



International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2020; 6(3): 261-272
© 2020 IJOS

www.orthopaper.com

Received: 04-05-2020

Accepted: 06-06-2020

Dr. Nitin Patil

Professor, Department of
Orthopaedics, Krishna Institute
of Medical Sciences, Karad,
Maharashtra, India

Dr. Jaykumar K

Resident, Department of
Orthopaedics, Krishna Institute
of Medical Sciences, Karad,
Maharashtra, India

Dr. Swapnil Chitnavis

Resident, Department of
Orthopaedics, Krishna Institute
of Medical Sciences, Karad,
Maharashtra, India

Talus fracture-A myth

Dr. Nitin Patil, Dr. Jaykumar K and Dr. Swapnil Chitnavis

DOI: <https://doi.org/10.22271/ortho.2020.v6.i3e.2208>

Abstract

Talus with its unique anatomy and function predisposes it to uncommon but serious injuries, usually due to high energy trauma. Obtaining satisfactory clinical results, while avoiding complications, presents a unique challenge in the treatment of talar fractures, especially of talar neck as it also remains controversial the requirement of emergency treatment in these fractures. Despite of all excellent management, nonunion rate in type 3 and type 4 Hawkins fracture was found to be 5% and AVN of body of talus was found to be 25% types 2,3,4 were associated with talar body dislocation which caused excessive pressure on soft tissues causing significant soft tissue complications. We retrospectively reviewed 25 patients with talar fractures treated operatively with an average follow up period of 1 year. Displaced talar fractures was a therapeutic challenge which had early and late complication

Keywords: Talus fracture unique anatomy predisposes obtaining satisfactory clinical

1. Introduction

Fractures of the talus rank second in frequency (after calcaneal fractures) of all tarsal bone injuries. The incidence of fractures of the talus ranges from 0.1% to 0.85% of all fractures. Of all the lower limb fractures it forms 2% fractures; and of foot fractures talar fractures make up about 5-7% (Kuner *et al.* 1978), but can be under reported. The relative infrequency of these injuries in part accounts for the lack of useful and objective data to guide treatment. The integrity of the talus is critical to normal function of the ankle, subtalar, and transverse tarsal joints.

Fractures of the talus are associated with significant morbidity in view of the blood supply, and these can be challenging for surgeons to manage. Fractures of the talus were first described in parachutists and pilots of the Royal Air Force who sustained these injuries upon impact with the ground, hence termed Aviator's Astragalus

The results with surgical management of these fractures have improved over the last few years, largely due to a greater understanding of the anatomy of the region [8]. However, the talus is well-protected from direct outer forces, and the traumatizing forces are transmitted mainly via the adjacent structures. There is reason to assume, therefore, that injury of the talus is often just one link in a more comprehensive injury.

2. Material and methods

We retrospectively reviewed 25 patients with talar fractures treated operatively with an average follow up period of 1 year. All adult patients with talus fracture admitted in Krishna Hospital, Karad, Maharashtra, India from January 2019 to December 2020 were involved. Fractures were classified as per Hawkins classification and were treated with closed/open reduction and internal fixation with CC screws. There were 25 patients with 15 males and 10 females.

Corresponding Author:

Dr. Jaykumar K

Resident, Department of
Orthopaedics, Krishna Institute
of Medical Sciences, Karad,
Maharashtra, India

Table 1: Marti/Weber classification of talar fractures (Marti 1978, Grob *et al.* 1985) and Hawkins classification of talar neck fractures (Hawkins 1965) showing prevalences in the study population

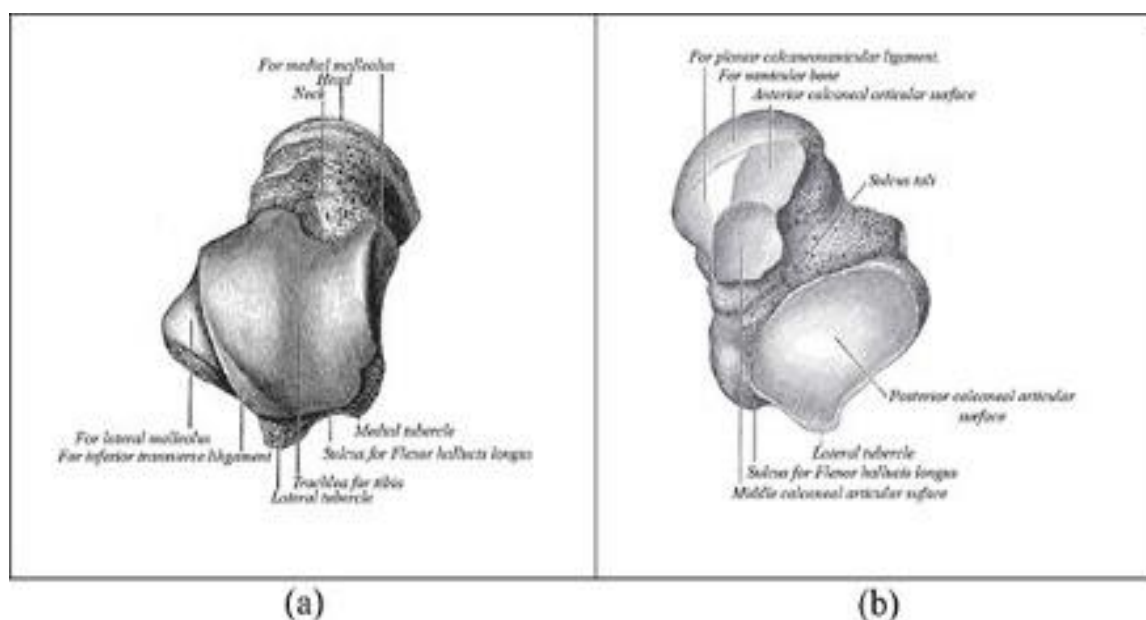
Fracture type	Marti/Weber classification	n	Hawkins classification	n
I	Distal talar neck and talar head fractures, peripheral fractures and osteochondral flakes	15	Undisplaced talar neck fractures	10
II	Undisplaced talar neck and corpus fractures	14	Talar neck fractures with dislocation and/or luxation of the subtalar joint	18
III	Dislocated talar neck and corpus fractures	32	Talar neck fractures with luxations involving the subtalar and ankle joints	17
IV	Proximal talar neck fractures with corpus tali luxated out of the intermalleolar space or comminuted fracture	19	Type III with additional luxation involving the talonavicular joint	1
Total		80		46

The case records including the X-ray reports, representing this material, were perused by the authors.

3. Anatomy

The talus is the second largest tarsal bone, with more than one

half of its surface covered by articular cartilage. Talus has 7 articular surfaces. It articulates with the tibia and fibula to form the ankle joint. Its biomechanical role includes the transmission of forces between the lower leg and the foot.

**Fig 1:** Anatomy of Talus

3.1. Blood supply of talus

The blood supply to the talus was described by Wildenauer and then by Haliburton in the 1950s [9]. The arteries that supply the talus in the order of significance are the posterior tibial, the anterior tibial and the perforating peroneal arteries [1]. In addition, the artery of the tarsal canal [a branch of the posterior tibial artery] and the artery of the tarsal sinus [a branch of the perforating peroneal artery] are two discrete vessels that form an anastomotic sling inferior to the talus from which branches arise and enter the talar neck area.

