Surgical Orthopedic Treatment

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The foot is a modernized hand, and while it has the same structure as the hand, it has lost its prehensile function and has acquired both weight-bearing and locomotor functions.

The structural orientation of the foot is essential for stable and pain-free weight bearing. Functional pain at the medial structures of the upper and lower ankles might be due to an exaggerated valgus or "ad latus" of the foot. The converse is true for the varus foot. It must be noted that every operative reorientation of the foot and ankle is amplified distal to the surgical site and may, without other means, create secondary imbalance.

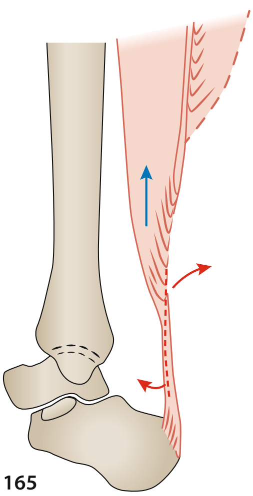
The muscular balance of the foot is essential for secure acceleration and deceleration, and in many cases the muscular imbalance causes the structural disorder.

Surgical treatment of foot and ankle disorders most often incorporates a whole "menu" of different measures combining structural and motor means that converge to a comprehensive aim. Those aims and the treatment rationale are described below.

1 Functional correction of the hindfoot in the sagittal plane

Muscle balance

Hindfoot equinus is a major sign of many foot diseases ***(E73)***. It concentrates on the adaptive shortening of the calf musculature. True equinus, including shortening of the musculus suralis is best treated by ***elongation tenotomy of the heel cord*** because all three muscles are involved ***(T788)***.



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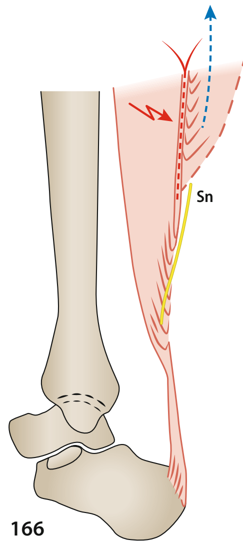
Functional equinus that appears clearly only with the knee joint extended ***(E74)*** is best treated by selective elongation of both gastrocnemii muscles because those muscles insert on the femur. The suralis muscle, which inserts on the lower leg, then preserves its integrity and function. Mild adaptation of this problem is best resolved in young, elastic musculature by anterior ***fasciotomy of the ventral muscle fascia of both gastrocnemii (T791)***.



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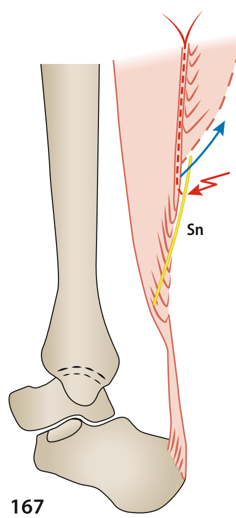
In older, stiff, and/or severe cases, ***tenotomy of both distal gastrocnemii (T793)***



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is more suitable to resolve the functional hyperflexion of the foot.

Paralytic pes equinus of the hindfoot must logically be treated by muscular substitution to reanimate extension of the foot. Following the clinical and eventual electroneurologic status, different tendons are better suited for being transferred to act as extensors. The most suitable muscle to be transferred is the ***musculus tibialis posterior onto the dorsum of the foot (T819).***

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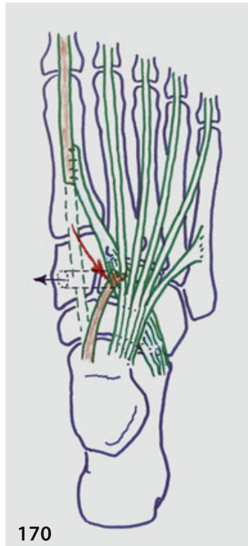
Attention must then be paid to the loss of hold of the longitudinal arch of the foot. It is generally wise to replace the removed posterior tibialis muscle with the flexor digitorum longus to avoid the risk of secondary collapse of the foot in pronation ***(T816)***.

If the posterior tibialis muscle is insufficient or inadequate for other reasons, ***the extensor digitorum longus and hallucis longus are transferred*** onto the dorsum of the foot ***(T821)***.



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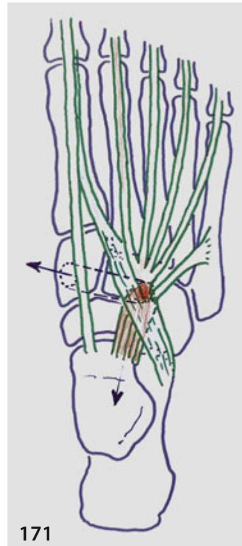

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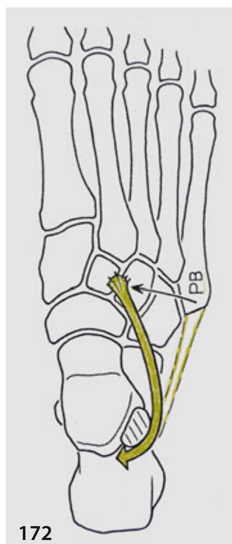
If functional, ***the musculus fibularis brevis is also transferred***.



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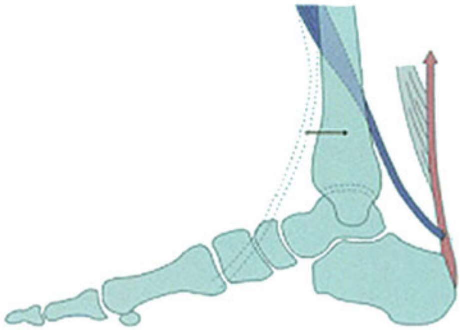
Hindfoot talus is linked to neurologic diseases, which include pathological weakness of the flexors. After evaluation of the relevant power of the foot extensors, those are ***transferred to the heel through the interosseus membrane.***



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Such a transfer is usually enough to position a foot plantigrade but is insufficient to substitute for the great power of the normal triceps surae.

Repetitive hammering of the posterosuperior apophysis of the calcaneus on the distal Achilles tendon triggers a chronic pre-Achillean bursitis (20). A tendinitis component may also occur. The aim of treatment is to ***remove the causal osteophyte (T614)*** to avoid recurrence of the bursitis.

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Upper ankle repair

Provided that the static bony alignment of the hindfoot, including the physiologic valgus, is stable, the collateral damage to the cartilage, bone, and ligaments must be addressed.

Cartilage repair

Long-lasting instability may cause ***osteochondral lesions***

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that behave like ***articular sequesters***.

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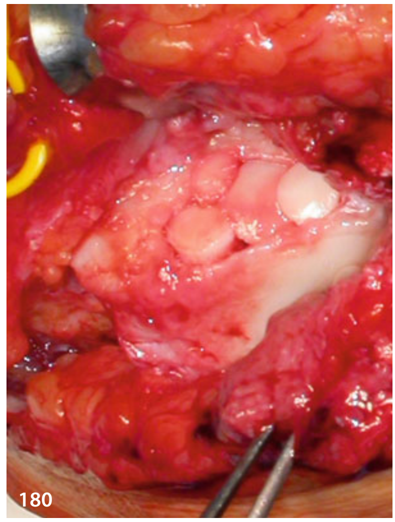
Surgical correction includes alignment, stabilization, and articular repair. *Cartilage repair* includes removal of the necrotic osteochondral tissue and substitution by means of ***autologous osteochondral transplants*** (21) ***(T573)***.



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The instability referred to above must be corrected by eventual static (reorientation osteotomy ***(T553, T612)*** and/or ligamentous (***ligament reconstruction***) ***(T773)*** means.

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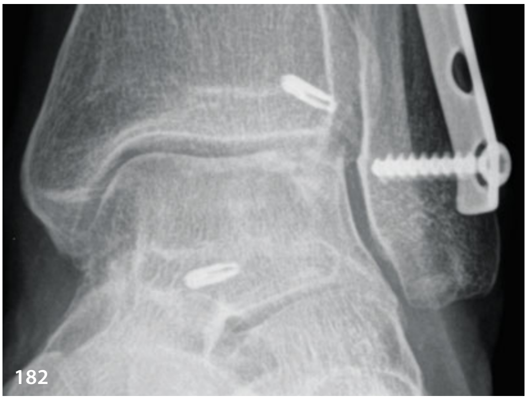
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Anterior cheilectomy of the upper ankle joint

Osteophytes of the anterior upper ankle joint

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represent an impingement that accelerates joint degeneration by impeding function and should be removed. Their origin is mostly due to abnormal motion between the tibia and talus, caused by insufficient ligamentous structures. The containment of the joint must be respected for anteroposterior stability, and thus ***osteophytes located on the talus are addressed first (T575).***


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Posterior cheilectomy of the upper ankle joint

Posterior impingement of the upper ankle joint involves the tibia, the talus, and the calcaneus. The flexion of the hindfoot is impeded by pain and morphologic anomalies, while the impingement is often triggered by trauma in plantar flexion. The posterior debridement concerns ***the posterior process of the talus***,


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which might be fragmented ***(R162)***, or the flexor hallucis longus tendon and its passage between both posterior talar tubercles ***(T581)***. Anatomic abnormalities such as additional muscles ***(E127)*** may also be involved, although this is rare. This surgical approach is exclusively ablative ***to remove the impinging structures***.

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2 Alignment of the hindfoot in the frontal plane

Frontal alignment of the hindfoot and the upper ankle joint is an essential element of varus/valgus stability ***(E15, R134)***. In the upper ankle joint, the talar tilt (frontal plane) is critical because it is a conical hinge joint. Vertical forces should act on mainly horizontal bearing surfaces to avoid shifting along the hinge axis. The mechanical guide is the medial malleolus on one side and the more or less recoiling lateral malleolus, which closes the "mortise," on the other side. It becomes clear that any relevant tilt of the talus within the mortise ***(R136)*** is mechanically unfavorable because of medial or lateral overload. The tibial plafond is less resistant than the talar dome. As a result, in misaligned hindfeet the tibial plafond gives way to overload, and the talus remains grossly intact. In stable upper ankle joints, the talar dome (not the tibial plafond) has a horizontal alignment (±2 degrees) within the frontal plane ***(R134)***. Excepting the rare posttraumatic malunions of intraarticular fractures of the distal tibia or fibula (malleolar fractures), reorienting the upper ankle joint naturally addresses both tibia and fibula.

If the axis of the lower leg presents a relevant angulation within the frontal plane (genu or crus varum) ***(E14)***, the knee joint must be considered and examined closely. A logical reconstruction of the lower limb must be comprehensive. A varus instability of the hindfoot that includes a genu varum with a medial overload of the knee joint would indicate the need for a ***valgus correction at the proximal end of the lower leg***,

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whereas in cases in which the lower leg is vertical, the valgus correction is best performed ***a few centimeters above the ankle joint (T557)***.

