Surgical Treatment of Traumatic Lesions

Contents

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5.1 Healing of Traumatized Biological Tissues

In foot and ankle surgery, soft tissue is relatively thin and requires particular care. Attention should be focused on the direct approach to the underlying structures to be treated. Undermining the thin soft tissue and using steady retractors harm the perfusion and jeopardize healing. Multiple incisions to the skin are not a problem per se. On the other hand, periosteo-fascio-cutaneous flaps can be created if the rule of thumb relating to centrifugal distribution of the vascular supply around joints is respected. This may help a lot when choosing approaches, especially in trauma.

Strain, or relative motion between fractured or ruptured biological tissues in general, limits healing of all living tissues [72] which react differently with regards to each other.

5.1.1 Bone

Direct bone healing only occurs if interfragmentary strain (or relative motion) is less than 2%. In mechanical conditions which include higher strain values, ***indirect bone healing*** occurs: bone resorbs at the extremities of the bone fragments (e.g. fracture site) [73]. The increased distance between the fragments while the interfragmentary mobility remains constant results in strain reduction. Periosteal callus is produced in the area of reduced strain and immobilizes the fragments. If the strain cannot be reduced by those natural means, non-union and pseudarthrosis ensue. This may be the case in single, simple fractures: strain due to relative motion between two single fragments concentrates in a single spot. If the environment of the bone extremities is non-vital or necrotic, natural stabilization cannot occur and the non-union remains atrophic. The same principle applies in arthrodesis. Fusing a single joint when a neighbour joint has been fused previously may be indicated about the foot and ankle. This condition renders the desired treatment more difficult due to the concentration of strain and should alert the surgeon to the need to optimize the biomechanical environment of the arthrodesis to avoid the dreaded non-union.

5.1.2 Cartilage

Cartilage does not heal if the tissue layers are submitted to a strain higher than 10%.

5.1.3 Granulation Tissue

Granulation tissue and probably subcutaneous tissue and skin cannot heal if relative motion exceeds 100%.

In conclusion, **reduction of strain of divided tissue enhances consolidation**.

On the other hand, joints undergo deterioration if they are immobilized during a relevant period of time [74] (“fracture disease”). Mobilization of joints soon after fractures forms the basis of internal fixation of fractures and continuous passive motion (CPM) [75] considerably reduces this invalidating condition. In the particular case of the upper ankle joint, up to 6 weeks of immobilization is clinically irrelevant to the end result.

There is thus a comfortable safe period of a few weeks after open surgical treatment of foot and ankle diseases and trauma which can be addressed to **reduce strain of the soft tissues by immobilization**. Optimal immobilization seems to be achieved by the ***Jones’ dressing cast*** [25,76]. The idea is to keep the surgical situs within a sterile environment together with a minimal relative motion of the skin and subcutaneous tissues. The quality of the rigid “shell” that is applied onto a compressed soft and sterile padding is probably very relevant. Plaster of Paris fulfils the requirements thanks to its moulding properties.

The principle of the original dressing popularized by Sir Robert Jones is completed by the resilient stability provided by the plaster without harm to the soft tissues.


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The multiple incisions about the foot and ankle are covered by moist, gel medicated gauze pads and sterile gauzes. The foot and lower leg are then padded with a significant layer of cotton and a cover of plaster of Paris immobilizes the dressing [38]. The first look at the operative wounds in programmed cases thus occurs after 2 weeks ***(T637)***.

Further functional care after this time depends on the procedure and includes the ankle, foot and orthosis (***cam-walker***),


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which allows for partial or full weight-bearing by ***reducing the mechanical lever*** on the foot by a convex sole. Walking around in bad weather conditions under full weight-bearing while still applying the cam-effect can be eased by an ***air permeable "snow-boot"-like cover***.


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Air-proof coverage such as polyethylene folders should be avoided all times because of the immediate creation of wet chambers.

5.2 Tendon Ruptures

5.2.1 Achilles Tendon Rupture

Ruptures of the Achilles tendon rarely occur within a full and healthy tendinous structure. There is often a vascularity problem involved or chronic tendinitis. A healthy, young heel cord holds in at least 1500 Newtons in a static mode. In dynamic load (e.g. running), the stress supported by the tendon can reach up to 8000 Newtons. Physiological data support that full weight-bearing of the lower limb and walking does not imply evident muscular activity of the gastrocnemius musculature. The scope of the treatment is thus the firm anatomical adaptation of the separated limbs of the tendon and firm hold of the upper ankle joint using a cam walker. Such treatment allows for full weight-bearing during the phase of consolidation. Secondary lengthening of the tendon after suture does not depend on a post-operative weight-bearing regimen [77].

The Achilles tendon is covered by very thin subcutaneous and skin layers. This region makes it very vulnerable to perfusion of the local soft tissues. Local skin microvascularity seems to follow a "horizontal" pattern between a strong medial (posterior tibial artery) and a lateral (peroneal artery) along the axis of the hindfoot [78]. The patient is placed prone with both legs lying on a transverse roll to have both feet hanging free. The tourniquet is placed on the thigh. Directly beneath the subcutaneous tissue, ***the peritenon is evaluated. No static distraction is applied to the skin.***

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It is safe to incise the skin along the long axis of the heel cord taking care not to touch the posterior crest of the underlying tendon which is poorly supplied by the arterial network. ***Skin incision is therefore positioned about 1.5 to 2 cm medial from the posterior crest.***

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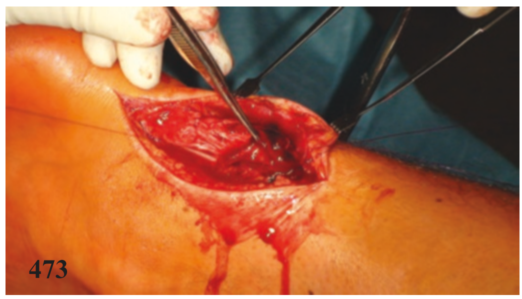
This approach allows the surgeon to keep away from any problem involving the sural nerve which might be endangered using a blind, percutaneous technique. At this point, the tendon ends are brought close together achieving at least a slight equinus of the foot that can be seen on the contralateral side ***(E88)***. This corresponds to the elastic recoil of the triceps surae which is always present under physiological conditions. Closing this suture should allow for positioning the foot in a plantigrade position with a slightly superior force as needed on the contralateral foot. A few reinforcing sutures complete the mechanical fixation. At this stage, knowing the essential nature of the peritenon to the regeneration of tendinous tissue [79], ***the peritenon is adapted above the tendon using a fine continuous suture thus closing the tendinous compartment***.



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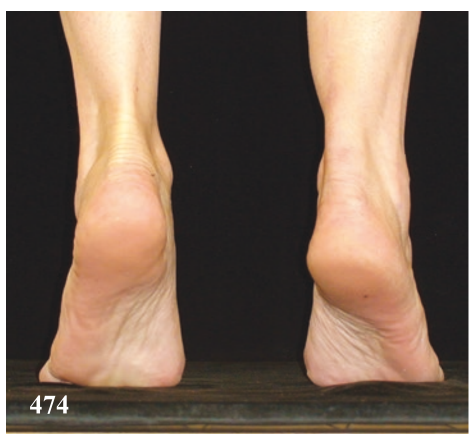
Tension of the tendon after suturing determines the rehabilitation capacity of the triceps surae. Stability of the montage is checked by holding the foot manually in orthogonal position. Final fixation will be using a closed lying cast in orthogonal position of the foot for 2 weeks.

