Fractures of the Talus: State of the Art

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Summary: Talus fractures occur rarely but are often associated with complications and functional limitations. Urgent reduction of associated dislocations is recommended with open reduction and internal fixation of displaced fractures when adjacent soft tissue injury permits. Delayed definitive fixation may reduce the risks of wound complications and infections. Restoration of articular and axial alignment is necessary to optimize ankle and hindfoot function. Despite this, posttraumatic arthrosis occurs frequently after talar neck and body fractures, especially with comminution of the talar body. Osteonecrosis is reported in up to half of talar neck fractures, although many of these injuries will revascularize without collapse of the talar dome. Initial fracture displacement and presence of open fractures increase the risk of osteonecrosis. Talar process fractures may be subtle and easily missed on plain radiographs. Advanced imaging will provide detail to facilitate treatment planning.

Key Words: talus, facture, Hawkins, osteonecrosis, lateral process

Level of Evidence: Therapeutic Level V. See Instructions for Authors for a complete description of levels of evidence.

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Talus fractures are uncommon, accounting for less than 2.5% of all fractures.[1–4] Most occur after high-energy trauma but some occur after low- or moderate-energy events, in particular, talus process fractures. The majority of prior reports on talus fractures have been limited to case series, that is, level 4 evidence. Small numbers of patients and heterogeneity of fracture patterns and other injury features have limited the quality of most studies and have hampered our understanding of these injuries and optimal treatment for them.

Because of the unique position of the talus, maintaining articulations with the tibial plafond, medial malleolus, distal fibula, navicular, and the 3 facets of the calcaneus, the majority of the talus is covered with articular cartilage. Injury to talar articular surfaces has implications for development of posttraumatic arthrosis (PTA) and associated pain and stiffness. Articular and extra-articular injuries to the talus can also alter the axial alignment, causing abnormalities of ankle, hindfoot, and/or midfoot function. Lastly, talar blood supply is easily compromised with trauma, particularly with displaced talar neck fractures, which may result in osteonecrosis.

This article will review treatment of talus fractures, with an emphasis on the talar neck and body. Previous literature will be evaluated, and treatment recommendations will be developed.

TALAR NECK AND BODY FRACTURES

Goals of treatment include restoration of articular and axial alignment followed by rigid fixation to maintain alignment until fracture union. Ideally, depending on bone quality, integrity of fixation, and extent of soft tissue injury, early range of motion exercise is initiated to minimize stiffness.

Optimal treatment relies on an accurate understanding of the injury. Plain ankle and foot radiographs are obtained to characterize the talus fracture and to identify adjacent injuries. Occasionally, computerized tomography scans may be helpful to further assess chondral injuries.[5] For talar neck fractures, the classification initially described by Hawkins,[6] and later expanded on,[1,6,7] provides descriptive and prognostic information. Type 1 indicates a nondisplaced fracture. Type II indicates a fracture with subluxation (IIA) or dislocation (IIB) at the subtalar joint. Type III refers to a fracture with a dislocated tibiotalar joint, and type IV indicates a dislocated talonavicular joint. Osteonecrosis has been shown to be related to initial fracture displacement, as described by the Hawkins' classification, because of progressive risk for damage to the blood supply to the talar body, much of which occurs in a retrograde fashion through the arteries of the tarsal canal and tarsal sinus (See **Figure, Supplemental Digital Content 1**, http://links.lww.com/BOT/A432).[8–12]

Associated soft tissue trauma is also common with talar neck and body fractures.[13–16] Open fractures occur frequently, accounting for 20%–25% of injuries, with greater incidence as fractures become more displaced.[1,6,7,17,18] Urgent surgical debridement should be undertaken. Closed injuries also are usually associated with severe swelling and may have elements of internal degloving, which increases risk for wound healing complications and infections. Urgent reduction of talus dislocations will minimize further soft tissue compromise.

