



**Federal state budgetary educational institution higher education  
«NORTH OSSETIAN STATE MEDICAL ACADEMY»  
Ministry of health of the Russian Federation**

# **Department of Traumatology and Orthopedics**

## **Fractures of the foot bones**

Educational and methodical manual for students

*Traumatology and orthopedics*

Vladikavkaz 2020

Approved at the meeting  
of the Department of traumatology  
and orthopedics on August  
27, 2020, Protocol No. 1  
«**APPROVED**»

**Professor, Doctor of Medical Sciences,  
the head of department of traumatology  
and orthopedics \_\_\_\_\_ S.S.Sabaev**

*Developers:*

Professor, Doctor of Medical Sciences,  
the head of department of traumatology  
and orthopedics

S.S.Sabaev

Recensents:

*Professor, Doctor of Medical Sciences,*

Totikov V.Z.

Professor, Doctor of Medical Sciences,

Mildzikhov G.B.

### **The purpose of the lesson.**

To introduce students to the classification of foot injuries, to teach students the clinical examination of patients with foot injuries, to form the students ' ability to conduct X-ray diagnostics of these injuries, to be able to provide first aid for these injuries.

### **After the practical lesson, the student should KNOW:**

1. The mechanism of injury to the bones of the foot.
2. Classification of injuries to the bones of the foot.
3. Clinical symptoms of foot injuries.
4. Radiological semiotics of these injuries.
5. Principles of treatment of foot injuries.
6. Principles of first aid for foot injuries.

### **After the practical lesson, the student should BE ABLE to:**

1. Find out complaints and collect anamnesis in patients with foot injuries.
2. Conduct a clinical examination of a patient with various injuries of the foot.
3. Interpret the radiological data.
4. Formulate a diagnosis of foot injuries.
5. Provide first aid to patients with foot injuries.

### **Lesson content:**

#### **Fractures of the foot bones**

Fractures of the foot bones occupy a significant place among the injuries of the bones of the skeleton. According to the literature, they account for 17 to 20% of all skeletal bone fractures. The metatarsals and phalanges of the fingers are most often injured, and the heel bone is the second most common injury.

#### **Structure of the foot**

1 tarsus, tarsus. The proximal part of the foot. It consists of seven bones:

talus, calcaneus, navicular, cuboid and three wedge-shaped.

2. Calcaneus, calcaneus.

3 Talus bone, talus.

7 Navicular bone, os naviculare.

8 Tuberosity of the navicular bone, tuberositas ossis navicularis.

9 Medial sphenoid bone, os cuneiforme mediale.

10 Intermediate sphenoid bone, os cuneiforme intermedium.

11 Lateral sphenoid bone, os cuneiforme laterale.

12 Cuboid bone, os cuboideum.

13 Sulcus tendon of the long fibular muscle, sulcus tendinis t. fibularis longi.

14 Tuberosity of the cuboid bone, tuberositas ossis cuboidei.

15 Calcaneus, processus calcaneus.

16 METATARSUS, metatarsus.

17 I - V metatarsals, ossa metatarsi (metatarsalia)

18 The base of the metatarsal bone, basis metatarsalis.

19 The body of the metatarsal, corpus metatarsal.

20 Metatarsal head, caput metatarsals

21 Tuberosity of the first metatarsal, tuberositas ossis metatarsalis primi.

22 Tuberosity of the fifth metatarsal, tub. ossis metatarsalis quinti.

23 FINGER BONES, ossa digitorum.

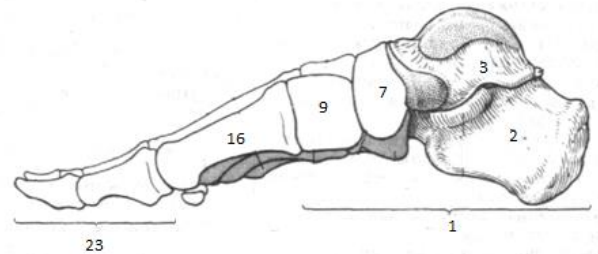
24 phalanges, phalanges.