The main supply of talus is through the artery of the tarsal canal, which gives off an additional branch that penetrates the deltoid ligament and supplies the medial talar wall. The main artery gives branches to the inferior talar neck, thereby supplying most of the talar body. Therefore most of the talar body is supplied by branches of the artery of the tarsal canal. The head and neck are supplied by the dorsalis pedis artery and the artery of tarsal sinus. The posterior part of the talus is supplied by branches of the posterior tibial artery via calcaneal branches that enter through the posterior tubercle.

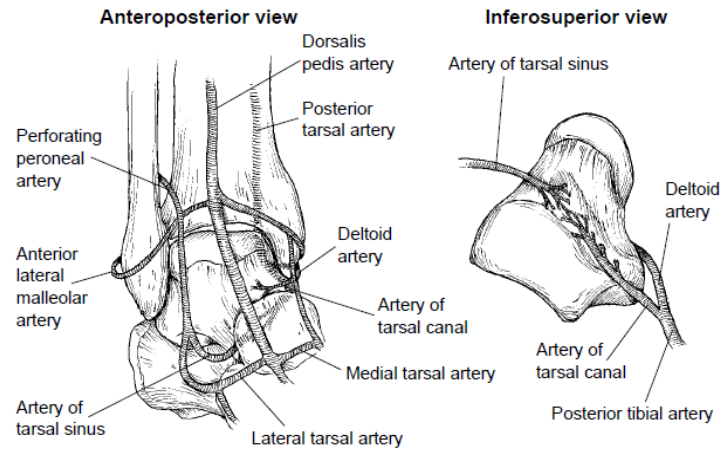


Fig 2: Blood supply to the talus

Almost 60% of the talus is covered with articular cartilage, and only a small portion of the talus may be perforated by blood vessels. This makes it more prone to avascular necrosis [3]. Additionally where there is a talar neck fracture, the intraosseus branches and artery to the tarsal canal (a branch of the posterior tibial artery) are disrupted. The talar body then only receives blood from the deltoid branch of the posterior tibial artery. This usually supplies the talar body posteromedially and therefore the risk of avascular necrosis is increased [10].

The superior aspect of the body is widest anteriorly and therefore fits more securely within the ankle mortise when it is in dorsiflexion. The articular medial wall is straight, while the lateral articular wall curves posteriorly, such that they meet at the posterior tubercle. The neck of the talus is oriented medially approximately 10 to 44 degrees with reference to the axis of the body of the talus and is the most vulnerable area of the bone after injury. In the sagittal plane, the neck deviates plantar ward between 5 and 50 degrees

The talus has no muscle or tendinous attachments and is supported solely by the joint capsules, ligaments, and synovial tissues. Ligaments that provide stability and allow motion

bind the talus to the tibia, fibula, calcaneus, and navicular. Because blood vessels reach the talus through the surrounding soft tissues, injury resulting in capsular disruption may be complicated by vascular compromise of the talus.

4. Mechanism of injury

The talus is a dense bone and fractures in non-pathological bone usually result from high energy impacts such as motor vehicle collisions. The mechanism is usually forced dorsiflexion of the foot as the talar neck is forced against the tibial crest [5]. This may occur when the driver exerts pressure on the brake pedal during a collision [5]. This was the mechanism described by Anderson where pilots exerted pressure on the rudder pedal as they crashed to the ground [5, 11]. It can also occur in case of increased load on a hyper plantar flexed foot as in case of ballerinas or even in a fall from a height. The talar injury which most often occurred in supination, apart from fracture of the neck, was compression fracture or shearing fracture medially in the trochlea. The injury which occurred in pronation was fracture of the talar neck or a compression fracture laterally in the trochlea.

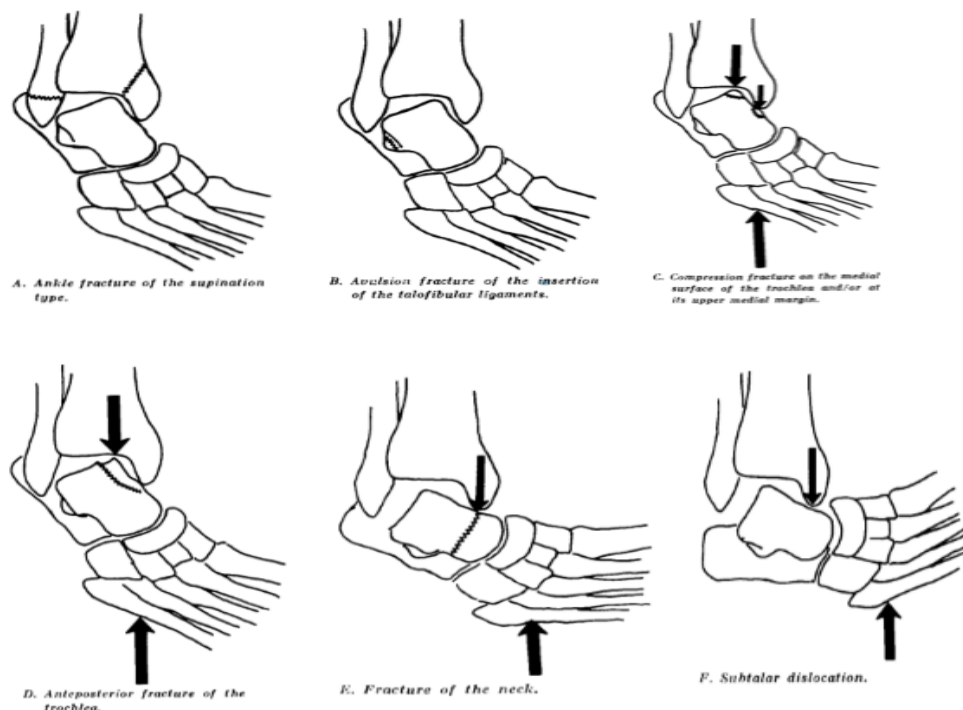


Fig 3: Mechanism of Talus Fracture

5. Imaging

Imaging is initially undertaken with plain radiography. The views required are anterior-posterior, lateral and mortise. Plain radiographs may detect talar neck fractures but there is a high false negative rate. Canale *et al.* advise special talar views that involve taking oblique x-rays of the foot to further evaluate the talar neck. This shows the calcaneus below the talar head and neck. The ankle is fully plantar flexed with pronation of the foot at 15 degrees. The inferior aspect of the foot is placed on the x-ray table. X-rays are then projected at a 75 degree angle to the table ^[16].

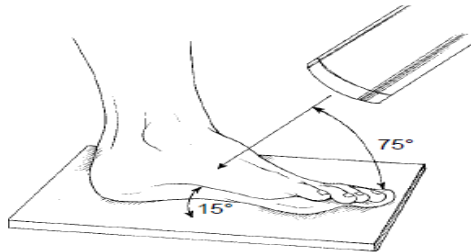


Fig 4: Radiographic positioning for the oblique view of the talar neck, as described by Canale and Kelly

Further characterization of the fracture may be carried out with CT scanning. Where a fracture is suspected or confirmed on X-ray, a CT scan should be obtained. A missed talar fracture, even with minimal displacement may have severe long term consequences ^[1].