Provisional closed reduction should be attempted in the emergency room. If an acceptable closed reduction is not possible, then urgent percutaneously assisted or open reduction in the operating room is essential.[7,18–20] Type III and type IV talar neck fractures are unlikely to be reducible through closed means (See **Figure, Supplemental Digital Content 2**, http://links.lww.com/BOT/A433).

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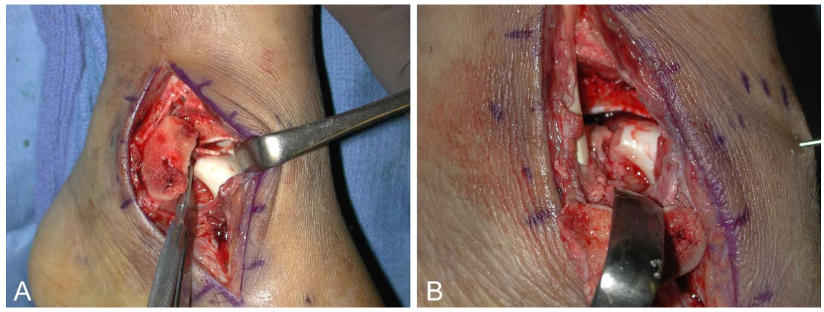

FIGURE 1. Medial malleolar osteotomy provides access to the posteromedial talar dome. The deltoid ligament is preserved with capsulotomy just anterior to the medial malleolus. Denuded chondral fragments are evident (A). The malleolus is reflected inferiorly showing the tibiotalar joint after debridement (B). Figure is reprinted with permission from Journal of bone and joint surgery, American. **Editor's note:** A color image accompanies the online version of this article.

Nonoperative management could be considered for nondisplaced talar neck and body fractures, in nonambulatory patients, or in those medically not able to tolerate surgery. Indications for nonoperative management occur very rarely. Splinting, followed by short leg casting for a period of several weeks until fracture union, should be undertaken. The current standard of care for fractures of the talar neck and body with any displacement is open reduction and internal fixation (ORIF). Open reduction is advocated to directly visualize the fractures, ensuring establishment of anatomic fracture alignment.

Dual anteromedial and anterolateral surgical exposures are recommended to optimize access to the talar neck and anterior body.[1,21–23] Although the usage of dual surgical exposures has never been shown to increase the risk for osteonecrosis,[2,21–23] dissection of the inferior aspect of the talar neck is avoided to protect remaining blood supply. The deltoid ligament should not be violated. Ipsilateral medial malleolar fractures occur frequently and may facilitate visualization of the medial talar body through the medial malleolus fracture, as the fractured malleolus may be reflected inferiorly. A medial malleolar osteotomy serves a similar purpose and is performed occasionally for the treatment of talar body fractures (Fig. 1).[2,23–27]

Provisional reductions of the talar neck and body are held with Kirshner wires, and thorough radiographic assessment is