Careful soft tissue handling allows for rapid rehabilitation and muscular power should come ***close to normal at 3 months.***



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5.2.2 Anterior Tibial Tendon Rupture

Ruptures of this tendon seldom occur but they often follow local injections of corticoid solutions causing necrosis. If the patient receives attention within a reasonable time, the stump may be found and ***reinsertion is anatomically feasible (E116)***.


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Due to the "missing structure" after such necrosis, and also to secondary retraction in those cases that do not seek immediate orthopaedic assistance, it is wise to look for a strong tendon substitute. The long extensors of the toes may be harvested easily at the metatarsal level and brought together to be fixed at the anatomical insertion site of the anterior tibial tendon. In order to save the functional stability of the toes, the distal limbs of the tendons are fixed individually onto the corresponding short extensor tendon of the toes.

5.2.3 Posterior Tibial Tendon Rupture

Although uncommon, and particularly underdiagnosed, the traumatic posterior tibial tendon rupture occurs mainly in active, middle-aged patients. Rupture occurs at plantar reception from a fall from a relevant height. The foot gets stressed in forced abduction, pronation and extension. Such as in many traumatic ruptures of the heel cord, there is probably no clearly definable degenerative aspect of the tendon prior to trauma. The consequence to this often-unrecognized pathological entity is a rapid alteration of the normal alignment of the foot, along with pain and joint degeneration.

5.3 Fractures

A fracture is a traumatic solution of continuity of the bone. As such, the anatomical restoration of the bone is clearly the optimal treatment. As a biological structure, the fractured bone causes immediate discharge of blood which accumulates as haematomas within generally confined spaces. Within the foot, there are a number of relatively small compartments which are separated by strong fibrous tissues. Those compartments contain muscles (intrinsic) and nervous structures which are very sensitive to hydraulic pressure and a fresh haematoma due to, e.g. a displaced fracture is likely to produce a local compartment syndrome with deleterious consequences [31, 80]. It is probable, though, that severe fracture-dislocations rupture most of the relevant intercompartmental walls and produce swellings which may jeopardize the vitality of the skin. In both cases, the hemodynamic, "hydraulic" period lasts up to 6 hours and surgical removal of the haematoma should be considered, if possible, together with the definitive bone and joint repair. Not to operate a malleolar fracture because of the swelling is unjustified if it is possible to start surgery within the first 6 hours after the trauma. After this period, the metabolic action of tissue oedema may put the soft tissues at risk when involving open surgical approaches because the swelling is intracellular and cannot be removed by open surgery.

Fractures about the foot most often involve joint surfaces. When evaluating those fractures and elaborating a plan of treatment, it is mandatory to know if those joints are essential or not for function. Essential joints should be reconstructed anatomically while non-essential joints may be used to reestablish functional orientation of the foot by fusion. Due to the importance of bone and joint alignment in the foot, the shape and dimensions of the bone are essential to restore after trauma.

Fracture treatment by means of reduction and fixation in the foot and ankle is thus mainly a matter of surgical approaches (cf next chapter), chronology (strategy) and rational tips and tricks.

5.3.1 Ankle Fractures

Malleolar and pilon fractures may safely be fixed by using one to three simultaneous open surgical approaches [81].

The fibula is poorly covered by soft tissue. The strict lateral incision and, especially, a lateral application of a plate may disturb healing and function. A longitudinal incision is best placed ***postero-lateral to the fibula***.

The *tibio-talar joint* is best visualized either from the front or the back or both. The anterior approach to the medial malleolus, taken along the axis of the vena saphena magna, is vascularized on both edges by vessels originating from the anterior and posterior tibial arteries [81] and thus allows visualizing and correct reduction of the crucial ***anterior arch of the medial malleolus***.

The posteromedial approach of the distal tibia, between the neurovascular bundle and the flexor hallucis longus allows visualizing and reduction of fractures of the posterior rim of the tibia ***(T611)(T667).***

5.3.1.1 Malleolar Fractures

The malleolar fracture is a lesion of the stabilizing part of the ankle joint. Due to the strong mechanical interaction between bone and ligaments, it may be important to interpret conventional radiographs to understand the comprehensive osteo-articular lesion which includes bone fractures and torn ligaments. As mentioned above, (p.33) the medial malleolus is the main and steady pillar of the ankle joint. The lateral malleolus plays the role of semi-mobile guide of the talus which might yield in traumatic external rotation.

If the external rotation trauma occurs in a plantar-flexed upper ankle joint, the narrow part of the talus is located between both malleoli and the talus and exerts a strong sheer onto the tip of the fibula. The fibula thus yields with an oblique fracture ***starting below the anterior tibio-fibular ligament and ending posteriorly about 1–2 cm above the joint***.


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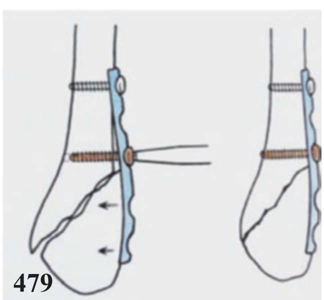
In most of the lateral malleolar fractures, the distal fragment goes posteriorly, together with the usual shortening of the bone along the oblique course of the fracture.

Reduction goes through the opposite way to the fracturing, by sliding the distal fibula along the oblique fracture site. The fixation means aim at avoiding recurrent dislocation. Plates may function as fixing devices ***acting like springs***: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their wide application surface reduces the pressure on fragile bone which has to be reduced. The postero-lateral aspect of the distal fibula allows for fixing a plate on solid cortical bone and thus offers a relatively large surface on its distal aspect for pressing safely the more fragile distal malleolus ***in the desired antero-medial direction*** [82].


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If the medial pillar, the medial malleolus, is also ruptured, the ***talus is not held to the lower leg by any structure*** and thus dislocates completely out of the malleolar mortise. The first aim is thus ***to reduce the dislocated joint***

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and to fix the medial malleolus anatomically. The approach is ***antero-medial***, parallel to the saphenous vein ***(F477)***.

After ***anatomic reconstruction of the medial malleolus***,


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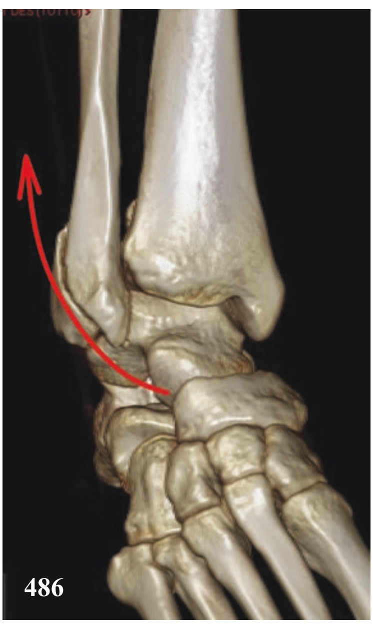
using screws, wires and/or pins, the fibula is then reduced and fixed through a postero-lateral approach ***(T613)***.

Fracture-dislocations of the upper ankle joint may include a partial or full lesion of the deltoid ligament without fracture of the medial malleolus.

This may be the case if the external rotation trauma is more violent, pushing the talus posteriorly, hinging more or less on the medial ligamentous structures. The talus thus pushes against the posterior aspect of the tibial plafond which yields under a load on a level which depends on ***the axis of the applied force within the sagittal plane.*** This axis correlates logically with the inclination of the shear fracture of the fibula.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Interestingly enough, the anterior, intermediate and posterior tibio-fibular ligament (syndesmosis) ***(O255-256)*** may remain intact together with the anterior fibula-talar ligament. The foot moves with both fibular and tibial fragments as single unit in external rotation.

