

Distal Tibial Fractures and Pilon Fractures

Zlomeniny dolního konce tibie a pilonu

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SUMMARY

Fractures of the distal tibia are often very severe injuries that generally occur in the context of high-energy trauma and present with significant concomitant soft tissue involvement. Open fractures and extensive destruction of the articular surfaces are important challenges to the treating surgeon.

In consequence the outcome for distal meta- and epiphyseal tibial fractures depends largely on the severity of the soft tissue injury and its management. Conventionally, tibial pilon fractures require surgical intervention. Conservative treatment would only be considered in some exceptional cases, for example, inoperability of the patient. Controversial discussion of optimal surgical technique and optimal timing of surgery is ongoing. There is broad consensus that soft tissue consolidation must have first priority as this is the basis for both fracture healing and good long-term outcomes. Surgical intervention can be managed as a one-stage or multi-stage procedure to achieve internal or external fracture fixation.

INTRODUCTION

The tibial diaphysis is the most frequent site of long bone fracture and accounts for 40% of all diaphyseal fractures. Approximately 7% of all tibial fractures are tibial pilon fractures, i.e. fractures with involvement of the distal tibial plafond (24, 45, 50).

Low energy injuries that follow activities such as skiing may result in typical spiral fractures caused by torsional forces in the region of the tibial diaphysis. Forced rotation at the upper ankle may cause the malleoli to break off or lead to intraarticular split fracture without significant impact on the articular surface (27, 45). High energy trauma may result in complex fracture patterns, often associated with severe soft tissue injury (19, 41, 44, 50).

Tibial pilon fractures (Destot 1911, Lyon, “le pilon”; French: pounder, pestle) are a separate entity within the classification of tibial fractures and describe high-energy axial impaction and bending fractures of the distal tibial metaphysis, including the tibial plafond. Typical accident mechanisms are high-energy trauma due to a fall from a great height or road traffic accidents. Since the introduction of airbags the rate of injuries to the lower extremities has increased markedly due to the enormous burst of energy into the footwell (19). Serious destruction of the distal tibial metaphysis and the surrounding soft tissue mantle is often the result of contusion or crushing accidents such as being run over, buried under rubble, caught up in a machine or after accidents at work.

Due to the minimal soft tissue cover in the region of the distal tibia these injuries are associated with severe soft tissue involvement that is frequently under-estimated at the outset, but which an experienced traumatologist would be looking for based on the accident mechanism

and the radiographic images (28, 46). The incidence of open fractures and the infection rates are far greater for these injuries. High energy combined with axial impaction means that the “harder” talus (in the sense of bone structure) is driven up into the tibial plafond, frequently resulting in extensive comminution of the epi- and metaphyseal bone (38). If there is only impaction, the fibula may remain intact. However, in about 80% of injuries there will be concomitant distal fibular fracture (6). If force is applied with the foot in plantar flexion, dorsal flexion, pro- or supination eccentric forces additional to the axial impaction forces, tiny cortical fragments may shear off (19).

DIAGNOSTICS

At clinical examination the typical signs of fracture will be present and, in many cases, the extent of relevant concomitant soft tissue injuries which may become clear later. Open fractures, dislocation and subluxations at the upper ankle joint due to involvement of the capsular ligamentous structures as well as serial disruptions and concomitant injuries should be identified when the patient first presents and taken into consideration when developing the treatment plan. When assessing injuries to the distal part of the lower leg it is very important to document all relevant previous illnesses and note current neurovascular status with regard to blood flow in the extremities as this information will influence therapeutic procedure (22). Ulcera cruris, compromised vascularity in occlusive arterial disease, chronic venous insufficiency peripheral edema, long-standing nicotine abuse, and Diabetes mellitus should alert the treating physician to modify care management to minimize potential com-

plications such as a much higher risk of infection, disordered wound healing and malunion which can lead in worst case to amputation (22, 40).

