8 Fractures of the Lateral Process of the Talus

Matthew P. Sullivan and Reza Firoozabadi

Historic and Contemporary Significance

The earliest reports in the peer-reviewed English literature describing lateral process fractures date back to the 1960s [1–4]. Dimon's seminal work on the topic described three patients treated operatively. He was well ahead of his time, describing the negative sequelae of delayed diagnosis, surgical anatomy, and a hypothesis of the complex injury mechanism that is remarkably similar to that, which is accepted today and has been described in ex vivo biomechanical studies. Early reports describe predominantly delayed diagnoses and the functional disability associated with late treatment. Interestingly, these early publications describing lateral process fractures use anatomic descriptors that differ from those used today. For example, throughout Dimon's manuscript, the lateral process is referred to as the anterolateral aspect of the posterior facet of the talus. By the mid-1990s, the predominant etiology of lateral process fractures was snowboarding misadventures [5, 6]. McCrory and Bladin were the first to describe the so-called snowboarder's ankle [5]. Since that time, numerous authors have reported epidemiologic and case series of snowboarding-related lateral process fractures [7, 8].

In the general population, lateral process fractures account for less than 1% of all ankle injuries [5, 7, 9] and about 10% of all talus factures [10]. In snowboarders, however, they account for greater than 30% of all ankle/hindfoot fractures [8]. Fracture incidence is most likely underreported, as this injury is frequently missed acutely, presenting as chronic ankle dysfunction, pain, and instability [11].

Diagnostic Dilemma

Lateral process fractures are commonly overlooked radiographically due to low index of suspicion by the interpreter and mistaken for severe ankle sprains [11, 12]. This was noted in Dimon's early work in 1961 [1]. Upwards of 15% of "severe ankle sprains" are missed lateral process fractures [5]. Delay or absence of diagnosis of lateral process fractures is the result of low index of suspicion and failure to interpret or obtain appropriate radiographic images. Plain x-rays can be challenging to interpret, and standard ankle views should be scrutinized for lateral process fractures in the correct clinical setting. The

M. P. Sullivan
Orthopaedic Trauma Service, State University of New York, Upstate University Hospital, Oneida, NY, USA

R. Firoozabadi (✉)
Department of Orthopaedics and Sports Medicine, Harborview Medical Center/University of Washington, Seattle, WA, USA
e-mail: rezaf2@uw.edu

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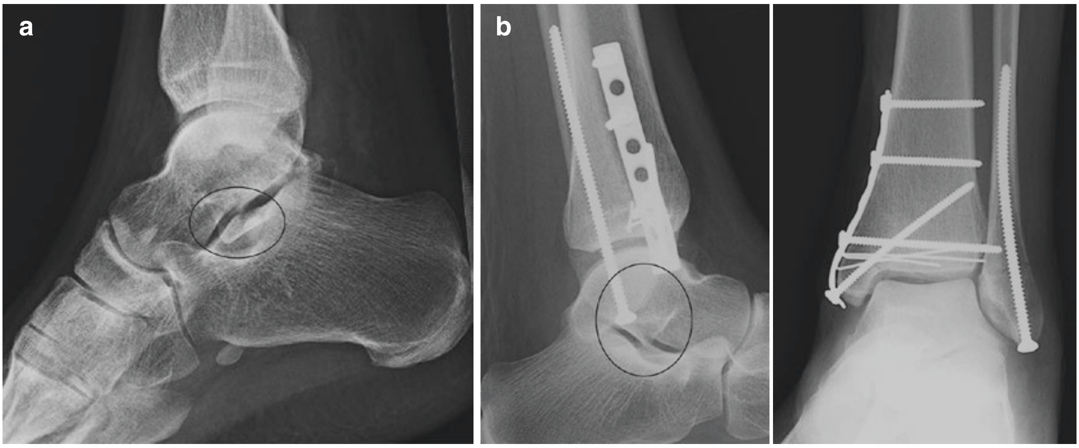

Fig. 8.1 (**a**) Lateral radiograph of the ankle demonstrating a double density, suggestive of a lateral process fracture. Routinely the lateral process is displaced distally when fractured causing the double density. (**b**) Intact lateral process. Notice the lack of a double density. Lateral process is circled in both images

lateral radiograph of the ankle can be very useful for diagnosis. If a double density is noted just distal to the subtalar joint, then one should have a high clinical suspicion of a lateral process fracture (Fig. 8.1). Additionally, a Broden view of the subtalar joint may reveal lateral process pathology [13]. CT scanning is critical to diagnosis and management and should always be obtained when there is suspicion of a lateral process fracture [14, 15]. Multiple small case series suggest that upwards of 50% of lateral process fractures are missed at the time of initial evaluation [2, 16, 17].

