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MINIREVIEWS

Subtalar dislocations: Mechanisms, clinical presentation and methods of reduction

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Abstract

Subtalar joint is a complex joint in hindfoot formed by the talus superiorly and the calcaneus and navicular inferiorly. Subtalar dislocations are high-mechanism injuries, which are caused by simultaneous dislocation of both talonavicular and talocalcaneal joints, without major fracture of the talus. They are usually classified as medial (most common), lateral, anterior and posterior dislocations, based on the position of foot in relation to talus and the indirect forces that have been applied to cause this significant injury. They are usually diagnosed by X rays, but computed tomography and magnetic resonance imaging can be used to identify associated intra-articular fractures and peri-talar soft tissue injuries respectively. Majority being closed injuries, can be managed in ED by closed reduction and cast immobilisation, but if they are open, have poor outcomes. Complications that ensue open dislocations are post-traumatic arthritis, instability and avascular necrosis.

Key Words: Joint; Subtalar; Joint dislocations; Flatfoot; Clubfoot; Talus

Core Tip: Subtalar dislocations are rare, high mechanism injuries. Comprehensive trauma assessment, along with limb specific assessment is the key approach to deal with these injuries. Lateral dislocations constitute for open injuries commonly, and must be managed according to the BOAST-Open fracture guidelines. Avascular necrosis of the talus due to injury to the canalis tarsi artery, are troublesome complication. Thus, one needs to have high index of suspicion when the dislocation is open or associated with talus fracture.

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INTRODUCTION

Subtalar dislocation is defined as the simultaneous dislocation of both talonavicular and talocalcaneal joints without major fracture of the talus[1]. The first cases of subtalar dislocations were described by Dufaurest[2] and Judey[3] in 1811, yet there followed a considerable period of senescence in exploring this injury. It was not till 1853 that Broca[4] delivered the first classification of subtalar dislocation, which Malgaigne and Buerguer[5] subsequently amended in 1856.

The classifications are founded on the four anatomical positions into which the foot dislocates in relation to talus[5]. The dislocations of the articulations of the talus include talocalcaneal, talonavicular or talo-crural joint. Subtalar dislocations account for approximately 1% of all dislocations[6]. This is a rare injury due to the anatomical and biomechanical stability afforded by the talo-calcaneal and talo-navicular joints, such that it is predominantly as a result of trauma and high-energy mechanisms[7,8]. One must be cognisant to deliver care as per suitable trauma protocols, and there must be a high degree of suspicion for attendant injuries to the talus, ankle, foot, soft tissue compromise, open fracture or dislocation and trauma to alternate body systems[9-11].

The aim of this review is to provide a concise overview of subtalar dislocations including anatomy, classification of injury, clinical presentation, diagnosis, treatment options, outcomes and complications. As a result of this article, we aim to improve the reader's understanding of this topic.

ANATOMY OF SUBTALAR JOINT

The subtalar joint is a complex joint in the hindfoot with many normal anatomic variations[12]. Considered a synovial joint structurally and a plane joint functionally, it is formed by the talus superiorly and the calcaneus and navicular inferiorly[13], it is comprised of three articulating surfaces, the anterior facet is a small articulation between the talus head and the anterior calcaneus facet, the middle facet between medial facet of talus and the middle facet of the calcaneus and a large posterior facet between the posterior facet of talus and the posterior facet of the calcaneus[14].

Anatomically it is considered as two separate chambers; an anterior chamber also known as the talocalcaneal navicular joint is formed by the often congruent anterior and middle facets[14], the floor is formed by the plantar calcaneo-navicular ligament (spring ligament) which has a cartilaginous articular surface[13]. This ligament complex plays a key role in stabilising the talus head, insufficiency can lead to acquired flat foot deformity[12]. The posterior chamber also referred to as the talocalcaneal joint or the anatomical subtalar joint formed by the posterior facet.

The differentiation of the subtalar joint into two distinct joints is only really preferred by anatomists [13]. From a functional point of view the two joints have a common single axis of motion and neither joint has movement independent of the other, therefore many orthopaedic surgeons consider the talocalcaneonavicular joint and the talocalcaneal joint to be one functional unit[15].

EPIDEMIOLOGY

Subtalar dislocations account for 1%-2% of all dislocations and 15% of all peri-talar injuries. Most frequent age of presentation is in the third decade. It occurs 6-10 times more frequently in men than in women and also dislocations were found to be more common on the right foot than the left[16]. Open injuries are present in 20%-25% of cases, where lateral dislocations are open in 41.8% of cases, while medial dislocations are open in 21.9% of cases[17]. These are typically as a result of high-energy injuries, 50% motor vehicle accidents, 20%-30% fall from heights and 14% from sport injuries[16].

