The Use of External Fixation in the Lower Extremity

41

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41.1 History

External fixation has an extensive history that can be traced back to the days of Hippocrates.[1] In those days, external fixation consisted of wooden rods tied around a fractured limb acting as a splint. Despite the advances of technology and metallurgy, modern principles of external fixation are still based largely upon its early predecessors. However, complications arising from lack of adequate training prevent the more widespread acceptance of external fixation as a definitive treatment option. It was not until the mid-1800s that many advances in external fixation first accelerated.[2,3]

In 1840, Francois Malgaigne is credited for the earliest form of a modern external fixator. Originally used for a patellar fracture, a claw-like device was placed over the fragments and tightened similar to a vice-grip to achieve reduction.[2,3] Later that decade, Rigaud took this concept to the next level by embedding the spikes into the bone itself for a fractured olecrenon. As the start of the twenty-first century approached and passed, many physicians played a role in developing external fixation devices. Parkhill and Lambotte are recognized for what we now see as a monorail fixator.[2,3] Codvilla used Parkhill and Lambotte's work for limb lengthening.[2,4] He was the first to utilize the unilateral fixator for elective procedures, which at that time, was used exclusively for traumatic injuries. Hoffman, Vidal, Charnley, along with many others, in their collective works redesigned the frame to increase stability and agility for fracture reduction.[2] Many others have contributed to the advancement of external fixation, based on the groundwork of the aforementioned, during what seemed to be an external fixation renaissance during the mid-1900s.

As a part of this history, one must acknowledge the works of Gavril A. Ilizarov, whose frame design bears his name. At the beginning of his career in Kurgan, Serbia, he treated World War II veterans using his system from parts out of a bus factory.[5,6] Much like spokes on a wheel, the design had several Kirschner wires passing through the bone while being secured to the ring. The rings would then be attached to each other with threaded rods to improve stability. More important than his original circular ring blueprint was the discovery of an entire new science of orthopedics: distraction osteogenesis.[2,4,5] Surprisingly, this discovery came about by accident. The limb length corticotomy was first done on an amputee with the intent to place an interpositional graft. However, the Z-type osteotomy that was preformed showed radiographs with boney callus within the gap, precluding the need for grafting. Henceforth, the dawning of modern-day callus distraction for diseases such as dwarfism, birth defects, residual deformities from trauma, and other musculoskeletal diseases. Before his death in 1992, he established the Kurgan All Union Scientific Institute for Restorative Traumatology and Orthopedics and with over 2,000 articles credited to his name.[2,6]

Since his seminal works, external fixation has experienced a mixed and regional response. Many surgeons

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consider it the device of last resort, while others push the envelope of its capacity. The reality of external fixation is that it remains an incredibly valuable tool for the treatment of certain conditions and injuries. What is most important about its utilization is a thorough understanding of principles related to its application as well as its management. This chapter will set out to summarize the basic fundamentals of external fixation use.

41.2 Principles

The very design of an external fixator allows it to conform to any limb and to be expandable to span adjacent body segments. In fact, external fixation has been used from small bones of hand and feet to the face and even the cranium and spine. Another advantage it possesses is the ability to be adjustable during the treatment period without requiring additional anesthesia and with little risk to the overall treatment plan. This obviously has its advantages for gradual deformity correction such as limb length, Charcot arthropathy, and other angular deformities. In sharp contrast to internal fixation, external fixation is multiplanar that can address all planes, distraction, compression, and rotation. Instead of requiring the bone to conform to the implant (as in nails and plates), the external fixator can conform to the bone.

The fundamental principles of application can be stratified into technical, biologic, and mechanical. Technical aspects involve the actual placement of pins or wires along with the methods used to minimize problems associated with the pins, which are the majority of all problems encountered. Biologic principles are those involving the creation of osteotomies as well as the understanding of the bone's response to external fixation. Simply placing an external fixator without paying attention to the bone's response is often the cause of failure. Unfortunately, the failure is blamed on the fixator when in fact, it was the fault of the practitioner who failed to recognize and respond to the bone's response. An example would be a stiff and static frame applied and left on too long, resulting in an atrophic nonunion and disuse osteopenia. The mechanical aspects involve the different frame constructs that can be used, their clinical context, and methods of adjustment to enhance the biologic response.

41.3 Technical Points

Half pins should be applied percutaneously with minimal skin incisions. Half pins are now self-drilling and self-tapping. Intuitively, there has been significant resistance to using such a design, with fears of poor purchase and thermal necrosis. In fact, there is evidence from experiments using thermocouples on near and far cortices during pin placement that self-drilling, self-tapping pins produce the least temperature rise.[7] In the small bones of the foot, smaller diameter pins (2–4 mm) should be used. In the hind foot, 5–6-mm pins can be utilized safely. In other long bones of the appendicular skeleton, we generally use 4–5-mm pins as well, except in the hand, which is analogous to the foot in this regard. When half pins are placed, the compartment through which they are placed should be placed on stretch. The practitioner must be aware of the safe windows of placement to avoid any nerve, vessel, or muscle/tendon injury. Also, if the pins are transcortical and not bicortical, there is risk of thermal injury as well as fracture. Care should also be taken not to overpenetrate the pins into the opposite compartment.

Skinny wire fixation has other technical issues. They are flexible and thus require some guidance during placement. They are used through the same windows as half pins, but they pose less risk to surrounding soft tissues due to the lack of cutting edges and threads. The same principles of bicortical fixation and compartmental considerations exist for such half pins. The wires are generally 1.6–2.2 mm in diameter. Common sense tells us that larger wire diameter, increased wire tension, more wires per ring, and wires at different planes, all enhance ring stability.[8] Also, due to their inherent flexibility, they must be tensioned to provide any axial load resistance. Tensioning of the wire increases the stability and rigidity of the frame.[9] Smooth wires are tensioned typically to 130 kg. Too much tensioning (greater than 155 kg) results in stretching or deformation of the wire itself. It is permissible, however, to use 70–100 kg of tension in open frames. The amount of tension required will vary for various applications and personal preferences. As true as it was in early Ilizarov days, wires crossing closer to 90° provide maximal stiffness to axial loading. If the wires cross less than 60°, it may allow for unwanted sliding of bone along those wires. The advent of olive wires, or wires with beads eccentrically, prevent such sliding and can also be used to effect directional control or compression of bone segments.

