Minimal-invasive surgery of intra-articular calcaneus fractures

Indications, Concepts and Technique

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Content

Introduction

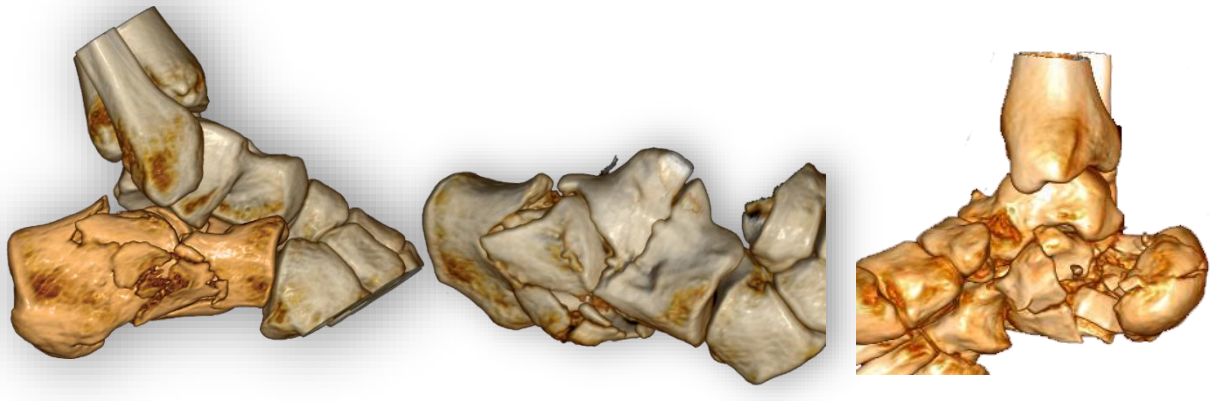
Dear colleague

For introduction including treatment options and indications please take a look at my earlier English manuscript on my Homepage: www.calcaneal-fracture.com

Preparation for surgery

If you are planning a minimally invasive surgery in covered technique you must be willing to take enough time for preparation and planning **before** starting surgery!!

Always use and demand 3D CT reconstruction besides standard radiographs and CT. For covered reduction and stabilization, it is essential to have a concrete understanding of the size, position, shape and location of the fragments including rotational misalignment.



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Indication and contraindication

Indications for our minimal invasive concepts are <u>all</u> intra-articular calcaneal fractures Additional to standard fracture situation we recommend this technique also for non, or minimally dislocated fractures due to its low complication risk, cast-free aftertreatment and immediate stable fixation.

The treatment of <u>comminuted fractures</u> including open cases are a main indication with surgery as soon as possible (within 3 days). Early surgery with reduction, evacuation of hematoma, stabilization and early functional treatment is the best way to avoid excessive swelling, blistering, compartment, soft-tissue complications and infection

Contraindications, in comparison to the open reduction technique, are rare. Due to the decreased wound complications risks, even older patients, smokers, and patients with co-morbidities can be treated with this technique in most cases and profit from early mobilization.

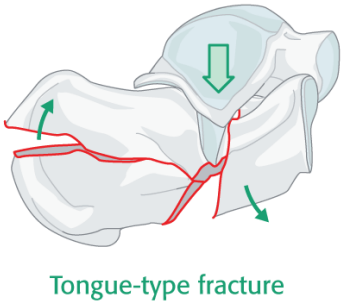
Fracture type and methods

Regarding the reduction technique, we differentiate 4 groups of fracture types. The Essex-Lopresti classification is used because of its simple characteristics and good correlation with the prognosis.

1) Essex-Lopresti tonque-type fractures
2) Essex-Lopresti depression-type fractures
3) Comminuted fractures - mainly because of a severe depression-type fracture
4) Atypical fractures with uncommon fractures lines, mainly following a direct trauma

1) Tongue-type fracture

With these fractures, there is a large, connected dorsal segment of the tuber calcaneus and a subtalar lateral joint segment. Shortening and varus malalignment of the foot normally is slight and the sustentaculum uninjured. The Westhues maneuver allows good reduction of this types of fractures.



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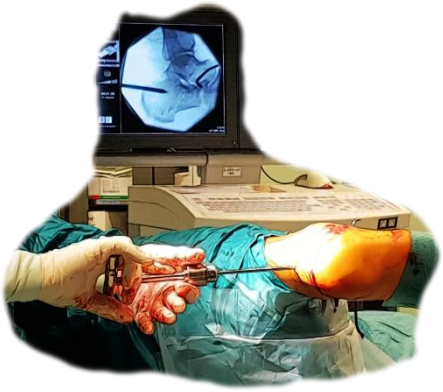
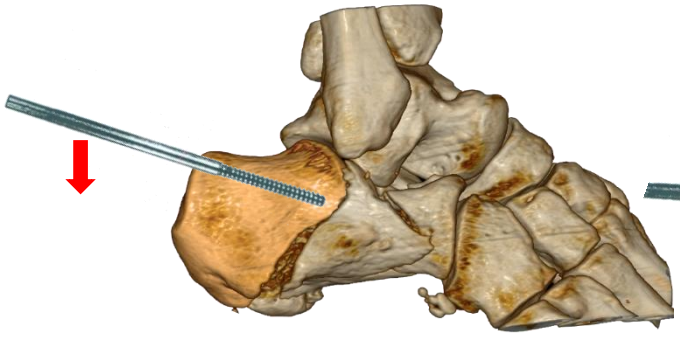
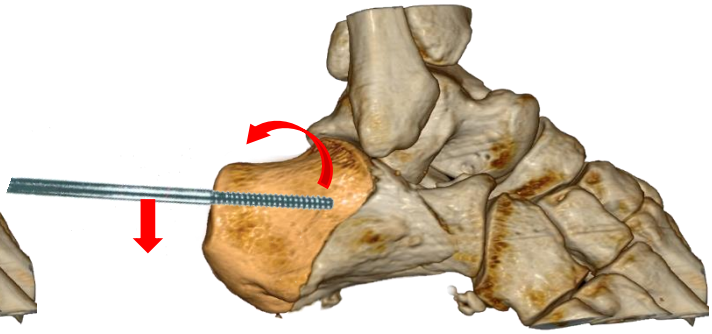
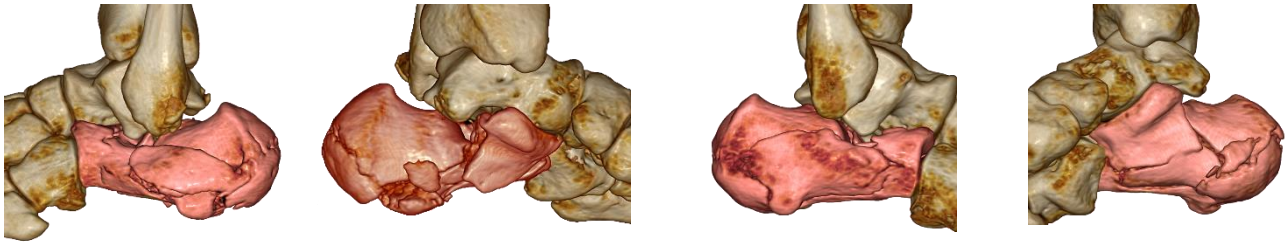