CLASSIFICATION OF INJURY

In 1853, Broca[4] then classified the injury according to the direction of dislocation: Medial, lateral and posterior. Subsequently in 1855 and 1856 that Henke *et al*[17], and Malgaigne and Buerguer[5] modified the Broca classification to include anterior subtalar dislocations. The foundation of classification is the anatomy of the foot in relation to the talus (Table 1)[18-21]. It is intriguing that the same system has continued for over a century and this may reflect the uncommon nature of the injury as well as the limited number of studies undertaken.

MECHANISM OF INJURY

This is often associated with high energy trauma, usually, motor vehicle accidents, or falls from a height [6]. However, patients may get these injuries from lower energy mechanisms such as sports injuries, twisting injuries of the foot or fall from standing, especially if the patient is elderly or obese[6]. Subtalar dislocation involves disruption of the surrounding ligaments: Interosseous talocalcaneal ligament (most important), anterior, posterior, lateral and medial talocalcaneal ligament[22]. Typically to cause this dislocation, an axial load is applied, when the patient has plantar flexed foot. The position of the foot in relation to the talus and the indirect forces that have been applied to cause significant and progressive ligamentous and capsular injury determine the type of dislocation, which can be either medial, lateral, anterior, posterior or total[22].

Medial dislocation (acquired clubfoot)

There is a forced inversion of a plantarflexed foot followed by external rotation of the talus with the lateral malleolus acting as a buttress which result in initial rupture of the talonavicular ligament followed by tearing of the interosseous ligament from anterior to posterior. The sustentaculum tali also act as fulcrum for the neck of the talus to pivot around. The reduction might be difficult and blocked by peroneal tendons, EDB (Extensor Digitorum Brevis) or talonavicular joint capsule, with the foot locked into supination[23].

Lateral dislocation (acquired flatfoot)

There is a forced eversion of a dorsiflexed foot followed by external rotation of the talus which leads to initial rupture of the deltoid ligament followed by the interosseous ligament and the talocalcaneal joint, then dorsal talonavicular ligament rupture. Here, the anterior process of the calcaneus acts as fulcrum for the anterolateral corner of the talus to pivot around. The reduction might be difficult and blocked by peroneus tertius (PT) tendon, flexor hallucis longus (FHL), or flexor digitorum longus (FDL), with the foot locked into pronation[6].

Posterior dislocation (shortened foot)

There is a heavy forced plantarflexion of the foot followed by a talocalcaneal joint slip[6]. This is an exceedingly rare entity. It is important to recognize that not all posterior subtalar dislocations are true posterior dislocations. Inokuchi *et al*[1] suggest that the position of the foot is important to define the type of subtalar dislocation: Supination or pronation of the foot at the time of injury leads to medial or lateral displacement. Usually, subtalar dislocation occurs with an associated rotational component. Few reports of posterior subtalar dislocation have been described to date, and all of these describe medial or lateral displacement[24].

Anterior dislocation (elongated foot)

There is an anterior traction of the foot on a fixed lower leg followed by a talocalcaneal joint slip[6]. Pure anterior subtalar dislocation is very rare, with few cases being reported in the past[8]. The first reported case of anterior subtalar dislocation was described by Malgaigne and Burger[5]. Zimmer *et al*[25] summarised eight series of 115 cases of subtalar dislocation-only about 1% of them were anterior dislocations.

Various mechanisms of injury have been proposed. Kanda *et al*[20] believe that anterior subtalar dislocation can be caused by forceful foot supination and ankle dorsiflexion when a patient falls from a height. Tabib *et al*[21] reported that the dislocation followed a direct rear impact over the posterior aspect of heel after a fall injury. Chuo *et al*[26] reported that anterior subtalar dislocation occurred when the patient withdrew the trapped foot.