The sequelae of delayed diagnosis or nonoperative management of displaced fractures have been well documented in numerous case series and subjectively and objectively result in poor function and pain. Post-traumatic subtalar osteoarthritis is more commonly seen in these patients as well [1, 2, 9, 13, 18, 19]. Missed displaced fractures tend to result in nonunion [18] presumably due to the intra-articular location and the considerable strain present in this area due to ligamentous attachments. Post-traumatic subtalar osteoarthritis likewise can be expected in the setting of missed injuries [20]. Nonunited fracture fragments may displace into the sinus tarsi resulting in severe disability [21] or result in symptomatic lateral ankle impingement [12]. Acute surgical management of displaced fractures result in superior function than those fractures that go on to nonunion in the setting of delayed diagnosis. Subtalar motion is negatively affected in both operative and nonoperative patients.

Local Anatomy and Functional Anatomy

The lateral process is composed of two facets: dorsolateral and inferomedial. The dorsolateral facet articulates with the distal fibula. The inferomedial facet makes up a significant portion of the posterior facet of the talus. It articulates with the posterior facet of the calcaneus, making up the subtalar joint. The ligamentous anatomy about the lateral ankle is highly complex and has been described in great detail. Several anatomic and biomechanical reports suggest at least 11 independent ligamentous structures contribute to lateral ankle stability. The lateral process of the talus serves as the attachment site for four important structures: the anterior talofibular ligament, posterior talofibular ligament, lateral talocalcaneal ligament, and talocalcaneal interosseous ligament [5, 22–25]. Sectioning studies suggest significant lateral ankle stability conferred by these ligaments, specifically, the anterior talofibular ligament in the plantar-flexed position, and posterior talofibular ligament and talocalcaneal

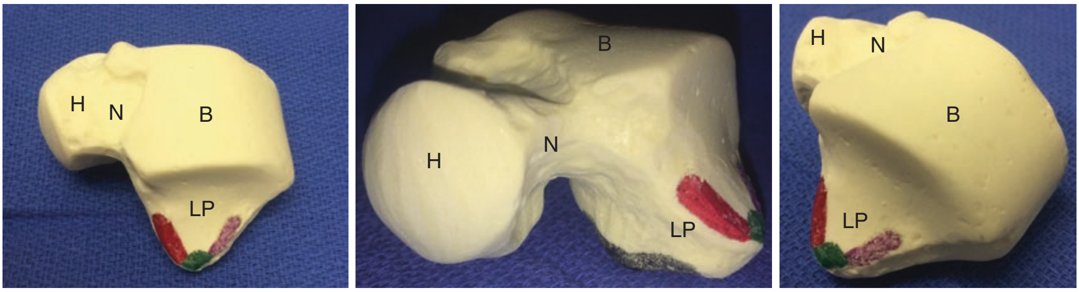

Fig. 8.2 Bone model demonstrating the ligamentous footprints on the lateral process: Red – anterior talofibular ligament. Purple – posterior talofibular ligament. Green – lateral talocalcaneal ligament. Black – talocalcaneal interosseous ligament. H – talar head. N – talar neck. B – talar body. LP – lateral process

interosseous ligament in all ankle positions [23, 25]. An understanding of the clinical anatomy in this region will guide fracture care. Figure 8.2 demonstrates the footprints of the four ligaments that attach to the lateral process. A simulated 1-cm^3 lateral process osteotomy at the apex of the process has been shown in a cadaver model to significantly impact the footprints of the lateral talocalcaneal, anterior talofibular, and posterior talofibular ligaments [26].

