An Original Study

Talar Neck Fractures Treated With Closed Reduction and Percutaneous Screw Fixation: A Case Series

Michael L. Fernandez, MD, Allison M. Wade, MD, Michael Dabbah, MD, and Paul J. Juliano, MD

Abstract

Talus fractures are relatively rare injuries, accounting for approximately 3% of all foot fractures. Fractures of the talar neck account for almost 50% of all talus fractures. Diagnosis and treatment of these fractures play an important role in patients' outcomes. Treatment of talar neck fractures has slowly evolved from closed treatment to open reduction and internal fixation. Treatment of type I and type II talar neck fractures is debated in the orthopedic community. Choosing which treatment to perform depends on injury severity, associated injuries, and surgeon experience and preference.

In this article, we report on our retrospective review of all talar neck fractures treated with closed reduction and percutaneous fixation between 1996 and 2001 at the Pennsylvania State University Milton S. Hershey Medical Center.

Diagnosis and treatment of talar neck fractures have always been challenging. The mechanism of injury for these fractures has often been described as a combination of axial compression forces and dorsiflexion at the ankle.[1-8] Peterson and colleagues[9] showed that talar neck fractures were produced by an axial force directed to the plantar surface of the foot just distal to the talus with the ankle in the neutral position. In addition, Hawkins[4] and Canale and Kelly[10] both noted a significant rotational component associated with talar neck fractures. Historically, these high-energy fractures were noted in plane crashes during the era when pilots controlled rudders with their feet. The sudden deceleration of a plane crash combined with the position of the pilot's feet resulted in hyperdorsiflexion of the foot.[1,2,8] Now, high-speed motor crashes and falls from a significant height consistently reproduce the mechanisms that cause talar neck fractures.

A trauma patient who presents after a motor vehicle accident or fall from a height and reports foot and/or ankle pain must undergo a thorough physical examination, including radiography. Standard anteroposte-

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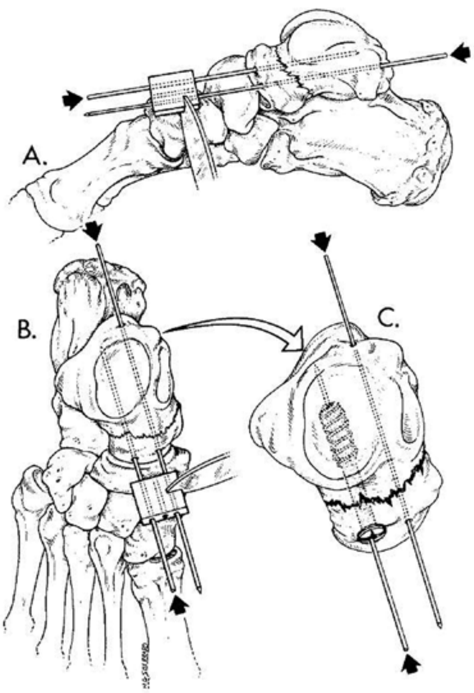

Figure 1. (A) Lateral view of first 2.0 guide pin, inserted posterolaterally and extending through dorsum of foot. (B) Superior view of 3-hole guide being used to insert second 2.0 guide pin laterally and in direction reverse that of first pin. (C) Partially threaded 4.5-mm cannulated screw placed anterior to posterior, with second screw placed posterior to anterior.

Figure 2. Anteroposterior (A) and lateral (B) radiographs of right Hawkins type I talar neck fracture after percutaneous pinning. Postoperative anteroposterior (C) and lateral (D) radiographs.

rior, lateral, and oblique radiographs of the foot and ankle should be obtained.[8] In evaluation of the talus specifically, it is also helpful to obtain the radiographic view described by Canale and Kelly[10] in 1978. For the Canale view, the ankle is placed in maximum equinus, 15° of foot pronation, and the beam is directed cephalad 75° from horizontal. Although originally described for evaluation of varus malunions of the talar neck, this view has become a helpful tool in radiographic evaluation of the acutely injured talus.[10] It is a direct anteroposterior view of the talar neck. When a severely comminuted fracture is being evaluated, or when plain radiographs are negative but there is a high clinical suspicion of a talar neck fracture, computed tomography (CT) may provide additional information. Studies have shown that the most accurate techniques for measuring talar neck displacement is CT.[11] Toolan and Sangeorzan[8] wrote that, when a CT scan has been formatted 3-dimensionally, the anatomy of the talus is more easily identified. They added that evaluation of vertical talar neck fractures is best performed in the transverse and sagittal planes.