Once half pins or wires are placed and the frame finalized, there should be a check on skin tension around each skin site. Any pressure or tension MUST be released. The majority of problems with pin tract complications are due to improper skin care. Another point that is based on anecdotal observation of the Ilizarov Institute is the soaking of pins in alcohol prior to insertion. Also, use of low-speed insertional reaming may help decrease the risk of thermal injury or mechanical microdamage during insertion.

41.4 Biologic Aspects

The biology of external fixation management has been widely studied and reported, but for some reason, apparently ignored. External fixation may be the most versatile device available in orthopedics, but most surgeons do not need the vast body of knowledge available. In fact, this may be due to cultural aversions in the United States, the external fixator remains relatively unpopular compared to other countries. The biology of healing in an external fixator is relatively simple. Stiffness of the "construct" should be modulated to match the biologic state of the bone. In other words, some situations require a very stiff construct while others require a flexible construct. Some conditions require compression, while others benefit from tension or even distraction. In general, early phases of treatment begin with stiff constructs, followed by progressive load transfer as the bone demonstrates a biologic response to healing (callus). In the fracture setting, we generally begin with a multiplanar frame that provides the most stable healing environment, so that the healing response can be initiated. Once a biologic response has been radiographically demonstrated, the fixator can be adjusted to begin transferring load to the newly formed callus. This gradual load transfer is monitored by the practitioner and done by progressive "de-stiffening" of the fixator. This can be done in many ways, and include removing bars, increasing the distance of bars from the load bearing axis (bone), removing fixation points (wires or pins), or using "dynamic" components that allow a predetermined spring stiffness and translation. Once an appropriate amount of healing has taken place, the fixator can be fully "dynamized" by removing all connecting elements and allowing a trail of unprotected weight-bearing with clamp assembly still connected to the bone. The clamp assemblies are kept connected in case healing is incomplete and some connecting bars need to be reconnected for a short period of time.

In some cases, such as a hypertrophic nonunion, where there is an abundance of biologic response but evidence of instability, the fixator can be used in the compression mode to provide added stability. If the condition is also associated with a deformity or shortening, the fixator can be used to effect a correction or lengthening, usually through the callous. Certain fixators allow an easy three-dimensional correction with computer assistance. Even in certain infected and hypertrophic nonunions, compression may potentially stimulate healing and help eradicate the infection.

In some cases, the fixator can be used in the distraction mode to either lengthen the limb or transport bone segments. The tenets of this method have been well elucidated by Ilizarov, and the reader is directed to those sources for a more detailed explanation of distraction osteogenesis. Distraction osteogenesis is the process of bone lengthening through callus distraction.[6,10] Bone formation using this technique is similar to intra-membranous bone formation and does not undergo the endochondral ossification seen with normal fracture healing. Under the appropriate timing and rate, osseous and soft tissues will proliferate within the designated gaps. The distraction rate varies by location, condition, and patient age. The latency period, which is the time period between the osteotomy and initiation of bone transport, also varies. In younger patients and bone that has excellent healing potential, latencies of only 5–7 days may be sufficient, where in other patients, latencies of 10–20 days are needed. If distraction is delayed, bone healing will occur and the tissues will not be able to distract. If the distraction is too soon, psuedoarthrosis and non-healing will occur. Callus formation must be allowed to span the initial gap. Also, some cases require a very slow distraction, as slow as 0.25 mm per day, while others need a relatively rapid rate of 1.0 mm per day. Ilizarov found that anything faster than 2.0 mm per day produced a suboptimal result.

Osteotomy creation also requires attention to biologic principles. Many techniques have been described, and the classic technique involves performing just a simple corticotomy, while sparing the medullary content. More recent techniques recognize that some violation of the medullary contents is acceptable, and use of multiple drill holes at the same level followed by a controlled fracture also work. Others use a gigli saw, which violates the medullary contents but seems to provide a reasonable response. A longer latency may be useful when such a technique is used. Many, however, warn against the use of a saw, probably due to the uncontrolled microdamage and macrodamage to both bone and surrounding tissues. Our preference is either a multiple corticotomy technique or a gigli saw.

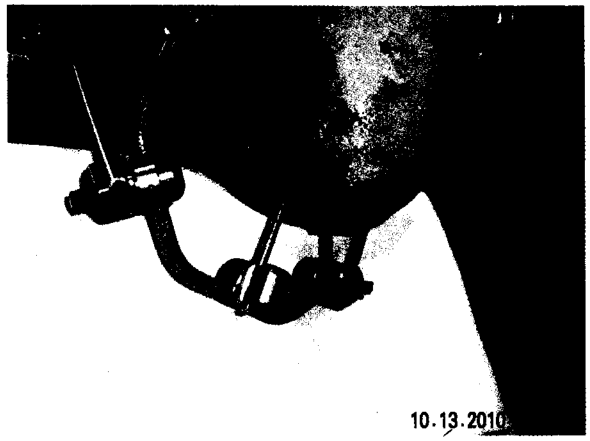

Fig. 41.1 Clinical photos of the posterior calcaneal pins used for ankle frames. Use of a "U" bar or foot frame is required. These pins do not loosen like transfixion pins

41.5 Mechanical Principles

The fundamental principle of external fixator application, whether for damage control or definitive treatment, revolves around the concept of the stable base (personal communication, James Hutson MD). The stable base concept involves constructing a stable frame in each critical segment of bone, usually with a minimum of two fixation points. As an example, if the fixator is a temporary fixator across the ankle, one stable base could be a two-pin, one-bar construct in the tibia, while the other would be a two- or three-pin frame using the calcaneus and forefoot. These two independently placed bases would then be connected to each other using intercalary bars and clamps. In a reconstruction setting, the stable bases could be a ring and pin/wire assembly.

