Journal of Orthopaedics, Trauma and Rehabilitation 17 (2013) 2–8

Contents lists available at SciVerse ScienceDirect

Journal of Orthopaedics, Trauma and Rehabilitation

Journal homepages: www.e-jotr.com & www.ejotr.org

Review Article

Surgical Management of Calcaneal Malunion
跟骨骨折畸形癒合的手術治療

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ARTICLE INFO

Article history:
Accepted January 2012

Keywords:
calcaneal malunion
surgical management

ABSTRACT

Calcaneal malunion is a common complication after conservative treatment or incorrect surgical treatment of calcaneal fracture. The typical pathoanatomies of calcaneal malunion are subtalar joint incongruity, loss of calcaneal height, arch collapse, varus or valgus deformity of the calcaneus, heel widening and so on. Calcaneal malunion often needs to be treated surgically. The classification of calcaneal malunion and the detailed clinical and radiographical assessment play important roles for surgical option. The main surgical methods include *in situ* subtalar arthrodesis, reconstruction of calcaneal thalamus and subtalar arthrodesis, calcaneal osteotomy with subtalar arthrodesis, corrective calcaneal osteotomy without subtalar arthrodesis. Each option has its different indications, advantages and disadvantages. Thus, the surgical treatment should be individualised.

中 文 摘 要

跟骨骨折畸形癒合是跟骨骨折保守治療或不正確的手術治療之後常見的併發症。常會出現距下關節面不平整，跟骨高度丟失，足弓塌陷，跟骨內外翻，跟骨增寬等典型的病理變化。跟骨骨折畸形癒合往往需要手術治療，畸形癒合的分型和詳細的臨床及影像學評估,在手術方法的選擇上起著重要作用。常見的手术方法主要有距下關節原位融合術，跟骨丘部重建距下關節融合術，跟骨截骨矯形距下關節融合術，保留距下關節的截骨矯形術等。它們各自具有不同的手術適應征及優缺點，需要根據患者的情況進行個體化選擇。

Introduction

The uncertain operative results for severely displaced calcaneal fractures and the complications of nonoperative management are the key reasons why calcaneal malunion develops. Once a severe calcaneal malunion causes the disorder of the motion axis from hindfoot to the whole lower limb, this will result in an abnormal gait with symptoms and dysfunction of the joints and muscles, eventually leading to pain and permanent disability.[1] Thus, calcaneal malunion may be life-altering to patients, not only because it imposes a great symptomatic effect but also because it carries a huge economic burden. Once calcaneal malunion occurs, surgery is always needed to prevent the vicious cycle of pathological changes and to preserve the hindfoot function as far as possible. However, both surgeons and patients should be aware that although surgeries may result in a more functional foot, there is still a considerable amount of disability as indicated by lower functional scores on the 36-Item Short Form Health Survey (SF-36) and American Orthopaedic Foot and Ankle Society hindfoot surveys.[1]

Pathoanatomy and Biomechanics of Calcaneal Malunion

The pathoanatomy of calcaneal malunion can be highly variable and will not only affect the biomechanics and function of the surrounding joints and soft tissues but also the alignment from lower limb to lower lumbar and may even cause neck and head pain. A comprehensive understanding of the pathoanatomic and biomechanical changes of calcaneal malunion will allow the surgeon to formulate the operative treatment. The main pathoanatomy changes can be summarised as follows.

An incongruous facet is known to be a direct cause of arthritis of the subtalar joint by the significant effect on pressure distribution upon load-bearing. The incongruity of the calcaneal facet with abnormal biomechanics will affect the function of ankle joint and transverse tarsal joint in the long term. Hence, anatomic reduction is pursued and displacement greater than 1 mm in calcaneal malunion should be treated surgically.