Apart from earliest possible reduction and/or emergency immobilization of the extremity, attention must be paid to existing or imminent compartment syndrome (22, 46, 48). Since the tibia with its thin soft tissue cover is vulnerable to injury and because the muscle compartments at the lower leg lie in close proximity, increased pressure due to trauma, hematoma or edema or even during the course after surgical intervention may lead to a critical increase in tissue pressure in all four tibial compartments (45). Although it has been assumed that tissue pressure is normally around 5–10 mm Hg, the absolute value for intracompartmental pressure in compartment syndrome remains unclear. It has been postulated that myoneuronal ischemia due to compartment syndrome should be expected at pressures above 30–35 mm Hg, depending on the average arterial pressure. Recommendations in the current literature state that compartment syndrome should be diagnosed clinically without reference to the pressures measured (46). The clinical picture is characterized by distinctly painful swelling and induration of the affected muscle compartments. Loss of sensitivity, hypesthesia of the dorsum of the foot and reduced motor function are generally manifest later and are a sign of late diagnosis. Sciatic neuralgia triggered by passive movement, lack of palpable pulse or loss of Doppler signals, distinctly delayed capillary recovery and the onset of paresis may indicate irreversible damage. If clinical assessment suggests the presence of compartment syndrome, surgical intervention in the form of immediate fasciotomy of all four compartments is indicated as an emergency procedure (23). In cases of dislocation or mid-foot injury, compartment syndrome in the region of the foot is likewise possible and should not be overlooked.

Imaging diagnostics

Standard diagnostic procedures include plain radiographs in two planes. To ensure that additional injuries and fractures are not missed, special views of the entire lower leg with imaging of the adjacent joints is essential. Since pilon fractures are generally complex fractures of the joint, computed tomography is also recommended to determine the fracture geometry and that of the articular surface, both of which are important to surgical planning (50, 51).

CT scanning provides more detailed images of the individual fracture components and, combined with knowledge of the pathomechanism of the pilon fracture and an understanding of the ligamentous structures in the region of the distal tibia and upper ankle joint, has contributed to a better understanding of what are often complex tibial pilon fractures. Six main fragments involved in tibial pilon fracture have been identified (51):

1. Medial malleolus fragment (rotation fracture)
2. Anterolateral fragment (axial force, fixation through the anterior syndesmotomic ligament)
3. Posterolateral fragment (axial force, fixation through the posterior syndesmotomic ligament)

4. Anterior tibial crest fragment (hyperextension)
5. Posterior tibial crest fragment (hyperflexion)
6. Central fragment (axial force)

Apart from clinical examination and imaging diagnostics additional tests may be necessary such as doppler sonography or (CT-) angiography if concomitant vascular injury is suspected (19). It will provide information on the location and extent of possible vascular damage. Interventional angiography is rarely required but may be utilized directly in therapy for vessel lesions.

CLASSIFICATION

According to the AO Classification of Müller and Nazarian fractures of the distal tibia are defined as extra-, partially intra-, and completely intra-articular (31). Fractures of the distal tibia have been given the number 43 in the AO Classification (Fig. 1a-c). Fractures of types 43 B3 and C1-C3 are the severest fracture patterns of the distal tibia with involvement of the distal tibial articular surface, thus corresponding to the classical tibial pilon fracture. Concomitant soft tissue injuries, which are not included in the afore-mentioned AO Classification, are described in the category of closed fractures by Tschern and Oestern (35), and in the category of open fractures by Gustilo and Anderson (18) and also by Tschern and Oestern (18).

Apart from the AO Classification one of the best known classifications is the one compiled by Ruedi and Allgöwer (42). It divided distal tibial fractures into 3 groups and formed the basis for the AO Classification, which is in widespread use today.

Malleolar fractures are referred to as Region 44 in the AO Classification and belong to the category upper ankle joint. Avulsion fractures of the anterior or posterior syndesmotomic ligament seen as a fracture of Chaput's tubercle or bony avulsion of the posterior Volkmann's triangle require special mention and diagnosis can often only be verified or visualized by CT imaging.

MANAGEMENT

Conservative management of distal tibial fractures can only be considered for the rare non-displaced closed fractures that can be exactly reduced and retained in stable fixation (Type 43-A1–3, B1) or in situations of desolate vascularity or general inoperability (5, 36). Immobilization in a lower-leg plaster cast with partial weight bearing on crutches, a walking frame or immobilization in a wheelchair with thrombosis prophylaxis can be implemented with constant evaluation of soft tissue conditions. Full weight bearing is generally possible after 6–8 weeks (19, 32, 45). Fracture of the distal tibia, especially in classical tibial pilon fractures with involvement of the distal tibial plafond and the distal metaphysis, is an injury that generally requires surgical intervention.