25 Proximal phalanx, phalanx proximalis.

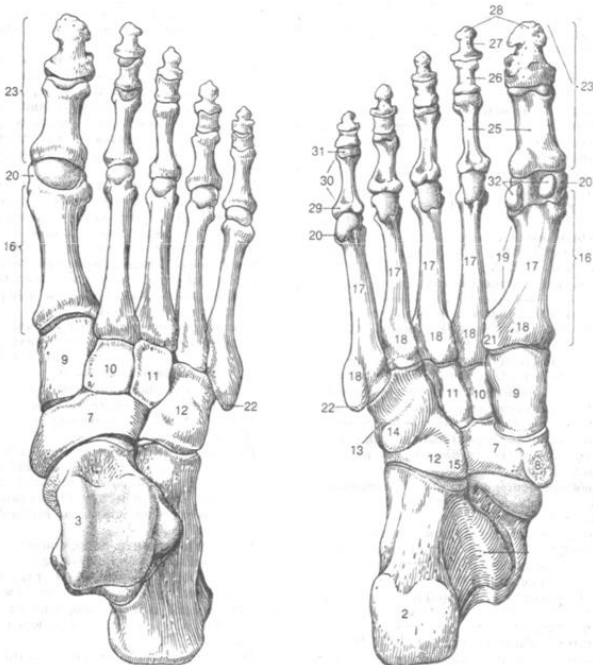
26 Middle Phalanx, phalanx media.

27 Distal phalanx, phalanx distalis.

28 Tuberosity of the distal phalanx, tub. phalangis distalis.

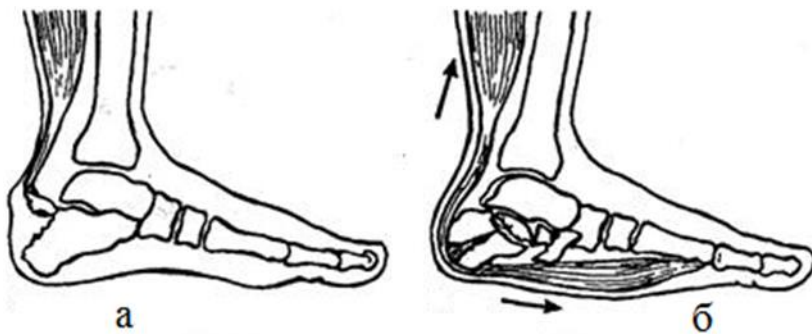


29 The base of the phalanx, basis phalangis.  
30 The body of the phalanx, corpus phalangis.  
31 Head of the phalanx, caput phalangis.  
32 Sesamoid bones, ossa sesamoidea..



