Calcaneal Fractures – Should We or Should We not Operate?

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Abstract

The best treatment for displaced, intraarticular fractures of the calcaneum remains controversial. Surgical treatment of these injuries is challenging and have a considerable learning curve. Studies comparing operative with nonoperative treatment including randomized trials and meta-analyses are fraught with a considerable number of confounders including highly variable fracture patterns, soft-tissue conditions, patient characteristics, surgeon experience, limited sensitivity of outcome measures, and rehabilitation protocols. It has become apparent that there is no single treatment that is suitable for all calcaneal fractures. Treatment should be tailored to the individual fracture pathoanatomy, accompanying soft-tissue damage, associated injuries, functional demand, and comorbidities of the patient. If operative treatment is chosen, reconstruction of the overall shape of the calcaneum and joint surfaces are of utmost importance to obtain a good functional result. Despite meticulous reconstruction, primary cartilage damage due to the impact at the time of injury may lead to posttraumatic subtalar arthritis. Even if subtalar fusion becomes necessary, patients benefit from primary anatomical reconstruction of the hindfoot geometry because *in situ* fusion is easier to perform and associated with better results than corrective fusion for hindfoot deformities in malunited calcaneal fractures. To minimize wound healing problems and stiffness due to scar formation after open reduction and internal fixation (ORIF) through extensile approaches several percutaneous and less invasive procedures through a direct approach over the sinus tarsi have successfully lowered the rates of infections and wound complications while ensuring exact anatomic reduction. There is evidence from multiple studies that malunited displaced calcaneal fractures result in painful arthritis and disabling, three-dimensional foot deformities for the affected patients. The poorest treatment results are reported after open surgical treatment that failed to achieve anatomic reconstruction of the calcaneum and its joints, thus combining the disadvantages of operative and nonoperative treatment. The crucial question, therefore, is not only whether to operate or not but also when and how to operate on calcaneal fractures if surgery is decided.

Keywords: *Arthritis, calcaneal fracture, internal fixation, malunion, nonoperative treatment, subtalar joint*
MeSH terms: *Calcaneus; fractures, bone; fracture fixation*

Introduction: Are We Asking the Right Questions?

The treatment of displaced, intraarticular calcaneal fractures (DIACF's) continues to generate controversy in the orthopedic community.[1] The question if operative or nonoperative treatment is better for these injuries is still not answered satisfactorily when applying the principles of evidence-based medicine, but maybe it is not the right question to ask from the beginning. Several prospective-randomized controlled trials (RCT's) have failed to show a significant overall superiority of either treatment at first sight, but have provided the readers with important information when having a closer look at the subgroups of their patient cohorts.[2-4] Only 1 small trial showed significantly better outcomes with ORIF.[5] This fact shows the dilemma of many orthopedic RCT's that are hard to overcome despite enormous efforts and resources that go into these studies. Systematic problems include the impossibility of true blinding with respect to treatment allocation, the great variety of fracture patterns and associated soft-tissue damage, the different patient characteristics such as associated injuries, comorbidities, compliance, and functional demand, the dependence on the surgeon's experience and performance. This leads to the problem of adequate power because of the many possible confounders and the problem of selection bias when trying to address this issue.[6] Furthermore, limited sensitivity of outcome measures and the lack of standardized, generally accepted scoring systems makes any general conclusions difficult.

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For the same reasons, three meta-analyses comparing operative versus nonoperative treatment of displaced intraarticular calcaneal fractures failed to produce a clear recommendation in the treatment of these injuries, although operative treatment was slightly favored if anatomic reduction could be achieved.[7-9] This raises the question of the specific technique and quality of operative treatment because DIACF's are challenging to treat with about 80% being intraarticular and a delicate soft-tissue cover with a vulnerable layer of skin over the lateral calcaneal wall that is prone to wound healing problems and a unique plantar skin that cannot be replaced with adequate tissue once it is avulsed or severely damaged.[10,11] Therefore, a considerable learning curve has been reported for calcaneal surgery that affects both the complication rates and functional outcome.[12,13]

It follows from these considerations that the question of operative versus nonoperative treatment of DIACF's is probably not the right one from the beginning, as neither the patient-related nor the surgeon-related factors can be fully standardized for these injuries.[1,6,14] This article tries to provide an overview on the present evidence.