Lengthy periods of immobilization of an extremity are associated with the usual risks of thrombosis, embolism, reflex dystrophy and contractures with subsequent per-

Fig. 1 a–c. Top down AO classification of distal tibial fractures referred to as 43

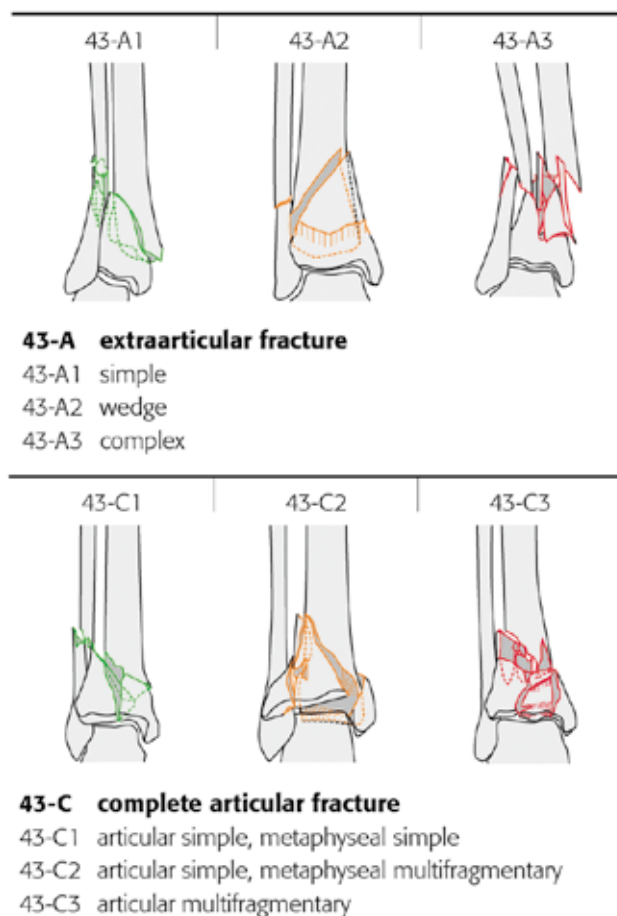
a/b
c/

Fig. 1a. 43-A extraarticular fracture. From left to right: 43-A1 simple; 43-A2 wedge; 43-A3 complex.

Fig. 1b. 43-B partial articular fracture. From left to right: 43-B1 pure split, 43-B2 split-depression; 43-B3 multifragmentary depression.

Fig. 1c. 43-C complete articular fracture. From left to right: 43-C1 articular simple, metaphyseal simple; 43-C2 articular simple, metaphyseal multifragmentary; 43-C3 articular multifragmentary.

sistent symptoms and restricted movement. Inadequate immobilization of complex distal tibial fractures, on the other hand, can lead to secondary reduction loss. The manifestation of secondary compartment syndrome or nonunion or consolidation in varus malalignment are additional risks of conservative management. Varus malalignment of the lower leg is generally less well tolerated than valgus malalignment (19). In cases of leg shortening, special raised shoes will help.

Surgical management

Surgical intervention aims to achieve anatomical reduction with restoration of axes, length and joint constellations, fixation stable enough for exercises, and early functional mobility. The main objective, as for every other joint fracture and especially for a load-bearing extremity, is the restoration of the articular surface.

Treatment procedure should be tailored in accordance with the concomitant soft tissue injuries and the fracture pattern (27, 44, 52, 59). A primary one-stage procedure with definitive fracture fixation and single-shot antibiotics is only relevant to simple fractures that present within 6–8 hours of trauma provided the soft tissues can tolerate several hours of surgery. A two-stage procedure with initial retention by external fixator followed by a conversion procedure be the treatment of choice for open fractures, fractures with extensive soft tissue injury, status