Injury Mechanism

The precise hindfoot position and force vector resulting in lateral process fracture has been disputed. The mechanisms in question include forced dorsiflexion plus eversion and external rotation [1, 6, 13, 20, 27] and forced dorsiflexion with hindfoot inversion [2, 4, 5, 9, 18]. Biomechanical cadaveric works performed by Boon et al. and Funk et al. make very convincing arguments against the previously accepted notion that hindfoot inversion is essential for these injuries. Rather, their combined works elegantly identify combined axial load plus dorsiflexion, eversion, and external rotation as the precise mechanism of injury. This is the exact position of the snowboarder's hindfoot during traumatic landing after an aerial maneuver. Dimon hypothesized this mechanism based on his understanding of hindfoot anatomy and the findings at surgery of the three patients he treated with lateral process fractures between 1956 and 1959. Specifically, he suggested forced dorsiflexion, eversion, and external rotation were required to cause lateral process fractures.

Management Principles

Operative indications for lateral process fractures are based exclusively on anecdotal reports, small case series, poor outcomes observed with delayed diagnoses, and the local anatomy of the fracture. Specialists recommend operative management for all displaced fractures and many minimally or nondisplaced fractures [1, 9, 18–21]. Nonoperative treatment should be considered in patterns in which fracture fragments are too small to support fixation. This primarily applies to avulsion fractures that are too small for fixation with mini-fragment plates or Kirschner wires. Exceedingly comminuted fractures, in which open reduction and internal fixation may not be possible, fare better with excision than simple immobilization. Given the significant contribution the lateral process makes to lateral ankle stability and to the articular surface of the subtalar joint, open reduction and fixation are appropriate for most fractures, even when only minimal displacement exists.

Associated hindfoot injuries are very common in these patients and appear to be markedly underreported. Von Knoch et al. reported that 88% (14/16) of their patients who underwent operative fixation of a lateral process fracture had a significant concomitant hindfoot injury identified at the time of surgery [20]. These injuries included posterior facet calcaneus cartilage lesions, calcaneofibular ligament rupture, peroneal tendon dislocation, and anterior talofibular ligament rupture. Klein et al. reported 46% rate of peroneal tendon dislocation associated with lateral process fractures [28]. The surgeon should maintain a high index of suspicion for associated injuries and treat them appropriately as outlined in this text.

Fixation Strategies

Goals of surgery The surgical goals for fixation of lateral process fractures are twofold. The first goal is to restore the congruity of the talar contribution to the subtalar joint (posterior facet). The second goal is to restore lateral ankle stability through stabilizing the ligamentous footprints of the lateral process.

Patient positioning The patient is positioned supine with a bump under the operative hip. A thigh tourniquet is applied, and the operative extremity is propped up on a radiolucent foam ramp. Fluoroscopy comes in from the contralateral side of the patient.

Surgical implants and instrumentation Medium or large external fixator with compression-distraction device

- Dental picks/shoulder hook
- Small sharp osteotomes
- 0.035″ and 0.045″ smooth Kirschner wires
- 2.0/2.4/2.7-mm stainless steel cortical screws
- Nine-hole 2.0-mm T-plate – three or four holes in transverse row
- Small, handheld plate/wire cutter
- Crushed cancellous allograft bone
- Headlight

Surgical approach The lateral process is approached through a straight incision centered directly over the fracture, extending from the distal aspect of the fibula distally toward the center of the cuboid. This is slightly more lateral than the anterolateral approach to the talar neck, which is typically in line with the fourth ray. The lateral process should be localized with fluoroscopic assistance prior to skin incision. This is demonstrated in Fig. 8.3. Once through skin, extensor digitorum brevis is elevated from posterolateral to anteromedial off of the calcaneus. This will give access to the lateral process, the sinus tarsi, and the subtalar joint. The fat is gently removed from the sinus in order to better visualize the anterior extent of the lateral process.

Distraction Once the exposure is complete an external fixator should be applied. This allows the subtalar joint to be easily visualized and