The decreased height of the calcaneus has significant ramifications since it flattens the talar inclination angle and diminishes the lever arm function of the Achilles tendon, which will decrease the strength of triceps surae muscle and reduce the push-off power

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doi:10.1016/j.jotr.2012.04.001

during gait.[2] The loss of talar inclination assumes the talus in a more horizontal, dorsiflexed position that may result in painful anterior impingement of the talar neck on the anterior tibial plafond and cause a rigid subtalar joint. With a rigid subtalar joint, more load is brought to the lateral column and leads to increased pressure on the lateral mid- and forefoot with lateral shift of the gait line.[3]

Traumatic flatfoot deformity can often be seen in calcaneal malunion, which is essentially caused by traumatic arch collapse without soft tissue factors. However, the long-term deformity will cause the contracture of gastrocnemius muscle and the shortening of Achilles tendon. Thus, the soft tissue balance should not be neglected during correction of the calcaneal deformity. The severe traumatic arch collapse will also oppress the plantar structures and cause an abnormal plantar pressure. We analysed the plantar pressure in 26 cases of calcaneal malunion and found that plantar pressure would be partly transferred from hindfoot to forefoot in calcaneal malunion patients, leading to abnormal gait and ulcers.[4]

A malunited calcaneal fracture with superior translation of the calcaneal tuberosity can also result in calcaneal varus, which will partly transfer the weight-bearing to the lateral side of the foot, significantly altering the hindfoot biomechanics. If severe varus hindfoot persists for a long time, the foot may lose its natural shock-absorbing ability through eversion of the heel in early stance phase and increase the risk of injuries.[5] Calcaneal valgus deformity and heel widening are two other features because of the lateral wall exostosis formed by the united lateral wall blow-out and superolateral translation. The exostosis can cause calcaneofibular impingement, pseudoarticulation formation and peroneal tendinosis, which will change the alignment and weaken the muscle strength of the lower limb.

A fixed cavovarus deformity is rare in calcaneal malunion, which may occur by the contracture and scarring of the posterior tibialis muscle, flexor hallucis longus (FHL) and flexor digitorum longus because of the compartment syndrome misdiagnosed in an acute injury.[6]

The Classification of Calcaneal Malunion

Nowadays, the widespread acknowledged classifications of calcaneal malunion are the Stephens and Sanders classification system and the Zwipp and Rammelt classification system. They are of great help in determining the appropriate treatment.

The Stephens and Sanders classification system is based on coronal computed tomography at the level of the posterior facet and divided into three types. Type I is characterised as a lateral wall exostosis with normal hindfoot alignment. Type II exhibits a lateral wall exostosis, subtalar arthritis and hindfoot malalignment of less than 10°. Type III malunion may have more extensive and severe subtalar arthritis than Type II with greater than 10° of hindfoot malalignment, which can result in an angular deformity caused by hindfoot varus or valgus (Figure 1).[7] However, this system is based solely on coronal CT images, and it cannot demonstrate hindfoot height or talar inclination. Moreover, we noticed that it was difficult to determine the extent of cartilage damage and preoperative plan by this classification to calcaneal malunion within 1 year after injury because the development of severe subtalar arthritis depended on not only the extent of cartilage damage but also on the duration and degree of weight-bearing after injury.[8]

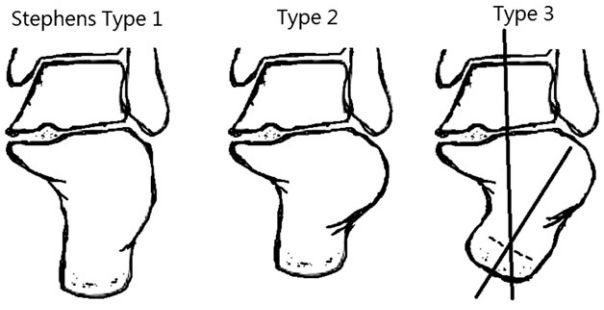

Figure 1. The Stephens and Sanders classification system of calcaneal malunion.

The Zwipp and Rammelt classification system includes five types. Type I is characterised as subtalar incongruence with arthritis but normal calcaneal shape. Type II exhibits the heel varus or valgus. Type III is loss of hindfoot height and Type IV is characterised as translation of calcaneal tuberosity without varus or valgus. In Type V, the talar tilt or dorsiflexion past neutral is the main feature.[9] This classification emphasises the potential issues that may exist after a traumatic injury, which has great significance in selecting the appropriate treatment methods.[8] However, calcaneal malunion with normal subtalar joint is not involved in this classification.