The Hawkins classification system is often used to describe talar neck fractures. Hawkins type I talar neck fractures, which are nondisplaced, can be treated with cast immobilization and non–weight-bearing for a period of approximately 6 to 12 weeks.[10,12-15] In cases of polytrauma, anticipated nonadherence, and/or necessary early mobility, however, internal fixation is recommended.[1] Hawkins type II talar neck fractures are displaced fractures with dislocation of the subtalar joint. The traditional suggestion for reducing this type of fracture and minimizing the risk for avascular necrosis (AVN) is that any fracture with 2 mm of displacement or rotational deformity should undergo open reduction and internal fixation (ORIF).[12,15] Hawkins type III injuries involve displacement and dislocation from the ankle and subtalar joints. These injuries are also traditionally treated with ORIF with or without a medial malleolar and/or fibular osteotomy.[1] Type IV injuries, initially described by Canale and Kelly,[10] are displaced fractures associated with an ankle, subtalar, and talonavicular dislocation.[16]

The talar body is vulnerable to AVN because of its blood supply. The artery of the tarsal canal, which branches off the posterior tibial artery approximately 1 cm proximal to the division of the medial and lateral plantar artery, is the most consistent blood supply to the talar body. Unfortunately, it is susceptible to injury with a talar neck fracture because of its position within the tarsal canal. The deltoid artery, a branch of the artery of the tarsal canal or posterior tibial artery, directly supplies blood to the medial quarter to half of the talar

Table I. Outcomes by Fracture Type

Fracture Type	Outcome			
	Excellent	Good	Fair	Poor
Hawkins I	2	0	1	0
Hawkins II	1	0	0	1[a]
Hawkins III	1	0	0	0
Total	**4**	**0**	**1**	**1**

[a]Patient also sustained ipsilateral talar body fracture.

Table II. Patients With Hawkins Sign and Progression to Avascular Necrosis

Hawkins Sign	Patients (n)	Progression to Avascular Necrosis (n)
Present	3	0
Absent	3	1
Total	**6**	**1**

body. Last, the artery of the sinus tarsi, which is vulnerable secondary to its size and location, supplies the lateral eighth to quarter of the talar body.[15,17]

There is a correlation between severity of injury to the talar neck and likelihood of progression to AVN.[10] The higher the injury grade, the higher the likelihood of disruption of the vascular anatomy of the talus, which, in turn, increases the risk for AVN. Type I injuries may damage only one source of the talar blood supply and therefore carry a small risk for AVN. Type II injuries damage possibly 2 of the 3 main sources of blood flow, and AVN may be noted in up to 40% of patients in this group. In type III injuries, all 3 sources of blood flow to the talus may be lost, and AVN may be noted in up to 84% of patients in this group.[2,10,16] In type IV injuries, 100% of patients develop AVN.

In 1970, Hawkins[4] noted a subchondral lucency in the talar dome approximately 6 to 8 weeks after injury—what came to be called the Hawkins sign. This subchondral lucency is a good prognostic indicator of absence of AVN. In a 1978 study, Canale and Kelly[10] substantiated the Hawkins sign. Of 23 patients who showed the Hawkins sign as early as 12 weeks after injury, only 1 developed AVN. The authors wrote that this subchondral lucency is indicative of hyperemia and disuse osteopenia and that it correlates well with the improbable progression of AVN in the talus but advised that a negative Hawkins sign does not necessarily mean AVN will develop. Although 20 of 26 patients (76.9%) with a negative Hawkins sign developed AVN, the remaining 6 (23.1%) did not. This study was conducted before use of magnetic resonance imaging (MRI). Studies conducted since then have shown MRI to be the most sensitive method for detecting AVN, though these studies involved the proximal femur, not the talus.[18,19]

Although recent studies have indicated that posttraumatic subtalar arthritis is the most common complication after operative treatment,[20] the most debilitating complication is AVN. Our hypothesis focused on closed reduction and percutaneous fixation of talar neck fractures and whether use of this minimally invasive approach can lower rates of AVN and possibly improve clinical outcomes for patients who sustain talar neck fractures.