UKH Linz reduction Westhues



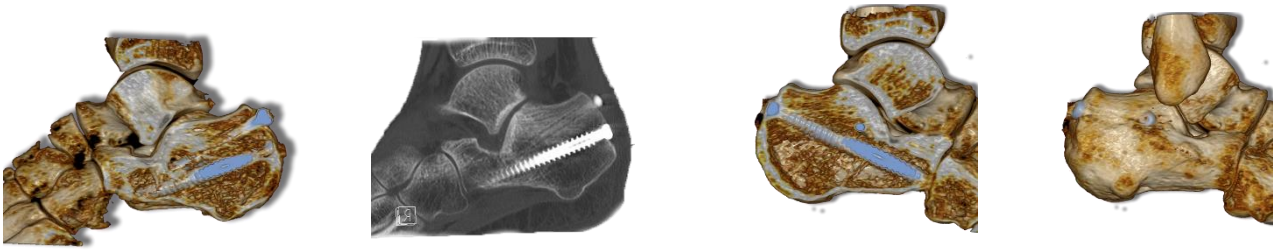


Case report; tongue-type fracture on both sides



left right

surgery 14 hours after trauma



radiological outcome after 6 months

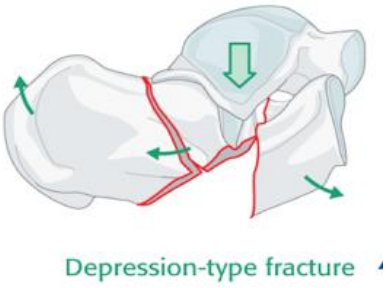
Soft tissue appearance after 6 months

UKH Linz Tongue-fracture on both sides, early surgery, functional after-treatment

2 years after the trauma the patient is completely free of symptoms with full function both sides.

2) Depression-type fracture

The characteristic fracture line runs between tuber calcanei and the central part of the calcaneal body. Shortening, varus malalignment, depression of the subtalar joint, tilting of the talus, broadening, break out of the lateral wall often with impingement of the upper ankle joint and/or fracture of the lateral ankle is common. For depression-type fractures an extension technique is usually indicated!



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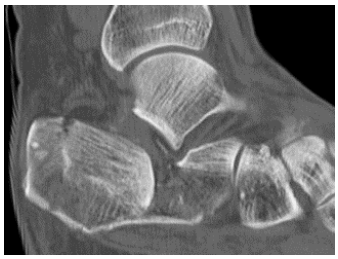

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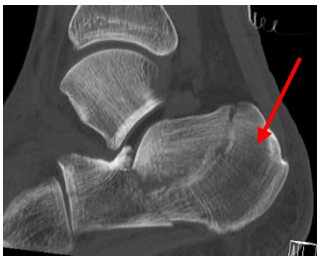
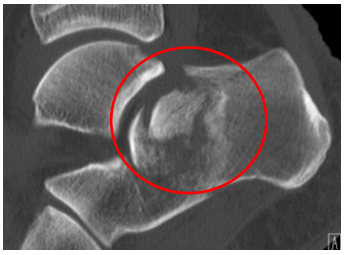


isolated tuber fragment, varus, shortening

,



isolated central joint fragments ,

blowed out lateral wall

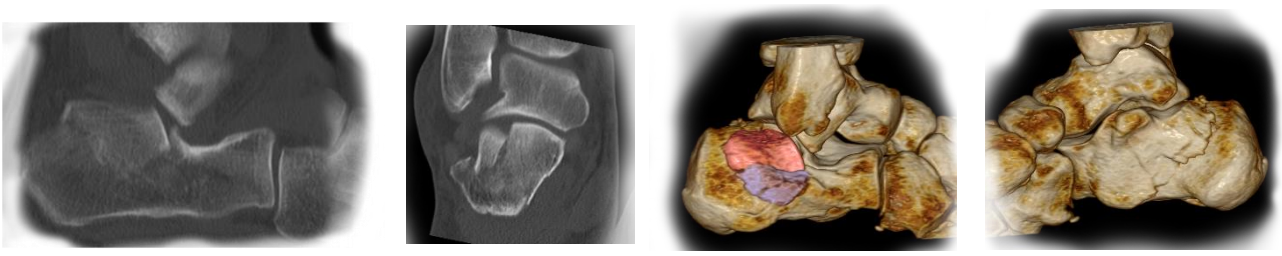
,

lateral abutment,

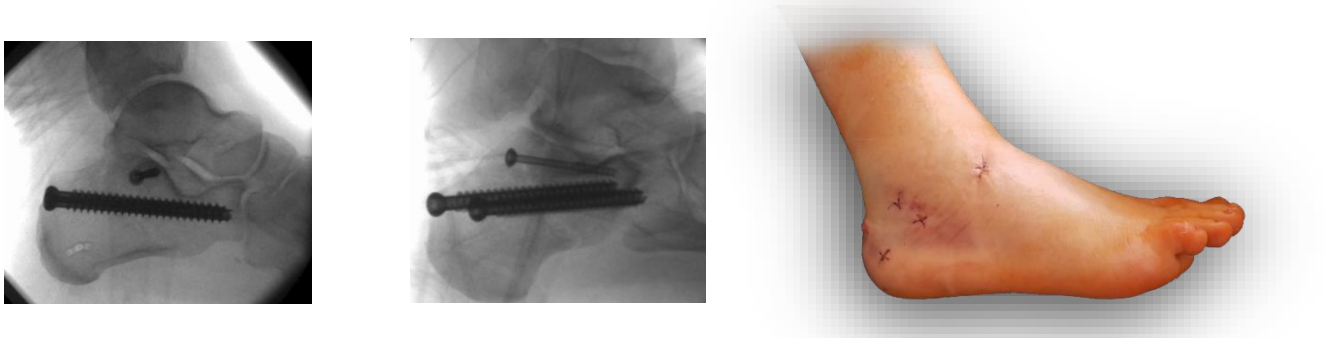
lateral malleolus fracture

,

Case example: simple joint depression-type fracture



depression – type fracture UKH Linz



depression – type fracture: radiological results and soft tissue situation postoperatively; two lateral incisions for the extension, one incision for the reduction of the joint fragments, one incision for the sustentaculum screw

3) Comminuted fractures

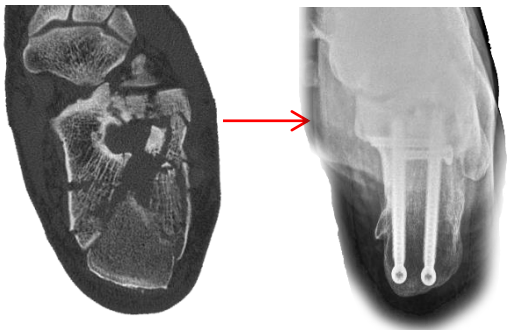
Comminuted fractures, (Sanders group 4, four or more main fragments)

Comminuted fractures are a main indication for our minimal-invasive technique with the 2-point distractor. In most of the cases anatomical reduction is not possible. One have to change the general goal of anatomical reduction to the realistic possibilities.