Clinical and Radiographic Evaluation

Detailed clinical evaluation of the malunion can provide important information for the surgeons to formulate the treatment plan. The chief complaint of pain is always the main reason for a patient to seek medical help. It may be challenging to identify the causes of the pain. Pain in the anterior ankle is commonly caused by impingement of the anterior ankle. Patients may have difficulty in dorsiflexion of the ankle, and forced ankle dorsiflexion may reproduce the pain. Plantar pain is mainly due to the traumatic arch collapse that oppresses the plantar structures or plantar exostosis from the malunited calcaneus. In the long term, the heel pad may be atrophic. Pain in the medial heel may be the consequence of tibia nerve or FHL tendon problems. Tinel's sign may be noted in tibial nerve problems and in patients with FHL tendon problems, and pain may be reproduced by passive motion of the hallux. Pain in the lateral heel is mainly due to subtalar arthritis, calcaneofibular impingement or peroneal tendinosis.[5] Symptomatic subtalar arthritis will limit the hindfoot inversion and eversion; thus, the patients may find it difficult to walking on uneven ground. The pain caused by calcaneofibular impingement is secondary to the lateral wall exostosis. The patients may complain of difficulty in shoe wearing as heel widening. In peroneal tendinosis patients, the palpation along the course of the peroneal tendons may reproduce the symptoms. The malunion of depressed calcaneal fracture can also result in posterior ankle impingement pain. It is mainly caused by the posterior calcaneal bone spike formed just behind the posterior facet, which may be aggravated by forced ankle plantarflexion.[10] The tarsal tunnel syndrome caused by calcaneal malunion, however, is rare. Manasseh et al[11] reported a case of tarsal tunnel syndrome caused by a small fragment just under the nerve in the tarsal tunnel causing pain, tingling and sensory hypoaesthesia along the branches of the posterior tibial nerve. Thus, in calcaneal malunion, the fragments under tarsal tunnel require special attention.

On physical examination, the hindfoot alignment should be compared with the normal contralateral side. The calcaneal varus is the most commonly encountered deformity. However, the true position of the calcaneal tuberosity may be masked in the presence of hindfoot oedema or heel widening as it may appear rectus but actually remains in varus when evaluated radiographically.[12] Moreover, care should be taken when dealing with hindfoot varus caused by forefoot deformity, and Coleman block test can distinguish them.[13] Changes in alignment may be more apparent on walking, and gait analysis should also be also performed. The

antalgic gait with shortened stance phase can often be observed.[5] Varus or valgus hindfoot deformity can also cause significant deforming forces on the midfoot and forefoot, and could result in an altered and poorly tolerated gait. Moreover, gait analysis may also reveal abnormalities with weakened push-off strength. The examination of active and passive ranges of motion of the ankle and subtalar joint is also important. Decreased ankle dorsiflexion and ankle stiffness can be attributed to the alteration in talar inclination. The subtalar joint motion can also diminish following a joint depression fracture. Neurologic assessment combined with the muscle strength assessment is necessary for patients with chronic problems. Finally, the evaluation of soft tissues and skins including previous incisions are essential, and any open lesions or draining sinuses must be examined as they may affect the option of the surgical approach.

Radiographs are indispensable in evaluating calcaneal malunion. It is recommended that radiographs of the contralateral unaffected foot be obtained for comparison. However, if bilateral calcaneal malunions are present, the average normal parameters can be used as reference. Standard anteroposterior and lateral radiographs can provide much information on the malunion, such as the loss of the heel height and the severity of arthritis. In addition, weight-bearing lateral radiographs are helpful in providing valuable information for preoperative planning with exact goniometric measurements (Figure 2). If anterior tibiotalar impingement is suspected, the lateral weight-bearing view with the ankle forced dorsiflexion and plantarflexion may be better than the standard view. The axial Harris radiograph is used to estimate whether there is malalignment, widened heel and lateral wall exostosis. The hindfoot alignment view allows a more accurate assessment of hindfoot alignment, especially the position of the calcaneal tuberosity in relation to the standing lower limb. However, Reilingh et al[14] believe that the long axial hindfoot view in bilateral stance is more reliable in the angular measurement of hindfoot alignment (Figure 3). The mortise view of the ankle can demonstrate subfibular abutment of the displaced calcaneal tuberosity. The indications for surgery include deformities of varus $>5^{\circ}$or valgus $>10^{\circ}$, heel widening >1 cm and lateral wall exostosis that restricts the motion of peroneal tendons. Broden's view allows radiographic assessment of the posterior facet. However, it is necessary to take