What is the Current Evidence?

Over the past 20 years, a sizeable number of clinical studies have described the operative treatment of DIACF's.[15-25] Conclusions on the best treatment are difficult because of diverse operative strategies and outcome measurements.

Several studies have shown that only anatomic reconstruction of the calcaneal shape and joint congruity will lead to acceptable functional results and thus merit the effort of operative treatment with its possible complications.[20-25] In biomechanical studies with pressure sensitive films, even small step-offs of 1 mm–2 mm in the posterior facet of the subtalar joint were associated with a significant load redistribution at the subtalar joint.[26,27] In a recent biomechanical trial, a gap of <3 mm did not lead to significant load changes[28] Consequently, inferior functional results were seen in numerous clinical series with a step of 2 mm.[2,3,22,23,29-31] Therefore, surgical reduction of intraarticular calcaneal fractures should be pursued in patients with a joint step-off of 2 mm or more. Fractures with a step-off of <2 mm or a gap of <3 mm may not merit the risks of operative treatment.

Few studies address the outcomes after extraarticular calcaneal fractures. However, there are reports on symptomatic malunions after extraarticular fractures with a substantial hindfoot varus or valgus deformity, with significant flattening, broadening or shortening of the heel, as well as bony prominences at the calcaneal tuberosity [Figure 1].[32,33] Therefore, reduction of displaced extraarticular fractures is recommended for substantial displacement.[1,33,34] Most of these fractures can be reduced and fixed percutaneously or via small incisions with screws under adequate fluoroscopic control. A dangerous extraarticular subtype of a tongue-type fracture with severe displacement of the superior margin of the calcaneal tuberosity ("beak fracture") is a surgical emergency. If early reduction cannot be achieved, skin necrosis will develop rapidly over the dorsal aspect of the heel.[34-36] This is particularly worrisome because full-thickness skin defects over the insertion of the Achilles tendon are particularly hard to treat.

Figure 1: Standing x-ray lateral view of a 68 years old woman, 14 years postcalcaneum fracture showing severely displaced extraarticular calcaneal fracture. She can only wear sandals and clogs as a result of her tuberosity malunion

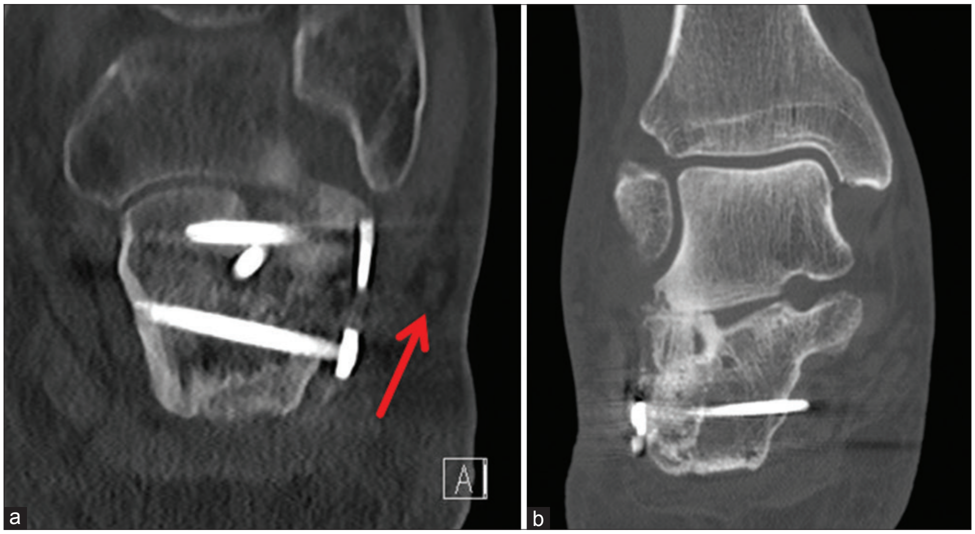

Figure 2: CT scan showing (a) Malreduction of a displaced, intraarticular calcaneal fracture despite open reduction and lateral plate fixation via an extensile approach. Such treatment combines the hazards and disadvantages of both operative and nonoperative treatment. Note the displacement of the peroneal tendons because of the displaced lateral fragment (red arrow). CT scan showing (b) A residual step-off in the subtalar joint which leads to significant load redistribution with the increased risk of posttraumatic arthritis. In the present case, there is complete loss of cartilage and cyst formation due to overload over the lateral aspect of the subtalar joint