The converse is true for, for example, valgus malunion of the upper ankle joint in which the correction is logically performed ***at the level of the deformity*** and naturally addresses both tibia and fibula, such as in ***malunited malleolar fractures (T553)***.


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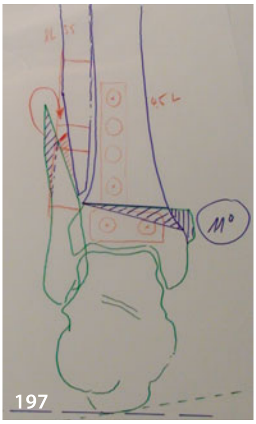
Attention is given to the vitality and perfusion of the soft tissues: A ***closing osteotomy without lengthening of the convex side*** of the correction is always safer.



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Isolated malunions after fractures of the distal fibula must be identified radiologically ***(T559)***,

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and a ***correction osteotomy at the fracture site (T561)***

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allows for stabilization through corrected joint congruency and functional restoration.

3 Alignment of the heel in the frontal plane

Referring to the conventional anteroposterior radiograph of the hindfoot under weight-bearing conditions ***(R134)*** and provided that the talar dome is horizontal, the tuber calcanei is, for natural stability, better situated lateral to the center of the talus by about 2 cm.

Hindfoot varus is most often the cause of chronic varus instability ***(R135)***, including recurring sprains and torn ligaments that lead to joint degeneration. Cartilage wear, osteochondritis dissecans, and loose cartilage fragments are the result. The axis of the heel within the frontal plane is modified if the ***tuber calcanei is translated within the frontal plane***

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and/or the tuber calcanei is rotated around a horizontal anteroposterior axis. These modifications can be performed through an osteotomy that divides the bone behind the posterior facet of the subtalar joint ***(T611)***. A lateral shift of the tuber calcanei lateralizes the heel cord at heel strike during gait and thus ***stabilizes the lower ankle joint in valgus***.

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If the effect of lateralizing the tuber calcanei is insufficient, ***dorsally extending the first ray (T685)***


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enhances the global correction by ***pronation of the foot***.

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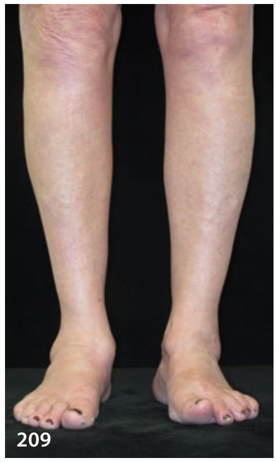
There are conditions that involve deformity in two places, ***both above and below the ankle joints***.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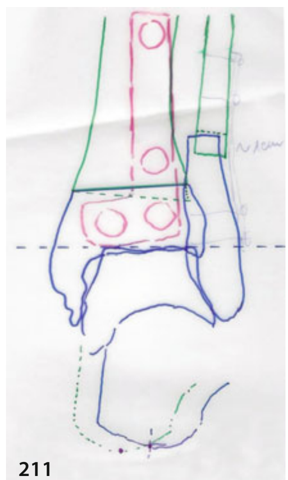
The statics are then considered using a radiograph taken under weight-bearing conditions. The supramalleolar correction, i.e., ***bringing the talus perfectly horizontal***, is planned first ***(T557)***, while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the position of the heel is considered afterward. If the heel is still malaligned, surgical correction is then also ***performed on the heel level (T612).***

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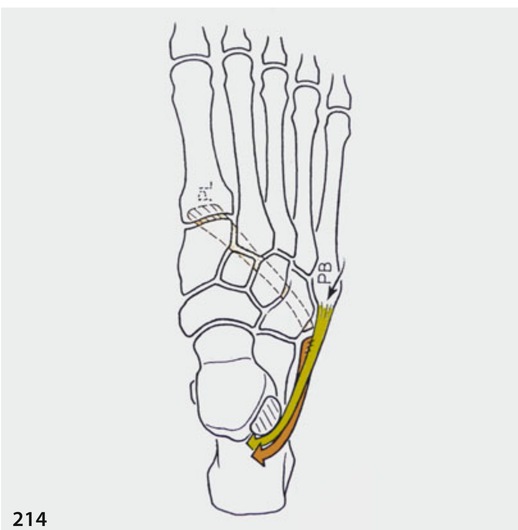
The motor counterpart of such correction is done by ***transferring the fibularis longus tendon*** to the insertion of the fibularis brevis ***(T827)***.



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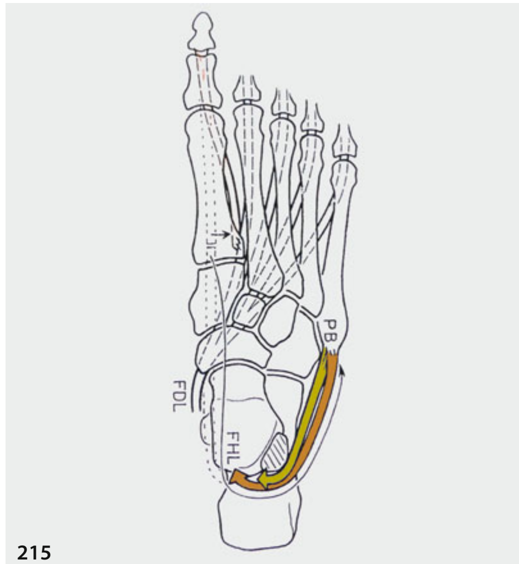
The plantar flexion of the first ray is weakened, and the pronation torque around the lower ankle joint is increased because the fibularis longus inserts on the plantar aspect of the first metatarsus and cuneiform. If a shift of the pronators is not yet sufficient, ***transferring the flexor hallucis longus to the basis of the fifth metatarsus (T833)*** logically increases this action.



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If the patient demonstrates a *tight heel cord*, which is frequently the case ***(E73)***, releasing the tightness corrects the muscular imbalance. Clinical examination informs the physician about the adequate level of the lengthening procedure ***(O165, O166, O167)***.

Hindfoot valgus may cause progressive overload of the lateral aspect of the upper and lower ankle joints. Correlated lesions include local ***osteonecrosis*** or osteochondritis of the talus.

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It results in an imbalance of the load and ***over-loading of the lateral aspect of the upper ankle joint***.

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The prerequisite for success is a perfectly vertical lower leg without relevant talar tilt. ***Moving the heel toward medial (T613)***

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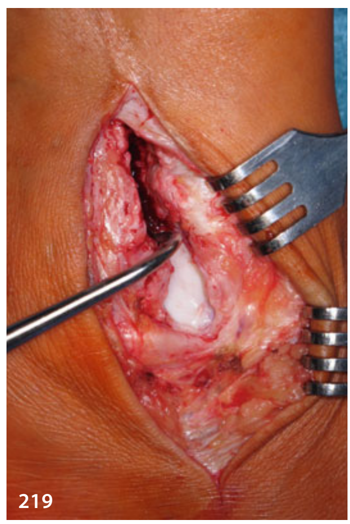
within the frontal plane logically corrects the load within the upper ankle joint.

4 Static articular stabilization of the hindfoot

The *ligamentous repair* is mostly centered on the lateral aspect and must be based on the anatomic position and shape of the ligament to be repaired or replaced.

Syndesmosis reconstruction of the upper ankle joint

Forced external rotation of the foot beneath the lower leg stresses the anterolateral ligamentous structures between the tibia and the fibula. The deltoid ligament is a very strong structure that tightens the medial aspect of the talus and the calcaneus beneath the medial malleolus. The lateral structures are generally less solid and yield at different levels: the fibula with the anterior syndesmosis and the interosseous membrane (malleolar fracture classified "Weber C") or without the syndesmosis (malleolar fracture classified "Weber B"). The ***insufficient (or absent) anterior tibiofibular syndesmosis (E79)*** after, e.g., fibular fracture



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jeopardizes the upper ankle joint by ***instability*** and secondary arthrosis.

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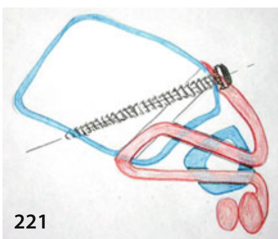
The best stabilization of the syndesmosis is ***surgical reconstruction of all three of its ligamentous parts*** with the anatomic congruency of the fibulotalar joint (22) ***(T770)***.



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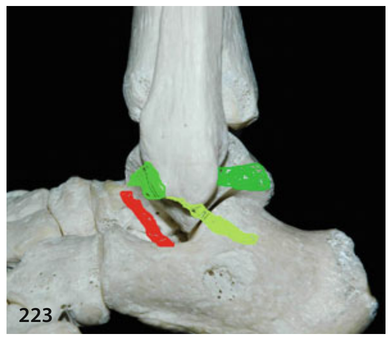
Ligament reconstruction of the ankle joints

In anterolateral instability of the upper ankle ***(E83)***, the talus shifts anteriorly and turns around the medial malleolus within the horizontal plane. Securing back the talus within the mortise is best performed naturally by a competent, anatomically placed, anterior fibulotalar ligament. In the presence of a substantial ligamentous structure, its refixation on the anterior fibula is sufficient (23) ***(T773)***. If this substantial structure is missing, the ligament is replaced by autologous tissue, if possible local and pedicled, to achieve the most "biological" repair. It appears clear that the ***anatomic trajectory of the ligaments***



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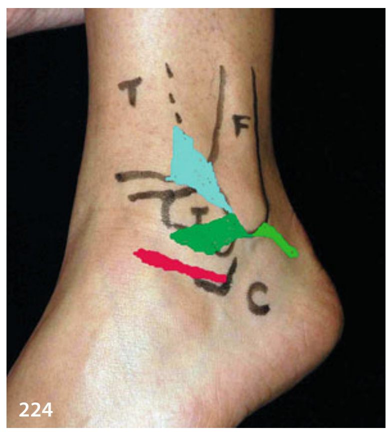

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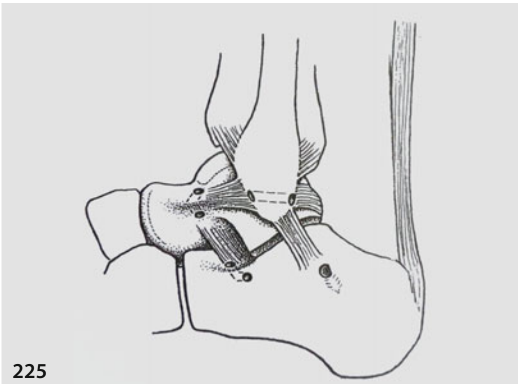
must be respected to achieve physiologic conditions. Under this aspect, then, three ligaments may be addressed for eventual substitution: the ***anterior fibulotalar (T779)***, the ***fibulocalcaneal (T777)***, and the ***cervical (T785)*** (anterolateral talocalcaneal) ligaments.