MRI scanning is not usually used in the early stage. It tends to be used where patients continue to complain of symptoms 4-6 weeks following injury in the presence of normal radiographs. It may then be useful to evaluate soft tissues, articular surfaces and possible bony injury ^[23]

6. Management and classification

Fractures of the talus can be classified by their anatomical locations, and include talar neck, head, body, lateral process and posterior process fractures. Of these fractures, talar neck fractures are the most common. Injuries to the head, neck, or body of the talus can interfere with normal coupled motion of these joints and result in permanent pain, loss of motion, and deformity. Outcomes vary widely and are related to the degree of initial fracture displacement.

Treatment of fractures of the talus depends on the location of the fracture ^[1]. Where there is an open fracture, neurovascular deficit or dislocation, immediate treatment is required. An undisplaced talar neck fracture where there is adequate alignment of articular surfaces may be treated non-operatively. Nondisplaced fractures have a favorable outcome in most cases. A cautious approach is required as even minimal displacement may require surgical fixation to avoid complications ^[1]. But the Failure to recognize the fracture displacement (even when minimal) can lead to under treatment and poor outcomes. The accuracy of closed reduction of displaced talar neck fractures can be very difficult to assess. Operative treatment should, therefore, be considered for all displaced fractures with more than 2mm displacement. An additional benefit of internal fixation is that it permits early motion.

6.1. Emergency treatment

Although delayed fixation may be suitable for talar neck fractures, a provisional closed reduction under local anesthesia to relieve the increased skin and neurovascular

bundle tension caused by displaced fracture fragments should be considered. Once reduced, the dislocated joint typically stabilizes because of the shape and fit of the articular surfaces and surrounding structures. Repeated forceful reduction attempts should be avoided.

Adelaar ^[18] recommended open reduction and internal fixation of any fracture with more than 3 to 5 mm dorsal displacement or any rotational deformity. Hence, the investigation done by Patel *et al.* ^[17] indicates that most expert orthopedic trauma surgeons do not believe that immediate operative treatment is necessary for displaced talar neck fractures. Most reported that the operation can wait more than 8 hours, with a significant proportion reporting that treatment in more than 24 hours is acceptable. Most authors have stressed that type II, III, and IV fractures should be treated by open anatomic reduction and stable internal fixation to restore articular congruity and permit early motion.

6.2. Operative treatment for talar neck fractures

The time of definitive fixation always depends on multiple factors, including fracture comminution, soft tissue conditions, available resources, surgeon experience and comfort level, and medical status of the patient ^[14]. In several clinical studies, the timing of internal fixation did not have a significant effect on the rate of avascular necrosis or the functional outcome ^[15,16].

Most surgeons recommend the use of dual surgical approaches, anteromedial and anterolateral, to allow accurate visualization and anatomic reduction of talar neck fractures. ^[16, 19, 20] The anteromedial approach begins at the anterior border of the medial malleolus and extends toward the navicular tuberosity, just between the anterior tibial and posterior tibial tendons. Laterally, the incision begins at the Chaput tubercle on the tibia and extends toward the bases of the third and fourth metatarsals ^[21].

However, the Ollier approach, oblique from the tip of the lateral malleolus to the neck of the talus, is also effective, and allows better control of the lateral process and the anterior part of the posterior subtalar joint. ^[22] It is important to carefully preserve any remaining talar blood supply, regardless of the approach or approaches.

The goal of talar neck fracture treatment is anatomic reduction of both the neck and subtalar joint, because even minimal residual displacement can adversely affect subtalar joint mechanics ^[8, 25].

Provisional K-wires may be placed in the talar body and talar head fragment to serve as a joystick to correct the displacement and deformity. This technique avoids the use of a pointed reduction clamp that may require a larger exposure and cause more vascular compromise ^[22].

To achieve stable internal fixation and decrease the rate of malunion, at least 2 screws are required. Numerous types of screws have been described for talar neck fracture fixation, but titanium screws have the advantage of compatibility with MRI, allowing early detection of osteonecrosis. Bio-absorbable screws have some theoretical advantages, in that they can be placed through the articular surface and resorb over time ^[26].

Most authors ^[10, 27] prefer to place screws from anterior to posterior because the fracture site is routinely exposed from an anterior approach. Optimal reduction often necessitates both anteromedial and anterolateral exposures during reduction and fixation ^[8]. This method of reduction and fixation is a possible explanation for reduced morbidity and better results.

7.1. Talar Neck

7.1.1. Classification

Hawkins described a classification for these fractures in 1970

which remains in use today ^[14, 15]. The classification uses plain radiography to assess the severity of the fracture to the talar neck.

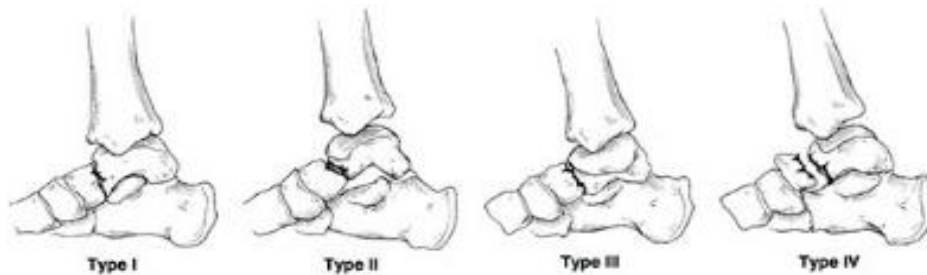


Fig 5: Hawkins Classification of Talar neck Fracture

Table 2: Hawkins Classification of Talar neck Fracture

Type	Description	AVN
Hawkins I	Nondisplaced	0-13% AVN
Hawkins II	Subtalar dislocation	20-50%
Hawkins III	Subtalar and tibiotalar dislocation	20-100%
Hawkins IV	Subtalar, tibiotalar, and talonavicular dislocation	70-100%

Type II fractures have been further divided by Vallier *et al.* into IIa and IIb. The IIa fracture does not include subtalar dislocation whereas IIb does. They observed an increased rate of avascular necrosis where the subtalar joint was dislocated ^[17]

7.1.2. Management

The goal of treatment of talar neck fractures is anatomic reduction, which requires attention to proper rotation, length, and angulation of the neck. Biomechanical studies on cadavers have shown why precisely reducing talar neck fractures leads to better outcomes. The altered hind foot mechanics with a talar neck fracture may be one factor that leads to subtalar posttraumatic arthrosis. For these reasons, open reduction and internal fixation is recommended for displaced fractures.

Type I fractures

Truly nondisplaced fractures of the talar neck can be treated successfully by cast immobilization. A cast is applied, and weight bearing is not allowed for 6 to 8 weeks or until osseous trabeculation is seen on radiographic follow-up to make certain that the fracture does not displace during treatment.

Type II fractures

Initial management of displaced talar neck fractures should involve prompt reduction to minimize soft tissue compromise which can often be performed in the emergency room. Even if closed reduction is successful in obtaining an anatomic reduction, immobilization in significant plantar-flexion is typically necessary to maintain position. For these reasons, operative treatment of all type II fractures has been recommended ^[10].