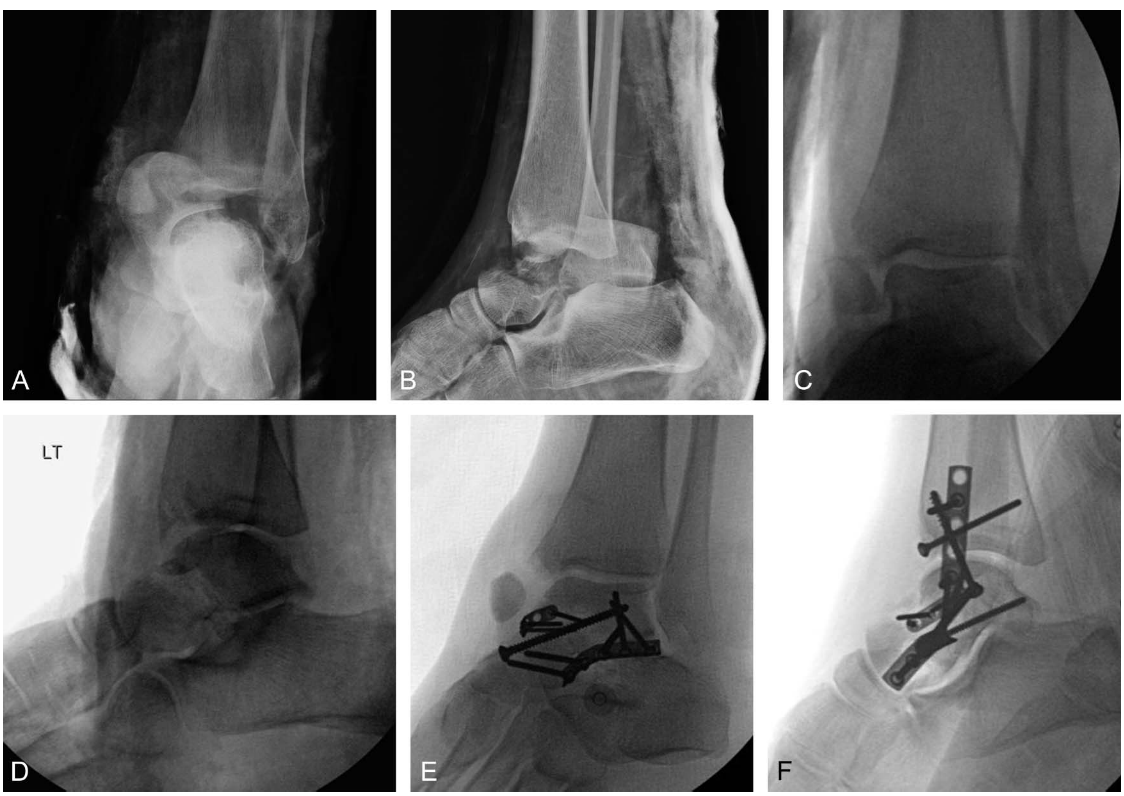

FIGURE 2. Injury anteroposterior (A) and lateral (B) radiographs of 28-year-old female status post motor vehicle collision, demonstrating talar neck fracture dislocation and associated medial malleolus fracture. Provisional closed reduction was performed (C, D). Two weeks later, ORIF was undertaken. Intraoperative mortise view (E) depicts reduction and fixation medially performed through the anteromedial approach and within the medial malleolus fracture. Mini-fragments plates were applied due to comminution. Postoperative lateral view demonstrates fixation of the medial malleolus (F).

TABLE 1. Early and Late Results After Surgical Treatment for Talar Neck Fracture. Total Number of Patients Treated for Each Group Within Hawkins' Classification Are Listed. Numbers and Percentages of Patients With Various Complications Are Listed

Authors	Fracture Classification	Open Fractures	Deep Infection	Wound Complications	AVN
Fournier et al[2]	33 Hawkins 1 48 Hawkins 2 29 Hawkins 3 4 Hawkins 4	31/114 (27%)	6/114 (5.3%)	NR	39/114 (34%)
Lindvall et al[17]	11 Hawkins 2 6 Hawkins 3 1 Hawkins 4	9/26 (27%)	2/26 (7.7%)	NR	13/26 (50%)
Sanders et al[29]	29 Hawkins 2 25 Hawkins 3 16 Hawkins 4	10/70 (14%)	NR	NR	5/44 (11%)
Vallier et al[18]	4 Hawkins 1 68 Hawkins 2 25 Hawkins 3 5 Hawkins 4	24/102 (24%)	3/60 (5.0%)	2/60 (3.3%)	19/39 (49%)
Vallier et al[7]	2 Hawkins 1 44 Hawkins 2 32 Hawkins 3 3 Hawkins 4	24/81 (30%)	1/77 (1.3%)	1/77 (1.3%)	16/65 (25%)
Xue et al[20]	19 Hawkins 2 9 Hawkins 3	0	0	1/28 (3.6%)	6/28 (21%)