In 2002, Fayazi and colleagues[21] had suggested an alternative to ORIF: closed reduction and percutaneous fixation. This procedure is performed to minimize further damage to soft-tissue structures, maintain and/or minimize disruption of the blood supply to the talus, and reduce surgery time.

In this article, we review the outcomes of a series of cases of talar neck fractures treated with closed reduction and percutaneous fixation at our institution.

Materials and Methods

Institutional review board approval was obtained to review all cases of talar neck fracture treated between 1996 and 2001 at our institution. Ten patients were identified in the operative cases database of Dr. Juliano, the senior surgeon. With pediatric patients, open injuries, and Hawkins type IV fractures excluded, 7 patients met our review criterion of having undergone closed reduction and percutaneous fixation of the talus. Of these 7 patients, 4 had Hawkins type I injuries, 2 had Hawkins type II, and 1 had Hawkins type III. One patient with a type I fracture was lost to follow-up, leaving 6 patients for the study. Radiographs and the Hawkins system were used to classify all injuries. Each patient underwent closed reduction, and a transfixion pin was placed through the calcaneal tuberosity and attached to a traction bow. Reduction was facilitated by placing the foot in plantarflexion and carefully maneuvering the heel from varus to valgus with the aid of the transfixion pin. Closed reduction of the 1 Hawkins type III injury in this series was done with a technique described by Baumhauer and Alvarez.[13] All the patients involved in this series underwent percutaneous

Table III. Overview of All 6 Patients

Pt	Sex	Age at Injury, y	Diagnosis	Associated Injuries	Mechanism of Injury	Time to Operating Room, h	Surgery Time, min	Hospital Stay, d	Follow-up, wk	Hawkins Sign	Complications	Hawkins Result
1	M	30	Hawkins type I, right foot	None	Bicycle accident: inversion-type injury	25	93	0	12	Positive	None	Fair
2	M	21	Hawkins type I, right foot	Right nondisplaced acetabular fracture	Motor vehicle accident: patient ejected	72	70	2	50	Positive	Subtalar arthritis	Excellent
3	F	20	Hawkins type I, right foot	Right ulnar styloid avulsion fracture, neck hematoma, sternal contusion	Motor vehicle accident: unrestrained driver	23	147	2	220	Negative	None (phone interview)	Excellent
4	M	30	Hawkins type II, right foot	None	Motorcycle accident: axial load	5	105	2	32	Positive	None	Excellent
5	F	35	Hawkins type II, left foot	Fracture of posterior medial tubercle of left talar body	Fall from 10 feet	48	72	2	152	Negative	Avascular necrosis, subtalar arthritis	Poor
6	M	56	Hawkins type III, right foot	Right medial malleolar fracture	Fall from 5 feet	4.5	125	1	24	Negative	Subtalar arthritis	Excellent

fixation of talar neck fractures as described by Fayazi and colleagues.[21] This procedure begins with a closed reduction attempt, as already described. Intraoperative fluoroscopy is used to check the adequacy of the reduction. In the case of less than anatomical reduction, conversion to open reduction is necessary. When the reduction is satisfactory, a small incision is made on the posterolateral aspect of the heel anterior to the Achilles tendon and posterior to the peroneal tendons. Blunt dissection is then continued through the subcutaneous tissue to the talar dome. Under fluoroscopic guidance, a 2.0-mm guide wire is put slightly superior to the posterolateral talar tubercle and perpendicular to the fracture line. The guide wire is then moved in an anteromedial fashion and is advanced through the dorsum of the foot. After this, another 2.0-mm guide wire is placed parallel and lateral to the original wire in the reverse direction using an AO/ASIF (Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation) 3-hole guide. This second wire is placed through a small incision on the dorsum of the foot anteromedial to posterolateral through the talar neck. Next, a partially threaded 4.5-mm cannulated screw is placed anterior to posterior, and the second screw is placed posterior to anterior (Figure 1). After the incisions are closed with 3-0 nylon, the patient is placed in a 3-sided coaptation splint.[21] Figure 2 shows a radiographic view of the percutaneous fixation.