CLINICAL PRESENTATION WITH ASSOCIATED TALAR INJURIES

One of the commonest presenting complaints in patients with subtalar dislocations is of pain and swelling of the ankle and/or midfoot. On examination, there may be bruising, an obvious gross swelling

Table 1 Classification of subtalar dislocation and associated mechanism of injury

Direction of dislocation	Percentage of all subtalar dislocations (%)	Position of foot at time of injury	Mechanism of injury
Medial (Calcaneus is medial to talus)	65-85[10]	Plantarflexion	"Acquired club foot", forceful inversion of forefoot[10], foot locked in supination
Lateral (Calcaneus is lateral to talus)	15-35[18]	Plantarflexion	"Acquired flat foot", forceful eversion of forefoot[10], foot locked in pronation
Posterior	0.8-2.5[7]	Hyper-plantarflexion	"Shortened foot", force applied to dorsum of foot leading to hyperplantarflexion[10]
Anterior	1[19]	Hyper-dorsiflexion	"Elongated foot", forceful foot supination and ankle dorsiflexion [20] or direct rear impact to posterior heel[21]

which might mask the bony deformity. Surrounding soft tissue involvement depends on the amount of energy involved and on the elapsed time from the injury[27]. There will be reduced range of motion as well as the foot may be locked in a position depending on the type of subtalar dislocation. Often subtalar dislocations as a result of the particular pattern and mechanism of injury will have adjacent bone fractures and injuries including the talus, cuboid, navicular and fibula (Table 2).

Medial subtalar dislocations are characterized by medial displacement of the foot and calcaneus[27]. The talar head is often palpable on the dorsum of the foot between the extensor digitorum longus and extensor hallucis longus tendons, usually locked in supination with inversion of the foot. It is sometimes called "basketball foot" as this is a common mechanism and another term for this injury is "acquired clubfoot"[28]. This type of dislocation is usually associated with fractures of the posterior process of talus, dorsomedial talar head, and navicular bone[29].

Lateral subtalar dislocations are most likely to result in an open dislocation (in upto 25% of the cases [30]) due to the high-energy mechanism leading to injury. Clinically lateral subtalar dislocations can be locked in pronation with eversion of the foot[28]. This type of dislocation is often associated with fractures of the lateral process of talus, anterior calcaneus, cuboid, and fibula[29]. The reduction might be blocked by PT tendon, FHL or FDL, and so the foot becomes locked in pronation.

Posterior subtalar dislocations are commonly accompanied by fractures of the malleoli, talus, or fifth metatarsal[31] and anterior subtalar dislocations are extremely rare and highly unstable injuries involving talus, calcaneal and navicular injuries[26].

DIAGNOSIS

Subtalar dislocations are almost always associated with bony injuries including fractures of the ankle, talar (lateral process and sustentaculum tali), calcaneal and navicular bones carrying the highest risk. The cuneiforms, cuboid and metatarsals might be injured as well[6]. Therefore, all parts of the foot which are at risk of being injured as a result of a subtalar dislocation have to be examined radiographically[9]. Radiographs and computed tomography (CT) are the mainstay of investigations and here we explore the appropriate techniques and findings.

Plain radiographs

The diagnosis of subtalar dislocation is usually made on AP, lateral, and oblique radiographs of the foot or ankle. Some special views might be also useful in diagnosis, *e.g.*, Canale view for evaluating talar neck fractures, which are often oblique to the transverse or sagittal plane of the foot, and are commonly associated with subtalar dislocation, and Harris view of the calcaneus, which allows visualization of the posterior and middle talocalcaneal joints[32]. The nature of the deformity often limits radiographic positioning. Remembering that the talar head and navicular should be congruent on all views can help overcome this limitation. Medial subtalar dislocation results in medial and plantar displacement of the navicular relative to the talar head and medial displacement of the calcaneus relative to the talus. Lateral subtalar dislocation results in lateral and dorsal displacement of the navicular relative to the talar head and lateral displacement of the calcaneus relative to the talus. Talonavicular impaction may prevent successful closed reduction and should therefore be recognized[32]. After reduction, AP and lateral radiographs of the foot as well as AP and mortise views of the ankle are obtained to confirm optimal results. In the absence of deformity, post-reduction radiographs are usually of better quality than those obtained at the time of injury and associated fractures become more apparent[6].

CT scan

Associated intra-articular fractures are difficult to identify at plain radiography and their presence can hinder anatomic reduction and worsen the overall prognosis. Therefore, routine post-reduction CT has

Table 2 Associated bony injuries with each type of dislocation

Bony involvement	Medial dislocation[28]	Lateral dislocation[28]	Posterior dislocation[29]	Anterior dislocation[30]
Talus	+	+	+	+
Navicular	+	-	-	+
Cuboid	-	+	-	-
Fibula	-	+	+	-
Calcaneum	-	+	-	+

been recommended to detect these fractures more accurately[32] and to look for subtalar debris[9].

Magnetic resonance imaging scan

Given the sensitivity of CT in diagnosis, further imaging is not typically indicated; however, magnetic resonance imaging has proven useful for persistent pain after trauma to aid in diagnosis of peri-talar soft tissue injuries and osteochondral injuries such as those in the talar head or dome[33].