Authors	AVN With Collapse	Nonunion	Malunion	PTA Subtalar	PTA Tibiotalar
Fournier et al[2]	8/114 (7.0%)	NR	37/114 (32%)	57/114 (50%)	47/114 (41%)
Lindvall et al[17]	NR	3/26 (12%)	5/26 (19%)	100%	15/26 (61%)
Sanders et al[29]	2/44 (4.5%)	NR	36%	78%	40%
Vallier et al[18]	12/39 (31%)	3/60 (5.0%)	NR	6/39 (15%)	7/39 (18%)
Vallier et al[7]	9/65 (14%)	2/65 (3.1%)	NR	25/65 (38%)	19/65 (29%)
Xue et al[20]	4/28 (14%)	1/28 (3.6%)	NR	7/28 (25%)	5/28 (18%)

AVN, avascular necrosis; NR, not reported.

undertaken until fracture alignment has been optimized.[1,28] A common pitfall is failure to identify dorsal and medial comminution of the talar neck. In this situation, aligning the cortical margins of the fracture will generate malalignment in varus and extension. Careful direct visualization of cortical reduction reads of the lateral talar neck, using the anterolateral exposure, reduces this tendency.[14,25] Most high-energy talar neck fractures have some comminution, which will leave cortical deficiency in the dorsal and medial neck when the fracture has been properly reduced. Local bone graft or allograft may be applied in these areas as needed to provide substrate and/or mechanical support.[29]

Definitive fixation with small fragment and mini-fragment implants is advocated to maintain fracture alignment, minimizing the occurrence of malunion (Fig. 2).[2,21,23,30] Mini-fragment screws with cruciform heads (2.0 or 2.4 mm) effectively secure osteochondral fractures. These may be placed through articular cartilage such that the flat head does

FIGURE 3. Lateral process fracture is seen on ankle mortise (A) and lateral (B) radiographs but is better characterized with CT scan (C, D). Comminution and impaction of the posterior facet of the subtalar joint are noted. Mortise (E) and lateral (F) views obtained 3 months after ORIF show healing after advancement of the lateral border of the lateral process to achieve structural contact between the intercalary fragments and the intact talar body.

not create prominence on the articular surface. They are particularly useful for talar dome fractures. Postoperative splinting is recommended initially to encourage soft tissue healing. Range of motion exercise is initiated once the surgical and traumatic wounds are adequately healed. Weightbearing is deferred for approximately 3 months.

Timing of definitive surgery should be based on the injury to the surrounding soft tissues. Early complications, including wound dehiscence, skin necrosis, and infection, have been reported in up to 77% of cases after immediate surgery.[4,6,31–33] More recent reports of delayed definitive care have been associated with much lower rates of soft tissue complications, ranging between 2% and 10%.[2,7,18,20] See Table 1. Previously, it was believed that urgent fixation would enhance revascularization of the talar body and minimize the incidence of osteonecrosis.[1,6,25,34–38] However, recent reports have not corroborated this idea. No association has been shown between timing of fixation and development of osteonecrosis.[7,17,18,39,40] It may be that blood supply to the body is maintained through posterior vessels.[10,12]

Early and late complications after talar neck and body fractures occur commonly. Soft tissue complications, including wound healing problems and infections, are minimized by urgent reduction of dislocations, urgent administration of antibiotics, surgical debridement for open fractures, and meticulous soft tissue handling during surgery.[41] Definitive procedures are best deferred until adequate resolution of swelling has occurred, ranging between one and 3 weeks after injury.[20,22,23]

Nonunion after talar neck or body fractures is rare, occurring in less than 5%.[3,7,18,20,42] The rate of malunion in previous reports varies between 0% and 37%, and is likely underestimated due to limitations in assessing articular and axial malalignment with plain radiography.[2,3,7,18,20,42,43] Malunion will generate pain and reduce mobility of the subtalar and transverse tarsal joints. Malunion will also contribute to PTA.[43–45]

The risk of osteonecrosis rises with greater initial fracture displacement[6,7,17,18,37,46,47] and occurs more often after open fractures.[17,18] A relative increase in the density of the talar body versus adjacent structures indicates osteonecrosis on plain radiographs.[1,6,40] Approximately, half of the patients with this early finding will undergo revascularization of the talar body without collapse.[7,17,18,39,48] This can take up to 2 years after injury.