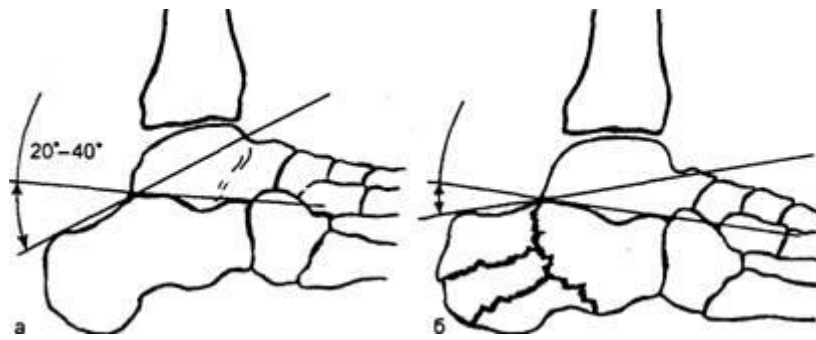
## Fractures of the calcaneus

The calcaneus, os calcaneum—the largest of all the bones of the foot, is involved in the formation of the longitudinal arch of the foot and is its posterior fulcrum, the plantar aponeurosis, the muscles of the foot and the tendon of the triceps muscle of the lower leg (calcaneus) are attached to the processes of the tubercle of the calcaneus. Under normal conditions, the application of forces on these muscles contributes to the active balancing of the foot. The main mechanism of a heel bone fracture is compression, the cause can be a fall from a height, a road accident, industrial and sports injuries. The bone falls under the pressure: from below — the support surface, from above—the talus bone, and when the ultimate strength of the shock-absorbing mechanisms and the strength of the bone itself is exhausted, a fracture occurs. In this case, the acting forces are distributed unevenly, the displacement of the fragments is explained by the pressing of the talus bone into the broken heel bone and the contraction of the plantar and calf muscles. As a rule, the force of the impact on the heel bone is significant and leads to great destruction of the latter, often a fracture of the heel bone is combined with fractures of other bones of the foot and spine.



variants of calcaneal bone fractures: a-beak-shaped; б-comminuted, compression

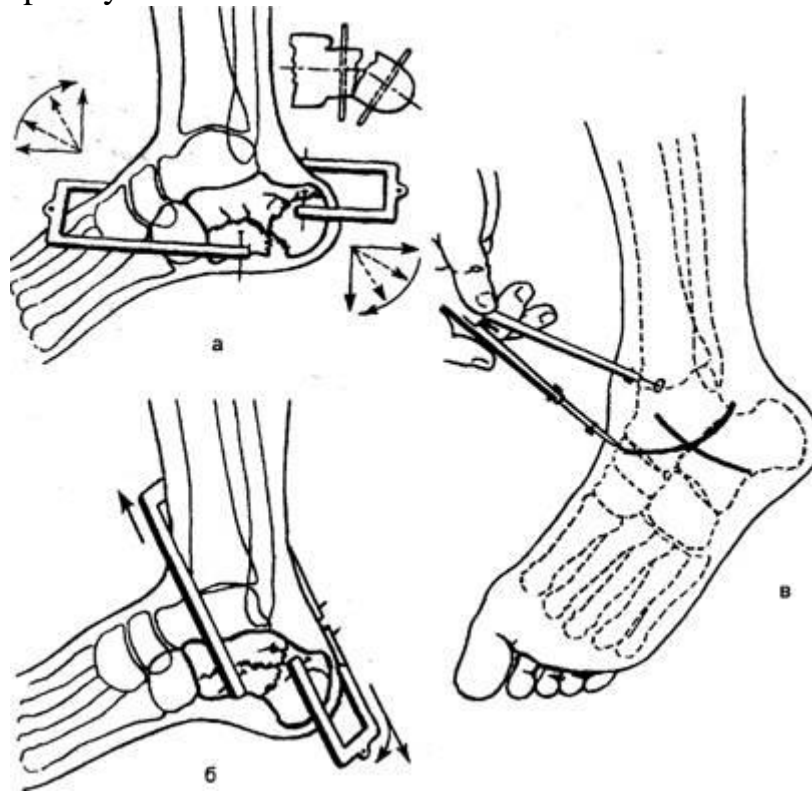
Fractures of the calcaneus are characterized by pain in the area of damage and the inability to load the foot. Attention is drawn to hallux valgus and varus deformity of the heel, expansion of the heel area, swelling of the foot, the presence of characteristic bruising in the heel area and on the plantar surface of the foot. The arches of the foot are flattened. Active movements in the ankle joint due to soft tissue edema and tension of the heel tendon are sharply limited, and in the subtalar joint are impossible. In the case of a fall from a height with a landing on the heel bumps, combined damage to the heel bones and spine is possible. Therefore, it is recommended to conduct an X-ray examination even in the absence of complaints in the first days after the injury. When reading the radiograph, special attention is paid to the angle of the articular part of the calcaneal mound (articular-tubercular angle) — the angle of the Beler, which is formed by the intersection of two lines, one of which connects the highest point of the anterior angle of the subtalar joint and the top of the posterior articular facet, and the other runs along the upper surface of the calcaneal mound. Normally, this angle is 20-40°. Depending on the severity of the fracture, the Beler angle decreases and may even have negative values.