We used the Hawkins scoring system (as originally described by Hawkins[4]) to evaluate 4 postoperative criteria: pain, limp, ankle range of motion (ROM), and subtalar ROM. In this system, the maximum number of points is 15. A patient with no pain is given 6 points; with pain only after fatigue, 3 points; with pain on walking, 0 point; with no limp, 3 points; with limp, 0 points. Ankle ROM and subtalar ROM are each rated on a 3-point scale: 3 points for full ROM, 2 for partial ROM, 1 for joint fusion, and 0 for fixed deformity. Scores of 13 to 15 were considered excellent; 10 to 12, good; 7 to 9, fair; and 6 or less, poor. Excellent and good results were deemed satisfactory.

For the 6 patients who were followed up, presence of Hawkins sign was assessed 6 to 8 weeks after injury, as suggested by Hawkins.[4] In addition, for this investigation, a diagnosis of posttraumatic subtalar arthritis was made when decreased ROM and/or pain was noted at the subtalar joint in association with degenerative changes on radiographs.

Results

Mean age at time of injury was 32 years (range, 20-56 years), mean time between injury and fixation was 29.6 hours (range, 4.5-72 hours), mean surgery time was 102 minutes (range, 70-147 minutes), mean hospital stay was 1.5 days (range, 0-2 days), and mean follow-up was 81.5 weeks. Five patients had associated fractures—an open Hawkins II talar neck fracture on the contralateral foot, an ipsilateral talar body fracture, an ipsilateral medial malleolar fracture, an occipital skull fracture, an ipsilateral acetabular fracture, and an ulnar styloid avulsion fracture.

Of the 6 patients, 4 had excellent results, 1 had a fair result, and 1 had a poor result (Table I). The 4 patients with excellent results did not develop AVN, but 2 of these 4 patients developed subtalar arthritis. Of the 3 type I patients, 2 had excellent results, and 1 had a fair result. Of the 2 type II patients, 1 had an excellent result, and 1 had a poor result. The 1 type III patient had an excellent result.

The type II patient with a poor result also had an ipsilateral talar body fracture. This patient subsequently developed AVN and subtalar arthritis and was treated with steroid injections and ultimately with subtalar arthrodesis. Two other patients (type I, type III) also developed subtalar arthritis.

A Hawkins sign was present in 3 of the 6 patients examined 6 to 8 weeks after injury. Of these 3 patients, none developed AVN. Of the 3 patients without a Hawkins sign, 1 had a type II fracture and developed radiographic AVN but did not progress to talar dome collapse (Table II).

Table III is an overview of all 6 patients who were followed up. Data include type of injury and results. The only poor result was for a patient who sustained a talar body fracture in addition to the talar neck fracture. Three patients had posttraumatic arthritis and pain. One patient was diagnosed with radiographic AVN but did not develop talar dome collapse.

Discussion

Fractures of the talar neck are associated with numerous complications, including AVN, malunion, nonunion, and posttraumatic arthritis. ORIF is advocated for displaced talar neck fractures.[13,22,23] Canale[23] and Hawkins[4] agreed that type III and type IV talar neck fractures should undergo ORIF. For type I and type II, however, treatment still depends on injury severity, associated injuries, and surgeon experience and preference.

The blood supply to the talus has been reviewed by several authors, including Baumhauer and Alvarez.[13] This supply is extremely vulnerable in talar neck fractures. Most of the vessels that supply the talus enter the head and supply the body in a retrograde manner. With this configuration, fractures through the talar neck can result in AVN of the talar dome and body. Owing to the unique blood supply of the talus, the risk of AVN is proportional to injury severity. In type III and type IV fractures, the only remaining blood supply to the dome may be through the deltoid ligament. Therefore, it is important to try to preserve the soft-tissue envelope around the talus. As a result, our hypothesis was that closed reduction and percutaneous fixation of talar neck fractures can lower rates of AVN and possibly improve clinical outcomes for patients with talar neck fractures.