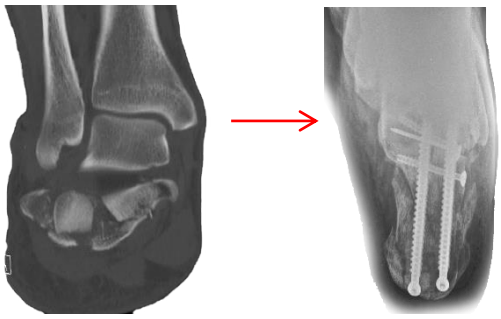
Objectives that can be achieved:

- correction of the axis, length, broadening and height
- primarily exercise stable fixation of the main fragments.
- prevention of excessive swelling and compartment syndrome
- minimal risk of skin necrosis and infection, no additional iatrogenic trauma
- short incisions (normally only stab incisions) no extensive scarring
- good soft tissue conditions for further operations, e.g. arthrodesis
- easy osteosynthesis material removal

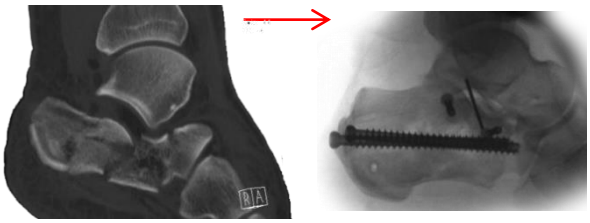
treatment goals for comminuted fractures



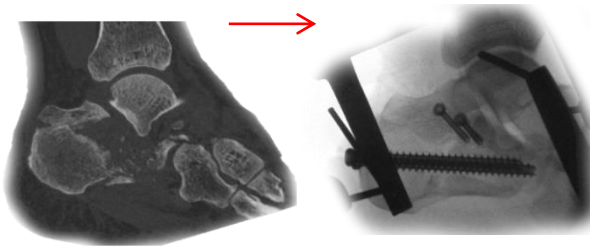
correction of length and axes



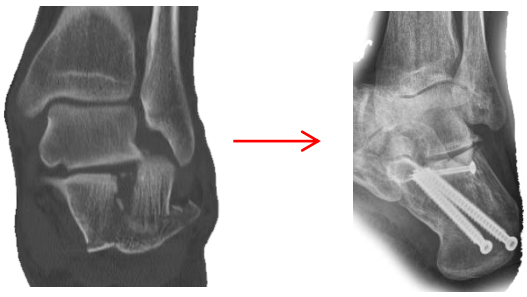
correction of broadening



correction of height



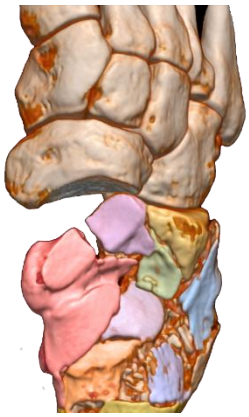
reduction and fixation of the main fragments

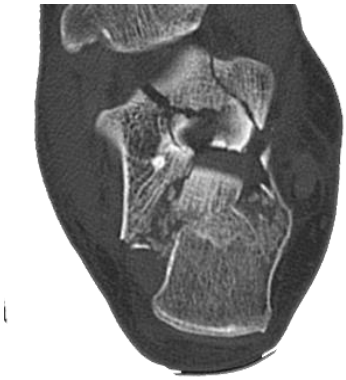


reduction of the impingement

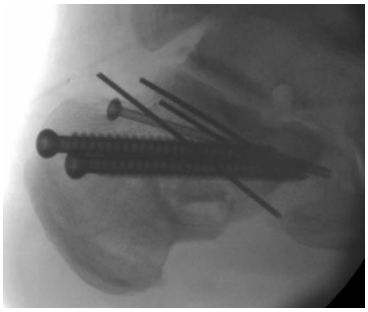
evacuation hematoma, stabilization of main fragments with stab incisions, cast free aftertreatment reduces complications as compartment, blistering, skin necrosis or infection

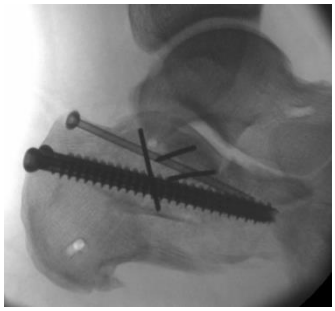
Case example: Comminuted fracture





fracture situation





closed reduction and internal fixation, soft tissue 6 weeks after surgery UKH Linz

4) atypical fractures

Fractures with an atypical injury mechanism and an uncharacteristic progression of the fracture lines are mostly result of a direct trauma. In most cases, standard reduction techniques with screw fixation are indicated. Depending on the fracture pattern, alternative ways of reduction and fixation techniques should be considered.

comminuted fracture of the anterior process of the calcaneus stabilized with an external fixator to reduce and maintain length UKH Linz

open fractures

Open fractures are treated with aggressive debridement and soft tissue management. Primarily, we perform fixation of the fracture with screw fixation, and in some cases, with external fixation.

open calcaneal fracture after direct trauma UKH Linz

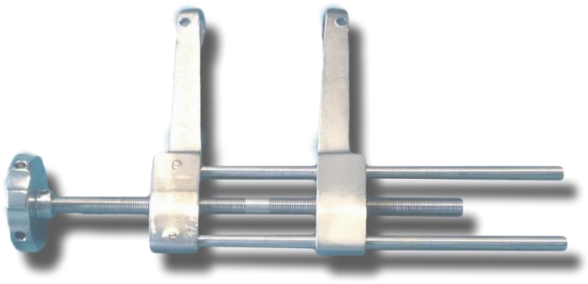
after surgery

soft tissue situation 6 weeks postoperatively and subsequent flap surgery

radiological results 9 months postoperatively, soft tissue situation healed

Surgical technique with 2-point-distractor by Fröhlich

For the treatment of joint-depression-type fractures and comminuted fractures a special calcaneus distractor is the most important instrument in minimal-invasive technique. We use this 2-point distractor designed and published by Peter Fröhlich in 1999.



Actually we have finished and patented a prototype of a new radiolucent and multi-angle device.

Instruments - osteosynthesis

- 2-point distractor
- 2 x 3 mm Kirschner wires as extension pins for the distractor
- Bolt cutter
- 7.3 mm fully threaded cannulated screws
- 4.0 mm cannulated screws for fixation of the joint fragments (sustentaculum screw) and smaller fragments (example: anterior process fracture)
- Possibly K-Wires in different sizes for fixation of smaller fragments or as a joystick for traction and aid in the reduction process
- Different raspatories, awls, elevators, tappets for the reduction.
- Schanz`screw and handle

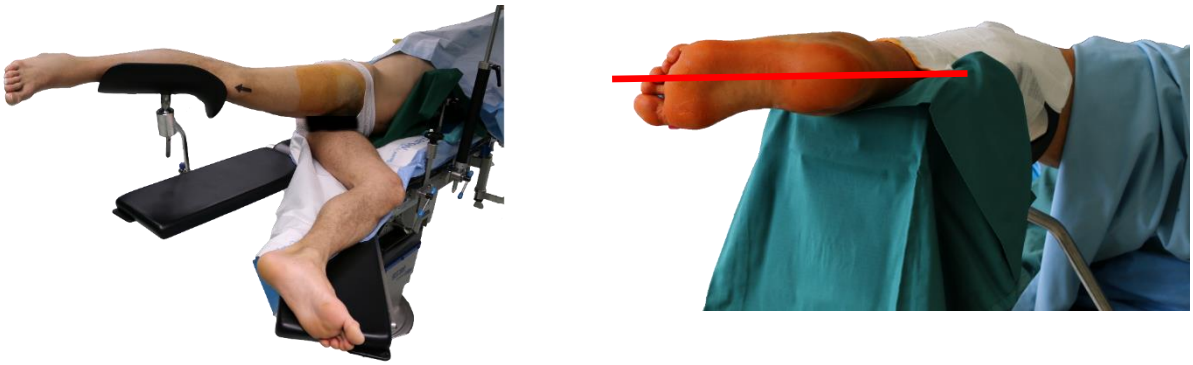
Anesthesia

Surgery is typically applied through regional anesthesia or general anesthesia.
Tourniquet isn't utilized.