There are a few mechanical principles of frame construction that are worthy of discussion. In a temporary setting, consideration should be given to subsequent incisions needed and longevity. If a second stage surgery is planned, then pin sites should avoid such areas in an effort to minimize colonization and seeding of subsequent implants. Most damage-control frames are in place for 1–3 weeks. However, several studies have identified that pins sites become colonized quickly and infected sites increase the risk of subsequent infection. In short-term construct, two pins in each segment suffice. However, if there is any chance that the fixator may be needed for a prolonged period of time, then multiple fixation points will be beneficial. A fixation point is either a half pin or wire in each stable base segment. As an example, if a long-term construct is anticipated, then having 4–5 fixation points (i.e., three half pins and two wires) provides the maximum flexibility. During the course of treatment, if any one or two fixation points (pin or wire) become irritated or infected, then removal of that particular wire or pin will not destabilize the construct.

In short-term damage-control settings, minimal segment fixation with a two-pin, one-bar stable base is generally sufficient. The practitioner should be familiar with the soft tissue windows for pin placement. With the ankle frame, a transcalcaneal approach has been traditionally used, with or without additional forefoot pins. The authors have abandoned the traditional transcalcaneal pin (medial to lateral) in favor of two posterior calcaneal body pins (Figs. 41.1–41.4). In the latter configuration, one pin enters the posterior medial body of the calcaneus and heads toward the calcaneocuboid joint. The other pin enters the posterior lateral body of the calcaneus and heads toward the medial sustentaculum. These two pins form an acute angle of about 20–30°. They are then connected via a "U" shape bar or assembly of bars. This forms the stable base of the hind foot. This U bar is then connected to the stable base of the tibia. Together they provide three advantages over standard transcalcaneal pins. First, they keep the heel and foot off the bed as does the "kick stand" frame. Second, the posterior pin placement provides a dorsiflexion moment that helps keep the foot out of equinus. Third, the clamp placement is such that it does not interfere with radiographic imaging.

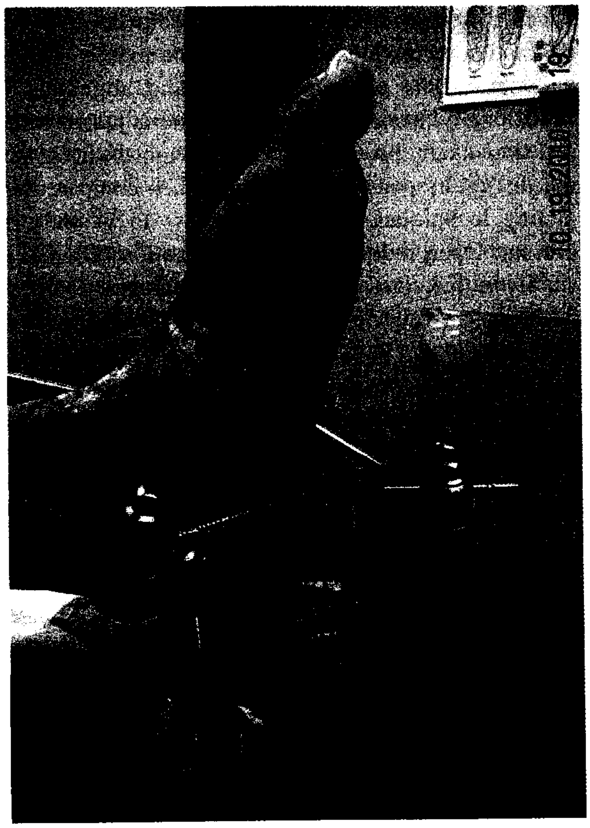

Fig. 41.2 Clinical photograph of the posterior calcaneal pins for the ankle frame. Note that an additional benefit is the lack of the heel contact with bedding and the "kickstand effect"

Fig. 41.3 Clinical photograph of the two diverging half pins providing more stability at two different points of fixation

Fig. 41.4 Radiographic lateral demonstrating construct. Note that no clamps obstruct the ankle joint and the relative dorsiflexion is maintained

In the midfoot, pins can be placed in any direction and crossing a midfoot joint is generally not problematic. In the forefoot, 5-mm pins should be replaced by either 4- or 3-mm pins to reduce the chance of stress risers in smaller bones. These pins can be attached to other aspects of the frame to reduce the "flop" of the forefoot.

When frames are placed for definitive treatment, they should be designed with the intention of progressive load transfer to the bone. Initially, most frames should be placed with the maximum stability, and then progressively de-stiffened as bone healing is demonstrated. In the lower extremity, we have found that a main support member (bar, dynamic tube, etc) should be placed in the anteromedial quadrant of the limb, and parallel to the long axis of the bone. This would correspond to the anteromedial tibia, and easily attached to pins placed perpendicular to the anteromedial face of the tibia in this area. This anteromedial bar is the first to be placed and last to be removed and provides the best mechanical support for the limb during weight-bearing. After the anteromedial longitudinal bar is applied, the frame is stiffened and stabilized by the addition of "delta" bars which course from the anteromedial quadrant to the lateral side. This delta construct provides the stability to both medial and lateral aspects of the limb. As time progresses and bone demonstrates healing, the delta bar can be removed to transfer load to the progressing callus. As bone continues to heal, the anteromedial bar can be moved further away from the limb to provide even further load transfer. Eventually, once healing has progressed enough, the bar can be removed in its entirety, but leaving each stable base in place (whether clamps or rings). The patient is then allowed to fully weight-bear for 1 or 2 weeks. If they successfully do so, without pain, and without any radiographic collapse, there is sufficient evidence of healing that each stable base can be removed (either in the office or outpatient surgery). This methodology incorporates the idea of progressive de-stiffening, which allows for a controlled load transfer to the bone. The authors has good success with a dynamic anteromedial component (Triax Monotube, Stryker, Mahwah, NJ), which is essentially a shock absorber that allows a variable amount of axial resistance (spring) and a dampening mechanism that can have a controlled amount of axial displacement (1–3 mm). It can also be used to distract or compress when needed.

