Injuries of the talus represents an important part of the foot and ankle trauma. Since talar bone connect the lower limb and foot, the sequelas of its trauma could have significant influence on the function of the whole lower limb and gait. The specific vascularization of the talus results in delayed union and even in the avascular necrosis. The diagnosis of the fractures of the talus can be made on the x-rays, but sometimes real picture of the fracture pattern can be seen only in the CT scans. Occult fractures such as osteochondral fractures and avascular necrosis can be exactly detected on MRI in aim not to be overlooked as the ankle sprain diagnosis. The precise reduction and stable internal fixation is mandatory in the treatment to enable the anatomical position of the talonavicular, talocrural and subtalar joint and to make possible early motion and rehabilitation, without weight bearing. On the other hand, crushed fractures, open fractures and the Hawkins III - IV fractures with the dislocations of the talar body sometimes needs salvage procedures like Blair or tibio-talar or tibio-calcaneal fusion. The first description dates from the year 1608. and was given by Fabricius from Hiddean who described the case of a dislocated talus.

In year 1919. Andersen made the first classification on a series of the talar fractures and described 18 cases caused by dorsal flexion of foot, and all were in the air-men, and which is why are sometimes called "aviator’s astragalus" in the literature. Talus is located between the malleolus, calcaneus and metatarsal bones and it is crucial for movement between the lower leg and foot. At the same time, talus is anatomically hidden, making it difficult to perform a surgical approach. It has poor blood supply, which makes surgical procedures more complicated. These injuries have been studied by numerous authors who have contributed to our knowledge about the fracture of the talus.

Due to its firmness, talus will first cause the fractures to all bones around it - ankle fractures, and only then will talar fracture itself. The fractures of the talus make up only 3% of all fractures of the foot.

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**ANATOMY- relevant data**

Several anatomical features of the talus has an impact on so-called complexity of these injuries. It is irregularly shaped bone, with no muscle attachments. 60% of the talus surface is covered with cartilage, which reduces the possibility of entering the blood vessels of the surrounding soft tissue and leads to problematic circulation of the talus (Figure 1). Talus is the narrowest in the neck, and thus it is the weakest point of the talus. The neck of the talus is oriented medial (medial side is shorter than the lateral), hence fractures tend to heal in varus position malunion. From the plantar side, the talocalcaneal intersosseous ligament is an important stabilizing element of the talus, and during the fracture, leads to the dorsal and varus dislocation of the head or the body of the talus, is the dislocation of the
talus occur when posterior talocalcaneal ligament is torn. Posterior talocalcaneal ligament is the last stabilizing structure during the injury process.

Beside the neck, head and the talar body, the lateral and medial posterior process can be the place of fracture. Medial process is the place of the attachment for the flexor hallucis longus and may be place of the fracture and non-union.

Lateral tubercle-process is the articular surface for the tip of the fibula and carries the strong bone complex of talocalcaneal ligaments, but it also has a role as a kind of hammer in the genesis of the fractures of the lateral calcaneus.

**CIRCULATION- an impact on the outcome after the talar fracture**

The circulation of the talus is very problematic, and consequently causes avascular necrosis as the most severe complication of the talus injuries.

The body of the talus receives vascularization from a.canalis tarsi and sinus tarsi, resulting from the branches and a.peronealis and a.tibialis anterior and rami deltoidei, which come from a.canalis tarsi (from a.tibialis posterior) and go through the deltoid ligament. Below of the neck of the talus, a.canalis tarsi and a.sinus tarsi make an anastomosis. A.dorsalis pedis reaches the dorsal side of the head and neck of the talus. (Figure 1).

**CLASSIFICATION OF TALAR INJURIES-FRACTURES**

Anatomical classification of talar fracture are made upon - due to the anatomical localization and its complexity, the fractures of the talus are divided into the fractures of the head, neck fractures, fractures of the talus body (including osteochondral and fractures of the posterior-lateral and medial processes), lateral tubercle fracture and open fractures of the talus. Beside fractures, talus can be dislocated, extruded without any fracture and this condition was described by the North and then recently occasionally by Apoxile.

1. FRACTURES OF THE TALAR HEAD account for 10% of all fractures of the talus. The mechanism of injury is the impaction of the head in the navicular bone with dorsal flexion of the foot. Clinically there is swelling and pain in inversion/eversion. Radiologically dislocations are rarely visible because the fragments are retained by strong inter tarsal ligaments and computer tomography-CT is hence better imaging procedure for this fracture.