Positioning

A standardized, stable position of the patient with an ideal approach to the foot and a properly adjusted image intensifier is inevitable for the success of this surgical technique. The patient is placed laterally with the injured foot on a leg-holder in upper and strictly horizontal position. A free approach to the whole foot is necessary for the proper mounting of the distraction device and the ideal positioning of the image intensifier. It should be possible to move the C-Arm 360 degrees around the foot.

It is highly recommended to prepare, standardize, document and train the positioning and usage of the equipment altogether with the complete surgical team prior to the surgery.



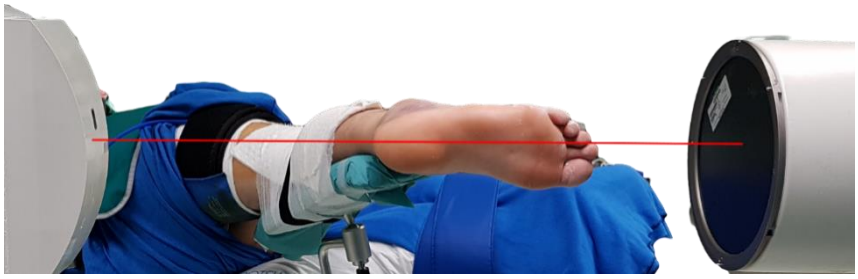
standard positioning UKH Linz

Imaging

With the minimal-invasive approach the fracture segments are not directly visualized so a perfect intraoperative imaging is necessary for success. It is essential that the surgeon is totally familiar with the imaging technique in order to be capable to accurately instruct the X-ray technicians. Uncertainties regarding the imaging during surgery should be avoided via preoperative planning and training the team.

With our technique, we need 3 standardized intraoperative views – lateral, Broden and axial views, the last years we added an additional view for the Sustentaculumscrew.

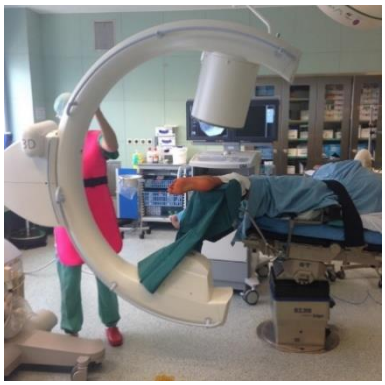
The image intensifier is positioned exactly in line with the length axis of the calcaneus.



standard positioning UKH Linz adjustment of the image intensifier

Together with the X-ray assistant all 4 intraoperative views are set and eventually marked. Afterwards the image intensifier wheels are locked in position, and only the C-arm remains moveable. Only 4 different instructions for intraoperative imaging are needed afterwards. Surgery should only be started when the imaging unit is appropriately positioned. It is highly recommended to use an iso-centric image intensifier to reduce time and effort for the required settings.

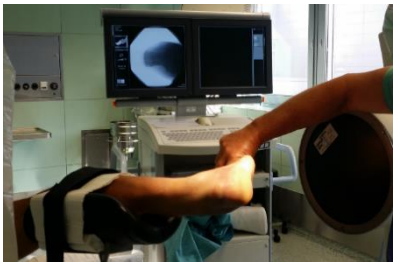
Lateral view: It is important to focus the joint surface of the talus. The calcaneus should be disregarded for the adjusting of the image intensifier (it is broken and out of shape). Lateral ligament instability due to subluxation can impede the adjustment of the image intensifier.

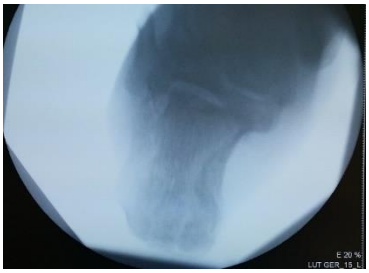


lateral view with the image intensifier

the exact orthogonal adjustment of the talus joint surface is essential!

Axial view: The C-arm is adjusted horizontally. In manual dorsal flexion of the foot evaluation of the axis of the calcaneus is possible. This view is essential for the exact positioning of the pins.





with the axial view the axis and width of the calcaneus can be determined and with a good adjustment also the position of the sustentaculum can be seen

Broden view: This projection is used to evaluate the subtalar joint and the posterior facet congruency. Proceeding from the previous adjustment, the C-arm just needs to be angled 45 degrees towards the head, while using an iso-centric image intensifier. With conventional image intensifier, a height adjustment of the tube is unfortunately needed. Practicing and specifying this procedure preoperatively is highly recommended.

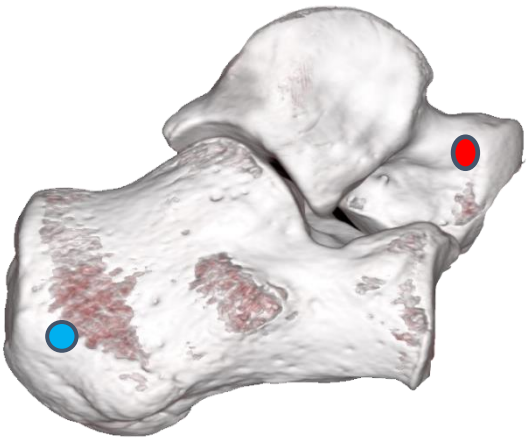
Broden view

Attention: Because of the curvature of the talus, a ´rotated' fracture fragment could be seen as anatomical in the Broden view. To avoid malalignment and inaccurate reduction, the posterior facet should always be checked at different angles of 35 and 55 degrees and in all extension and flexion positions of the foot. It is only perfect if it is perfect in all views!!!

Sustentculumview: For the positioning of the Sustentaculumscrew we found a special adjustment technique that allows a safe and easy placement. See chapter Sustentaculum screw.

Overview of the technique

- Insertion of the pins in the talus and calcaneus
- Reduction of the varus malalignment
- Extension with the distraction device and reconstruction of the length
- Lateral incision, evacuation of the hematoma
- Reduction of the central joint fragments with the raspatory, joystick, tappet
- Insertion of K-wires in preparation for the insertion of the 4.0 mm sustentaculum screws
- Insertion of the 4.0 mm lag screw
- Reduction and fixation of the anterior process, tuber fragment, etc.
- Dorsal K-wire insertion in preparation for the insertion of the 7.3 mm fully threaded screws with the distraction device locked in position
- Insertion of the 7.3 mm fully threaded screws for fixation of the axis and length and to neutralize forces across the joint fragments
- Wound closure

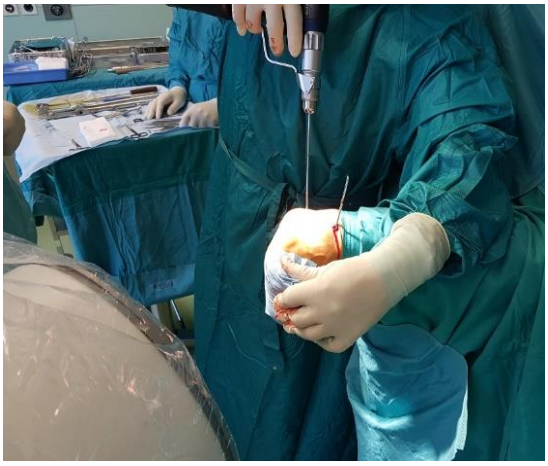


The two pins for the extension device are positioned in the anterior process of the talus and in the tuber calcanei. The position of the pins in these locations allows minimal overlay and interference of the distractor device and the joint for a good view through the image intensifier. Additional we can insert all osteosynthesis screws without removing the pins.