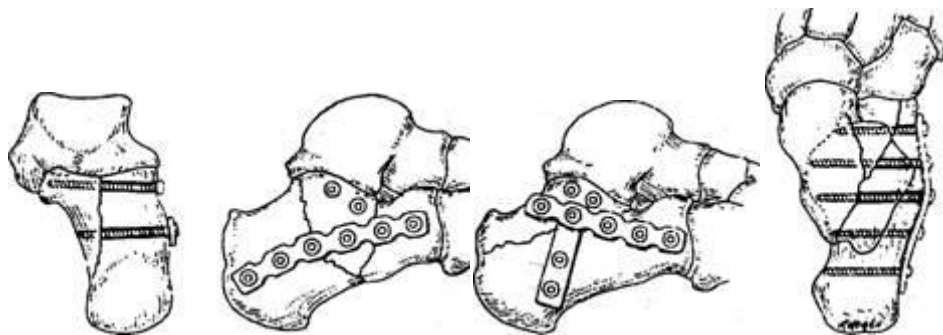
the angle of the Bellaire is normal and with fractures of the calcaneus

Treatment: For isolated marginal fractures of the calcaneal tubercle and fractures of the calcaneal bone without displacement \* of the fragments, after local anesthesia, a plaster bandage is applied to the knee joint with careful modeling of the arches. The foot is set at an angle of  $95^\circ$ . For walking, a heel or a metal stirrup is pinned. Walking with the support of the leg is allowed after 7-10 days. The duration of immobilization is 8-10 weeks. Working capacity is restored after 3-4 months. Treatment of comminuted or compression fractures with displacement of bone fragments is very difficult. The reposition is performed under intraosseous anesthesia or anesthesia. The lower leg is bent to an angle of  $90^\circ$ , the foot - to an angle of  $100-120^\circ$ , and then, creating an anti-pull for the anterior part of the foot, produce traction along the axis of the calcaneus. This eliminates the displacement of the fragments of the calcaneus along the length. In conclusion, the traction for the heel hillock in the plantar side eliminates the displacement of the posterior part of the calcaneus upwards, which restores the longitudinal arch of the foot. Lateral displacements are eliminated by compressing the heel bone from the sides with the hands or apparatus. To implement a more powerful pull for the fragments during reposition, a spoke is carried out through the heel hillock, which is fixed in a bracket, for the latter and produce traction. Repositioning with two spokes is more effective. One spoke for traction is carried out through the proximal fragment of the heel bone hillock, and for counter-traction-through the distal fragment of the anterior part of the heel bone at the level of the posterior talus surface. To accurately guide the needle through the desired fragment, the distance from the point of insertion of the needle to the inner ankle and calcaneal tubercle (clearly defined palpatory bone landmarks) is determined using a compass. Then, from these landmarks directly on the patient's foot, two arcs are drawn with a compass (according to the distances found), at the intersection of which the point of insertion of the spoke will be located. For fresh fractures, the reposition is performed simultaneously, for stale ones - within 1-2 weeks with the use of the Ilizarov apparatus. First, the fragments are distracted along the length of the calcaneus, then the angle of the Beler is gradually restored, synchronously moving the brackets along the corresponding arcs with the preservation (or strengthening) of the distraction force. In this case, the front part of the calcaneus rests on the talus bone, and the tubercle shifts to the plantar side. The degree of restoration of the longitudinal arch of the foot is controlled by an X-ray. The fragments are fixed with a bundle of spokes (percutaneously) and a circular plaster cast. After reposition, a long-circular bandage is applied to the middle third of the thigh. When the lower leg and foot are bent at an angle of  $110-115^\circ$ , special attention is paid to the modeling of the bandage for the formation of the arch of the foot. The duration of

immobilization is 3-4 months, and after 1 1/2-2 months, the bandage is shortened to the knee joint or replaced. If the closed reposition is unsuccessful, surgical treatment using bone grafts is used. A plaster cast is applied to the middle of the thigh for up to 3-4 months. Working capacity is restored after 5-6 months