Numerous surgical approaches have been described for talar neck fractures. The medial approach allows easy access to the talar neck and is commonly used. An incision just medial to the tibialis anterior starting at the navicular tuberosity exposes the neck and can be extended proximally to facilitate fixation of a malleolar fracture or to perform a malleolar osteotomy. Surgical exposure can contribute to circulatory compromise of the talus. Care must be taken to avoid stripping of the dorsal neck vessels and to preserve the deltoid branches entering at the level of the deep deltoid ligament. The disadvantage of the medial approach is that the exposure is less extensible than that which can be achieved along the lateral aspect of the neck. This limited exposure makes judging rotation and medial neck shortening difficult. Medial neck comminution or impaction can be underestimated; if either condition is present, compression-screw fixation of the medial neck will result in shortening and varus malalignment. In these circumstances, a separate lateral exposure allows a more accurate assessment of reduction and better fixation. The anterolateral approach lateral to the common extensor digitorum longus-peroneus tertius tendon sheath provides exposure to the stronger lateral talar neck. A wide enough skin bridge must exist between the two incisions, and stripping of the dorsal talar neck must be avoided. Once the fracture has been reduced, it is provisionally stabilized with Kirsch wires. Two screws (one medial and one lateral) are inserted from a point just off the articular surface of the head and directed posteriorly into the body (Fig. 2, B). Lag screws can be used unless there is significant neck comminution that would result in neck shortening or malalignment when the fracture is compressed. Bone graft is occasionally necessary to make up for large impaction defects of the medial talar neck (Fig. 5, A).

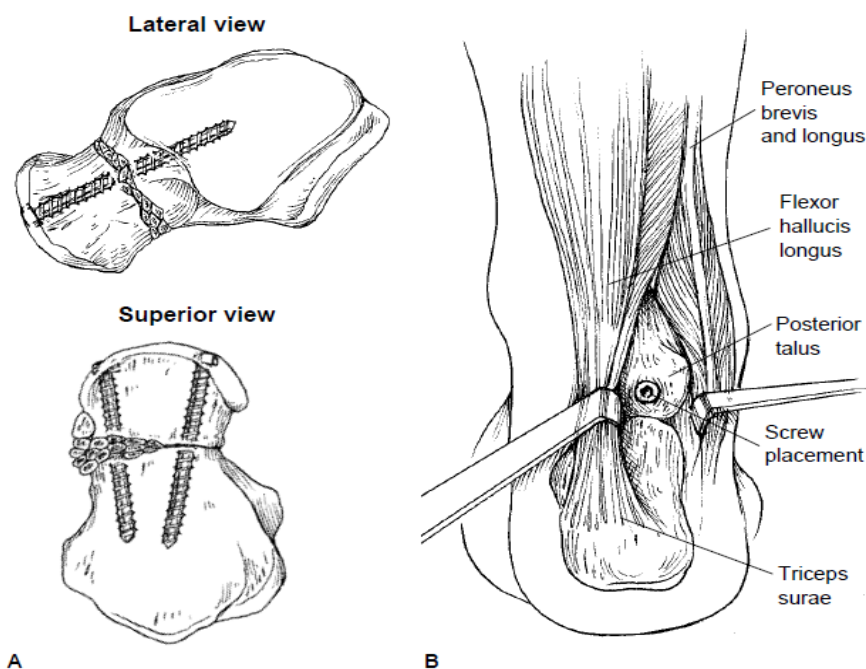


Fig 6: A, Placement of bone graft into an impaction defect in the medial talar neck B, posterolateral exposure of the talus as described by Trillat *et al.* [14]

Another alternative to screw placement is the posterolateral approach described by Trillat *et al.* [14]. An incision is made lateral to the heel cord in the interval between the flexor hallucis longus and peroneal muscles. This allows safe access to the entire posterior talar process. Care must be taken during exposure to avoid injury to the peroneal artery and its branches. Most commonly, the posterolateral exposure is used in combination with an initial anteromedial or anterolateral approach for provisional fracture reduction and stabilization with Kirschner wires under image intensification. The patient is then positioned prone or on one side, and a posterolateral approach is used for placement of cannulated screws for final fracture fixation. Alternatively, if anatomic reduction can be accomplished with closed manipulation, posterior-to-anterior screw fixation can be used through a single posterior approach.

Type III Fractures

Urgent open reduction is mandated to relieve compression from the displaced body on the neurovascular bundle and skin medially and to minimize the occurrence of osteonecrosis. Careful attention to the soft tissues around the deltoid ligament and medial surface of the talus is necessary, as these may contain the only remaining intact blood supply. Fracture stabilization can be carried out as described for type II fractures. In cases of contaminated wounds when the talar body is totally extruded and completely devoid of soft-tissue attachment, consideration should be given to discarding the

body fragment and planning a staged reconstruction.

Type IV Fractures

Type IV injuries are treated in a manner similar to type III injuries, with urgent open reduction and internal fixation. The talar body and head fragments are reduced and rigidly fixed. Stability of the talonavicular joint is then assessed; if it is unstable, consideration should be given to pinning the talonavicular joint. The significance of this injury is that osteonecrosis of both the talar body and the head fragment is possible [10].

7.2. Fractures of talar body

Talar body fractures occur less frequently than fractures of the talar neck [13]. Because fractures of the talar body involve both the ankle joint and the posterior facet of the subtalar joint, accurate reconstruction of a congruent articular surface is required.

7.2.1. Evaluation and classification

Fractures in which the inferior fracture line propagates in front of the lateral process are considered talar neck fractures. Fractures in which the inferior fracture line propagates behind the lateral process involve the posterior facet of the subtalar joint and are therefore considered talar body fractures. Talar body fractures have been classified by [22] on the basis of anatomic location, as follows:

Table 3: Classification of Talar body Fractures

Sneppen <i>et al.</i>		Simpler	
Type A	Transchondral or osteochondral	Group I	Proper or cleavage fractures (horizontal, sagittal, shear, or coronal)
Type B	Coronal shear		
Type C	Sagittal shear		
Type D	Posterior tubercle	Group II	Talar process or tubercle fractures
Type E	Lateral process		
Type F	Crush fractures	Group III	Compression or impaction fractures

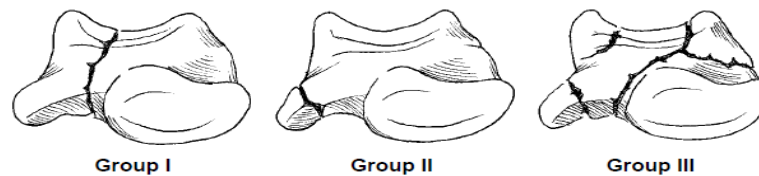


Fig 7: Talar body fractures, Group I are fractures of the body proper or cleavage fractures (horizontal, sagittal [shown], shear, or coronal). Group II are talar process or tubercle fractures (lateral talar-process fracture shown). Group III are compression or impaction fractures of the articular surface of the body

7.3. Treatment of talar process and tubercle fractures

Snowboarders are at increased risk of lateral process fractures due to the forces involved in landing a jump and the position of the feet when hitting the ground. These injuries are often missed or neglected; this can lead to significant disability, because such fractures can involve a substantial portion of the ankle and subtalar articular surface. In general, nondisplaced

process or tubercle fractures can be treated with casting and maintenance of non-weight bearing status. For displaced fractures with significant articular involvement, consideration should be given to operative fixation. Not uncommonly, however, the extent of comminution precludes operative fixation, and fragments can only be either excised or managed nonoperatively.