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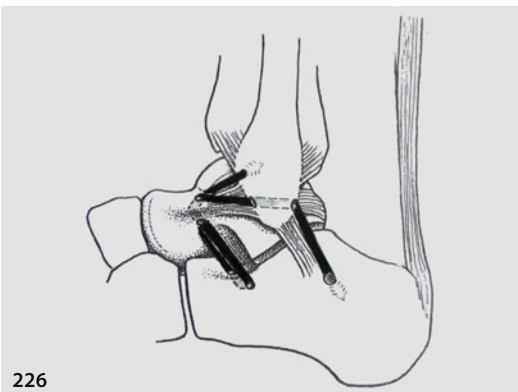

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The posterior ***fibulotalar*** ligament is thus intact and ruptures only in complete dislocation of the upper ankle joint.

A relevant lesion on the medial side is more serious and more arthrogenic due to the secondary laxity: The talus then does not turn around the medial malleolus within the horizontal plane but is free to slide in any direction.

A complete rupture of the deltoid ligament is rare without complete dislocation of the joint. Optimal treatment is performed immediately after the trauma ***(F431)***.

5 Arthrodeses of the hindfoot

Alignment of the hindfoot is obtained through arthrodeses if realigning osteotomies are excluded. Arthrodeses must allow for realignment in all three planes considering angular and translational means.

Upper ankle fusion

If the upper ankle undergoes painful articular destruction limiting its mobility, fusion in the anatomic axis is the logical treatment. The cause of joint deterioration is often linked to ***malorientation***

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and/or instability, which ***destroys the cartilage layers***.

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Subtalar mobility should be painless, but an additional subtalar arthrolysis with eventual osteophytectomy can help limit the damage to the lower ankle joint and improve function. Fusion should be done with a very precise anatomic angulation between tibia and talus ***(T565)***, including a slight external rotation because after the fusion the foot is designated to scroll about the coxa pedis. Positioning the talus within the sagittal plane is also critical because, most often, destruction of the upper ankle joint goes along with ***anterior translation of the talus***

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due to its conical shape within the horizontal plane.

Shifting the whole foot posteriorly (T566)

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within the ankle mortise centralizes the lower ankle joint beneath the tibia and reduces the foot lever, easing the gait. Attention should be addressed to the length of the fibula. Fusion between tibia and talus includes osteochondral tissue removal, which shortens the limb by a relevant length. The ***fibula should be shortened***

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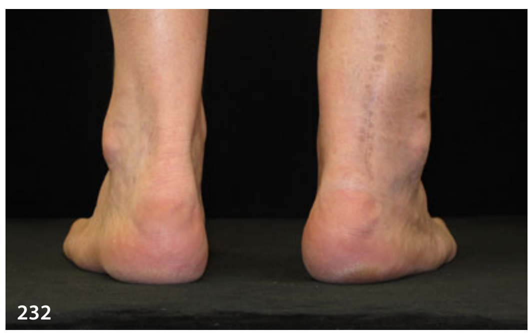
by at least the same amount to ***avoid secondary fibulocalcaneal impingement***.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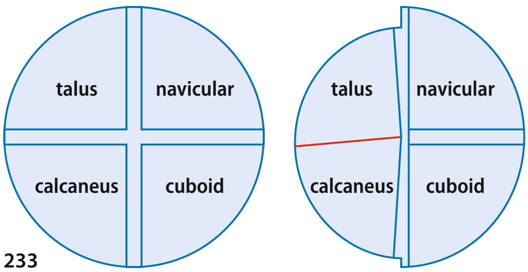
Subtalar fusion

If the subtalar joint undergoes painful articular destruction limiting its mobility, fusion in the anatomic axis is the logical treatment. All four bones of the hindfoot – talus, navicular, calcaneus, and cuboid – are “cross-linked,” forming in part the lower ankle joint. If only one of the joints is fused, the ***orientation of the whole hindfoot will be modified*** but not necessarily in the desired fashion.



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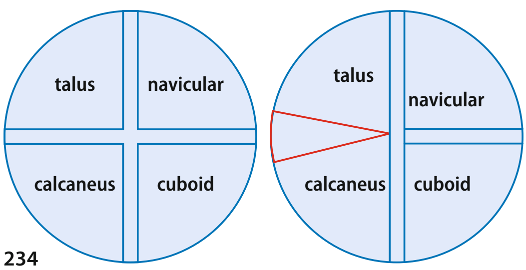
In such cases an interposition spacer (e.g., autologous bone block) must be included to ***restore orientation of the hindfoot*** (***T591***).



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Fusing the subtalar joint alone significantly reduces and modifies motion at the talonavicular joint.

The clearest example of this kind of reconstruction is subtalar fusion after calcaneal malunion.

If the sagittal angle between the axis of the talus and axis of the calcaneus is significantly reduced, or, in particular, ***the calcaneus is flattened after trauma***,

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the whole ***ankle joint is maloriented***.


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The clinical problem is that of pain due to residual mobility within a destroyed joint: to a lateral fibulocalcaneal and to an anterior tibiotalar impingement. ***Push-off is weakened***


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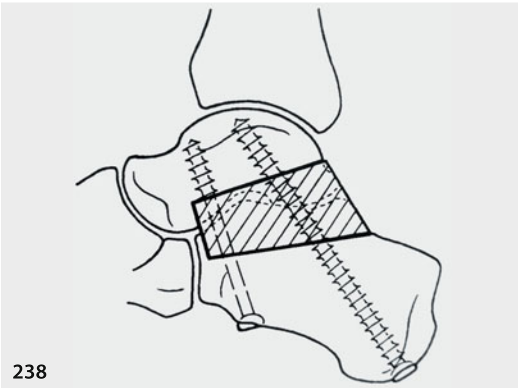
due to the reduced height of the ankle and the resulting relative lengthening of the heel cord. Reconstruction must involve a ***solid biological (autologous bone) spacer***



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joining both talus and calcaneus to allow for a functional and impingement-free upper ankle joint. The ***height of the ankle joint is corrected,***

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and the ***push-off is restored.***

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In congenital and degenerative disorders, the correct length of the calf muscles and tendons must be checked precisely and adapted to the structural correction to avoid true equinus of the foot. While in most "flat feet" the heel is in equinus and must be reset by, for example, a gastrocnemius recession, in posttraumatic situations the length of the heel cord is normal and should not be changed when correcting the equinus calcaneus.

Tibiotalocalcaneal fusion

If the painful articular destruction involves both the upper ankle and the subtalar joints (posttraumatic, diabetic arthropathy, chronic deformity with joint degeneration), the hindfoot must be placed in a very precise position beneath the tibia, allowing for uneventful function of the midtarsal and forefoot joints. This includes a perfect plantar foot in relation to the axis of the lower leg and a slight external rotation allowing for rolling over the medial edge of the foot. Stable fixation is demanding because there is no constant, clear tension band side of the hindfoot. The normal alignment of the hindfoot from the distal tibia to the heel is angulated in valgus, varying between 5 degrees and 11 degrees (24). In fact, considering the three-dimensional environment, the ***anatomic transarticular bony alignment of the***

weight-bearing heel to the distal tibia follows a circular arc.

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This circular arc lies within a vertical plane that cuts the tuber calcanei, the posterior facet of the subtalar joint, and the upper ankle joint in about the center of their articular surface. The posterior facet of the subtalar joint is located slightly posterolateral to the center of the tibiotalar joint. Consequently, the ***vertical plane is angulated inward*** to about 15–20 degrees in relation to the sagittal plane.

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The most logical fixation device supporting the lower leg on the top of the foot thus follows this arc from the tuber calcanei to the metaphysis of the tibia and consists of a nail ***(T606)***. This nail must be understood as a ***"bone" nail***

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in contrast to commonly used "medullary" nails. Thanks to the solid bony internal structure of the calcaneus, the talus, and the distal tibia, the nail allows ***bone contact on its whole length***

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provided that a cavity with the same shape as the nail is drilled along its whole length ***(T602)***. Functional after-treatment allows for more rapid consolidation and rehabilitation.

Talonavicular fusion

Fusing the talonavicular joint alone, both subtalar and calcaneocuboid joint motions are reduced to an irrelevant magnitude; therefore, such a procedure is seldom indicated.

6 Horizontal and sagittal correction of the heel and midfoot

Correction of eversion

Central calcaneus osteotomy

Medial support of the hindfoot is provided by the sustentaculum tali ***(E90)*** and the long medial muscle tendons. If the sustentaculum tali does not hold the talus in the correct position, the resulting deformity must be assessed within the sagittal ***(R150)*** and the horizontal ***(R142)*** planes, both planes that indicate eversion. Within the sagittal plane one observes a flexed talus, while within the horizontal plane there is adduction of the talus corresponding to an increased divergence between the axes of the talus and the calcaneus. As a result, it should be possible to influence and correct the morphology of a symptomatic and mobile flat foot by reorienting the socket of the joint by means of a reorientation of the acetabulum pedis ***(T631)***. A very similar problem has been studied in treating hip dysplasia (coxa pelvis; 25) which, in common with the problem connected with coxa pedis, has seen a preference for an extraarticular procedure, thus respecting the essential mobility of the joint (26). Central calcaneal osteotomy (27) responds to this trend and repositions the talus on the calcaneus within the horizontal and sagittal plane and thus corrects eversion. It secures medial stability without reducing the arc of motion of the coxa pedis ***(E85)***. Additional means include shortening of the posterior tibial tendon and transferring the long flexor of the toes to the plantar cuneiform ***(T813)***. All these measures are effective to restore the longitudinal arch of the foot.


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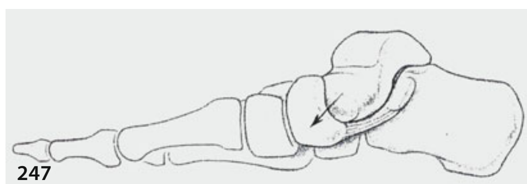
Congenital flat feet may be symptomatic medially at the insufficient posterior tibial muscle and tendon and laterally at the crucial angle of Gissane, thus causing an impingement ***(E88)***.

A lack of function of the posterior tibial muscle may also be due to an abnormal insertion pattern about the medial aspect of the foot. Presence of an accessory navicular bone ***(E103, O295)*** and its attachment to the posterior tibial tendon impedes the correct inversion power of the corresponding muscle.

Feet such as these lack articular stability at the midfoot, and the retracted calf muscles cause an ***equinus of the hindfoot.***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Congenital or acquired flat feet include an insufficient hold of the anterior talus on top of the calcaneus. More specifically, the ***sustentaculum tali is inefficient***.