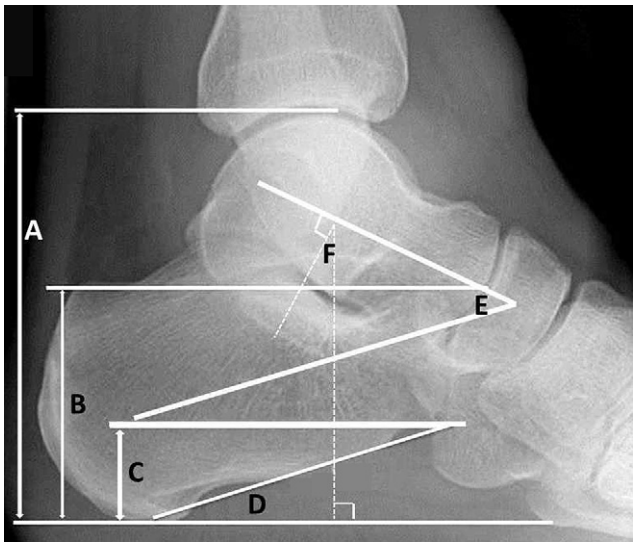

Figure 2. Exact goniometric measurements on weight-bearing lateral radiograph. (A) The hindfoot height; (B) the cuboid-bottom distance; (C) the calcaneal-bottom distance; (D) the calcaneal pitch; (E) the lateral talocalcaneal angle; (F) the talar inclination angle.

Figure 3. The long axial hindfoot view shows the relationship between calcaneal tuberosity and axis of lower limb.

the radiographs several times with the tube inclination in different degrees to display the three-dimensional views of the facet. CT scan with three-dimensional reconstruction had been routinely advised in preoperative planning, especially for the complex calcaneal malunion. Postoperatively, CT scan is also recommended in the evaluation of the bony fusion of the arthrodesis site. When more than 50% of the posterior subtalar joint is fused on the CT scan, arthrodesis could be regarded as successful.[15] Magnetic resonance imaging has limited value in diagnosing the bony deformities; however, it has a specific advantage in the diagnosis of any pathological change(s) and assessment of the prognosis. Easely et al[16] found that greater than 2 mm of avascular subchondral bone at the arthrodesis site would significantly increase the nonunion risk.

Surgical Management

Symptomatic calcaneal malunion usually needs to be treated surgically. Nonsurgical methods can only be attempted in a small portion of patients with Stephens Type I calcaneal malunion. Lateral wall exostectomy and decompression is necessary in most patients with Stephens Type I calcaneal malunion.

The open reduction and internal fixation is suitable for patients with relatively good soft tissue and joints condition within 6–12 weeks after the calcaneal fracture. It has the advantages of better reduction, less damage and faster recovery. However, most patients initially consulted with doctors after they had the calcaneal injuries, which were complicated with calcaneal malunion and even subtalar osteoarthritis. Therefore, open reduction and internal fixation can be performed only in a few patients. At present, subtalar arthrodesis is still the most commonly used method for calcaneal malunion. The outcome may be related to the initial treatment. Arthrodesis after failed open reduction and internal fixation may obtain better

functional outcomes and fewer wound complications than arthrodesis following nonoperative treatment. [17]