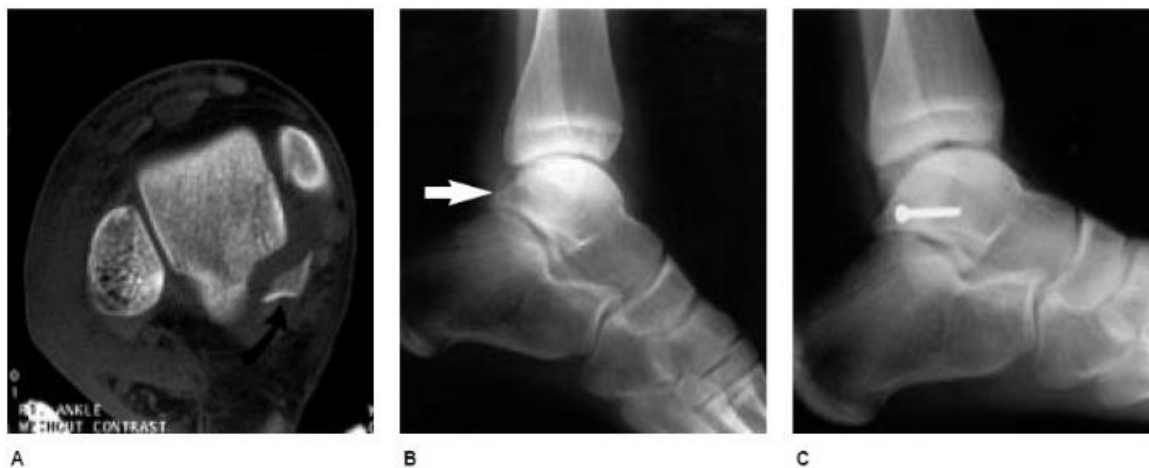


Fig 8: Preoperative CT scan (A) and lateral radiograph (B) showing a displaced posteromedial talar tubercle fracture (arrows). C, radiograph obtained after lar-screw fixation.

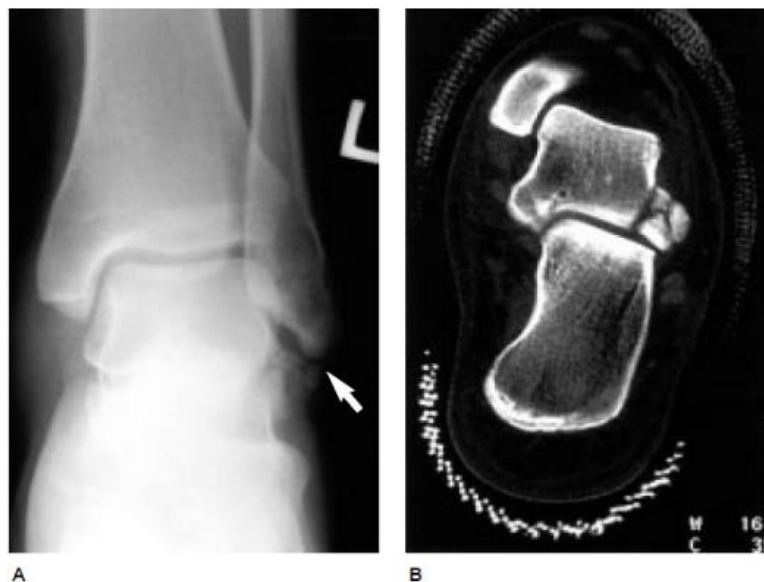


Fig 9: Plain radiograph (A) and CT scan (B) demonstrate a comminuted lateral talar process fracture (arrow), which was subsequently treated by excision of fragments

7.4. Treatment of cleavage and compression fractures

Displaced cleavage and crush fractures of the talar body are optimally treated with anatomic reduction and internal fixation. Because these fractures occur beneath the ankle, a mortise, medial, or lateral malleolar osteotomy is often necessary to gain exposure to the fracture [16]. Once the

fracture has been exposed, temporary Kirschner-wire fixation is used before final fracture stabilization with screws. Bioabsorbable pins or subarticular screws can be helpful. Severe injuries with significant impaction of the cancellous bone of the talus may require bone grafting.

8. Postoperative rehabilitation

	Goals	Intervention
Phase I for Early Motion and Rehabilitation: Week 1-6	Initiate early active motion control edema and pain Maintain motion of affected/unaffected joints in the foot	<ul style="list-style-type: none"> ▪ Surgical scar protection ▪ Mobilization to ankle/foot to increase joint mobility ▪ Elevation with intermittent ice compression ▪ Active ROM exercises (i.e. ankle pumps) to increase circulation to the foot and promote cartilage healing ▪ PROM to joints of the ankle/foot (increase ROM, control pain, once edema is lowered) ▪ Instruction in non-weight bearing crutch ambulation
Phase II for Early Motion and Rehabilitation: Weeks 6-12	Partial weight bearing Prevention of necrosis of the talus Continue with joint mobilization in Phase I as needed Increase Ankle Range of Motion to 50-75% of normal	<ul style="list-style-type: none"> ▪ Initiate instruction in partial weight bearing restriction with crutch ambulation. ▪ Patient performing PROM exercises actively to ankle ▪ Aquatic therapy – ambulation in waist to chest high water (partial wt. bearing). ▪ Instruction in donning and doffing walking boot. ▪ Pain free open chain exercises with band. ▪ Stationary bike to pain free tolerance without walking boot.
Phase III for Early Motion and Rehabilitation: Weeks 12-24	Full weight bearing at 12 weeks Normal ankle/foot ROM Normal gait mechanics without walking boot	<p>Initiation of gait training in parallel bars</p> <ul style="list-style-type: none"> ▪ Progressive resistive strengthening of ankle musculature with band ▪ Proprioceptive weight bearing activities for balance ▪ Gait training on treadmill with progression to incline surface ▪ Single leg support activities ▪ Fast walking with progression to jogging for patient specific activities

The duration of sick leave averaged 7 (0.5–24) months for the entire study population

Case study



PREOPERATIVE RADIOGRAPH

IMMEDIATE POST OPERATIVE

AT UNION



COMPLETE PLANTAR FLEXION



COMPLETE DORSIFLEXION

8. Results

All patients were followed prospectively post operatively and clinical and radiological evaluation was done. Results were analyzed. The final follow-up examination included

determination of the AHS score (ankle–hind foot scale) from the American orthopaedic foot and ankle society (AOFAS), range of motion evaluation and radiological analysis.

