletes), but two athletes involved in soccer were also included. At an average follow-up of 2.4 years (12 months to 3.7 years), all athletes reported an average 96.4% functional rating compared to their pre-injury level, with 12 athletes rating their ankle as 100%. Early rehabilitation and ambulation were encouraged, which included the use of an ankle Cryo/Cuff™, with athletes encouraged to weight bear in a walking boot within a week postoperatively.

The ability of athletes to be weaned off their rehabilitative devices and the time required to reach activity goals are shown in Table 16.1 [8]. Those athletes with isolated Weber A and B lateral malleolar fractures were able to return to sport within the shortest time. In this study, return to full activity was seen as early as 4 weeks. Two out of the six athletes did not rate their ankle 100% in either flexibility or decreased stability issues. Two athletes in this study (with isolated medial malleolar fractures) required deltoid ligament repair at the same time. These athletes took longer to return to competition, with one patient taking 24 weeks to return to motocross racing.

Athletes with bimalleolar fractures required 12.7 ± 4.0 weeks to return to competition, while athletes with syndesmotic injury and pilon fractures took slightly longer. The authors did not document the recovery of patients with stable and undisplaced ankle fractures that underwent non-operative treatment. There is a lack of evidence with regard to outcomes and return to competition in athletes with such injuries but they felt that early rehabilitation and ambulation would be possible in such cases, and a similar return to sport should be expected [2]. No study was found that documents arthroscopic-assisted ankle fracture fixation and its value in return to elite sports resumption, compared to a control group (without arthroscopy). Further work is required to objectively describe the potentially added value of arthroscopy in this return-to-sport perspective.

16.7 Conclusion

The incidence of ankle fractures is low, making up less than 3% of all ankle injuries in athletes. Optimal management for the elite athlete has to address the demand for early and safe return to a high level of activity. The evidence for current best practice in athlete-related ankle fractures remains limited. A thorough history, examination, and adequate imaging are essential to correctly diagnose injuries and decide upon the optimal treatment plan. Early rehabilitation allows for an early return to sport within 2–4 months depending on the fracture severity. Surgical reduction (when indicated) and provision of stability by fixation optimize both outcomes and return to competition in the athlete ankle fracture. Arthroscopy may be helpful in diagnosing (and treating) intra-articular pathology (up to 60% of ankle fractures may have a cartilage injury). Furthermore, arthroscopy may also have a role in the assessment of syndesmosis stability and can assist in the accurate reduction of displaced (tibial plafond, malleolar, and talar) fractures. Arthroscopic techniques allow for a more rapid rehabilitation, with fewer complications, than conventional techniques in athletes.

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