In situ subtalar arthrodesis is indicated for patients with Stephens Type II and Zwipp Type I calcaneal malunion, where the calcaneal height is normal or minimally decreased and the calcaneal axial angulation deformity is gentle. This option can preserve the hindfoot height and biomechanics with little deformities being corrected. Savva and Saxby [18] treated 17 cases of Stephens Type II malunited calcaneal fracture with *in situ* subtalar arthrodesis, and the mean talar inclination angle was only restored to 36% of the normal side. The subtalar joint can be accessed by various approaches: a medial oblique incision, an incision from the tip of the fibula to the base of the fourth metatarsal, or a lateral L-shape incision (Figure 4A and 4B).[19] After the subtalar joint is exposed, all the cartilage and sclerotic subchondral bone should be removed until a bleeding surface is obtained. Then, the subtalar joint can be fixated in neutral position or approximately 5° of valgus with or without bone graft. Two 6.5-mm partially threaded screws inserted from calcaneus to the talus is traditionally used (Figure 5A–5D). Joveniaux et al[20] use one or two bone staples to stabilise the arthrodesis sites the staples can be placed through the same surgical approach, avoiding additional incisions and fluoroscopy. Repeated placement of the implants should be avoided since Corpuz et al[21] reported that talar fractures can occur. Varus malunion and nonunion are the most important causes of failure of subtalar arthrodesis. Therefore, when the joint is reduced, the tibiocalcaneal alignment should be assessed. Postoperatively, the patients should be restricted from any weight-bearing activity until bony union is achieved. The effect of bone graft on the union rate may be controversial. Although insertion of bone grafts in not always required and 100% union without bone graft was also reported,[22] it is advised that it is better to use corticocancellous bone grafts.[19] Attention should be paid to pack excessive bone graft to the joint, or overdistraction would occur and the hindfoot would swing into varus. *In situ* subtalar arthrodesis can also be performed arthroscopically, especially for patients with high risk of wound problems such as diabetes or peripheral vascular disease. The classic portals for arthroscopic arthrodesis are the anterolateral and posterolateral portals. However, the selection of portals depends on the experience of the surgeons. Lee et al[23] introduced the posterolateral and posteromedial portals to provide a better visualisation of the posterior subtalar facet. Moreover, El Shazly et al[24] described an accessory anterolateral portal 1 cm distal and 0.5 cm anterior to the tip of the lateral malleolus for further visualisation and instrumentation. In some cases of difficult arthroscopic visualisation, fluoroscopy is useful to check the degree of bone resection. Finally, screw fixation is performed, and there is no difference between one or two screw fixation techniques in terms of healing.[25]

When the subtalar joint arthrodesis is needed in patients with significant collapse of the hindfoot with various kinds of depression posterior subtalar facet and severe calcaneal axial angulation deformity (Stephens Type II and Zwipp Type III), the reconstruction of calcaneal thalamus and subtalar arthrodesis is preferred.[26] We once treated a series of malunited calcaneal fracture especially with traumatic flatfoot by this technique with good results, and it is an effective method for calcaneal malunion.[27,28] When performing this technique, a vertical posterolateral approach positioned lateral to the Achilles tendon is advised to avoid wound healing complications.[29] However, it may not be possible to narrow the lateral wall and release the calcaneocuboid joint. Therefore, the modified L-shape lateral approach should be used. If calcaneofibular impingement is present, a lateral wall exostectomy should be performed. Clare et al[30] advised that the saw blade should be angled slightly medially relative to the longitudinal axis of the calcaneus, leaving more residual bone plantarly to provide decompression for calcaneofibular impingement. The fragment should be preserved as the supplement for graft material. Attention should be paid in case the calcaneal thalamus collapses as the talus is usually embedded into the calcaneal body. A half-inch curved osteotome can be used to identify the posterior facet of the subtalar joint.[12] Direct intra-articular distraction with lateral, posterior and posteromedial capsulotomy can facilitate the height restoration of the calcaneal thalamus. The varus deformity can be corrected by distracting the medial subtalar joint gap higher than the lateral gap, and vice versa. In most cases, the addition of calcaneal osteotomy can be avoided.[27] The selection of bone blocks for graft depends on the lost height of the calcaneal thalamus. If the loss is less than 1 cm, the previously excised lateral wall fragment can be used. Otherwise, one or two tricortical bone blocks from iliac crest tailored as the shape of calcaneal thalamus should be used. The reconstructed calcaneal thalamus should be tested for several times to prevent hindfoot varus in low tension.[27] Once the correction is confirmed, fixation can be performed with two or three fully threaded cancellous screws from posteroinferior aspect of the calcaneus into the talar body and neck (Figure 6A–6E). Finally, Achilles tendon lengthening may be needed if the ankle cannot be dorsiflexed to neutral positiona as a result of the restoration of the calcaneal height. Postoperatively, the patients should be put on a cast and should refrain from any weight-bearing activity for 8–10 weeks to prevent collapse of the graft. A short leg walking cast is then used for an additional 4–6 weeks. Physical therapy of oedema control, gait training and ankle mobilisation can be helpful.