The deltoid ligament covers a wide surface beneath the medial malleolus. After reduction of the dislocated joint, it is essential to verify that all layers of the ligament are located at their anatomical sites. Accidental interposition of ligamentous structures within the joint must be looked for and removed. Healing occurs through scarring in an uninterrupted orthogonal position of the hindfoot. Useful ***suturing of the deltoid ligament is illusory***.


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5.3.1.2 Rupture of the Distal Tibio-Fibular Syndesmosis

If the forced external rotation applied on the foot occurs in a "locked" ankle position, in which the wide part of the talar dome lies between both malleoli (dorsal extension of the joint), ***the anterior tibio-fibular ligament (syndesmosis) is torn, most often through an avulsion on the fibular side*** [83].


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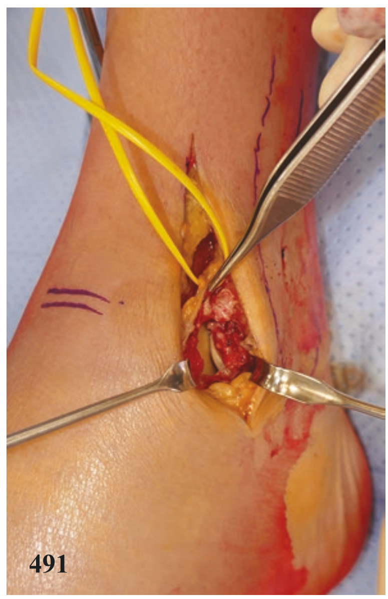
This can occur with or without a fracture of the distal fibula. The lesion which is linked to the tibio-fibular syndesmosis may run proximally through the interosseous membrane, dissociating the fibula from the tibia. This lesion ends with a fracture on the proximal aspect of the fibula.

Logically, such a fracture can be located on any level above the upper ankle joint. The rotation and length of the fibula is best performed through open reduction and internal fixation of the fracture. In selected cases though, including fractures located at the proximal epiphysis of the fibula, the best option to avoid jeopardizing the fibular nerve is to concentrate surgical care to the lateral aspect of the upper ankle joint. Anatomical reduction of the distal fibula onto the lateral aspect of the distal tibia and lateral talus is best controlled by direct visualization. At this location, ***the superficial fibular nerve crosses the field and is best protected by a loop***.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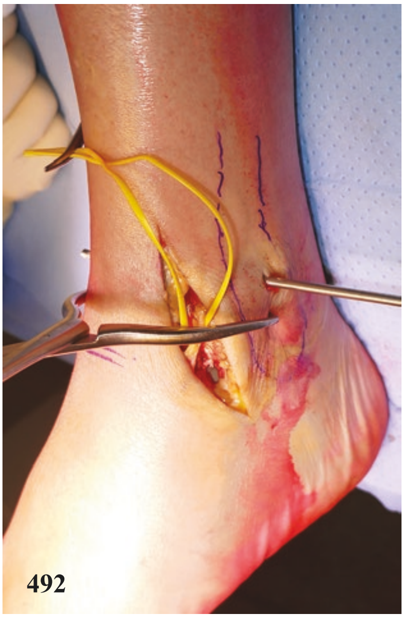
In any case, the lateral malleolus must be secured back to its buttressing position of the lateral talus.

An efficient procedure is to compress the distal fibula against the tibia horizontally at the level of the syndesmosis using ***forceps (T588) between the tibia and the fibula***



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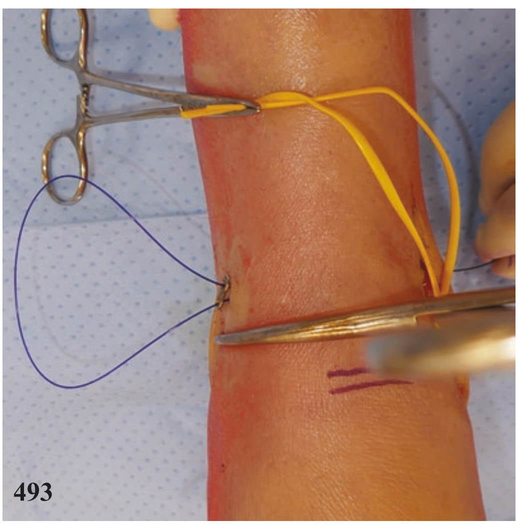
at the level of the syndesmosis. Optimal fixation of the syndesmosis takes into consideration the relative physiological mobility between tibia and fibula. A trans-syndesmotic strong suture is ***inserted as a loop***



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which holds the medial cortex of the tibia and the lateral cortex of the fibula, pulling down the distal fibula within its tibial gutter.

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5.3.1.3 Pilon Fractures

The fracture of the pilon tibial is a ***lesion of the weight-bearing part of the ankle joint***.

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This fracture is most sensitive in the anatomical restoration of the peripheral edge and border of the joint surface. The lateral pillar of the tibia by means of the antero-lateral corner of the joint which carries the tubercle of Chaput is one of the critical locations. The ankle is poorly covered by soft tissue and therefore surgical approaches are essential to avoid eventual necroses. In general, up to three approaches can be used simultaneously to safely fix a pilon fracture [81]. A ***longitudinal incision centred on Chaput's tubercle***

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saves the blood supply from the anterior tibial artery on one side and the ***anterior fibular artery*** on the other side ***(T605)***. This artery perforates the interosseus membrane at about 2 cm above the anterior syndesmosis and ***runs antero-laterally to join the sinus tarsi vessels***.

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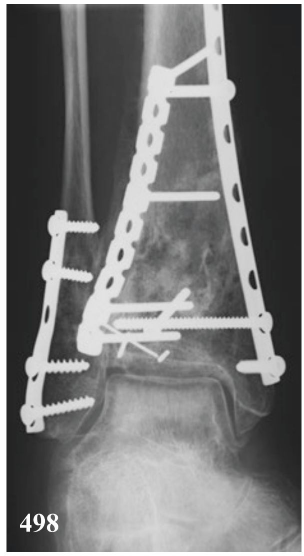
Buttressing the antero-lateral pillar of the tibia



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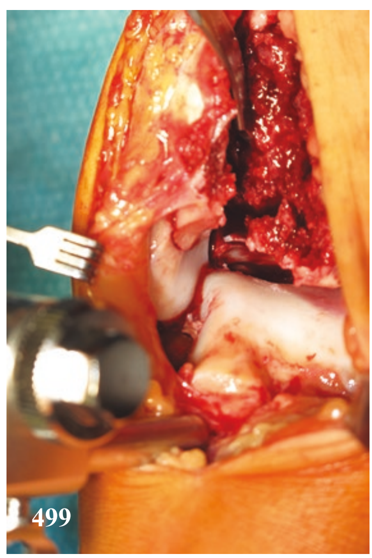
by a more proximally anchored plate avoids secondary impaction of the joint surface. Such impaction causes a peripheral joint incongruency which destabilizes the joint and leads to post-traumatic arthrosis.

In pilon fractures, of which there are several, particularly centrally dislocated fragments, steady intra-operative joint distraction by a ***"distractor"*** locked ***in the tibia and the talus*** allows for instrumental space to reduce the fragments of the joint surface ***(T655)***. This is particularly useful laterally, for antero-lateral impaction of the Chaput's tubercle or medially, ***at the anterior aspect of the medial malleolus.***



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A second rationale vision of the pilon tibial is performed through a ***postero-medial approach (T608-611)***.