TREATMENT

Taking into account that the majority of subtalar dislocations result from high energy mechanisms, there is the potential for adjacent attendant injuries. Following Advanced Trauma Life Support protocols[34], to start with Airway including cervical spine protection, Breathing, Circulation, Disability and Exposure (ABCDE) assessment of the patient, and then limb specific management, necessitating assessment of the neurovascular status and soft tissue.

Majority of these dislocations could be treated by closed reduction and cast immobilisation or by operative stabilisation with an external fixator or if necessary percutaneous K-wire arthrodesis of subtalar and talonavicular joint as a temporizing measure[35].

Early treatment with closed reduction under sedation or more commonly general anaesthetic is required to avoid progressive soft tissue and neurovascular damage[9]. Closed reduction is best achieved through relaxation of the gastrocnemius and soleus which may act as a significant deforming force at the calcaneus, by knee flexion and subsequent traction-countertraction manoeuvre. Once reduction achieved, it is important to reassess the limb neurovascular status, and a plaster backslab offers a simple yet effective method of immobilisation and splintage. Circumferential casting and constrictive bandages should be avoided as this may exacerbate residual swelling and lead to increased compartment pressures, whereas limb elevation will help counteract this process[23]. The table below shows treatment modalities for different dislocations (Table 3).

Open dislocations depict the more severe spectrum of injuries with poor outcomes. Common challenges including infection, post-traumatic arthrosis, and higher chance of talus avascular necrosis [36,37]. These injuries must be treated urgently, with initial broad-spectrum antibiotics in line with local antimicrobial stewardship and tetanus prophylaxis and managed with the same respect as open fractures. Although not directly related, we can utilise the principles through comparative guidance on the management of open fractures, one example is the British Orthopaedic Standards for Trauma-open fractures[38]. Coordinated care with plastic surgical specialists may help with timely preparations for reconstructive care if required. Acute treatment requires wound debridement and extensive irrigation of the injury zone, as well as reduction to an anatomical position. Immobilisation with plaster slab may be sufficient in some cases, yet where there is greater instability and loss of soft tissue coverage, Kirschner wires or even an external fixator may be required as alternative methods of stabilisation[39,40].

COMPLICATIONS + OUTCOMES

The sequelae of subtalar dislocations are grossly described through three key areas: Avascular necrosis of the talus (following injury to canalis tarsi artery), posttraumatic osteoarthritis and instability[41].

Avascular necrosis (AVN) also known as osteonecrosis, is defined as bone death due to ischemia, characterised by stereotypical pattern of cell death and complex repair process of bone resorption and formation[42]. The unique extra and intraosseous vascular anatomy of the talus predisposes for compromised healing potential and AVN as severe sequelae[43]. Avascular necrosis of the talus is a troublesome complication, which is more common in open subtalar dislocations or with talus fractures with rates of up to 50%[40].

Table 3 Reduction methods as per dislocation anatomy

Direction of Dislocation	Reduction manoeuvre (in addition to traction)	Structures that commonly obstruct reduction	Open reduction approach
Medial	Dorsiflexion and eversion of foot	Talar head, extensor digitorum brevis	Ollier's approach or antero-lateral approach
Lateral	Plantarflexion and inversion of foot	Flexor digitorum longus and tibialis posterior	Direct incision atop of talar head
Posterior	Plantarflexion of foot and once talar head disengages from navicular, the foot is dorsiflexed and tractioned distally		
Anterior	Posterior translation of foot whilst under traction		

Post-traumatic arthritis is of variable incidence, however high energy mechanism of injury, evidence of intra-articular talar and calcaneus fractures with osteochondral defects and open fractures are associated with a worse prognosis[36,19]. This can be a cause of significant pain and disability in the longterm[23]. Management is dependent on the pain and functional impact to the patient. For those with more advanced disease and poorly managed pain, physiotherapy and analgesia are unlikely to be adequate. In the presence of adjacent talonavicular and calcaneocuboid arthritis a triple fusion may be considered. Yet subtalar fusion may be reserved for those patients without adjacent arthrosis[39].

Instability is present as a result of ligamentous disruption following dislocation.

CONCLUSION

Subtalar dislocations are rare, high mechanism injuries. Comprehensive trauma assessment, along with limb specific assessment is the key approach to deal with these injuries. Lateral dislocations constitute for open injuries commonly, and must be managed according to the BOAST-Open fracture guidelines. Avascular necrosis of the talus due to injury to the canalis tarsi artery, are troublesome complication. Thus, one needs to have high index of suspicion when the dislocation is open or associated with talus fracture.

FOOTNOTES

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