41.6 Applications

The vast array of uses of external fixation is many. It is a wonderful modality to have in a surgeon's repertoire. Ambitious use must be tempered with wisdom and it falls on the surgeon to do what is in the best interest of the patient by asking not whether "it could be done," but rather "should it be done." Today, as it was in the past, external fixation has its primary usage in traumatic injuries with substantial bone loss or comminution.

Pilon fractures are high-energy injuries of the distal tibia that result in severe comminution. The use of internal fixation is problematic with little workable bone to fixate, and the soft tissue envelope surrounding the ankle is not amenable to tissue dissection and plating. Vascular integrity remains intact with external frames since they are applied percutaneously and therefore decrease incidence of infection in theory. By creating tension on surrounding soft tissues via a distraction technique called ligamentotaxis, it places the injured site to proper length and alignment.[11] Additionally, external fixators can be adjusted time and time again, provide for early weight-bearing, do not disrupt osseous blood supply when compared to plating techniques, and grant access to wounds if present. Open reduction, internal fixation (ORIF) is simply not amenable to these advantages, thereby issuing disuse atrophy, serial casting, prolonged non-weight-bearing, and possible subsequent surgical interventions.

Despite this, external fixation has not been shown to be conclusively superior or inferior to ORIF. A recent literature review of such a comparison states the statistical differences between the two in regards to healing time, malunion, nonunion, and infection were not significant.[12] Additionally, some advocate the usage of both internal and external fixation simultaneously to achieve reduction.[13] Furthermore, external fixation can be utilized in fracture management of those patients who suffer from peripheral vascular disease. This is done with smooth and olive technique.[14]

External fixation today can be used to fuse any number of joints in the lower extremities. The current literature suggests that arthrodesis is the gold standard for severe osteoarthritis. With its predictable outcome to relieve pain, it is equally predictable to have surrounding joints become painful and subsequent to arthrodesis themselves. Ankle replacement technology continues to improve and provide an alternative to fusion, but is riddled with various complications and limitations.[15] An alternative to either the above is called distraction arthroplasty.[15,16,26] Using external fixation to distract the soft tissues decreasing the mechanical stress allows the cartilage repair process to begin, sometimes being augmented with allograft materials after debridement. Since Charnley's original paper using a unilateral fixator for ankle arthrodesis,[17] external fixation has expanded to subtalar, midfoot, first metatarsal-phalangeal arthrodesis, and others.

Indications for surgical intervention of Charcot arthropathy are failure of conservative care, bone and joint instability, intractable ulceration, and alternate to amputation. Currently, there are no clearly defined guidelines for procedure of choice or timing to treat Charcot arthropathy.[18] Charcot arthropathy can be treated with external fixation in both acute and chronic phases. This is important because there are those who advocate early surgical intervention, even in an acute phase, to prevent further breakdown and impairment. Additionally, it can be used in patients with concomitant ulceration and further provides offloading to wounds.[19,20]

External fixation has its place among children and congenital deformities such as idiopathic clubfoot, arthrogryposis, or limb lengthening.[21] In such cases, deformities often present themselves in all three cardinal planes. Multilevel rings and olive wires can gradually place pedal structures into alignment while allowing the soft tissues to adapt. This is important to remember in juvenile patients younger than 8 years of age since it can be expected that soft tissue is still amenable to correction without osteotomies.[22] If osteotomies are required in children with open physes, the external fixation device can span over physes (leaving a 1- to 2-cm safe zone) and joints without causing compromise.[23]

41.7 Complications

External fixation is of course not without its complications with the device itself. Delayed union, neurovascular insult, pin tract infections, tissue necrosis, and construct stability are synonymous with external fixation failures.[24] Its bulky and cumbersome construct makes daily tasks such as getting dressed difficult. Patient understanding and commitment of themselves and support are vitally important to successful external fixation.

Pin breakage and tract infections are a very real and common complication of external fixation devices. They require maintenance and continuous monitoring. In a recent study, there are some predictors for pin track failure.[25] Heavier ring configuration, active patient, uncontrolled blood glucose, and tourniquet time have been linked for pin track complications.

Delayed/nonunion, with the application of external fixation, can arise from poor reduction, interposition of soft tissue, and disruption of osseous blood supply. This means the surgeon must address these issues at the application of external fixation. Bone grafts, compression, and atraumatic technique limit this problem. One should not sacrifice the above at the expense of the neurovascular bundle. Neurovascular insult can occur if safe zones are not utilized and axis of pin insertion ignored. Knowledge of cross-sectional anatomy will reduce neurovascular insult.

Pressure necrosis occurs when the frame itself is in close proximity to a swollen limb. The soft tissue blood supply is exsanguinated and death of tissue results. This too can lead to pin tract infections. Additionally, tension on the skin from pin placement can lead to tissue necrosis. This tension can be relieved by making a stab incision along the pin.

It is felt by many that these problems are best avoided by using plates and screws; however, their complications are not all that dissimilar. Even if all technical pearls are adhered to, failure can ensue such as contracture of soft tissue or angulations of bone. Armed with knowledge and foresight, many complications associated with external fixation can be avoided. Adequate reduction and alignment, early weight-bearing, and preservation of soft tissue are necessary regardless of fixation technique.