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The incision is located halfway between the heel cord and the medial malleolus leaving the posterior tibial artery and the tibial nerve medial. This pathway allows for saving the arterial supply of the talus. The flexor hallucis longus muscle can be retracted laterally from the approach to the bone. In complex intra-articular fractures, which completely separate the joint surface from the proximal tibia, the posterior direct visualization and anatomical reduction of the posterior articular edge of the tibia shall be the first step to the reconstruction of the joint.

As a second step, still under joint distraction, alignment of the anterior part of the articular fragments from the anterior aspect of the joint is eased considerably.

The fractured fibula is approached through a third and separate incision which runs preferentially ***posterior to the lateral crest of the fibula***

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to avoid painful scarring ***(T613)***.

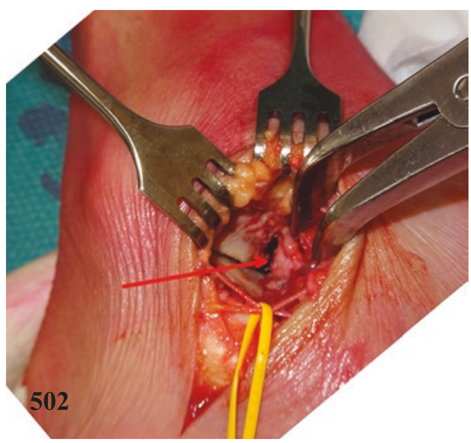
5.3.2 Fractures of the Talus

The talus acts as the intermediate link of a cardan joint. The two corresponding joints are the upper ankle joint and the talo-calcaneo-navicular joint or lower ankle joint. This unique position within the human lower leg means the bone is covered by about 80% cartilage of four major joint surfaces. It is thus clear that the integrity of the cartilage layers, their position and their orientation is of major importance for stable function of the foot. Reconstruction of fractures of this bone ideally requires the direct vision of the involved joint.

Talus fractures may be divided into two different types of lesions.

5.3.2.1 Peripheral Fractures

In peripheral fractures, there is a joint problem due to an external force such as a dislocation or quasi-dislocation in one of the four joints which link the talus to the upper ankle joint, the calcaneus and the navicular bone. The centre of the talus remains intact while the fracture causes a joint incongruence which impedes smooth articular function. Untreated, those fractures lead to joint stiffness and arthrosis. The most common peripheral fracture of the talus is the fracture of the lateral process, commonly called "***snowboarder's fracture***" ***(E110)*** which occurs at a forced pronation about the talo-calcaneo-cuboidal joint (coxa pedis) (right foot).



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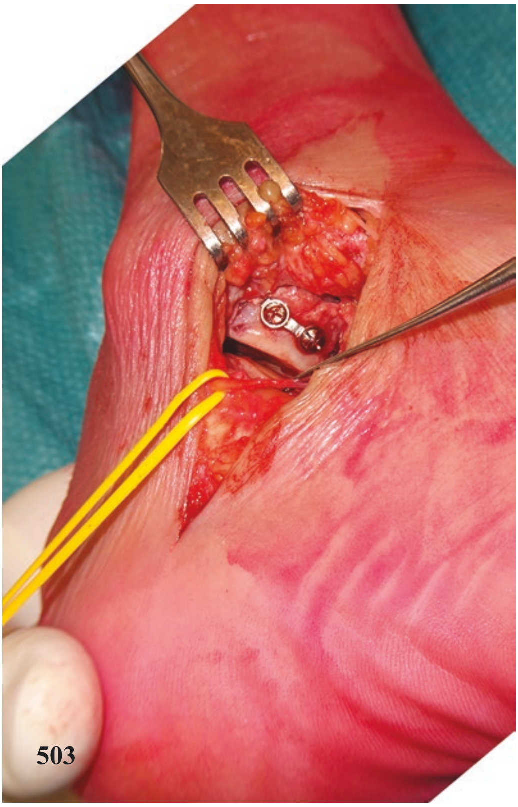
Evaluation of this lesion is not easy because there are two options for re-establishing smooth and pain-free articular function: anatomic reduction and stable internal fixation or debridement and resection of occasional small fragments. The first option is taken when the fracture produces a large and monolithic fragment, easy to handle for ***fixation***



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The second option is taken when the fracture produces multiple fragments where the articular portion cannot be recognized and, furthermore, is not re-fixable.

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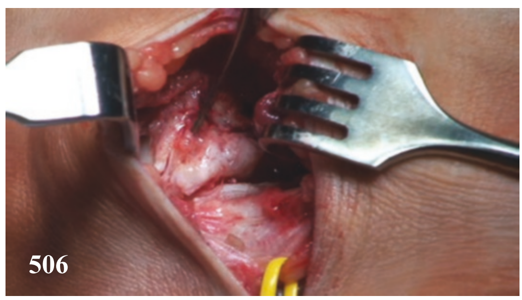
The fracture is ***directly inspected*** (right foot)



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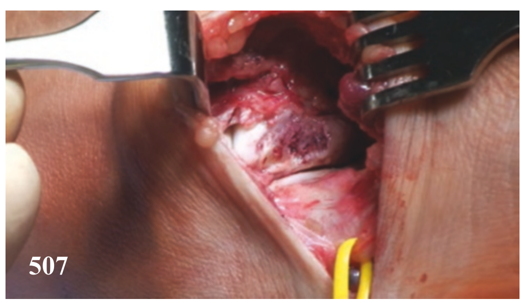
and ***judged to be resected***



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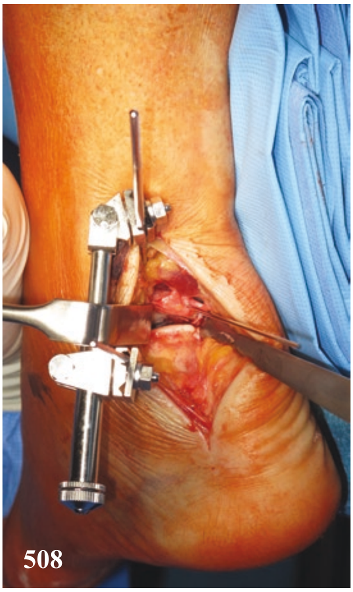
thus leading to excellent functional and pain-free results.

Natural healing of a fragmented lateral process of the talus may lead to painful impingement ***(E110)(O244)*** about the crucial angle of Gissane and secondary arthrosis of the subtalar joint.

A similar condition may occur in maximal flexion of the upper ankle joint. Abutment of the posterior process of the talus may produce its fracture. Here too, ***either removal or refixation*** of the fragment is indicated ***(O215-216)***.



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5.3.2.2 Central Fractures

Central fractures including neck fractures of the talus occur particularly in a locked, plantigrade hindfoot. Those fractures can be produced "in vitro" by applying violent stress along the lower leg axis [84,85]. Forced hyperextension of the foot is known to produce fractures of the tibia, in particular, malleolar and pilon fractures without harming the talus [86].

In ***central fractures,***

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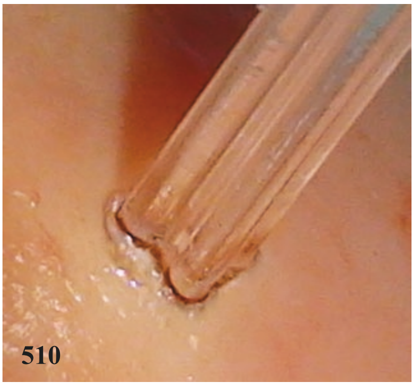
the general shape and external dimension of the foot is jeopardized. This fracture separates the upper ankle joint from one or both other joints. Under this aspect, the fracture type can be compared to the so-called "two-column fractures" of the acetabulum or to the more complex distal articular fractures of the tibia (AO 43-C fractures).