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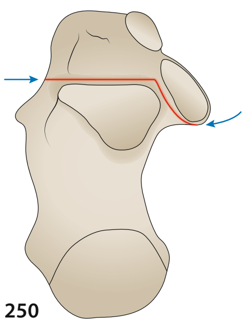
The aim is to restore the anatomic alignment of the hindfoot together with normal motion of the coxa pedis. The hold of the talus in its place above the calcaneus is performed by pushing the anterior part of the calcaneus beneath the talus ***(O256, T631)***. The calcaneus is thus divided ***between the posterior facet and the sustentaculum tali (T627),***



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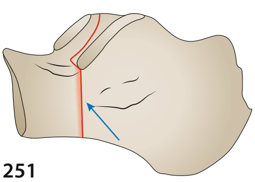

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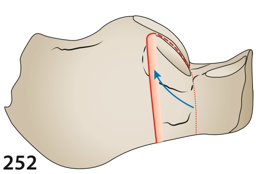

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and a bone block is interposed ***(T629)***. The ***calcaneus increases in length***.

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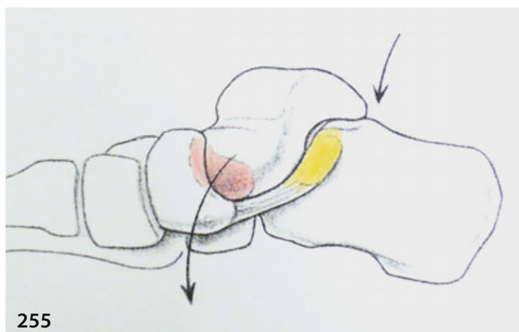
The talus is lifted and turned toward the lateral direction: It moves following a complex helicoidal motion ***(E87)***. ***The talus is raised in supination***.



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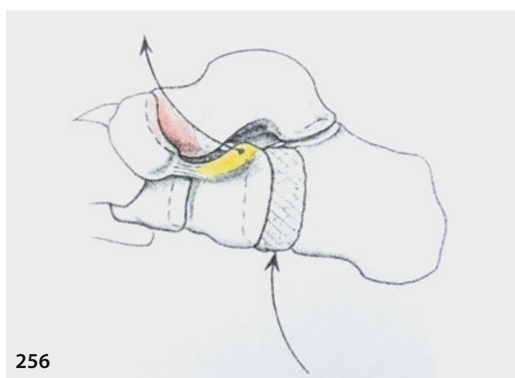

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The acetabulum pedis closes, and the normal valgus of the heel can be restored.

The ***sustentaculum tali is pushed forward*** beneath the anterior aspect of the talus,

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thus restoring the ***straight alignment of the talus to the first metatarsus*** within the horizontal and sagittal planes ***(R141, R149)***.

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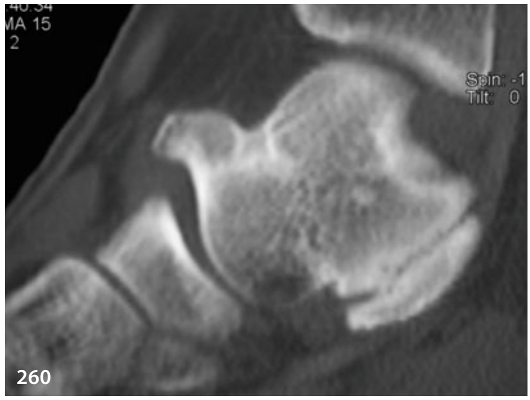
Another cause of misalignment is the **subtalar coalition** ***(R158)*** that may block normal motion of the coxa pedis, resulting in a ***"dorsal beak" onto the talar head.***



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Radiographs under weight-bearing conditions demonstrate the ***sag of the medial column*** at the talonavicular joint ***(R150)***.


261

Prior to elongation osteotomy, the calcaneus must be liberated from the talus to allow for ***reorientation within both transverse and sagittal planes***.

262

The raising of the talus supinates the midfoot and ***realigns the talus to the first metatarsus*** within the horizontal plane.


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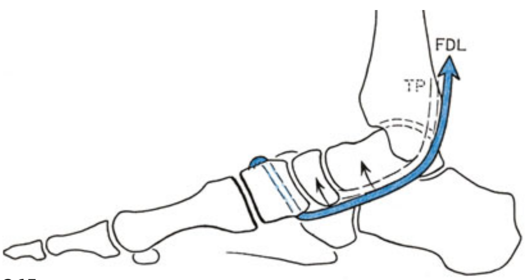
The resulting realignment must be held by a strengthened supinator muscle. Powering the supinators means assisting the medial suspension provided by the posterior tibial muscle and tendon. The flexor digitorum longus tendon follows the path of the posterior tibial tendon and receives about the midfoot a relevant tendon sheath from the flexor hallucis longus tendon. Sectioning the tendon of the flexor digitorum longus proximal to this sheath and transferring it to the plantar aspect of, e.g., the first cuneiform ***(T816) empowers supination***



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and does not result in sacrificing any relevant function to the toes.

Following these procedures, the forefoot is aligned to the hindfoot, and the equinus usually becomes very evident. Testing the effective shortening of the calf muscles ***(E73)***, the corresponding ***lengthening of the tendons*** is then achieved (***T788, T791, T793)***.


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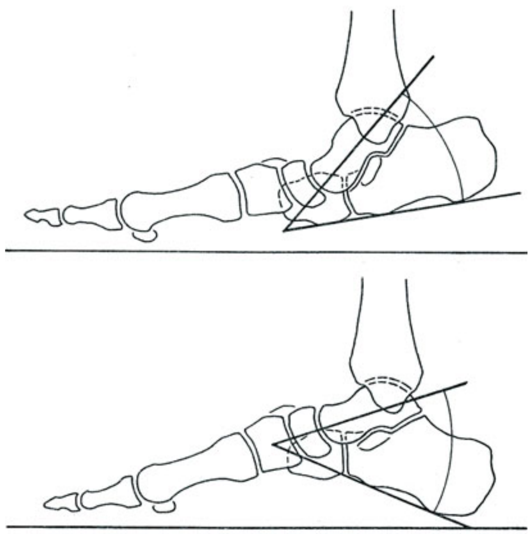
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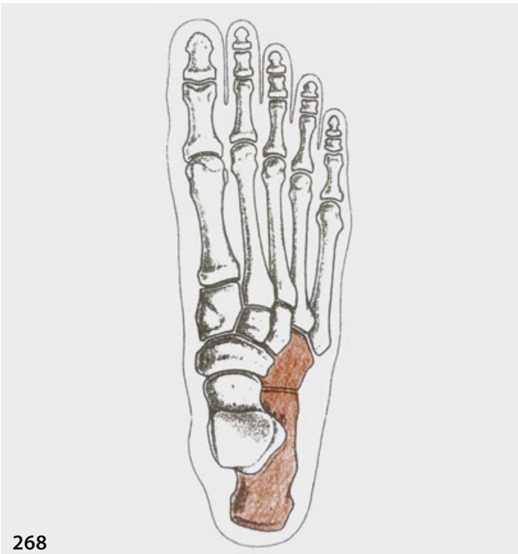
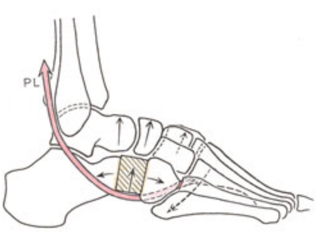
Calcaneocuboid distraction fusion

The "calcaneopedal unit" (28) is a concept elaborated on the basis of the coxa pedis. The entire acetabulum pedis construct includes the calcaneus, the cuboid, and the navicular bones ***(E90)***. ***Fusing the calcaneus to the cuboid*** thus affects only some of the talocalcaneonavicular joint mobility –



268

so little, in fact, that its clinical relevance is close to zero. However, the alignment between the calcaneus and the cuboid is essential for the whole hindfoot and forefoot alignment. In particular, moving alignment upward increases pronation of the forefoot, while using it with an interposed bone block corrects eversion and puts the ***peroneus longus tendon under tension***. This effect pulls down the first metatarsus, thus increasing the "cavus effect" on the medial arch.



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Differentiating the localization of the cuboid on the anterior process of the calcaneus allows for rotation of the forefoot within a frontal plane. The center of such rotation is the talonavicular joint (10). Due to its simple lateral approach, this correction is justified in specific calcaneocuboid misalignment, in local arthropathy (arthrosis), and in ***global correction of symptomatic eversion*** (pronation).

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Correction of inversion

Central talus osteotomy

Pes adductus is a relevant component of clubfoot deformity. In young patients suffering a pes cavus-varus-adductus ***(E60)*** without joint degeneration and good mobility, lengthening (and eventually rotating) the talar neck is a very powerful means to ***correct the adductus***.


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In fact, this correction aims at restoring the normal divergence of the talus and the calcaneus. To do so, lengthening the medial column of the foot, together with the release of the adjacent soft tissues by means of joint capsules ***(T616)*** (talonavicular joint) and tendons (posterior tibial tendon) ***pushes the forefoot in abduction (T621)*** and ***increases the anteromedial weight bearing*** of the foot (left foot).


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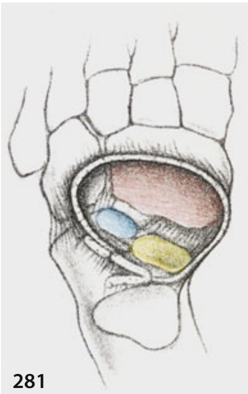
A prerequisite is very safe vascularity of the soft tissues and good mobility of the joints. The intervention includes a complete ***medial opening of the acetabulum pedis (T616)***.



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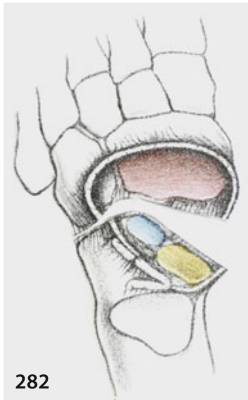

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The effect of the necessary release of the posterior tibial tendon may be increased by transferring it onto the opposite side of the foot (dorsolateral) ***(T819)***. The foot rotates horizontally around the calcaneocuboid joint. Therefore, a frequent complement to the medial opening and eventual lengthening of the talar neck is the ***shortening of the lateral column***

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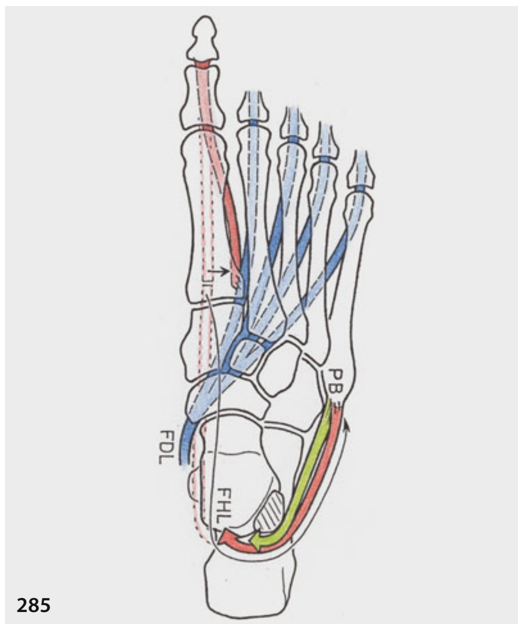
by fusing the calcaneocuboid joint ***(O323)*** and extending the first metatarsus ***(T685)***. The calcaneocuboid joint minimally affects the mobility of the lower ankle joint and is very well supported. This procedure limits the soft tissue strain on the medial side of the foot.