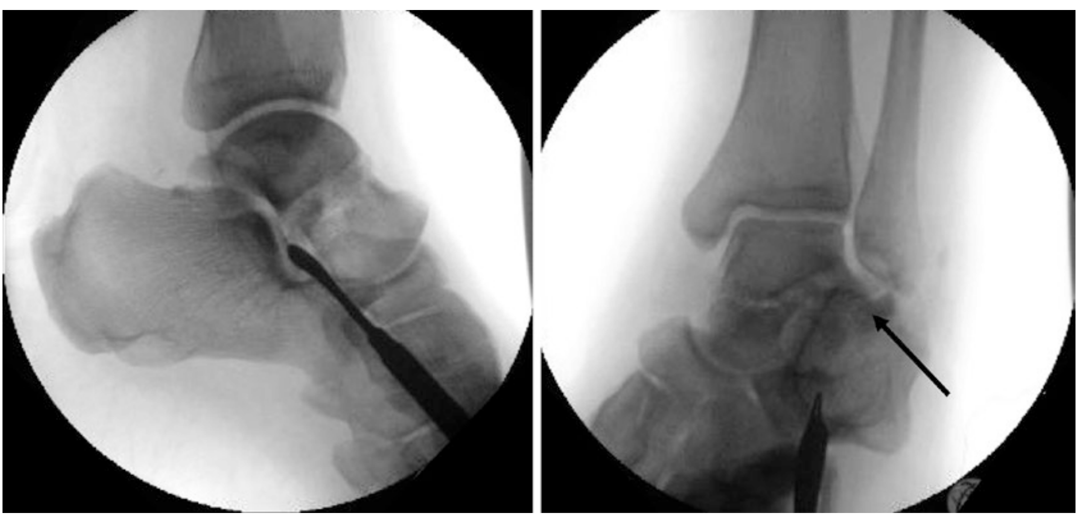

Fig. 8.3 The lateral process is localized on the lateral (freer elevator tip) and mortise view (arrow tip)

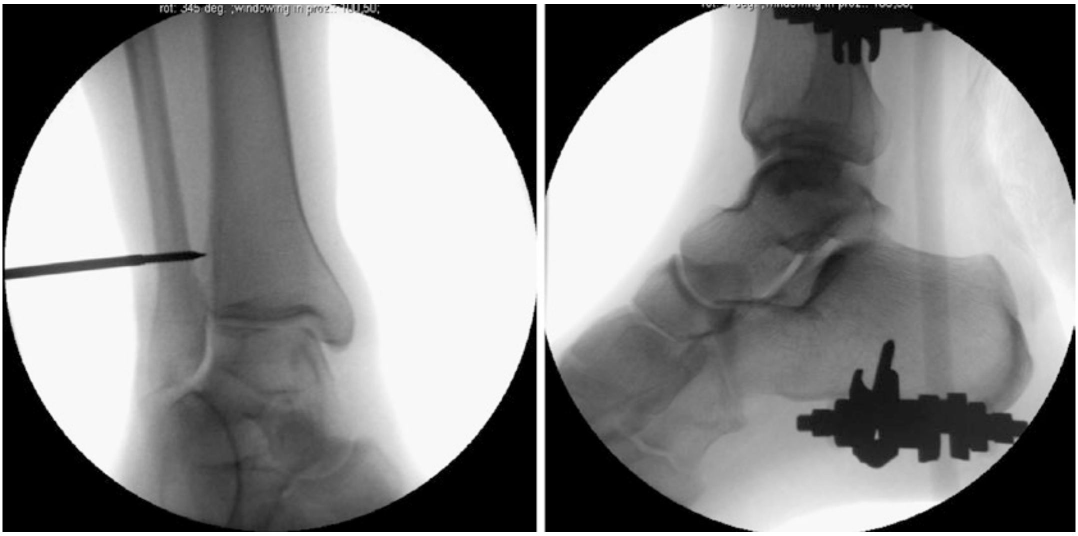

Fig. 8.4 Appropriate pin placement for monorail distracting external fixator. Notice the lateral calcaneal half pin is centered within the calcaneus. This allows for a more appropriate vector for distracting the subtalar joint without having the hardware in the way of the approach and reduction

space to be created in which the surgeon can work in in order to reduce and stabilize the lateral process. Our preference is to build a monorail external fixator to assist in distraction, as opposed to utilizing a universal distractor. We feel that there are numerous benefits to a well-built frame, specifically greater freedom of movement and distraction, as well as its less cumbersome nature and radiolucency. Figure 8.4 demonstrates the most appropriate pin placement. In order to distract across the subtalar joint and provide the greatest visualization of the lateral process, a monorail system is set up from the fibula to the midportion of the calcaneus. A 4 -mm terminally threaded Schanz pin is the most appropriate for the fibula. A 4- or 5-mm Schanz pin may be used for the calcaneal pin. Notice that the lateral calcaneal half pin is placed more anterior than is typical for an ankle spanning external fixator or a medial-based calcaneal pin for a joint depression calcaneus fracture. Figure 8.5 demonstrates the distraction achieved by a laterally based monorail external fixator utilizing the distraction device found on most external fixator sets. The lateral process is very well visualized both fluoroscopically and clinically after distraction is applied.