Triple arthrodesis is considered an effective option with limited alternatives in disabilities originating from severe malunion with subtalar and calcaneocuboid arthritis, although it is performed less often because of the inevitable loss of motion in midfoot and hindfoot.[31] Traditionally, triple arthrodesis is performed through double approaches. However, Jeng et al[32] introduced a single medial approach for triple arthrodesis to avoid the wound problems. Jackson et al[33] followed this technique and certified good views of all the joint surfaces and good results of correction. The medial incision can be made 8 cm in length from the posterior

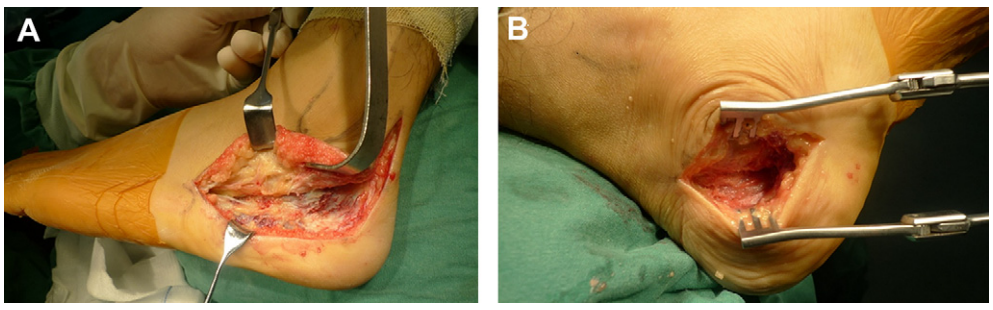

Figure 4. (A) The modified L-shape approach; (B) the medial oblique approach.

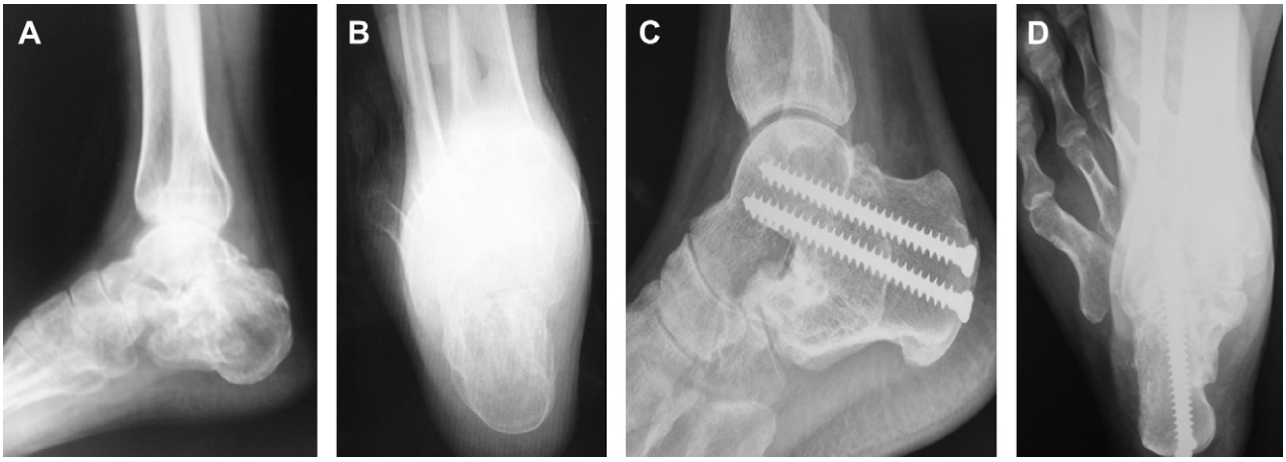

Figure 5. (A, B) Preoperative X-rays of calcaneal malunion with minimally decreased hindfoot height and gentle calcaneal axial angulation. (C, D) Postoperative X-rays in 1 year after *in situ* subtalar arthrodesis.