The most common complication after talar neck fracture is PTA.[7,17,18,20,29,31,35,49–52] It occurs even more often

FIGURE 4. Posterior process fracture is seen on lateral foot radiograph (A) and CT scan (B, C). Intraoperative lateral and mortise views after ORIF through a posteromedial approach (D, E).

with fractures of the talar body, where up to 100% of patients have PTA at final follow-up.[4,6,7,17,18,46,53–55] Despite modern surgical tactics over half of patients will develop arthrosis in the ankle and/or subtalar joints.[2,4,7,17,18,29] Secondary procedures such as tibiotalar or subtalar arthrodesis may be indicated; these can be effective in relieving pain and improving function.

Ideally, with careful attention to surgical timing and technique, complications should be limited to those associated with characteristics of the initial injury including direct damage to the soft tissues, blood supply, cartilage, and bone.

LATERAL AND POSTERIOR PROCESS FRACTURES

Fractures of the talar processes may be subtle and difficult to discern on plain radiography (See **Figure, Supplemental Digital Content 3**, http://links.lww.com/BOT/A434).[56–62] Consequently, these injuries are often missed. Moderate- and high-energy etiology of these injuries is most frequent.[63] The classic presentation of a lateral process fracture is secondary to snowboarding injury.[62,64] Plain ankle and foot radiographs are usually diagnostic. Lateral process fractures are best seen on ankle mortise and 45° internal oblique views, whereas posterior process fractures may be best depicted on lateral foot radiographs. Computed tomography (CT) is an important adjunct in characterizing these fractures to determine the most effective treatment.[56,57] Small, truly nondisplaced fractures may be treated with nonweightbearing and a brief period of immobilization.[61] However, fractures with 2 or more millimeters of displacement should be treated surgically. Small, nonreconstructable fragments may be excised, whereas larger fragments are treated with ORIF to maximize subtalar joint function.[59–61]

Lateral process fractures are approached through an incision from the tip of the distal fibula extended distally along the axis of the fourth metatarsal.[23,27,65,66] The distal extent of this exposure is critical to adequately visualize the posterior facet of the subtalar joint to treat fractures of the undersurface of the talar body. The origin of the extensor digitorum brevis is elevated, promoting exposure of the lateral process. By dissecting distally onto the intact talar neck, a key cortical reduction read can often be seen. The anterolateral incision follows the axis of the fourth metatarsal, extending toward the anterior distal edge of the fibula. In the presence of talar body fracture or ipsilateral tibial plafond fracture, this incision can be directed more anteriorly, approximately one centimeter anterior to the anterior border of the distal fibula and parallel to it. The tibiotalar capsule is incised sharply, allowing excellent visualization of the lateral talar dome and the lateral process. Frequently, impaction fractures are noted along the lateral aspects of the tibiotalar and subtalar joints. These should be directly inspected, and associated denuded cartilage or detached osteochondral fragments of the talus and calcaneus are excised.

The subtalar joint must be carefully visualized for loose osteochondral pieces. Often fractures seem radiographically small or inconsequential. However, scrutiny of CT scans and direct operative inspection will reveal that many lateral process fractures are comminuted, frequently extending into the midportion of the talar body. Excision of multiple fragments comprising a large volume of the articular surface could generate instability or malalignment, and is not advised.