Closed treatment is surely acceptable in patients without gross deformity including lateral displacement of the calcaneum near the fibula, hindfoot varus, and valgus deformity, or relevant joint displacement.[14,37] On the other hand, the sequelae of malunions or nonunions of displaced extraarticular and intraarticular calcaneal fractures after either nonoperative management or inadequate reduction or fixation are well documented.[24,37-45] Residual step-offs in the subtalar joint or severe cartilage damage at the time of the injury regularly lead to residual pain, joint dysfunction, and posttraumatic arthritis of the subtalar joint [Figure 2].[2,23,41,42] The fixed deformities seen in malunited calcaneal fractures are a direct consequence of the primary fracture patholoanatomy with loss of calcaneal height, broadening of the heel, hindfoot varus or valgus malalignment, lateral shift of the heel after fracture-dislocations and even talar tilt within the ankle mortise in severe deformities. These bony deformities, in turn, lead to a number of soft-tissue problems such as painful callosities or ulcerations around overloaded portions of the hindfoot, impingement and/or chronic dislocation of the peroneal tendons at the displaced lateral calcaneal wall, flexor hallucis longus entrapment along the medial wall or sustentaculum tali, fibulocalcanear abutment, sural or posterior tibial neuritis and claw toes from unrecognized compartment syndrome.[39,40,42-47]

The dilemma of randomized controlled trials on calcaneal fractures

With the well-documented sequelae of calcaneal malunions and the established role of normal hindfoot geometry and subtalar joint congruity for overall foot function, the question arises why these accepted facts do not translate into significant differences between operative and nonoperative treatment of DIACF's in several of the RCTs that have been conducted with tremendous efforts. The reasons are manifold and shall be looked at in more detail.

First, the treatment of DIACF's is challenging both with respect to adequate reduction and soft-tissue handling and therefore associated with a considerable learning curve for the individual surgeon.[20,21] Surgical treatment by hospitals with a low caseload is fraught with higher complication rates and less favorable outcome.[13] The inclusion of patients into a multicenter trial by surgeons who contribute 1 or 2 cases/year like in the UK Heel Fracture Trial will therefore negatively impact the results for the patients treated operatively.[4,6] Indeed, these patients had a higher infection rate when compared to the current literature. In contrast, in another RCT with all patients being treated by a single, experienced surgeon the differences between the study groups were highly significant and the benefits of adequate operative treatment became evident.[5]

Second, failure to reconstruct Böhler's angle and to reduce the subtalar joint within 2 mm are established negative prognostic factors.[2,20-25,29-31,48-53] Therefore, an operative treatment that does not restore the calcaneal anatomy combines the hazards of surgery in an area with a delicate soft-tissue cover with the risk of subtalar arthritis and other well-known sequelae of calcaneal malunions. Indeed, in 2 of the recent RCT's residual step-offs in the subtalar joint of 2 mm or more were seen in 22%–40% of the operatively treated patients.[3,4] When looking at the subgroups of the patients treated surgically, Buckley *et al*. in another RCT found significantly better results for patients with adequate joint reduction within 2 mm and patients with a higher individual Böhler's angle.[2] The same was seen in a *post hoc* analysis of Agren *et al*.[53] of their original RCT with a followup of 8–12 years.[3] When grouping the patients of the RCT into those with superior and inferior results, operative treatment, higher postoperative Böhler's angle and articular surface restoration were significantly more common in the superior group.[53] Consequently, significantly higher rates of subtalar fusions are reported for patients treated nonoperatively in two of the larger RCT's.[2,4]

Third, the fracture patterns of DIACF's are highly variable. Applying a single surgical technique to all patients to minimize confounders forces surgeons into a treatment method that they may not be comfortable with or that they would otherwise not have been chosen for a particular fracture.[6] A similar problem is seen when looking closer at the frequently cited long term RCT by Ibrahim *et al*.[54] These authors when comparing operative to nonoperative treatment for DIACF's used K-wire fixation of the subtalar joint through a small sinus tarsi approach and without any attempt to anatomically reduce the joint surface. This type of operative treatment would not be encouraged anymore today.