According to the tridimensional character of the deformity, the exaggerated varus component is also corrected by a lateralizing tuber calcanei osteotomy ***(T612)***. The extension osteotomy of the first metatarsus reduces the anteromedial buttress of the foot.

The motor component of this correction is very important for avoiding relapses because the etiology is essentially neurologic through a muscular imbalance that most often must be cleared by electroneurography. The foot pronators must be powered. This includes, besides the mentioned posterior tibial tendon transfer along the fibularis tertius tendon ***(T819)***, a lateralizing transfer of the anterior tibial tendon, a transfer of the fibularis longus to the fibularis brevis tendon ***(T827)***, and transfer of the ***flexor hallucis longus tendon to the basis of the fifth metatarsus (T833).***



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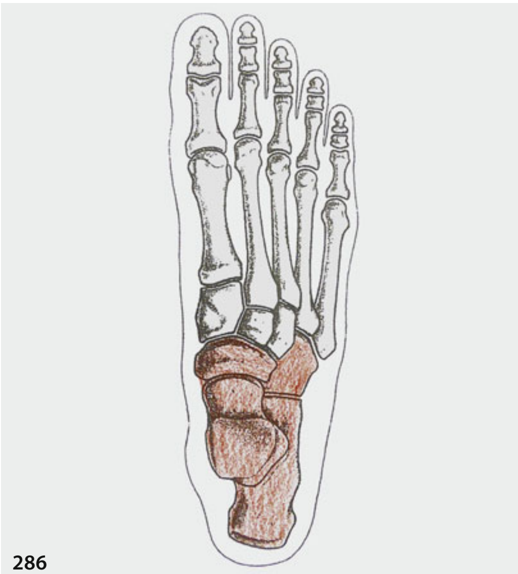
Correction by global fusion: triple arthrodesis

Triple arthrodesis fuses the talonavicular, the talocalcaneal, and the calcaneocuboid joints. Fusing the ***four mentioned bones***



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is a very efficient intervention that addresses painful degenerative and posttraumatic conditions or ***malorientation of the lower ankle joint***

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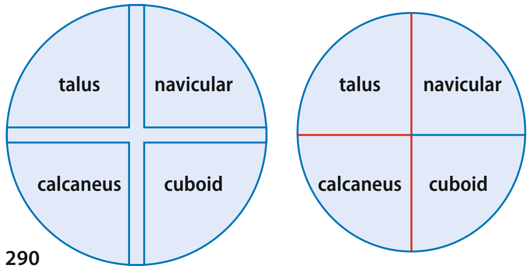
and allows for a free reorientation of the whole hindfoot and midfoot within the sagittal and the horizontal planes ***(T642)***. All four bones are mobilized completely and reassembled with the desired horizontal and sagittal orientation in a ***slightly reduced dimension.***



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The ***talometatarsal axis is realigned*** within both sagittal and horizontal planes.

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If the indication includes a deformity due to neuromuscular imbalance or degenerative insufficiency of the posterior tibial tendon, the corresponding imbalance must be corrected by the adequate tendon transfer ***(O265)***. In some cases, the deformity recurs within the fusion if the imbalance persists. Such recurrences are particularly frequent in Charcot–Marie–Tooth disease, in which the muscular imbalance progresses stepwise. Other expansions of this reconstruction occur in selected cases of diabetic arthropathy in which the medial column of the foot, the talometatarsal axis, is malaligned. Here, the triple arthrodesis is associated with a talometatarsal arthrodesis ***(O321)***.

7 Horizontal and sagittal correction of the midfoot

Correction of eversion

Eversion of the midfoot and/or forefoot corresponds mechanically to a collapse of the longitudinal medial arch of the foot ***(O255)***. An occasional accessory navicular bone is testimony to a certain posterior tibial muscle/tendon insufficiency. In essence, those deformities have to be observed in the three planes of space and only then can be quantitatively evaluated. There are deformities that are more clearly expressed within the horizontal plane (abduction) and others that are more visible within the sagittal plane, which corresponds roughly to a dorsal extension of the medial forefoot and an equinus or plantar flexion of the hindfoot.

Talonavicular fusion

The talonavicular fusion is part of the triple arthrodesis. As previously stated, this single fusion modifies the orientation of the midfoot. The indication is probably exceptional because it blocks a major part of the lower ankle joint's mobility. This is due to this joint being essential for functional hindfoot motion.

Naviculocuneiform fusion

Pes pronatus or planus may present its main deformity distal to the talonavicular joint. The ***abnormal abduction and extension (eversion) of the forefoot*** may concentrate on the naviculocuneiform joint.

294

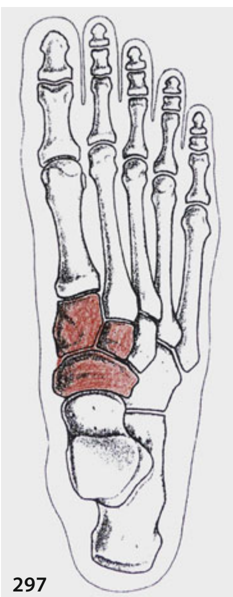
On the horizontal radiologic view of the weight-bearing foot, the talus is well covered by the navicular bone, and ***the pathological angle in abduction is more distal***.

295

Orientation within the sagittal plane is less affected.

296

The “talar foot” by means of the first three rays is corrected surgically in either plantar flexion – thus correcting the deformity within the sagittal plane – or/and adduction within the horizontal plane. Both sagittal and horizontal components are more or less pronounced anyway. The naviculocuneiform joints are not essential for foot function and are thus ***destined for correcting these deformities (T648)***.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In cases in which the sagittal sag of the medial column is located at the talonavicular joint *and* the naviculocuneiform joint, the naviculocuneiform fusion is associated with the central calcaneal osteotomy ***(O256)***. One thus simultaneously achieves ***sagittal correction of the talometatarsal axis***

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301

and ***correction of the abduction***


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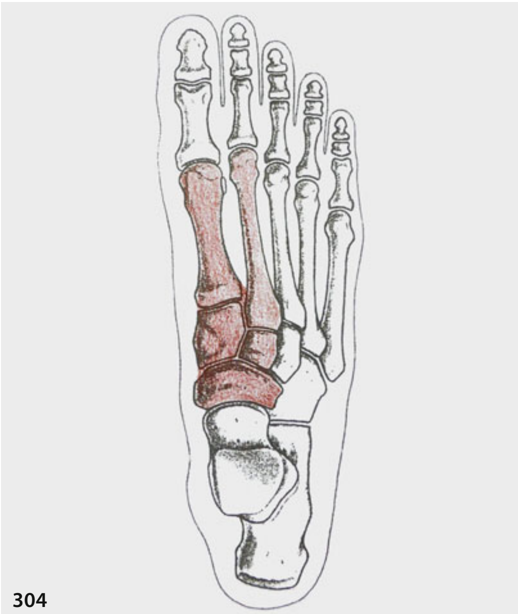
within the horizontal plane while preserving all essential articular mobility of the foot.

The process lateralis tali no longer impinges on the calcaneus at the crucial angle of Gissane.

Naviculometatarsal fusion



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In cases of degenerative deformities, the instability is frequently located at the naviculocuneiform level as well as more distally at the cuneometatarsal level. The medial forefoot suffers from a missing functional buttress, and the entire foot pronates. Diagnostics is essential to exclude an eventual insufficient tibialis posterior function. Radiologic verification demonstrates the ***sagittal sag of both naviculo-cuneiform and cuneometatarsal joints***.

305

The horizontal plane demonstrates discrete abduction within the naviculocuneiform joint and a ***metatarsus primus adductus.***

306

As nonessential joints, the medial tarsometatarsal joints are fused and arranged in both ***horizontal (adduction) (T665)***

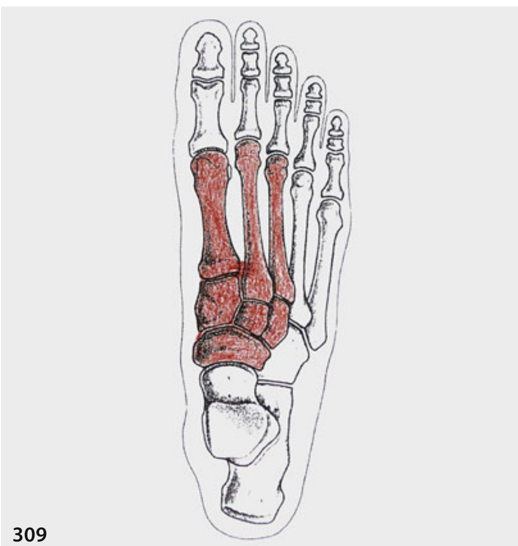
307

and ***sagittal (flexion) planes*** to reestablish the anteriomedial buttress of the foot ***(T666)***.

308

The motor counterpart of the correction of imbalanced pes pronatus is logically corrected by either powering the supinators ***(O265)*** or powering the flexors of the first ray ***(T835)***.

In particular cases in which ***all three medial rays are involved,***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the ***abnormal abduction and extension (eversion) about the midfoot*** or the naviculocuneiform joints is associated with an ***adduction situated at the tarsometatarsal*** joints


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without including any articular sag in the sagittal plane.

311

Sometimes called "serpentine feet" or "Z-feet," the correction is also located on both aspects and is thus performed in ***adduction inversion at the naviculocuneiform*** level and in ***abduction eversion at all three medial tarsometatarsal joints.***

312

The radiographic appearance demonstrates a ***"true lateral"*** of the hindfoot as well as of the forefoot.