The **first pin** is inserted in the anterior process of the talus exactly in frontal and axial plane while assessing alignment via the lateral view.

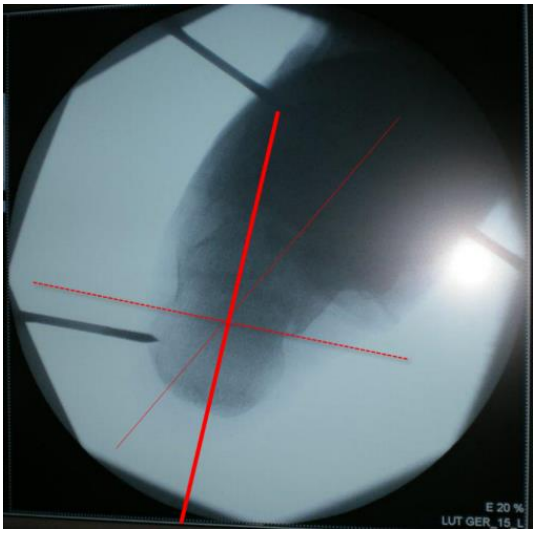
talus PIN

The **second pin** is inserted into the distal plantar region of the tuber calcaneus. The lateral view is used to mark the entry point of the pin. Afterwards, a change to the plantar view is needed to determine the axis of the tuber fragment.



calcaneus PIN in axial view under dorsal flexion

It is important to insert the pin in manual dorsal flexion of the foot and exactly perpendicular to the angulated axis of tuber fragment. With the varus malalignment of the foot a significant convergence of the pins on the medial side is obvious. Otherwise, correction of the varus malalignment is not possible and the reduction will not succeed!



calcaneal PIN insertion exactly 90 degrees to the varus angulated axis of the tuber calcanei. This must be measured through the axial view

significant convergence of the PINs on the medial side

manual reduction of the varus

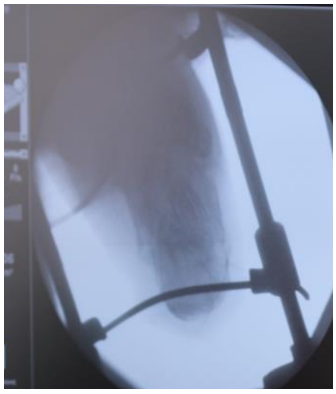
afterwards montage of the medial distraction device

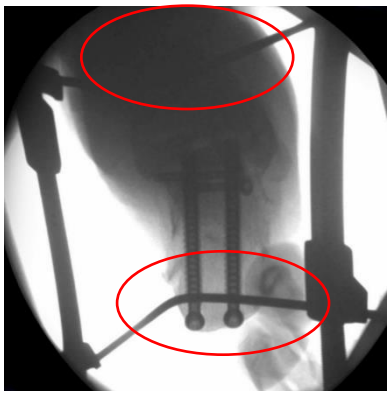
After the manual correction of the varus, the medial and lateral distraction devices can be mounted. Extension of the foot is needed for reconstruction of the calcaneal length and to create place for the reduction of the central joint fragments and to stabilize the fracture in preparation for the screw fixation.

Both extension devices are mounted

to avoid slipping of the devices, bending of the K-Wires is recommended. Afterwards you can shorten the PIN`s

Extension is applied alternately medial and lateral while using the lateral and axial view until adequate reduction of the length is completed. As indicated by the bending of the K-wires, significant traction is needed to successfully reduce the fracture. Without adequate distraction (respectively wrong positioning of the pins) it is not possible to anatomically reduce the central joint fragments. Hint: If you have problems for reduction of central fragments, you normally have not enough extension.

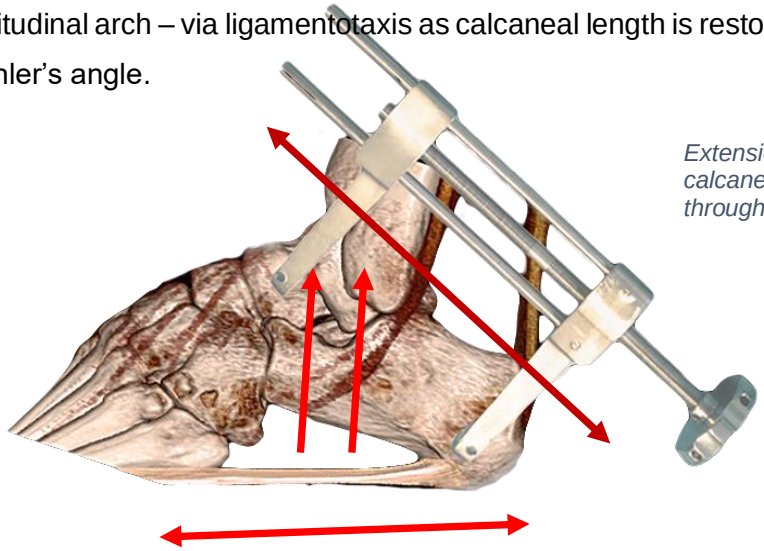




Significant bending of the pin during reduction of the varus and length

Screw fixation should be achieved during the already mounted distraction devices after the reduction and fixation of the central joint fragments (depending on case possibly decrease extension)

The tension of the ligaments of the foot (particularly the plantar fascia) can help to raise the longitudinal arch – via ligamentotaxis as calcaneal length is restored. This is a big aid to correct Boehler's angle.



Extension between the talus and the calcaneus causes raising of the foot arch through tension of the plantar fascia

Reduction of the central joint fragments

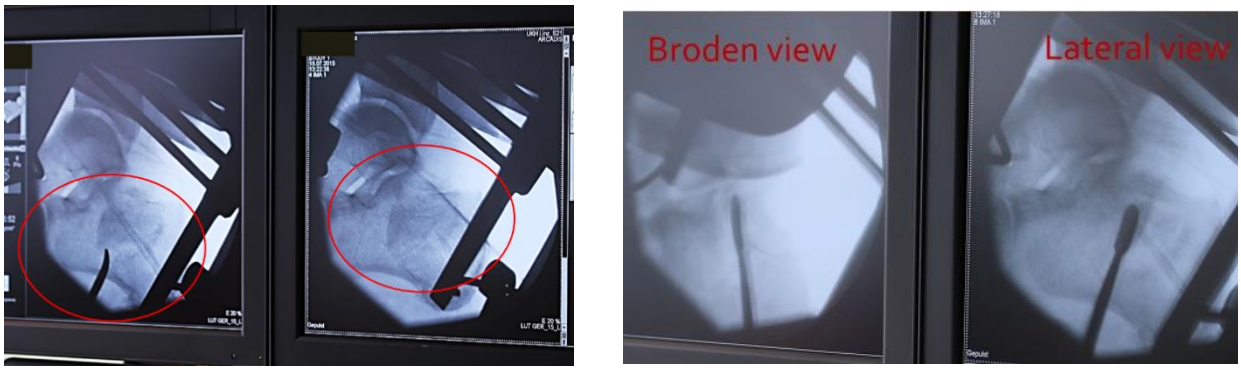
In joint-depression-type fractures we usually find one or more joint fragments in increasing severity of the fracture from lateral to medial. Bursting of the lateral wall is common. Precondition for the reduction is enough space subtalar through an extension stabilizing length and axes. We never use compression devices.