Fourth, selection bias is a concern when undertaking RCT's of a larger scale. Recruiting patients for a surgical RCT is getting more difficult with well-informed patients who gather information not only from the treating surgeon. In the UK Heel Fracture Trial, only 151 of 502 eligible patients were finally included into the study ("attrition bias").[4] Obviously, many patients with severely displaced fractures were not willing to be potentially randomized into the nonoperative treatment group. This left a large group of patients with less severely displaced fractures in the operative group that was then uniformly treated with plate fixation through an extensile lateral approach. It may be speculated, that many of those patients with simple Sanders Type 2 fractures could have been treated with percutaneous or less invasive methods that could have resulted in superior function and less soft-tissue complications.[55-59] Therefore, comparative trials should also include those patients with severe injuries.

Finally, there are confounders in RCT's that cannot be influenced by the treating surgeon. In particular, patients receiving workers' compensation have lower functional scores after a variety of injuries including DIACF's.[2,18,50] When excluding patients with worker's compensation from their RCT, Buckley *et al*. found significantly superior results for the patients treated operatively compared with those treated nonoperatively.[2]

When to Operate?

It follows from the above said that there is no general consensus on the indications for surgical treatment of calcaneal fractures. From the available evidence, many authors agree that, in the absence of local or systemic contraindications, DIACF's with joint displacement of 2 mm and more should be reduced anatomically to avoid painful hindfoot deformities and posttraumatic arthritis of the subtalar joint.[1,2,12,14-16,20-23,30,32,33,46,50-52] Extraarticular fractures with a substantial hindfoot varus or valgus deformity (>10°) and those with significant flattening, broadening, or shortening of the heel should also be reduced, preferably via small or percutaneous approaches.[32-34]

When not to Operate?

Systemic contraindications to ORIF include severe neurovascular insufficiency, poorly controlled insulin-dependent diabetes mellitus, noncompliance (e.g., substance abuse), and severe systemic disorders with immunodeficiency and/or poor overall prognosis.[33,34] Higher patient age by itself is not a contraindication to surgery because favorable results can be obtained in active patients beyond 65 years of age.[18,60] Treatment is rather tailored to the functional demand, comorbidities, and compliance of the patients.[1,14]

Nonoperative treatment is also generally preferred in nondisplaced or minimally displaced fractures [Figure 3] where the calcaneum is centered beneath the talus, and there is a mild flattening of Böhler's angle and limited joint step-off.[1,2,14,16,33,37,46] Treatment should be functional with early ankle and subtalar range of motion exercises

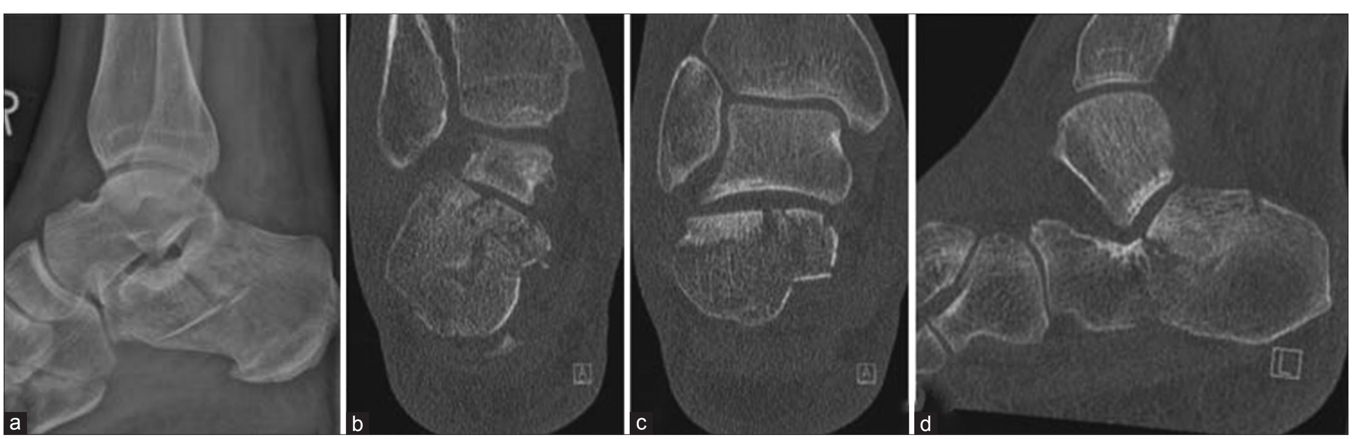

Figure 3: (a) X-ray showing mildly displaced fractures without gross deformities of the heel for which nonoperative treatment is a good treatment option. (b-d) The computer tomography scans showing multiple fragmentation of the subtalar joint but with a minimal step-off of 1 mm