Reduction strategies, implant selection, and placement The surgeon must scrutinize the preoperative CT scan in order to understand the morphology of the fracture pattern, extent of subtalar involvement, and presence of articular impaction. Restoration of subchondral congruence is only possible after articular impaction is addressed. Figure 8.6 demonstrates posterior facet articular impaction. This is disimpacted with a small brown handle AO elevator, a freer elevator, or a small osteotome, followed by placement of crushed cancellous allograft into the cancellous defect, and fixation with a mini-fragment T-plate with several subchondral screws (Fig. 8.7) with or without Kirschner wires. Alternatively, autograft can be used from the calcaneus or proximal tibia.

Implant selection should be based on the fracture pattern. A single, large fracture fragment may accommodate several 2.4- or 2.7-mm lag screws. A mini-fragment plate may function as a washer in this fracture pattern. Clamping of the lateral process is not optimal due to limited space. As such, the large fracture fragment should be reduced with the assistance of a dental pick, shoulder hook, or elevator, wired in place, and then compressed with lag screws. Figure 8.8 dem-

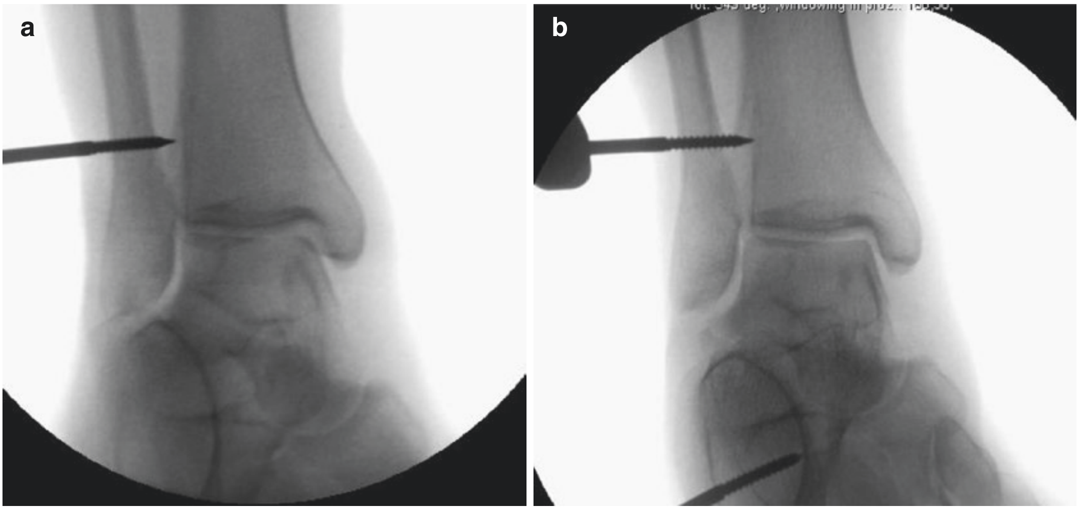

Fig. 8.5 A monorail, lateral-based external fixator is statically applied in (**a**). (**b**) Demonstrates markedly enhanced visualization of the lateral process following distraction. Clinically, there is considerably more space for reduction and implant placement with application of distraction