41.8 Conclusion

The use of external fixation has many indications in the treatment of lower extremity, including trauma (both temporary and definitive), reconstructive surgery, bone transport, arthrodiastasis and Charcot foot and ankle surgery. The demands are great, and surgical experience and training is necessary. The principles and techniques applied by the surgeon are paramount to the management of these complex lower extremity pathologies. Sound principles and techniques are necessary to minimize postoperative complications. Timing of surgery, soft tissue monitoring, and understanding of the bone healing, especially in a patient with peripheral diabetic neuropathy, are vital for the patient's long-term success. Caution needs to be taken throughout the patient care as intraoperative as well as postoperative complications are avoided by knowledge, experience, and training along with appropriate patient selection.

Below are several different examples of cases where external fixation can be used in the lower extremity. This chapter should serve as a brief overview.

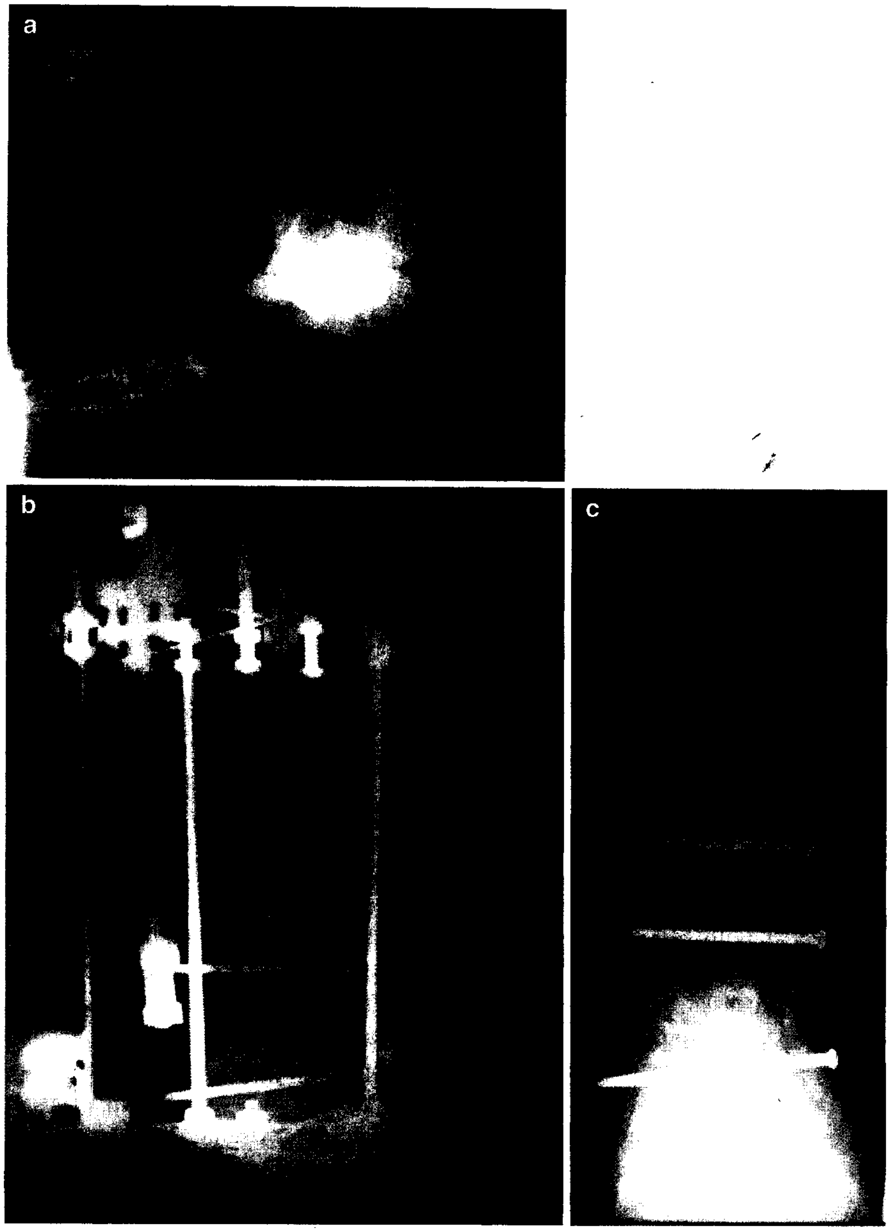

Fig. 41.5 (**a**) Pre op rheumatoid ankle arthritis – lateral view. (**b**) Post op rheumatoid arthritis ankle fusion AP view. (**c**) Post op following the removal of the external fixation with a fibula onlay graft

41.9 Cases

41.9.1 Case #1

This is a 58-year-old female who presented with a very painful left arthritic ankle. This patient suffered from rheumatoid arthritis and was affected with poly arthropathy, particularly her left ankle, bilateral shoulder, and wrist. The treatment plan was consistent for an ankle arthrodesis with internal and external fixation. The external fixation was used as a static frame; she was unable to be non-weight-bearing because of her upper extremity involvement. Therefore the external fixation was very helpful in her postoperative