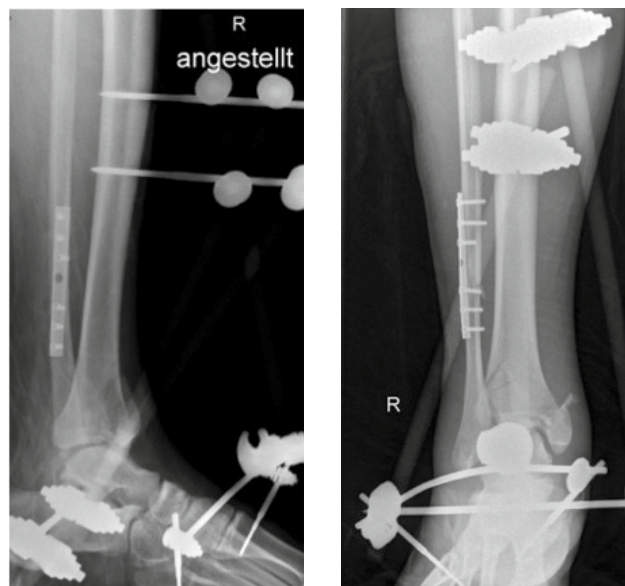


Fig. 2. AP and lateral radiographs. 21-year-old patient who was struck by a heavy item at work and suffered a closed pilon tibial fracture with a fracture of the distal fibula and a luxation of the ankle joint. Two-stage procedure with reposition of the ankle joint, open reduction and internal fixation of the distal fibula to restore the length and rotational alignment of the lower leg and retention by external fixator and. In the course open reduction and internal fixation of the distal tibia with screws and a tibia LCP was performed.



Fig. 3. AP and lateral radiographs of pilon fractures treated with different screws and plating systems. At the top two patients, 47- and 36-year-old, who fell off a ladder and suffered C3 fractures treated with Pilon-LCPs. Subjacent on the left a 22-year-old woman who contracted a pilon fracture during floor exercises which was fixed with a distal radius-LCP. At the bottom on the right the same patient as shown above treated with a two-stage procedure. The 21-year-old patient suffered a pilon fracture with a concomitant fracture of the distal fibula as well as a dislocation of the ankle joint. After reposition, open reduction and internal fixation of the fibula and retention with an external fixator open reduction and internal fixation with a pilon-LCP and screws was performed.

after compartment release, vasomotor injuries or in patients with compromising comorbidities (8, 11, 25, 27) (Fig. 2). In these cases of bad perfusion of the lower leg or severe soft tissue damage even definitive stabilization with external fixator is recommended as a good alternative (11, 61).

It may be advantageous to stabilize simultaneous fibular fractures with a plate combined with a joint-bridging external fixator as a primary intervention (5, 27, 30).

Anatomical reduction of the fibula will restore the lateral column of the upper ankle joint as well as length and rotational alignment of the lower leg. Possibly, anatomical reduction of the tibial metaphysis and the articular surface and restoration of the malleolar mortise can be simplified by ligamentotaxis. In open fractures with significant soft tissue injury, radical wound debridement is essential to decrease the risk of wound infection. Temporary vacuum-assisted wound closure can be achieved