Most Hawkins type I talar neck fractures have good clinical outcomes with low risk of AVN and no reports of talar malunion.[15] In type II fractures, unsatisfactory results have been reported in up to 60% of cases, AVN in up to 71% of cases, and arthritis in up to 64% of cases. Compared with type I and type II fractures, type III fractures have a less favorable prognosis, and complications are abundant.[16] Fifty percent of these fractures may be open, which increases the risk for talar body infections. Unsatisfactory results have been reported in up to 91% of these cases and AVN in up to 100%.[4]

Several factors are involved in the unsatisfactory outcomes for these injuries. First, the insult to the talus surface at time of injury significantly harms the articular cartilage, and the damage may result in posttraumatic arthritis.[16] Second, when ORIF is warranted, dissection of surrounding soft tissues causes further disruption of an already compromised blood supply,[21] which may contribute to development of AVN in the talus. Third, a delay in treatment may increase the risk for subsequent AVN,[8,12,15] though recent reports have suggested that time to reduction does not predict outcome, union, or development of AVN.[20,24]

The purpose of this retrospective study was to determine the rates of AVN and overall clinical outcome in patients who underwent closed reduction and percutaneous fixation for talar neck fractures. We reviewed the results of 6 such patients. Use of the Hawkins scoring system revealed excellent scores (13-15 points) in 4 (67%) of these patients. Canale and Kelly[10] reported a Hawkins foot score of 59% (a satisfactory result), but they included patients who underwent both ORIF and closed reduction.

Complications of talar neck fractures are well documented.[4,10,13,15,23,25] Grob and colleagues[26] reported a 37% incidence of posttraumatic subtalar arthritis in a series of 41 patients, Canale and Kelly[10] and Canale[23] reported a 52% incidence of AVN, Lorentzen and colleagues[27] reported a 65% incidence of subtalar arthritis (mean follow-up, 22 months), and Lindvall and colleagues[20] reported a 100% incidence of radiographic posttraumatic arthritis involving at least the subtalar joint. In the present study, we found a 50% incidence of subtalar arthritis and a 17% rate of AVN at a mean follow-up (~20 months) similar to that of Lorentzen and colleagues.[27] Our rates of subtalar arthritis and AVN are slightly lower than those in the literature and may be the result of our small patient population and relatively short follow-up.

Small population and short follow-up are valid criticisms of this study, but we should point out that the mean follow-up for the 4 patients with satisfactory results was 81.5 weeks. This outcome gives value to the study in that adequate time was allowed in which potential complications could be documented in these patients. In addition, the patient with a fair outcome had a follow-up of only 12 weeks. We could argue that, with a longer follow-up, the Hawkins score for this patient might have been higher (ie, the outcome might have been better). Finally, these injuries are rare and are often associated with other injuries that may necessitate ORIF, thus removing the option of percutaneous fixation. However, we believe that closed reduction and percutaneous fixation preserves the soft tissue around the talus and thereby lowers the incidence of radiographic AVN.

Nevertheless, more studies are warranted, particularly studies with a larger patient population. Furthermore, a comparison of talar neck fractures treated with ORIF and talar neck fractures treated with closed reduction and percutaneous fixation in the same patient population would be valuable. Finally, time to reduction may be an important predictor of functional outcome and could be included in future studies.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