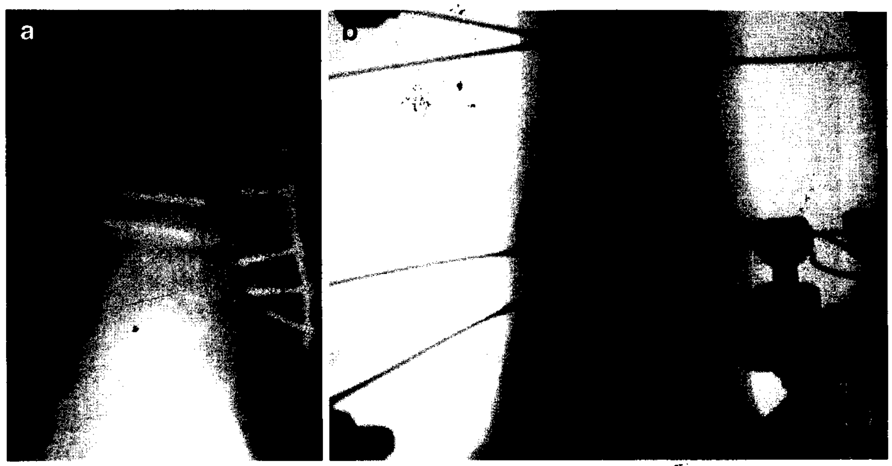

Fig. 41.6 (**a**) Pre op AP radiograph demonstrating a patient with post traumatic arthritis. (**b**) Intra operative ankle mortise view with distraction of the tibial–talar joint

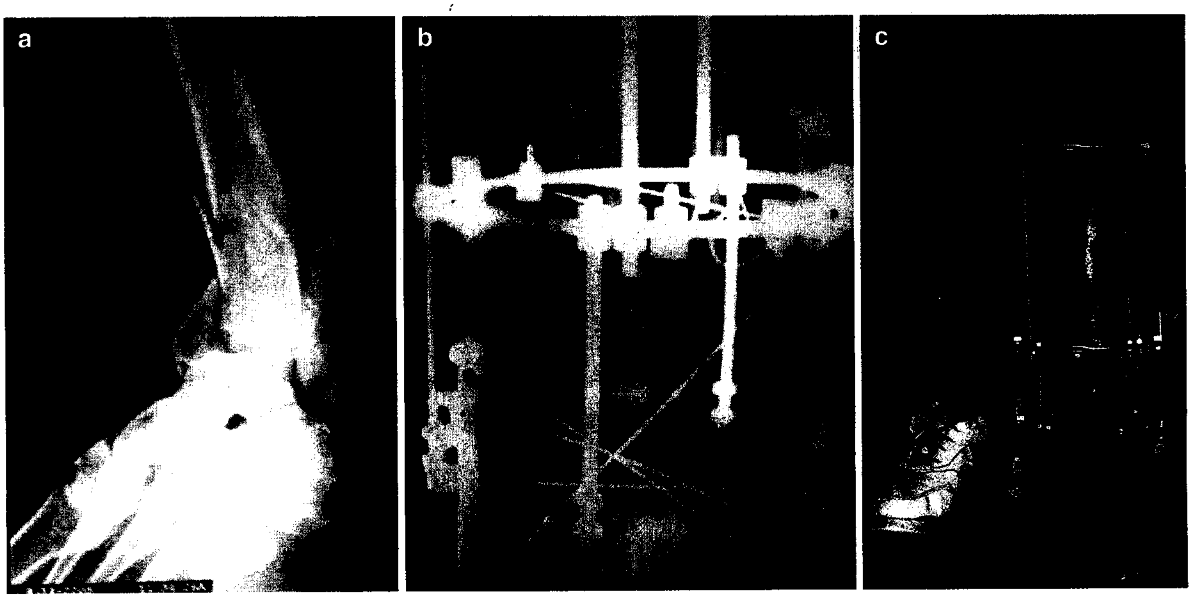

Fig. 41.7 (**a**) Pre operative intra-articular pilon fracture. (**b**) Post operative radiograph demonstrating reduction of a pilon fracture with the use of an Ilizarov external fixator. (**c**) Post op clinical view of an external fixator

course allowing the patient to be full weight-bearing (Fig. 41.5a–c).

41.9.2 Case #2

This is a 44-year-old male who presented with post-traumatic ankle arthritis. Surgical treatment consisted of removal of hardware, ankle arthroplasty, and distraction arthrodiastasis with an external fixator (Fig. 41.6a and b).

41.9.3 Case #3

This is a 49-year-old male who presented with a pilon fracture. The reduction was performed with percutaneous technique. The patient was placed on a fracture table, distraction was applied, and an external fixator was applied with compression being applied via the olive wires. The olive wires were tensioned off of the stable block of the external fixator (Fig. 41.7a–c).