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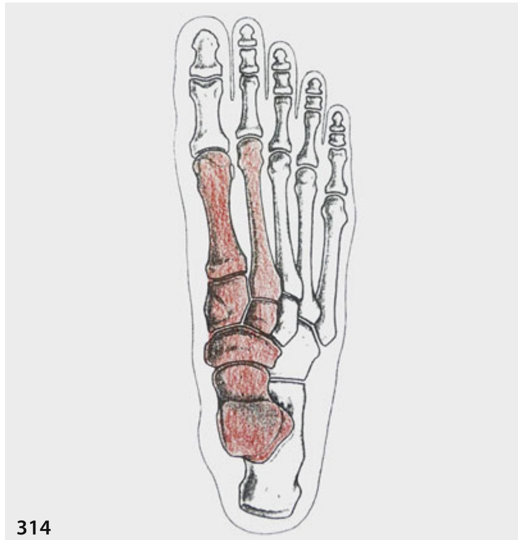
Talometatarsal fusion

If the articular degeneration includes the whole first ray, reorientation is done by ***fusing the talus in straight alignment with the first metatarsus***.


314

This fusion is justified if the misalignment is symptomatic because it can occur after trauma or diabetic arthropathy. ***Involvement of the talonavicular joint*** must be verified

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316

because it is the essential joint of the midfoot. As the means of fixation run along the long axis of the foot, axial rotation about this axis must be locked. The simplest locking is achieved through ***axial internal splinting through the third or the second ray***.

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This reasonably invasive fixation is sufficient for lower body weights and addresses the essential stability of the first ray, allowing full ***function of the upper ankle joint***.

319

A more invasive kind of reconstruction consists in stabilizing the axial rotation within the subtalar joint, indicated if there is a clinical hyperlaxity ***(E17)*** in heavy patients. The end result then corresponds to an association of a ***first ray stabilization with a triple arthrodesis (O293)***.

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321

Correction of inversion

Calcaneocuboid fusion

Triple arthrodesis is a very good tool to correct any deformity of the hindfoot situated beneath the upper ankle joint. Fusing the calcaneocuboid joint alone allows for localized shortening of the lateral column of the foot ***(O284)*** and thus a specific ***abduction of the midfoot*** that can be scaled by the quantity of bone removed.

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323

Gliding dorsally, the cuboid within the fusion adds a relevant pronating component within the correction.

First metatarsal extension osteotomy

Structural supination of the foot should also be investigated on the metatarsal level. A plantar-flexed first metatarsal is then easily corrected by an extension osteotomy of the first metatarsus ***(T685)***.

Dorsolateral tarsectomy

Pes supinatus presents a convexity dorsolateral to the foot. This deformity also leads to hindfoot instability with recurrent sprains. By rotating the foot around an oblique axis that includes the plantar aspect of the medial cuneiform and the cuboid, the deformity can be resolved in many cases. Essential joints may be involved depending on the severity of the deformity. A dorsolateral bone wedge is taken from the navicular and cuneiform bones ***(T649)***. The calcaneocuboid joint may also be fused in some cases. Instead of purely shortening the lateral column within the calcaneocuboid joint, the cuboid can be translated upward during the fusion. This concept is very efficient in ***turning the hindfoot in eversion and in extension.***

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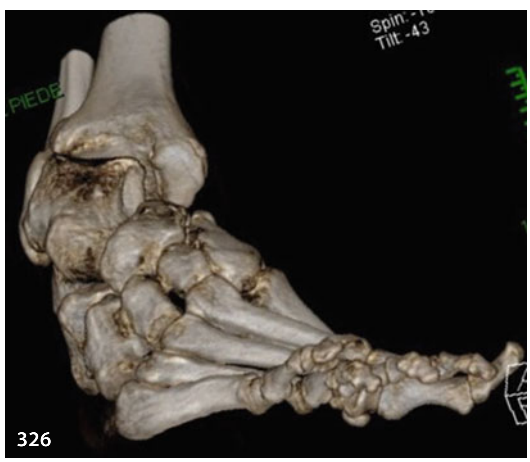
The procedure is especially indicated in severe deformities and in rigid feet suffering a posttraumatic ankylosis that impedes functional adaptation to the ground. The foot is corrected at the location of the deformity ***in extension and pronation.***



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The lateral tarsometatarsal joints ***adapt in flexion*** after the dorsolateral extension.

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The motor counterpart consists of powering the pronators of the foot. Correction of imbalanced pes supinatus is performed in a quantitative, rational way by transferring one or more muscle tendons of the supinators to the lateral dorsal aspect of the midfoot. It is wise to quantify the power of those muscles in the preoperative planning. The simplest transfer is the anterior tibial tendon shift to the lateral side of the foot. Transferring the posterior tibialis tendon on the lateral dorsum of the foot has the advantage of weakening the causal supination ***(T819)***. In more severe cases, additional transfer of the long extensor tendons of the toes on the lateral aspect of the dorsum of the foot empowers the dorsal extension of the foot ***(T825)***. This has the advantage of helping correct the claw or hammer toes that often occur in this kind of pathology. However, the power of the long flexor tendons must be evaluated during preoperative planning. While removing the power of the long extensor of the toes, the metatarsophalangeal joints relax in flexion as desired. On the other hand, the long flexors of the toes may provoke increased flexion of the whole toe by curling them. In order to stabilize the toes, the distal limb of the long extensor tendons is fixed onto the corresponding short extensor tendon. On the lateral side of the foot, the simplest transfer is that of the long fibular tendon to the short fibular tendon ***(T827)***. This move has the advantage of weakening the plantar flexion of the bases of the first metatarsus for a passive eversion. Preoperative examination should focus on the stability of the first tarsometatarsal joint. In the case of instability, removing the fibularis longus tendon from its location causes an insufficient anteromedial buttress together with a metatarsus primus adductus. Still on the lateral aspect of the foot, the fibularis brevis muscle and tendon are considerably empowered in severe cases by transferring the flexor hallucis longus onto the base of the fifth metatarsus ***(T833)***.

8 Horizontal and sagittal correction of the metatarsus

Medial and central tarsometatarsal fusion

Pes adductus may be located specifically at the ***tarsometatarsal joints***.


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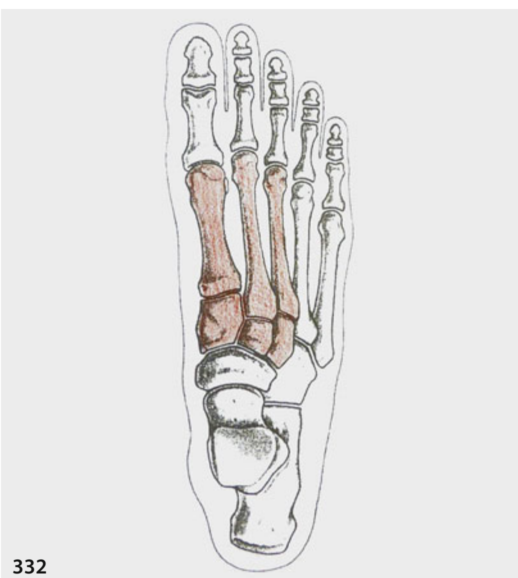
The whole gait may be altered, though without relevant metatarsalgia. The logical treatment is abduction arthrodesis of the ***first three tarsometatarsal joints***.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The fourth and fifth tarsometatarsal joints may spontaneously follow the correction. In severe cases, an arthrolysis will suffice for reorientation of the lateral column.

The dorsal extension component of the correction is important to consider in order to ***reduce the eventual exaggerated medial arch***


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and thus the overloaded lateral edge of the foot. A slight ***component of pronation*** results.


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The aim is horizontal ***alignment of the talus and the first metatarsus***.


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Due to the length of the metatarsi, the angulation at the fusion site remains modest in consideration of the morphologic result ***(T675)***.

Pes abductus occurs frequently in polyarthritis and in degenerative ***destruction of the medial tarso-metatarsal joints***.


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In this case, the foot ***collapses anteromedially***.


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This condition is treated logically by ***adduction of the central metatarsi and, in particular, flexion of the first metatarsus***.

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This allows for ***restoration of the medial arch*** of the foot.

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Arthrodesis at the corresponding tarsometatarsal joints is the optimal spot to restore functional stability and preserve the essential joints of the foot.

In the sagittal plane, malalignment of the metatarsus may be linked to the corresponding tarsometatarsal arthrosis and causes invalidating metatarsalgia. Fusing the arthritic joints is a highly effective way to realign ***the axes of the two central medial metatarsi in extension***

340

and the medial metatarsus in slight flexion ***(E62)***. This treatment is very efficient because the correction is performed at the base of the bones.

Lateral tarsometatarsal arthroplasty

The pathological abductus or adductus also concerns the morphology of the fourth and fifth tarsometatarsal joints. However, the fourth and fifth rays belong to the "calcaneal foot": These joints should be considered essential, and they require a wide range of functional adaptation during gait and are provided with one joint less than the medial three rays. Simple, complete arthrolysis of the two joints allows the fourth and fifth metatarsi to follow the corrected axis of the third tarsometatarsal joint. If the deformity is very severe or if the ***fourth and fifth tarsometatarsal joints are arthritic,***

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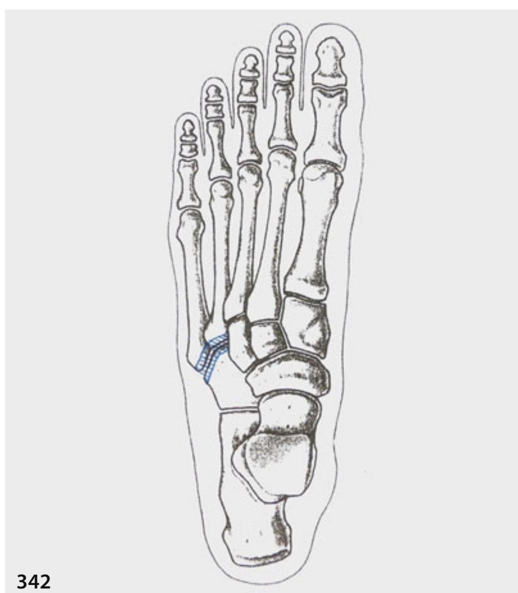
arthroplasty of the two joints by ***resection of the subchondral bone*** and interposing chondrogenic soft tissue (autologous tendons) ***(T680)***



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provides for a ***functional and stable reconstruction***.

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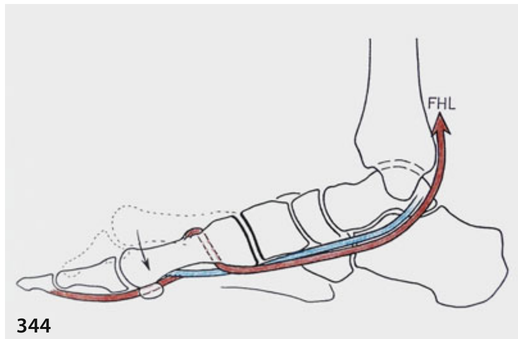
The plantar articular and ligamentous layers remain intact, acting as plantar tension bands ***(T677)***. In cases of tarsometatarsal destructive arthropathy, such as that occurring in rheumatoid arthritis, fusing the central (second and third) tarsometatarsal joints or all three medial tarsometatarsal joints ***(T675)*** may solve the articular and weight-bearing problems of the medial aspect of the anterior heel in one step. In opposition to the individual correction performed at the diaphyseal level, realignment at the first three tarsometatarsal joints allows for the most extensive correction of misalignment of the anterior heel.