and gradual mobilization of the patients in their own shoes with partial weight-bearing of 20 kg on the affected foot, provided adequate patient compliance.[1]

Timing of Surgery

Osteosynthesis for closed calcaneal fractures is usually performed within 1–2 weeks after the accident when hematoma and swelling have markedly decreased and skin blisters healed. If surgery is delayed beyond 2 weeks after the trauma, beginning fibrous union and soft-tissue shrinking will render anatomic reduction difficult, thus increasing the risk of wound healing problems and infection.[23,61] If percutaneous fixation is planned, surgery should generally not be delayed more than 7 days after the injury because purely percutaneous reduction reportedly gets difficult beyond that time.[55]

Emergency procedures

Open fractures, closed fractures with impeding compartment syndrome and with the severe incarceration of the soft tissues by displaced bony fragments, like beak fractures are treated as emergencies.[34-36] In these cases, treatment is focused on avoiding soft-tissue complications.[62,63] Treatment principles include debridement of all heavily contaminated and avital tissue, copious lavage, gross (or definite) reduction by percutaneous

Figure 4: (a-d) Less invasive anatomic reduction and fixation of a displaced, intraarticular calcaneal fracture (Sanders Type 3 AB) in a 26-year-old male who sustained a fall from a roof. (e) The displaced posterior facet can be reduced under direct vision via the sinus tarsi approach. The reduction sequence is essentially the same as with an extensile approach. (f-h) Fixation is achieved with screws introduced percutaneously and a contoured interlocking plate that is slid in via the sinus tarsi approach and tunnelled beneath the peroneal tendons. Anatomic reduction is verified with intraoperative fluoroscopy. (i-k) Standing radiographs at 3 years followup show bony union without loss of correction and a congruent subtalar joint without signs of posttraumatic arthritis

leverage or direct manipulation, temporary fixation with K-wires supplemented by tibiometatarsal external fixation to assist soft-tissue consolidation, and early definite fixation with soft-tissue coverage.[64] With these staged treatment protocols, complication rates could be substantially reduced in recent studies.[65,66]

In patients with crush injuries, i.e., severe soft-tissue damage and multiple level fractures to the foot, early amputation should be considered individually if functional reconstruction does not appear feasible to avoid protracted courses and multiple reoperations in case of limb salvage.[67-69] In polytraumatized patients, the decision to amputate also depends on the overall condition of the patient.[70]

Choice of Approaches

Extensile lateral approach

Complex fractures with severe displacement and multiple intraarticular fracture lines at the subtalar joint can be effectively treated through an extensile lateral approach.[15] This approach allows good visualization of the comminuted lateral wall, the fractured posterior facet, the sinus tarsi, and the anterior process including the calcaneocuboidal joint. However, it requires careful soft-tissue handling with elevation of a full thickness fasciocutaneous flap form the lateral calcaneal wall, gentle mobilization of the peroneal tendons within their sheet, respecting the course of the sural nerve and the lateral calcaneal artery,[71] preservation of the unique glabrous skin at the heel and the abductor digiti quinti muscle to avoid soft-tissue complications.[1,15,19,33] Still, the development of wound edge necrosis, soft tissue, and bone infection as well as arthrofibrosis and stiffness of the subtalar joint cannot be completely avoided despite a meticulous surgical technique. Therefore several alternative approaches have been proposed.

Sinus tarsi approach

The direct lateral approach to the subthalamic portion of the lateral calcaneal wall runs parallel to the peroneal tendons in a slightly curved manner close to the subtalar joint.[72] This approach requires less soft-tissue dissection as compared to the extensile lateral approach. However, it cuts directly through the angiosome of the lateral calcaneal artery and may lead to scarring of the peroneal tendons and the sural nerve.