Nondislocated fractures of the head of the talus are treated non-operatively by applying below knee plaster cast for a period of 8-12 weeks (functional cast), after which the union is achieved and radiographically is visible.

Large fractures that affect more than 50% of the talar head require internal fixation. The approach to this fracture is the medial and fixation is obtained by bioabsorbable screws, K-wires or small screws and the bone defect in the head is filled by the bone graft.
When the fracture cannot be securely fixed with screws, then the primary fusion-arthrodesis of the talonavicular joint is suggested with the use of bone graft from the iliac crest with plate and screw fixation, through the anteromedial approach. This preserves the blood supply and anatomical dimension of the bone can be achieved.

Complications that occur after the fractures of the head of the talus are:
1. Instability due to fracture size. If a fragment of the head of the talus is larger than 50%, its resulting in instability of the talonavicular joint.
2. Arthrosis of the talonavicular joint.
3. Osteonecrosis of the head of the talus, not common.

TALAR NECK FRACTURES are the most common talar fractures and represent about 50% of all fractures of the talus.

It is well known that the anterior edge of the tibia fractures the neck, without fracturing the anterior lip. But some cadaveric studies have shown that even a full dorsal flexion of the foot is not enough to break the neck of the talus, unless simultaneous pressure on the foot - contraction of m. triceps surae - is applied.

Fractures of the neck of the talus occur most frequently between the age of 20-40 years, and they are three times more common in males, indicating greater physical activity and force of greater intensity.

Thus, according to Kelikian, mechanism of injury is conditioned upon the narrow neck of the talus, the lack of protective cartilage, that lies between different leverage sizes (foot-smaller one and the lower leg-longer one). The front edge of the tibia strikes the neck of the talus and the dividing line runs from the medial and lateral downwards. Next comes the injury of talocalcaneal ligament and rupture of posterior capsule of subtalar and talonavicular joint could occur. If the dorsal flexion continues, the tibia extruded the fragments of the talus from the subtalar and talocrural joint. The posterior talar fragment body moves posteromedially or posterolaterally depending on the position of the foot (inversion or eversion) at the time of injury.

The diagnosis depends on the X-ray, but CT is more precise and helpful procedure.

Depending on the events during the talar fracture, the following classification of fractures of the neck of the talus was made by Hawkins in 1970 based on displacement of the talar neck and body and on the basis of congruence of the subtalar and ankle joint.

**Type I fractures** - vertical, nondislocated fractures. According to the author, fractures that can not be dislocated in bringing the ankle in neutral position belong to this type. The circulation of these fractures is preserved and in theory these fractures break only those blood vessels that come from dorsolateral part of the neck of the talus. The treatment consists of a reduction (if needed) and cast immobilization for a period of 6-8 weeks. It is only when the X-ray controls show trabeculae crossing the fracture line, that weight bearing is allowed. The incidence of avascular necrosis is lowest, accounting to up to 13% of complications. It is only type of the talar neck fracture that can be treated non-operatively.

**Type II fractures** - lead to displacement of the talus and the subtalar luxation (subluxation). In these fractures the circulation is cut off to the dorsolateral as well as in the sinus tarsi and canalis tarsi, so the incidence of avascular necrosis is up to 50%.

The fixation could be obtained by K-wires, temporarily, after which the final fixation by canulated screws is preferable, either from the anterior or posterior approach (Figure 3a,3b). Posterior fracture fixation is mechanically more stable. (Figure 3c.)
Type III fractures - there is incongruence in the ankle and the subtalar joint. The body of the talus goes postero-medial, between the posterior tibial surface and the Achilles tendon. These fractures results from high energy trauma and they are often open."4,5,11,13"

In many cases the head is dislocated postero-medially, which can lead to compression of the neurovascular structure, and the circulation of these fractures is then very vulnerable, whereas the incidence of avascular necrosis is up to 80%-100%.

Some authors recognize type IV fractures - which include fractures of the neck of the talus with dislocation of the ankle, the subtalar and talonavicular joint. The treatment is similar to that in the type III fractures, with distraction obtained by the external fixation and the internal fixation with the canulated screws. The prognosis is worse then in the type III.