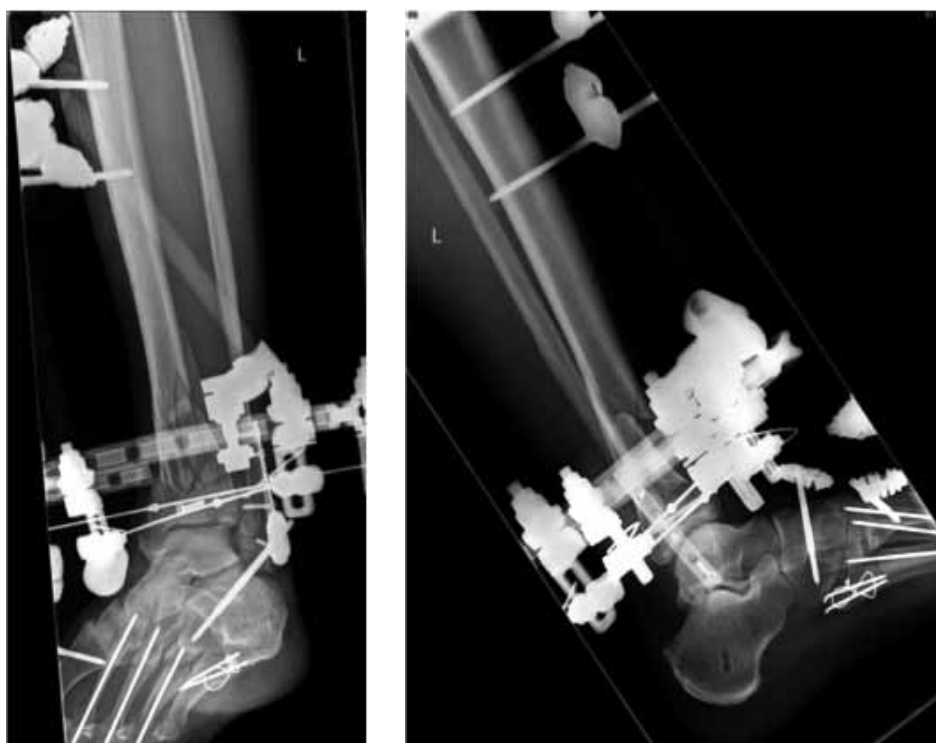


Fig. 4. A complex distal tibia fracture (43-C3) with compromised soft tissue treated with a hybrid ring fixator. A 62-year-old patient who was struck by a car and suffered an open pilon fracture which was fixed with a hybrid ring fixator. Soft tissue closure was performed with a latissimus dorsi flap.

by insertion of a foam in appropriate technique. The same procedure also facilitates application of dressings and wound drainage after compartment release. If bone surfaces or even implants are exposed, one-stage surgery with appropriate flap transfer should be performed since this has been shown to improve the overall outcome (16).

The course of treatment focuses on reduction of swelling by elevation of the extremity, cryotherapy and sufficient analgesic therapy. Regular evaluation of the soft tissues is important for the early recognition of (imminent) compartment syndrome. Early mobilization of the patient with partial weight bearing of the affected limb is a priority.

After consolidation of the soft tissues and/or clearly visible demarcation permitting the plastic surgeon to plan soft tissue reconstruction, conversion to internal fixation can take place. If primary treatment of a concomitant fibular fracture was not possible, the fibula should now be reduced and stabilized by fixation. Stabilization of the fibula is performed as usual through a posterolateral skin incision to ensure the largest possible tissue bridge between the skin incisions. Generally, a one-third tubular plate as a neutralization plate is adequate for fibula fixation or a bridging plate if there are bone defects.

Reconstruction of the distal tibia requires a profound knowledge of the anatomy and good preoperative planning. Preoperative assessment based on the CT scans should reveal whether autologous cancellous bone grafting or allogenic bone substitutes are required

to fill larger defects arising from massive impression and impaction of the tibial metaphysis, especially in situations of poor bone quality, whereby, with the advent of locking implants, bone substitution procedures are becoming less common. The postoperative outcome is highly dependent on the reconstruction of the tibial articular surface and the recovery of the adjacent soft tissue (21, 32).

The routine approach to the distal tibia is through an anteromedial skin incision. Surgery should be preceded by preoperative single-shot antibiotic administration, for example of a cephalosporin (46). Step-by-step reduction of the fragments to reconstruct the articular surface can be facilitated by temporary insertion of K-wires. Isolated screws and well established plating systems

ensure definitive fixation. A variety of locking plates (e.g. pilon-LCP, distal tibia-LCP, distal radius-LCP) are applied depending on the size of the fragments, fracture geometry and the condition of the soft tissues (Fig. 3). To minimize surgical insult to the damaged tissue, these plates may be positioned in slide-insertion technique. The proximal screws can then be inserted through stab incisions to preserve the soft tissues. If internal fixation does not achieve sufficient stability for exercises, the external fixator may have to be left in situ. However, in many cases, the external fixator can be removed to permit functional rehabilitation of the adjacent joints. Loading capacity for the plated lower leg generally remains clearly restricted to around 20 kg for 6–8 weeks postoperatively (19, 45).

If the soft tissue injury, course of infection, patient-specific circumstances or the fracture geometry do not favor two-stage internal fixation, the external fixator will remain as the definitive solution. If the fracture pattern is highly complex, alternatives include stabilization by means of a ring fixator combined with a tubular rod fixator as a hybrid or an Ilizarov fixator (11, 14, 61) (Fig. 4). In these cases, the joint block can be stabilized with wires to preserve the soft tissue. This will permit some motion and exercising of the upper ankle joint.