*Reposition of calcaneal bone fragments by simultaneous skeletal traction . a - the initial stage; b - the final stage; b-the method of determining the location of the needle insertion ( using an X-ray image ).*



*Osteosynthesis in calcaneal bone fractures.*

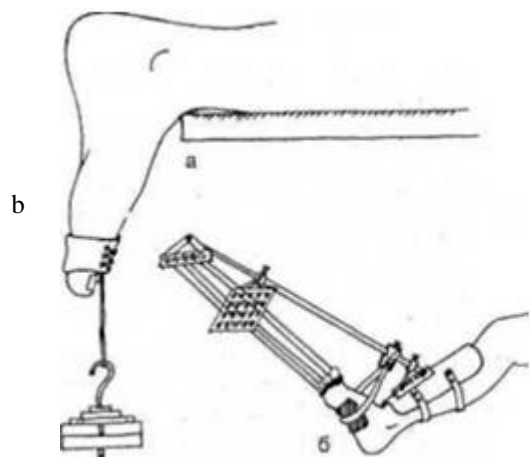
In case of a detached fracture of the upper part of the calcaneal tubercle in the form of a "duck's beak", a simultaneous reposition and the application of a plaster cast for up to 6 weeks (flexion of the lower leg up to 100° and plantar flexion of the foot up to 115°) is used. If the simultaneous reposition proves to be untenable, then open reposition and fixation of the bone fragment with one or two metal screws are used. The immobilization is the same as with a closed reposition. After removing the plaster cast, regardless of the treatment methods used, rehabilitation treatment is carried out using physiotherapy procedures, physical therapy and massage. To prevent the development of post-traumatic flat feet, it is mandatory to prescribe the wearing of an orthopedic insole-supinator. Currently, for the treatment of complex fractures of the calcaneus (especially old) or open injuries, the compression-distraction method is used

with the help of the Ilizarov apparatus. Under intraosseous anesthesia, three spokes are carried out in the frontal plane: 1-through the calcaneal tubercle, 2-through the cuboid and anterior part of the calcaneus, 3-through the diaphysis of the metatarsal bones. Impose a device of two half-rings and a ring. Moving the semi-ring with a spoke in the area of the heel hillock posteriorly, the displacement of fragments along the length of the heel bone is eliminated, and the tension of this spoke, bent in the plantar side, restores the arch of the foot. The tension of the spokes drawn through the area of the tarsus completes the formation of the longitudinal plantar arch of the foot. The non-removed displacement during one-stage reposition during treatment is corrected by microdistraction. The time of fixing the foot in the device is 2-3 months.

### FRACTURES OF THE METATARSAL BONES

There are fractures of the base, bdiaphysis and neck. In most cases, fractures occur as a result of direct trauma: falling heavy objects on the front of the foot, getting the foot under the wheel of a moving vehicle. Fractures are also observed as a result of indirect violence (falling from a height, sharp turning of the foot), as well as fatigue fractures. Fatigue fractures of the metatarsal bones are known in the literature as "marching fractures". The main signs of a fracture are swelling and pain in the back of the foot, sharp local soreness with axial load on the metatarsal bones through the corresponding fingers, extensive hematoma on the back and plantar surfaces of the foot. The final diagnosis is made after radiography of the foot in two projections.

**Treatment.** Fractures without displacement of fragments, isolated fractures of the II-V metatarsal bones are treated on an outpatient basis. Patients are put on a plaster cast from the tips of the fingers to the upper third of the lower leg, paying special attention to modeling the plantar arches of the foot. In an isolated fracture without displacement of fragments, the duration of immobilization is 6 weeks, in multiple fractures-8 weeks. To prevent compression of the foot by increasing edema, hematoma, the plaster bandage is immediately cut along the front surface throughout and fixed with a soft bandage, the leg is given an elevated position, cold is applied locally.



methods of repositioning the fragments: a-with the help of the cargo;  
- with the help of the apparatus