For reduction we typically do not require a sinus tarsi approach. With in-depth preoperative analysis of the fractur, good planning and technique combined with perfect intraoperative radiological viewing we think to have enough possibilities for good reduction and osteosynthesis sonly with stab incisions. In some situation especially for atypical fractures or if we see a complete instability and tilting of the sustentaculum in comminuted fractures we also use this approach.

For the reduction of the joint fragments we use different techniques

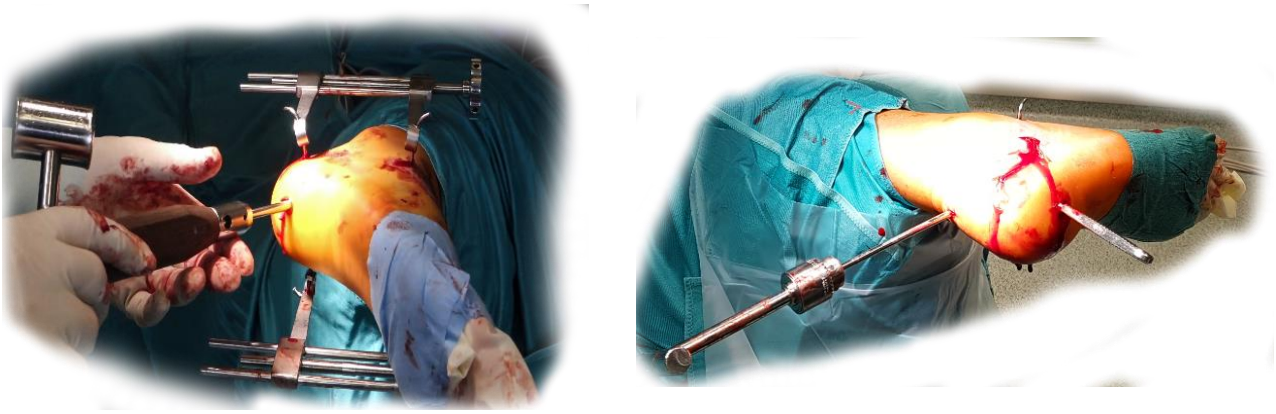
One common way is manipulation with a raspatory through stab incisions from lateral.

Incision, then insertion of the raspatory and manipulating and reducing the depressed joint fragment



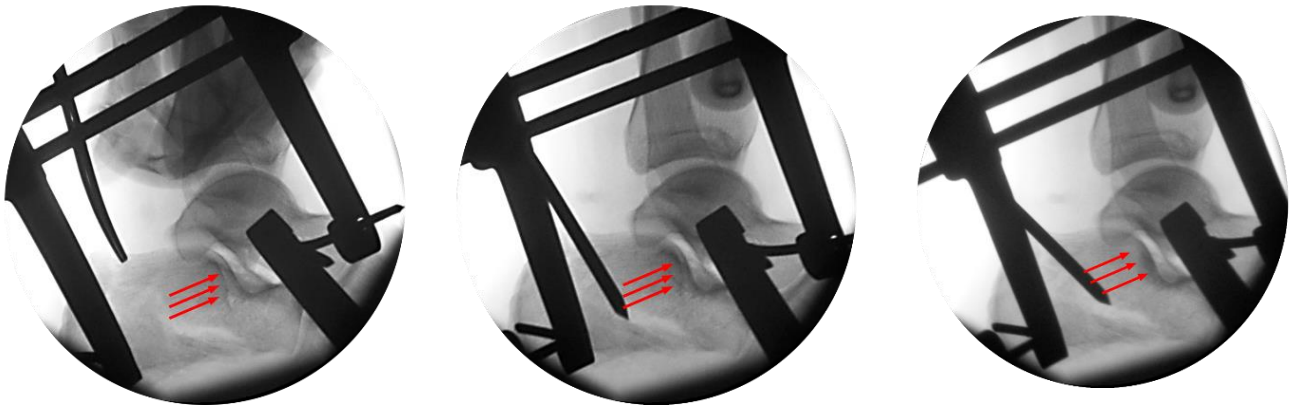
Reduction of a lateral fragment, examination through Broden and lateral view

We also tried with a tappet through a stab incision from plantar, but we do not recommend anymore.

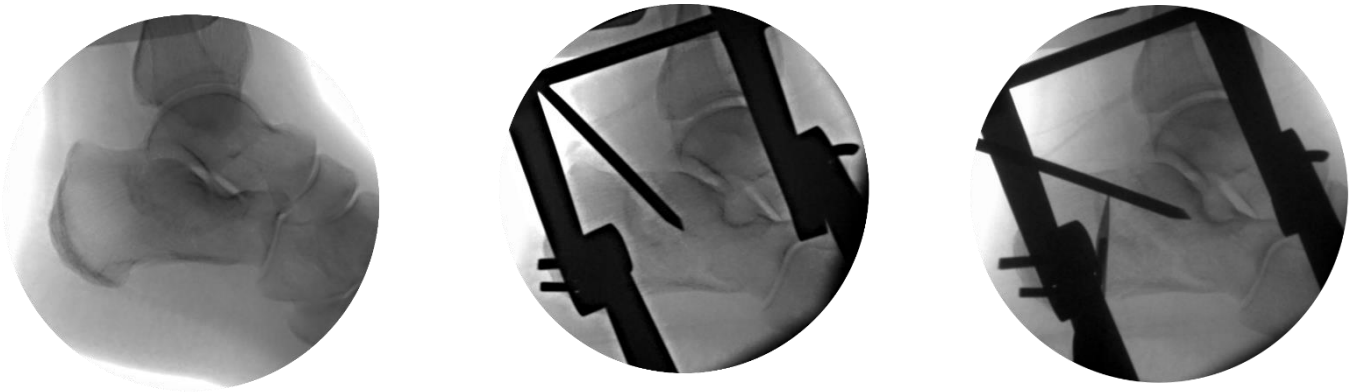


Raising with a bone tamper; left with extension; right with reduction technique by Westhues

Last time we prefer a postero-lateral approach. Additional to good manipulation possibilities you can also work on Boehlers angle.

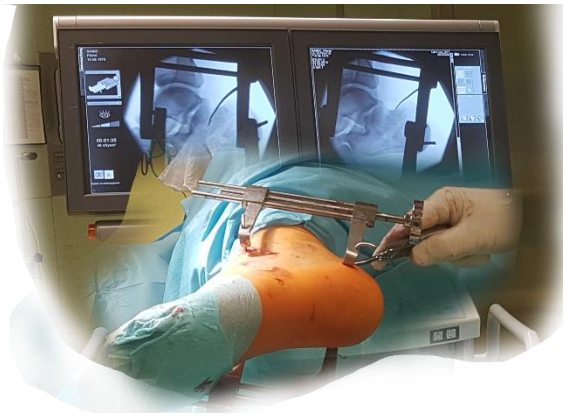


Postero-lateral approach, use the fracture gap, lift and reduce the central lateral depressed joint fragment



Another case, same technique

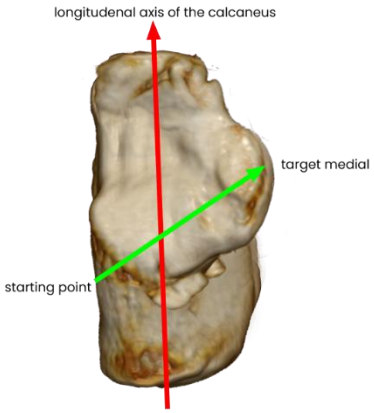
Reduction from dorso-lateral – clinical situation



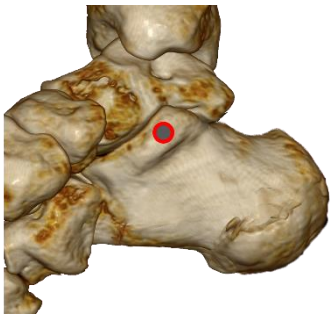
Sustentaculum screw

The sustentaculum usually remains intact, due to the typical fracture mechanism, the powerful talocalcaneal ligaments and the strong trabecular structure of the sustentaculum tali itself. Because of this, the sustentaculum is an excellent fixation point for attachment of the dislocated postero-lateral and – medial joint fragments, as well as for the lateral wall part. The osteosynthesis with the so called sustentaculum screw is an often-mentioned procedure in the literature. The complex anatomical shape of the sustentaculum and the difficult visualization seems to make it hard to place the screw, but with a correct insertion point and a special view through the image converter you can place it safe and easy. We call it Sustentaculumview.