Alternatively, simple extraarticular fractures (Type 43-A) may be stabilized by plate osteosynthesis, slide-insertion plates or intramedullary nails (54). Both procedures have advantages and disadvantages and should be discussed and evaluated for each individual case. The literature describes an increased risk of pseudarthrosis



Fig. 5. AP and lateral view of an arthrodesis nail performed in both patients after open, complex pilon fractures. On the left a 49-year-old polytraumatized patient who fell from a great height and sustained an open C3 pilon fracture. A primary arthrodesis with autologous spongiosa graft from the fibula, bone morphogenic protein addition and an Expert Hindfoot Arthrodesis Nail (HAN) was performed. On the right a 76-year-old patient with a pseudarthrosis after deep wound infection and multiple revisions amongst others an arthrodesis was performed with a hybrid ring fixator. When a consolidation failed a rearthrodesis with an Expert Hindfoot Arthrodesis Nail (HAN) was carried out.

for extraarticular fractures of the distal tibia (53, 60). Nail fixation has the advantage that it is less invasive and the approach is away from the fracture site, but it is often difficult to perform distal locking in a small metaphyseal fragment (45, 60). Furthermore, cases of postoperative, approach-related knee pain have been described (60). Closed reduction is more prone to malalignment and occasionally ends in rotational deformity (54). A slide-insertion plate is most likely to ensure better reduction and is generally easier to anchor in the distal fragment (60). However, some studies have reported higher rates of infection and disordered wound healing (43), perhaps partly because the approach to the distal tibia lies close to the fracture site in the area of greatest soft tissue injury (60). Soft tissue irritation due to the implanted plate has also been described as well as the need for a longer period of partial weight bearing and a possible risk of implant failure as loading increases (43).

In cases of extensive destruction of the articular surface or very poor bone quality anatomical reconstruction may not be possible so that primary arthrodesis becomes a necessity (3, 29). This can be achieved by external fixator, screw osteosynthesis, or special arthrodesis nails (Fig. 5). Amputation need only be considered when faced with the severest combinations of bone and soft tissue injury and, possibly, for patients whose survival is threatened (27, 47).

Depending on the soft tissue insult and the possible course of infections, especially if implanted material is

exposed, reconstruction of soft tissue structures by plastic surgery will complement the therapeutic strategy.

In this regard early multidisciplinary co-evaluation of the soft tissue status and the course of healing by the plastic surgeon is advantageous. The aim must be to optimize the coordination of the ongoing reconstructive concept since the outcome is greatly determined by the extent of soft tissue injury. The importance of initial radical debridement cannot be overestimated in these cases of distinct crush and shear traumata. In these cases, adequate radical debridement should not be compromised by concerns that soft tissue closure will not be possible later on. The presence of contaminated or necrotic tissue leads to a much higher risk of infection which, in turn, may retard the healing process and compromise the final outcome. If soft tissue injury is extensive, it can be valuable to invite the plastic surgeon to participate in initial debridement to ensure that all soft tissue reconstruction options remain open. The technique of vacuum-assisted wound closure has contributed greatly to perioperative wound management in relevant patients. It means that a dressing can be applied intraoperatively under sterile conditions and can be left in place until the next intervention, thus contributing to patient comfort and pain reduction since dressings do not need to be changed.

If the initial trauma has not damaged the soft tissue but later on wound healing proves to be disordered, the vascular situation must be investigated. The same applies to patients with vascular risk factors.



Fig. 6. 52-year-old patient with a deep wound infection and osteomyelitis in the course of an open fracture and open reduction and internal fixation with a plate. Reosteosynthesis and filling with autologous spongiosa graft after formation of a pseudarthrosis. When again there were no fracture consolidation an arthrodesis was performed using an arthrodesis plate. A deep wound infection and a large soft tissue defect with exposure of the metal necessitated the removal of the plate as well as the wound closure with a gracilis muscle flap by the colleagues of plastic surgery and an additionally stabilization with a ring fixator. Four years after the accident the soft tissue situation as well as the arthrodesis was consolidated and the patient was able to walk.