9 Correction of the anterior heel

Weight-bearing problems of the anterior heel are due to a functional mismatch of load distribution on the sesamoids and the lesser metatarsal heads (4;17) ***(O350)***.

Muscle balance

Powering the flexors of the first metatarsus should help to achieve a better anteromedial buttress of the foot and correct hyperpronation. In certain cases, powering flexion of the first metatarsus by ***transferring the flexor hallucis longus tendon to the base of the first metatarsus (T835)*** is sufficient to reestablish the medial arch of the foot.



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The distal limb of the tendon is secured onto the distal aspect of the flexor digitorum longus. Unfortunately, the power of this reconstruction is insufficient in many cases; therefore, a bony stabilization is most often required.

First tarsometatarsal and first intermetatarsal space fusion

Alignment of the metatarsal heads and sesamoids is critical for smooth push-off and gait ***(E46, R146, O350)***. Alignment of the metatarsus refers to the sagittal as well as the horizontal alignment of the metatarsal heads (Lelièvre parabola) (19). As a rule of thumb, the radiologic axis of the first metatarsus should be aligned with the axis of the talus in both sagittal and horizontal planes.

Restoring a functional anteromedial buttress of the forefoot is indicated in frequent instability of the first ray ***(E115)***, which is characterized by a hypermobile first tarsometatarsal joint in the sagittal and also in the horizontal plane (4, 11). The radiographic image under weight-bearing conditions often reveals a widened space between the first and second metatarsus and between the first cuneiform and the second metatarsus ***(R144)***. The cuneometatarsal and the metatarsophalangeal joint are often of the ***condylar type***. ***Second metatarsal hyperplasia*** is the rule for clinical relevancy.

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The lateral incidence often demonstrates a slight **plantar opening of the innominate joints.**

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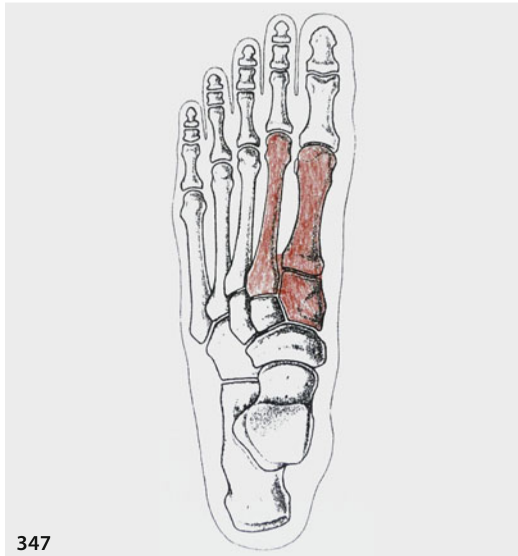
Reorienting the first metatarsus and fusing it to the second metatarsus and the first cuneiform (29) creates a ***new functional and less mobile entity***:



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the three bones ***articulate around the second cuneiform*** and thus limit, but not block, the functional sagittal mobility of the first ray.

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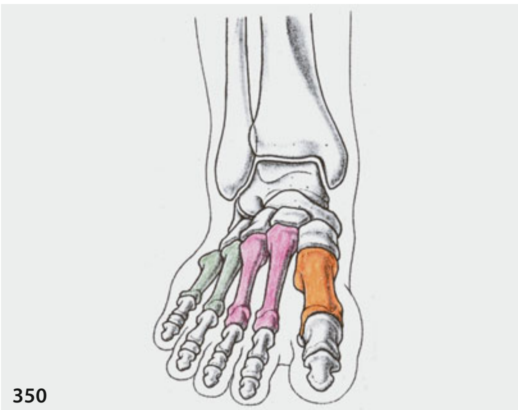
The first tarsometatarsal and intermetatarsal 1–2 arthrodesis provides, by its congruency, the lowest probability of recurrence of metatarsus adductus ***(T665)***.

Extension and shortening osteotomy of the central metatarsals

Symptoms of the missing anteromedial buttress are logically linked to the compensatory overload of the neighboring metatarsals. The ***second and third metatarsals are considered to be the central axis of the foot (A5)***,



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with minimal mobility at the tarsometatarsal level. The position of the metatarsal heads in relation to one another is crucial because during push-off they are loaded together, starting in a roughly horizontal plane and ending in a vertical plane. They are thus loaded on a full arc of 90 degrees ***(E46)***. The importance of the aforementioned Lelièvre parabola becomes clear at this point. If the alignment does not follow the parabola ***(E44)***, for instance when the second and third metatarsals are "too long" in relation to the first metatarsus (so-called Morton's foot; 4), at push-off (i.e., in a vertical position) those central metatarsi remain quite alone in the duty of taking load, which may provoke pain and premature degeneration of the corresponding metatarsophalangeal joints ***(O384)***. In fact, the plantar plate beneath the metatarsal heads suffers and is at high risk of getting torn off, thus jeopardizing the stability of the joint. In the long run, the toe dislocates dorsally, increasing disability and pain.

There are two principles to follow for correcting alignment of the lesser metatarsal heads: either a central diaphyseal or a basal metaphyseal osteotomy.

Diaphyseal osteotomy

Diaphyseal osteotomy allows for an immediate, highly precise correction but is somewhat invasive and includes implants ***(T694)***. The metatarsus can be extended, flexed, shortened, or lengthened without anatomic limitations and without disturbing the adjacent joints. As mentioned above, this correction is most often a ***corollary to the correction of the anteromedial buttress***.

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Logically, this correction is mainly needed on the central metatarsi because they suffer from an occasionally insufficient first ray, which has more mechanical freedom. It happens, however, on rare occasions that the fourth metatarsus (or, very rarely, the third alone) presents an isolated overload that is accompanied by a corresponding plantar callus. In these cases, a precise osteotomy fixed definitively by a plate can produce the desired harmonious functional weight-bearing pattern of the anterior heel.

Metatarsus quintus abductus is sometimes associated with imbalanced medial metatarsi (splay foot) ***(R145)***,

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and the problem is relieved by orienting the metatarsus ***on the diaphyseal level (T711).***

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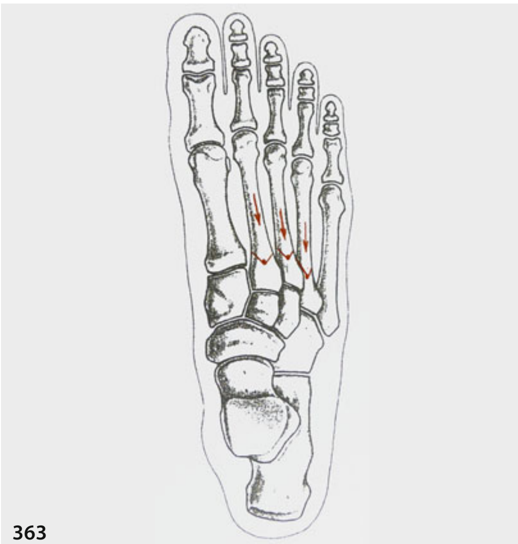
Basal osteotomy

Basal osteotomy, although less invasive, allows for physiologic approximative adjustment of the metatarsal head by weight bearing ("self-adjustment"). The sagittally guided slide of the bone is assured by the ***inclined chevron-like shape of the osteotomy (T706).***

Additionally, the said musculature avoids any rotational malunion that logically would have deleterious consequences on the rotational orientation of the toes and their joints.

In summary, the displacement path of the distal limb of the metatarsus (long limb) is oblique upward, allowing for ***adequate shortening***.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Essential components of the treatment are the postoperative plantar orthosis (***retrocapital cushion or "pelote"***), while the interosseous musculature (dorsal and plantar musculi interossei), which remains intact, ***cushions and limits the sagittal bony correction***.

This procedure ***(T706)*** is less predictive than diaphyseal osteotomy because it is self-adjusting and thus is well indicated in the elderly, osteoporotic, noncompliant, or smoking patient with local vitality problems, including peripheral arteriosclerosis.


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10 Correction of the metatarsophalangeal joints

First ray

The first metatarsophalangeal joint may experience local overload over time. Certain morphology, including a relatively long first metatarsus (index metatarsus plus) and an Egyptian morphotype, favors joint degeneration ***(R148)***.

Following a degree of joint degeneration and reduction in mobility, either the joint can be decompressed or reoriented, the head remodeled, or the joint fused.

Joint decompression

If the joint surface is acceptable in a young person, and the combination of an Egyptian morphotype and an index metatarsus plus is present, the pressure within the joint is reduced by ***shortening the first metatarsus (T684) and/or the first phalanx (T744).***

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Metatarsophalangeal joint reorientation

If the cartilage is still there and the length of the ***metatarsi is balanced***,

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the sagittal diameter is reduced by a ***dorsal closing intraarticular wedge-shaped osteotomy (T715).***

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Cheilectomy

If the joint is less mobile and the ***cartilage is worn out***,

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the ***dorsal third of the metatarsal head is removed***.

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Neither aforementioned principle affects the metatarsosesamoid joint.

Metatarso-phalangeo-sesamoid fusion

In the case of highly ***advanced degeneration***

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and ***involvement of the metatarsosesamoid joint***,

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fusion is indicated.

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The first phalanx should be ***oriented horizontally (T732)***.

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This is well tolerated in the first ray, allowing for most sporting activities even when the correction is performed bilaterally. Functional ***buttressing of the tip of the toe***

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is essential for a ***good clinical result***.

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Lesser rays

Lesser metatarsophalangeal joints (2–5) are essential joints that respond badly to fusion because the soft tissues beneath the phalanges are too weak to allow for the forces of push-off. There are no sesamoid bones protecting the long flexor tendon. Motion between the metatarsus and the first phalanx is essential for a smooth gait. Repeated intraarticular surgery may lead to limited mobility, ankylosis, and painful degeneration with osteophytes.

Subcapital extension osteotomy

Metatarsus 2 or 3 ***cephalic osteonecrosis*** (morbus Freiberg)

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is best approached by an extending reorienting osteotomy. In fact, the local anatomic conditions demonstrate a long extension of the cartilaginous layer on the plantar side of the metatarsal head. The necrotic part of the head is eliminated by a conical, dorsal wedged intracapital excision and corresponding ***extension osteotomy (T727)***.