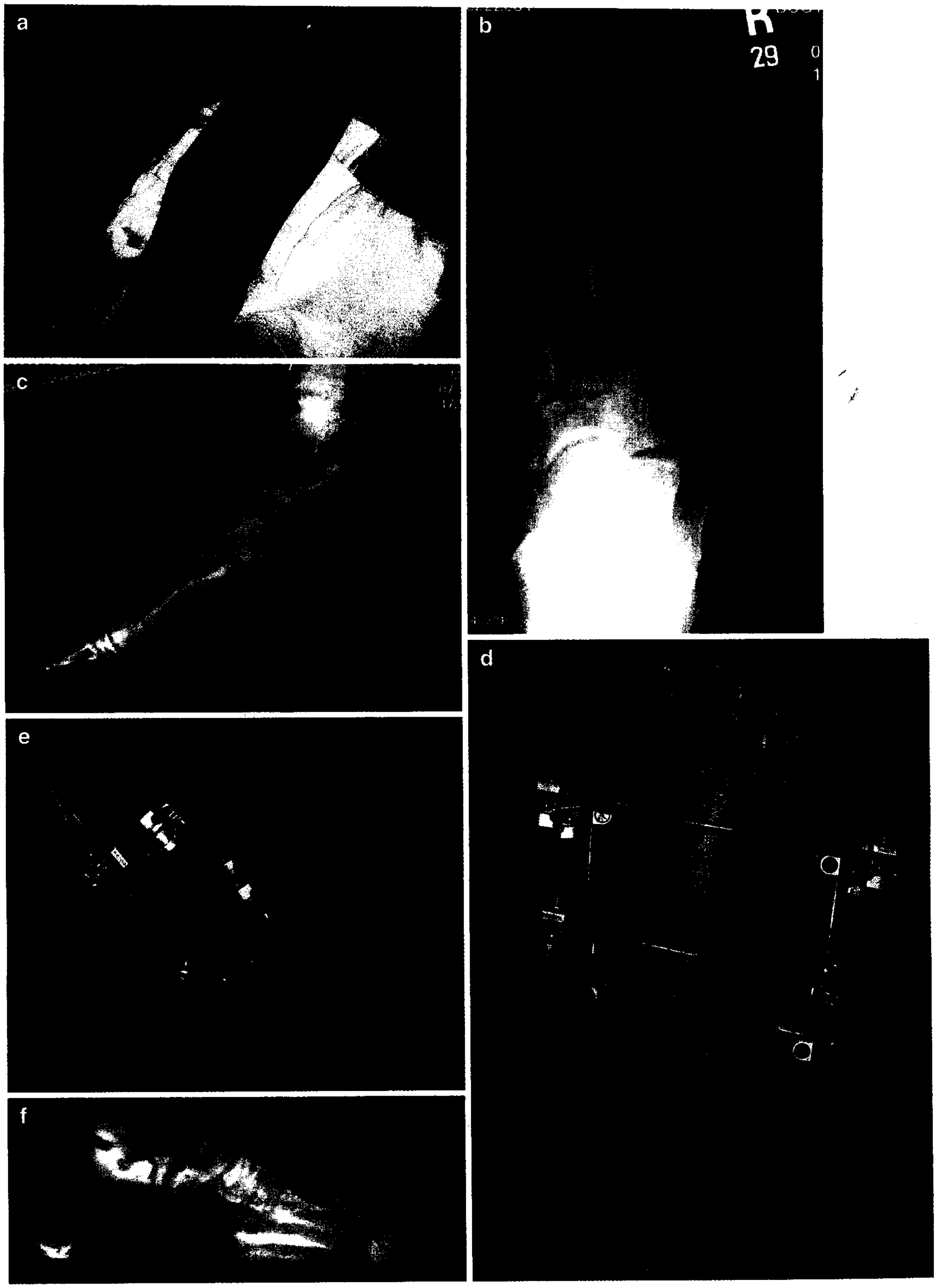

Fig. 41.8 (**a**) Clinical pre op mid foot dislocation. (**b**) Pre op AP view of a Lis Franc's dislocation. (**c**) Pre op mid foot dislocation lateral view. (**d**) Post op clinical view of the external fixation for a mid foot dislocation. (**e**) Clinical view of external fixation (**f**) Post op reduction – lateral radiograph full weight-bearing

Fig. 41.9 (**a**) The patient is on the fracture table with weight distraction and applying percutaneous smooth and olive wires for fracture reduction. (**b**) Post reduction with olive wires and a multi level circular frame for stability. (**c**) Post op clinical view following percutaneous external fixation of an ankle fracture

41.9.4 Case #4

This is a 36-year-male who presented post motor vehicle accident with a midfoot dislocation. He was initially treated with an external fixation for immediate reduction and to allow the soft tissue edema to reduce. Subsequently, he was fixated with internal screw fixation, followed by hardware removal (Fig. 41.8a–f).

41.9.5 Case #5

This is a 41-year-old male who presented with a history of falling off a roof. He was diagnosed with an intra-articular distal tibia and fibula fractures. The patient was treated with a multilevel circular external fixator with smooth and olive wire technique (Fig. 41.9a–c).