When the fragments are displaced, the reposition is performed under local anesthesia. By pulling on the fingers (using a gauze loop), the

traumatologist eliminates the displacement along the length, and by squeezing the fracture site-along the width. Reposition is possible with the help of the device. The duration of immobilization with a circular plaster cast is 7-8 weeks.



skeletal traction in metatarsal fractures

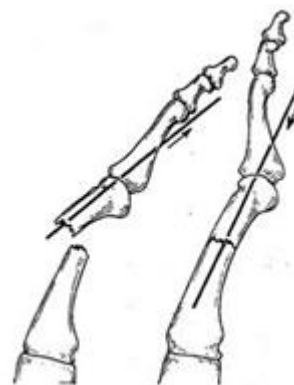
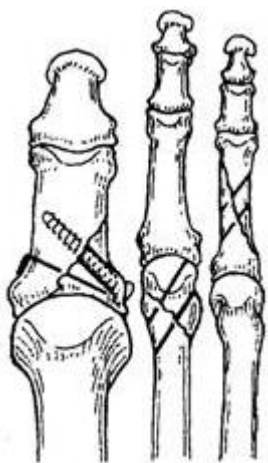


In case of a fracture of the First metatarsal with displacement, due to its importance in the supporting function of the foot, the victims should be referred to hospital treatment. The use of skeletal traction and external fixation devices increases the effectiveness of treatment. In the presence of significant edema or increasing hematoma on the back of the foot, to prevent circulatory disorders and the subsequent development of necrosis of the skin and soft tissues, it is necessary to dissect the skin, subcutaneous tissue and fascia along the outer-back surface, bind the bleeding vessels and remove blood clots; apply provision sutures and an aseptic bandage to the wound, and immobilize the limb with a dissected plaster bandage. 2-3 days after the reduction of edema and restoration of local blood circulation, the wound is sewn up. During development necrosis should be performed at an early stage of necrectomy, and the resulting defect should be closed with a skin flap. The non-rightness or unstopability of the fragments in a closed way serves as an indication for the operation. The set fragments are fixed with metal rods or spokes held intramedularly or transversely in an oblique or transverse direction. Immobilization with a plaster cast is continued for 6-8 weeks, the spokes are removed through the windows cut in the bandage after 3-4 weeks. After removing the bandage, they prescribe the wearing of orthopedic insoles-supinators for a period of 6-8 months, conduct courses of massage, physical therapy, paraffin or ozokerite applications. The ability to work is restored through 1 0 - 1 2 ned.

## FRACTURES OF THE PHALANGES OF THE TOES

There are such fractures quite often. This is due to the fact that the phalanges of the fingers are less protected from external influences. Most often, fractures are caused by direct trauma (a fall of gravity on the foot or compression of the fingers with a load) and relatively rarely-indirect. The most common fractures are the distal phalanges of the I and II fingers. These fingers, in comparison with the rest, protrude significantly forward. Complete fractures of the phalanx can be transverse, oblique, T-shaped or comminuted. In fractures of the phalanges of the toes in the first hours after the injury, significant swelling, pain at the level of the fracture during palpation, as well as with axial load on the damaged finger and passive finger movements; bruising is determined on the lateral and back surfaces, less often on the plantar side. Displacement of fragments in closed fractures of the phalanges of the toes in most cases does not happen. Sometimes the pull of the extensors leads to an angular displacement of the fragments, an angle open to the rear.

The displacement is particularly pronounced on the proximal phalanx of the thumb. Fractures of the phalanges of the toes are radiologically examined in direct and lateral projections. To clarify the displacement of the fragments, the image is taken in a semi-lateral projection (oblique).