Rather, intercalary osteochondral fragments, which are impacted, may be retained in such position, provided no mechanical impediment to the subtalar joint is identified. In such cases, the lateral margin of the process must be reduced anatomically to the depth of the intact undersurface of the talus. Alternatively, if intercalary fragments are loose and too small to reduce and stabilize, these can be excised and the adjacent border of the lateral process can be advanced to contact the intact talus. Subtalar joint congruity is then maintained. This tactic provides ample bony support for foot function. The process fragments may be provisionally stabilized with Kirschner wires, followed by mini-fragment screw and/or plate fixation (Fig. 3).

Sequential rotational views between 15° (ankle mortise view) and 60 degrees of internal rotation of the ankle are helpful in assessing the reduction and fixation.[65] Often, lateral process fractures are present in conjunction with talar neck and/or body fractures.[18,23] It is generally most effective to reduce and stabilize the neck and major body fragments before incorporating the lateral process into the construct.

Posterior process fractures are approached through a posteromedial exposure. Positioning may be prone or supine.[23,66,67] In the supine position, a soft bump is placed beneath the contralateral hip to cause external rotation of the affected hip, placing the medial surface of the ankle and foot toward the surgeon. The approach is directed between the medial border of the Achilles tendon and the posterior edge of the medial malleolus. Depending on the fracture location, deep dissection is directed posterior to the flexor digitorum longus tendon and adjacent to the neurovascular bundle, or it is directed anterior to the flexor hallucis longus tendon and adjacent to the neurovascular bundle.[23,54] The capsule in this area is robust, it is sharply incised and elevated to access the posteromedial process. The fracture is reduced and ultimately stabilized with mini-fragment screws (Fig. 4). Range of motion exercise is initiated once soft tissue swelling has subsided to an acceptable level, and nonweightbearing is recommended for approximately 2 months.

Recent reports of small case series' of patients with posterior or lateral process factures suggest that nonunions occur infrequently, but mild to moderate stiffness and activity-related mild pain are common. These symptoms are consistent with mild degenerative changes on plain radiography of the subtalar joint.[61,63,67–71] Severe PTA is unlikely.

TALAR HEAD FRACTURES

Talar head fractures in isolation occur infrequently.[72,73] Most are associated with talonavicular dislocation, resulting in shear fractures which include articular impaction. Again, these fractures are easily missed, particularly when spontaneous reduction occurs before presentation.[74] Plain anteroposterior, lateral, and oblique foot radiographs should be supplemented with CT scans to accurately characterize talar head fractures.

Displaced fractures are treated with ORIF to optimize midfoot function.[72,75] The anteromedial exposure is extended distally between the tibialis anterior and tibialis posterior tendons to the distal edge of the navicular. Talonavicular capsulotomy followed by subperiosteal elevation of the tendons in both dorsal and plantar directions will promote visualization. The navicular has a prominent medial edge, which must be debrided with a rongeur to adequately access, reduce, and stabilize talar head fractures. Provisional fixation with Kirschner wires oriented perpendicular to the fracture is then possible, and mini-fragment (2.0 or 2.4 mm) screws are placed in the same orientation for definitive fixation. Long screws are desirable to counteract the tendency for the fixation to fail secondary to shear forces. Range of motion exercise is initiated after approximately 2–3 weeks, but weightbearing is deferred for approximately 2 months to permit fracture healing.

Most patients will heal uneventfully with some level of mild permanent stiffness, which is well tolerated in the medial midfoot. Severe PTA is uncommon.[72] Rarely, avascular necrosis of the talar head can ensue. If the head collapses, prominent implants should be removed, along with debridement of irregular osteochondral surfaces. Midfoot pain due to arthrosis can be managed with activity modification, medication, and/or custom orthotics.

CONCLUSIONS

Talus fractures occur rarely and are associated with complications and functional limitations. Urgent reduction of associated dislocations is recommended with ORIF for displaced fractures when adjacent soft tissue injury permits. Restoration of articular and axial alignment is necessary to optimize ankle and hindfoot function.

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