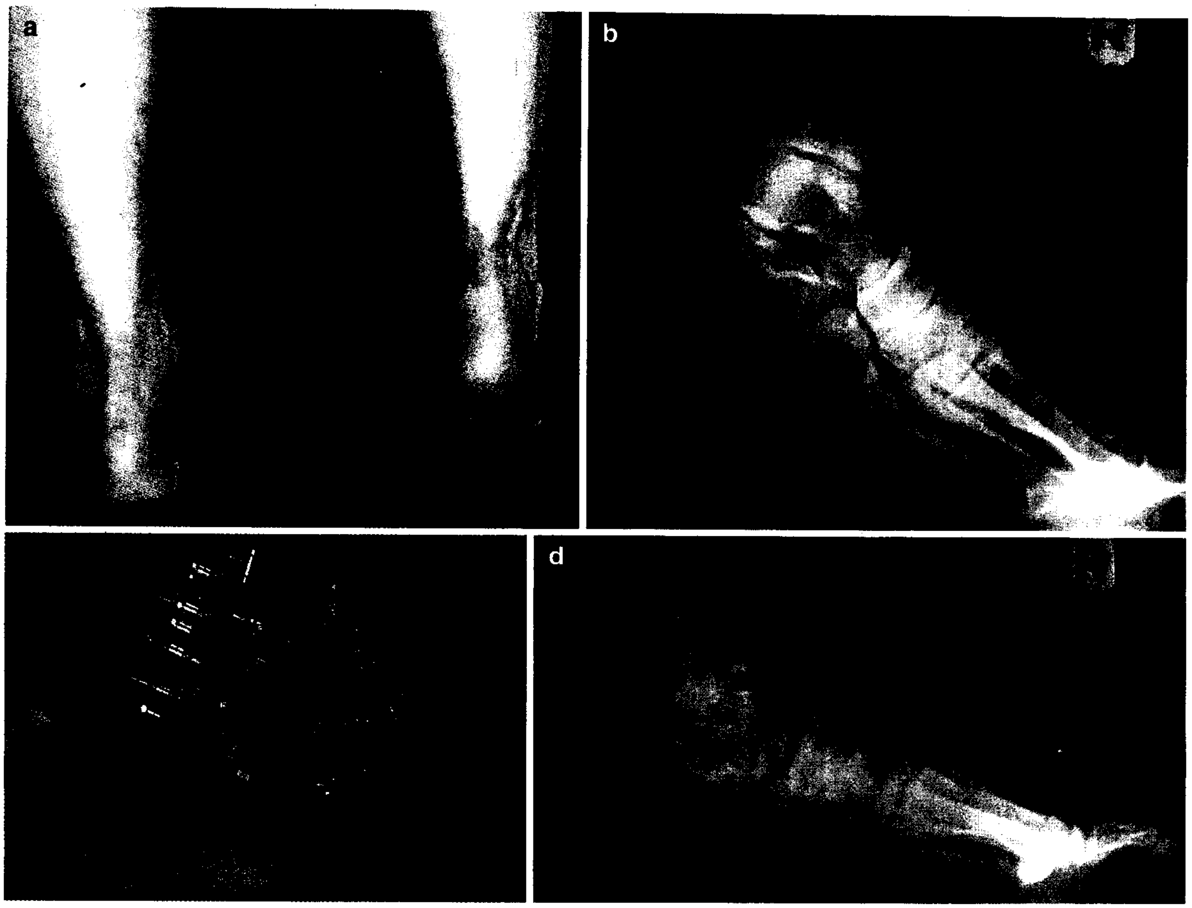

Fig. 41.10 (a) A patient with a significant post traumatic ankle joint equinis. (b) Pre op lateral weight bearing radiograph demonstrating the equinis deformity. (c) Post operative view of an external fixator with hinges and motors anterior and posterior. (d) Post op lateral radiograph post removal of a dynamic external fixator following slow gradual correction

41.9.6 Case #6

This is a 47-year-old male who has posttraumatic ankle joint contracture. Because of the extensive soft tissue damage and scar, this patient was put into a multilevel circular external fixator for a slow dynamic correction. Please note that the hinges are placed along the axis of the ankle joint and a "push/ pull motor" was added to the frame (Fig. 41.10a–d).

Fig. 41.11 Status post vascular comprises a thromboembolic event following application of an external fixator

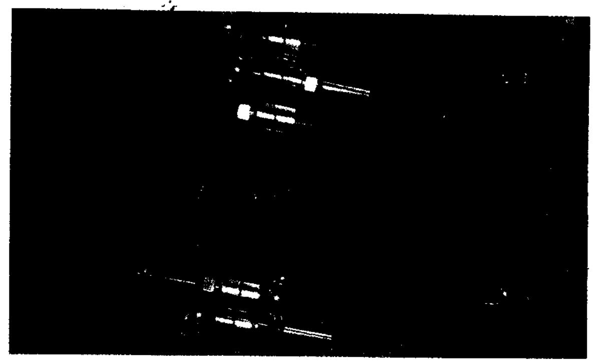

Fig. 41.13 Complication of early pin track infection and poor wire placement

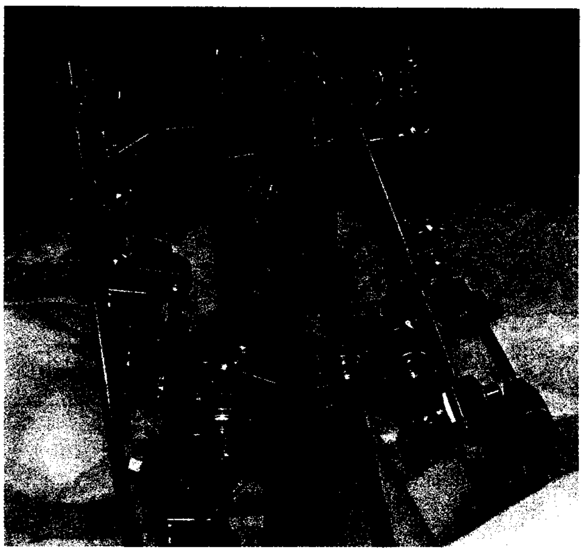

Fig. 41.12 Post application of an external fixator with soft tissue comprise in a diabetic patient with charcot arthropathy

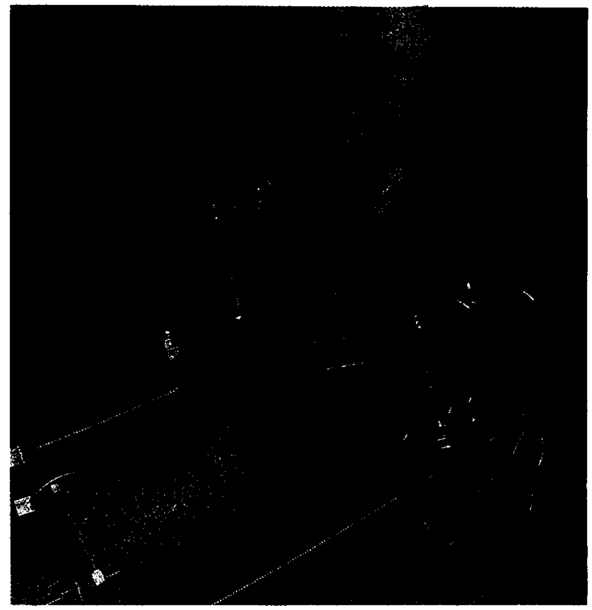

Fig. 41.14 Complications of early pin track infection

41.9.7 Complication Cases

Case A – A patient who unfortunately experienced a thromboembolic event following surgery (Fig. 41.11)

Case B – A patient who is a diabetic with soft tissue compromise following Charcot reconstruction (Fig. 41.12)

Case C – A patient who is developing a pin track infection because of poor wire placement (Fig. 41.13)

Case D – A patient who is experiencing a pin track infection and cellulitus because of poor wire management (Fig. 41.14)

Case E – A patient who experienced a poor application of a posterior medial wire which in turn traumatized the posterior tibial artery (Fig. 41.15)

Fig. 41.15 Complication following an application of an external fixator–smooth wire traumatized the posterior tibial artery

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