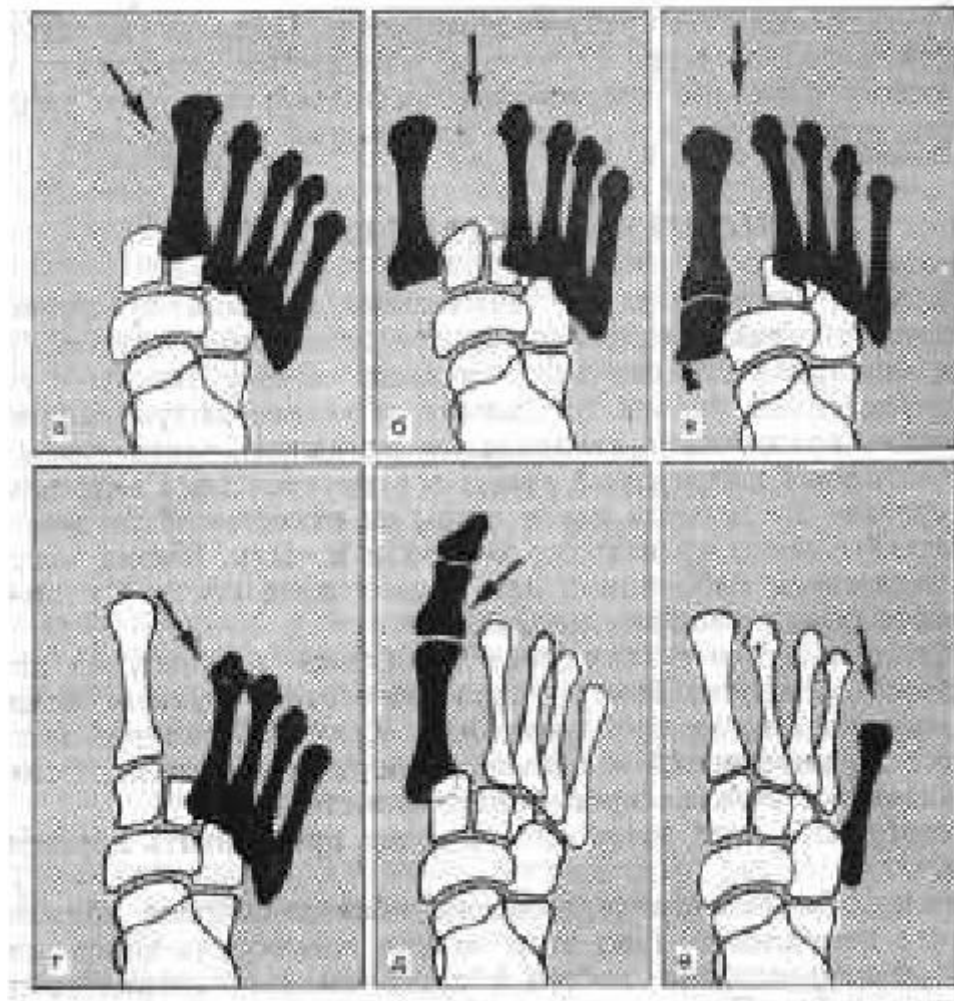
osteosynthesis with a needle

**Treatment.** In case of fractures of the distal phalanges without displacement of the fragments, it is sufficient to immobilize the fingers with a plantar plaster splint for a period of 2 to 3 weeks. To remove the submarginal hematoma, the nail plate is drilled or burned with a red-hot thin needle. Isolated fractures of the phalanges of the II-V fingers can be fixed with several layers of a sticky patch

in the form of a ring. Displacement of fragments of the proximal phalanges, especially the I finger, is eliminated under local anesthesia with a 1% solution of novocaine. By stretching the finger along the length using a gauze loop with simultaneous pressure on the fragments from the plantar side, the angular deformation is eliminated, then a well-modeled plantar plaster splint is applied for a period of 3 weeks. To fix the fragments, use spokes inserted percutaneously, followed by immobilization with a longeta for up to 3 weeks.