References

1. Anderson HG. *The Medical and Surgical Aspects of Aviation*. London, UK: Oxford Medical; 1919.
2. Coltart WD. Aviator's astragalus. *J Bone Joint Surg Br.* 1952;34(4):545-566.
3. Gibson A, Inkster RG. Fractures of the talus. *Can Med Assoc J.* 1934;31(4):357-362.
4. Hawkins LG. Fractures of the neck of the talus. *J Bone Joint Surg Am.* 1970;52(5):991-1002.
5. Jensenius H. Fractures of the astragulus. *Acta Orthop Scand.* 1950;19(1):195-209.
6. Kenwright J, Taylor RG. Major injuries of the talus. *J Bone Joint Surg Br.* 1970;52(1):36-48.
7. Swanson TV, Bray TJ, Holmes GB Jr. Fractures of the talar neck. *J Bone Joint Surg Am.* 1992;74(4):544-551.
8. Toolan BC, Sangeorzan BJ. *The Traumatized Foot: Fractures of the Talus*. AAOS Monograph Series; 2001:1-11.
9. Peterson L, Romanus B, Dahlberg E. Fracture of the collum tali—an experimental study. *J Biomech.* 1976;9(4):277-279.
10. Canale ST, Kelly FB Jr. Fractures of the neck of the talus. Long-term evaluation of seventy-one cases. *J Bone Joint Surg Am.* 1978;60(2):143-156.
11. Chan G, Sanders DW, Yuan X, Jenkinson RJ, Willits K. Clinical accuracy of imaging techniques for talar neck malunion. *J Orthop Trauma.* 2008;22(6):415-418.
12. Adelaar RS. Fractures of the talus. *Instr Course Lect.* 1990;39:147-156.
13. Baumhauer JF, Alvarez RG. Controversies in treating talus fractures. *Orthop Clin North Am.* 1995;26(2):335-351.
14. DeLee JC. Fractures and dislocations of the foot. In: Mann RA, Coughlin MJ, eds. *Surgery of the Foot and Ankle.* 6th ed. St. Louis, MO: Mosby; 1993:1539-1600.
15. Higgins TF, Baumgaertner MR. Diagnosis and treatment of fractures of the talus: a comprehensive review of the literature. *Foot Ankle Int.* 1999;20(9):595-605.
16. Berlet GC, Lee TH, Massa EG. Talar neck fractures. *Orthop Clin North Am.* 2001;32(1):53-64.
17. Mulfinger GL, Trueta J. The blood supply of the talus. *J Bone Joint Surg Br.* 1970;52(1):160-167.
18. Mitchell MD, Kundel HL, Steinberg ME, Kressel HY, Alavi A, Axel L. Avascular necrosis of the hip: comparison of MR, CT, and scintigraphy. *AJR Am J Roentgenol*. 1986;147(1):67-71.
19. Henderson RC. Posttraumatic necrosis of the talus: the Hawkins sign versus magnetic resonance imaging. *J Orthop Trauma.* 1991;5(1):96-99.
20. Lindvall E, Haidukewych G, DiPasquale T, Herscovici D Jr, Sanders R. Open reduction and stable fixation of isolated, displaced talar neck and body fractures. *J Bone Joint Surg Am.* 2004;86(10):2229-2234.
21. Fayazi AH, Reid JS, Juliano PJ. Percutaneous pinning of talar neck fractures. *Am J Orthop.* 2002;31(2):76-78.
22. Günal I, Atilla S, Araç S, Gürsoy Y, Karagözlu H. A new technique of talectomy for severe fracture-dislocation of the talus. *J Bone Joint Surg Br.* 1993;75(1):69-71.
23. Canale ST. Fractures of the neck of the talus. *Orthopedics.* 1990;13(10):1105-1115.
24. Vallier HA, Nork SE, Barei DP, Benirschke SK, Sangeorzan BJ. Talar neck fractures: results and outcomes. *J Bone Joint Surg Am.* 2004;86(8):1616-1624.
25. Daniels TR, Smith JW. Foot fellow's review: Talar neck fractures. *Foot Ankle.* 1993;14(4):225-234.
26. Grob D, Simpson LA, Weber BG, Bray T. Operative treatment of displaced talus fractures. *Clin Orthop.* 1985;(199):88-96.
27. Lorentzen JE, Christensen SB, Krogsoe O, Sneppen O. Fractures of the neck of the talus. *Acta Orthop Scand.* 1977;48(1):115-120.

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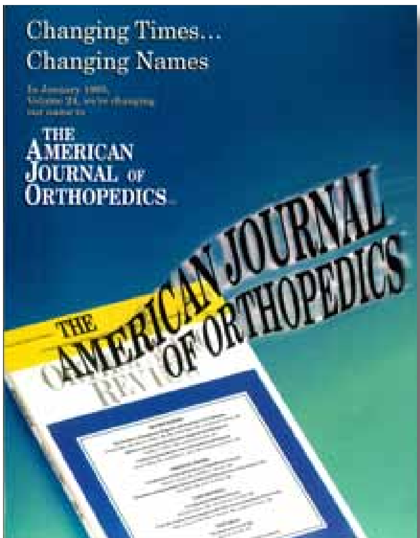

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