Rather, a small oblique lateral approach over the sinus tarsi, slightly above the angle of Gissane ("sinus tarsi approach") has gained increasing popularity for less invasive reduction and fixation of calcaneal fractures.[73-75] These small approaches may also be helpful if an attempted percutaneous reduction proves impossible and direct access to the joint is required.[55] With this approach, the peroneal tendons are gently mobilized plantarly within their sheets and the subtalar joint can be visualized directly from above. Manipulation and reduction of the main fragments is carried out percutaneously, but the joint fragments can be manipulated directly through the approach [Figure 4]. Definite fixation is achieved with percutaneous screws or bolts,[73,76] an intramedullary nail with locking screws,[77,78]

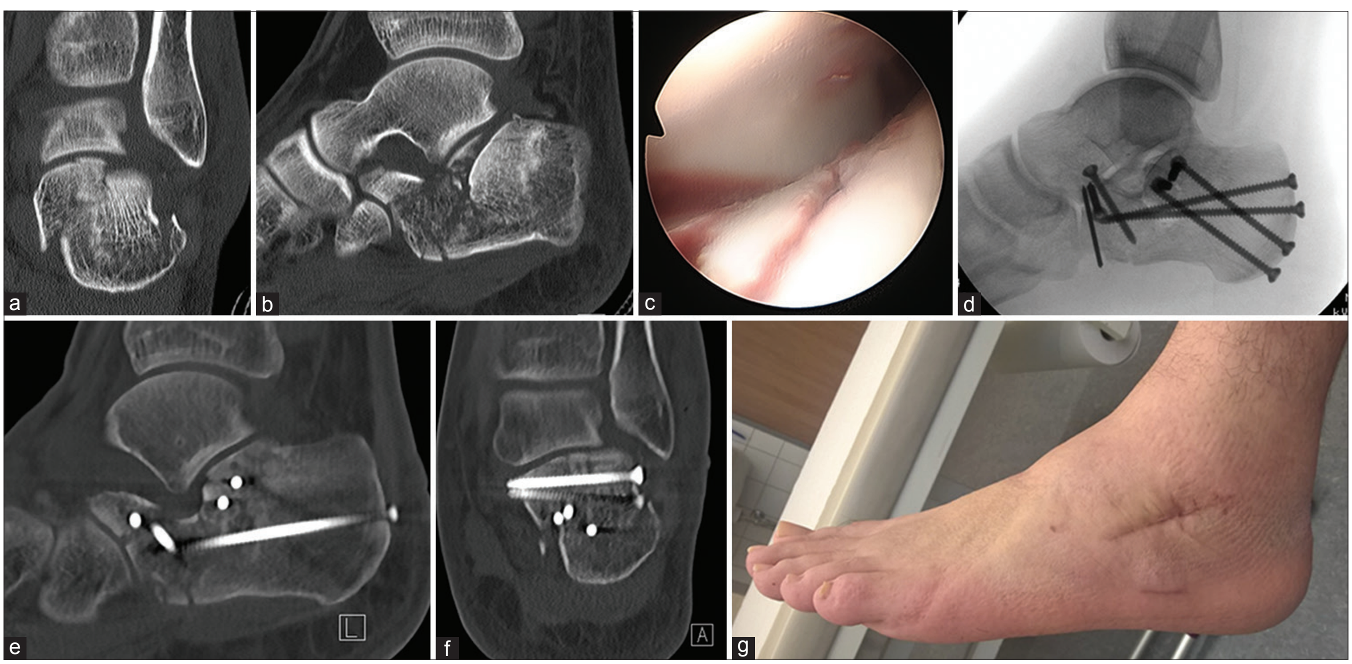

Figure 5: (a and b) Sanders Type 3 BC fracture in a 36-year-old male who fell from a height of 1.5 m. Preoperative computed tomography scanning showing an additional multifragmentary fracture of the anterior process with joint displacement. Therefore, the sinus tarsi approach is extended to the calcaneocuboid joint. (c) Because the fracture lines are situated relatively far medially, dry arthroscopy is used for control of anatomic joint reduction. (d-f) Intraoperative fluoroscopy and postoperative computed tomography scans showing anatomic reconstruction of the overall shape of the calcaneum and its joints. (g) Uneventful appearance of the scar at 8 weeks followup. This case illustrates the necessity of individual planning of the therapeutic approach for displaced, intraarticular calcaneal fractures

or a small plate that is sled in through the approach and tunnelled beneath the peroneal tendons.[74,79] Recent comparative studies show reduced rates of soft-tissue complications while achieving and maintaining adequate reduction.[58,76,80]