medial malleolus to the talonavicular joint. The talonavicular joint can be exposed by dividing capsule and releasing the posterior tibial tendon. The interosseous ligament is divided to allow exposure of all three facets of the subtalar joint. The remaining talonavicular joint capsule is then dissected sharply to help opening the joint. Access to the calcaneocuboid joint is more difficult. The calcaneocuboid joint capsule and the bifurcate ligament can be dissected by feel with a blade across the joint. A lamina spreader is used to expose the remnant of the talonavicular joint. The reduced subtalar joint can be fixed with a single 6.5-mm cannulated screw from the posterior calcaneus into the talar body. The talonavicular joint and calcaneocuboid joint can be fixed with 5.0-mm cannulated screws.[33] Postoperatively, when the sutures were removed, partial weight bearing walking is permitted for 4 weeks followed by full weight bearing walking for another 6 weeks until arthrodesis is evident. A removable walking boot and a short leg cast can be used alternately for walking and rest. The triple arthrodesis can also be performed arthroscopically. Lui and Chan[34] confirmed the efficacy of the arthroscopic triple arthrodesis by cadaveric study and cautioned about the risk of neural damage.

For the correction of severe calcaneal malunion (Stephens Type III, Zwipp Type IV and Type V), subtalar arthrodesis alone may be insufficient since uncorrected calcaneal tuberosity will make the varus recurrent despite the fact that the heel is fixed in valgus. In

Figure 6. (A–C) Preoperative X-rays and CT scans show significant collapse and varus deformity of the calcaneus. (D, E) Postoperative X-rays 2 years after the reconstruction of calcaneal thalamus and subtalar arthrodesis.

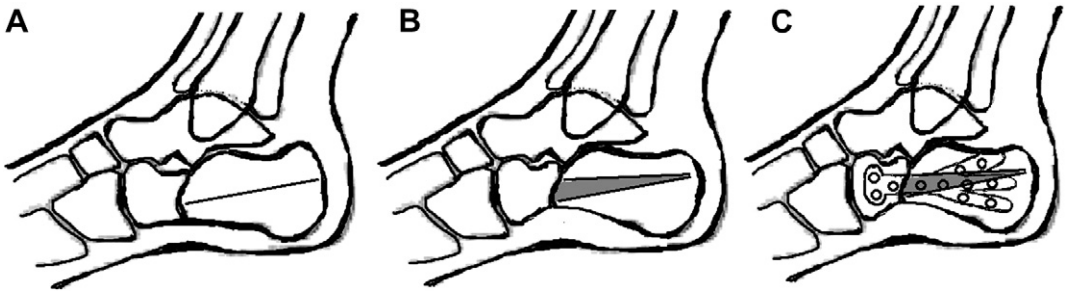

Figure 7. (A) The line in the calcaneus shows the design of calcaneal osteotomy. (B) The grey area shows the design of bone graft. (C) Plate fixation without subtalar arthrodesis.

this situation, calcaneal osteotomy is necessary. However, in consideration of the complexity of the calcaneal malunited fracture, the osteotomy should be individualised. Moreover, if the subtalar joint can be preserved when osteotomy is performed, better function of the hindfoot may be obtained.

The vertical sliding osteotomy with subtalar arthrodesis is considered as an alternative to the reconstruction of calcaneal thalamus and subtalar arthrodesis. It is suitable for patients with calcaneal height loss >8 mm, arch collapse and Böhler angle <10°; however, little can be done to correct the talar inclination angle and decompress the anterior ankle joint.[35] In this technique, a slightly oblique approach, just posterior to the subtalar facet, is advised. The calcaneal tuberosity is osteotomised vertically and then shifted plantarward. Achilles tendon lengthening is needed to obtain sufficient plantar translation of the calcaneal tuberosity. This technique is especially effective to the traumatic flatfoot; however, it was not widely used because of the technical difficulty.