Untreated, those fractures lead to misalignment of the whole foot with consecutive dysfunction and disability.

5.3.2.3 Approaches

Both peripheral and central lesions can, of course, run together.

Peripheral fractures may be approached directly through one single approach, wherever they occur, and the complexity of the talar joints is such that the fracture fragments in selected cases may be better removed rather than reduced and fixed. The function of the local joint needs to be assessed case by case to achieve a rationally sound treatment, taking into account the eventual risk of post-traumatic bony impingements. Some fractures involve essential aspects of the bone and due to their small dimensions, fixation means may include fibrin glue and/or ***rotational stable (bone guiding) resorbable pins***.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Central fractures of the talus


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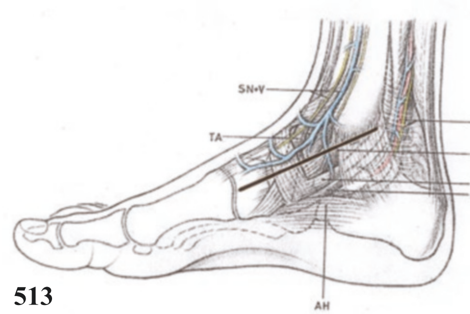
should be reduced and fixed from at least two (sometimes three) approaches ***(T614)(T622)*** because both joints, above and below the talus, are involved and the medial and lateral side must be checked for reduction. Involving the shape of the whole bone which guides four major joints about the hindfoot, a minute misalignment of the "shell" of the bone may lead to an unacceptable shape on the other side of the bone. The most rational approaches (best efficiency/morbidity coefficient) may be found in the **longitudinal medial approach** ***(T615)*** from the tibialis posterior tendon insertion passing above the sustentaculum tali, **the antero-lateral oblique approach** ***(T620)*** (modified Ducroquet approach [87]) and the **postero-lateral vertical approach** ***(T600)***, parallel to the heel cord [88]. All three approaches can be performed simultaneously in a normal vascular environment.

Medial Approach

The ***medial approach***



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is meant to visualize the subtalar joint congruency between the talar head, the navicular and the sustentaculum tali as well as the continuity of the medial wall of the talus. In selected cases, in which the fracture is located in the middle third of the bone, an ***osteotomy of the medial malleolus*** and the tilting of it downwards and towards posterior allows an improvement in the visualization of the fracture while keeping the postero-medial blood supply, which comes from the posterior tibial artery, protected. A ***distracting device fixed between the tibia and the calcaneus***


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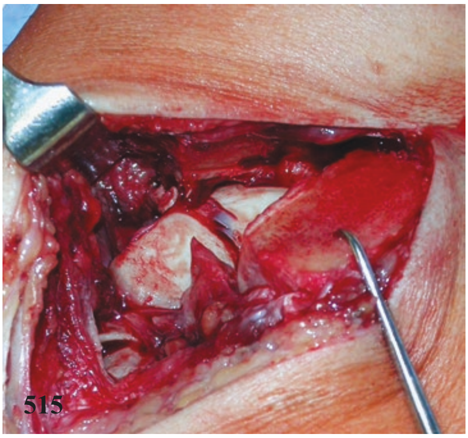
allows for simultaneous ***visual control of the medial tibio-talar and subtalar joint surfaces***.



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Antero-Lateral Approach

The ***antero-lateral approach (T620)***

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is used to visualize the lateral subtalar joint and the bony wall between neck and processus lateralis tali [87].

This approach is optimal for visualizing the ***processus lateralis tali, and includes eventual static distraction between the lateral aspect of the talar neck and the tuber calcanei.***

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The entire region is visualized without relevant damage to the soft tissue, having both edges of the skin vascularized by the branches of the tibialis anterior artery and the lateral calcaneal artery. The musculus extensor brevis of the toes is reclined from proximal to distal, it covers well the bony situs and allows visualization of the lateral aspect of all four bones of the hindfoot: the talus, the anterior part of the calcaneus, the navicular bone and the cuboid.

Postero-Lateral Approach

The postero-lateral approach ***(T600)*** is performed in one precise, single plane, running parallel to the heel cord and medial to the nervus suralis [44,88]. This approach naturally gives the ***optimal axis for screws fixing talus neck fractures***.

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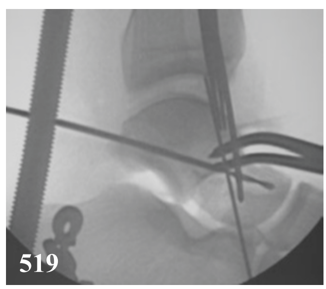

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The distal belly of the musculus flexor hallucis longus is kept medially, protecting the neuro-vascular bundle. The entire posterior articular aspect of the subtalar joint is visualized, together with the posterior aspect of the upper ankle joint.

5.3.3 Calcaneus Fractures

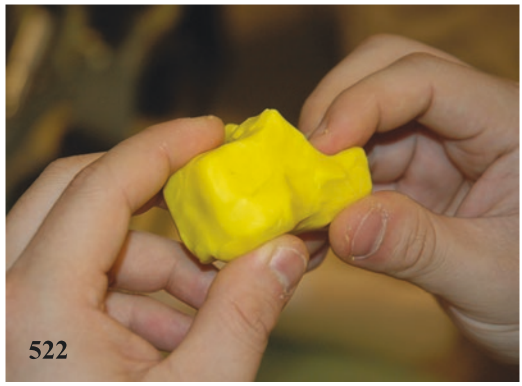
Calcaneus fractures follow a similar fate to the central talus fractures. A particular aspect of calcaneus fractures is the high risk of bleeding within the deep compartment of the foot, increasing the intra-compartmental hydraulic pressure and compartment ***syndrome*** [31]. This occurs more often in simple, but dislocated fractures where the inter-compartmental walls are intact. Thus, the diagnosis must be done at once to avoid the irreversible consequences. The latter include shortening of the quadratus plantae muscle and the shortening of the flexors of the toes. In the long run, the forefoot presents ***multiple distal hammer toes***.


520


521

Avoiding compartment syndrome of the foot necessitates, after recognition of pathological intra-compartmental pressure, the urgent release of the inter-compartmental walls (septae or aponeuroses) [80].

Reduction and internal fixation are indicated for all fractures which include intra-articular courses. Even non-displaced intra-articular fractures of the calcaneus are known to show a high likelihood of secondary displacement which can produce an articular step. Another particular aspect of calcaneus fractures is that the shape and outer dimension of the bone are mandatory for uneventful function. For this reason, learning and teaching open reduction and internal fixation of calcaneus and talus fractures may be made easier by using soft malleable materials (plastiline) [89].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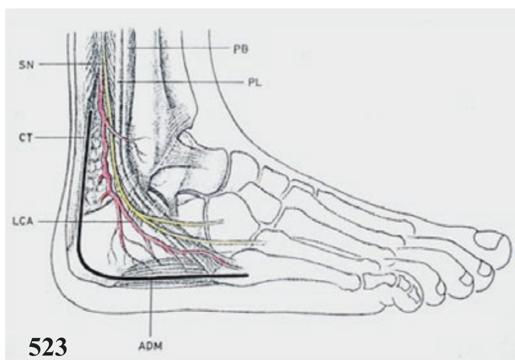
The aim is thus to restore the shape and orientation of the whole bone. A vascular-safe approach [33] is made ***respecting the vascularity of the lateral submalleolar aspect of the foot***.