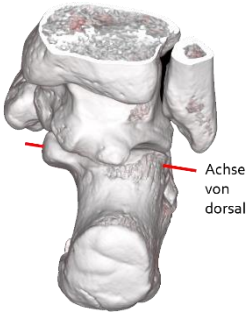
The sustentaculum screw is placed in a lateral-dorsal to medial-ventral direction. The entry point of the screw is behind the lateral, the target below the medial malleolus. The guidewire must be tilted almost 30 to 40 degrees to the longitudinal axis of the foot and lies very close below the joint gap.



axes



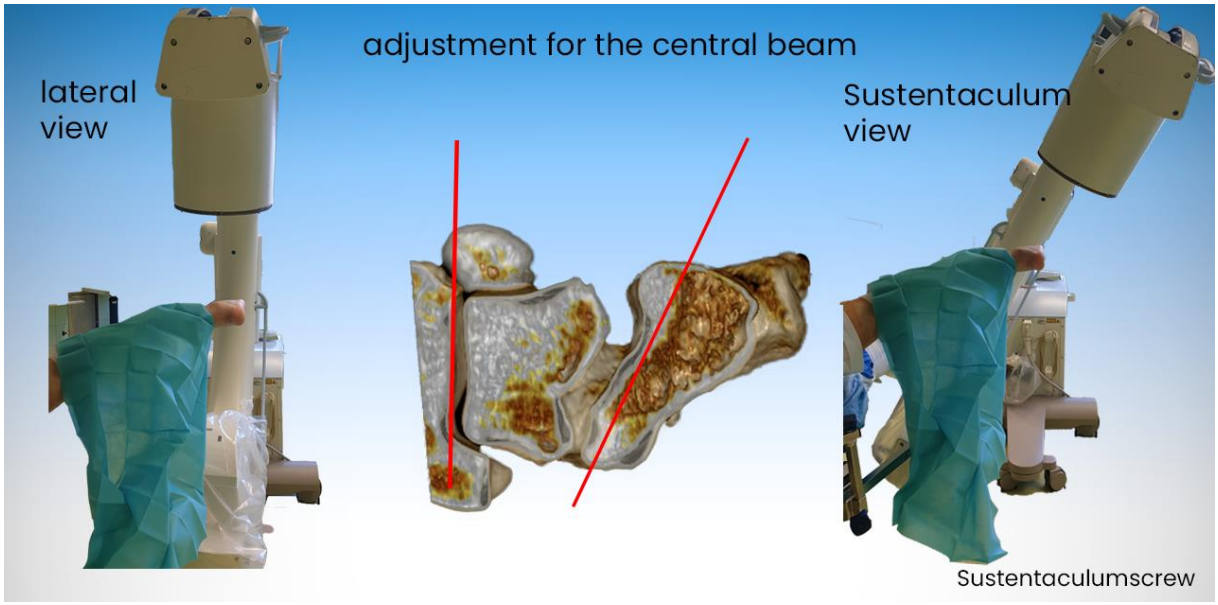
medial target



view from dorsal

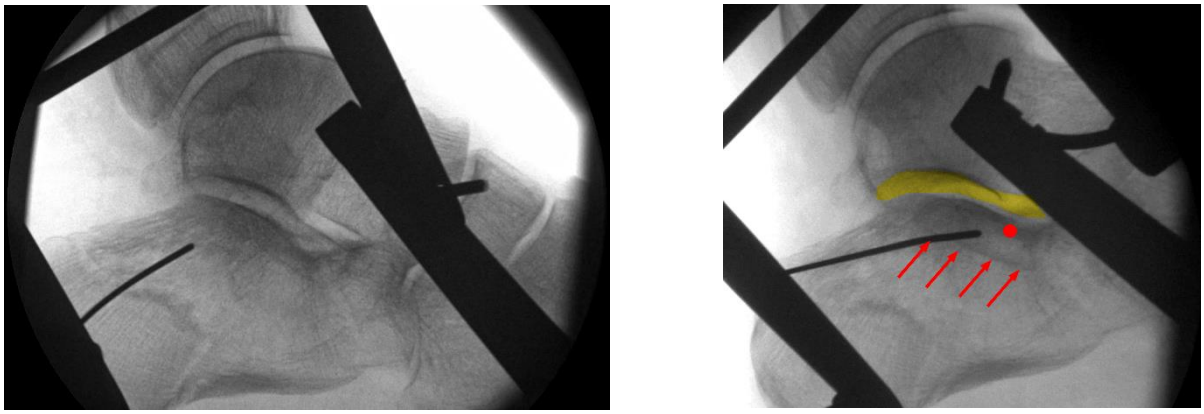
Insertion point and angle of about 30-40 degrees to hit the sustentaculum

After positioning the wire on the lateral wall, you must tilt your C-arm about 30 degrees to center the beam in the axis of the sustentaculum.



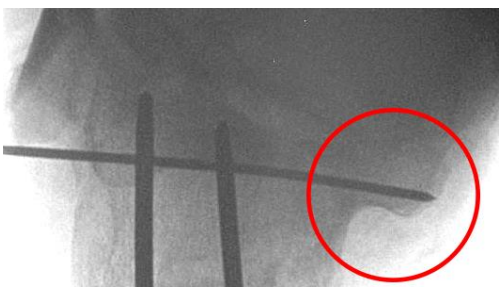
Starting from the standard lateral view optimized for the dorsal lateral joint of the calcaneus you have to tilt the C-arm about 20-30 degrees to adjust your central beam for the sustentaculum – see the anatomical slice.

Now you can determine its boney shadow, define your target and bring in your guidewire without danger to be intraarticular or below the sustentaculum.



In the lateral view you see the joint line lateral and medial, in the Sustentaculumview you see through the joint gap and you can determine the shadow of the sustentaculum

Control the position additional through all standard views. In the plantar view, the screw length can be measured with a second pin. It is recommended to drill the wire medially through and hold the guidewire with a clamp when removing the drill. Usually 4.0 mm cannulated lag screw are used.