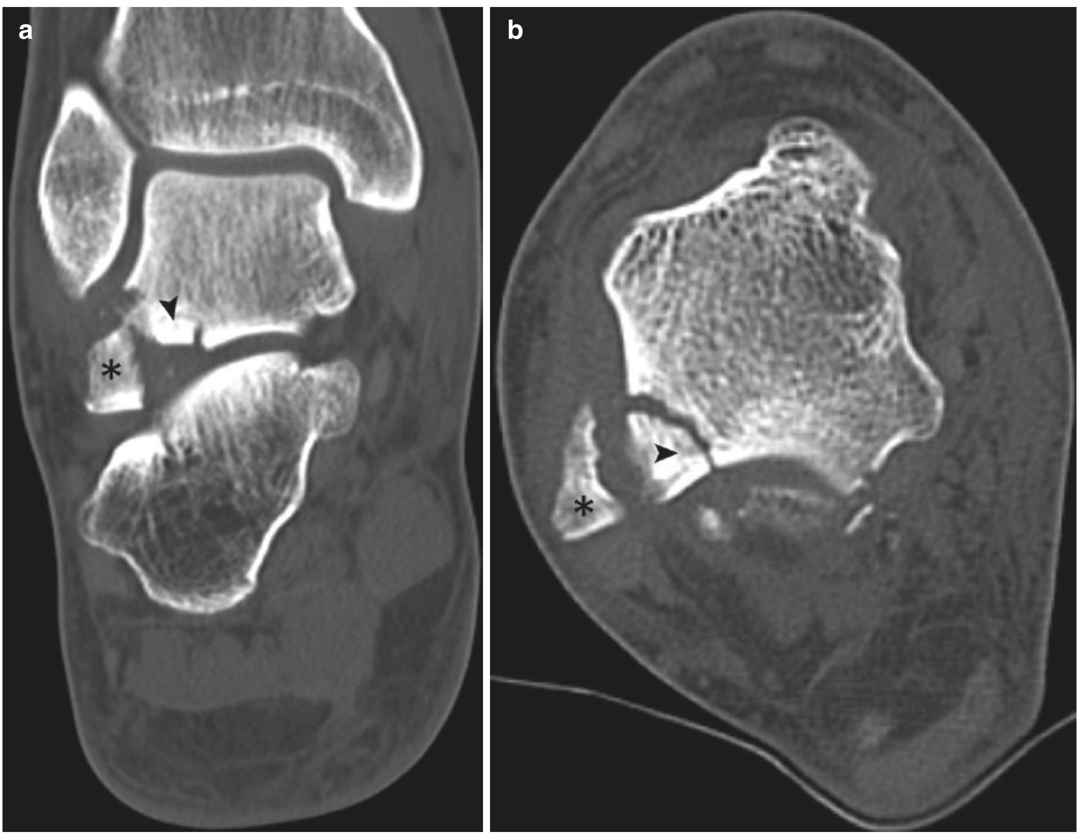

Fig. 8.6 Coronal (**a**) and Axial (**b**) plane CT images demonstrate a large lateral process fracture (*) with posterior facet impaction (➤)

onstrates a large lateral process fracture reduced and wired into place. Careful wire placement allows the surgeon to wire the fracture together then lay the plate down onto the anterior face of the lateral process (Fig. 8.9). Well-placed subchondral wires can then be cut, bent, and tamped down as described by Firoozabadi et al. order to provide additional fixation [29]. Caution should be used when compressing along comminuted fractures as this may result in over-compression and a loss of reduction. T-plate plus wire fixation is appropriate when significant comminution is present. The typical reduction "reads" are the posterior talar facet articular surface and the anterior aspect of the lateral process.

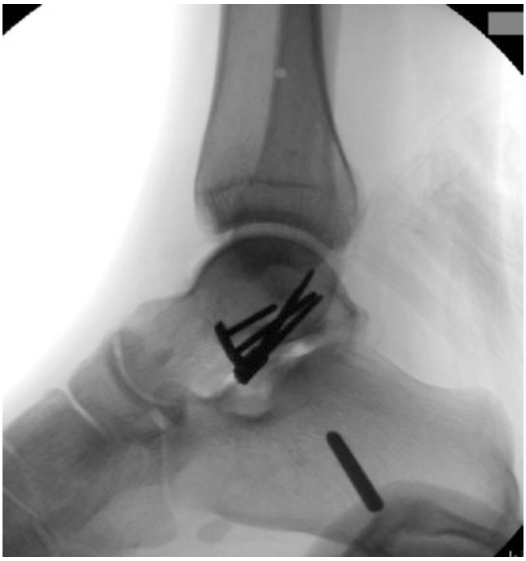

Fig. 8.7 Intraoperative lateral view of a fixation construct for lateral process fracture with subtalar articular impaction. 4 2.4 mm cortical screws are placed through the transverse row of the T plate. These "rafting" screws support the subchondral bone and provide adequate stability until re-vascularization of the articular segment, and creeping substitution of the allograft can take place