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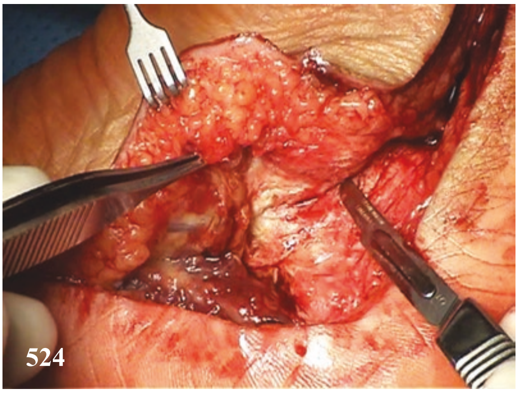
The vascularity of the soft tissue about the hindfoot is "centrifugal". By centrifugal vascularity, we mean a main source of blood supply from the deep layers at the centre of a joint and vascularity which spreads out centrifugally from this centre. The main weight-bearing function of the calcaneus occurs at the posterior facet which is located beneath the lateral malleolus. It is therefore logical to approach, visualize and repair the posterior facet from a lateral approach using the soft tissue of the postero-lateral aspect of the foot like a soft tissue flap. The ***postero-lateral periosteo-fascio-cutaneous flap*** [90]



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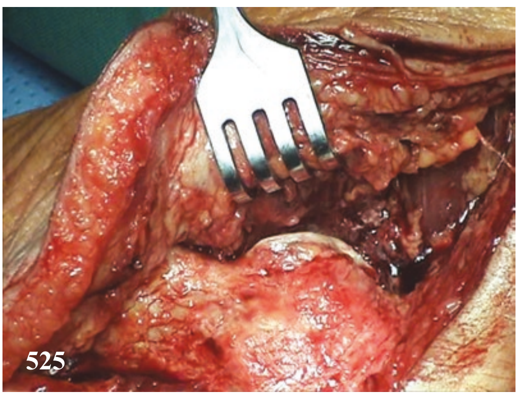
is reclined upwards allowing for visualization of ***the subtalar***



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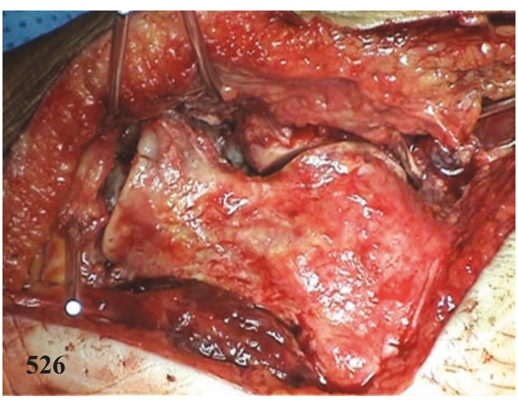
and **calcaneo-cuboidal joints** [91].



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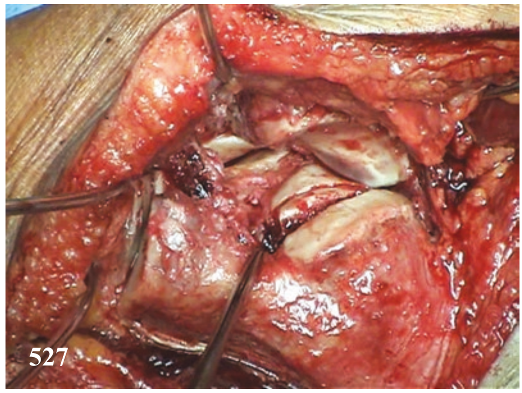
The medial aspect of the subtalar joint (***sustentaculum tali***) may also be visualized and checked with this approach.



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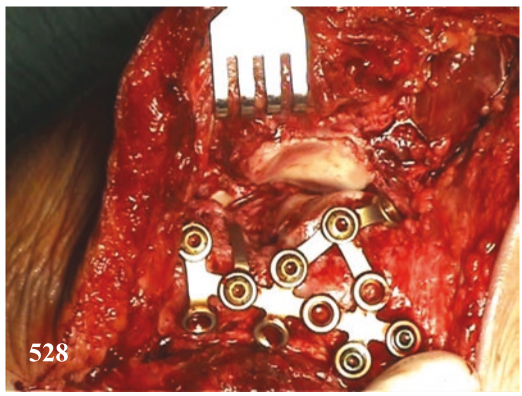
Congruency of the articular surfaces after fixation of the fragments is perfectly visualized



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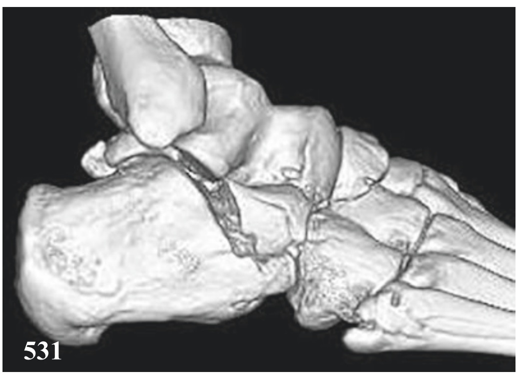
and the approach is safe for ***rapid consolidation of the soft tissues.***

529

Such anatomical reconstruction allows for a good, ***long-lasting result (11 years follow-up).***

530

In rare cases of anterior calcaneus fractures, meaning fractures of the ***processus anterior calcanei***, the safe approach respecting the vascularity of the soft tissues is the oblique antero-lateral approach of the hindfoot [87]. Those fractures occur through the yield of the midtarsal joints. The navicular bone dislocates towards medial together with the cuboid and in some cases with a part of the anterior process of the calcaneus (swivel lesion) [92]. So-called ***Chopart fracture-dislocations***



531

also produce these kinds of lesions. For this reason, those fractures are often linked to a fracture of the talus which is addressed through the same approach.

Medial calcaneus fractures involve the ***sustentaculum tali.***

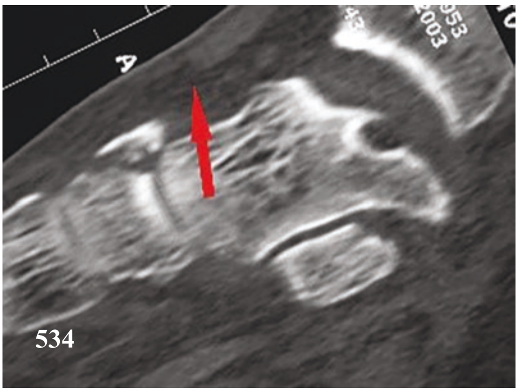
532

These fractures are severe lesions because the sustentaculum tali holds the talus at its physiological height. This fracture also corresponds to a protrusion of the talus within the acetabulum pedis by breaking its posterior wall. A minimal dislocation of this fracture should be reduced and fixed anatomically for proper articular function. The sustentaculum tali, like the medial malleolus of the upper ankle joint, is the fixed reference spot for the whole joint ***(E107).*** The best approach is performed directly on the sustentaculum tali between the tendons of the flexor digitorum longus and the flexor hallucis longus (***E119)***. The local bone offers a good hold ***for screws which cross the whole calcaneus***.