Percutaneous fixation

Minimally-invasive fixation of calcaneal fractures significantly reduces the risk of soft-tissue complications.[55-58,74,80] Many authors consider percutaneous reduction and screw fixation in cases of extraarticular and simple intraarticular fractures with the posterior facet being displaced as a whole as in Sanders Type IIC fractures.[55,81] These techniques can be extended to intraarticular fractures with only 1 displaced fracture line across the subtalar joint (i.e., Sanders Types IIA and IIB) with proper control of the articular reduction with subtalar arthroscopy or three-dimensional (3D) fluoroscopy.[82,83] However, performing percutaneous reduction and fixation irrespective of the type of fracture and without adequate control of reduction carries the risk of inadequate reduction and loss of fixation.[84-86]

The reported rates of superficial wound edge necroses range between 2% and 30% of all cases after osteosynthesis through an extended lateral approach,[15,18,21,23,58,61,75,87-89] between 0% and 12% the use of a sinus tarsi approach,[58,74,76,78,80] and between 0% and 6% with percutaneous fixation.[55,82,83,90,91] Further approaches are available for specific fracture patterns.

Dislocation approach

For fracture–dislocations of the calcaneum with direct compression of the fibular tip by the tuberosity fragment and subsequent dislocation of the peroneal tendons, an extension of the direct lateral approach (dislocation approach) allows access to the displaced tuberosity and lateral joint fragment from above.[16] It starts over the lateral malleolus, thus allowing fixation of an accompanying fibular fracture and reattachment of the peroneal retinacle after fracture reduction and rerouting of the tendons. Reduction and fixation of the main fragments is usually straightforward with compression screws inserted from laterally into the sustentaculum tali.[1,33]

Sustentacular approach

A small medial approach directly over the sustentaculum tali is used in cases of isolated fractures of the sustentaculum tali or in addition to the extended lateral approach with fragmentation of the medial joint facet in more complex fracture patterns.[1,16,34,92] The incision of about 3 cm lies horizontally over the palpable sustentaculum. The nearby posterior tibial and flexor digitorum longus tendons are held away with vessel loops and the posterior tibial neurovascular bundle is usually not exposed. The medial joint facet is reduced under direct vision and the sustentaculum is generally fixed with 3.5 mm compression screws.[92]

Considerations on Reduction and Fixation

Control of reduction

Given the importance of anatomic reduction as extensively discussed above, adequate control of reduction is essential regardless of the choice of approaches. Precise intra-operative control of the reduction of the subtalar joint can be achieved after initial K-wire fixation either by open subtalar arthroscopy[93] or intraoperative 3D fluoroscopy [Figure 5].[94] If an intraarticular step-off is found, the K-wires are removed and joint reduction can be corrected immediately thus preventing painful postoperative conditions or the need for further surgery. In clinical series, relevant irregularities or screw malpositioning within the subtalar joint could be detected in >20% of cases that had been judged as being anatomically reduced with conventional fluoroscopy.[93-95]

Internal fixation and defect filling

For internal fixation, various calcaneal plates have been designed. Most authors use a single lateral plate that displays the anatomical features of the calcaneum, providing support to the tuberosity, the thalamic portion with the posterior joint facet and the anterior process.[15,16,19-23,33,96] Most current plate designs are polyaxially locked plate designs.[1,97] If an interlocking plate is used, 1 or 2 conventional screws should be placed first to bring the plate close to the bone thus increasing stability by friction and avoiding soft-tissue impingement from plate protrusion.[98] The need of filling subthalamic impaction defects with bone grafting or synthetic bone substitutes is controversial and its use not substantiated by clinical evidence.[99]