There is sufficient room on the lateral process to place fixation without compromising the subtalar joint or talofibular articulation. A 1.5-mm, 2.0-mm, and 2.4-mm T-plates may be contoured to sit on the anterior face of the lateral process. The plate is not to be placed laterally. This will result in impingement of the talofibular articulation. The T is turned upside down such that the transverse row lies distal, which allows for placement of rafting screws. Figure 8.10 demonstrates the safe location for plate placement of lateral process. Notice that the subtalar joint is not violated. The transverse row in the plate is placed parallel to the subtalar joint. We have found that the most appropriate plate for this facture is a nine-hole 2.0-mm nonlocking T-plate with four holes in the transverse row. Typically, this must be cut down to three holes in the shaft of the plate. Distraction of the subtalar joint makes it possible to place the medial most screws into the transverse row of the plate. The surgeon must clinically and radiographically confirm prior to leaving the OR that all wires and screws are fully contained within bone. Furthermore, the underside of a freer elevator can be used to palpate the joint surface of the talus to confirm that no step-off exists.

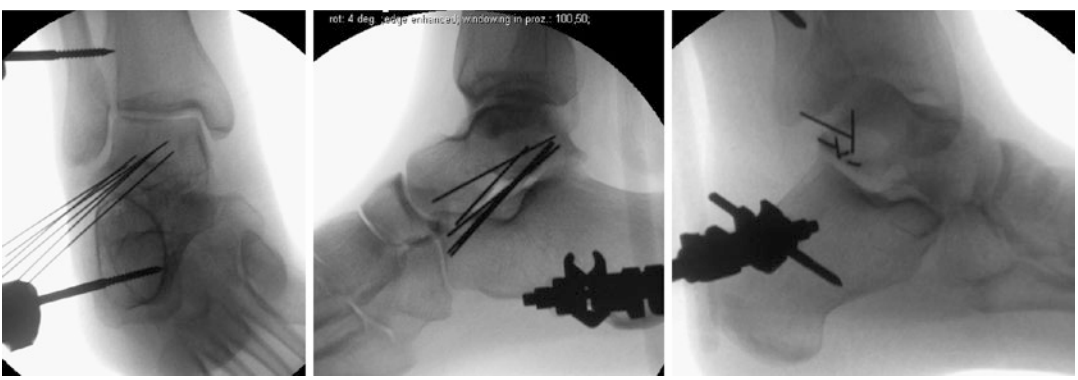

Fig. 8.8 A large lateral process fracture is reduced and provisional held in place with multiple .045" wires. Notice multiple views of the subtalar joint nicely demonstrate "safe" placement of all wires