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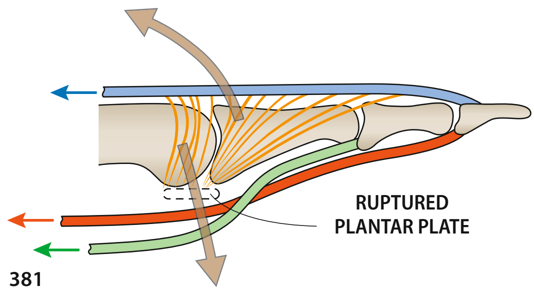
Such a procedure brings the basis of the first phalanx to face an intact cartilaginous layer on the metatarsal side (30).

11 Functional reorientation of the toes

Sagittal plane

The toes are essential to resume a smooth gait and push-off. While the first ray is the last part of the body to leave the ground at push-off, the lesser toes are linked to the windlass mechanism ***(E49)***. This mechanism allows for an elastic recoil through the plantar fascia, starting at the plantar aspect of the heel and ending at the plantar aspect of the first phalanx of the toes ***(E49)*** (12). Weight bearing leaving the toes free causes a passive plantar flexion at the metatarsophalangeal joints**.** When the plantar plate of the metatarsophalangeal joint is torn by chronic overload or iatrogenically after plantar fasciotomy, this ***mechanism is disturbed.***



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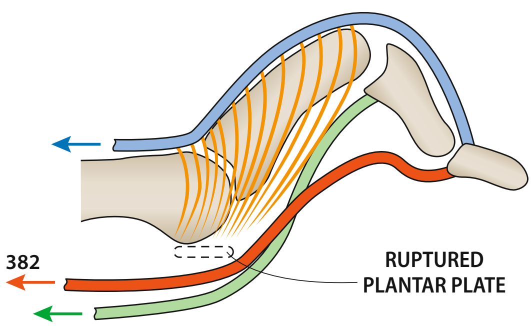
The ***first phalanx is extended, and the second phalanx is flexed***.



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The result is a "hammer toe." At the end of the process, due to the torn plantar plate of the metatarsophalangeal joint, ***the toe dislocates dorsally***.


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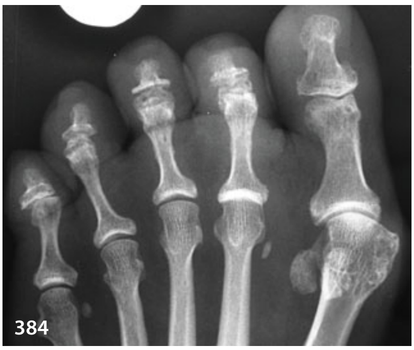
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The aim is thus to restore active metatarsophalangeal flexion ***to relocate the toe, facing the metatarsal head.***


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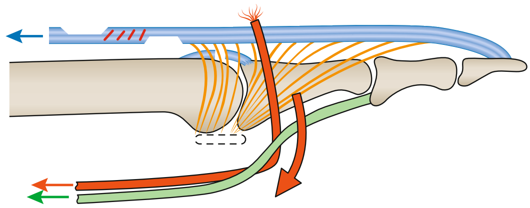
Reducing the metatarsophalangeal dislocation and restoring the axis of the first phalanx by plantar flexion requires an active force pulling the first phalanx plantarward, such as that provided by a tendon transfer.

Tendon transfer

Transferring the long flexor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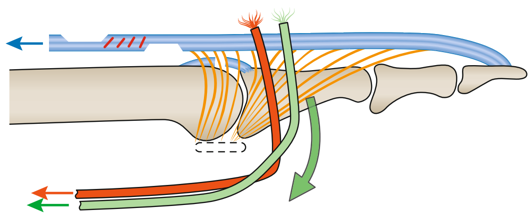
and, in severe cases, ***also the short flexor***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of the toe onto the first phalanx corrects the hammer toe deformity by flexing the first phalanx of the toe.

The ***hammer toe deformity in the relaxed foot***


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does not correct with passive extension of the hindfoot, which tenses the long flexors of the toes.

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Transferring the flexors onto the first phalanx ***corrects the position of the toes*** in the relaxed foot

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and additionally ***pulls down the first phalanx of the toes*** if the hindfoot is extended passively.

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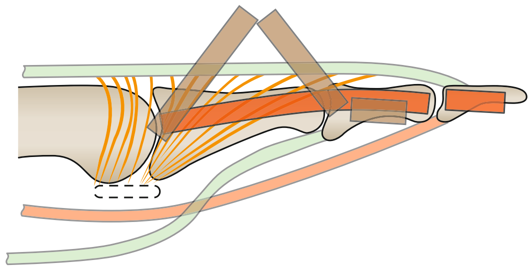
This correction must then be performed on all toes ***(T847)*** because of the strong mutual functional interference of the flexors between the toes. In cases in which passive extension of the distal interphalangeal joint is hyperlax and allows for passive extension of more than 20 degrees, removing the long flexor tendon results in painful hypercorrection of the hammer toe and an absent buttress of the tip of the toe. This complication produces a swan-neck deformity of the toe ***(E65)***.

Proximal interphalangeal fusion

In cases of hyperlax toes, ***fusion of the proximal interphalangeal joint (T755)***



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allows the essential flexion power to be left to the hypermobile distal interphalangeal joint while ***stabilizing the toe in the correct axis (T759)***

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and avoiding the swan-neck deformity ***(E65)***. This procedure alone, however, does not allow the reduction of a dislocated metatarsophalangeal joint.

If the ***metatarsophalangeal joint is dislocated and the proximal interphalangeal joint is ankylosed in flexion,***


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both ***proximal interphalangeal joint reorienting fusion*** ***and*** ***long flexor tendon transfer to the first phalanx*** restore good function with corrected morphology.


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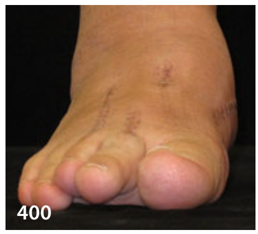
Skin plasty

To achieve a functional push-off, the toes must touch the ground at their pulps, and the angle of the toe in function is relevant ***(E125)***. In the case of metatarsalgia treated by elevating the metatarsus by osteotomy or tarsometatarsal fusion, the entire toe also tends to elevate and leave the ground. It appears that the skin and underlying soft tissue above the metatarsophalangeal joint undergo relative shortening, pulling the toes in extension. If systematic stretching of the joints in plantar flexion is not sufficient, lengthening plasty (e.g., ***Z-plasty or V–Y plasty***) of the dorsal skin corrects the position of the toes ***(T511)***.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Distal interphalangeal reorientation

The pulps of the toes are essential for the last contact with the ground during push-off. The sagittal pitch of the distal phalanx is critical in the lesser toes. Localized toe hyperflexion that appears in children is mostly linked to a ***shortening of the corresponding long flexor of the toe***.


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Treatment logically addresses the flexor close to the insertion at the end phalanx. An ***arthrolysis of the retracted distal interphalangeal joint***


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is also indicated ***(T551)***.

In cases of painful degeneration of the joint and, especially, hyperlax distal interphalangeal joints, the buttress is transferred proximally, causing pain and discomfort. In the case of (often unrecognized) compartment syndrome of the foot, retraction of the long flexor of the toes causes a flexion contracture of the distal interphalangeal joints that may become rigid. Ectopic calluses are testimony to such a condition. Reorientation of the pulp of the toe is best performed through a ***fusion*** in correct position ***of the distal interphalangeal joint***.


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Horizontal plane

Osteotomy of the first phalanx

In so-called hallux valgus interphalangeus, neither proximal nor distal joint lines about the first phalanx within the horizontal plane are parallel. This rare deformity may provoke chronic conflict with the second toe and impede function of the long flexor tendon. Alignment through a ***diaphyseal adduction osteotomy*** corrects impingement and function ***(T742).***


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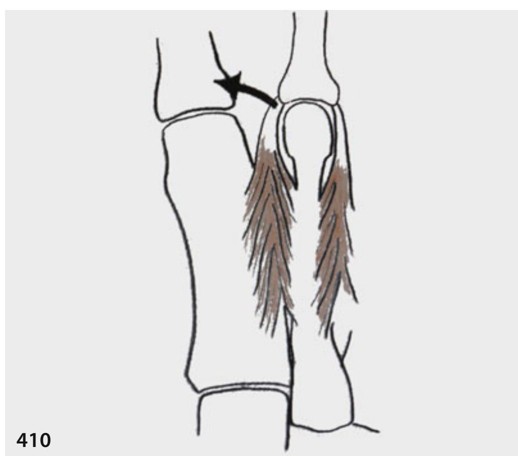
Tendon transfer

Surgical release of the metatarso-sesamoid-phalangeal joint, including tenotomy of the adductor hallucis muscle, may cause a secondary imbalance of the toe in varus ***(E52)***. This deformity is not compatible with a smooth gait. If the joint is functional and not painful, the functional reconstruction is best performed by correcting muscle balance. The ***first interosseous muscle***, if remaining intact after the previous surgical procedures, may be used to ***pull the first phalanx of the hallux in valgus (T841)***.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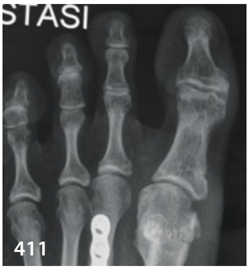
A complete ***medial arthrolysis*** of the joint must accompany this procedure.



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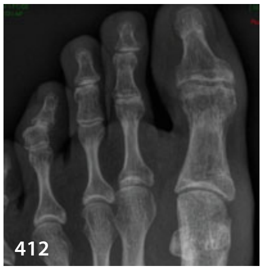
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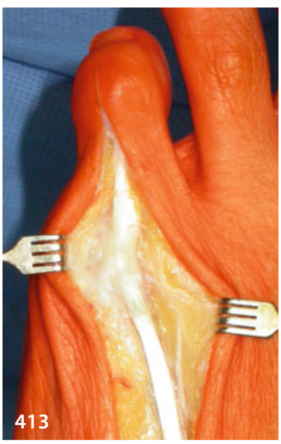
Supination of the last toe may result in very painful conditions while bearing weight ***(E54)***. Active pronation can be found using the power of the corresponding extensor muscle. Even though the short extensor does not exist, harvesting the distal limb of the ***extensor digitorum longus tendon***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and connecting it to the abductor digiti minimi does not result in functional insufficiency ***(T851)***.

Axial correction

Discrepancy of the lengths of the toes and metatarsi may occur together and cause an ***imbalance of the forefoot during push-off*** (***E46***) when the metatarsus is vertical.


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The aim is to restore ***morphologic harmony of the levers*** of the toe pulps.


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The morphology of the toes indicates that the ***best bone to act on for such an adaptation*** is the first phalanx.


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Precise shortening ***osteotomies of both the metatarsi (T691) and the basic phalanges (T749)*** may resolve this problem.


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