Primary fusion of comminuted fractures

Several authors advocate primary subtalar fusion in the cases of highly comminuted fractures (Sanders type IV) that are associated with less favorable functional results.[20,100,101] In such cases, ORIF of the calcaneum is followed by removal of all remaining cartilage and fusion with autologous bone graft and 1 or 2 6.5 mm–8.0 mm cancellous bone lag screws.[46] In a recent RCT on Sanders type IV fractures, primary fusion was not superior to ORIF and only 1 of 17 patients randomly allocated to ORIF went on to a secondary fusion.[102] The rates of secondary subtalar fusion for symptomatic posttraumatic arthritis range between 0%[103] and 14%.[20,29] with most authors reporting rates between 2 and 6%.[18] It may therefore be reasonable to perform ORIF on patients with Sanders type IV fractures and perform secondary arthrodesis only if painful subtalar arthritis develops.[1] *In situ* fusion of a well reduced and solidly healed calcaneal fracture is easier to achieve and associated with less complications and better clinical outcome than corrective arthrodesis for malunited calcaneal fractures that have been treated conservatively at first presentation.[47,104]

Postoperative care, rehabilitation and implant removal

Rehabilitation aims at early mobilization of the patient with physical therapy that includes active and passive range of motion exercises in the ankle, subtalar and mid-tarsal joints starting at the second postoperative day. In addition, continuous passive motion of the subtalar joint is initiated. Patients are restricted to partial weight-bearing of about 20 kg in their own shoes for 6–12 weeks, depending on the the fracture pattern and bone quality. Implant removal 1 year after plate fixation is only advocated in cases of protruding hardware or massive arthrofibrosis with limited range of motion, mostly after plate fixation through extensile approaches. If the latter is present, implant removal is combined with extraintraarticular and intraarticular arthrolysis and debridement employing subtalar arthroscopy.[93]

What Results can be Expected?

A multitude of clinical studies reports the short term to mid term results after operative treatment for intraarticular calcaneal fractures. Comparison of theses studies is notoriously difficult due to the diverse patient cohorts, treatment protocols, and outcome measurements. Clinical series with >100 patients and followed for >1 year showed good to excellent results with open reduction and lateral plate fixation in 60%–85% of cases using different outcome criteria.[20,21,23,29,105,106] These results seem to prevail on the long term with available followup of 8–15 years.[17-19,25]

Negative prognostic factors that have been identified in different clinical studies include a severe fracture pattern (as represented by the Zwipp or Sanders classification), open and bilateral fractures, eligibility for workers' compensation, high workload, failure to reconstruct Böhler's angle, and residual step-offs in the subtalar joint of 2 mm or more.[2,12,13,15,20-25,29,30,37,48-53,61,105,106] Axial impaction at the time of surgery results in primary cartilage damage that may lead to posttraumatic arthritis irrespective of the kind of treatment.[107]

Higher patient age by itself does not negatively affect outcome after operative treatment of calcaneal fractures.[18,60,108] However, care has to be taken not to misjudge low-velocity injuries in the elderly population with osteoporosis or diabetes that are challenging to treat and prone to complications.[109,110]

Conclusions

Fractures of the calcaneum display a variable fracture pattern and thus require an individualized treatment approach and precise preoperative planning. Open fractures and closed fractures with compartment syndrome or severe soft-tissue incarceration resulting from internal fragment pressure are treated as emergencies. Nondisplaced, mildly displaced extraarticular fractures, intraarticular fractures with step-offs of <2 mm and patients with general contraindications to surgery are treated nonoperatively. Severely displaced extraarticular and less severe intraarticular fractures may be treated with percutaneous reduction and fixation with excellent results. Percutaneous reduction and fixation are also helpful as a temporary measure in more severe fracture patterns with critical soft tissues or a critical overall condition of the patient. In the absence of contraindications, the majority of displaced, intraarticular fractures are best treated by ORIF. Selected, less invasive approaches and novel fixation techniques have the potential to minimize soft-tissue complications while ensuring anatomic reduction and stable fixation. For the best outcomes, the procedure should be performed by a surgeon experienced in both the operative treatment of calcaneus fractures as well as the complications that may arise in both operative and nonoperative management. Nonoperative treatment of severely displaced fractures or failure to achieve anatomic reduction with surgical treatment regularly results in painful malunions with rapidly evolving subtalar arthritis.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

Stefan Rammelt and Michael Swords are members of the Foot and Ankle Expert Group and the Foot and Ankle Education Task Force of AOTrauma, a nonprofit organization. As such they receive support for travel and housing to meetings of the respective groups. No financial conflict of interest results for this review article.

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