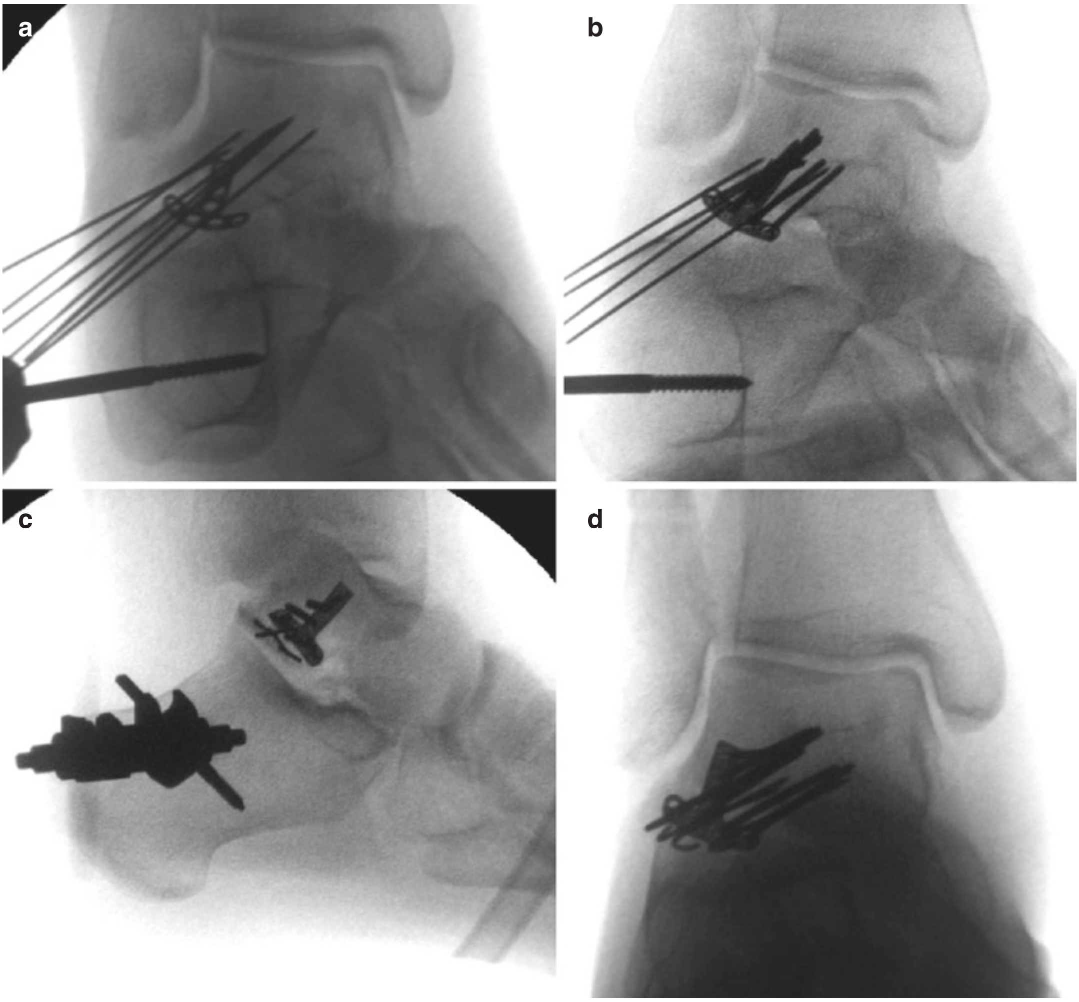

Fig. 8.9 (**a**) 0.045” K-wires are placed thoughtfully such that a contoured 2.0-mm T plate may sit on the anterior face of the lateral process without having to remove wire fixation. (**b**) Screws placed through the transverse distal row of the T plate raft the posterior facet. (**c**) Subtalar view demonstrates rafting wires, and screws are safely placed in an extra-articular location. (**d**) Wires are ultimately cut, bent, and tamped into the cortex of the lateral process

The wound is closed with 4–0 Nylon suture with the Allgöwer sequentially tensioned skin closure technique.

Post op care Postoperatively, the patient is placed in a well-padded plaster splint. The surgeon must pay particular attention to not allow the foot to supinate or plantar-flex as the splint is hardening. A supination equines deformity will severely compromise the patient’s ability to recover from this injury. Once the skin incision is healed and sutures are removed, patients are instructed to begin range of motion, with specific focus on subtalar motion. Non-weight-bearing is maintained for 6–12 weeks after surgery.

Complications

Subtalar arthrosis and stiffness have been described by many authors as occurring in these injuries, even after appropriate management.

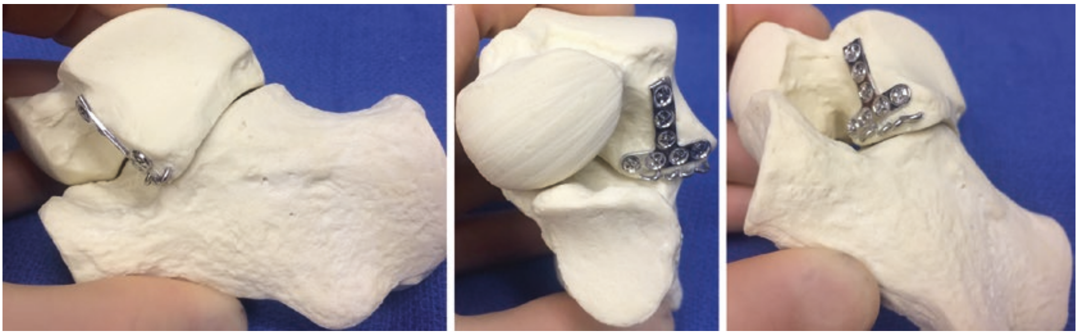

Fig. 8.10 Bone model demonstrating safe plate placement on the lateral process so as to avoid violation of the subtalar joint and the talofibular articulation. The plate is placed on the anterior face of the lateral process. Subchondral rafting wires can safely be placed slightly more lateral. When left in place after plate fixation, these wires will provide added stability to the dis-impacted subchondral bone/bone graft. They should be bent, cut, and impacted into cortical bone so as to prevent loosening and backing out

When appropriate and timely management is performed, roughly 80% of patients return to their pre-injury level of function [13, 20, 30].

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