Particularly in this region the quality of the soft tissue mantle restored by reconstructive procedure must be meticulously evaluated in addition to assessment of wound closure since it is of critical importance and will determine, for example, whether the patient can wear normal shoes in future. Isolated skin transplant is definitely only useful where the wound bed is well vascularized and there is a certain minimum of residual soft tissue cover. The distal lower leg is characterized by few options for local flap transfer so that free tissue transfer

is often indicated (Fig. 6). The procedure of random-pattern flap transfer (e.g. an advancement flap of adjacent skin combined with split-skin graft) is generally associated with complications, does not successfully achieve rapid, stable soft tissue coverage and, therefore, aggravates the soft tissue situation.

Another important aspect of soft tissue reconstruction to treat these types of injuries is the need to cover the exposed areas of bone, whereby the fracture or the implants may be exposed. Here, reconstructive tissue trans-

fer not only serves to close the defect but also permits the introduction of vascularized tissue and may accelerate fracture consolidation and facilitate endogenic bacterial clearing of contaminated wounds (26, 33). The ultimate choice of flap will inevitably take into account individual donor site morbidity. For less extensive defects in this region fasciocutaneous flaps (e.g. anterolateral thigh flap (ALT)) (34) as well as muscle flaps (e.g. gracilis muscle flaps) (10) with additional split-skin coverage are valid options. These procedures should aim to compromise the contours of the distal lower leg and ankle as little as possible for as short a time as possible to facilitate early and uncomplicated ability to wear shoes (13). The option of a combined vascularized bone/soft tissue graft completes the spectrum of reconstructive procedures for massive, combined injury patterns with "critical size" bone defects beyond the scope of non-vascularized bone grafts (58).

COMPLICATIONS

In the region of the lower leg the trauma itself and the surgical interventions can cause pressure increase in the muscle compartments. The anterior tibial compartment is the one most often affected. Manifest or imminent compartment syndrome are indications for immediate surgical dermatofasciotomy of all four compartments to prevent irreversible damage (23).

Infection is the most frequent complication and occurs in about 20–25% of primary open lower-leg fractures (2, 3, 45). Postoperative wound infections after internal fixation are quoted in the literature at 14 – 55% (2, 7, 55). Given the special soft tissue situation of the distal lower leg and the typical accident mechanisms, even primary closed fractures are at risk of early and/or late infections such as superficial and deep wound infections, posttraumatic implant-related osteitis as well as chronic osteomyelitis later in the course (12). These conditions are managed according to the standards set out for septic surgery with radical wound debridement, sequestrectomy, repeated irrigation and drainage. The situation may demand premature implant removal or a conversion procedure (6). The option of free transfer of well vascularized flaps completes the treatment spectrum for bone infections in terms of reconstructive surgery (26, 33).

Complications such as disordered wound healing, skin necrosis and course of infection are not eased by the anatomy of the distal lower leg and ankle joint, which receive their main blood supply through the branches of the anterior tibial artery that anastomose through the perforating branches with the branches of the posterior tibial artery. The shear forces that are common to pilon fractures put the integrity of the vascular plexus and, consequently, the blood supply to the skin above it at serious risk (32).

Apart from those complications that are generally related to soft tissue injury, complex tibial pilon fractures, like all intraarticular fractures, and more so given the weight-bearing function of the lower leg, are suscepti-

ble to posttraumatic arthrosis (12, 39, 41). Inadequate reduction or secondary reduction losses lead to deformities and axial deviations that must be seen as prearthrotic deformities and go hand in hand with load-related symptoms, incorrect loading, restricted range of motion, and impingement syndromes (21, 49). Varus deformities occur most frequently and should be corrected from an axial deviation of 5–10° according to current literature (19, 45). Leg length differences due to posttraumatic shortening of up to 2 cm can be compensated for by appropriately raised shoes.

It is not uncommon to see delayed fracture healing and/or the formation of pseudarthroses as a result of severe soft tissue injury, increased infection rates and complex fracture patterns (1). Larger bone defects and avital bone fragments can be managed by cancellous bone grafting (32), BMP filling (15), vascularized bone transfer (58) or conversion procedure with repeat fixation. Implant removal in pilon fractures should be considered very carefully (19). Implants may be removed on the request of the patient or to address mechanical irritation caused by the implant.