Pain (40 points)	
None	40
Mild, occasional	30
Moderate, daily	20
Severe, almost always present	0
Function (50 points)	
<i>Activity limitations, support requirement</i>	
No limitations, no support	10
No limitation of daily activities, limitation of recreational activities, no support	7
Limited daily and recreational activities, cane	4
Severe limitation of daily and recreational activities, walker, crutches, wheelchair, brace	0
<i>Maximum walking distance, blocks</i>	
Greater than 6	5
4-6	4
1-3	2
Less than 1	0
<i>Walking surfaces</i>	
No difficulty on any surface	5
Some difficulty on uneven terrain, stairs, inclines, ladders	3
Severe difficulty on uneven terrain, stairs, inclines, ladders	0
<i>Gait abnormality</i>	
None, slight	8
Obvious	4
Marked	0
<i>Sagittal motion (flexion plus extension)</i>	
Normal or mild restriction (30° or more)	8
Moderate restriction (15°-29°)	4
Severe restriction (less than 150)	0
<i>Hindfoot motion (inversion plus eversion)</i>	
Normal or mild restriction (75%-100% normal)	6
Moderate restriction (25%-74% normal)	3
Marked restriction (less than 25% normal)	0
<i>Ankle-hindfoot stability (anteroposterior, varus-valgus)</i>	
Stable	8
Definitely unstable	0
Alignment (10 points)	
Good, plantigrade foot, midfoot well aligned	15
Fair, plantigrade foot, some degree of midfoot malalignment observed, no symptoms	8
Poor, nonplantigrade foot, severe malalignment, symptoms	0
Total=	100
American Orthopaedic Foot and Ankle Society	

9. Complications

Post operatively ankle fractures is associated with number of complications. Osteonecrosis and malunion are the common complications, and prompt and accurate reduction minimizes their incidence and severity. In order to identify avascular necrosis of the talus, *Hawkins sign* may be used. This is seen as a radiolucent band on a radiograph 6-8 weeks following a fracture. Its presence indicates subchondral atrophy and that the talus is unlikely to develop avascular necrosis as there is sufficient vascularity. In those who have undergone avascular necrosis of the talus a number of options are available. These include talectomy, pantalar arthrodesis, tibiotalar arthrodesis and tibio-calcaneal arthrodesis. Also, the low rate of secondary talar necrosis confirms the importance of early fracture reduction and interfragmentary compression to reduce the rate of collapse of talar corpus also osteosynthesis permits early mobilization of the joint reducing the rate of joint stiffness.

Post rehabilitation pain was observed in 11 patients - 6 had

pain after sports or walking longer distances, 5 complained of pain after walking short distances or at rest. Posttraumatic hind foot arthrosis has been reported to occur in more than 90% of patients with displaced talus fractures. Salvage can be difficult and often necessitates extended arthrodesis procedures. We found a correlation between the radiographic findings of arthrosis and both the severity of the fracture. The patient's age at the time of injury, duration of follow-up or concomitant injuries of the ankle joints did not significantly affect the development of arthrosis.

Types II, III, IV were associated with talar body dislocation which caused excessive pressure on soft tissues having significant soft tissue complications.

10. Discussion

Position of the ankle while the trauma occurred plays paramount importance in the causation and management of fracture. Experimentally an ankle fracture may be induced by forced dorsiflexion of the pronated foot (Lauge Hansen 1942),

but in clinical materials a dorsiflexion type of fracture does not seem to occur (Dinsell & Spangler 1963, Solonen & Lauttamus 1965, 1968).

Undisplaced talar neck fractures can be treated without surgery (Beck 1991, Dávid *et al.* 1996), but to shorten the duration of joint immobilization, some authors recommend internal fixation of Hawkins type I fractures (Hausel 1980, Haase *et al.* 1995, Kundel *et al.* 1995, Schulze *et al.* 1998). There is a consensus that dislocated talar fractures should be operated on (Kundel *et al.* 1995, Schulze *et al.* 1998). The results of treatment of talar fractures are due mainly to the presence of bone necrosis or secondary arthrosis in the surrounding joints. Müller (1978) found necrosis in almost half of 44 talar fractures, most of which had been treated without surgery, but arthrodesis was necessary in 9 patients. In a multi-center study, the German AO-group showed that the collapse rate could be lowered by surgery (Kuner and Lindenmaier 1983). Consequently, internal fixation is commonest and non-operative treatment is used in exceptional cases (Dávid *et al.* 1996).

A possible dorsiflexion trauma of the talus, therefore, cannot be detected on the basis of the ankle trauma. Fractures of the neck of the talus are currently believed to be due to dorsiflexion (Kleiger 1948, Watson Jones 1962, Bircher 1965, Jackson 1965, Dickson 1965), although a few cases are on record in which the genesis appears to have been forced plantar flexion (Pennal 1963).

In the present material, however, the fractures of the neck of the talus were particularly common in relation to supination injury of the foot, but were seen also in pronation and supination-external rotation trauma. In some cases these fractures of the talar neck may of course be imagined to be due to simultaneous forced dorsiflexion of the foot. But if dorsiflexion alone was the genetic mechanism of fracture of the neck, one would expect an equal distribution of the fractures in conformity with the number of ankle fractures.

Table 4: Mechanism of Ankle Fracture and Mode of Injury

Type of ankle fracture	Fall 1-8 m	Road accident	Heavy weight over foot	Twisting	Total
Supination	7	5	2	1	15
Pronation	2	1	2	0	5
Supination-external rotation	1	1	1	0	3
Pronation-external rotation	1	1	0	0	2
Total	11	8	5	1	25

However, the fractures of the neck were of an entirely different distribution, and this difference cannot be assumed to be due to chance ($P < 0.001$). Consequently, the theory of dorsiflexion as the sole cause of neck fracture has to be rejected. Instead, there are two possibilities: Either the named rotating movements of the foot, in particular supination, may per se have caused the talar fracture, or else the fracture has been induced by a simultaneous dorsiflexion trauma which in that case must be particularly apt to occur in supination, more rare in pronation or supination-external rotation.

It may be concluded, therefore, that the position of the foot at the moment of the accident was of decisive importance to the frequency at which fractures of the talar neck occurred. Supination, in particular, predisposed to this fracture. The quantitative role of supination trauma in the genesis of fracture affecting the talar neck cannot be deduced from the present study.

As regards trochlear fractures, it was found in the present material that a medial site was typical of the supination trauma, whereas a lateral site was typical of pronation or pronation external rotation trauma.

Table 5: Mechanism of Ankle Fracture and Type of Ankle Fracture

Type of ankle fracture	Fracture of neck	Fracture of trochlea medial	lateral	Subtalar dislocation	Total
Supination	8	6	0	1	15
Pronation	3	0	2	0	5
Supination-external rotation	2	0	0	1	3
Pronation-external rotation	0	0	2	0	2
Total	13	6	4	2	25

These findings are in conformity with the current views on the genesis of trochlear injuries (Kleiger 1963), but at variance with a few other studies (Cameron 1956, Berndt & Harty 1959, Pennal 1963). A study by Rodop *et al.* found that 39% of ankle and midfoot fractures may be missed at this initial stage. In their small study, they found eight cases that were missed initially on Plain radiography. These patients were at first treated conservatively. They were eventually diagnosed through Magnetic Resonance Imaging (MRI) and CT scanning [21]. They concluded that if there remains suspicion about a talar fracture then further imaging is recommended to reduce the risk of complications. These imaging modalities may also be beneficial for operative planning [22].