### **FRACTURES IN THE LISFRANC JOINT.**

Fractures of this localization account for up to 2% of the total number of traumatic dislocations of the limbs and 29% of the number of traumatic dislocations of the foot. In clinical practice, these injuries are quite common, but due to insufficient correct diagnosis, they are sometimes classified as rare. In most cases, dislocations in the Lisfranc joint are accompanied by fractures



Types of complete (a, b, c) and incomplete (d, d, e) fractures in the Lisfranc joint.

a-dislocation of all metatarsal bones to the outside;

b, c-divergent (divergent) dislocation;

d-dislocation of the II-V metatarsal bones outwards;

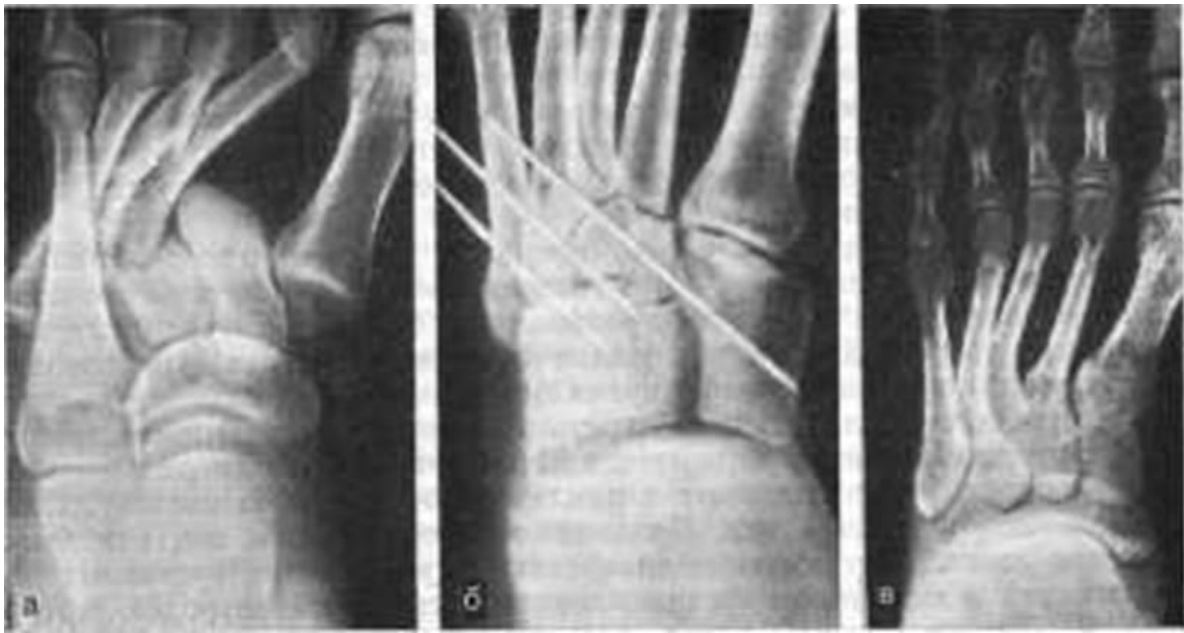
d-isolated fracture of the I metatarsal bone inwards and in the sole;

e-isolated dislocation of the V metatarsal bone outwards and posteriorly.

Dislocations and fractures in the Lisfranc joint are more common in men, which is explained by the nature of the physical work they perform in the workplace. The clinical picture of fractures and dislocations is characterized by severe local pain. Palpation, passive rotational movements,

slight compression of the forefoot cause sharp pain at the level of the Lisfranc joint. During the examination, the deformity of the foot characteristic of different types of fractures and dislocations is determined. Often there are signs of a disorder of the blood supply to the foot.

The diagnosis is specified by the radiograph.



Treatment. Reduction should be undertaken immediately under general, less often – under local anesthesia. Apply forced simultaneous traction for the distal part of the foot, and with an isolated dislocation-for the finger of the same name; at the same time, pressure is applied on the protruding bases of the metatarsal bones. Then, for 6-8 weeks, a non-quilted plaster cast is applied to the foot and lower leg. After removing the plaster cast, the patient should wear a supinator for 6-12 months. If the reduction fails, surgical intervention is indicated. After the reduction, repeated dislocations often occur. To prevent them, they should be fixed with 2-4 spokes, which are passed through the metatarsal bones into cuboid and triangular ones.