In type III and IV neck fracture internal fixation is mandatory.20,24,25 The surgical approach should consist of two incisions: medial and lateral one. Medial incision goes between the tibialis anterior tendon and the tibialis posterior and allows access to the medial side of the neck. The incision can be extended proximal and on the way to do osteotomy of the medial malleolus, when necessary 25. The second incision is lateral one. Sometimes the temporary external fixation is necessary to obtain the broader view and make reduction possible (Figure 4). Further, the external fixation can stabilize the site of injury for the certain period, while internal fixation can be early or delayed one.26

The results of the treatment depends on the type of fracture, but also on the type of treatment.26 Complication rate in this fractures is high. Posttraumatic arthritis is most common, especially in group III (incidence is up to 50%) and it seems that the length of immobilization affects the occurrence of subtalar arthrosis.

Avascular osteonecrosis is described and assessed by MRI, but it is less common than osteoarthrosis.27

Avascular necrosis is a common complication of fractures of the talus, and it correlates with the initial displacement. The diagnosis of AVN is usually set on the basis of X-ray, it is not easy to diagnose, and occurs usually within 8 weeks, sometimes the diagnosis can be set in the 12th week. X-ray should be done after 6 to 8 weeks after injury, without plaster, in order to detect the existence of Hawkins’s sign which is defined as a relative osteopenia (subchondral bone atrophy).4,5,11,20 Positive Hawkins’s sign indicates that the circulation is preserved, but the negative Hawkins sign does not mean that AVN has not developed. One must know that only 30% of AVN lead to a collapse of the talus and there is no unified attitude in the treatment of AVN. The diagnosis of AVN is made by MRI. It ranges from 0% in type I to 20-80% in type III-IV, mean value is 58%.4 Symptomatic treatment is arthrodesis (Blair) or miniartrotomic fusion.4,521

Skin necrosis and osteomyelitis - the skin problem is one of the complication of talus fractures, especially those of Hawkins type III and IV, after the postero-medial dis-placement of the talus, and open fractures. To reduce the risk of osteomyelitis, it is necessary to perform aggressive debridement, irrigation, antibiotic administration, followed by soft tissue coverage if necessary. Osteomyelitis of the talus is extremely difficult to treat and it is often ends with excision of the body of the talus.4,8,11,13

Disturbance of healing

a. nonunion - very rare in fractures of the talus, even if there is AVN of the body of the talus.
b. delayed union- is not so rare in fractures of the talus, and occur in 0-10%. In the study, Peterson and colleagues found a delayed healing in 13% of patients, but none of them did not developed pseudoarthrosis\textsuperscript{11,19}.

c. malunion with disturbance of the axis is a relatively common complication, leading to arthritis, the most common with the varus deformity, caused by comination of the neck of the talus. According to some studies this complication occurs more frequently in Hawkins II fractures, which can be explained by the fact that these fractures are treated with closed reduction more often than type III ones\textsuperscript{20}.

d. osteoarthritis of subtalar joint and ankle - it has been shown in several studies that subtalar arthritis usually occurs in the fracture of the neck, but also in the talar head fracture\textsuperscript{21}. The rate differs from 50% to 100%\textsuperscript{5,11}.

In order to prevent arthrosis, some authors recommend early mobilization\textsuperscript{22}.

3. TALAR BODY FRACTURES comprise 7-38% of fractures of the talus and occur when the foot is extended, which sometimes, leads to the dislocations of the talus\textsuperscript{5,13}. These fractures may or may not be associated with fracture of the neck of the talus\textsuperscript{5,20}.

Clinical there is a swelling visible from the front side and painful movements (inversion / eversion, flexion and extension).

The fractures of the body of the talus have been devided into 5 groups (5):

1. Osteochondral fractures;
2. Fractures of the body, where the dividing line can be in sagittal, frontal and axial planes;
3. Fracture of posterior processes or tubercule (medial posterior tubercule);
4. Fracture of the lateral tubercle-process;
5. Compression or impaction fracture/ crushed one;

3.1 Osteochondral fractures can be acute one or chronic, for which a synonym is used- osteochondritis dissecans. It is overlooked in 60-75% in the diagnosis of the ankle sprain. Actually it is present in 2-6% of all ankle sprains, but diagnosis can be made on conventional X rays, but on CT, MRI is more sensitive and helpful. The treatment depends on the classification: stage 1 is stable, while stage 2-3 unstable, Stage 4 represent the cartilage defect. Stage one is treated nonoperatively, while stage 3 by arthroscopic, assisted fixation or open the joint, sometimes needed osteotomy of malleolus\textsuperscript{25,29}.