However, Swanson *et al.* [28] compared the biomechanical strengths of various fixation methods in a transverse, non-comminuted talar neck fracture model, and concluded that posterior-to-anterior screw fixation was stronger. Posterior-to-anterior screw fixation has potential disadvantages, including requiring an additional posterior approach with potential injury to the peroneal artery and its branches and screw head prominence that can limit ankle plantar flexion. Furthermore, if a postero-anterior screw is situated in the lower half of the head, the shaft of the screw protrudes into the roof of the sinus or canal tarsi, and can injure the canal tarsi artery [29]. Attain *et al.* [27] studied different screw configurations in a comminuted talar neck fracture model. They compared 3 anteroposterior screws, 2 cannulated posteroanterior screws, 1 screw from anterior to posterior, and a medially applied blade plate. They concluded that the anteroposterior screws had approximately 20% lower yield point and stiffness compared to the posteroanterior screws or blade plate techniques, but this difference was not statistically significant. Posterior-to-anterior screw placement provides superior mechanical strength compared with insertion from anterior to posterior [15]. Sanders [10] has suggested that screws can be placed on either side of the flexor hallucis groove and directed anteromedially. On the basis of their findings in a cadaveric study, Ebraheim *et al.* [16] suggested that the best point of insertion for anterior to-posterior screws is the lateral tubercle of the posterior process.

Pitfalls of posterior-to-anterior screw fixation include penetration of the subtalar joint or lateral trochlear surface, injury to the flexor hallucis longus tendon, and restriction of ankle plantar-flexion due to screwhead impingement. These potential problems can be minimized by placement of smaller-diameter countersunk screws directed along the talar axis. The timing of operative treatment of type II fractures remains controversial. There are no data to suggest that emergent treatment of type II fractures improves outcome, but

most would agree that they should be treated with all possible expediency.

Lag screws are typically used to compress talar neck fractures to withstand early motion which, is beneficial for ankle and subtalar joint function. However, when there is comminution of the talar neck, especially the medial column, the use of a lag screw may be contraindicated, as it will cause deformity and malunion. Transfixion screws are used to avoid compression and maintain the correct length of the talus [18, 20]. Bone grafting is occasionally needed to replace areas of impaction defects to restore the neck length.

For comminuted talar neck fractures, many authors have advocated plate fixation with or without neutralization screw fixation (Figure 4) [10, 19, 20, 30]. By providing a solid buttress as a bridging strut, plates can be placed on the most comminuted column of the talus, either medial, lateral, or bilateral columns. Plate sizes used range from 2 to 2.7 mm. Plates not only provide longitudinal structural support, but also prevent supination or pronation of the distal fragment.

Also Intraoperative fluoroscopy is a valuable tool to assess the reduction accuracy and implant position. Arthroscopic techniques under fluoroscopy may be helpful to provide better visualization of the articular surface, which may enhance reduction accuracy and allow debridement of loose fragments. A French multicentre study of 114 patients looked at internal fixation of both talar neck and body fractures with a five-year follow-up. They found that reduction quality was better with K-wire fixation than screws using the Kitaoka score. Screws could cause excessive compression, especially where comminution was present [22]. They recommended using screws for simple fractures and plates where there is comminution.

Nonoperative vs. Operative Management

There is a general consensus that dislocated talar fractures should be operated on. The collapse rate of the talus has been shown to be lowered due to surgical intervention. Surgical repair allows better healing and decreases the chance of any further complications such as avascular necrosis or severe arthrosis of the ankle. Immediate reduction of fracture dislocations is essential to preserve blood supply to the talus and to also avoid secondary soft tissue edema. Unlike non-operative treatment it also permits early mobilization of the joint. Indications for non-operative treatment are used solely for undisplaced talar fractures. If stable fixation with surgical treatment is not used than prolonged immobilization of the ankle is used. A non-weight bearing status is usually preferred. Due to the long term immobilization of the ankle significant problems can arise such as secondary arthrosis, muscle atrophy, and cartilage atrophy [with 2/3 of the bone surface being covered by cartilage]

In the study by Canale, 25% of patients who had avascular necrosis, malunion, arthritis and infection required a further procedure [16]. It has been shown by Tezvel *et al.* in a study of 26 patients to have a sensitivity of 100% and a specificity of 57.7% [24] of Hawkin's sign.

Dennison *et al.* report good functional outcome following excision of the necrotic body of the talus with tibioalcaneal fusion using an Ilizarov frame [25].

9. Conclusion

Talar neck fractures are by far the most common and are classified using Hawkins classification. On the basis of a genetic classification of the ankle fracture, it could be concluded that the position of the foot at the moment of

accident was of decisive importance to the frequency at which talar fractures occurred, supination in particular predisposing to fracture of the neck as well as trochlea of the talus.

The vascular supply of the talus is such that fractures to the neck and body have a high likelihood of developing avascular necrosis. Other complications of talar fractures seen during our study on 25 cases of talus fracture, osteoarthritis and talar dislocation. Types II, III, IV were associated with talar body dislocation which caused excessive pressure on soft tissues having significant soft tissue complications. Hence early anatomical reduction and stable operative fixation of talar fractures is of vital importance to achieve a good functional outcome, quality of life and patient satisfaction. Hence Operative fixation Should be used in most cases of talar fractures, within as minimum time frame as possible to achieve successful outcome

10. References

1. Sanders DW. Fracture and dislocations of talus. In Rockwood and Greens Fracture in adults. 8th edition. Wolters Kluwer Health, 2015, 2593-4.
2. Canale ST, Beaty JH. Campbell operative orthopaedics. Edn International. 2012; 4(12):4162-3.
3. Eastwood DM. Foot Decision Making. AO Principles of fracture management. 4th edition. Thieme Stuttgart: New York, 2000, 591.
4. Anderson HG. The medical and surgical aspects of aviation. London: Oxford University Press; 1919:49.
5. Charcot JM. Sur Quelques Arthropathies qui paraissent pendre d'une lesion cerveau ou de la moelle epiniere. Arch Physiol Normale Pathol. 1868; 1:161-78.
6. Juliano PJ, Dabbah M, Harris TG. Talar neck fractures. Foot Ankle Clin. 2004; 9(4):723-36.
7. Dormans JP, Fischer RC, Pill SG. Orthopaedics in the developing world: present and future concerns. J Am Acad Ortho Surg. 2001; 9:289-96.
8. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating system for the ankle, hindfoot, midfoot, hallux and lesser toes. Foot Ankle Int. 1994; 15:349-53.
9. Grob D, Simpson LA, Weber BG, Bray T. Operative treatment of displaced talar neck fractures. Clin Orthop. 1985; 199:88-96.
10. Comfort TH, Behrans F, Gaither DW, Denis F, Sigmond M. Long-term results of displaced talar neck fractures. Clin Orthop. 1985; 199:81-7.
11. Lindvall E, Haidukewych F, Dipasquale T, Herscovici D, Sanders R. Open reduction and stable fixation of isolated, displaced talar neck and body fractures. J Bone Joint Surg. 2004; 86:2229-34.
12. Garcia RE, Sanz HFJ, Galdran FJ, Cano EJM, Alcazar LFL. Talar neck fractures: results and complication by type. J Foot Ankle Surg. 2002; 8:203-8.
13. Schulze W, Richter J, Russe O, Ingelfinger P, Muhr G. Surgical treatment of talus fractures: A retrospective study of 80 cases followed for 1-15 years. Acta Orthop Scand. 2002; 73:344-51.
14. Saudan M, Peter R, Delmi M. Talar neck fractures. A 9-year follow-up of 40 cases. Rev Chir Orthop Reparatrice Appar Mot. 2002; 88:168-76.
15. Onuminya JE. The role of the traditional bonesetter in primary fracture care in Nigeria. S Afr Med J. 2004; 94:652-8.
16. Berndt AL, Harty M. Transchondral fractures