533

5.3.4 Fractures of the Navicular Bone

The acetabular cup of the coxa pedis represents an essential factor for a functional pro/supination of the hindfoot. The anterior wall of the acetabulum pedis ***(E114)*** is represented by the proximal articular facet of the navicular bone. Similar to the acetabulum in which the most frequent fracture is the posterior wall fracture due to posterior subluxation of the femoral head, dorso-lateral subluxation of the talar head causes a ***dorso-lateral fracture of the navicular bone.***



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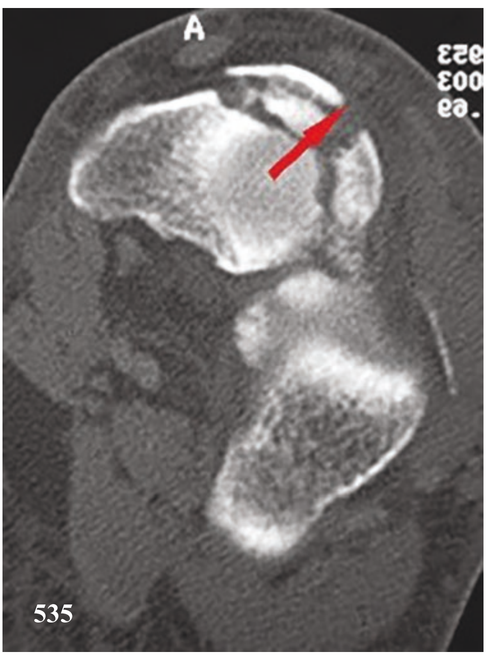

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When compared to the acetabulum coxae and its fractures [93], these lesions must be reduced perfectly, aiming at anatomical reduction of the joint surface. In this case, a ***single antero-lateral approach can be sufficient for the treatment.***


536

In more central fractures, due to protrusion of the coxa pedis, ***both extremities of the navicular bone may diverge.***

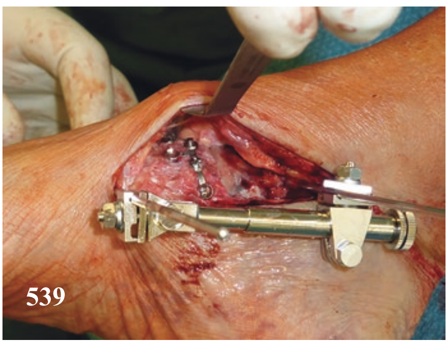

537

Similar to central fractures of the talus, it is logical to approach those fractures from medial and lateral to check for anatomical reduction. This allows for the checking of joint congruency at both extremities of the bone. Insight to the joint surfaces, such as for pilon and talus fractures, is best provided by

static bone distraction between the adjacent bones, the talus and the cuneiforms.


538

The “bipolar” medial and lateral view allows for limiting occasional devascularization of the bone. The plantar aspect of the navicular remains attached to the strong spring ligament or plantar calcaneo-navicular ligament. This part may represent the reference fragment in multifragmented fractures [94]. Multifragmentary fractures may thus be secured for functional after-treatment with the ***help of a dorsal plate***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and occasional locking ***screws to be fixed to the plantar reference fragment***.


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The naviculo-cuneiform joint facets can be considered non-essential joints and may help in finding a reference grip to the occasional screw fixations which cross those joints.

The aforementioned “Chopart fracture-dislocations” ***(F531)*** involve the “crossroads” of the hindfoot by means of the space between talus, calcaneus, navicular and cuboid. The ***combination of navicular and talus fractures***

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542

belong to those lesions and should not be missed. Any suspicion of traumatic lesions in this region should be followed up by a detailed CT examination.

5.3.5 Tarso-Metatarsal Fractures

Surgeons should be highly attentive to tarso-metatarsal fractures in foot trauma because they often are difficult to diagnose and treatment should follow the relevancy of the articular function.

The freshly traumatized foot should first be evaluated clinically though the severity of fractures and eventual dislocations about the tarsometatarsal joints are ***not always suggestive clinically***.

543

A **comparison with the other foot** should be made.

544

Immediate radiological assessment prior to any reduction manoeuvres allows the setting of a treatment strategy and ***avoids any additional harm***.

545

546

Assessing the comprehensive lesion is essential to ***set out the strategy*** by means of the chronology of the treatment.

These fractures occur through a strong sprain in plantar flexion and rotation of the foot and are common in motorcycle accidents or in pedestrians who have been knocked down. The likelihood of compartment syndrome [80] should be evaluated in all these cases. In those fracture-dislocations, immediate open reduction allows for recognizing soft tissue entrapments of muscles and/or tendons. It eases reduction and avoids any risk of compartment bleeding. The single central approach, ***lateral to the anterior neuro-vascular bundle*** allows for good visualization and handling.


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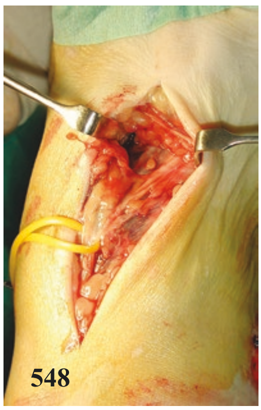
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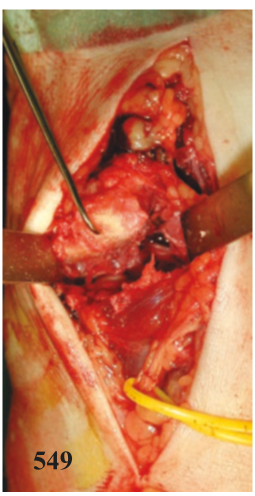
It is essential to recognize ***soft tissue entrapments*** and the reduction of ***locked dislocated fragments.***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Treatment relies on the recognition of the stability of the foot through the central (second and third) rays which can be fused at their respective TMT joints without any relevant loss of function. Temporary alignment with percutaneous wires is followed by ***percutaneous interfragmentary and transarticular fixation by screws***.


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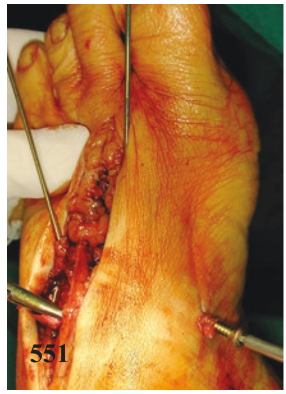
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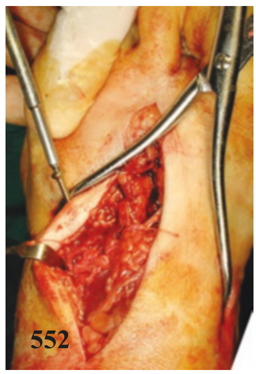
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553

The first ray holds a kind of intermediate position in the need for anatomical joint reconstruction or fusion.

It is also important to remember the ***need for mobility at the lateral (fourth and fifth) rays***


554

which should not be fused in order to achieve good function [95].

Symmetry to the other foot, if asymptomatic, should be respected.

555

556

In **non-evident dislocations**, diagnosis is much more difficult and as a result, is often missed. As an example, a short run on uneven ground in poor visibility and wearing high heels has a high exposure to such trauma.

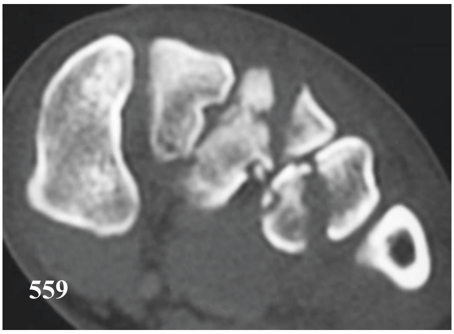
Localization of pain and ***painful examination of the single joints*** raises the suspicion of the lesion.

557

The complexity of the ***juxta-articular tarso-metatarsal fractures***

558

requires a ***CT-examination*** for a rational treatment plan.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The key lesion, focussing attention to the roof of the forefoot which is the second ray ***(A6)***, the torn or insufficient ***Lisfranc's ligament between the first cuneiform and the second metatarsal***, must be recognized.