DISCUSSION

Pilon fractures are serious injuries to the load-bearing lower extremity and are associated with high complication rates. The prognosis is decisively dependent on the extent of destruction of the articular surface, the severity of soft tissue injury and the management of these two conditions. The importance of this statement can be further underlined by saying that a tibial pilon fracture is an injury to the soft tissues associated with bone fracture. The soft tissue damage, severity of the injury, joint reconstruction and the optimal timing of relevant surgical interventions have a directly proportional influence on the outcome (19, 37, 38). There is broad consensus in the literature that preservation of the soft tissue is paramount to all initial procedures and has priority over joint reconstruction (6, 30, 44). Optimal surgical management and its timing remain topics of controversial discussion. According to Borelli et al. the complication rate, especially the incidence of pseudarthroses, can be decreased by a two-stage procedure (4, 55). Hahn et al. postulate that this is due to less periosteal stripping of the fragments in a two-stage procedure (19).

Egol et al. showed that simultaneous fracture fixation of the distal fibula for distal metaphyseal tibial fractures when stabilized by intramedullary nailing reduced the rate of secondary correction loss (9). However, the study by Ristiniemi et al. found an increased rate of delayed fracture healing for stabilization of the distal fibula by osteosynthesis (40). Williams et al. also reported a higher complication rate for osteosynthesis of the fibula (57). Streicher and Reilmann suggest that in larger defects with extensive soft tissue injury, primary shortening of the limb by a few millimetres improves local blood circulation and promotes soft tissue recovery and fracture consolidation later on (45). In two-stage definitive fracture care, additional plating of the fibula

does however seem to increase the overall stability of the osteosynthesis (6, 56).

Apart from fibula plating, external versus internal fixation remains the subject of controversial discussion. Ristiniemi et al. attribute delayed fracture healing in the 2-ring hybrid fixator predominantly to the extent of residual fracture displacement (40). In contrast, Endres et al. even propagate an improved outcome for C2 and C3 fractures for initial fixation to healing in the hybrid fixator compared to internal stabilization of pilon fractures by osteosynthesis (11). In the fixator group, pin infections were not uncommon and required surgical revision in 18% of cases. Infection rates and delayed healing were nevertheless higher in the internal fixation group.

More recent publications generally recommend a two-stage procedure, depending on the extent of soft tissue damage, with a conversion to internal osteosynthesis (22, 37, 48). Treatment to healing in an external fixator is recommended in cases of extensive soft tissue insult or C3 comminuted fractures, patient inoperability, or compromising factors such as peripheral arterial occlusive disease or diabetes mellitus (20).

Even the optimal mode of internal fixation remains the topic of ongoing discussions. Plating and screw fixation as well as combined procedures are common. Optimal treatment always means the procedure that offers sufficient stability because too much rigidity can compromise fracture healing. Given the anatomical situation and the not uncommon complications such as disordered wound healing and skin necrosis, it is important to consider less invasive approaches and careful preparation of the soft tissues. As an alternative to the preferred anteromedial approach to the distal tibial metaphysis Grose et al. described a lateral approach to minimize the risk of disordered wound healing and skin necrosis (17). In select cases a lateral approach to injuries of the ventrolateral tibial metaphysis may offer a tissue friendly alternative. However, the anteromedial approach to the distal tibial metaphysis remains standard procedure due to the complexity of these fractures.

One significant factor contributing to the risk of delayed fracture healing and the need for revision surgery is nicotine abuse or the number of cigarettes the patient is smoking per day at the time of injury (40).

CONCLUSIONS

The outcome for tibial pilon fractures depends to a great extent on differentiated soft tissue management. High infection rates, disordered wound healing, nonunion and late complications as well as posttraumatic joint degeneration and chronic osteomyelitis are some of the challenges surgeons will face in the management of tibial pilon fractures. The treatment regime should be interdisciplinary, permit flexible response to complications, accommodate the patient's individual needs and be properly scheduled. A review of the current literature has revealed that a two-stage or multi-stage procedure that respects the condition of the soft tissue is generally recommended.

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