- (osteochondritis dissecans) of the talus. *J. Bone Jt Surg.* 1959; 41-A:988-1020.
17. Bircher J. Frakturen und Luxationen des Talus. *Helv. chir. Acta.* 1965; 52:289-298.
 18. Cameron BM. Osteochondritis dissecans of the ankle joint. *J. Bone Jt Surg.* 1956; 38-A:857-861.
 19. Dinstl K, Spangler H. Über Luxationsfrakturen im Bereich des oberen Sprunggelenks. *Arch. orthop. Unfall-Chir.* 1963; 55:317-328.
 20. Hansen NL. Ankelbrud, genetisk diagnose og reposition. *Diss. Munksgaard, Copenhagen*, 1942.
 21. Jackson WST, Dickson DD. Fractures and dislocations. In: Du Vries, H. L. *Surgery of the foot.* C. V. Mosby, Saint Louis, 1965.
 22. Jones Watson. *Fractures and joint injuries.* Livingstone, London, 1962.
 23. Kleiger B. Fractures of the talus. *J. Bone Jt Surg.* 1948; SO-A:735-744.
 24. Kleiger B. The mechanism and the roentgenographic evaluation of fracture of the tarsal bones. *Clin. Orthop. SO*, 1363, 10-19.
 25. Klossner O. Late results of operative and non-operative treatment of severe ankle fractures. *Acta chir. scand., Suppl*, 1962, 293.
 26. Kristensen B. Treatment of malleolar fractures according to Lauge Hansens method. Preliminary results. *Acta chir. scand.* 1949; 97:362-379.
 27. Pennal GF. Fractures of the talus. *Clin. Orthop. SO*, 1963, 53-63.
 28. Soloncn KA, Lauttamus L. Treatment of malleolar fractures. *Acta orthop. scand.* 1965; 39:223-237.
 29. Soloncn KAB, Lauttamus L. Operative treatment of orthop. scand. 1968; 36:321-336.
 30. Fortin PT, Balazsy JE. Talus fractures: evaluation and treatment. *J Am Acad Orthop Surg.* 2001; 9:114-27. [http://dx.doi.org/10.5435/00124635-200103000-00005]
 31. RW B. Rockwood and Green's fractures in adults. 7th Edition ed. Philadelphia: Lippincott Williams & Wilkins 2001. July 2002.
 32. Adelaar RS, Madrian JR. Avascular necrosis of the talus. *Orthop Clin North Am.* 2004; 35(3):383-95. [xi.]. [http://dx.doi.org/10.1016/j.ocl.2004.02.010]
 33. Coltart WD. Aviator's astragalus. *J Bone Joint Surg Br.* 1952; 34-B(4): 545-66.
 34. Anderson HG. *The Medical and Surgical Aspects of Aviation.* London: Henry Frowde, Oxford University Press, 1919.
 35. Elgafy H, Ebraheim NA, Tile M, Stephen D, Kase J. Fractures of the talus: experience of two level 1 trauma centers. *Foot Ankle Int.* 2000; 21(12): 1023-9. [http://dx.doi.org/10.1177/107110070002101208]
 36. Chan GM, Yoshida D. Fracture of the lateral process of the talus associated with snowboarding. *Ann Emerg Med* 2003; 41(6):854-8. [http://dx.doi.org/10.1067/mem.2003.213]
 37. Vallier HA, Nork SE, Benirschke SK, Sangeorzan BJ. Surgical treatment of talar body fractures. *J Bone Joint Surg Am* 2004; 86-A(Suppl. 1(Pt 2)):180-92. [http://dx.doi.org/10.2106/00004623-200409001-00008]
 38. Haliburton R, Sullivan R. The Extra-osseous and Intra-osseous Blood Supply of the Talus. *J Bone Joint Surg Am.* 1958; 40A(5):1115-20. [http://dx.doi.org/10.2106/00004623-195840050-00014]
 39. Lin SS, Montemurro NJ. New modification to the Hawkins classification scheme is more predictive of osteonecrosis: commentary on an article by Heather A. Vallier, MD, *et al.* A new look at the Hawkins classification for talar neck fractures: which features of injury and treatment are predictive of osteonecrosis? *J Bone Joint Surg Am.* 2014; 96(3):e25. [http://dx.doi.org/10.2106/JBJS.M.01465]
 40. Archdeacon M, Wilber R. Fractures of the talar neck. *Orthop Clin North Am.* 2002; 33(1):247-62. [x.]. [http://dx.doi.org/10.1016/S0030-5898(03)00083-X]
 41. Halvorson JJ, Winter SB, Teasdall RD, Scott AT. Talar neck fractures: a systematic review of the literature. *J Foot Ankle Surg.* 2013; 52(1):56-61. [http://dx.doi.org/10.1053/j.jfas.2012.10.008]
 42. Funk JR, Rudd RW, King RJ, Srinivasan SC, Bailey AM, Crandall JR. Injuries caused by brake pedal loading of the midfoot. *Biomed Sci Instrum.* 2012; 48:134-40.
 43. Canale ST. Fractures of the neck of the talus. *Orthopedics* 1990; 13(10):1105-15.
 44. Hawkins LG. Fractures of the neck of the talus. *J Bone Joint Surg Am.* 1970; 52(5):991-1002. [http://dx.doi.org/10.2106/00004623-197052050-00013]
 45. 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):143-56. [http://dx.doi.org/10.2106/00004623-197860020-00001]
 46. Vallier HA, Reichard SG, Boyd AJ, Moore TA. A new look at the Hawkins classification for talar neck fractures: which features of injury and treatment are predictive of osteonecrosis? *J Bone Joint Surg Am.* 2014; 96(3):192-7. [http://dx.doi.org/10.2106/JBJS.L.01680]
 47. Koehler S. *Talus fractures: Wolters Kluwer*; 2013 [cited 2015] Available from: <http://www.uptodate.com/contents/talus-fractures-2013>.
 48. Dale JD, Ha AS, Chew FS. Update on talar fracture patterns: a large level I trauma center study. *AJR Am J Roentgenol.* 2013; 201(5):1087-92. [http://dx.doi.org/10.2214/AJR.12.9918]
 49. Buckley R, Strands A. Talus-Displaced neck fracture [cited 2015] Available from: https://www2.aofoundation.org/wps/portal/surgery/?showPage=redfix&bone=Foot&segment=Talus&classification=81-Neck+fractures&treatment=&method=Displaced+fractures&implanttype=ORIF+-+screw+fixation&redfix_url=1283868262857 2015.