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The question which arises most is in which cases should the joint be fused or in which cases should it be reconstructed [96]. The central axis (second tarsometatarsal joint) is the joint which best ***supports an occasional fusion***.


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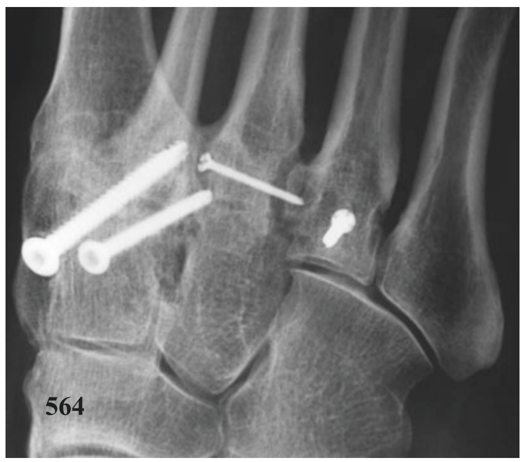
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Lateral TMT (4 and 5) joints do not allow for an occasional fusion after intra-articular fractures ***(A8)***.

5.3.6 Metatarsal Fractures

Diaphyseal fractures of the central metatarsi should be grossly aligned to respect the alignment of the anterior heel [34]. In most cases, a central medullary nailing is sufficient due to the combined stabilizing action of the intrinsic musculature (interossei). The

distal metaphyseal fractures which escape from the stabilizing intermetatarsal ligament

565

must be stabilized precisely to ***avoid*** secondary extension and in particular ***rotational mal- or non-union***

566

and to secure the anatomical parabolic alignment of the metatarsal heads or anterior ***heel and the rotational alignment of the toes.***

567

Fifth metatarsus fractures [97] are quite common. Twisting the foot in supination causes a proximal fifth metatarsus fracture, either within the joint, the proximal metaphysis or the diaphysis. Intra-articular fractures produce a relatively small proximal fragment in relation to the wide insertion surface covered by the fibularis brevis tendon. Those frequent fractures are thus generally stable and allow for immediate weight-bearing and walking within a FAO including a convex sole (cam walker). More seldom, the fracture does not allow for this kind of functional treatment and may not heal.

These cases require open reduction and internal fixation to become asymptomatic.


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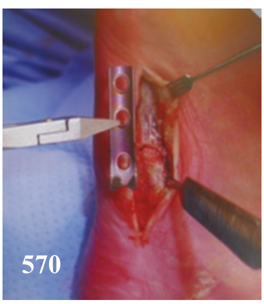
Two months post-trauma the fracture is still not consolidated and is painful. Treatment includes tension band fixation using a ***plate with prongs*** [98, p. 81] ***which are impacted from proximal***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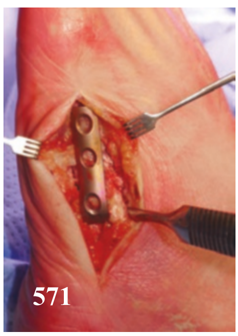
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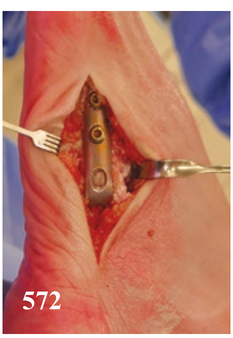
and fixed by ***tensioning the plate onto the bone*** using screws.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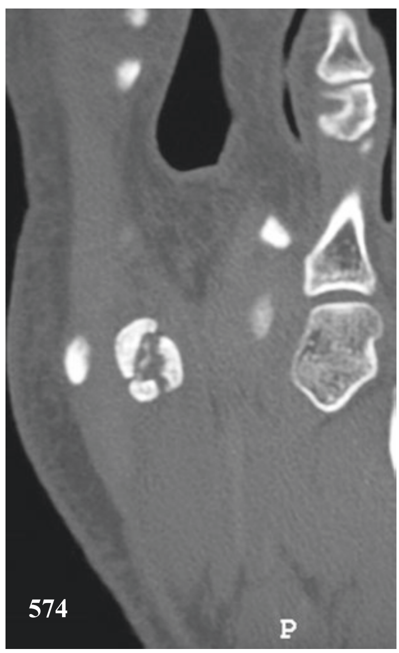
573

If the fracture dissociates the fifth metatarsus within the proximal metaphysis, the fracture is fundamentally unstable because the proximal fragment is firmly held by the fibularis brevis muscle while the distal fragment is tributary to the fibularis tertius muscle. Stable bone fixation is required to allow for healing [99].

Diaphyseal fractures can consolidate without problems, especially if they are long-shaped and present a low interfragmentary strain. The problem consists of the level and critical position of the fifth metatarsal head after consolidation. It might be too high (extension), too proximal (shortening) or twisted, which positions the corresponding toe in an unfavourable way ***(E54).*** In those cases, operative restoration of normal anatomy seems evident. In cases of non-relevant dislocation, non-operative treatment should include multiple radiological checks of the stability of the fracture.

5.3.7 Fractures of the Sesamoid Bones

Multipartite sesamoids are mostly due to an acute or fatigue fracture ***(E64)***. Assessment is done by CT for ***evaluation of the number, shape and dimension of the fragments as well as the density of bone***.



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An eventual bone graft is indicated [100]. The medial sesamoid fracture is approached from the medial utility line ***(T618)*** and the metatarsophalangeal arthrotomy. The ***lateral sesamoid is approached from plantar***, the patient lying prone.

575

The articular layer is inspected and the ***quality of the cartilage*** evaluated.

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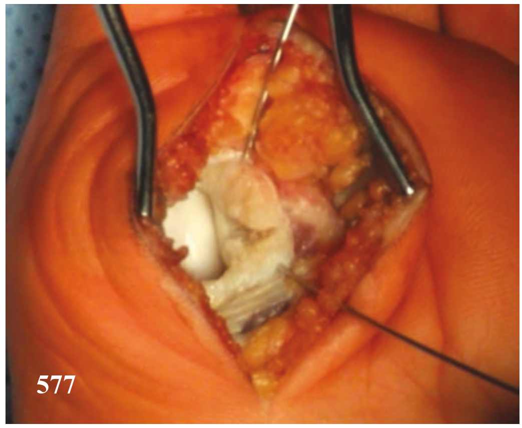
Eventual necrotic bone is extracted after lifting the cartilaginous layer and replaced by cancellous bone harvested at the metatarsal head. Reduction is eased by using ***joysticks*** (K-wires).



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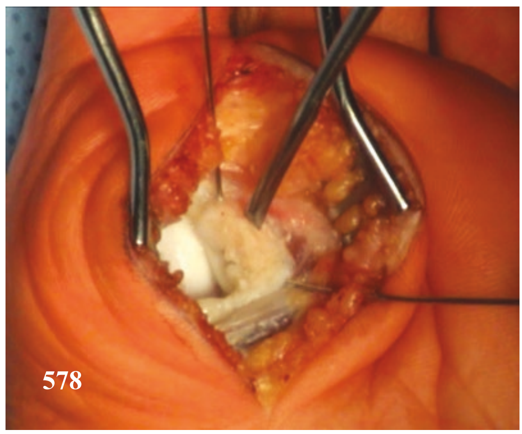

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The fragments are definitively ***fixed using 1.5 mm screws***.


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580

The skin is closed with ***anatomically adapting single stitches which remain for 3 weeks.***


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582

This technique avoids any step between the edges of the scar. Such a scar would remodel badly and remain painful.