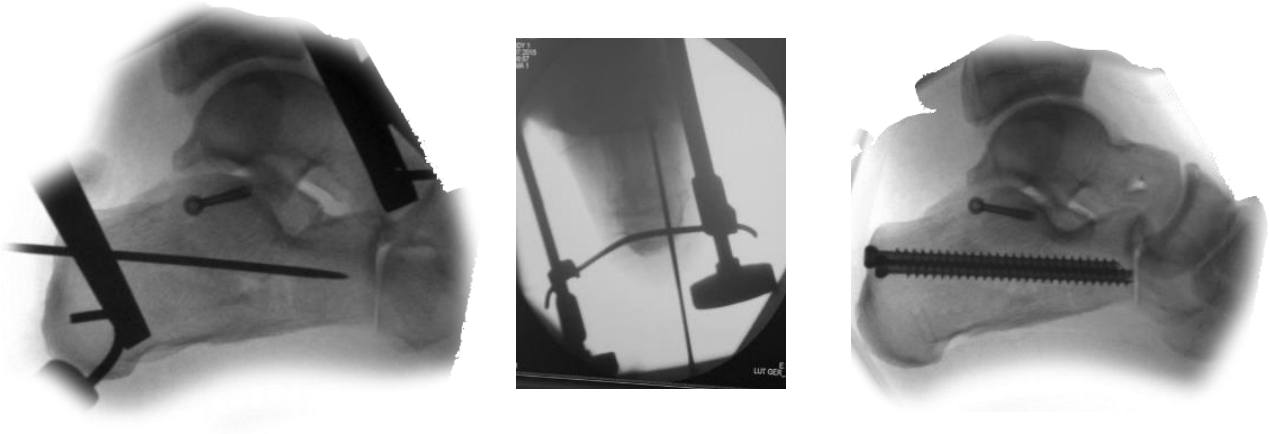


Sustentaculumscrews

With narrow osteochondral fragments (comminuted fractures), fixation is alternatively achieved only using K-wires. For transverse fractures through the sustentaculum it is important not to place the screw in the fracture gap. The reduction of the posterior facet is optimally visualized with the Brodèn view. Be careful and use different angles of the C-arm and different flexions of the foot to control the reduction and position of the screw.

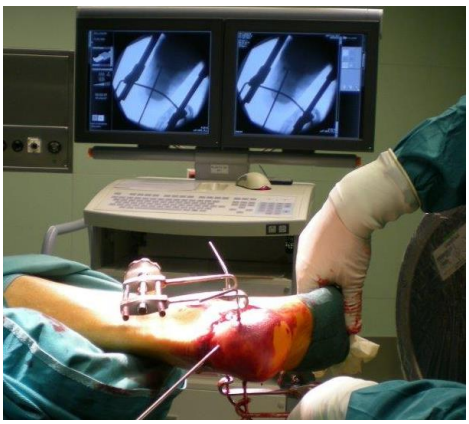
Static fixation with the 7.3 mm screws

The last step of the procedure is the stabilization of the reduction with 7.3 mm fully threated screws serving as a statically internal fixation without any compression. In literature many different placement techniques are described. In most of the cases we place the screws superior to the transverse tuber pin and angulated in a dorsal to plantar direction.



Insertion of the K-Wire and of the cannulated full threated screws

We try to position the screws proximal of the insertion of the Achilles tendon and find less irritation, good stability and support of the joint fragments as with beams of a roof truss. This is even more important when you have bone defects after reduction because of the compression of cancellous bone.



surgical situation with axial view to control the position and the parallel insertion of the screws

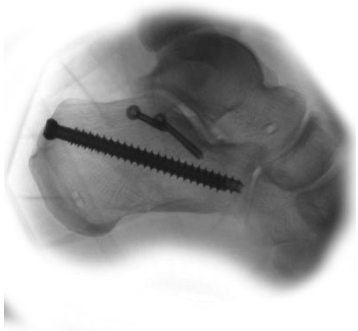
The insertion of autologous bone or bone substitute grafts is not necessary and is not recommended in recent literature. The head of the screws should be subcortical to prevent soft tissue irritation. We don't need drains.

Screw fixation usually with mounted extension device

soft tissue status 1 day after surgery

Follow-up treatment

What we have learned the last years: With sufficient reduction and correct osteosynthesis, we always obtain enough stability for immediate functional treatment even in comminuted fractures. Don`t use joint-transfixing K-wires! they are not necessary and, in our opinion, reduce the stability in the fracture area. (see presentation on www.calcaneal-fracture.com) Furthermore, early mobilisation is not possible.



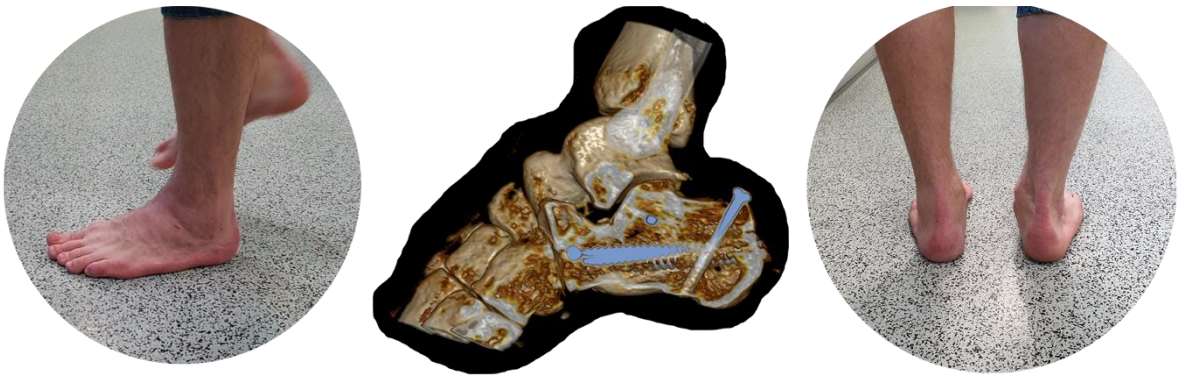
We perform a very loose wound closure to allow a residual hematoma to remove itself. A slight post-operative bleeding is common. Therefore, a bandage replacement the day after surgery is mandatory. On this occasion the patient is advised to move all joints in the foot area as much as possible. Personal contact and detailed instructions are very important to reduce the patient's fear of exercises. Early supervised physical therapy should be prescribed. We believe that it reduced swelling, increase mobility and limits post-operative decalcification of the bones and helps to heal the chondral lesions.

Different patients first day after surgery

70 y, male, calcaneal fracture both sides, MIS, 3 weeks after surgery

Suture removal from 10 to 14 days. After 3 weeks we start with ground contact. Bony healing of the calcaneus can be expected at 6 weeks. We begin with the active weight-bearing recovery phase with increasing load. We don`t use heel-offloading shoes. Full weight bearing and walking on even ground without crutches should be possible after 12 weeks. A CT - control is done at this time.

weight-bearing after 6 weeks



clinical and radiological result after 12 weeks

Epilog

If you have any questions or you would like to comment, feel free to contact us. We would be pleased about feedback. We appreciate your input to further develop our technique and new devices to aid in this technique.

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Updates, infos and case reports

https://www.calcaneal-fracture.com

Additional documents

Video at the OTA Video Library

https://otaonline.org/multimedia/17980365/minimal-invasive-treatment-of-intraarticular

"Minimal invasive Versorgung intra-artikulärer Fersenbeinfrakturen mit dem 2-Punkt-Distraktor" issue from April 2017 of the journal "Operativen Orthopädie und Traumatologie" Oper Orthop Traumatol (DOI 10.1007/s00064-016-0478-0)

http://www.springermedizin.de/operative-orthopaedieund-traumatologie

3 presentations on the medical video platform VuMedi: www.vumedi.com

https://www.vumedi.com/video/minimal-invasive-surgery-of-intraarticular-fractures-of-the-calcaneus-update-2017/

https://www.vumedi.com/video/minimal-invasive-treatment-of-intra-articular-calcaneal-fractures/

https://www.vumedi.com/video/calcaneal-fracture-placement-of-the-sustentaculumscrew-in-minimal-invasive-technique/

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