For extra-articular calcaneal malunion with severe varus malalignment, a lateral closing-wedge osteotomy is an advisable option.[36] The osteotomy angle is based on the abnormal Böhler angle. Once the angle is confirmed, a wedge osteotomy with narrow medial aspect and wide lateral aspect can be executed. This lateral opening-wedge osteotomy can be used for valgus malalignment. Aly[37] recently treated 34 cases of malunited calcaneal valgus by lateral opening wedge osteotomy, and good results were reported. A medial translation osteotomy can also be used for calcaneal valgus deformities with traumatic flatfoot. A lateral oblique incision parallel to the peroneal tendons, approximately 1 cm posterior to the Achilles tendon, is traditionally used.[38] The osteotomy plane should be perpendicular to the axis of the calcaneus and 45° to the floor. The osteotomy fragment can be translated medially and plantarly to correct the valgus heel and reconstruct the medial foot arch.[28]

In recent years, the importance of preservation of the subtalar joint in management of calcaneal malunion has been emphasised, which allows more normal biomechanics and avoids arthritic changes in adjacent joints.[39] We also noticed that in most calcaneal malunion patients within 9 months, the articular surface wound not be severely destroyed even though the incongruity of the calcaneal facet and hindfoot malalignment was present. The calcaneal osteotomy without subtalar arthrodesis can be more beneficial in these patients. However, in some patients, the arthritis of the subtalar joint can still progress after the osteotomy, and secondary subtalar arthrodesis might be needed. Thus, strict indications for this procedure should be followed: (1) young patients with less severe malunion within 9 months of injury; (2) obsolete calcaneal fracture of Sanders Types IIA, IIB, IIC, IIIAC and IIIAB without severe cartilage damage and degeneration; (3) malunion with articular surface collapsing into the calcaneal thalamus but identifiable contour of the tongue fragment or compressed posterior articular fragment. Cases of difficult identification of the contour of the tongue fragment and compressed posterior articular fragment and comminuted and severe malunited calcaneal fracture such as Sanders Type IIIBC and Type IV are contraindicated for corrective osteotomy because of the difficulty, if not impossibility, of achieving anatomic reduction and the high probability of arthritis.[8] Detailed preoperative planning includes the determination of the osteotomy site, the degree of elevation of the calcaneal thalamus, and the size and shape of the bone graft which should be formulated before the operation. The modified L-shape lateral approach is used in this technique. The full thickness flap should be dissected subperioseally to expose the subtalar joint. Three Kirschner wires are then placed into the lateral malleolus, cuboid and talar neck for further exposure of the subtalar joint, calcaneocuboid joint and the posterolateral part of the calcaneus. An osteotome is used to divide the collapsed and anteroinferior rotationally displaced posterior articular fragment along its articular surface to the medial side. Then, osteotomy should be performed internally at the base of the fragment to the medial aspect of the fragment or even to the medial wall of the calcaneus (Figure 7A). Next, the posterior articular fragment can be elevated superoposteriorly to reduce the calcaneal thalamus (Figure 7B). After elevating the fragment, the bone defect should be packed with bone blocks either from lateral wall exostectomy or from iliac crest. The displaced and tilted articular surface and the calcaneal height can then be corrected. Intraoperative radiographs are needed to check the reconstruction of the articular surface and correction of the hindfoot alignment. The osteotomy is then stabilised by an appropriate malleable titanium calcaneal plate (Figure 7C). Postoperatively, the operated foot is immobilised in a short leg cast for 4–6 weeks. Ankle functional exercise can be started gradually after removal of the cast. Full weight bearing walking must be deferred until the osteotomy site is completely healed. We have treated 24 cases of calcaneal malunion by this technique with special emphasis on restoration of the congruity of the subtalar joint and prevention the hindfoot varus deformity with good result.[8]

Conclusion

Salvage operation of calcaneal malunion is challenging. The appropriate surgical option depends on the pathoanatomy and the clinical and radiographic assessment. If calcaneal height is normal or minimally decreased, *in situ* subtalar arthrodesis is preferred, while reconstruction of calcaneal thalamus and subtalar arthrodesis is suitable for subtalar joint arthritis with significant collapse of the calcaneal height. However, if severe malalignment is present, calcaneal osteotomy should be performed. Corrective calcaneal osteotomy without subtalar arthrodesis has its specific advantages; however, the indications should be followed strictly. Moreover, auxiliary operations such as Achilles tendon lengthening, peroneal tenolysis, or plantar osteophyte excision should not be neglected because they may directly or indirectly affect the result of the operation.

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