3.2 Injuries-fractures of the talus body are estimated by X-ray (besides the classical AP and profile radiographs, the Canale and Broden plane, oblique plane of the middle part of the foot can be also used), but the sometimes the CT is necessary to present the fracture line. MRI is rarely needed. CT presents the relationship of the fragment well and so differentiates type 1 from type 2 fractures of the talus neck and the body as well (figure 5).

Treatment may be non-operative in non-dislocated fractures, but the open reduction and internal fixation are required more frequently. The goal of treatment is anatomic reduction and stable fixation. In the past, favored fixation of the talar body fractures was with two screws, but as there are usually small fragments, the preferred method is now reduced one with small screws and sometimes with the plate.

3.3. Fractures of the posterior process. The lateral is larger than the medial and it can represent an accessory bone (up to 30%)\textsuperscript{2}. Thus can be misdiagnosed to the os trigonum. In asymptomatic os trigonum or larger fractures the internal fixation can be performed\textsuperscript{7}.

3.4. Fractures of the lateral process

There are few synonyms for this injury: fracture of the lateral processus, fracture of the lateral tubercle, fracture of the posterior facet. Nowadays, it is commonly known as "snowboard fracture"\textsuperscript{11}. They occur in less than 1%. Because of similarities in the mechanism of injury and location of pain these fractures are often misinterpreted as a sprained ankle and the diagnosis is overlooked in up to the 30% of cases\textsuperscript{11,13}. When in doubt, the CT examination is indicated. It can be treated with the plaster cast or fixed with Herberts screws\textsuperscript{11}.

3.5. Crushed fractures - are caused by the high loading force\textsuperscript{13}. This kind of fractures are very difficult for treatment. They can be fixed, with previous distraction\textsuperscript{5,30}. Due to the posttraumatic arthritic changes in a lot of the cases subtalar or pantalar arthrodesis may be required.

4. OPEN FRACTURES OF THE TALUS

These are characterized by a dislocation, impaired circulation, contamination and damage to soft tissue. They occur in Hawkins type 2 and 3. The percentage of infection is up to 38%, especially in the case of the talus extrusion when it is better not to return, but keep the length of the foot using an external fixation, limited internal fixation and skin coverage. In the failed cases, the Blair arthrodesis or tibio-calcaneal arthrodesis can be performed.

Open fractures of the body of the talus must be treated surgically, with irrigation, small fragments extirpation, external fixation and later ankle arthrodesis. To prevent the lose of the hindfoot length, the fusion could be performed with the bone graft inserted\textsuperscript{11}.

Anyhow, one must keep in mind, given by poor vascularization of certain parts of the talus (especially cartilaginous surfaces), that these injuries can produce long-lasting painful symptoms, and therefore requires early diagnosis (CT, MRI) and the right and proper treatment (eg, via arthroscopy technique).

**SUMMARY**

**PRELOMI TALUSA - SAVREMENO LEĆENJE**

Povrede talusa predstavljaju značajan segment povreda stopala skočnog zgloba i stopala. Stoga što talus spaja potkolencu i stopalo, posledice njegove povrede mogu da imaju značajan uticaj na funkciju cele noge i hoda. Specifičnost vaskularizacije talusa ima za posledicu usporeno srasstane i avaskularnu nekrozu talusa. Dijagnoza povreda i preloma talusa može se postaviti na nativnoj radiografiji, ali se preciznija slika dobija na kompjuterizovanoj tomografiji-CT-u. Avaskularna nekroz talusa se, osim na radiografiji, najranije uočava na magnetnoj rezonanci-MRI.
Okultne-male povrede kao osteohondralni prelomi se vide tek na CT ili MRI-u, čiji je značaj veliki jer se veliki broj ovih povreda prevedu pod dijagnozom distorzije skočnog zgloba.

Precizna repozicija i unutrašnja fiksacija su neophodne u lećenju ovih preloma, u cilju dobijanja anatomске pozicije i odnosa u talokruralnom, talonavikularnom i subtalarnom zglobu, čime se postiže rana pokretljivost i rehabeilitacija, ali bez oslonca. Sa druge strane kraši prelomi, i tip III i IV Hawkinsovih preloma vrata talusa sa lukscijama, nekada zahtevaju artrodeze tipa Blerove ili tibiokalkanealne artrodeze.

Ključne reči: prelomi talusa, hirurško lećenje, komplikacije

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